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U.S. EPA Contract

68-W8-0093

Donohue & Associates, Inc.

EPA Contract No.: 68-W8-0093
Work Assignment No.: 20-5F45
Donohue Project No.: 20022.000

FINAL DESIGN INVESTIGATION REPORT

SOUTH ANDOVER
FIRST OPERABLE UNIT
ANDOVER, MINNESOTA

FEBRUARY 1991

Prepared for:

U.S. Environmental Protection Agency
Remedial Enforcement and Response Branch
Region V
77 West Jackson Boulevard
Chicago, Illinois 60604

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FINAL DESIGN INVESTIGATION REPORT
SOUTH ANDOVER
FIRST OPERABLE UNIT
ANDOVER, MINNESOTA

FEBRUARY 1992

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TABLE OF CONTENTS

TABLE OF CONTENTS i

LIST OF TABLES iii

LIST OF FIGURES iv

LIST OF APPENDICES v

Section	Title	Page
	Executive Summary	vii
1.0	Introduction	1-1
	1.1 Program Summary	1-1
2.0	Background Information and Previous Investigations	2-1
	2.1 Site Background and Setting	2-1
	2.1.1 Site Location and Description	2-1
	2.1.2 Population and Land Use	2-1
	2.1.3 Site History	2-2
	2.1.4 Regulatory Response Actions	2-4
	2.1.5 Current Conditions	2-5
	2.2 Previous Investigations	2-5
	2.2.1 Subterranean Engineering Geotechnical Investigation (1978)	2-5
	2.2.2 RMT and PEDCo Environmental Program (1979)	2-6
	2.2.3 US EPA Region V FIT Program (1981)	2-6
	2.2.4 CH2M Hill Remedial Investigation (1985)	2-7
	2.2.5 Donohue Second Operable Unit RI (1990)	2-9
	2.3 Geology	2-9
	2.3.1 Regional Geology	2-9
	2.3.2 Site Geology	2-10
	2.4 Hydrogeology	2-11
	2.4.1 Regional Hydrogeology	2-11
	2.4.1.1 Glacial Drift Aquifers	2-12
	2.4.1.2 Bedrock Aquifers	2-12
	2.4.2 Site-Specific Hydrogeology	2-13
	2.4.2.1 Hydraulic Characteristics of Glacial Deposits	2-13
	2.4.2.2 Groundwater Flow Characteristics	2-13
	2.5 Groundwater Quality	2-14

3.0 Donohue Field Investigation 3-1
3.1 General 3-1
3.2 Soil Boring and Geotechnical Sampling 3-1
3.2.1 Soil Boring Procedure 3-1
3.2.2 Chemical Soil Sampling 3-2
3.2.3 Geotechnical Sampling 3-2
3.3 Monitoring Well Installation 3-2
3.3.1 Monitoring Well Construction Procedures 3-2
3.3.2 Well Abandonment 3-3
3.4 Hydraulic Characterization 3-3
3.5 Groundwater and Residential Well Sampling 3-4

4.0 Investigative Results 4-1
4.1 Site Geology 4-1
4.2 Site Hydrogeology 4-3
4.3 Geotechnical Testing 4-5
4.4 Chemical Sampling Results 4-5
4.4.1 Soil 4-5
4.4.2 Groundwater 4-6
4.5 Water Quality Results 4-8
4.6 Well Abandonments 4-8

5.0 Summary and Conclusions 5-1
5.1 Summary 5-1
5.1.1 Previous Investigations 5-1
5.1.2 Design Investigation Activities 5-1
5.1.3 Site Geology and Hydrogeology 5-1
5.1.4 Nature and Extent of Contamination 5-2
5.2 Data Limitations 5-3

6.0 References 6-1

LIST OF TABLES

Table		Follows Page
2-1	Summary of Detected Organic Compounds - Surficial Soil, CH2M Hill RI/FS	2-7
2-2	Summary of Detected Organic Compounds - Pilot Borings, CH2M Hill RI/FS	2-7
2-3	Summary of Inorganic Compounds Detected Above Background - Surficial Soil, CH2M Hill RI/FS	2-7
2-4	Summary of Organic Compounds Detected in Groundwater Above RALs or MCLs, CH2M Hill RI/FS	2-7
2-5	Summary of Inorganic Compounds Detected in Groundwater Above Background, RALs, or MCLs - CH2M Hill RI/FS	2-7
2-6	Summary of Inorganic Compounds Detected in Residential Wells Above Background, RALs, or MCLs - CH2M Hill RI/FS	2-7
2-7	Summary of Detected Volatile Organic Compounds - Soil	2-9
2-8	Summary of Detected Semi-Volatile Organic Compounds - Soil	2-9
2-9	Summary of Detected Pesticide/PCB Compounds - Soil	2-9
2-10	Summary of Detected Inorganic Compounds - Soil	2-9
2-11	Summary of Detected Volatile Organic Compounds - Sediment and Surface Water	2-9
2-12	Summary of Detected Semi-Volatile Organic Compounds - Sediment and Surface Water	2-9
2-13	Summary of Detected Pesticide/PCB Compounds - Sediment and Surface Water	2-9
2-14	Summary of Detected Inorganic Compounds - Surface Water	2-9
2-15	Summary of Detected Inorganic Compounds - Sediment	2-9
3-1	Soil Borings	3-2
3-2	Well Construction Details	3-3
3-3	Sampling Well Details	3-4
4-1	Geotechnical Analysis Results	4-1

LIST OF TABLES
(Continued)

Table		Follows Page
4-2	Summary of Detected Organic Compounds - Soil Borings	4-5
4-3	Summary of Detected Inorganic Compounds - Soil Borings	4-6
4-4	Summary of Detected Organic Compounds - Groundwater from Upper Sand Aquifer	4-6
4-5	Summary of Detected Organic Compounds - Groundwater from Aquitard	4-6
4-6	Summary of Detected Organic Compounds - Groundwater from Lower Sand Aquifer	4-6
4-7	Summary of Detected Organic Compounds - Groundwater from Residential Wells	4-6
4-8	Summary of Detected Inorganic Compounds - Groundwater from Upper Sand Aquifer	4-7
4-9	Summary of Detected Inorganic Compounds - Groundwater from Aquitard	4-7
4-10	Summary of Detected Inorganic Compounds - Groundwater from Lower Sand Aquifer	4-7
4-11	Summary of Detected Inorganic Compounds - Groundwater from Residential Wells	4-7

LIST OF FIGURES

Figure		Follows Page
2-1	Site Location Map	2-1
2-2	Site Map	2-1
2-3	Reported Waste Disposal Activities	2-2
2-4	Potential Sources of Contamination	2-2
2-5	Maximum Tire Coverage	2-2
2-6	Summary of Previous Investigation	2-5

LIST OF FIGURES
(Continued)

Figure		Follows Page
2-7	Regional Geologic Cross-Section	2-11
2-8	Site Stratigraphic Column, (CH2M Hill, 1988)	2-11
2-9	Regional Bedrock Topography	2-12
2-10	Water Table Map, (CH2M Hill, 1988)	2-14
2-11	Potentiometric Surface of Lower Sand Aquifer, (CH2M Hill, 1988)	2-14
3-1	Well Locations and Location of Geologic Cross-Sections	3-1
4-1	Site Stratigraphic Column	4-1
4-2	Cross-Section A-A'	4-1
4-3	Cross-Section B-B'	4-1
4-4	Water Table Map	4-3
4-5	Potentiometric Surface Map	4-4
4-6	Detected Arsenic Locations and Concentrations - Upper Sand Aquifer	4-8
4-7	Detected Arsenic Locations and Concentrations - Lower Sand Aquifer	4-8

LIST OF APPENDICES

A Record of Decision

B Technical Memorandum - Soil Boring/Well Installation Program

C Soil Boring Logs

D Minnesota Department of Health Well Installation Forms

E Well Construction Diagrams

LIST OF APPENDICES
(Continued)

F Minnesota Department of Health Well Abandonment Records

G Technical Memorandum - Slug Testing and Hydraulic Characterization

H Technical Memorandum - Groundwater Sampling Program

I Technical Memorandum - Geologic Evaluation

J Technical Memorandum - Hydrogeologic Evaluation

K Geotechnical Laboratory Reports

L Technical Memorandum Chemical Sampling Results Comparison

M Analytical Results for Soil and Groundwater

ARCS/R/SANDOVER/AT6

EXECUTIVE SUMMARY

Donohue, Inc. (Donohue) is submitting this Design Investigation (DI) Report for the South Andover Superfund Site to the U.S. Environmental Protection Agency (EPA) in response to EPA Work Assignment No. 13-5N45 (Region V ARCS Contract No. 68-W8-0093). The South Andover Design Investigation was conducted to determine current groundwater quality within the surficial aquifer system (Operable Unit I), and to provide the EPA with data useful for determining whether an existing Record of Decision (ROD) issued by the EPA for Operable Unit I (OU-I) should be implemented or revised. Investigation activities also included the collection of information useful for screening and implementing remedial design alternatives in the event groundwater impacts were noted.

The South Andover site is located in Andover, Minnesota (Anoka County) 16 miles north-northwest of Minneapolis. The site is comprised of several privately owned parcels, which jointly encompass more than 50 acres. Several active businesses involved with auto salvaging operations occur both on and adjacent to the site. Private residences are also located along the west side of the site, and continued residential development occurs both to the north and south.

Background historical information indicates that waste storage and disposal activities occurred at the South Andover site from the mid 1950s to the mid to late 1970s. Wastes stored on-site have reportedly included ink, paint sludges, adhesives, chlorinated and nonchlorinated solvents, as well as large quantities of tires. Past operations have included on-site incineration, open pit dumping, burning of solid, liquid, and chemical wastes, solvent recovery operations, and the salvaging of electrical equipment including transformers.

Actions to limit and regulate waste storage and disposal operations were implemented by Anoka County and the Minnesota Pollution Control Agency (MPCA) in the mid 1970s to early 1980s. Failure of the Potentially Responsible Parties (PRPs) to comply with regulatory criteria resulted in the ranking and inclusion of the South Andover site in the Superfund program.

Several investigations have been conducted since the late 1970s to evaluate identified concerns at the South Andover site. Studies have identified local contamination of groundwater, soil, sediments, and surface water by inorganic and organic compounds. Inventoried drums have been sampled and found to include ink and ink sludge, paint and paint sludge, and various other chlorinated and nonchlorinated solvents and resins (CH2M Hill, 1988).

The most recent investigation is the Second Operable Unit (OU-2) Remedial Investigation (RI) undertaken to assess the nature and extent of potential chemical contamination occurring in on-site soils (Donohue 1991). In particular, OU-2 RI program results have revealed areas of local soil contamination. The nature and extent of soil and buried contamination are not homogeneous horizontally or vertically. Rather, physical and chemical impacts at the South Andover site are distributed as localized "hot spots".

Activities completed during the South Andover DI field investigation include the completion of a site survey, soil borings, monitoring well installation and well development activities. Chemical soil samples were collected during soil boring activities, and groundwater samples were collected from newly installed monitoring wells, existing monitoring wells, and residential wells located on and near the site.

Results of the Design Investigation have shown that the South Andover site is underlain by three major hydrostratigraphic units which include (1) an Upper Sand Aquifer; (2) an intervening aquitard; and (3) the Lower Sand Aquifer. The aquitard may be subdivided into three subunits based on differing lithologies and hydraulic properties. Groundwater in the upper sand aquifer flows radially from the northeast towards the west-southwest. Groundwater in the lower sand aquifer flows from the northeast towards the west-southwest. Downward vertical movement of groundwater is indicated for the Upper Sand Aquifer and the Aquitard unit.

Analytical results for soil samples collected during the DI have revealed that several Semi-Volatile Organic Compounds (SVOCs) and inorganics at the South Andover Site occur at concentrations greater than those commonly found in U.S. soils under natural conditions. The occurrence of SVOCs, inorganics, and other compounds detected during the RI are discussed in more detail in the RI Report (Donohue, 1991).

Low level contamination of both on-site soils and groundwater by Volatile Organic Compounds (VOCs) exists in isolated areas. VOC contamination does not correlate well with site physical characteristics. Rather, the observed distribution may be interpreted as being consistent with site history which describes isolated locations for leaking drum storage and dumping. The concentrations of VOCs detected do not present significant risks and do not exceed Maximum Contaminant Levels (MCLs) or Recommended Allowable Limits (RALs), suggesting that such occurrences may not be significant or warrant further investigation.

No groundwater quality impacts attributable to polyaromatic hydrocarbons (PAHs) were noted. There is no pattern of distribution to relate occurrences of PAH in soil with past tire fires, solvent burning activities, or known or suspected drum storage areas.

Soils and groundwater are locally impacted by bis(2-ethylhexyl)phthalate (BEHP). Although detected levels of BEHP in groundwater do not exceed state or federal standards, the low levels of BEHP in the Upper Sand Aquifer pose an excess cancer risk of 1.2E-06.

Secondary MCLs which are based on the aesthetic quality of water and not health risks, were exceeded for manganese and iron in groundwater samples taken primarily from the Upper Sand Aquifer. The MCL for arsenic was exceeded in groundwater extracted from one monitoring well which was screened in the Upper Sand Aquifer. Elevated levels of iron and manganese are probably not attributable to on-site sources at the South Andover site. The majority of

arsenic exceedances occurred near the south-southwestern portion of the site. While the observed direction of groundwater flow suggests an on-site source, no soil arsenic source has been identified. Results of the baseline risk assessment completed during the South Andover RI/FS (OU-2) indicate that an unacceptable excess cancer risk may be associated with the groundwater pathway due to the presence of arsenic.

1.0 INTRODUCTION

Donohue & Associates, Inc. (Donohue), was retained by the U.S. Environmental Protection Agency (EPA) to provide professional services to EPA Region V under the ARCS program. Donohue performed a Design Investigation (DI) at the South Andover site in Minnesota in response to Work Assignment No. 13-5N45, Region V ARCS Program Contract No. 68-W8-0093. This investigation was completed to evaluate current groundwater quality at the site, and determine whether potential environmental impacts to public health and welfare are indicated. Information obtained from this study was also collected to allow EPA to determine whether the remedial actions discussed in a March 30, 1988 Record of Decision (ROD) should be undertaken.

Uncertainly concerning the likelihood of whether significant groundwater contamination was present at the South Andover site was reported following issuance of the ROD. This ambiguity lead the EPA to initiate a DI (this study) to further evaluate current site conditions, and provide information useful for implementing remedial alternatives in the event significant contamination is detected.

1.1 PROGRAM SUMMARY

Activities completed by Donohue as part of the DI included advancing soil borings, field screening of soil samples, installing new and replacement monitoring wells, groundwater sampling of monitoring and residential wells, slug testing, and geotechnical testing.

Six soil borings were completed to facilitate the installation of six new or replacement monitoring wells. In general, soil borings were continuously sampled. Groundwater monitoring wells were constructed in each boring to provide information on groundwater levels, provide for hydraulic characterization, and allow for groundwater sampling.

Soil samples recovered from borings were field screened for select volatile organic compounds (VOCs) through the use of a photoionization detector (PID). After field screening, soil samples were classified and logged by an on-site geologist. Selected soil samples were submitted for geotechnical analysis to confirm field classifications and provide supplemental geotechnical information. Soil samples also underwent chemical analysis to supplement the concurrent Second Operable Unit RI/FS.

Water levels were measured in new and existing monitoring wells to determine depth to water, general groundwater flow directions, and hydraulic gradients within the unconsolidated deposits at the site. In addition, groundwater samples were collected from 20 monitoring wells and 4 residential wells.

Groundwater samples were analyzed for Target Compound List (TCL) VOCs, TCL semi-volatile organic compounds (SVOCs), TCL inorganics (metals), chemical oxygen demand (COD), total phosphorous (TP), total suspended solids (TSS), and total solids (TS). Groundwater samples from three wells also underwent PCB analysis.

Groundwater samples collected from residential wells were analyzed for VOCs, BNAs, TCL inorganics (metals) and cyanide. Groundwater from one residential well was also analyzed for PCBs and pesticides. Field parameters, including pH, conductivity and temperature were measured on all water samples.

Slug tests were conducted on newly completed monitoring wells to determine the hydraulic conductivity of the geologic units at the screened interval. Laboratory falling head permeability tests were completed to provide hydraulic conductivity information for fine grained units (low hydraulic conductivity).

2.0 BACKGROUND INFORMATION AND PREVIOUS INVESTIGATIONS

2.1 SITE BACKGROUND AND SETTING

2.1.1 Site Location and Description

The South Andover site is located near the southern limits of Andover, Minnesota, approximately 16 miles north-northwest of Minneapolis and 3 miles northeast of the City of Anoka. The site is situated at 45° 16' N Latitude, and 93° 12' W Longitude, in the south half of Section 34, Township 32 North, Range 24 West (Grow Township) (Figure 2-1).

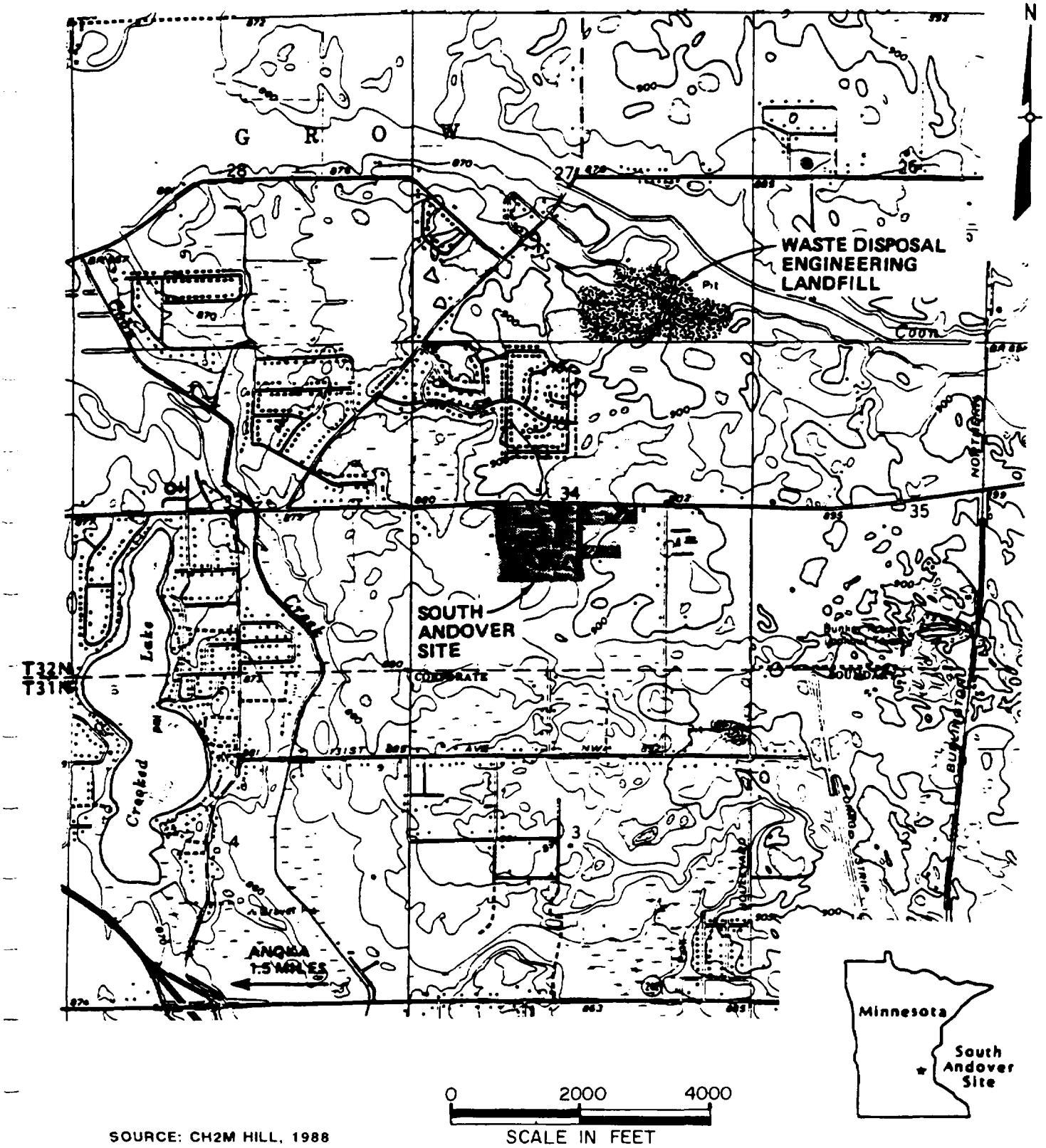
The South Andover site is comprised of several parcels of land which jointly total approximately 50 acres. As shown in Figure 2-2, the site is irregular in shape. Bunker Lake Boulevard defines the northern extent of the site, while Jay Street is located approximately 500 feet east of the site. Several small businesses involved with used car and auto parts sales, auto salvage operations, and auto body repair exist both at the site, and adjacent to the site along both roads. For many years this area was sparsely populated. However, residential development was initiated 1/4-mile north of the site in the early 1970s, and continued development is occurring to the east, north, and south.

During project planning for the RI/FS (Donohue, 1990), the site was divided into six areas designated A through F. These areas are shown on Figure 2-2 and described in detail in the RI Final Work Plan (Donohue, 1990). The extent of each area was determined from file information concerning prior land use, aerial photographs, and previous investigation results. These areas were delineated to focus planning of sample collection activities. The areas do not necessarily meet consistent physical, chemical, or operational criteria.

2.1.2 Population and Land Use

The South Andover site is located near a large metropolitan area which includes Minneapolis (population 370,951), Anoka (population 16,408), and Andover (population 13,086). Manufacturing is the leading source of income for residents of the area, with wholesale and retail trade being the largest industrial employer in the area. Tourism, lumbering, and farming are other important industries.

Small businesses and new residential developments are common in the vicinity of the South Andover site. Small businesses deal in used cars, auto parts, auto salvage and auto body repair. Several small recreational lakes are also located in the area. Crooked Lake lies 1 mile west of the site and Bunker Lake is 1-1/4 mile to the east. The site is generally located within the Coon Creek watershed.



SOURCE: CH2M HILL, 1988

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FIGURE 2.1

SITE LOCATION MAP

SOUTH ANDOVER SUPERFUND SITE
DESIGN INVESTIGATION
ANDOVER, MINNESOTA

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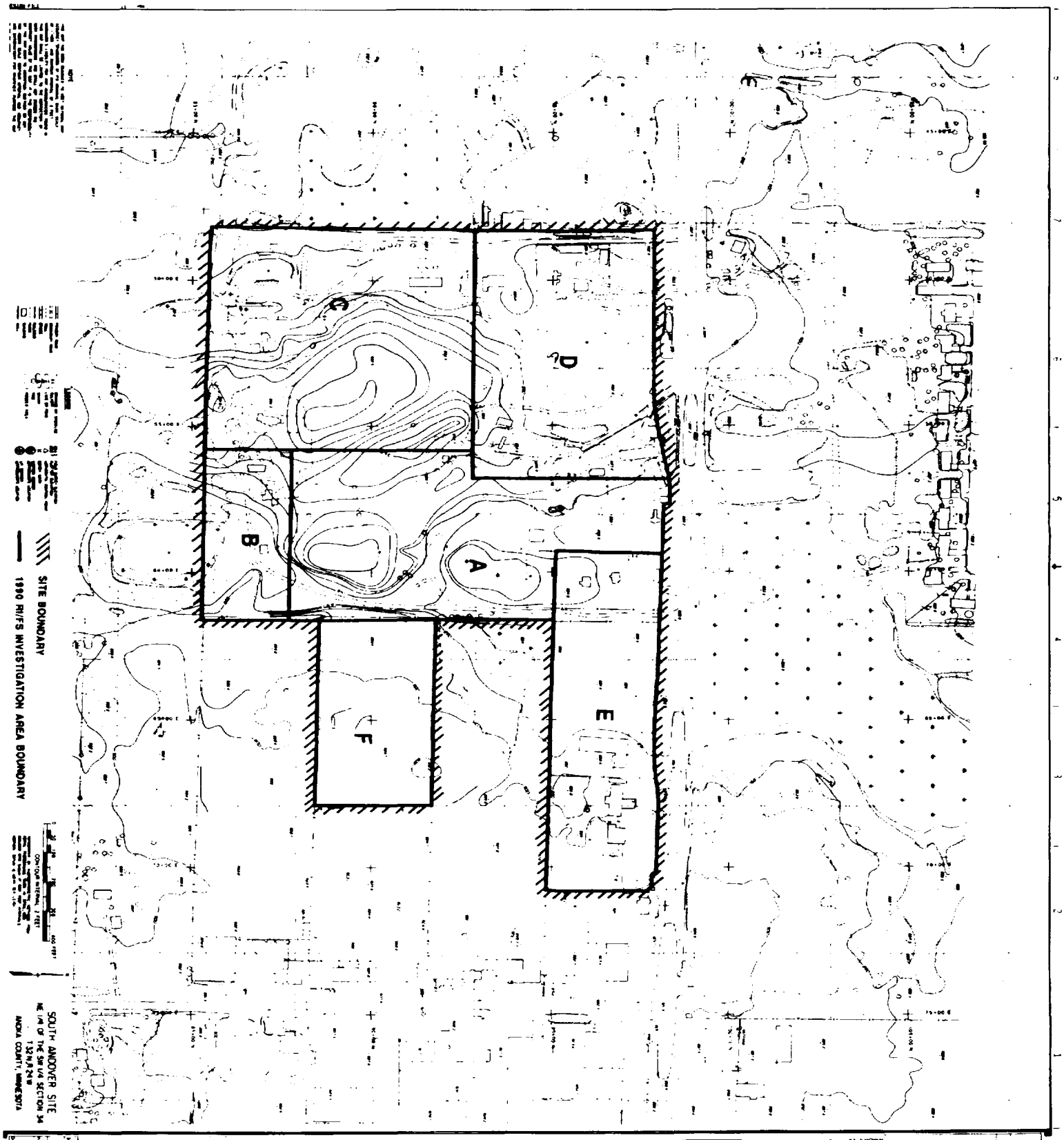

FIGURE 2-2
SITE MAP
SOUTH ANDOVER SUPERFUND SITE
DESIGN INVESTIGATION
ANDOVER, MINNESOTA

Donohue

The former David and Shirley Heidelberger property (now Meyer) was also used for the storage of drummed industrial wastes. Approximately 200 drums of chemical waste were stored along the northern edge of the property. Uncontrolled spillage was reported to have occurred periodically.

Available information indicates that the storage of thousands of gallons of paints, adhesives, and greases on the Charles Mistelske property (Commercial Auto Parts) were initiated in 1973.

Several operations were allegedly conducted at the former Cyril Link-Pumpkin City Enterprises property (now Klar). This reportedly included the storage of transformers and other salvaged electrical equipment and junk, smelting operations, and the storage of numerous drums of chemical wastes and solvents.

Two tire fires have occurred at the South Andover site. The first fire occurred during July 1988, near the northeastern portion of the Cecil Heidelberger property. This fire was confined to this general area where small piles of tires and rubber chips were located. The use of water during the fire may have resulted in pyrolysis, potentially releasing various organic contaminants into the soil or groundwater. Review of historical chemistry data on tire fires indicates that the use of water to extinguish tire fires aids in the formation of polynuclear aromatic hydrocarbons (PAHs) and volatile aromatic compounds (VOCs) including benzo[a]pyrene, pyrene, chrysene, anthracene, phenanthrene, benzene, toluene, and styrene. Investigation of possible contamination of the surficial soil or groundwater from the July 1988 tire fire was addressed during the Design Investigation by analyzing the surficial soil and groundwater for aromatic volatile organic compounds and polynuclear aromatic hydrocarbons.

A second, much larger tire fire occurred at the South Andover site on February 7, 1989. Information obtained from the MPCA indicates that this fire involved approximately 300,000 tires, encompassing three to five acres near the southeastern portion of the Cecil Heidelberger property. A fire break was established around the fire area, with limited use of water. The fire was smothered with sand after burning approximately two to three days. A limited number of empty drums, and drums containing industrial chemical wastes were involved in the fire.

The majority of tires have been removed. Tire removal has allowed for more extensive soil sampling during the Design Investigation than previously performed.

The Waste Disposal Engineering Landfill is located 3,000 feet northeast of the site. This landfill, which formerly accepted hazardous waste, is a National Priorities List site.

2.1.3 Site History

Historical background information indicates that auto salvage operations, and the storage, disposal and incineration of ink, ink and paint sludge, adhesives, chlorinated and non-chlorinated solvents, and other wastes have occurred at various locations across the site. Solvent recovery, and the storage of transformers and salvaged electrical equipment have also been reported. The disposal of more than 3 million tires at the site partially obscured former drum storage and chemical waste disposal sites. The removal activities were completed in the Spring of 1990 prior to the onset of Design Investigation field activities. Figure 2-3 identifies past and present landowners at the site and lists waste disposal activities reported to have occurred on their properties. Figure 2-4 shows specific areas identified by CH2M Hill (1988) as potential sources of contamination.

Industrial waste handling operations are reported to have been initiated at the South Andover site during the mid 1950s. It has been estimated that more than 1,000 drums of waste were stored on several contiguous parcels owned by Cecil Heidelberger, William Batson, David and Shirley Heidelberger, Charles Mistelske, and Cyril Link (Figure 2-3). Each of these occurrences is discussed more fully below.

Activities conducted at the Cecil Heidelberger property reportedly included auto salvage operations, and the unregulated storage and on-site disposal of drummed chemical wastes. Available information suggests that both trenching and depression filling in former wetland areas occurred at the site. Indiscriminate dumping and burning of wastes is also known to have occurred locally.

Available information indicates that drums containing inks and solvents were stored at the Cecil Heidelberger Musket Ranch and Trading Post as early as 1954, and on-site waste disposal activities began in 1965. Solvent recovery, the sale of decantable liquids, and the periodic dumping and burning of other wastes reportedly occurred on this property. No records documenting waste storage or disposal activities were kept by the Heidelbergers.

Approximately 75 percent of the Heidelberger property was later covered with waste tires until their removal in the Spring of 1990. This activity has provided site access to other potential drum storage and chemical waste storage areas. The maximum extent of tires at the South Andover site as determined from a review of historic aerial photos is depicted in Figure 2-5.

Open pit burning of liquid wastes are reported to have been initiated at the William Batson property in 1970 (Vapor Steam Baths). Thousands of barrels of solids and liquids were allegedly burned in open pits at this site. In addition, liquid wastes may have been dumped into a wetland located near the western edge of the property, prior to the infilling of the wetland (now Bob's Auto Parts).

2.1.4 Regulatory Response Actions

Actions to limit waste handling operations at the various properties at the South Andover site began in 1973 when Anoka County officials instructed Cecil Heidelberger to remove and dispose of chemical wastes stored on his property. Investigation of the site was initiated by the MPCA in 1973 after a citizen complaint of suspected residential well contamination was received. In 1976, the MPCA issued a Citation of Violation to Cecil and Marian Heidelberger for unregulated chemical waste storage. These individuals continued processing waste in early 1977, and stopped accepting waste in 1978 when they sold the property to Parmak, Inc. Parmak intended to reclaim the several million stockpiled tires located on the property.

The MPCA initiated actions to regulate the other identified waste handlers in 1980 and 1981. Notice of Violations for the improper storage and disposal of chemical wastes were served to Shirley Heidelberger, Cyril Link and Charles Mistelske. Cecil Heidelberger continued to dispose of additional industrial waste at this time by mixing the contents of 700 drums with waste oil for use as fuel in an asphalt plant.

Available MPCA correspondence has indicated that ACME Tag Company, Bemis Company, Color-Add Packaging, and Standard Solvents Company were notified by the MPCA in 1980 as to their potential responsible party (PRP) status. Sixteen parties, including site owners, operators, and waste generators were notified in 1982 by the EPA Office of Enforcement and Compliance Monitoring that the EPA was considering actions at the site. All parties were also informed of their potential joint and several liability related to these activities. The MPCA took similar actions in 1983, outlining remedial actions for the sites.

In July 1985 the EPA notified 21 PRPs that it was the intent of that agency to conduct a Remedial Investigation/Feasibility Study (RI/FS) at the South Andover site, but that EPA would also consider an offer by the PRPs to conduct the RI/FS. Failure on the part of the PRPs to negotiate such action resulted in the EPA using Superfund to conduct the South Andover RI/FS under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA).

Copies of the Proposed Plan for Remedial Action (RA) for the surficial aquifer (Operable Unit I) were sent to the PRPs on February 1, 1988. On February 26, the EPA Region V Office notified all PRPs that the EPA intended to conduct an RA, and that the PRPs had 60 days to submit a good faith proposal. No response was received upon issuance of the Record of Decision (ROD) on March 30, 1988.

A Remedial Investigation (RI) involving soil gas surveying, soil borings, monitoring well installation, and soil and groundwater sampling was performed by CH2M Hill during the period from fall of 1985 through the summer of 1987. Chemical results from the RI generally supported earlier studies, indicating

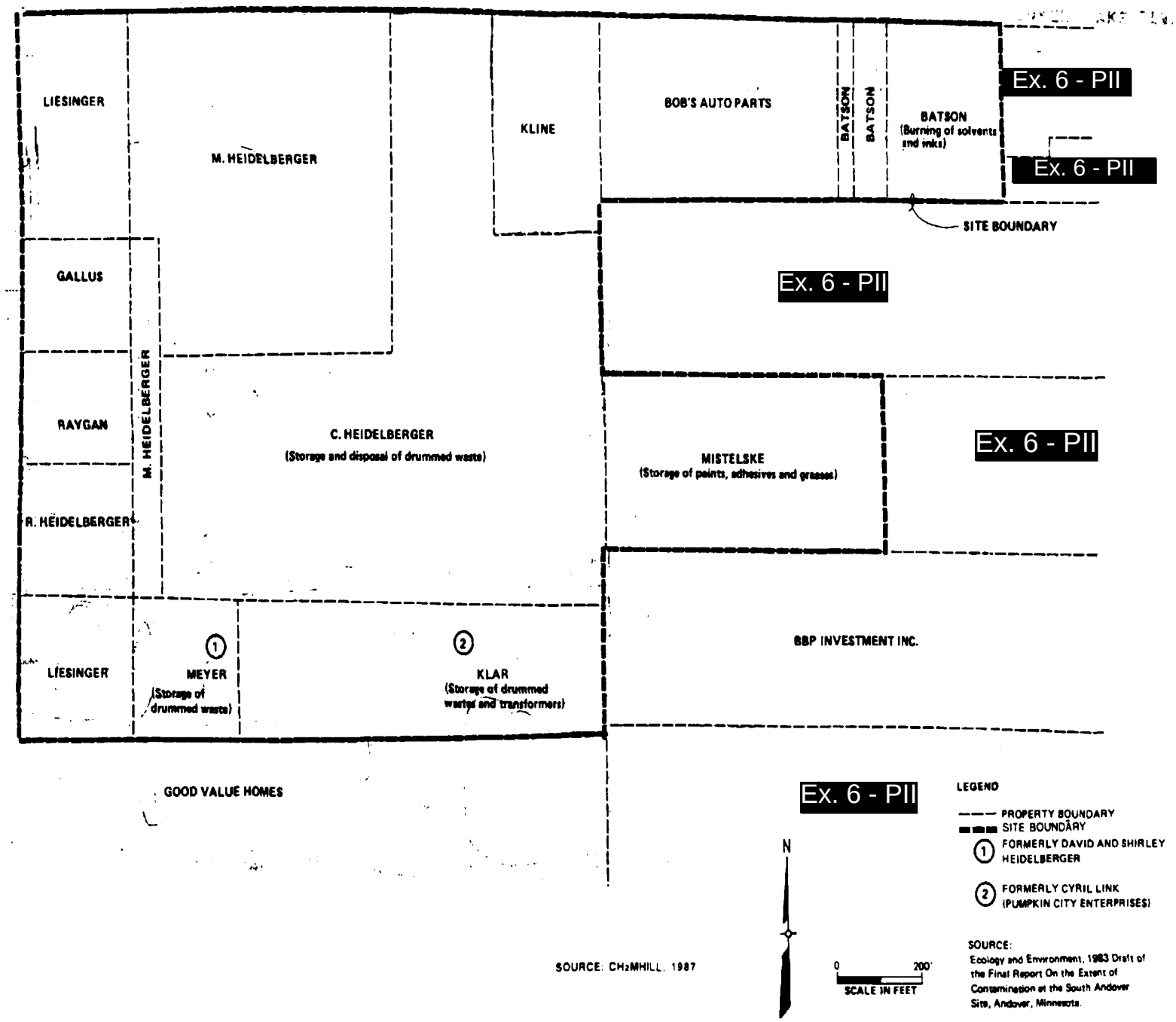

FIGURE 2-3

REPORTED WASTE DISPOSAL ACTIVITIES

SOUTH ANDOVER SUPERFUND SITE
DESIGN INVESTIGATION
ANDOVER, MINNESOTA

20022

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JULY 1991

that soil and groundwater contamination does occur across selected areas of the site. This information was further evaluated, and potential remedial alternatives to remediate on-site concerns developed during a subsequent Feasibility Study (FS)

Information obtained from the CH2M Hill RI/FS led the EPA to issue a Record of Decision (ROD) on March 30, 1988 (Appendix A). The ROD presents a summary of existing site conditions and discusses the feasibility of implementing remedial alternatives for the surficial aquifer, designated as Operable Unit I (OU-I). In the ROD, the EPA concluded that a groundwater extraction and treatment system should be implemented to limit the extent of groundwater contamination within OU-I. Additional groundwater sampling conducted for the issuance of the ROD has yielded ambiguous results regarding the presence or absence of groundwater contamination, suggesting that implementation of the ROD may not be warranted at this time. This uncertainty resulted in the EPA initiating the Design Investigation to further characterize on-site conditions. This report includes the results of this investigation.

2.1.5 Current Conditions

A few isolated shredded tires and radial tire steel belts are scattered across areas of the Cecil and David Heidelberger properties. A major portion of the site (excepting active businesses) has been fenced, and access into the site is locked.

Major residential development is occurring both directly north-northwest and south of the site. The northern development is essentially complete, while initial grading activities are occurring south of the site. Single family residences located on the western portion of the site are also currently occupied.

Auto repair and salvage operations continue to occur both on, and adjacent to, the South Andover site.

2.2 PREVIOUS INVESTIGATIONS

Several subsurface investigations have been conducted at the South Andover site since the late 1970's. Previously investigated areas are depicted in Figure 2-6.

2.2.1 Subterranean Engineering Geotechnical Investigation (1978)

An early geotechnical boring investigation for International Tire Recycling Corporation was conducted by Subterranean Engineering to assess the suitability of soils for construction purposes. This boring program revealed that oil soaked soils, peat, and fill materials occurred in a former wetland area located near the northern entrance to the site from Bunker Lake Boulevard. The oil soaked soil had been buried under 4 feet of sand fill material.

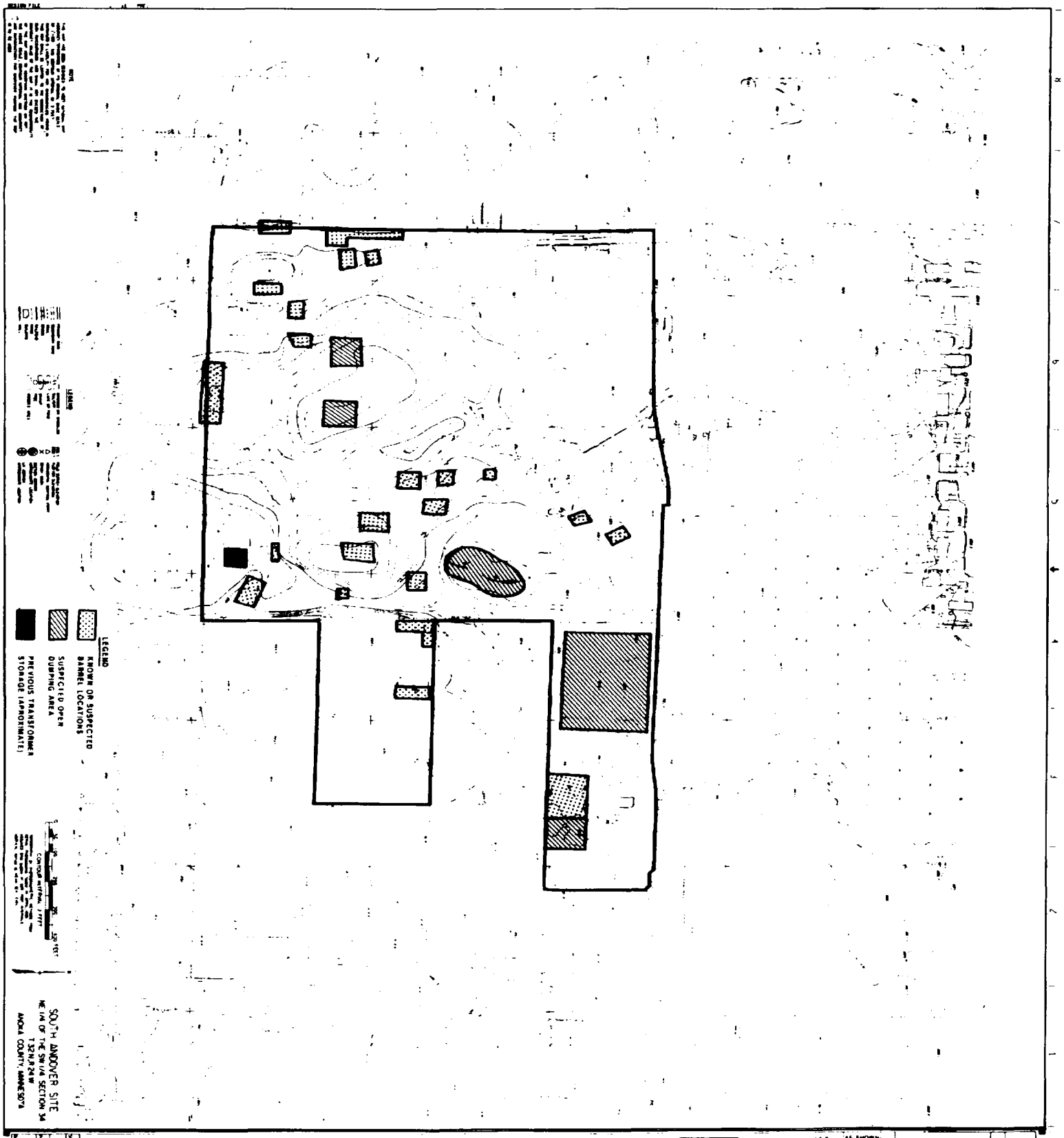
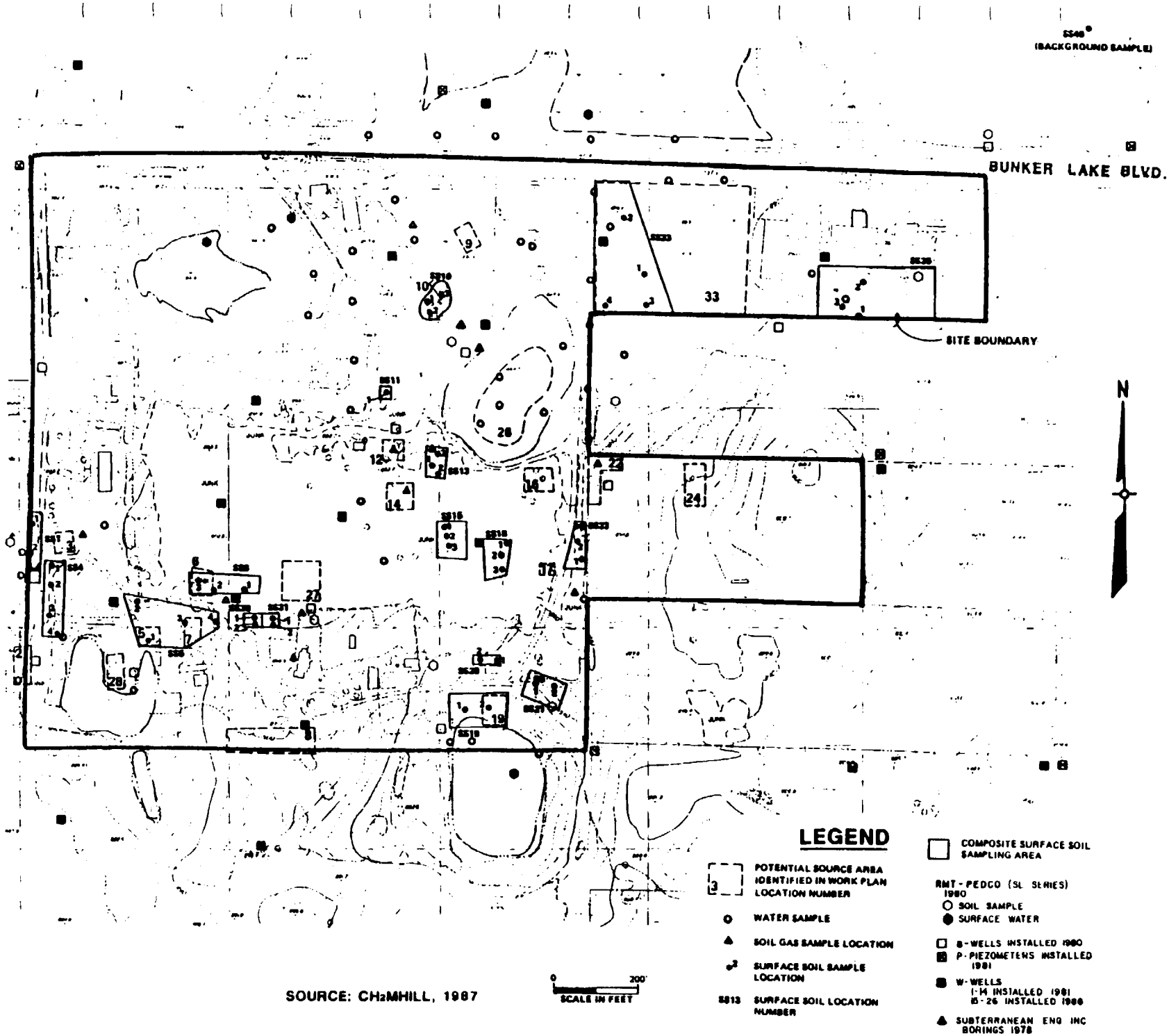


FIGURE 2-4
POTENTIAL SOURCES OF CONTAMINATION
SOUTH ANDOVER SUPERFUND SITE
DESIGN INVESTIGATION
ANDOVER, MINNESOTA

Donohue ENGINEERS ARCHITECTS SCIENTISTS

AS SHOWN
JULY 1991



SOURCE: CH2MHILL, 1987

20022

FIGURE 2-6

SUMMARY OF PREVIOUS INVESTIGATIONS

SOUTH ANDOVER SUPERFUND SITE
DESIGN INVESTIGATION
ANDOVER, MINNESOTA

JULY 1991

Donohue ENGINEERS ARCHITECTS SCIENTISTS

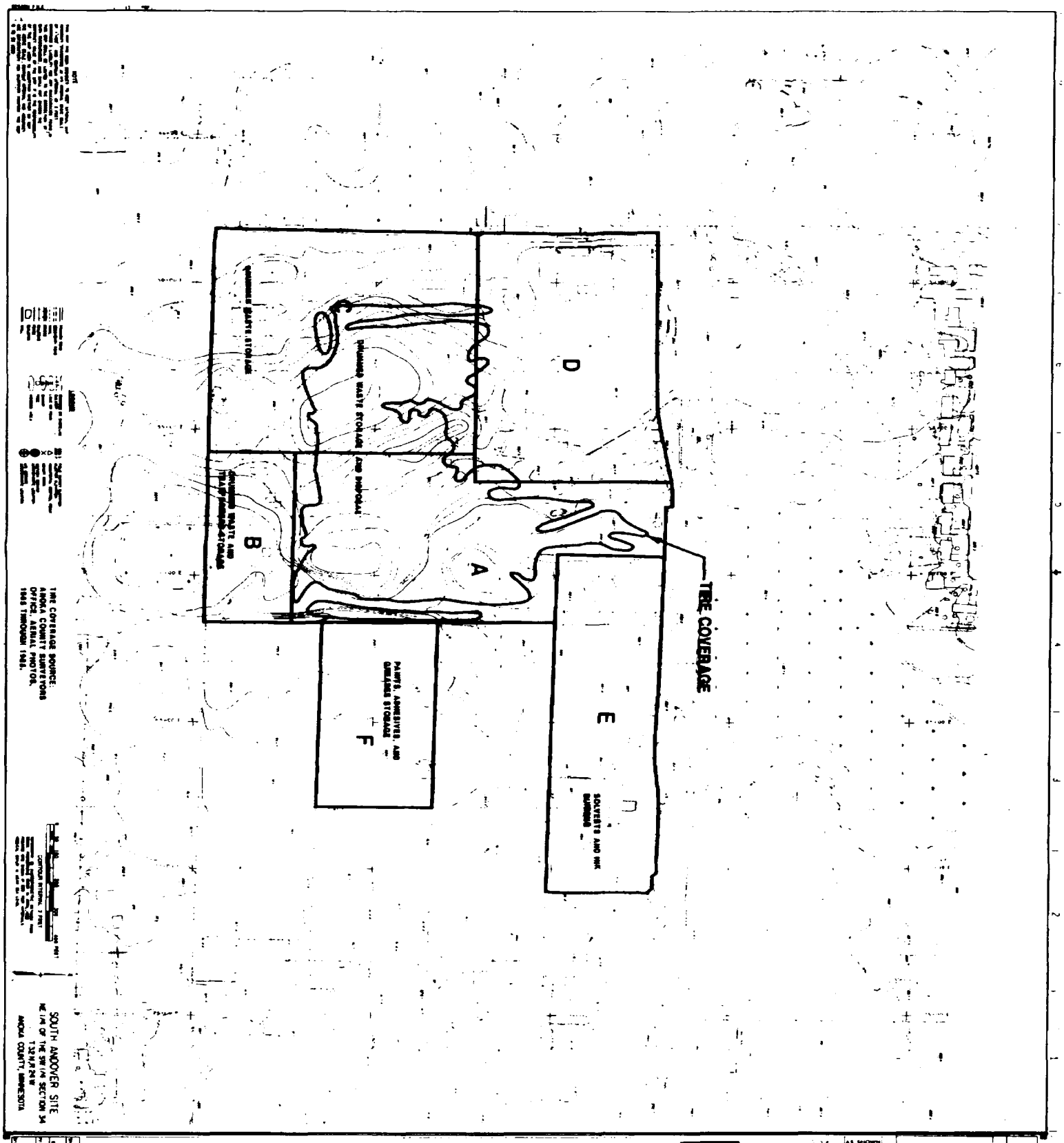


FIGURE 2-5
MAXIMUM TIRE COVERAGE
SOUTH ANDOVER SUPERFUND SITE
DESIGN INVESTIGATION
ANDOVER, MINNESOTA

Donohue ENGINEERS ARCHITECTS SCIENTISTS

AS SHOWN
JAN 1988
RC
CCM
RC
Revisions

2.2.2 Residual Management Technology (RMT) and PEDco Environmental (1979)

RMT and PEDco Environmental conducted a more extensive soil boring and well installation program for the MPCA and US EPA Region V Technical Assistance Panels Program (1979). This investigation included the completion of a series of well nests either at, or near, the South Andover site (24 wells at 10 locations). Soil samples were collected from depths ranging from 1 to 4.5 feet below the ground surface at 8 locations across the site. Results from the RMT/PEDco boring program have indicated that surficial soils locally contain concentrations of selected metals (chromium, lead, zinc, and copper) which exceed levels normally observed in native soils. In addition, the data has revealed local contamination of surficial soil by various organic constituents.

A preliminary hydrogeologic investigation of the Heidelberger property was conducted by RMT/PEDco in 1979, with a subsequent well installation program in 1980. Major conclusions drawn by RMT/PEDco suggested that groundwater contamination occurs within the water table aquifer (Upper Sand Aquifer). Deeper wells penetrating the silt aquitard underlying the Upper Sand Aquifer also indicate organic and inorganic contamination. Well B8C showed elevated levels of methylene chloride and tetrachloroethylene. In addition, Wells B8C, B1C, B4B, and B10C located randomly across the site contained levels of cyanide and selenium above Primary Drinking Water Standards.

2.2.3 US EPA Region V Field Investigation Team (FIT) Program (1981)

The US EPA Region V Field Investigation Team (FIT) program performed by Ecology and Environment (1981) also involved the chemical sampling of soils. The results obtained indicate that soil contamination may occur to a maximum depth of 102 feet. However, the significance of the data obtained during this study is not known. Discussions given in the FIT report suggest that the observed contamination may have been caused by either laboratory induced effects from trichlorofluoromethane, or field contamination by acetone and methylene chloride. Toluene was detected in soil samples from 44 and 49-foot depths, near two wells exhibiting potential groundwater contamination. Observed contamination of deeper soils was reported to have been caused by aqueous phase transport. The concentrations of inorganic constituents in soils were inconclusive, and were considered to fall within normal background concentrations.

The Ecology and Environment (FIT) field investigation focused on completing an expanded groundwater investigation at the South Andover site. Twenty-two piezometers and 26 additional monitoring wells were installed during FIT activities. This study revealed that while groundwater flow within the surficial aquifer is multi-directional, with groundwater generally being directed from the northeast towards the south.

The most significant groundwater contamination detected during the FIT investigation was due to high concentrations of polynuclear aromatic hydrocarbons (PAHs) and trace metals. Other wells contained significant levels of inorganic and organic compounds, with organic contamination restricted to on-site locations.

The FIT study also attempted to evaluate the interrelationship between groundwater quality at the South Andover site and observed groundwater contamination at the Waste Disposal Engineering Landfill (3,000 feet north). However, the information obtained was not sufficient to complete this assessment, and relationship between these sites remains unclear.

2.2.4 CH2M Hill Remedial Investigation (1985)

Subsurface investigations were conducted by CH2M Hill in 1985 and 1986 during a Remedial Investigation conducted for EPA. This program included chemical sampling of surficial soils (average 3-foot depth), soil sampling within deeper borings, the installation and sampling of groundwater monitoring wells, and sediment and surface water sampling.

An additional 19 groundwater monitoring wells were installed as part of the CH2M Hill investigation. Groundwater sampling data obtained during this investigation support the results of the RMT/PEDco study, indicating that the surficial aquifer has been impacted by selected metals and VOCs.

CH2M Hill determined that three major overburden units are present at the South Andover site. These include a fine sand unit defined as the Upper Sand Aquifer, a lacustrine silt and clay aquitard, and a fine to medium sand unit (Lower Sand Aquifer). CH2M Hill concluded that horizontal groundwater flow in the Upper and Lower Sand Aquifers is generally directed to the west and southwest, respectively. However, CH2M Hill considered downward groundwater flow within the Upper Sand Aquifer and aquitard dominant. The direction of vertical flow in the Lower Sand Aquifer was not evaluated by CH2M Hill because of insufficient well coverage.

Soil and groundwater impacts reported by CH2M Hill are summarized in Tables 2-1 through 2-6. Contamination of surficial soil by VOCs, PCBs, metals, and other substances was reported to occur at the majority of sample locations. Soil samples from the aquitard also showed low levels of VOCs indicating that contamination may occur at depth. The soils and groundwater data from this investigation are discussed below in further detail.

Summaries of organic compounds detected in the soil samples are presented in Tables 2-1 and 2-2. Many of the volatile organic compounds (VOCs) detected were also present in field blanks suggesting their occurrence is a result of system contamination introduced during sampling or analysis. While low levels of several other VOCs were also detected in soil samples, their concentration does not appear significant.

TABLE 2-1

SUMMARY OF DETECTED ORGANIC COMPOUNDS
SURFICIAL SOIL SAMPLES
CH2M Hill RI/FS
1986

Units: ppb

Sample Number:	SS1	SS4	SS5	SS5	SS6	SS6	SS10	SS10	SS11	SS13	SS13	SS15	SS18	SS19	SS19D	SS19	SS20	SS20	SS21	SS21
Sample Depth:	0-6 in	0-6 in	0-6 in	24-36 in	0-6 in	24-36 in	0-6 in	24-36 in	0-6 in	6-12 in	24-36 in	0-6 in	0-6 in	0-6 in	0-6 in	12-24 in	0-6 in	24-36 in	0-6 in	24-36 in
Volatile Organic Compounds																				
Methylene Chloride	71B	39B	116B	3094B	86B	34B	55B	--	63B	53B	18B	130B	107B	80B	89B	39B	51B	120B	49B	53B
Acetone	--	--	27B	--	30B	53B	--	--	--	--	19B	--	--	--	--	36B	--	90B	--	--
Chloroform	--	6	--	--	--	--	8	--	--	--	--	--	--	--	--	--	--	--	--	--
2-Butanone	--	--	--	12155B	--	18B	--	11248B	--	--	13B	--	--	--	--	--	--	19B	--	--
1,1,1-Trichloroethane	--	--	4J	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Toluene	--	11	3J	--	5	--	--	--	--	--	--	--	--	2J	--	--	--	--	--	--

Sample Number:	SS1	SS4	SS5	SS5	SS6	SS6	SS10	SS10	SS11	SS11D	SS13	SS13	SS13	SS15	SS18	SS19	SS19D	SS19	SS20	SS20	SS21	SS21
Sample Depth:	0-6 in	0-6 in	0-6 in	24-36 in	0-6 in	24-36 in	0-6 in	24-36 in	0-6 in	0-6 in	0-6 in	6-12 in	24-36 in	0-6 in	0-6 in	0-6 in	0-6 in	12-24 in	0-6 in	24-36 in	0-6 in	24-36 in
Semi-Volatile Organic Compounds																						
Isophorone	--	--	74J	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Benzoic Acid	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Diethyl Phthalate	302J	--	---	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
N-Nitrosodiphenylamine	--	--	--	--	--	--	--	101J	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Phenanthrene	--	191J	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Di-n-butyl phthalate	1616	822J	254J	254J	981	56JB	362J	618J	799	551	1258	1165	--	1189	1279	1307	1499	78JB	--	200JB	451	457
Fluoranthene	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Pyrene	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Butyl-benzyl phthalate	377J	--	--	43J	539J	--	--	--	37J	45J	--	--	--	--	--	--	--	--	--	--	69J	--
Benz(a)athracene	--	215J	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
bis(2-ethylhexyl) phthalate	1185JB	1311JB	613	331J	2954B	130JB	760JB	556JB	--	--	472B	720B	59B	2054B	320JB	404JB	736JB	250JB	322JB	170JB	472	244J
Benzo(b)fluoranthene	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Benzo(k)fluoranthene	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Benzo(a)pyrene	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Chrysene	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

Sample Number:	SS1	SS4	SS5	SS6	SS6	SS10	SS10	SS11	SS11D	SS13	SS13	SS15	SS18	SS19	SS19D	SS19	SS20	SS20	SS21	SS21	SS23	SS25
Sample Depth:	0-6 in	0-6 in	0-6 in	0-6 in	24-36 in	0-6 in	24-36 in	0-6 in	0-6 in	0-6 in	24-36 in	0-6 in	0-6 in	0-6 in	0-6 in	12-24 in	0-6 in	24-36 in	0-6 in	24-36 in	0-6 in	0-6 in
PCB/Pesticides																						
Heptachlor	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Endosulfan I	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Dieldrin	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
4,4'-DDT	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Chlordane	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aroclor 1254	1500	--	1100	--	--	--	--	2000	2000	--	--	--	--	4800C	5500C	9500C	--	--	--	--	--	300

TABLE 2-1

SUMMARY OF DETECTED ORGANIC COMPOUNDS
SURFICIAL SOIL SAMPLES
CH2M Hill RI/FS
1986
(cont.)

Units: ppb

Sample Number:	SS25	SS25	SS30	SS30	SS30D	SS31	SS31	SS33	SS36	SSFB1	SSFB1D	SSFB2
Sample Depth:	0-6 in	24-36 in	0-6 in	24-36 in	24-36 in	0-6 in	24-36 in	12-24 in	12-6 in	___	___	___
Volatile Organic Compounds												
Methylene Chloride	61B	20B	18B	31B	27B	19B	17B	20B	10B	51B	19B	120B
Acetone	28B	25B	5JB	47B	14B	6JB	6JB	--	65B	--	8JB	36B
Chloroform	--	--	--	--	--	--	--	--	--	--	--	--
2-Butanone	--	--	--	--	--	--	--	24B	17B	--	--	--
1,1,1-Trichloroethane	--	--	--	--	--	--	--	--	--	--	--	--
Toluene	--	--	--	--	1JB	1JB	1JB	--	8J	3J	1JB	--

Sample Number:	SS23	SS25	SS25D	SS25	SS30	SS30	SS30D	SS31	SS33	SS33	SS40	SSFB1	SSFB2
Sample Depth:	0-6 in	0-6 in	0-6 in	24-36 in	0-6 in	24-36 in	24-36 in	0-6 in	0-6 in	12-24 in	6-12 in	___	___
Semi-Volatile Organic Compounds													
Isophorone	--	--	--	--	--	--	--	--	--	--	--	--	--
Benzoic Acid	--	--	140J	--	--	--	--	--	--	--	--	--	--
Diethyl Phthalate	--	--	--	--	--	--	--	--	--	--	--	--	--
N-Nitrosodiphenylamine	--	--	--	--	--	--	--	--	--	--	--	87J	--
Phenanthrene	--	--	--	--	--	--	--	--	72J	--	--	--	--
Di-n-butyl Phthalate	36B	300JB	210JB	200JB	--	--	--	--	140JB	92JB	65JB	101B	87JB
Fluoranthene	--	--	--	--	--	--	--	--	120J	--	--	--	--
Pyrene	--	--	--	--	--	--	--	--	120J	--	--	--	--
Butyl-benzyl Phthalate	--	--	150J	--	--	--	--	--	--	--	--	--	--
Benz(a)anthracene	--	--	--	--	--	--	--	--	89J	--	--	--	--
bis(2-ethylhexyl) Phthalate	431	2600B	1500B	130JB	48J	120J	70J	26J	95JB	160JB	38JB	365J	73JB
Benzo(b)fluoranthene	--	--	--	--	--	--	--	--	150J	--	--	--	--
Benzo(k)fluoranthene	--	--	--	--	--	--	--	--	150J	--	--	--	--
Benzo(a)pyrene	--	--	--	--	--	83JB	84JB	--	78J	--	--	--	--
Chrysene	--	--	--	--	--	--	--	--	59J	--	--	--	--

Sample Number:	SS25	SS30	SS30	SS31	SS31	SS33	SS33	SS40
Sample Depth:	24-36 in	0-6 in	24-36 in	0-6 in	24-36 in	0-6 in	12-24 in	6-12 in
PCB/Pesticides								
Heptachlor	--	--	--	--	--	--	100	--
Edosulfan I	--	--	--	--	--	--	11J	--
Dieldrin	--	--	--	--	--	--	6J	--
4,4'-DDT	--	--	--	--	--	--	73	--
Chlordane	--	--	--	--	--	--	230	--
Aroclor 1254	--	--	--	--	--	--	--	--

NOTES:

- No volatile organic compounds were found in samples taken from SS13 (0-6 in), SS23 (0-6 in), SS33 (0-6 in), SS40 (12-24 in).
- No PCBs or pesticides were found in samples taken from SS4 (0-6 in), SS6 (0-6 and 24-36 in), SS10 (0-6 and 24-36 in), SS13 (0-6 and 24-36 in), SS15 (0-6 in), SS18 (0-6 in), SS20 (0-6 and 24-36 in), SS21 (0-6 and 24-36 in), SS23 (0-6 in), SS25 (24-36 in), SS30 0-6 and 24-36 in), SS31 (0-6 and 24-36 in), SS33 (0-6 in), and SS40 (6-12 in).

-- Not detected.
B Compound found in associated lab blank.
J Estimated concentration, result is less than specified detection limit.
C Pesticide identification confirmed by GC/MS.

TABLE 2-2

SUMMARY OF DETECTED ORGANIC COMPOUNDS
PILOT BORING SAMPLES
CH2M Hill RI/FS
1986

Units: ppb

Boring Number:	W15	W15	W19	W19	W19	W19	W19	W19	W19	W21	W21	W23	W23	W23	W23
Sample Depth:	39 ft	55 ft	21 ft	31 ft	41 ft	70 ft	80 ft	95 ft	125 ft	40 ft	90 ft	22 ft	37 ft	62 ft	77 ft
Volatile Organic Compounds															
Methylene Chloride	62B	18J	8.8B	6B	15B	4.7JB	7.1JB	3.8JB	2.9JB	960B	16B	29B	21900B	32B	370B
Acetone	2000B	23J	17B	5.5JB	14B	11B	13B	6JB	7.1JB	7700B	26B	67B	7400	65B	11J
Carbon Disulfide	16B	5.1JB	2.9JB	2.8JB	3.7JB	2.3JB	4.7JB	2.9JB	2.6JB	--	--	--	--	--	--
trans-1,2-Dichloroethylene	--	--	--	2.4J	--	--	--	--	--	--	--	--	--	--	--
2-Butanone	1800	--	--	--	--	--	--	--	--	6200B	11B	7JB	1600JB	8J	3J
Benzene	--	--	--	--	--	--	--	--	--	--	--	--	--	1J	--
4-Methyl-2-Pentanone	140	3.2J	--	--	--	--	--	--	2.7J	180J	--	--	--	--	--
Toluene	6.5J	3.7J	8	--	4.1	--	9.1	--	4.9J	370B	1.6J	--	--	--	--
Chlorobenzene	--	--	3.1J	--	--	--	--	--	--	--	--	--	--	--	--
Ethyl Benzene	--	--	--	--	--	--	--	--	--	--	--	28	--	--	--
Xylenes	--	--	6J	--	--	--	--	--	--	--	--	51	--	--	--

Semi-Volatile Organic Compounds	W15 39 ft	W19 70 ft	W19 95 ft	W21 90 ft	W23 22 ft	W23 37 ft	W23 62 ft	W23 77 ft
4-Nitrophenol	--	--	150JB	--	--	--	--	--
N-Nitrosodiphenylamine	--	--	--	--	82JB	--	--	--
Pentachlorophenol	--	--	--	110JB	--	--	--	--
Di-n-butyl Phthalate	--	--	--	1800B	2100B	--	--	--
bis(2-ethylhexyl) Phthalate	73J	290J	150J	150J	76JB	290JB	150JB	470B

PCB/Pesticides	W23 22 ft
Beta BHC	13

NOTES:

- No semi-volatile organic compounds were found in samples taken from W15 (55 ft), W19 (21, 31, 41, 80, and 125 ft), and W21 (40 ft).
- No PCB/pesticides were found in samples taken from W15 (39 and 55 ft), W19 (21, 31, 41, 70, 80, 95, and 125 ft), W21 (40 and 90 ft), and W23 (37, 62, and 77 ft).

-- Not detected.
J Estimated concentration, result is less than the specified detection limit.
B Compound also found in associated blank.

A/RP/SANDOVER/AU6

Although the semi-volatile compounds (SVOCs) diethyl phthalate, 4-nitrophenol, pentochlorophenol, N-nitroso-diphenylamine, di-n-butyl phthalate, and bis(2-ethylhexyl) phthalate were detected, the concentrations observed were not significantly above system contamination. Other SVOCs, primarily PAHs, were detected in a few of the surficial soil samples (but not in deeper boring samples).

Pesticide/PCB compounds were detected in seven of the composite surficial soil samples analyzed. Most of these samples were collected from former suspected drum storage or open dumping areas.

Table 2-3 presents a summary of inorganic compounds detected above selected background levels in surficial soil samples collected by CH2M Hill. The background levels listed in the summary table were derived by combining data from this investigation (Sample SS-40) with that from another site in Minnesota (the Arrowhead Refinery). Background levels for other inorganic compounds were not determined due to the variant nature of those elements in natural soil.

A summary of organic compounds detected in groundwater above Minnesota Recommended Allowable Limits (RALs) or above Federal Maximum Contaminant Levels (MCLs) is presented in Table 2-4. The RALs apply to private water supplies for which there are no standards regulating levels of drinking water contaminants. The MCLs, which apply to public water systems, are applicable and are used to identify potentially significant contamination. As the table indicates, several monitoring wells and one residential well contained levels of organic compounds exceeding either the RALs or MCLs. In particular, the RAL for bis(2-ethylhexyl) phthalate (BEHP) is exceeded in 14 of the wells. BEHP contamination appears to occur in both the upper and lower sand aquifers, implying some interconnection between the two water systems. It should be noted that lower aquifer wells W1C and W2C are not double-cased and the data may not accurately represent the water quality of this aquifer. Wells W15C and W23, however, are both double-cased and contain elevated levels of BEHP. Other exceedances of groundwater standards are less consistent and do not indicate widespread contamination of the entire aquifer system.

Tables 2-5 and 2-6 present summaries of inorganic compounds detected above RALs, MCLs, or background levels in monitoring and residential wells, respectively. The background levels established by CH2M Hill were determined using 95 percent upper confidence limit from samples of 8 upgradient wells. The data reveals that the groundwater may contain elevated levels of 12 metals. Elevated levels of iron, manganese, and zinc appear to be the most pervasive. All the elevated levels of zinc in the monitoring wells, however, occurred in wells constructed of materials coated with zinc (i.e. galvanized) and may not be indicative of aquifer contamination. It is unknown whether the residential wells are constructed of galvanized material. Iron and manganese groundwater levels are generally high in the region (Eriskson, et al, 1974).

TABLE 2-3

SUMMARY OF INORGANIC COMPOUNDS DETECTED ABOVE BACKGROUND LEVELS
SURFICIAL SOIL SAMPLES
CH2M Hill RI/FS
1986

Units: ppm

Sample Number:	Back-	SS1	SS4	SS6	SS11	SS15	SS18	SS19	SS19D	SS19
Sample Depth:	ground	0-6 in	0-6 in	0-6 in	0-6 in	0-6 in	0-6 in	0-6 in	0-6 in	12-24 in
Barium	131	--	--	--	--	--	--	--	178J	--
Chromium, total	22	700	31	180	--	42	24	80	111	--
Copper	74	--	85	--	--	--	--	1289	2032	202
Lead	27	3203*	77	868	--	194*	33.8*	2282	1283	58.5
Zinc	84	--	107*	--	103*	--	--	365*	631*	119

	SS25	SS25D	SS33
	0-6 in	0-6 in	0-6 in
Barium	--	--	--
Chromium, total	--	--	29
Copper	--	--	--
Lead	97	65.4	--
Zinc	85	--	--

NOTES:

- No inorganic compounds were detected above background in samples taken from SS5 (0-6 and 24-36 in), SS6 (24-36 in), SS10 (0-6 and 24-36 in), SS11D (0-6 in), SS13 (0-6, 6-12, and 24-36 in), SS20 (0-6 and 24-36 in), SS21 (0-6 and 24-36 in), SS23 (0-6 in), SS25 (25-36 in), SS30 (0-6 and 24-36 in), Ss33 (12-24 in), SSFB1, and SSFB2.

* Dry weight calculation.
J Estimated concentration.
-- Not detected above background levels.

A/RP/SANDOVER/AU7

TABLE 2-4

SUMMARY OF ORGANIC COMPOUNDS DETECTED IN GROUNDWATER ABOVE MINNESOTA
RECOMMENDED ALLOWABLE LIMITS OR MAXIMUM CONTAMINANT LEVELS
CH_2M Hill RI/FS
1986

Units: ppb

	Recommended Allowable Limit	Maximum Contaminant Level	WIA (Duplicate)	W2A	W2B	W8B	W19A	W19B	W20A	W21B	W23A	W24A	W26A	B3B	B6A	B6B	B9A	W1C	W2C	W15C	W23C	RW008 (061186)
Vinyl Chloride	0.10	2	2J	--	--	--	--	--	--	--	--	--	--	--	--	--	12	--	--	--	--	--
Methylene Chloride	50	NE	--	--	--	--	--	--	--	--	1600	--	--	--	--	--	--	--	--	--	--	--
Acetone	700	NE	--	--	--	--	--	--	--	--	8900	--	--	--	--	--	--	--	--	--	--	--
1,2-Dichloroethylene, trans	70	7	--	--	--	--	8	9	--	--	--	--	--	--	--	8	--	--	--	--	--	--
Trichloroethylene	30	5	7	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1,1,1-Trichloroethane	600	200	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	330
1,1,2-Trichloroethane	3.0	NE	33	--	--	--	--	--	--	--	--	28	--	--	--	--	37	--	--	--	--	--
Tetrachloroethylene	7	NE	20	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Toluene	1000	NE	--	--	--	--	--	--	--	3200JB	--	--	--	--	--	--	--	--	--	--	--	--
Bis(2-ethylhexyl)phthalate	20	NE	--	58	33B	38	--	--	91	2200	64	--	47JB	180	370	--	--	340	560	170	70	130

B Compound also detected in associated blank
J Estimated value due to minor QC deviations
NE No level established

A/RP/SANDOVER/AW7

TABLE 2-5

SUMMARY OF INORGANIC COMPOUNDS DETECTED ABOVE BACKGROUND
STATE OF MINNESOTA RECOMMENDED ALLOWABLE DRINKING WATER LIMITS (RALS), OR MAXIMUM CONTAMINANT LEVELS
GROUNDWATER
CH2M Hill RI/FS
1986

Units: ppb

UPPER SAND AQUIFER WELLS:	Back-ground	RAL	MCL	W1A*	W1AD*	W2A*	W4A*	W4AD*	W6A*	W8A*	W17A	W18A	W19A	W20A	W21A	W22A	W23A	W25A	B4A*	B6A*	B7A*	B8A*	B8AD*	B10A*
Compound																								
Aluminum	138	NE	NE	--	--	--	--	--	--	--	--	--	164J	--	157J	330	--	--	--	186J	--	142J	148J	--
Arsenic	NE	0.2	50	--+	--+	--+	--+	--+	--+	--+	--+	--+	--+	--+	--+	--+	--+	--+	--+	--+	--+	--+	--+	--+
Barium	121	2000	1000	--	--	--	--	--	--	--	167J	511	--	--	--	137J	122J	--	--	--	--	--	--	--
Cadmium	4	4.0	10	--	--	--	--	--	--	--	--	--	--	--	--	--	6	--	--	--	--	--	--	--
Iron	88	NE	300^	142	164	--	21000	19500	2320	21900	648	6420	4950	--	--	206	30400	114	21900	12000	1760	1180	1080	3810
Lead	NE	20	50	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Nickel	NE	70	NE	--	--	168	--	--	--	--	--	--	--	--	--	105	--	--	--	--	--	--	--	--
Manganese	163	300	50^	--	--	3300	207	211	142	137	1550	2200	279	74	84	755	1280	--	113	437	--	547	572	113
Vanadium	NE	700	NE	--	--	--	---	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	860E
Zinc	1228	NE	5000^	--	--	2660E	--	--	--	1340E	--	--	--	--	--	--	--	--	--	--	--	--	--	--

UPPER SAND AQUIFER WELLS:	Back-ground	RAL	MCL	W1B*	W2B*	W4B*	W6B*	W8B*	W15B	W19B	W21B	W23B	B2B*	B2BD*	B3B*	B8B*	B9B*	B10B*
Compound																		
Aluminum	138	NE	NE	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Arsenic	NE	0.2	50	--+	--+	--+	--+	--+	--+	--+	--+	--+	--+	--+	--+	--+	--+	--+
Barium	121	2000	1000	--	123J	--	--	--	--	511	--	315	--	--	--	128J	209	--
Cadmium	4	4.0	10	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Iron	88	NE	300^	353	264	28600	2240	906	857	6420	--	750	92J	--	--	348	1410	2320
Lead	NE	20	50	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Nickel	NE	70	NE	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Manganese	163	300	50^	267	239	888	290	507	197	2200	67	395	126	124	158	2200	380	167
Vanadium	NE	20	NE	--	--	--	--	--	--	33B	--	--	--	--	--	--	--	--
Zinc	1228	700	5000^	--	3900E	3240E	--	916E	--	--	--	--	--	134	--	--	--	--

TABLE 2-5

SUMMARY OF INORGANIC COMPOUNDS DETECTED ABOVE BACKGROUND OR
STATE OF MINNESOTA RECOMMENDED ALLOWABLE DRINKING WATER LIMITS (RALS)
GROUNDWATER
CH2M Hill RI/FS
1986
(Continued)

Units: ppb

AQUITARD WELLS: Compound	Background	RAL	B4B*	B6B*
Aluminum	138	NE	--	--
Arsenic	NE	0.2	17.4	--+
Barium	121	2000	289	--
Cadmium	4	4.0	--	--
Iron	88	NE	20700	21300
Lead	NE	20	--	--
Nickel	NE	70	--	--
Manganese	163	300	157	249
Vanadium			--	--
Zinc	1228	700	1370	--

LOWER AQUIFER WELLS: Compound	Background	RAL	W2C*	W15C	W19C	W23C	B4C*
Aluminum	138	NE	--	--	--	--	--
Arsenic	NE	0.2	--+	--+	--+	--+	--+
Barium	121	2000	--	--	--	--	132J
Cadmium	4	4.0	--	--	--	--	--
Iron	88	NE	175	162	--	--	--
Lead	NE	20	23	--	--	--	--
Nickel	NE	70	--	--	--	--	--
Manganese	163	300	656	172	50	79	--
Vanadium							
Zinc	1228	700	5220	--	--	--	--

NOTES:

No inorganic compounds were detected above background or RALs in samples W9A, W16A, W20A, W24A, B3A, B9A, W9B, W21B, B2BD, B3B, W1C, W19C, W21C, W23C, B8C, B10C, GWFB3, GWFB4, GWFB5, GWFB6, AND GWFB7.

-- Not detected
J Concentration greater than instrument detection limit but less than EPA required detection limit.
NE No level established.
+ Detection limit greater than RAL.
* Galvanized well.
^ Secondary level.

A/RP/SANDOVER/AU8

TABLE 2-6

SUMMARY OF INORGANIC COMPOUNDS DETECTED ABOVE
BACKGROUND LEVELS, MINNESOTA RECOMMENDED ALLOWABLE, OR MAXIMUM CONTAMINANT LEVELS
DRINKING WATER LIMITS (RALs)
RESIDENTIAL WELLS
CH2M Hill RI/FS
1986

Units: ppb

Compound	MCL	Back-ground	RAL	RW001	RW002	RW004	RW004D	RW005	RW006	RW008 (1-7-86)	RW008 6-11-86)
Aluminum	NE	138	NE	--	--	--	--	--	536	39000	--
Barium	1000	121	2000	--	--	167	160	--	--	429	--
Cadmium	10	4	5	--	--	--	--	--	--	356	--
Chromium, Total	50	NE	100	--	--	--	--	--	--	127	--
Cobalt	NE	NE	1.0	--	--	6.5	6.0	--	--	45.5	--
Iron	300+	88	NE	--	--	11100	9940	1080	8620	69600	--
Lead	50	NE	20	--	--	--	--	--	1220	12900	--
Manganese	50+	163	300	277	55.5	846	821	--	--	1790	358
Nickel	NE	NE	70	--	--	--	--	--	--	106	--
Vanadium	NE	NE	20	--	--	--	--	--	--	129	--
Zinc	5000+	1228	700	--	--	3330	3090	--	12200	113000	--

NOTES:

- No inorganic compounds were detected above the background levels or RALs in samples from RW002, RW003, RW007, RWFB1, RWFB2.

-- Not detected above established levels.
NE No level established.
+ Secondary standard.

A/RP/SANDOVER/AU9

2.2.5 Donohue Second Operable Unit RI (1990)

Subsurface investigations were conducted by Donohue in 1990 as part of the Second Operable Unit RI/FS. Program elements completed during the RI field investigation included a site survey, geophysical and geomorphological investigations, and chemical sampling during shallow and deep boring and trenching programs. Other activities completed by Donohue included surface water and sediment sampling.

Four primary indicators of physical impacts to the site were observed. Tire waste, fill materials, stains or odors, and tar-like substances demonstrated heterogeneous and widespread lateral distribution. Almost all areas of the site have physical evidence of fill to a minimum 3-foot depth. Generally, physical impacts are confined to surface horizons. Visual evidence of physical impacts were absent below the 9-foot depth at all sample locations.

Chemical data for soils, surface water, and sediments are summarized in Tables 2-7 through 2-15. An in-depth discussion of the chemical data obtained for each media is given in Chapter 4 of the RI Report (Donohue 1991). The following presents a summary of the nature and distribution of contamination detected during the OU-2 RI.

The following types of compounds were detected in soil, sediment, or surface water at the South Andover site: halogenated volatile organics (methylene chloride, chloroform, 1,1,1-trichloroethane, trichloroethene, tetrachloroethene); nonhalogenated volatile organics (acetone, carbon disulfide, 2-butanone, 4-methyl-2-pentanone, 2-hexanone, toluene, ethyl benzene, styrene, xylenes); halogenated semivolatile organics (PCBs, DDD, DDT, chlorinated phenols); nonhalogenated semivolatile organics (PAHs, phthalates, phenols); and inorganics (metals, cyanide).

2.3 GEOLOGY

The following discussion of geology, based on previously published information, is divided into two sections. The first describes the regional geology of the Anoka Sand Plain and the second, the site geology of the immediate area of the South Andover site. Each section includes descriptions of glacial and bedrock stratigraphy. A more detailed discussion of site geology, based on information collected during the Design Investigation is presented in Section 4.

2.3.1 Regional Geology

The regional geology of east central Minnesota is dominated by the Anoka Sand Plain physiographic region. This broad sand plain covers approximately 850 square miles in east-central Minnesota (Farnham, 1956). The area has been subjected to several glacial advances and retreats during the Pleistocene Epoch. The present landscape strongly reflects the influence of mid- to late Wisconsinan glaciation and subsequent modification by aeolian and fluvial

TABLE 2-7

SUMMARY OF DETECTED VOLATILE ORGANIC COMPOUNDS
SOIL
South Andover RI/FS
1990

	Naturally Occurring Soil Concentrations[c]	Surface Soil[a]	Subsurface Soil[b]				Background Soil
		Range of Concentrations Detected, ppb					
		0-6 Inches	0-3 Feet	3-6 Feet	6-14 Feet	>14 Feet	
Methylene Chloride	-	8J-78J (GS04B)	4J-160D (GS05E)	20J-160J (TS22)	21J-22J (GS07C)	9B (W1CR)	6J-58J
Acetone	-	4J-7J (GS09C)	4J-420JD (GS05E)	3J-540JD (GS03B)	12-13,000JB (W23AR)	10J-6,60D (BS11)	5J[d]
Carbon Disulfide	-*	1J-10J (GS05C)	1J-46J (GS09C-C)	1J-23JD (GS03B)	2J-7J (GS07C)	ND	1J-10J
Chloroform	-	0.6J-7J (GS02B)	ND	3J (GS03B)	ND	ND	ND
2-Butanone	-	2J-40 (GS06E)	39JD-98JB (GS05E)	1J-57 (TS22)	1J (GS07C)	ND	ND
4-Methyl-2-pentanone	-	ND	ND	ND	3,200J (W23AR)	ND	ND
2-Hexanone	-	ND	2J	ND	5,100J (W23AR)	ND	ND
1,1,1-Trichloroethane	-	2J-12J (GS18C)	2J-4J (GS14C)	2J-3J (GS04C)	2J-3J (GS07C)	ND	2J
Trichloroethene	-	4J (GS05C)	5J (GS09C)	ND	ND	ND	ND
Tetrachloroethene	-	1J (GS11)	ND	3J (BS04)	ND	ND	ND
Toluene	1,000-5,000	0.9J-100J (GS02B)	2J-180JD (GS05E)	2J-2,600,000JE (BS05)	2J-33,000J (BS05)	1J-14	1J-29
Ethyl Benzene	1,000-5,000	ND	2J-8J (GS14C)	6J-290,000J (BS05)	ND	ND	ND
Styrene	-	ND	7J (GS05E)	ND	ND	ND	ND
Xylenes (Total)	3,000-15,000	5J (GS05C)	1J-33J (GS05E)	27J-2,600,000JE (BS05)	15,000J (BS05)	ND	ND

a: GS samples, 0-6 inches only.
b: Includes GS (>6 inches), BS, and TS samples.
c: Dragun, 1988.
d: Includes samples taken from 2-4-foot depth interval.
ND: Not detected.
B: Compound also detected in associated laboratory blank.
*: Naturally occurring compound, measured concentration not available. Concentration "should be at least a few ppm" (Dragun, 1988).
J: Value "estimated" due to minor QC deviations.
Values in parenthesis are sample locations of the maximum detected concentrations.

A/RP/SANDOVER/AT8

TABLE 2-8

SUMMARY OF DETECTED SEMIVOLATILE ORGANIC COMPOUNDS
SOIL
South Andover RI/FS
1990

Range of Concentrations Detected, ppb

	Naturally Occurring Soil Concentrations[c]	Surface Soil[a]		Subsurface Soil[b]			
		Background	0-6 Inches	0-3 Feet	3-6 Feet	6-14 Feet	>14 Feet
1,4-Dichlorobenzene	-	ND	ND	1300J (GS08E)	ND	ND	ND
Phenol	-	ND	ND	ND	150J-210J (BS01)	ND	ND
4-Methylphenol	-	ND	ND	ND	47J-100J (BS01)	ND	ND
Benzyl Alcohol	-	ND	320J (GS01C)	ND	ND	ND	ND
Benzoic Acid	140-11,000	ND	37J-5,600 (GS01C)	80J-10,000J (B6AR)	71J-1,100J (TS05)	37JB-880J (TS11)	ND
Naphthalene	1,000-5,000	ND	52J-290J (GS12A)	37J-740J (B6AR)	280J-5,700J (BS04)	68J-79J (TS16)	89J (B6A-R)
4-chloro-3-methyl phenol	-	ND	ND	41J (GS12A)	ND	ND	ND
2-Methylnaphthalene	-	ND	38J-340J (GS12A)	40J-1400J (B6A-R)	170J-550J (TS05)	230J-240J (TS11)	ND
Dimethylphthalate	-	ND	55J (GS01C)	1,000 (GS03A)	ND	ND	ND
Acenaphthylene	-	ND	42J-350JD (GS12A)	51-330J (B6A-R)	ND	ND	ND
2,6-Dinitrotoluene	-	ND	42J (GS12A)	ND	ND	ND	ND
Acenophthene	-	ND	49J-1,300 (GS12A)	20J-1,800J (B6A-R)	910J-9,200J (BS04)	53J-250J (TS11)	ND
Dibenzofuran	-	ND	1,000JD-1,200 (GS12A)	160J-450J (GS08E)	200J-5,400J (BS04)	ND	ND
Diethylphthalate	-	ND	110J (GS16C)	ND	ND	55J-250J (GS07L)	86J (B6A-R)
Fluorene	-	ND	47J-3,300 (GS12C)	44J-1,200J (B6A-R, TS18)	62J-9,300J (BS04)	48J-150J (TS11)	ND
N-nitrosodiphenylamine	-	ND	48J-120J (GS01A)	45J-360J (TS11)	ND	ND	ND
Hexachlorobenzene	-	ND	90J (GS08E)	ND	28J-38,000J (BS04)	ND	ND
Pentachlorophenol	-	ND	100J (GS06D)	110J (GS12A)	ND	ND	ND
Phenanthrene	-*	ND	38J-16,000D (GS12A)	46J-14,000J (TS18)	ND	52J-690 (TS11)	ND
Anthracene	-*	ND	60J-4,300D (GS12A)	35J-2,600J (TS18)	170J-14,000J (BS04)	46J-100J (TS11)	ND
Di-n-butylphthalate	-*	ND	45J-970 (GS16C)	63J-12,000D (GS02E)	80J-660J (TS04)	ND	ND
Fluoranthene	0-40	47J	41J-19,000D (GS12A)	43J-19,000 (GS08E)	37J-28,000J (BS04)	47J-220J (TS11)	ND
Pyrene	0-15	63J	45J-11,000D (GS12A)	37J-21,000 (GS08E)	41J-36,000 (BS04)	37J-360J (TS11)	ND
Butylbenzylphthalate	-*	46J	37J-5,300J (GS06D)	71J-33,000D (GS02E)	81J-490J (TS04)	81J (GS07C)	55J (B6A-R)
Benzo(a)anthracene	0-10	ND	45J-9,300D (GS12A)	100J-9,300 (GS08E)	66J-23,000J (BS04)	120J (TS11)	ND
Chrysene	5,000	ND	44J-7,500D (GS12A)	47J-9,200 (GS08E)	310J-25,000 (BS04)	180J (TS11)	ND
bis(2-ethylhexyl)phthalate	-*	90J-170J	39J-17,000 (GS12A)	72J-10,000J (TS04)	52J-1,400J (BS01)	38J-6100 (GS07L)	110J-690 (B6A-R)
Di-n-octylphthalate	-*	150J	39J-230J (GS09E)	130J-220J (GS14C)	ND	380-450 (BS03)	ND
Benzo(b)fluoranthene	0-30	ND	56JX-13,000XD (GS12A)	47JX-18,000X (GS08E)	150J-25,000J (BS04)	98J (TS11)	ND
Benzo(k)fluoranthene	0-15	ND	56JX-13,000JXD (GS12A)	47JX-18,000JX (GS08E)	200J-16,000J (BS04)	ND	ND
Benzo(a)pyrene	0-8,000	ND	86J-6,200D (GS12A)	89J-6,500 (GS08E)	200JX-20,000J (BS04)	48J-88J (TS11)	ND
Indeno(1,2,3-cd)pyrene	0-15	ND	40J-2,900D (GS12A)	43J-3,000J (TS18)	710J-14,000J (BS04)	ND	ND
Dibenzo(a,h)anthracene	-	ND	35J-1,300JD (GS12A)	380J-810J (GS08E)	370J-7,200J (BS04)	ND	ND
Benzo(g,h,i)perylene	0-20	ND	43J-2,900D (GS12A)	43J-3,300J (TS18)	760-13,000J (BS04)	ND	ND

[a]: GS samples, 0-6 inches only.
[b]: Includes GS (>6 inches), BS, and TS samples.
[c]: Dragun, 1988.
J: Value "estimated" due to minor QC deviations.
D: Sample diluted to bring concentration within linear calibration range.
X: Chemical coeluted with another compound.
ND: Not detected.
*: Naturally occurring compound, measured concentration not available. Concentration "should be at least a few ppm" (Dragun, 1988).

Values in parenthesis are sample locations of highest detected concentrations.

A/RP/SANDOVER/ATO

TABLE 2-9

SUMMARY OF DETECTED PESTICIDE/PCB COMPOUNDS
SOIL
South Andover RI/FS
1990

Range of Concentrations Detected (ppb)

Analyte	Surface Soil[a]	Subsurface Soil[b] 0-3'	3-6'	6-14'
beta - BHC	33J(FDGS06E)	ND	ND	ND
Endosulfin I	110(GS12)	ND	ND	ND
4,4 DDE	30(GS06)	ND	ND	ND
4,4-DDD	85(GS06)	1.8J-150(TS04)	89-160(TS17)	45J(BS15)
4,4 DDT	46-110(GS12A)	20-29J(BS131)	110J-140(BS04)	ND
Endosulfan Sulfate	140(GS12)	17J(TS11)	ND	ND
Aldrin	ND	13(TS11)	ND	ND
Aroclor-1254	180J-1,800(GS03B-01)	200J-11,000(BS10)	ND	ND
Aroclor-1260	1,200J-15,000JC(GS03E)	570-4,700C(BS12)	ND	ND

a: GS samples, 0-6 inches only.
b: Includes GS (>6"), TS, and BS samples.
J: Value "estimated" due to minor QC deviations.

Values in parenthesis are sample locations of highest detected concentrations.

A/RP/SANDOVER/AT9

TABLE 2-10

SUMMARY OF DETECTED INORGANIC COMPOUNDS
SOIL
South Andover RI/FS
1990

Range of Concentrations Detected, ppm

	Average Soil Concentration[c]	Surface Soil[a] Background	Surface Soil[a] 0-6 Inches	Subsurface Soil[b] 0-3 Feet	Subsurface Soil[b] 3-6 Feet	Subsurface Soil[b] 6-14 Feet	Subsurface Soil[b] >14 Feet
Aluminum	71,000	3,180-5,480	2,210-140,000 (GS04B)	1,400-46,800 (TS13)	2,080J-7,740 (TS22)	1198.995-4,400 (BS06)	988J-7,330 (BS08)
Antimony	2-10	2.9JB	2.3JB-75.9 (GS04E)	2.9JB-11.3JB (BS10)	3.0JB-3.1JB (GS11C)	3.1JB-5.3JB (BS15)	8.2JB (BS08)
Arsenic	10	0.81B-1.7B	0.84B-9.3 (GS07C)	0.60B-22.2J (BS15)	0.54JB-4.4 (TS15)	0.01JB-4.3J (BS15)	0.47JB-2.1B (BS01)
Barium	430	22.8JB-234J	17.8JB-222J (GS01C)	17.1B-218 (GS06E)	12.8B-242 (TS18)	8.8B-51.8B (BS06)	8.7B-44.3B (BS01)
Beryllium	6	0.21B-0.22B	0.2B-3.2 (GS04B)	0.21B-0.82JB (TS13)	0.22B-0.94JB (TS17)	0.28B (BS02)	0.28B-0.43JB (W1C-R)
Cadium	0.06	ND	0.4JB-29.8 (GS04E)	0.49JB-43.6J (BS15)	0.69B-1.4 (BS15)	0.74B-1.06B (BS09)	ND
Calcium	-	442B-969B	400JB-21,500J (GS07E)	405B-24,800J (GS05E)	486B-25,400 (BS01)	376B-8,760J (BS09)	972B-26,000 (B7B)
Chromium	100	3.5J-6.1J	3.1J-382J (GS02E)	3.2J-490J (GS01E)	3.2J-57.1J (TS04)	3.3J-160J (BS05)	3.6J-16.6(W1C-R)
Cobalt	8	1.5B-3.1B	0.73B-18.0 (GS16A)	1.5B-18 (BS10)	2.5JB-12.9B (TS22)	1.2B-6.1B (BS06)	2.0JB-7.70B (W1C-R)
Copper	30	2.3B-10.7	1.6JB-9,660 (GS04B)	2.8B-3,780J (GS08E)	2.7B-160 (TS13)	2.2B-42.8J (BS05)	2.7JB-25.4 (BS08)
Iron	-	4,430-6,870	1,760-56,300 (GS02E)	2,780-83,000 (GS07E)	1,970-20,600J (BS01)	1,930J-10,200J (BS09)	2,060J-12,100J (W1C-R)
Lead	10	2.4-57.6	2.6-1,980 (GS04E)	1.8-1,180 (BS10)	2.1J-232J (TS04)	0.02-207 (BS05)	0.68JB-2.9J (BS01)
Magnesium	-	632B-825B	296B-5,320 (GS01E)	221B-7,500 (TS17)	524B-6,320 (BS02)	454B-2370 (BS09)	692B-9,330 (B7B)
Manganese	600	153J-359	16.8-4,400J (GS02E)	44.2-1,020 (GS06E)	19.3-849 (TS15)	15.5-287J (BS09)	33.3-240J (BS01)
Mercury	0.03	0.47	0.08-0.58 (GS06D)	0.11-0.62 (TS18)	0.13 (TS04)	0.09-0.15 (BS05)	ND
Nickel	100	3.7B-5.4B	3.2B-291 (GS04B)	2.8B-133 (GS07E)	2.9B-28.8 (TS22)	2.7B-11.0 (TS14)	4.2B-20.8 (W1C-R)
Potassium	-	160B-367B	132B-555B (GS01E)	42.4B-762 (GS06A)	148B-551B (BS15)	89JB-631B	138B-741B (BS08)
Selenium	0.50	ND	0.33JB-2.6J (GS08E)	0.48JB-11.6 (TS13)	ND	0.55JB-1.6JB (W23A-R)	ND
Silver	0.05	ND	4.0-16.3 (GS04B)	0.58JB-15.4 (TS13)	1.0JB-2.1B (BS01)	0.48B-47 (BS06)	1.0JB (BS01)
Sodium	-	24.8JB-54.6JB	24.0JB-255B (GS01C)	24.9B-1,110JB (BS10)	28.9JB-955JB (BS08)	36.4B-1,650J (W23A-R)	58.3JB-1,040JB (W1C-R)
Thallium	5	ND	ND	0.54JB-2.7B (BS02)	0.44JB-2.7JB (TS17)	0.29JB-0.71JB (TS14)	0.98JB (BS01)
Vanadium	100	6.7B-10.8	5.0B-30.7 (GS02E)	4.5B-80.9 (BS10)	3.6B-22.5B (TS22)	4.7B-18.4 (W23A-R)	8.2B-31.2 (BS08)
Zinc	50	11.7-28.3	10.9J-4,540 (GS04B)	9.1-8,030J (BS15)	8.0-452 (TS05)	7.3-276 (TS06)	8.3-24.7J (BS01)
Cyanide	-	ND	1.2-65.1 (GS03C)	0.18JB-13.6 (GS02E)	0.38JB-55 (BS01)	0.31JB-5.7 (BS05)	ND

a: GS samples, 0-6 inches only.
b: Includes GS (>6 inches), TS, and BS samples.
c: New Lyme Landfill RI/FS, CH_2MHill, 1985.
J: Value "estimated" due to minor QC deviations.
B: Value above instrument detection limit but below contract detection limit.

Values in parenthesis are sample locations of highest detection concentrations.

A/RP/SANDOVER/AT8

TABLE 2-11

SUMMARY OF DETECTED VOLATILE ORGANIC COMPOUNDS
SEDIMENT AND SURFACE WATER
South Andover RI/FS
1990

Range of Concentrations Detected, ppb

	U.S. EPA Ambient Water Quality Criteria (for Protection of Aquatic Life)		1991 Coon Creek, MN Water Quality			
	Acute	Chronic	Chronic Standards	Sediment	Surface Water	Surface Water Trip Blanks
Methylene Chloride	193,000	NE	1,561	28JB (SD01)	5J-7J (SW03)	8J-9J
Acetone	NE	NE	SS	54JB-190JB (SD04)	6J-18 (SW01)	18
Toluene	17,500	NE	253	9J-2,500JE (SD04)	37 (SW04)	ND

NE: No level established.
SS: Must be determined by MPCA on a site-specific basis.
J: Value "estimated" due to minor QC deviations.
B: Compound detected in associated laboratory blank.
E: Concentration exceeds calibration range of GC/MS instrument.

Values in parenthesis are sample locations of the maximum detected concentrations.

A/RP/SANDOVER/AU1

TABLE 2-12

SUMMARY OF DETECTED SEMIVOLATILE ORGANIC COMPOUNDS
SEDIMENT AND SURFACE WATER
South Andover RI/FS
1990

Range of Concentrations Detected, ppb

Semivolatile Organic Compounds	U.S. EPA Ambient Water Quality Criteria (for Protection of Aquatic Life) Acute	Chronic	1991 Coon Creek, MN Water Quality Chronic Standards	Sediment	Surface Water	Surface Water Trip Blanks
Bis(2-ethylhexyl) phthalate	11,100	3	SS	ND	1J (SW03)	ND

J: Value "estimated" due to minor QC deviations.
B: Compound detected in associated laboratory blank.
SS: Must be determined by MPCA on a site-specific basis.

Value in parenthesis is sample location where constituent was detected.

A/RP/SANDOVER/AU1

TABLE 2-13

SUMMARY OF DETECTED PESTICIDE/PCB COMPOUNDS
SEDIMENT AND SURFACE WATER
South Andover RI/FS
1990

Pesticides/PCB	Range of Concentrations Detected, ppb Sediment
4,4'-DDD	130 (SD04)
4,4'-DDT	120-140 (SD04)

J: Value "estimated" due to minor QC deviations.
B: Compound detected in associated laboratory blank.

Values in parenthesis are sample locations of highest detected concentrations.

A/RP/SANDOVER/AU1

TABLE 2-14

SUMMARY OF DETECTED INORGANIC COMPOUNDS
SURFACE WATER
South Andover RI/FS
1990

Compound	U.S. EPA Ambient Water Quality Criteria (for Protection of Aquatic Life) Acute	Chronic	1991 Coon Creek, MN Water Quality Chronic Standards	Range of Concentrations Detected, ppb	Field Blank Blanks
Aluminum	NE	NE	125	43.B - 695 (SW04)	ND
Arsenic	360	190	70	2.1B - 6.6JB (SW04)	ND
Barium	NE	NE	SS	26.4B - 374J (SW04)	ND
Beryllium	130	5.3	SS	2.3B - 3.1B (SW04)	ND
Cadmium	1.8*	0.66*	0.66*	3.0B - 8.0 (SW01)	ND
Calcium	NE	NE	SS	15,100 - 56,200 (SW02)	385B
Chromium	16	11	11[o]	2.0JB - 7.0JB (SW01)	ND
Cobalt	NE	NE	SS	5.6B - 9.5B (SW04)	ND
Copper	9.2*	6.5*	6.4*	7.7JB - 39.3 (SW01)	ND
Iron	NE	NE	SS	122J - 6,890 (SW04)	23.4JB
Lead	34	1.3	1.3*	1.2B - 6.6 (SW04)	ND
Magnesium	NE	NE	SS	3,990JB - 13,400 (SW01)	71.4JB
Manganese	NE	NE	SS	9.8B - 619 (SW04)	ND
Mercury	2.4	0.012	0.0069	0.28 (SW02)	ND
Nickel	1100*	56*	88*	10.1JB (SW03)	ND
Potassium	NE	NE	SS	1,150JB - 9,260J (SW01)	ND
Selenium	260*	35	5.0	2.0B - 3.0B (SW04B)	ND
Sodium	NE	NE	SS	6,640J - 39,400J (SW02)	99.9B
Thallium	140	40	SS	1.8JB (SW04)	ND
Vanadium	NE	NE	SS	2.1B - 6.8B (SW04)	ND
Zinc	180*	47*	59*	16.8JB - 219JB (SW04)	22.5J
Cyanide	22	0.52	5.2	2.3B - 7.5B (SW04)	ND

NE: No level established.
SS: Must be determined by MPCA on a site-specific basis.
J: Value "estimated" due to minor QC deviations.
B: Value above instrument detection limit, but below contract required detection limit.
Values in parenthesis are sample locations of highest detected concentrations.
*Based on water hardness equal to 50 mg/l $CaCO_3$.
[o]Chromium +6.

A/RP/SANDOVER/AU1

TABLE 2-15

SUMMARY OF DETECTED INORGANIC COMPOUNDS
SEDIMENT
South Andover RI/FS
1990

	Range of Concentrations Detected, ppm
Aluminum	1,850 - 12,500J (SD04)
Arsenic	1.3B - 5.1JB (SD04)
Barium	11.1JB - 192 (SD01)
Calcium	1,040B - 16,200 (SD02)
Chromium	3.4 - 17.7 (SD04)
Cobalt	1.6B - 14.8B (SD01)
Copper	3.2JB - 54 (SD04)
Iron	1,700J - 40,500J (SD01)
Lead	1.2J - 442J (SD01)
Magnesium	558B - 6,570 (SD02)
Manganese	21.5 - 825 (SD01)
Nickel	6.7B - 18.4B (SD01)
Potassium	174JB - 910JB (SD04)
Selenium	0.33JB - 2.8JB (SD04)
Silver	1.8B (SD02)
Sodium	799JB - 5,140JB (SD04)
Thallium	4.8B (SD01)
Vanadium	3.6B - 27.3B (SD04)
Zinc	9.8 - 290 (SD01)
Cyanide	0.65 - 2.5J (SD01)

J: Value "estimated" due to minor QC deviations.
B: Value above instrument detection limit but below contract required detection limit.

Values in parenthesis are sample locations of highest detected concentrations.

processes. Glacial deposits consist primarily of till and outwash which range in thickness from 100 to 300 feet. Glacial activity recorded in the region included the most recent advances of the Superior lobe and the Grantsburg sublobe during the mid- and late-Wisconsinan Period. The Superior till consists of massive, red, silty, clayey sand. The till deposited by the Grantsburg sublobe is typically a calcareous, gray silty, clayey sand. Gray outwash sand comprising the Anoka Sand Plain was deposited as the Grantsburg sublobe retreated. These glaciofluvial deposits form a 20- to 60-foot mantle over the underlying till units.

The bedrock underlying the Anoka Sand Plain consists predominantly of Cambrian and Precambrian sandstones with interbedded shales and siltstones overlying a Precambrian basement complex. Bedrock elevations range from less than 600 feet to more than 850 feet (Jirsa et al., 1986), and reflect the presence of bedrock valleys up to 300 feet deep. Regional bedrock and glacial stratigraphy is presented in Figure 2-7 which shows a geologic cross-section through Anoka and Sherburne Counties.

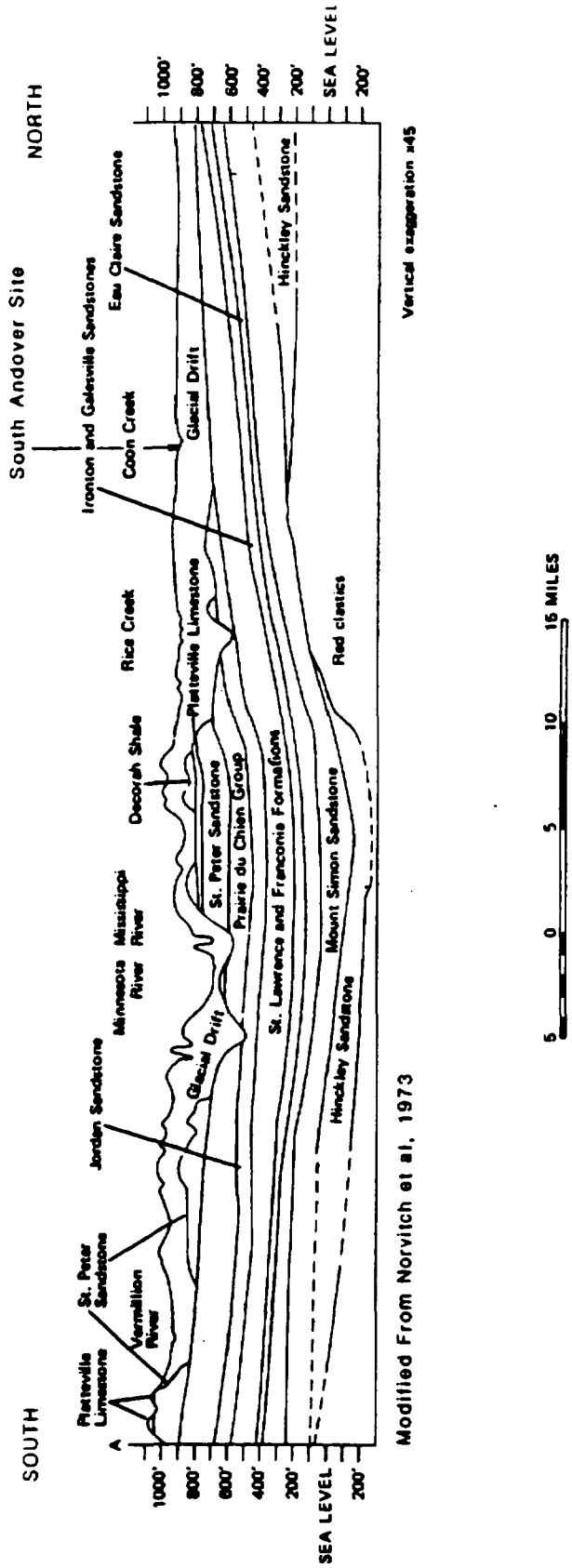
2.3.2 Site Geology

The following discussion of the geology at the South Andover site is based upon data collected during the following investigations: Subterranean Engineering (1978), Residual Management Technology/PEDco Environmental (1980), Ecology and Environment (1983), Pace Laboratory (1984), and CH2M Hill (1987). The following discussions do not incorporate recent data obtained by Donohue's investigations.

Previous subsurface investigations have reported that four major unconsolidated units are present at the South Andover site. Their relative positions are illustrated in the site stratigraphic column (Figure 2-8). The Upper Sand Aquifer is comprised primarily of the outwash and dune sands of the Anoka Sand Plain. The underlying Middle Aquitard consists primarily of lake sediments, with localized, discontinuous till bodies. The Lower Sand Aquifer is glaciofluvial in origin, most likely Superior Lobe outwash. Reddish-brown Superior Lobe clayey till underlies the Lower Sand Aquifer.

The Upper Sand Aquifer consists of fine-grained, subrounded sand with a trace of medium sand and silt. The unit ranges from 20 to 50 feet in thickness at the site. A 2- to 7-foot thick silty sand (topsoil) is present within the unit. Wetland deposits characterized by black organic-rich silt also occur locally.

A silt unit underlies the Upper Sand Aquifer. This unit called the Middle Aquitard ranges in thickness from 50 to 70 feet. Lithologic differences have allowed the aquitard to be divided to three subunits: (1) the uppermost unit is a localized, discontinuous, thin, gray sandy clay recognized regionally as the Grantsburg Sublobe till, underlain by (2) a silt sandy silt unit of probable glacio-lacustrine origin, which overlies (3) a glacio-lacustrine clay and clayey silt unit. Twenty-six feet of relief is exhibited by the upper surface of the middle aquitard.



SOURCE: CH2M HILL, 1987

20022

FIGURE 2.7

REGIONAL GEOLOGIC CROSS SECTION

SOUTH ANDOVER SUPERFUND SITE
DESIGN INVESTIGATION
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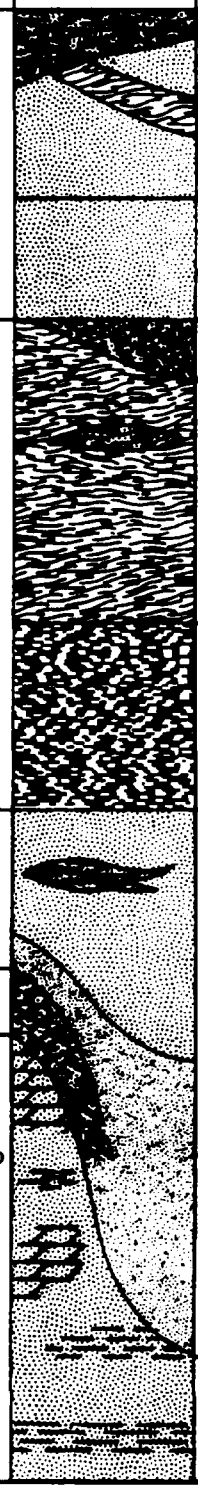
SYSTEM	GEOLOGIC UNIT	THICK-NESS	DESCRIPTION	ORIGIN	SITE NAME
Quaternary	Sand	20'-50'	0-8' Silty Fine Sand	Topsoil & Fill	Upper Sand Aquifer
			0-12' Fine Sand	Fill	
			0-8' Black Organic Silt	Swamp Deposits	
			5'-16' Brown Fine Sand	Dune Sand or Grantsburg Outwash	
			5'-26' Gray Fine Sand and Silty Sand		
	Sandy Clay	50'-70'	0-5' Gray Sandy Clay	Grantsburg Till	Middle Aquitard
	Silt and Sandy Silt		20'-40' Silt and Sandy Silt, 4' Lens of Silty Sand, Traces of Coarse Sand and Gravel	Glacio-Lacustrine Over Most of Site. May Be Till in SW Corner	
	Clayey Silt and Clay		10'-45' Clayey Silt and Clay, Laminated, up to 1/2" Bands of Red Clay	Glacio-lacustrine	
	Sand and Gravel	9'-35+	Sand, Sand and Gravel and Silty Sand	Superior Outwash or Ice Contact Deposits	Lower Sand Aquifer
	Sandy Clay	0-5+			
Cambrian	St. Lawrence Formation and Franconia Formation	up to 150'	Red Sandy Clay	Superior Till	Superior Till
			Yellow Siltstone, Tan and Green Shale and Sandstone		Bedrock



SOURCE: CH2MHILL, 1988

20022

FIGURE 2.8
SITE STRATIGRAPHIC CROSS SECTION
(CH2MHILL, 1988)
SOUTH ANDOVER SUPERFUND SITE
DESIGN INVESTIGATION
ANDOVER, MINNESOTA

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The Superior lobe till is the lowermost unconsolidated glacial unit occurring at the site. The Superior Lobe till consists of red sandy clay to five feet thick. The continuity of this unit beneath the site is not well defined (CH2M Hill, 1988).

Bedrock Units

The uppermost bedrock units underlying the South Andover site are assigned to the St. Lawrence and Franconia Formations (Figure 2-7). Both formations consist predominantly of interbedded sandstone and shale. Approximately 100 feet of topographic relief is observed on the subcropping bedrock surface beneath the site, with progressive deepening toward the west (CH2M Hill, 1988). While depth to bedrock at the site is not well defined, available data suggests that bedrock generally is found between depths of 85 and 160 feet. Regional bedrock topography is shown in Figure 2-9. A deep southwest-trending preglacial bedrock valley is located west of the site. It is likely that a tributary to this major bedrock feature extends under the site. Another bedrock valley is located towards the southeast. This feature extends to the northwest, towards the site.

2.4 HYDROGEOLOGY

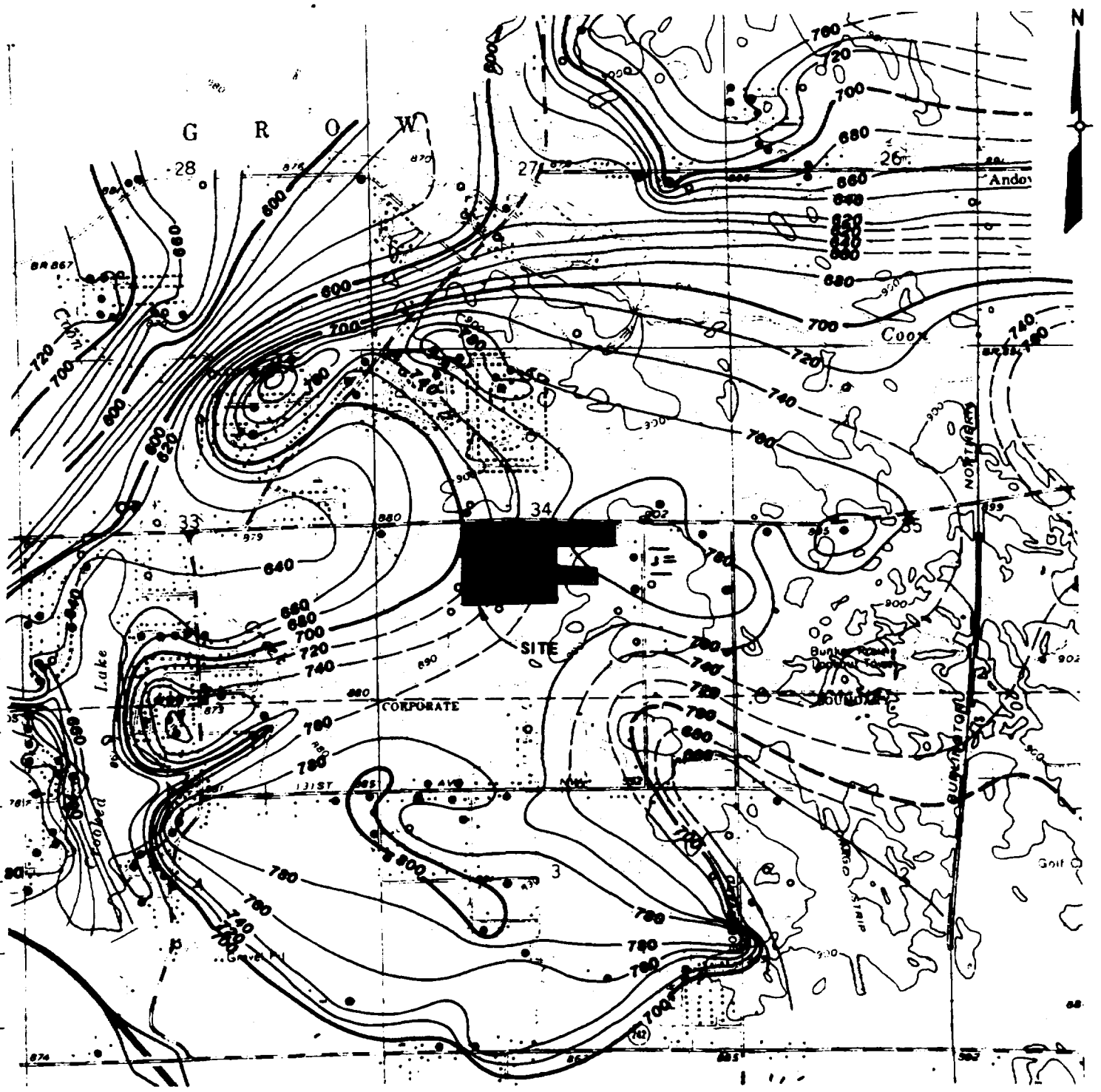
2.4.1 Regional Hydrogeology

Major aquifers used in the region occur both within glacial drift deposits and in the underlying bedrock. The principal bedrock aquifers include the Jordan Sandstone, the Franconia-Ironton-Galesville Formations, and the Mt. Simon-Hinckley-Fond du Lac Formations. These units consist primarily of quartzose sandstones, with interbedded siltstones and some shale. Groundwater flow within the bedrock aquifer is towards the southeast (Erickson et al., 1974).

The lithologic and hydraulic characteristics of the glacial drift are varied. Well-sorted, coarse-grained outwash or sandy-till deposits typically serve as aquifer units, while interbedded poorly stratified clay and silt glacial till or lacustrine deposits act as intervening aquicludes or aquitards. Typically, thicker sequences of glacial drift overlie bedrock valleys, excavated by preglacial and interglacial stream action.

The unconfined (water table) aquifer system is located within the glacial drift unit throughout Anoka County. Depth to the water table ranges from 5 to 15 feet in this general vicinity. Regional groundwater flow within the surficial aquifer is directed toward the southeast, except where flow is locally affected by major streams bisecting the region.

The South Andover site is located in the Coon Creek watershed. Nearly all water used in this watershed is obtained from groundwater sources. While the most readily available source of groundwater in the region is the upper unconsolidated outwash unit, major water users commonly obtain supplies from Cambrian or Precambrian sandstone beds underlying the drift. Most wells



Contour Interval 20 Feet

LEGEND

- ○ Drift Borehole Log
- ● Bedrock Borehole Log

0 2000 4000

SCALE IN FEET

SOURCE: CH2M HILL, 1987

20022

FIGURE 2.9

REGIONAL BEDROCK TOPOGRAPHY

SOUTH ANDOVER SUPERFUND SITE
DESIGN INVESTIGATION
ANDOVER, MINNESOTA

JULY 1991

Donohue ENGINEERS ARCHITECTS SCIENTISTS

drawing water supplies from the Franconia-Ironton-Galesville aquifer have been completed at depths of 150 to 500 feet. Wells completed in the glacial drift range from 20 to 150 feet deep (Erickson et al., 1974). Municipal water supplies account for nearly 50 percent of water use in the region.

2.4.1.1 Glacial Drift Aquifers

Gray, fine-grained outwash sand forms the uppermost aquifer unit within the Anoka Sand Plain. This aquifer (Upper Sand Aquifer) can yield up to several hundred gallons per minute (gpm), depending on the lithologic characteristic of the unit and the saturated thickness penetrated. The majority of residences located near the site use municipal water. Major water users (industries, municipalities, etc.) commonly use wells screened in Paleozoic sandstone bedrock units.

The Upper Sand Aquifer is underlain by an aquitard composed of laminated silt and clay which represents glacial lake deposits, or the Grantsburg Sublobe till. Thickness of the aquitard ranges from 50 to 70 feet in the vicinity of the site. This aquitard has been reported to typically display low hydraulic conductivity (CH2M Hill, 1988).

A Lower Sand Aquifer unit underlies the gray till of the Grantsburg Sublobe. Comprised of sand and gravel units (outwash and ice contact deposits), this aquifer is an important water supply source in the region. The hydraulic conductivity, saturated thickness, and yields associated with this aquifer are highly variable. The Lower Sand Aquifer is underlain by the Superior lobe till. The Superior Lobe till was identified by CH2M Hill (1988) as an aquitard.

2.4.1.2 Bedrock Aquifers

The principal bedrock water supply aquifer in this region is the Jordan Sandstone which is characterized by its high porosity and hydraulic conductivity. Well yields from this unit locally exceed 1,000 gpm. The Jordan Sandstone is underlain by the St. Lawrence Formation which is considered a confining bed because of its low hydraulic conductivity.

The Franconia and Ironton-Galesville Formations underlying the St. Lawrence Formation form a common aquifer unit. Hydraulic conductivity is highly variable within this aquifer. Hydraulic conductivity values range from 1.2×10^{-2} cm/sec to 1.4×10^{-3} cm/sec, with a reported storage coefficient of 10^{-4} to 10^{-6} (CH2M Hill, 1988). Reported yields typically range from 15 gpm to 600 gpm, with a maximum of 1,200 gpm (Erickson et al., 1974). The aquifer is underlain by the Eau Claire Formation. The Eau Claire may yield small quantities of water to wells but is considered a poor water source.

The Mt. Simon, Hinckley and Fond du Lac Formations are hydraulically connected. Reported yields from this aquifer unit range from 10 gpm to 600 gpm with a reported maximum yield of 1,300 gpm. Kanivetsky (1979) reported hydraulic conductivities ranging from 7.0×10^{-2} cm/sec to 9.0×10^{-2} cm/sec. The storage coefficient observed for this unit ranges from 10^{-2} to 10^{-6}.

2.4.2 Site-Specific Hydrogeology

2.4.2.1 Hydraulic Characteristics of Glacial Deposits

The hydraulic characteristics of the Upper Sand Aquifer, till aquitard, and Lower Sand Aquifer were evaluated by CH2M Hill during the Operable Unit I RI. This work was accomplished by using a variety of field and laboratory data including water elevation information, slug test data, lab permeabilities and pump test data. The hydrogeologic information obtained by CH2M Hill is discussed below.

The calculated mean hydraulic conductivity of the Upper Sand Aquifer as determined from slug test analysis is 1.4×10^{-4} cm/sec. This value reflects the relatively coarse sandy nature of the surficial soils.

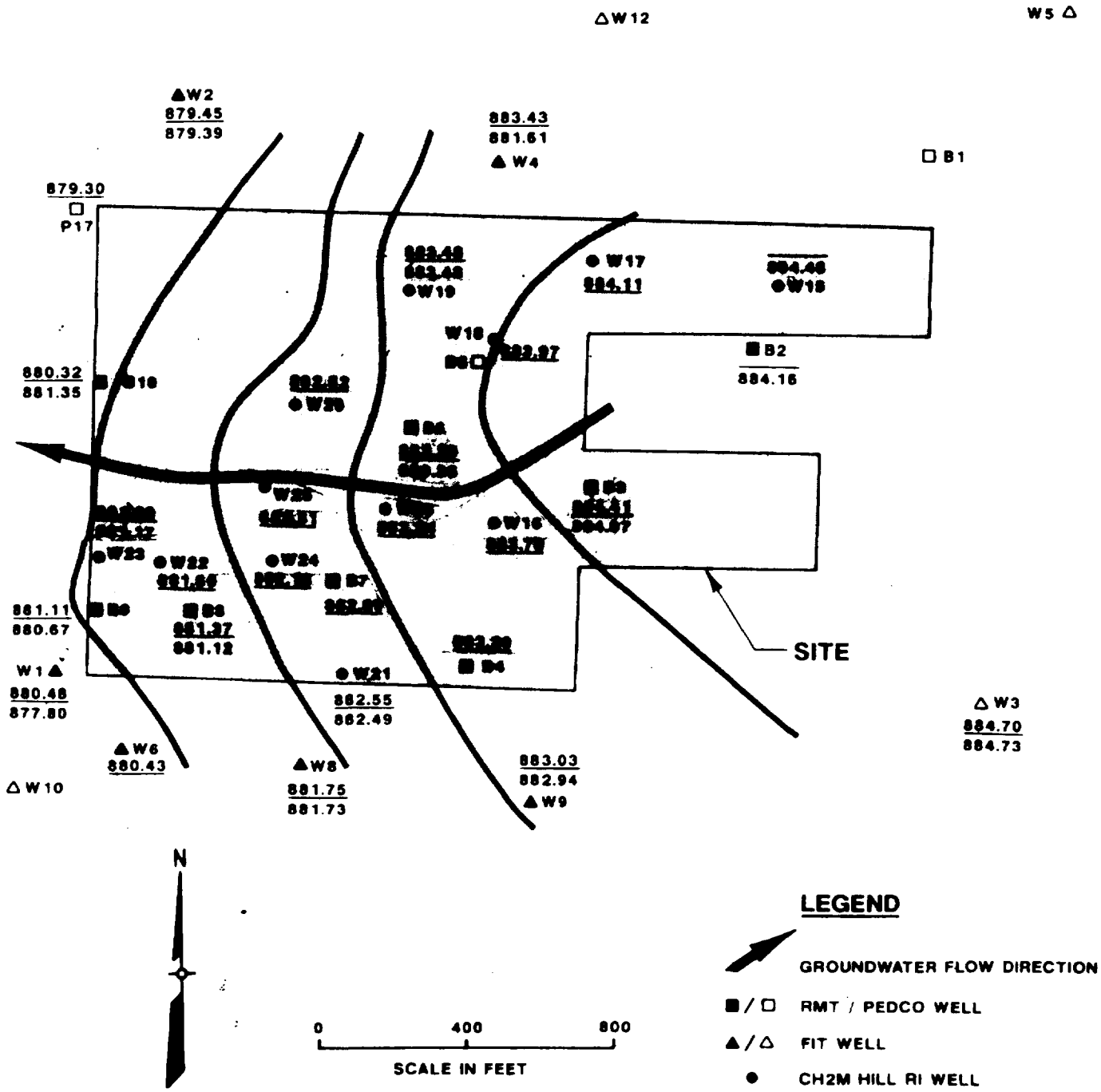
The intervening aquitard exhibits a calculated mean hydraulic conductivity of 9.2×10^{-6} cm/sec near the upper portion of the unit, decreasing to 2.3×10^{-6} cm/sec near its base. The lower hydraulic conductivity associated with the till aquitard is expected due to the composition of this unit.

A pump test was performed by CH2M Hill in the Lower Sand Aquifer to determine aquifer hydraulic conductivity and evaluate potential interconnection between aquifer units. Program results have indicated that some hydraulic interconnection exists between the lower and upper aquifer systems indicating that the Lower Sand Aquifer is semi-confined. The hydraulic conductivity of this unit is 4.6×10^{-3} cm/sec as calculated by the Hantush semi-confined method. The observed variability in grain size for this unit suggests that the hydraulic conductivity of this aquifer also varies by area.

2.4.2.2 Groundwater Flow Characteristics

Measured water table elevations range from 871 feet to 885 feet above MSL, indicating that depth to water is typically 5 to 10 feet below the ground surface at the South Andover site. The average saturated thickness reported for the Upper Sand Aquifer is 25 feet, increasing slightly to the southeast. Historic water level information reported for this aquifer by the U.S.G.S. in Anoka County indicate an annual fluctuation of 5 feet (2 feet seasonally).

The general configuration of the water table as determined by CH2M Hill is presented in Figure 2-10. Horizontal groundwater flow in the Upper Sand Aquifer flows radially from the northeast toward the west-southwest.



SOURCE: CH2M HILL, 1988

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FIGURE 2-10
WATER TABLE MAP (CH2MHILL, 1988)
SOUTH ANDOVER SUPERFUND SITE
DESIGN INVESTIGATION
ANDOVER, MINNESOTA

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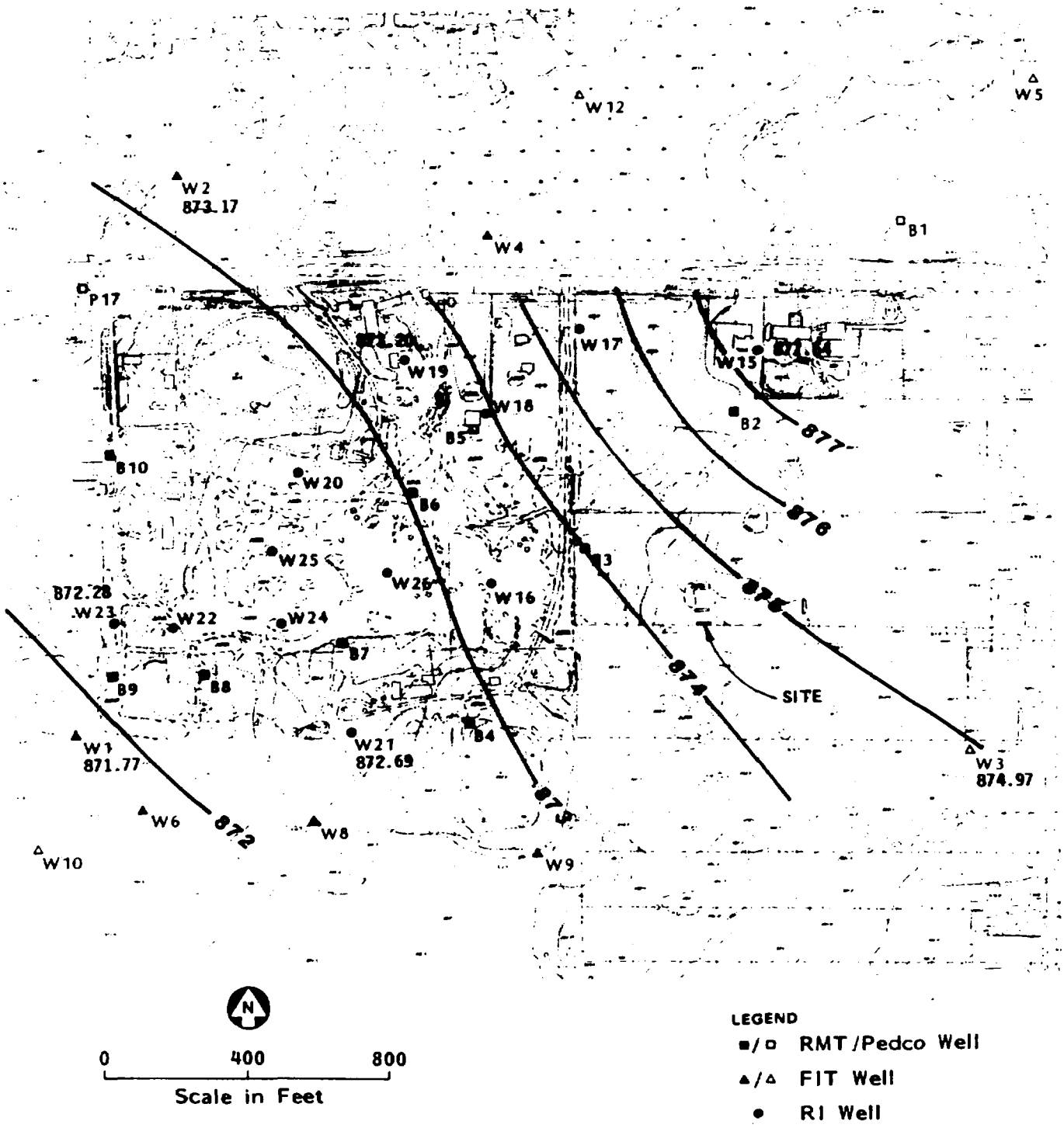

SOURCE: CH2MHILL, 1987

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FIGURE 2-11
POTENTIOMETRIC SURFACE OF LOWER SAND AQUIFIER, (CH2MHILL, 1988)
SOUTH ANDOVER SUPERFUND SITE
DESIGN INVESTIGATION
ANDOVER, MINNESOTA

JULY 1991

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Horizontal flow gradients range from 0.0024 ft/ft to 0.0052 ft/ft, with a maximum downward vertical flow gradient of 0.10 ft/ft (CH2M Hill, 1988). Calculated flow rates range from 17 ft/yr to 37 ft/yr horizontally, and 3.5 ft/yr to 230 ft/yr vertically.

Groundwater flow within the Lower Sand Aquifer is depicted on the potentiometric surface map prepared by CH2M Hill (Figure 2-11). Groundwater flow in the Lower Sand Aquifer is towards the west-southwest, with horizontal gradients ranging from 0.00076 ft/ft to 0.006 ft/ft. Gradients are steepest in the northeast and generally decrease towards the west-southwest. CH2M Hill attributed this variation to a thickening of the aquifer towards the southwest. Average horizontal groundwater flow velocities calculated for the Lower Sand Aquifer range from 16 ft/yr to 125 ft/yr. Vertical gradients and average vertical flow rates for this aquifer were not determined by CH2M Hill. Possible interaction of the Lower Sand Aquifer with the underlying bedrock aquifer was also not evaluated.

Groundwater movement through the middle aquitard is generally downward. Calculated flow velocities as reported by CH2M Hill (1988) range from 0.78 ft/yr to 2.55 ft/yr.

2.5 GROUNDWATER QUALITY

Groundwater in this region is of the calcium magnesium bicarbonate type and is generally hard to very hard. Groundwater commonly contains high levels of iron and manganese. The range of 2 major ion concentrations occurring in groundwater from the surficial aquifer is greater than in bedrock aquifers due to the heterogeneous mineralogical composition of the glacial drift. Total dissolved solids for the glacial drift aquifers ranges from 123 mg/l to 420 mg/l, with maximum iron and manganese concentrations of approximately 42 mg/l and 1.6 mg/l, respectively. Total dissolved solids for the bedrock aquifers ranges from 160 mg/l to 390 mg/l, with maximum iron and manganese concentrations of 3.8 mg/l and 0.36 mg/l, respectively (Erickson et al., 1974).

3.0 DONOHUE FIELD INVESTIGATION

3.1 GENERAL

The project tasks completed as part of the Donohue field investigation were executed in accordance with the revised Final Site Investigation Plan (April, 1990) prepared by Donohue, except for deviations necessary due to field conditions or on-site constraints. All work was performed in a manner which complied with the health and safety procedures outlined in the Site Health and Safety Plan.

Objectives of the DI field investigation program completed by Donohue were to obtain information useful for:

1. Determining the present extent and composition of groundwater contamination within the surficial aquifer (OU-1).

2. Determining the vertical and horizontal groundwater gradients as well as general groundwater flow directions in geologic units beneath the site.

3. Provide criteria for use by EPA and MPCA in determining whether it is appropriate to implement or modify the existing ROD.

The technical approach and techniques used to accomplish these objectives included the completion of soil borings and monitoring well installations; geotechnical analysis of select soil samples; hydraulic characterization at newly completed monitoring well installations; and groundwater sampling of new and select existing monitoring wells; and sampling of private water supply wells.

3.2 SOIL BORING AND GEOTECHNICAL SAMPLING

3.2.1 Soil Boring Procedure

Donohue completed the soil boring and monitoring well installation program for the South Andover DI during the months of August and September 1990. New and existing well locations are shown in Figure 3-1. Soil intrusive activities completed by Donohue included the completion of six soil borings and six wells. Soil borings were completed using both hollow stem auger and mud rotary drilling methods. Continuous soil samples were taken in each boring except at B7B-R. At B7B-R, soil samples below 15 feet were taken at 5-foot intervals due to difficulties involved in continuously sampling in flowing sands which rose several feet inside the hollow stem augers.

All borings completed for the DI were converted to groundwater monitoring wells. These wells replaced nonfunctional wells that were also abandoned during DI field activities. Information collected from borings and monitoring wells was used to evaluate (1) site geology, (2) groundwater flow directions, (3) hydraulic gradients, (4) groundwater flow velocities, and (5) groundwater chemistry.

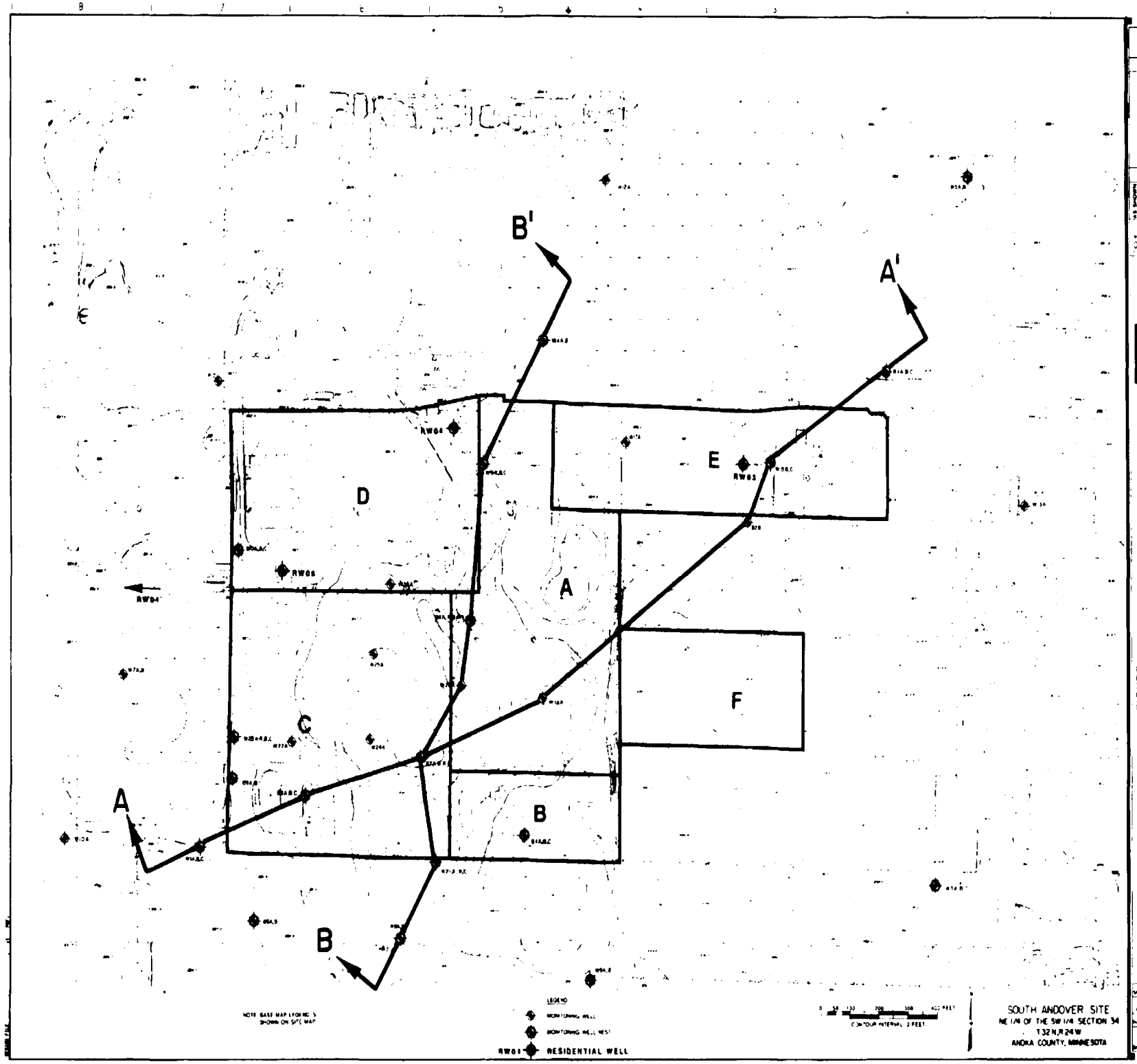

FIGURE 3-1

WELL LOCATIONS AND LOCATION OF GEOLOGIC CROSS SECTIONS
SOUTH ANDOVER SUPERFUND SITE
DESIGN INVESTIGATION
ANDOVER, MINNESOTA

JULY 1988

Soil borings were advanced through the upper sand aquifer and into the intermediate aquitard using 4-1/4 inch I.D. (6-8 inch OD) hollow stem augers. Borings extending through the intermediate aquitard were double cased. Double cased installations were completed by drilling and sampling with hollow stem augers until the intermediate sand aquifer was encountered. After withdrawing the augers the borehole was overdrilled using 12-inch air rotary methods. After overdrilling, eight-inch diameter steel casing was installed and the annular space grouted with cement-bentonite grout. Drilling and sampling was continued through the intermediate aquitard and into the lower sand aquifer using 5-7/8 inch mud rotary techniques and six inch temporary steel casing. A list of borings completed during the DI, including total depth, is included in Table 3-1. A detailed description of activities associated with soil borings completed for the DI is included in a technical memorandum prepared by the on-site Donohue hydrogeologist found in Appendix B.

All samples recovered from DI borings were field screened for volatile organic compounds using a photoionization detector (PID). The PID was slowly run up the length of the sample immediately after opening the split spoon sampler. Field screening results were recorded directly on the boring logs at the appropriate sample interval. Boring logs completed during the DI are included in Appendix C.

3.2.2 Chemical Soil Sampling

Soil samples for chemical analysis were taken from monitoring well borings completed for the DI. This information was collected to supplement the work being completed by Donohue under a separate work assignment to EPA as part of the Second Operable Unit RI/FS.

3.2.3 Geotechnical Sampling

Select samples from borings completed during the DI were submitted for geotechnical analyses including grain size, Atterberg limits and laboratory permeability testing. Samples were selected from major unconsolidated geologic units to verify field classifications and assist in geologic and hydrogeologic evaluations.

3.3 MONITORING WELL INSTALLATION

3.3.1 Monitoring Well Construction Procedures

Soil borings completed as part of the DI were used for the installation of monitoring wells. Monitoring wells installed during the DI replaced wells abandoned during the DI or to provide supplemental hydrogeologic and groundwater quality information. In addition, monitoring well information allowed hydraulic characterization of the aquifer over the screened interval to be performed. Two monitoring wells (B6A-R and W23A-R) were screened as observation wells within the Upper Sand Aquifer, two wells (B6B-R and B7B-R) were screened in the aquitard, and two double cased wells (W1C-R and B7C) were screened within the Lower Sand Aquifer.

TABLE 3-1

SOIL BORINGS
South Andover DI
1990

Boring No.	Surface Elev Ft. MSL	Total Depth (Ft.)	Soil Types Encountered*
B1C-R	887.5	92.0	SP, ML, SM
B6A-R	895.3	26.0	SP
B6B-R	895.1	54.0	SM, ML, SP
B7B-R	902.2	58.0	SM, SP, ML, GW
B7C	902.2	107.0	ML, CL, SM
B23A-R	883.3	15.0	SM, SP, SW

* Unified Soil Classifications

SP - Poorly graded sands
ML - Silt, gravelly-sandy silt
SM - Silty sands
GW - Well graded gravels and gravel sand mixtures
CL - Lean clay, gravelly-sandy lean clays
SW - Well graded sands

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Well installations were completed in accordance with Minnesota Department of Health (MDH) regulations. Completed MDH well installation forms are attached in Appendix D. All wells installed during the DI were constructed using 2-inch diameter, Schedule 5, Type 304 stainless steel riser and continuous wire wrap, 0.010 inch slot stainless steel screens. Screen lengths varied for observation wells and piezometer installations at 10 and 5 feet, respectively. Wells installed in the Lower Sand Aquifer (W1C-R and B7C) were completed in borings completed using double cased drilling methods. The eight inch outer casing seated in the Aquitard was dedicated to these well installations to minimize the potential for cross contamination between the Lower Sand Aquifer and the Upper Sand Aquifer.

Table 3-2 summarizes well construction details of monitoring wells installed during the DI. Completed well construction forms are provided in Appendix E. A detailed account of the DI monitoring well installation program and variations occurring as a result of site constraints are provided in a field technical memorandum prepared by the on-site hydrogeologist included in Appendix B.

3.3.2 Well Abandonment

Four groundwater monitoring wells installed during previous investigations were abandoned in accordance with MDH requirements during the DI. Well abandonments were completed to accommodate development in areas adjacent to the site or because well integrity had become questionable due to damage or vandalism. Two additional wells scheduled for abandonments were repaired and returned to service. Minnesota Department of Health well abandonment forms are included in Appendix F.

3.4 HYDRAULIC CHARACTERIZATION

Hydraulic characterization involved in-field hydraulic conductivity (slug) testing of all wells installed during the DI. In addition, laboratory falling head permeability tests were completed as part of the geotechnical testing program. Hydraulic characterization provided hydraulic conductivity values for select unconsolidated geologic formation at the South Andover site. Hydraulic conductivity values can be used to assess preferential groundwater flow pathways and to calculate average groundwater flow velocities.

In-field hydraulic characterization was completed following development at new well locations. In-field slug testing was completed by injecting a stainless steel "slug" into a well and monitoring the falling head as the water level within the well returned to equilibrium with the groundwater system. In addition, rising head slug tests were completed by reversing the process used for falling head tests and again monitoring the water level in the well as it approached equilibrium. Water level measurements during slug testing were made using pressure transducers recorded on a Datalogger® computerized data recorder. Slug test results were analyzed using the methods of Bower and Rice (1976) through a computer program developed at Donohue. Slug testing procedures and the methods used for data evaluation are described in Appendix G.

TABLE 3-2

WELL CONSTRUCTION DETAILS
South Andover DI
1991

Well No.	Ground Elevation (Ft MSL)	Top of Riser Elevation (Ft MSL)	Total Boring Depth (Ft)	Screen Length (Ft)	Depth of Screened Interval (Ft)	Depth to Bottom of Seal (Ft)
W1C-R	NA	NA	94.0	5.0	88.3-92.3	85.0
B6A-R	895.3	897.05	22.0	10.0	12.0-22.0	10.0
B6B-R	895.1	897.44	52.0	5.0	45.0-50.0	43.1
B7B-R	902.2	904.64	55.0	5.0	50.0-55.0	48.7
B7C	902.2	904.67	111.0	5.0	100.5-105.5	98.5
W23A-R	883.3	885.21	15.0	10.0	5.0-15.0	3.0

NA: Not available.

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3.5 GROUNDWATER AND RESIDENTIAL WELL SAMPLING

To assess current groundwater quality at the South Andover site and the extent of potential impacts, 22 groundwater monitoring wells and 4 residential water supply wells were sampled. All samples from groundwater monitoring wells were analyzed for Target Compound List (TCL) Volatile Organic Analytes (VOA), TCL Base Neutral Analytes (BNA), and TAL inorganics, and three samples were analyzed for TCL PCBs and pesticides.

In addition to the analyses discussed above, all samples recovered from monitoring wells were analyzed for Chemical Oxygen Demand (COD), Total Phosphorous (TP), Total Suspended Solids (TSS), and Total Solids (TS) to provide information useful for the selection of discharge options and design of a remediation system if determined necessary. The organic loading factor, as well as the solids and phosphorous content were also determined.

All water samples taken from residential wells were analyzed for volatiles, BNAs, metals and cyanide. In addition, the sample recovered from one well was analyzed for PCBs and pesticides. These analyses were completed to characterize current groundwater quality and assist in the design of an extraction system.

A field memorandum discussing the details of the groundwater sampling program is given in Appendix H. Table 3-3 shows in which formation the sampling wells are screened.

TABLE 3-3

SAMPLING WELL DETAILS
South Andover DI

Well No.	Ground Elevation (Ft MSL)	Groundwater Elevation on 12/90 (Ft MSL)	Screened Formation	Comments
W1A	889.0	877.24	Upper Sand Aquifer	Water Table Observation Well
B6A-R	895.3	879.76	Upper Sand Aquifer	Water Table Observation Well
W9A	889.6	878.55	Upper Sand Aquifer	Water Table Observation Well
W16A	900.1	880.85*	Upper Sand Aquifer	Water Table Observation Well
W17A	885.6	879.98	Upper Sand Aquifer	Water Table Observation Well
W19A	891.9	879.62	Upper Sand Aquifer	Water Table Observation Well
W21A	896.9	879.01	Upper Sand Aquifer	Water Table Observation Well
W23AR	883.3	---	Upper Sand Aquifer	Water Table Observation Well
W26A	888.0	880.46*	Upper Sand Aquifer	Water Table Observation Well
B7A	902.1	879.17	Upper Sand Aquifer	Water Table Observation Well
B8A	882.4	877.87	Upper Sand Aquifer	Water Table Observation Well
W1B	888.61	875.32	Upper Sand Aquifer	Bottom of Upper Sand Aquifer Well
W15B	889.6	880.18	Upper Sand Aquifer	Bottom of Upper Sand Aquifer Well
W21B	896.9	879.51	Upper Sand Aquifer	Bottom of Upper Sand Aquifer Well
W23B	883.1	877.67	Upper Sand Aquifer	Bottom of Upper Sand Aquifer Well
B6B-R	895.1	880.26*	Aquitard	Subunit 2 of Aquitard
B7B-R	902.2	879.57	Aquitard	Subunit 2 of Aquitard
W1C-R	887.5	869.20*	Lower Sand Aquifer	Top of Lower Sand Aquifer Well
W21C	896.9	869.72	Lower Sand Aquifer	Top of Lower Sand Aquifer Well
W23C	883.3	869.44	Lower Sand Aquifer	Top of Lower Sand Aquifer Well
B4C	884.2	869.01	Lower Sand Aquifer	Top of Lower Sand Aquifer Well
B7C	902.2	869.85*	Lower Sand Aquifer	Top of Lower Sand Aquifer Well
RW1	881	866*	Lower Sand Aquifer**	Screen Setting 92 - 98 ft.
RW3	890	875*	Bedrock**	Well Depth 139 ft.
RW4	885	---	Aquitard**	Well Depth Approx. 35 ft.
RW6	886	880*	Upper Sand Aquifer**	Well Depth 14 ft.

* Denotes reading date other than 12/90.
** Estimated based on well depths.

RP/SANDOVER/AZ4

4.0 INVESTIGATIVE RESULTS

4.1 SITE GEOLOGY

Six soil borings completed during the DI encountered three unconsolidated units. Soil boring depths are summarized in Table 4-1. Unconsolidated units beneath the South Andover site consist of: (1) an upper sand unit; (2) an intermediate lacustrine silt and till unit; and (3) a lower sand unit. Site stratigraphy is depicted in the site stratigraphic column shown in Figure 4-1.

The information collected during the DI boring program more clearly defined the lithology of the lacustrine aquitard. While unconsolidated units may occur below the lower sand unit, the borings completed for the DI were not extended to a sufficient depth to investigate this possibility.

The location of geologic cross-sections completed for the DI are shown in Figure 3-1. Cross-sections (Figures 4-2 and 4-3) were completed using information obtained during the DI and earlier investigations. Detailed discussion of site geology, and a comparison of the results of the Design Investigation with previous interpretations is given in the technical memorandum included in Appendix I. General site geology is discussed below.

Upper Sand Unit

The Upper Sand Unit consists of medium-grained sand with occasional lenses of fine silty sand. The unit ranges from 25- to 37-foot thick in borings completed for the DI. In general, a 0-3.5-foot thick layer of silty sand topsoil is present at the surface of the upper sand aquifer. Sands within the upper sand unit were deposited as glacial outwash or wind blown deposits.

The thickness of the Upper Sand Unit as determined during the DI generally agrees with the thickness previously reported. However, the maximum thickness of the Upper Sand Unit is less than the maximum thickness previously reported. In addition, surficial silty sand deposits were encountered during the DI at depths greater than previously reported.

Lacustrine Aquitard

The lacustrine Aquitard is composed of three units: (1) a discontinuous silt layer which includes lenses of glacial till and sandy till; (2) a discontinuous glacio-lacustrine silty sand; and (3) a continuous silt and clay unit (Figure 4-1). While all three subunits are interpreted to represent glacio-lacustrine origin, these subunits differ in their lithologic and hydraulic properties. The total thickness of the Aquitard, as determined during the DI, ranged from 47.5 feet at the southwestern corner of the site (W1C-R) to 65.0 feet in the south central portion of the site (B7C).

TABLE 4-1

GEOTECHNICAL ANALYSIS RESULTS
South Andover DI
1990

Boring No.	Sample Depth (ft)	Gravel % Retained on a #4 Sieve	Sand % Passing #4 but Retained on a #200	Silt and Clay % Passing #200	USCS Classification*	Liquid Limit	Plasticity Index	Conductivity (cm/sec)
W1C-R	20.0 - 22.0	0	97	3	SP	NP	NP	-
W1C-R	64.0 - 66.0	0	0.1	99	ML	26	0	2.0E-06
W1C-R	40.0 - 42.0	0	5.3	94.7	ML	NP	NP	-
W1C-R	52.0 - 53.0	0	3.1	96.9	ML	NP	NP	-
W1C-R	63.0 - 64.0	0	1.8	98.2	ML	NP	NP	-
B6A-R	13.0 - 14.0	0	98.6	1.4	SP	NP	NP	-
B7B-R	24.0 - 25.0	0.3	96.5	3.2	SP	NP	NP	-
B7C	64.0 - 65.0	1.6	44.5	53.9	ML	NP	NP	-
B7C	89.0 - 91.0	0	0	100	ML	24	1	9.5E-07
B7C	100.0 - 101.0	6.1	54.9	39	SM	NP	NP	-
W23A-R	12.0 - 14.0	1.3	96.4	2.3	SP	NP	NP	-

NP: Non-plastic.

* SP - Poorly graded sands
ML - Silt, gravelly-sandy silt
SM - Silty sands

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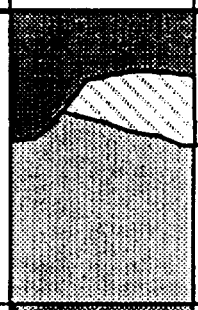
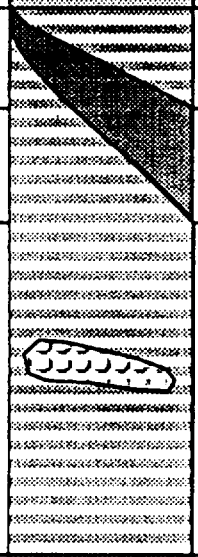
GEOLOGIC SYSTEM	GEO-LOGIC UNIT	GRAPHIC LOG	PHYSICAL DESCRIPTION	ORIGIN	HYDRO-STRATIGRAPHIC UNIT	
HOLOCENE	SAND		0–3.5′ SILTY FINE SAND, FILL MATERIAL, OR ORGANIC SOIL	SOIL OR FILL	UPPER SAND AQUIFER	
QUARTERNARY			23–40.5′ BROWN TO GRAY, FINE SAND	AEOLIAN OR OUTWASH SANDS		
	SILT		0–10.5′ GRAY LAMINATED SILT	GLACIO-LACUSTRINE	SUBUNIT 1	AQUITARD
	SILTY SAND & SAND		0–13.5′ GRAY LAMINATED SILTY SAND & SAND	GLACIO-LACUSTRINE	SUBUNIT 2	
	SILT AND CLAY		33–45′ LAMINATED SILTS AND CLAY	GLACIO-LACUSTRINE	SUBUNIT 3	
	SILTY SAND		7′+ GRAY SILTY SAND	OUTWASH SANDS	LOWER SAND AQUIFER	

NOTE: Stratigraphy reflects information collected during the Design Investigation

20022

FIGURE 4–1

SITE HYDROSTRATIGRAPHIC COLUMN

SOUTH ANDOVER SUPERFUND SITE
DESIGN INVESTIGATION
ANDOVER, MINNESOTA

Donohue ENGINEERS ARCHITECTS SCIENTISTS

July 1991

M :DI SITE HYDRO

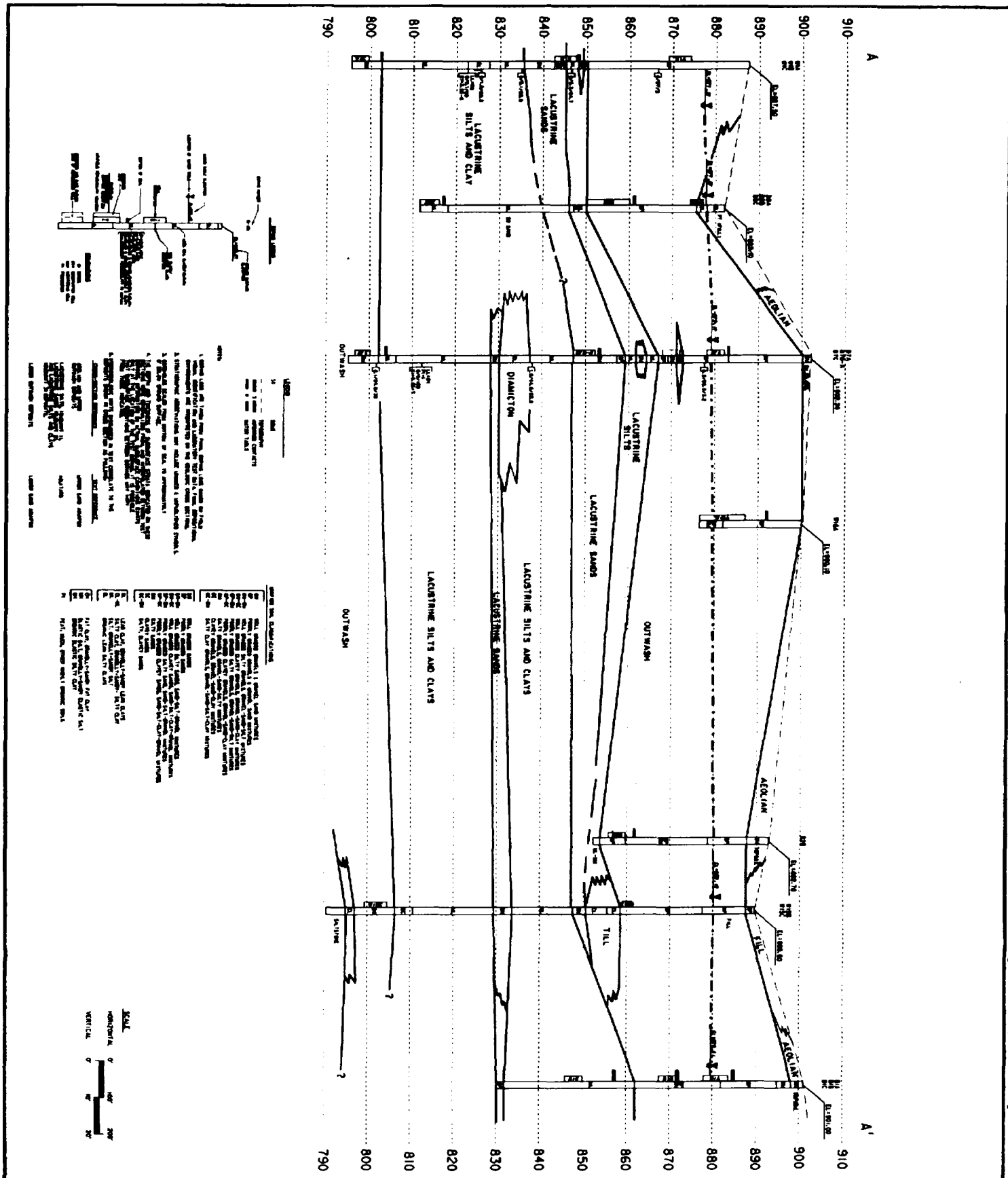


FIGURE 4-2
GEOLOGIC CROSS SECTION A-A'
SOUTH ANDOVER SUPERFUND SITE
DESIGN INVESTIGATION
ANDOVER, MINNESOTA

Dornbush ENGINEERS ARCHITECTS SCIENTISTS

Scale	AS SHOWN
Date	JULY 1991
Designer	RBC
Drafter	DLJ
Checker	JEU
Approver	

No.	Revisions	By	Date

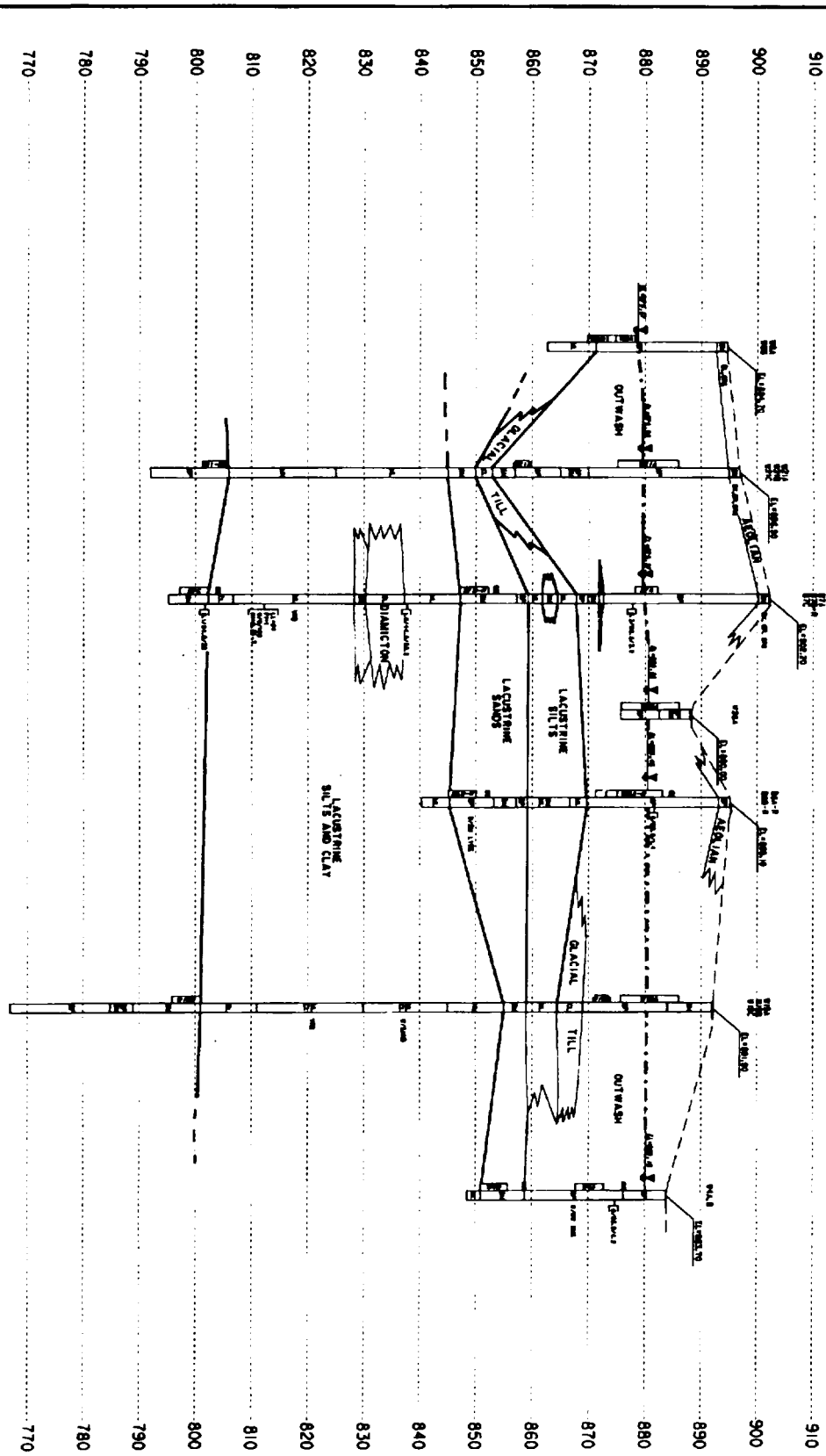


FIGURE 4-3
GEOLOGIC CROSS SECTION B-B'
SOUTH ANDOVER SUPERFUND SITE
DESIGN INVESTIGATION
ANDOVER, MINNESOTA

Dornbush ENGINEERS ARCHITECTS SCIENTISTS

Scale	AS SHOWN				
Date	JULY 1991				
Designer	RBC				
Drafter	DLJ				
Checker	JEU				
Approver		No.	Revisions	By	Date

Subunit 1

The uppermost Aquitard subunit (subunit 1) ranges in thickness from 5.0 to 10.5 feet in borings advanced during the DI. In general, subunit 1 is composed of laminated gray silts suggestive of deposition in a fairly low energy lacustrine environment. At well nests W1 and B7, subunit 1 is interbedded with a 1.5-foot thick layer of sand and silty sand possibly due to an increase in the energy of the glacio-lacustrine depositional environment. Lenses of glacial till found with or directly above subunit 1 at W15, W19, and W21 may be remnants of the Grantsburg Till. Ice rafting may be one possible mechanism explaining the presence of the till deposition in a predominantly glacio-lacustrine depositional environment.

Subunit 1 was previously reported by CH2M Hill (1988) as discontinuous and comprised exclusively of Grantsburg Till. Results of the DI have shown that subunit 1, comprised of both glacio-lacustrine and till deposits, is more extensive than previously reported. Reinterpretation of site geology has resulted in increasing the thickness of subunit 1 from that previously reported, resulting a corresponding decrease in the thickness of the underlying units.

Subunit 2

Changes in lithology and hydraulic properties have been used to differentiate subunit 2 from the other subunits comprising the aquitard. Silty sand and sand previously included within subunit 1 have been reassigned to subunit 2. Stratification within subunit 2 suggests glacio-lacustrine or glacio-fluvial origin.

Subunit 2 was previously reported (CH2M Hill 1988) as a discontinuous silty sand and sand layer. However, subunit 2 was encountered in all DI borings extending through the Aquitard. The thickness of subunit 2 at DI boring locations ranged from 9.5 feet (W1C-R) to 13.5 feet (B6B-R). Wells B6B-R and B7B-R installed during the DI are screened within subunit 2.

Subunit 3

The thickest subunit of the Aquitard, subunit 3, is composed of gray silt and clay. Fine grained materials in this subunit are both laminated and unlaminated but are generally of lacustrine origin. The thickness of subunit 3 encountered in DI borings W1C-R and W7C, which fully penetrate the Aquitard, range from 33 feet and 45 feet, respectively.

A seven-foot thick lens of dark gray silty clay till underlain by a 1 foot thick lens of dark gray brown silty sand was encountered in DI boring B7C. This unit is discontinuous with its extent and origin not currently known.

Lower Sand Unit

The lithology of the Lower Sand Aquifer is similar to that previously reported, consisting of dark gray-brown to brown silty sand. This unit was encountered at the southwest corner of the site (W1C-R) and near the south-central portion of the site (B7C) at depths of 86 and 100 feet, respectively. Since borings completed during the DI did not penetrate the lower sand unit, its thickness was not defined. The minimum thickness of the lower sand unit defined by DI borings is seven feet.

4.2 SITE HYDROGEOLOGY

General

Previous investigations of the South Andover site determined that three hydrogeologic units exist beneath the site. CH2M Hill (1988) defined these units as the (1) Upper Sand Aquifer; (2) the Middle Aquitard; and (3) Lower Sand Aquifer. Design Investigation results confirmed the presence of these hydrogeologic units. As discussed above, DI hydraulic characterization information has three hydrogeologic subunits comprising the Aquitard. Therefore, the five hydrostratigraphic units addressed during this hydrogeologic evaluation include the (1) Upper Sand Aquifer; (2) Aquitard - subunit 1; (3) Aquitard - subunit 2; (4) Aquitard - subunit 3; and (5) Lower Sand Aquifer. A detailed discussion of site hydrogeology is presented in a technical memo attached in Appendix J. Key points resulting from the hydrogeologic evaluation are summarized below.

Upper Sand Aquifer

Water elevation information for wells completed in the Upper Sand Aquifer was plotted and contoured to produce the water table contour map shown in Figure 4-4. Water table contours show horizontal groundwater in the Upper Sand Aquifer to flow from the northeast to the west-southwest. Horizontal gradients within the unit range from 0.003 ft/ft to 0.0006 ft/ft with an average gradient of 0.0018 ft/ft. Horizontal groundwater flow velocities calculated for the Upper Sand Aquifer range from 15 ft/yr to 76 ft/yr.

The vertical component of groundwater flow in the Upper Sand Aquifer was evaluated by comparing water elevation data from wells screened at the water table and the bottom of the Upper Sand Aquifer. Vertical gradients calculated between wells at the top and bottom of the Upper Sand Aquifer suggest that both upward and downward vertical groundwater flow is occurring in the Upper Sand Aquifer. The average downward vertical gradient in the Upper Sand Aquifer is 0.040 ft/ft. Comparison of measured horizontal and vertical gradients indicates that the vertical movement of groundwater is dominant.

Following the methods used by CH2M Hill (1988) average vertical flow velocity was calculated under anisotropic conditions where $K_{horizontal}/K_{vertical} = 3$. Vertical flow velocities calculated for the Upper Sand Aquifer ranged from 25 ft/yr to 714 ft/yr.

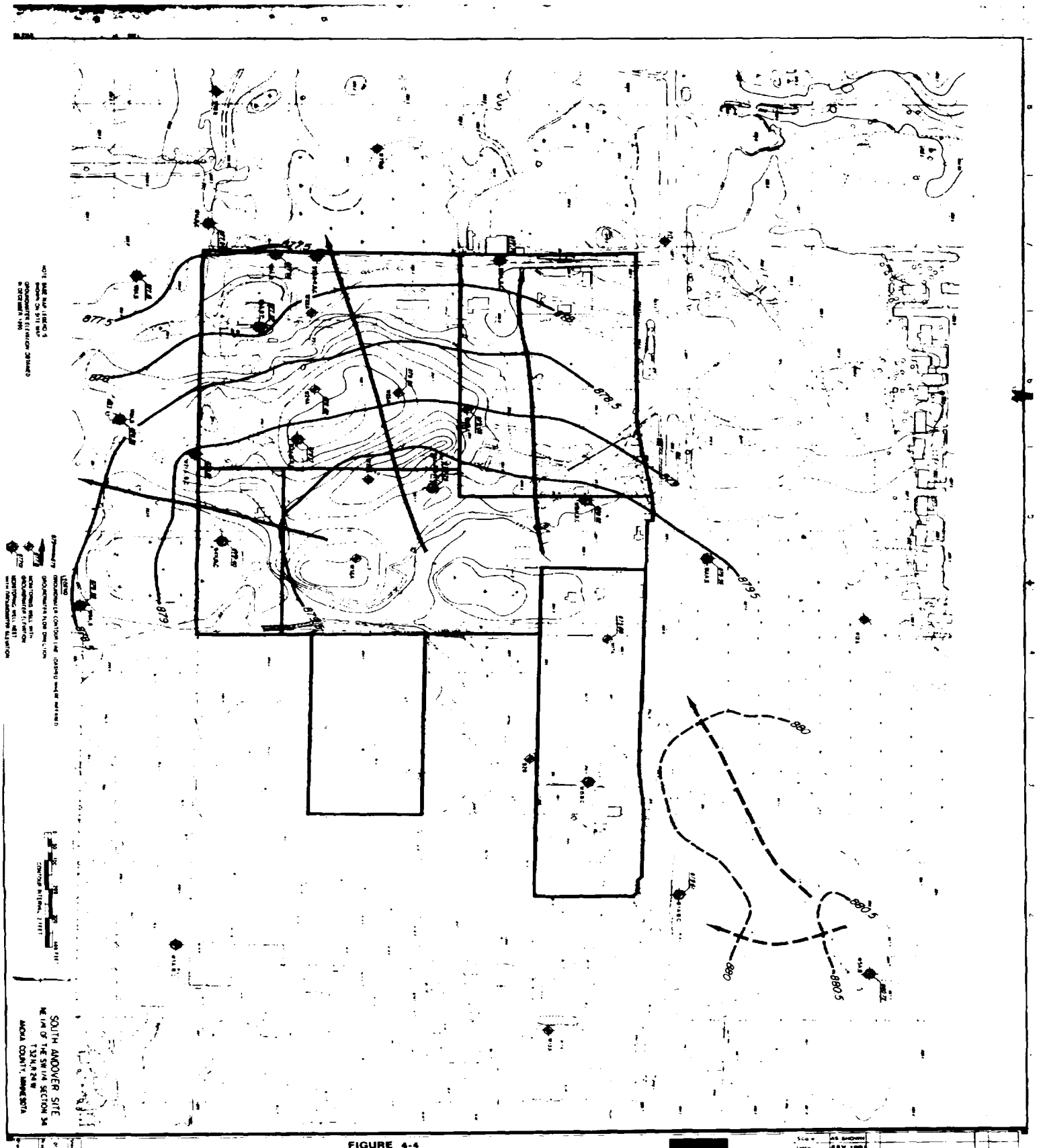


FIGURE 4-4
WATER TABLE MAP
SOUTH ANDOVER SUPERFUND SITE
DESIGN INVESTIGATION
ANDOVER, MINNESOTA

Dames & Moore
ENGINEERS
ARCHITECTS
SCIENTISTS

Scale	AS SHOWN
Date	JULY 1993
Designer	RC
Drafter	LCB
Checker	RC
Approver	DV

No.	Revisions	By	Date

Aquitard - Subunit 1

No groundwater monitoring wells at the South Andover site are screened in subunit 1 of the Aquitard. In addition, no geotechnical sampling was performed in this unit to allow for laboratory permeability testing. While the absence of well and laboratory data preclude the calculation of hydraulic gradients and average groundwater flow velocities, the lithologic similarities between subunit 1 and subunit 3 suggests the hydraulic conductivity for subunit 1 is on the order of 1×10^{-5} cm/sec. Furthermore, the presence of interlayered sand units may increase the hydraulic conductivity and groundwater flow velocities associated with subunit 1.

Aquitard - Subunit 2

Two wells installed during the DI are screened within subunit 2 of the Aquitard. Groundwater flow directions can not be determined based on two sampling points. In addition, the absence of more wells distributed vertically and horizontally throughout the unit prevents calculation of vertical and horizontal hydraulic gradients. The presence of wells in subunit 2, however, did permit the determination of hydraulic conductivity. The logarithmic mean hydraulic conductivity of subunit 2 is 2.4×10^{-5} cm/sec. The inability to determine hydraulic gradients in subunit 2 prevents calculation of average groundwater flow velocities.

Aquitard - Subunit 3

Since no existing or recently installed wells are known to be screened in subunit 3, the horizontal groundwater flow direction and horizontal hydraulic gradient within the unit was not determined. The mean vertical hydraulic conductivity determined through laboratory falling head permeability analyses of two samples taken in subunit 3 is 1.4×10^{-6} cm/sec. An average vertical hydraulic gradient for subunit 3 could only be calculated at one well location (B7). The vertical hydraulic gradient at this location of 0.19 ft/ft.

The average vertical flow velocity for subunit 3 calculated using data obtained during the DI field program is 0.7 ft/yr. Vertical flow is expected to dominate in a low hydraulic conductivity layer (aquitard) located between two higher hydraulic conductivity units (Upper Sand Aquifer and Lower Sand Aquifer).

Lower Sand Aquifer

The Lower Sand Aquifer was the deepest hydrostratigraphic unit encountered during the DI field program. Water levels of wells screened in the Lower Sand Aquifer were plotted and contoured to produce the potentiometric surface map shown as Figure 4-5.

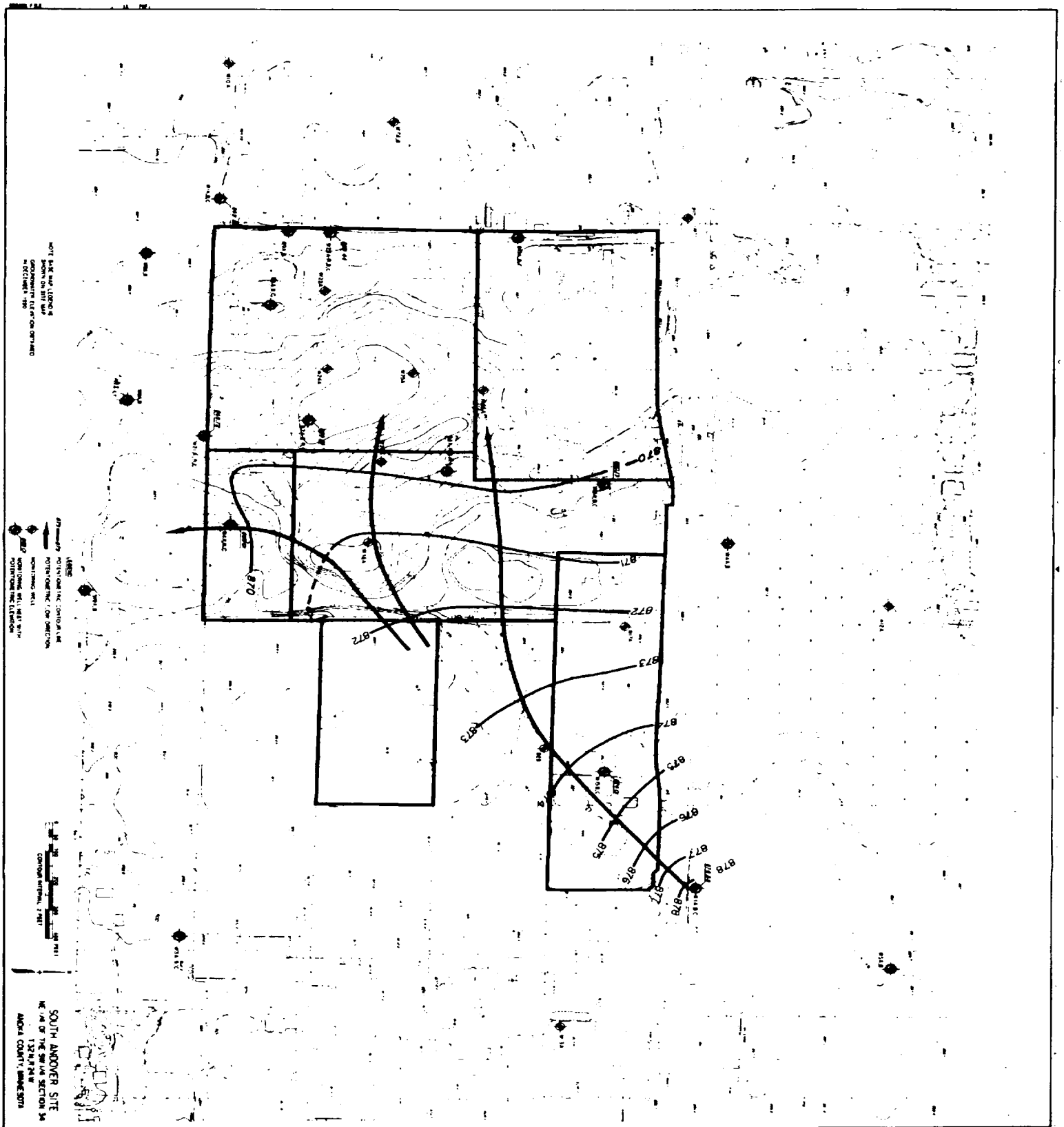


FIGURE 4-5
POTENTIOMETRIC SURFACE MAP
SOUTH ANDOVER SUPERFUND SITE
DESIGN INVESTIGATION
ANDOVER, MINNESOTA

Dames & Moore ENGINEERS ARCHITECTS SCIENTISTS

Scale	AS SHOWN
Date	JULY 1986
Drawn by	RC
Checked by	CCM
Approved by	RC
Approved by	DR

Horizontal groundwater flow within this aquifer is from northeast to west-southwest. Horizontal hydraulic gradients for the aquifer range from 0.002 ft/ft to 0.009 ft/ft, with an average of 0.0055 ft/ft. Hydraulic characterization during this investigation has determined a mean hydraulic conductivity of 7.6×10^{-4} cm/sec for the Lower Sand Aquifer with an average horizontal groundwater flow velocity estimated at 17 ft/yr. Wells screened at the top and bottom of the Lower Sand Aquifer do not exist, and therefore calculation of vertical groundwater gradients and flow velocities was not performed.

4.3 GEOTECHNICAL TESTING

Grain size analyses, Atterberg limits and laboratory falling head permeability tests were conducted on select samples recovered from DI borings. Table 4-1 summarizes the results of geotechnical testing performed. Final geotechnical laboratory reports are included in Appendix K.

Classification of soil types made visually while in the field are supported by grain size analyses. Samples within the upper sand unit are consistently comprised of poorly graded sands (SP) with little or no fines.

Grain size and Atterberg limit analyses within the till aquitard were conducted on samples recovered from subunits 1 and 3. Grain size analyses and Atterberg limit test results show these subunits are composed of nonplastic silts (ML). Laboratory vertical hydraulic conductivities performed on two samples from subunit 3 range from 2.0×10^{-6} cm/sec to 9.5×10^{-7} cm/sec.

Grain size analysis completed on one sample from the Lower Sand Aquifer shows this unit is comprised of silty sand (SM).

4.4 CHEMICAL SAMPLING RESULTS

Analytical results for soil and groundwater samples collected from the South Andover site during this investigation and the concurrent RI/FS (OU-2) are compared to those reported previously by CH2M Hill (1988) in Appendix L of this report. Technical Memorandum 10 of the RI report (Donohue 1991) presents and discusses the chemical results for all media samples during the CH2M Hill and Donohue investigations. A discussion of chemical sampling results for soil and groundwater samples collected during the DI follows.

4.4.1 Soil

A summary of organic compounds detected in DI soil boring samples is presented in Table 4-2. Sample W23A-R (6-8-foot depth) contained the highest frequency and concentration of volatile organic compounds (VOCs). This sample contained methylene chloride (13,000 ppb), acetone (3,200 ppb), and 4-methyl-2-pentanone (5,100 ppb). No VOCs, however, were detected at other sampling intervals at the same location. Acetone was also detected at relatively high levels at B6AR (24-24 feet) (530 ppb) and W1C-R (0-2 feet) (2,000 ppb). Low levels of

TABLE 4-2

SUMMARY OF DETECTED ORGANIC COMPOUNDS
SOIL BORING SAMPLES
South Andover DI
1990

Units: ppb

Sample Location:	Naturally Occurring Concentrations[a]	B6AR			B6BR	B7B				W1CR			W23AR
Sample Depth (ft):		0-2	10-12	24-26	50-52	0-2	34-36	44-46	54-56	0-2	44-45.5	88-89	6-8
Volatile Organic Compounds													
Methylene Chloride	--	--	--	--	--	--	--	--	--	--	9B	--	--
Acetone	--	--	--	530JE	--	--	12J	--	--	2000E	--	97J	13000JB
4-Methyl-2-pentanone	--	--	--	--	--	--	--	--	--	--	--	--	3200J
2-Hexanone	--	--	--	--	--	--	--	--	--	--	--	--	5100J
Toluene	1,000-5,000	2J	--	--	1J	4J	14	6J, 2J (dup)	--	2J	--	--	--
Xylenes (total)	3,000-15,000	10	--	--	--	--	--	--	--	--	--	--	--
Semi-Volatile Organic Compounds													
Benzoic Acid	140-11,000	10,000J	--	--	--	--	--	--	--	--	--	--	--
Naphthalene	1,000-5,000	740J	--	89J	--	--	--	--	--	--	--	--	--
2-Methylnaphthalene	--	1400J	--	--	--	--	--	--	--	--	--	--	--
Acenaphthylene	--	330J	--	--	--	--	--	--	--	--	--	--	--
Acenaphthene	--	1800J	--	--	--	--	--	--	--	--	--	--	--
Diethylphthalate	--	--	55J	86J	--	--	--	--	--	--	--	--	--
Fluorene	--	1200J	--	--	--	--	--	--	--	--	--	--	--
Phenanthrene		3200											
Anthracene	--	900J	--	--	--	--	--	--	--	--	--	--	--
Fluoranthene	0-40	1000J	--	--	--	--	--	--	--	--	--	--	--
Pyrene	0-15	1600J	--	--	--	--	--	--	--	--	--	--	--
Butylbenzylphthalate	--	--	--	55J	--	--	--	--	--	--	--	--	--
Benzo(a)anthracene	0-10	530J	--	--	--	--	--	--	--	--	--	--	--
Chrysene	5,000	670J	--	--	--	--	--	--	--	--	--	--	--
bis(2-Ethylhexyl)phthalate	--	590J	250J	310J	690	--	210J	--	160J	120J	180J	--	--
Benzo(b)fluoranthene	0-30	550J	--	--	--	--	--	--	--	--	--	--	--
Benzo(k)fluoranthene	0-15	340JX	--	--	--	--	--	--	--	--	--	--	--
Benzo(a)pyrene	0-8,000	530J	--	--	--	--	--	--	--	--	--	--	--
4,4'-DDT	--	20	--	--	--	--	--	--	--	--	--	--	--

[a] Dragun, 1988.
J Estimated value due to minor QC deviations.
E Value exceeds linear range of calibration curve.
- Not detected.
x Chemical coelulted with another compound.

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VOCs were detected in six other samples, while no VOCs were detected in four samples. The occurrences of methylene chloride may be field or lab induced contamination and may not be indicative of site contamination. No VOCs exceeded typical concentration ranges for naturally occurring compounds in soil (Dragun, 1988).

The highest frequency and concentrations of semi-volatile organic compounds (SVOCs) were detected at B6A-R (0-2 feet). The majority of SVOCs detected at this location are polyaromatic hydrocarbons (PAHs). Soil at this location (0-2 feet) also contained benzoic acid (10,000 ppb), fluorene (1,200 ppb), fluoranthene (1,000 ppb), bis(2-ethylhexyl)phthalate (590 ppb) and 4,4'-DDT (20 ppb). Naphthalene, diethylphthalate, and butyl benzyl phthalate were detected in B6A-R at the deeper depth intervals. The concentrations detected in B6A-R for benzoic acid, naphthalene, chrysene, and benzo[a]pyrene do not exceed levels found in natural soils. Bis(2-ethylhexyl)phthalate was also detected in seven other boring samples.

A summary of inorganic compounds detected in DI soil samples is presented in Table 4-3. Antimony was not detected. Arsenic was detected in all but one DI soil boring, but was not above average U.S. soil concentration at any location (New Lyme RI/FS, CH2M Hill, 1985). Cadmium was detected in three samples at levels slightly above U.S. average concentrations. Selenium was detected only at W23A-R (6-8 feet below average U.S. soil concentrations). Cyanide was detected at one location (W23A-R) at two depth intervals. Zinc was detected at elevated levels in three samples taken at two locations (B6A-R and W23A-R).

Overall, impacts to soil samples collected during this investigation by organic and inorganic compounds appears limited to B6A-R and W23A-R. These occurrences are restricted to the central and southwestern areas of the South Andover site. These results are consistent with the "hot-spot" type of contaminant distribution found during the OU-2 RI.

The combined soils data from both DI and RI field activities are summarized in Section 2.2.5 and discussed in further detail in Chapter 4 of the Final Second Operable Unit RI Report (Donohue 1991).

4.4.2 Groundwater

Summaries of organic compounds detected in groundwater during the 1990 sampling event are presented in Tables 4-4, 4-5, 4-6, and 4-7. This data indicates that both the Upper and Lower Sand Aquifers are locally impacted by low levels of organics. Samples from well clusters W21 and W23, which are both located southwest or downgradient of the site, contained the highest frequency and concentration of volatile organic compounds (VOCs). Two other wells, W19A and B7C, contained detectable levels of acetone. However, since none of the detected concentrations exceed regulatory levels (MCL or RAL), no significant risks are indicated. VOC contamination is not evident at any of the remaining well locations.

TABLE 4-3

SUMMARY OF DETECTED INORGANIC COMPOUNDS
SOIL BORING SAMPLES
South Andover DI
1990

Units: ppm

Sample Location:		B6AR			B6BR	B7B					W1CR			W23AR			
Sample Depth (ft):	Average U.S. Soil Concentration*	0-2	10-12	24-26	50-52	0-2	34-36	44-46	44-46 (Duplicate)	54-56	0-2	44-45.5	88-89	0-2	0-2 (Duplicate)	6-8	12-14
Aluminum	71,000	3020J	1290J	988J	4960J	4380	3020	1900	2310	4160	2780J	1640	6060	4050J	4020J	4290J	1380J
Arsenic	10	1.70B	0.77B	0.82B	1.30B	1.80B	1.40B	0.96B	1.90B	1.40JB	2.20J	0.54B	0.47JB	0.87JB	0.70JB	1.20JB	--
Barium	430	36.80JB	13.00JB	16.50JB	31.70JB	32.90B	30.10B	16.60B	19.30B	30.30B	25.50JB	8.70B	23.60JB	35.60JB	38.20JB	32.30JB	9.40JB
Beryllium	6	0.25B	--	--	0.28B	0.28JB	0.30JB	--	--	--	0.23B	--	0.43JB	--	0.28B	--	--
Cadmium	0.06	1.00	--	--	--	--	--	--	--	--	--	--	--	1.00B	0.83B	--	--
Calcium	--	1180	379B	1440	14000	670B	26000	20200	22400	13600	681B	4940	9170	3360J	3940J	4530J	5750J
Chromium	--	5.70	3.30J	5.30	9.20	4.70	7.80	4.80	6.40	8.40	3.90J	5.50	16.60	20.30	18.10	9.80	5.50
Cobalt	8	5.10B	2.50JB	2.00JB	5.50B	2.90B	4.90B	3.30	--	6.10B	2.10JB	3.30B	7.70B	3.40B	3.60B	2.00B	2.80B
Copper	30	9.00	3.10B	3.20B	16.70	5.90J	3.10JB	2.80JB	2.70JB	9.90J	4.50B	5.80JB	14.80	20.00	19.80	9.40	4.40B
Iron	--	5950J	3180J	2060J	9300J	5410	5860	4610	5410	8890	3890J	3370	12100J	5850J	6190J	2670J	3020J
Lead	10	69.80	1.40	1.80	2.40	5.00J	2.50J	1.60J	1.80J	1.70J	3.90	0.68JB	1.80J	84.50	113	4.10JB	6.00
Magnesium	--	784B	494B	773	6090	729B	9330	5840	6470	5070	601B	1420	5500	999B	966B	1100B	2060
Manganese	600	177J	142J	33.30J	210J	208	206	157	166	200	169J	51.10	192	143J	154J	28.40J	35.20J
Mercury	0.03	--	0.09	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Nickel	100	6.00B	3.40B	4.20B	11.60	--	10.30	8.30B	--	10.80	3.20B	--	20.80	6.30B	5.80B	5.60B	3.80B
Potassium	--	196B	146B	138B	487B	--	475B	253B	351B	310B	151B	--	431JB	328JB	366JB	298JB	249JB
Selenium	0.50	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1.60JB	--
Sodium	--	66.40JB	47.10JB	84.60B	326B	--	91B	84.30B	149B	228B	41.80JB	124B	1040JB	1010JB	1010JB	1650J	1120JB
Vanadium	100	9.20B	4.90B	8.20B	21.30	10.00B	11.80	9.60B	10.10B	23.70	6.50B	9.00B	26.80	12.30	10.90	18.40	7.50B
Zinc	50	797	8.90J	9.60J	19.90	16.70	19.80	12.40	16.50	19.10	13.10J	8.30	22.50	105	116	13.90	10.90
Cyanide	--	--	--	--	--	--	--	--	--	--	--	--	--	0.55JB	1.55J	--	--

* New Lyme Landfill RI/FS, CH_2MHill, 1985.
J Estimated value due to minor QC deviations.
B Value above instrument detection limit but below contract required detection limit.

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TABLE 4-4

SUMMARY OF DETECTED ORGANIC COMPOUNDS
GROUNDWATER FROM UPPER SAND AQUIFER
South Andover DI
1990

Units: ppb

	Maximum Contaminant Level	Minnesota Recommended Allowable Limit	Field Blank (B6AR)	W9A (Field Dup)	W16A	W16A (Field Dup)	W17A	W19A	W21A	W21B	W23B	W23AR
Volatile Organic Compounds												
Methylene Chloride	NE	50	--	--	11	--	--	--	--	11	--	--
Acetone	NE	700	8J	30	--	--	--	7J	--	--	--	400D
1,2-Dichloroethane	5	4.0	--	--	--	--	--	--	--	1J	--	--
2-Butanone	NE	300	--	--	--	--	--	--	--	--	--	50
Trichloroethene	5	30	--	--	--	--	--	--	--	4J	--	4J
4-Methyl-2-pentanone	NE	NE	--	--	--	--	--	--	--	--	--	8J
Tetrachloroethene	NE	7.0	--	--	--	--	--	--	--	1J	--	--
Ethyl Benzene	NE	700	--	--	--	--	--	--	--	8	--	--
Total Xylenes	NE	10,000	--	--	--	--	--	--	--	4J	--	--
Semi-Volatile Organic Compounds												
Bis(2-Ethylhexyl) phthalate	NE	20	--	--	--	2J	5J	9J	2J	--	6J	--

-- Not detected.
J Estimate due to minor QC deviations.
D Sample had to be diluted to bring it within the linear range of the calibration curve.
NE No level established.

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TABLE 4-5

SUMMARY OF DETECTED ORGANIC COMPOUNDS
GROUNDWATER FROM AQUITARD
South Andover DI
1990

Units: ppb

Volatile Organic Compounds	B7B-12	Minnesota Recommended Allowable Limit
Acetone	54	700

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TABLE 4-6

SUMMARY OF DETECTED ORGANIC COMPOUNDS
GROUNDWATER FROM LOWER SAND AQUIFER
South Andover DI
1990

Units: ppb

Volatile Organic Compounds	Maximum Containment Level	Minnesota Recommended Allowable Limit	Field Blank (W23C)	W21C	W23C	B7C
Methylene Chloride	NE	50	--	--	24	--
Acetone	NE	700	14J	--	--	160
1,1,1 Trichloroethane	200	600	1J	--	--	--
4-Methyl-2-pentanone	NE	NE	1J	--	--	--
Total Xylenes	NE	10,000	--	1J	--	--
Semi-Volatile Organic Compounds						
Bis(2-ethylhexyl) phthalate	NE	20	--	--	1J	--

\- Not detected.
J Estimated value due to minor QC deviations.
NE No level established.

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TABLE 4-7

SUMMARY OF DETECTED ORGANIC COMPOUNDS
GROUNDWATER FROM RESIDENTIAL WELLS
South Andover DI
1990

Units: ppb

Volatile Organic Compounds	Maximum Contaminant Level	Recommended Allowable Limit	Field Blank (RW01)	RW01
Methylene Chloride	NE	50	--	4
1,1,1-trichloroethane	200	600	2	--
Styrene	NE	10	1000	--

-- Not detected.
NE No level established.

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The only semi-volatile organic compound (SVOC) detected in the groundwater at South Andover was BEHP. Five Upper Sand Aquifer wells (W16A, W17A, W19A, W21A, and W23B) contained low levels of BEHP. W23C was the only Lower Sand Aquifer well sampled which contained BEHP. No BEHP was detected in residential wells during the 1990 sampling event. The BEHP levels do no exceed regulatory standards (MCLs or RALs).

While PCB contamination has been reported for on-site soils (Donohue, 1991), no PCB or pesticide compounds were detected in any of the groundwater samples. This occurrence suggests that transport through the vadose zone has been retarded due to the immobile nature of these compounds.

Inorganic sampling results are summarized in Tables 4-8 through 4-11. The MCL for arsenic was exceeded in one groundwater sample. This sample was taken from monitoring well W21B which was screened in the Upper Sand Aquifer.

The standards for iron and manganese are secondary MCLs (SMCLs) set to maintain the aesthetic quality of water and do not reflect health risks. The SMCL for manganese was exceed in 12 monitoring wells (W1A, W1B, W15B, W17A, W21B, W23A-R, W23B, B6A-R, B7A, B8A, B6B-R, and B7B-R). Six monitoring wells exceeded the SMCL for iron (W1A, W15B, W23A-R, B8A, W21B, and W23C). Although Upper Sand Aquifer wells yielded samples with concentrations of iron and manganese above Minnesota RALs, groundwater in the region generally contains elevated levels of both compounds. Maximum iron and manganese concentrations are approximately 42,000 and 1,600 ppb, respectively, for glacial drift aquifers in the area (Erickson, et al, 1974). The levels detected are all below these maximum levels. Iron and manganese, therefore, are not considered to be site related or significant.

Exceedances for the zinc RAL occurred only in wells constructed of galvanized materials, and therefore, are not considered truly representative of zinc concentrations in the Upper Sand Aquifer.

Samples collected from both wells screened in the lacustrine aquitard contained manganese at concentrations above the RAL. Neither well contained arsenic, and no other exceedances were noted.

The SMCL for iron was exceeded in groundwater sampled from monitoring well W23C. This well is screened in the Lower Sand Aquifer. The RAL for arsenic was exceeded in four of the five deep wells sampled (W1C-R, B7C, W21C, and B4C). The concentration and locations of these occurrences are shown on Figure 4-7. Manganese and iron standards were each exceeded once in the residential well samples (RW01 for manganese, and RW04 for iron) (Table 4-11). As previously discussed, iron and manganese concentrations in groundwater are not considered to be site related or significant.

TABLE 4-8

SUMMARY OF DETECTED INORGANIC COMPOUNDS
GROUNDWATER FROM UPPER SAND AQUIFER
South Andover DI
1990

Units: ppb

	Recommended Allowable Limit	Maximum Contaminant Level	Field Blank (W1B)	Field Blank (B6A-R)	W1A*	W1B*	W9A*	W9A* (Field Duplicate)	W15B	W16A
Aluminum	NE	NE	36.4B	31.2JB	39.2	--	--	59.4JB	65.20JB	--
Arsenic	0.2	50	--	--	--	--	--	4.1B	--	--
Barium	2000	1000	--	6.5B	--	129B	83.1B	44.9B	59.8B	25.3B
Beryllium	0.08	NE	--	1.5B	--	--	--	--	--	--
Calcium	NE	NE	297B	1200B	56700	76300	27300	32600	57800	47100
Copper	1000	1000+	--	--	--	--	--	--	--	--
Iron	NE	300+	--	--	416J	58.2JB	--	44B	849J	61.1JB
Lead	20	50	--	--	--	--	--	1.6B	--	--
Magnesium	NE	NE	52.90B	157B	14000	18800	5130	4960B	17500	9420
Manganese	300	50+	--	--	75.90	387	31.8	29.7	194	--
Nickel	70	NE	--	--	--	--	--	--	--	--
Potassium	NE	NE	--	--	--	--	--	1920B	1340B	--
Selenium	10	50	--	--	--	--	--	--	--	--
Sodium	NE	NE	643JB	--	4680JB	4680JB	2880JB	23300	7410J	2960B
Thallium	0.3	NE	--	--	--	--	--	1.0B	--	--
Vanadium	20	NE	--	--	--	--	--	--	--	--
Zinc	700	5000	13.3B	10.3JB	2210	601	201	8.8JB	44J	19.7JB

	W16A (Field Duplicate)	W17A	W19A	W21A	W21B	W23A-R	W23B	W26A	B6A-R	B7A*	B8A*
Aluminum	--	41.9JB	39.6JB	--	--	40.2JB	32.6JB	--	41.8JB	--	--
Arsenic	--	--	--	--	78.40	15.3	--	--	--	--	--
Barium	26.4B	171B	140B	39.7B	31.4B	94.8B	155B	60.6B	106B	148B	215
Beryllium	--	--	--	--	--	--	--	--	--	--	--
Calcium	48100	52700	15800	13200	59100	105000	4200	8120	35300	37200	44000
Copper	--	10.7JB	--	--		--	--	--	6.6JB	--	--
Iron	23.4JB	31.7B	22.1B	89.5JB	743	16500	184	49.7JB	15.2B	--	6740J
Lead	--	1.4JB	--	4.5J	--	1.8JB	--	--	--	--	--
Magnesium	9610	10600	3690B	3140B	13200	8080	9230	1020B	15500	9360	9170
Manganese	--	472	32	11.1B	632	814	254	15.6	115	414	1030
Nickel	--	--	--	6.5JB	6.5JB	--	--	16.6JB	11.3B	--	29.2B
Potassium	--	3740B	6450	2030B	1990B	1420B	859B	3490B	18100	838B	25200
Selenium	--	--	--	--	--	--	--	2.2JB	--	--	14.6
Sodium	2990B	6960	6240	6090	3300B	13100	2310B	1830B	5320	4790	11800J
Thallium	--	--	--	--	--	--	--	--	--	--	--
Vanadium	--	--	--	7.4B	--	--	--	--	--	--	--
Zinc	28.1J	51.1	45.8	29.5J	18.1JB	18JB	5.0JB	46.3JB	16.6JB	647	4080

+Secondary Standard.
*Galvanized Well.
-Not detected.
NE No Level Established.

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TABLE 4-9

SUMMARY OF DETECTED INORGANIC COMPOUNDS
GROUNDWATER FROM AQUITARD
South Andover DI
1990

Units: ppb

	Recommended Allowable Limit	Maximum Contaminant Level	B6B-R	Field Dup B6B-R	B7B-R
Aluminum	NE	NE	44.1 JB	--	35 JB
Barium	2,000	1,000	132 B	130 B	58.2 B
Calcium	NE	NE	60,400	61,600	15,800
Iron	NE	300+	32.2 B	30.2 B	14.9 B
Lead	20	50	--	--	1.2 B
Magnesium	NE	NE	12,200	12,400	5,080
Manganese	300	50+	188	188	61.1
Potassium	NE	NE	1,580 B	1,550 B	5,120
Sodium	NE	NE	7,470	7,470	15,300
Zinc	700	5,000	7.3 JB	7.0 B	8.8 JB

\+ Secondary Standard.
J Estimated due to minor QC deviations.
B Above the instrument detection limit, but below contract required detection limit.
NE No level established.
-- Not detected.

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TABLE 4-10

SUMMARY OF DETECTED INORGANIC COMPOUNDS
GROUNDWATER FROM LOWER SAND AQUIFER
South Andover DI
1990

Units: ppb

	Recommended Allowable Limit	Maximum Contaminant Level	Field Blank (W23C)	W1C-R	B7C (10-18-90)	W21C	W23C	B4C*	B7C (11-5-90)
Aluminum	NE	NE	41.5JB	41.8	29.7JB	--	72.5B	64.0JB	55.6JB
Arsenic	0.2	50°	--	2.6B	5.8B	7.2B	4.0B	--	6.0B
Barium	2000	1000	19.8JB	38.6B	40.8B	25.3B	21.5	73.2B	84.4B
Calcium	NE	NE	411JB	36400	33300	45600	35800	12800	29300
Copper	1000	1000+°	4.5JB	--	--	--	--	--	--
Iron	NE	300+	40.9JB	14.8B	14.8B	39.8JB	43B	--	27.8JB
Lead	20	50	--	1.2B	1.7B	3.0JB	--	--	--
Magnesium	NE	NE	141JB	7180	4910B	8620	6390	570B	4430B
Manganese	300	50+	2.8B	40	24.8	26.4	30.9	--	26.2
Potassium	NE	NE	451JB	1160B	1310B	--	833	17100	973B
Sodium	NE	NE	437JB	9440	24500	3580	5570	28900	19900J
Thallium	0.3	NE	2.6JB	--	--	--	--	--	--
Zinc	700	5000	17.5JB	7.0JB	4.8JB	18.3JB	18.2JB	33.9J	50.4J

° Proposed Standard.
+ Secondary Standard.
* Galvanized Well.
NE No level established.

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TABLE 4-11

SUMMARY OF DETECTED INORGANIC COMPOUNDS
GROUNDWATER FROM RESIDENTIAL WELLS
South Andover DI
1990

Units: ppb

	Recommended Allowable Limit	Maximum Contaminant Level	RW01	RW03	RW03 (Duplicate)	RW04	RW06
Barium	2,000	1,000	28.4	14.5	16.2	126	12.8
Calcium	NE	NE	34,400	--	30,900	67,000	23,800
Iron	NE	300+	80.5	--	--	3,700	--
Magnesium	NE	NE	7,210	7,920	7,910	12,200	4,770
Manganese	300	50+	127	22.5	--	--	--
Sodium	NE	NE	4,830	2,990	3,000	--	--
Zinc	700	5,000+	--	--	--	--	59.3
Strontium	NE	NE	60.6	55.3	55.3	82.5	39.0

+ Secondary standard.
NE No level established.
-- Not detected.

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The South Andover Second Operable Unit RI baseline risk assessment results indicate that arsenic is the only inorganic compound potentially posing significant risk. As Figures 4-6 and 4-7 illustrate, occurrences of arsenic are localized at the southwest (downgradient) portion of the site. No arsenic was detected in groundwater from wells on the northeast portion of the South Andover site. Although an on-site arsenic source is indicated, no such source was found during the RI field investigation.

4.5 WATER QUALITY RESULTS

Water quality samples were also collected from the 20 monitoring wells sampled for chemical constituents. The analytical parameters were chemical oxygen demand (COD), total dissolved solids (TDS), total phosphorous (TP), and total suspended solids (TSS).

The analytical results are presented in Table M-9 of Appendix M. The state water quality standard and the federal secondary maximum contaminant level for TDS is 500 mg/l. None of the collected samples exceeded this standard. No state or federal drinking water standards have been set for the water quality parameters analyzed for during the DI.

4.6 WELL ABANDONMENTS

Four groundwater monitoring wells installed during previous site investigations were abandoned during DI field activities. Wells were abandoned either because well integrity had become questionable due to damage or vandalism, or to accommodate development in areas adjacent to the site. This work included the abandonment of three water table wells installed in the Upper Sand Aquifer (B6A, W11A, and W23A) and one Lower Sand Aquifer well (W1C). All wells were abandoned in accordance with Minnesota Department of Health (MDH) regulations. Completed well abandonment forms (on file with the MDH) are attached in Appendix F. Two additional wells originally scheduled for abandonment were repaired to operational condition.

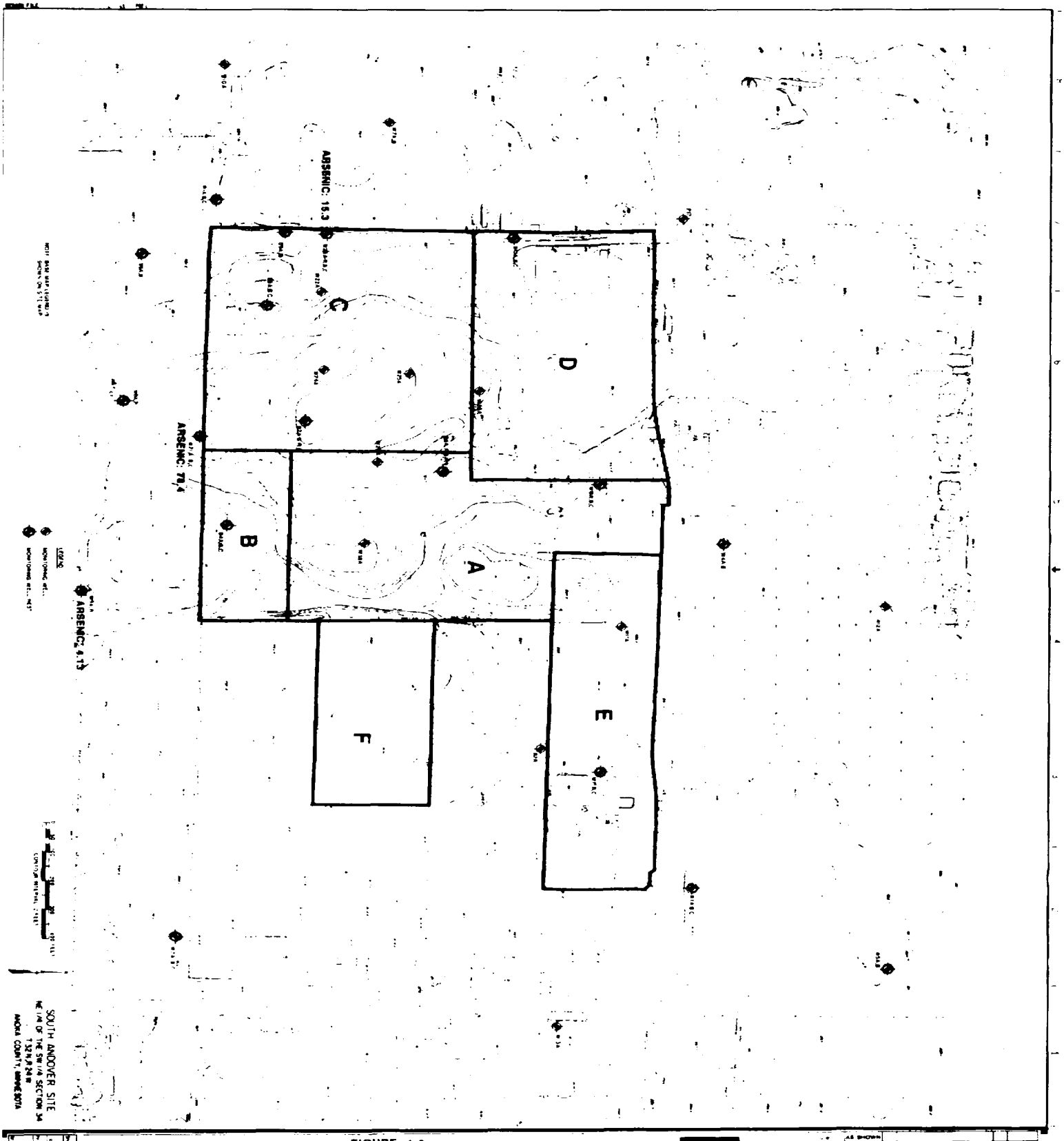

FIGURE 4-6
DETECTED ARSENIC LOCATIONS AND CONCENTRATIONS (ppb) UPPER SAND AQUIFER
SOUTH ANDOVER SUPERFUND SITE
DESIGN INVESTIGATION
ANDOVER, MINNESOTA

Dames & Moore ENGINEERS ARCHITECTS SCIENTISTS

AS SHOWN
JULY 1992

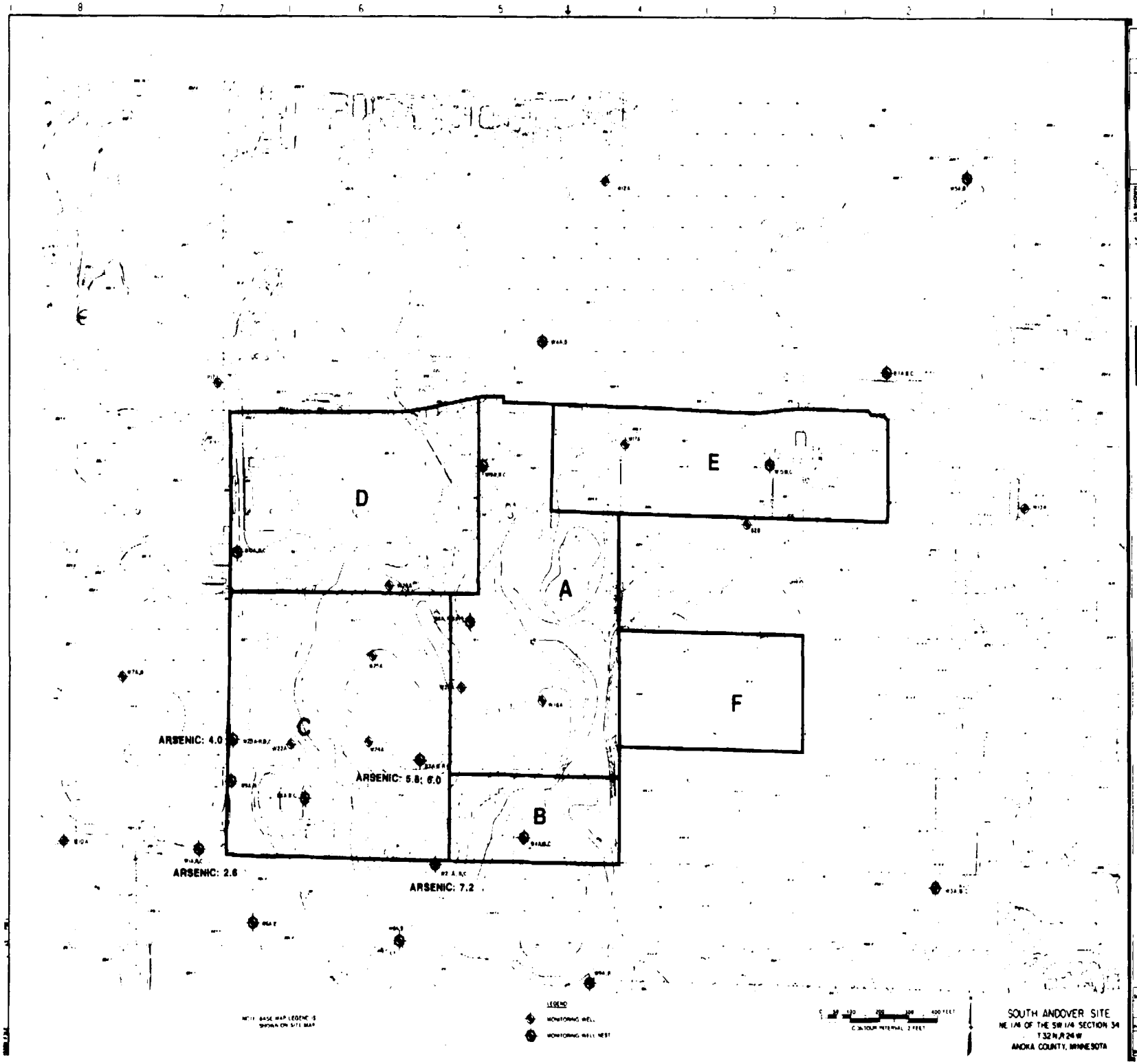

FIGURE 4-7
DETECTED ARSENIC LOCATIONS AND CONCENTRATIONS (ppb) LOWER SAND AQUIFER
SOUTH ANDOVER SUPERFUND SITE
DESIGN INVESTIGATION
ANDOVER, MINNESOTA

5.0 SUMMARY AND CONCLUSIONS

5.1 SUMMARY

The Design Investigation for the South Andover Superfund Site First Operable Unit (OU-1) was completed to evaluate subsurface conditions and groundwater quality at the site, and determine whether potential environmental impacts to public health and welfare are present. Information was also collected to allow EPA to determine whether the remedial actions discussed in a March 30, 1988 Record of Decision (ROD) should be undertaken. The following summarizes key information concerning the South Andover site which was obtained from the DI and several prior investigations.

5.1.1 Previous Investigations

Five subsurface investigations have been conducted at the South Andover site since the late 1970s. These studies have identified local contamination of groundwater, soil, sediments, and surface water by inorganic and organic compounds. The most recent investigations were conducted by Donohue and focused on addressing potential impacts from on-site soils (OU-2). Results of the OU-2 investigation (RI) revealed the presence of volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), and inorganic compounds at isolated locations across the site. The detected contaminants in on-site soils are generally consistent with the site's operational and waste storage history, and the main potential contaminants of concern are polyaromatic hydrocarbons (PAHs), PCBs, lead, and antimony.

5.1.2 Design Investigation Activities

The DI field investigation included the completion of six soil borings used for the collection of chemical and geotechnical samples and monitoring well installation. The six new wells installed during the DI, as well as select existing site wells and residential wells were sampled and tested to determine groundwater flow direction, gradients, hydraulic conductivities, velocities, and current groundwater quality. Four existing monitoring wells were abandoned to accommodate nearby development activities or because well integrity had become questionable.

5.1.3 Site Geology and Hydrogeology

Unconsolidated units beneath the South Andover site consist of: (1) an upper sand unit (Upper Sand Aquifer), (2) and intermediate lacustrine silt and till unit (Lacustrine Aquitard), and (3) a lower sand unit (Lower Sand Aquifer).

The Upper Sand Aquifer is comprised of medium-grained sand with occasional lenses of fine silty sand. The thickness of this unit ranges from 25 feet to 37 feet. Groundwater in the Upper Sand Aquifer flows from northeast to the west-southwest at a horizontal velocity from 15 ft/yr to 76 ft/yr.

Substantial vertical downward hydraulic gradients were observed, suggesting that groundwater flow within the Upper Sand Aquifer is predominantly vertical, not horizontal.

The Lacustrine Aquitard consists of three subunits: (1) a discontinuous silt layer containing lenses of glacial till and sandy silt, (2) a discontinuous glacio-lacustrine silty sand unit, and (3) a continuous silt and clay unit. The total thickness of the Lacustrine Aquitard ranges from 47.5 to 65.0 feet. Vertical flow is expected to dominate in all three subunits of the Lacustrine Aquitard.

The Lower Sand Aquifer is comprised of dark grey-brown to brown silty sand. DI soil borings did not penetrate this unit (minimum thickness of seven feet).

Groundwater within the Lower Sand Aquifer flows from the northeast towards the west-southwest at an average velocity of 17 ft/yr.

Interconnection between the Upper and Lower Sand Aquifer systems appears likely. This conclusion is supported by the predominance of a vertical hydraulic gradient within the Upper Sand Aquifer and Lacustrine Aquitard, and the results of a previous pump test conducted at the site by CH2M Hill (1988).

5.1.4 Nature and Extent of Contamination

The only organic and inorganic compounds detected in soils sampled during the DI at levels exceeding typical concentration ranges reported for soil (Dragun, 1988 and New Lyme Landfill RI/FS, CH2M Hill, 1985) were PAHs, cadmium, and zinc. Soil samples collected during the OU-2 RI contained elevated levels of PAHs, PCBs, lead, and antimony. The difference in analytical results between the two studies is likely a result of the limited number of samples collected during the DI and the heterogeneous hot-spot type of chemical distribution encountered at the South Andover site.

Groundwater from both aquifer systems locally contained low level of VOCs and SVOCs. Detected organic compound concentrations, however, do not exceed regulatory levels.

Secondary MCLs which are based on the aesthetic quality of water and not health risks, were exceeded for manganese and iron in groundwater samples taken primarily from the Upper Sand Aquifer. The majority of these exceedances can be attributed to either regional groundwater characteristics or galvanized well construction materials. The MCL for arsenic was exceeded in one groundwater sample taken in a monitoring well which was screened in the Upper sand Aquifer. A baseline risk assessment computed during the OU-2 RI indicates that arsenic is the only inorganic compound potentially posing significant groundwater risk. Although no arsenic was detected in on-site upgradient wells, the significance of this occurrence is unclear since no on-site arsenic source was identified during OU-2 activities.

5.2 DATA LIMITATIONS

For an environmental investigation at any site, there are data limitations and residual uncertainty inherent to sampling and analytical procedures used, evaluations performed, and assumptions made. The primary uncertainty related to the South Andover DI pertains to the issue of data sufficiency.

To determine the nature and extent of contamination at the South Andover site, 22 wells and 6 soil borings (one of which was not analyzed), were sampled to represent over 50 acres. As 5 of the 6 soil borings were used for replacement well installation, these locations were selected based upon existing well locations. The sixth soil boring was not analyzed for chemical constituents. The borings, along with previously gathered data, were sufficient to evaluate the physical characteristics of the surficial aquifer. The borings, however, were insufficient to completely characterize the lacustrine Aquitard and the Lower Sand Aquifer. Soils chemical data supplement data gathered during O.U.-2 RI field activities.

Groundwater analytical data were collected from 22 wells (5 of which were replacement wells). All well locations were selected by U.S. EPA in consultation with the MPCA and Donohue. The majority of existing wells were made of galvanized materials. The data from these wells, particularly for zinc, may not be representative of actual groundwater quality beneath the site. Not all samples were collected during the same sampling period. Seasonal fluctuations of water levels and groundwater quality may be reflected in the data.

6.0 REFERENCES

CH2M Hill, Inc., 1988, Final Remedial Investigation Report, Contract No. 68-01-7251, U.S. Environmental Protection Agency.

Donohue & Associates, Inc., 1991, Final Remedial Investigation Report, South Andover Second Operable Unit Remedial Investigation/Feasibility Study, Contract No. 68-W8-0093, United States Environmental Protection Agency.

Dragun, J., 1988, The Soil Chemistry of Hazardous Materials: The Hazardous Materials Control Research Institute, Silver Spring, Maryland, 458 p.

Erickson, D.W. et al., 1974, Water Resources of the Rum River Watershed, East-Central Minnesota, U.S.G.S Atlas HA-509.

Farnham, R.S., 1956, Geology of the Anoka Sandplain in 1956 Annual Meeting Guidebook for Field Trips, G.M. Schwartz, Editor, Geological Society of America.

Jirsa, M.A., B.M. Olsen, and B.A. Bloomgren, 1986, Bedrock Geologic and Topographic Maps of the Seven-County Twin Cities Metropolitan Area, Minnesota. Miscellaneous Map Series M-55, Minnesota Geological Survey.

Residuals Management Technology, Inc., 1981, Technical Assistance to Andover, Preliminary Hydrogeologic Report on the Heidelberger Site, Contract No. 68-01-6005, U.S. Environmental Protection Agency.

A/RP/SANDOVER/AT6

APPENDIX A

RECORD OF DECISION

RECORD OF DECISION
INITIAL GROUNDWATER OPERABLE UNIT

SITE NAME AND LOCATION

South Andover
Andover, Minnesota

STATEMENT OF BASIS AND PURPOSE

This decision document presents the selected remedial action for the South Andover site developed in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980, as amended by the Superfund Amendments and Reauthorization Act of 1986 and consistent with the National Oil and Hazardous Substances Pollution Contingency Plan to the extent practicable.

This decision is based upon the contents of the administrative record for the South Andover site.

The State of Minnesota concurs with the selected remedy.

DESCRIPTION OF THE REMEDY

This initial groundwater operable unit was developed to protect public health and the environment by controlling the migration of contaminants present in the surficial aquifer. The operable unit is fully consistent with all planned future site activities. Future site activities include locating contaminant source areas and developing the overall site remedy.

The major components of the selected remedy are as follows:

- Extract groundwater from the surficial aquifer;
- Provide municipal water to private well users on or near the site;
- Monitor groundwater movement at the site; and
- Place restrictions on new wells on or near the site.

DECLARATION

The selected remedy is protective of human health and the environment, will attain the applicable or relevant and appropriate requirements of other Federal and State environmental laws and is cost effective.

This remedy utilizes permanent solutions and alternative treatment technologies to the maximum extent practicable for this action. However, because this action will not difinitively address any potential contaminant

source areas, due to its limited scope of migration control, this remedy does not satisfy the statutory preference for treatment as a principal element. Subsequent actions are planned for the site that will address all remaining concerns.

3/30/88
Date

Robert Springer for
Valdas V. Adamkus
Regional Administrator

ADMINISTRATIVE RECORD INDEX
South Andover
Minnesota

FICHE/FRAME	PAGES	DATE	TITLE	AUTHOR	RECIPIENT	DOCUMENT TYPE
	2	00/00/00	Summary of soil and groundwater sampling	MToepfer - USEPA	TYantos - Anoka Cty	Correspondence
	2	00/00/00	Notes on site events			Handwritten Notes
	100	00/00/00	Technical Status Report October 1984 to November 1987	CH2M Hill	USEPA	Memorandum
	1	00/00/00	Superfund Project Begins at S. Andover Site	Coons Rapids Challenge		Newspaper Article
	8	00/00/00	Community Relations Plan for Waste Disposal Engineering Inc.			Other
	20	00/00/00	Draft ROD for the Andover site	Kulma, USEPA	see listing	Other
	3	00/00/00	Emergency Action Plan	MPCA		Other
	4	00/00/00	Background on South Andover site			Other
	5	00/00/00	Chronolcgy of Events Relevant to Andover sites			Other
	5	00/00/00	Remedial Response Fact Sheet			Other
	6	00/00/00	Preliminary Assessment	Ecology & Environment		Other
	7	00/00/00	Questions and answers re site			Other
	10	00/00/00	Worksheet For Hazardous Waste Site Ranking Model			Other
	13	00/00/00	Site Photos			Photographs
	2	00/00/00	Summary of past and future response activities			Reports/Studies
	21	00/00/00	Statement of Work RI/FS			Reports/Studies
	37	00/00/00	Interim Status Report	JDOskvarek - Ecology & Environment		Reports/Studies

ADMINISTRATIVE RECORD INDEX
South Andover
Minnesota

FICHE/FRAME	PAGES	DATE	TITLE	AUTHOR	RECIPIENT	DOCUMENT TYPE
			on the Extent of Contamination at the South Andover site			
	27	00/00/00	Residential Water Well Records			Sampling/Data
	3	77/00/00	3 Drawings showing - Zones of significant contamination at the South Andover site; - Soil Distribution Map; and - Subsurface Contour Map of the Glacial Till			Maps
	9	78/09/19	Soil Investigation Tire Recycling Bldg	Pederson - Subterranean Engr	MRouse - Int'l Tire Recyc	Correspondence
	5	79/02/14	Technical Assistant Request: Cecil Heidelberger Well contamination problem	TMHoffman - MPCA	KKlenitsch - USEPA	Correspondence
	13	79/08/00	Technical Assistance to MPCA	PEDCO Environmental	USEPA	Reports/Studies
	7	79/11/15	Notice of Noncompliance	DLWikre - MPCA	CHeidelberger	Correspondence
	7	79/11/15	Certified Letter to PRP Heidelberger notifying him of noncompliance	Clark, MPCA	Heidelberger,PRP	Correspondence
	4	79/11/28	Identification and Preliminary Assessment	TCohn		Other
	1	79/12/03	Site Inspection 11/16/79 Musket Ranch and Trading Post			Memorandum
	2	79/12/06	Site Visit Musket Ranch and Trading Post - 11/16/79	TCohn - USEPA		Memorandum
	9	79/12/07	Site Inspection	TCohn		Reports/Studies
	17	80/00/00	Notice of Violation	DLWikre - MPCA	Various PRPs	Correspondence
	17	80/00/00	Heidelberger	PEDCO Labs		Sampling/Data

ADMINISTRATIVE RECORD INDEX
South Andover
Minnesota

FICHE/FRAME	PAGES	DATE	TITLE	AUTHOR	RECIPIENT	DOCUMENT TYPE
			Sample Summaries			
	1	80/02/26	Site Inspection Andover City Investment	TCohn - USEPA	JGoldstein - USEPA	Memorandum
	1	80/04/01	Site Inspection Musket Ranch and Trading Post	TCohn - USEPA	JGoldstein - USEPA	Memorandum
	2	80/04/17	Planned meeting on Musket Ranch	MToepfer - USEPA	MKanner - MPCA	Memorandum
	8	80/05/08	Purge and Trap Analysis Lab No. 2-1070	Twin City Testing	Anoka City Health Dept.	Sampling/Data
	3	80/05/19	Field Investigation Report concerning presence of PCBs at Pumpkin City Investments	RJGraedinger		Other
	2	80/05/23	Placement and drilling of wells	MToepfer - USEPA	JBrossman	Memorandum
	6	80/05/30	Trip Report to determine point locations for well placement	MToepfer - USEPA	File	Memorandum
	70	80/06/27	Subsurface exploration and observation well installations at the Andover, MN site	Soil Testing Services of Minnesota	PEDCO Environmental, Inc.	Reports/Studies
	3	80/07/22	Letter to Mistelske of Commercial Auto Parts and Schennell of Wilber Auto Parts informing them of potential responsibility	Clark, MPCA	see title field	Correspondence
	18	80/08/04	Certified Letter to PRPs informing them of their potential responsibility	Clark, MPCA	PRPs	Correspondence
	36	80/10/13	MPCA Agenda Item Control Sheet Meeting Date 10/28/80	MKanner - MPCA		Other
	14	81/01/00	Transcript of Statement by Carl Ray Barker			Other

ADMINISTRATIVE RECORD INDEX
South Andover
Minnesota

ICHE/FRAME	PAGES	DATE	TITLE	AUTHOR	RECIPIENT	DOCUMENT TYPE
	157	81/01/00	Technical Assistance to Andover, MN Preliminary Hydrogeologic Report on the Heidelberger site	RMT		Reports/Studies
	4	81/01/11	MPCA Agenda Item Control Sheet	MKanner - MPCA		Other
	4	81/01/23	Final Strategy Determination Musket Ranch	MToepfer - USEPA		Other
	1	81/02/03	RMT Findings to date	GHMadany	MELynch	Memorandum
	5	81/02/23	Summary of 2/2/81 meeting and requests for past records etc and position on cleanup	MKanner - MPCA	Attys for PRPs	Correspondence
	14	81/03/09	Letter forwarding "Andover Groundwater Monitoring Plan" with attachments	Vanderboom, Pace Labs	MKanner	Correspondence
	4	81/03/19	Enclosing statments of three (3) transporters of hazardous waste	BLSias - Minn Ofc of Atty Gen'l	CBenedict - USEPA	Correspondence
	37	81/03/30	Andover Drum Inventory	WRO'Connor - Pace Labs	Bemis Co and MPCA	Reports/Studies
	44	81/04/06	Report entitled:Andover Groundwater Monitoring	Pace Labs	Bemis Co.Inc.	Reports/Studies
	31	81/04/06	Andover Groundwater Monitoring 3/9-16/81	Pace Labs	Bemis Co	Reports/Studies
	4	81/05/01	Emergency Action Plan	MKanner, MPCA	Braun, USEPA	Reports/Studies
	3	81/03/09	Interim Report re recent activities	JDOskvarek - Ecology & Environment	File	Memorandum
	1	81/09/10	Withdrawal of offer made in letter of 7/17/81	CLBader - Bemis Co	MKanner - MPCA	Correspondence
	8	81/09/30	Interim Report	JDOskarek - Ecology & Environment	File	Memorandum

ADMINISTRATIVE RECORD INDEX
South Andover
Minnesota

FICHE/FRAME	PAGES	DATE	TITLE	AUTHOR	RECIPIENT	DOCUMENT TYPE
	17	81/10/23	Mitre Model Scoring of Andover, MN	Ecology & Environment		Other
	1	81/12/09	Andover sites Fact Sheet			Fact Sheet
	7	81/12/09	Appendix E, Model Worksheets from HRS Scoring Package	USEPA		Report/Study
	2	82/03/14	Letter to USEPA from Standard Solvents Atty. informing USEPA that they are working with Kanner to resolve "the problems at Andover"	Standard Solvents Atty.	Summerlee, USEPA	Correspondence
	28	82/03/15	Demand Letters to PRPs:	WASullivan - USEPA		Correspondence
			Parmak Inc.			
			Carl Ray Barker			
			Cyrle Link			
			William Baston			
			Charles Mistelske			
			Standard Solvents			
			Irving Schermell			
			Shirley Heidelberger			
			David Heidelberger			
			Marion Heidelberger			
			Cecil Heidelberger			
			Color-Ad Packaging			
			ACME Tag			
			Bemis Co			
	1	82/03/22	Response to demand letter	CCHeidelberger	KLSummerlee - USEPA	Correspondence

ADMINISTRATIVE RECORD INDEX
South Andover
Minnesota

FICHE/FRAME	PAGES	DATE	TITLE	AUTHOR	RECIPIENT	DOCUMENT TYPE
	2	82/03/29	Response to demand letter	CBarker	EPA	Correspondence
	2	82/03/31	Response to demand letter	GOLudcke - Atty for Color-Ad	KLSummerlee - USEPA	Correspondence
	2	82/03/31	Response to demand letter	KWRouse for Parmak	KLSummerlee - USEPA	Correspondence
	1	82/04/02	Response to demand letter	RILang - Atty for Acme Tag	KLSummerlee - USEPA	Correspondence
	2	82/04/14	Response to demand letter	WHull, Standard Solvents	KLSummerlee	Correspondence
	3	82/04/28	Log of Site Inspection			Log Books
	1	82/06/07	Response to Congressional Inquiry	Adamkus, USEPA	Strangeland	Correspondence
	25	82/06/28	HRS Scoring Package			Other
	15	82/05/00	Anodover Sites Data Review Mead Case 909, 775, 793	AFHaenerer - USEPA	BWright - USEPA	Memorandum
	20	83/01/03	Demand Letters to PRPs	LJBreimhurst - MPCA		Correspondence
			Color-Ad Packaging			
			Acme Tag			
			Bemis Co			
			Vapors Steam Bath			
			David Heidelberger			
			Cyril Link			
			Marion Heidelberger			
			Cecil Heidelberger			
			Parmak Inc			
			Standard Solvents			
	1	83/01/03	Memo re: Groundwater Contamination in the area of S. Andover	G.Englund, Water Supply, MDPH	Water Well Contractors	Memorandum
	1	83/01/10	Response to MPCA Demand Letter	DHeidelberger	MPCA	Correspondence

ADMINISTRATIVE RECORD INDEX
South Andover
Minnesota

FIL	E/FRAME	PAGES	DATE	TITLE	AUTHOR	RECIPIENT	DOCUMENT TYPE
		1	83/01/10	Response to MPCA demand letter	RILang - Atty for Acme Tag	MPCA	Correspondence
		1	83/01/11	Response to MPCA demand letter	WDHull - Atty for Std Solvents	MPCA	Correspondence
		1	83/01/17	Response to MPCA demand letter	CLBader - Bemis Co	MPCA	Correspondence
		3	83/01/24	Response to letter of 1/10/83	MKanner - MPCA	RILang-Atty for Acme Tag	Correspondence
		2	83/01/25	Response to MPCA demand letter	KWRouse - Atty for Parmak	MPCA	Correspondence
		2	83/01/25	Response to MPCA demand letter	WDHull - Atty for Std Solvents	MPCA	Correspondence
		5	83/04/07	MPCA Agenda Item Control Sheet	DDay - MPCA		Other
		10	83/04/18	Notice of MPCA Bd. meeting to authorize to negotiate a Superfund cooperative agreement with USEPA	Kanner, MPCA	PRPs	Correspondence
		2	83/05/24	Site Tour with Consultants on 5/12/83	DDay - USEPA	File	Memorandum
		3	83/05/31	Notes of phone conversation with RBoice re review of site conditions	DDay - MPCA		Communication Record
		1	83/07/00	South Andover Conditions at listing and status	USEPA		Other
		9	83/08/04	Letter to USEPA from Brustman, MPCA forwarding Community Relations Plan for Waste Disposal Engineering, Inc.	Brustman, MPCA	Marcia Carlson, USEPA	Correspondence
		2	83/08/12	Review of 8/9/83 meeting re hazardous waste containers encountered during tire moving activities	DDay - MPCA	RSlaback & CHeicelberger	Correspondence

ADMINISTRATIVE RECORD INDEX
South Andover
Minnesota

FICHE/FRAME	PAGES	DATE	TITLE	AUTHOR	RECIPIENT	DOCUMENT TYPE
	3	84/03/08	Notification of Superfund project and start of 60 day comment period	BGConstantelos - USEPA	TNMarren - MSPA	Correspondence
	52	84/06/05	MPCA Agenda Item Control Sheet Meeting Date 84/06/25	MVennewitz - MPCA		Other
	3	84/08/16	Follow-up and response to 7/25/84 meeting	MKVennewitz - MPCA	ESherrell	Correspondence
	2	84/08/20	Letter informing Hull, atty. for Standard Solvents outlining Consent Order to be drafted	MKVennewitz,MPCA	W.Hull,Standard Solv.Atty	Correspondence
	54	84/09/04	Draft Consent Order	M.K. Vennewitz	Attys for PRPs	Pleadings/Orders
	75	84/09/14	Work Plan for Removal of Drums and Contaminated Soils	Pace Labs		Reports/Studies
	25	84/09/21	Action Memo: Authorization to Proceed with a Remedial Investigation and Feasibility Study at South Andover site	BGConstantelos - USEPA	WWAdamkus - USEPA	Memorandum
	2	84/10/03	Letter to USEPA and MPCA from Bemis & Co. Attys. notifying them of intention to proceed with remedial action at the site	McDonald, Bemis Co. Inc.Atty.	USEPA,MPCA	Correspondence
	2	84/10/03	Notice on behalf of Bemis Co., Standard Solvents, Color-Ad Packaging and Acme Tag of intent to proceed with remedial actions	DCMcDonald - Briggs and Moran	USEPA and MPCA	Correspondence
	2	84/10/09	Follow-up to 10/2/84 inspection/meeting at Commercial Auto Parts	MKVennewitz - MPCA	ESherrell	Correspondence
	2	84/11/28	Final Drum Inventory			Other
	1	85/00/00	Article from the Coon Rapids Challenge,Winter	Coon Rapids Challenge paper		Newspaper Article

ADMINISTRATIVE RECORD INDEX
South Andover
Minnesota

FILE/FRAME	PAGES	DATE	TITLE	AUTHOR	RECIPIENT	DOCUMENT TYPE
			85/86:"Superfund Project Begins..."			
	48	85/01/16	Prescreening Results	WAO'Connor - Pace Labs	MVennewitz - MPCA	Sampling/Data
	5	85/01/28	Review of PCB test results	WAO'Connor - Pace Labs	MVennewitz - M,PCA	Correspondence
	3	85/03/25	Response to 3/7/85 letters re barrels uncovered	MKVennewitz - MPCA	CHeidelberger	Correspondence
	17	85/06/25	Site Safety Plan South Andover	JBDalgleish		Other
	4	85/07/30	Demand Letters and list of addressees	BGConstantelos - USEPA	Attached list	Correspondence
	2	85/08/00	Notes of phone conversation with various PRPs	KStreet - USEPA		Communication Record
	21	85/08/00	PRP replies to notice letters			Correspondence
	49	85/08/14	Final Work Plan RI/FS	CHEM Hill and Ecology & Envrnmnt		Reports/Studies
	4	85/09/00	Superfund Program Fact Sheet South Andover Site	USEPA AND MPCA		Fact Sheet
	15	85/09/00	Community Relations Plan	MPCA		Reports/Studies
	1	85/09/19	USEPA News Release: EPA To Brief Residents on S. Andover Superfund Site	USEPA		Press Release
	16	85/10/23	Request to sign access agreement Letters sent to:	RGrigues - USEPA		Correspondence
			CMisteiske			
			RSlaback (Signed)			
			Cyrle Link			
			CHeidelberger			
			DHeidelberger			

ADMINISTRATIVE RECORD INDEX
South Andover
Minnesota

FICHE/FRAME	PAGES	DATE	TITLE	AUTHOR	RECIPIENT	DOCUMENT TYPE
			WBaston			
			HHaluptzok (Signed)			
	6	85/10/31	Proposal for Technical and Operationing Procedures for Remediation of South Andover site	Rollins Environmental Services	MPCA	Reports/Studies
	2	85/11/22	Summary of Events which occurred between Nov 14 - 21 re CHeidelberger	GWong - USEPA		Handwritten Notes
	17	86/01/16	Site Safety Plan South Andover	JBDalgleish		Other
	6	85/02/14	Data Summary	JBDalgleish - Barr Engr	PSmith - CH2M Hill	Correspondence
	2	86/05/20	Action Memo: Authorization for Supplemental Funding of the RI/FS	BGConstantelos - USEPA	WWGackus - USEPA	Memorandum
	1	86/08/18	Request for advice on wells when grading housing development area	RWNelson	GWong - USEPA	Correspondence
	1	86/08/27	Notes of phone conversation with RGrimes re Offsite monitoring wells 2 new developments in the S. Andover area	GWong - USEPA		Communication Record
	1	86/08/27	Notes of phone conversation with DRobohm-MPCA and PSmith-CH2M Hill re potential developers near S. Andover site	GWong - USEPA		Communication Record
	2	86/08/29	Response to inquiries re new housing development	DJRobohm - MPCA	RPacker	Correspondence
	1	86/09/11	Response to inquiry about wells when grading	RGrimes - USEPA	RWNelson	Correspondence
	1	86/09/30	Notes of phone conversation with JPeterson re	GWong - USEPA		Communication Record

ADMINISTRATIVE RECORD INDEX
South Andover
Minnesota

FI	I/FRAME	PAGES	DATE	TITLE	AUTHOR	RECIPIENT	DOCUMENT TYPE
		2	87/06/10	High Court strengthens landowners rights	Minneapolis Star and Tribune		Newspaper Article
		1	87/06/13	Landowner rights ruling sets stage for lawsuits	Minneapolis Star and Tribune		Newspaper Article
		2	87/08/19	Status memo for the S. Andover site	G.Wong,USEPA	see listing	Memorandum
		500	88/01/29	Remedial Investigation Report, Final, South Andover Site Andover, Mn			Reports/Studies
		350	88/01/29	Public Review Draft Feasibility Study Report South Andover, Andover, Mn			Reports/Studies
		4	88/02/00	Superfund Fact Sheet summarizing S.Andover site Feasibility Study	USEPA together with MPCA		Fact Sheet
		132	88/02/08	Transcript of proceedings from Feb.8, Public Hearing in Andover	Hintz, Court Reporter	USEPA	Meeting Notes
		1	88/02/12	Newspaper Article: "Alternative for Andover's Chemical Waste Site Cleanup Recommended"	J.Yelle,Anoka County Union		Newspaper Article
		4	88/02/14	Letter to USEPA from Heidelberger re: his comments on"the proposed pumping, treating and dumping..."	Heidelberger	Hall,USEPA	Correspondence
		42	88/02/14	Letter to USEPA from Andover landowner Sonstaby with attachments re: her opinion of how poorly State and local govt. dealt with site	Sonstaby,Andover landowner	Hall,USEPA	Correspondence
		1	88/02/17	Memo to interested persons re: FS comment period	Hall,Brustman,USEPA	interested persons	Fact Sheet

ADMINISTRATIVE RECORD INDEX
South Andover
Minnesota

FICHE/FRAME	PAGES	DATE	TITLE	AUTHOR	RECIPIENT	DOCUMENT TYPE
			extension			
	2	88/02/18	Trip Report on TCAAP Meeting with Army and MPCA	USEPA		Meeting Notes
	2	88/02/22	Letter to USEPA from the Anoka County Health & Social Services Dept. forwarding their comments on the RI/FS dated 1-29-88	Anoka County Health & Soc.Serv.Dept	Dagnell, USEPA	Correspondence
	4	88/02/25	Certified Letter to PRPs re: their potential responsibility	Mary Sage,USEPA	PRPs,see listing	Correspondence
	2	88/03/04	Letter to USEPA from the City of Andover forwarding comments to the RI/FS	Elling,Andover City Councilman	Hall,USEPA	Correspondence
	2	88/03/04	Letter to USEPA from the City of Andover forwarding their comments to the RI/FS	Ortel,acting mayor of Andover	Hall,USEPA	Correspondence
	35	88/03/30	ROD	USEPA		Reports/Studies

GUIDANCE INDEX

ADMINISTRATIVE RECORD INDEX
South Andover
Minnesota

FILE/FRAME	PAGES	DATE	TITLE	AUTHOR	RECIPIENT	DOCUMENT TYPE
			CERCLA			Guidance
			SARA			Guidance
			RCRA			Guidance
			NCP			Guidance
			Superfund brochure: The New Superfund, What It Is, How It Works			Guidance
		87/01/00	Superfund brochure: EPA Journal- The New Superfund Jan/Feb 87			Guidance
		87/05/00	Superfund brochure: Your Guide to the USEPA			Guidance
			Superfund brochure: Toxic Chemicals, What They Are, How They Affect You			Guidance
			Superfund brochure: Superfund Glossary			Guidance
		85/06/00	Guidance on Feasibility Studies Under CERCLA			Guidance
		85/08/00	Guidance on Remedial Investigations Under CERCLA			Guidance

SUMMARY OF REMEDIAL ALTERNATIVE SELECTION
SOUTH ANDOVER SITE
GROUNDWATER OPERABLE UNIT

SITE LOCATION AND DESCRIPTION

The South Andover site is located in the southern portion of Andover, Minnesota, approximately 16 miles north - northeast of Minneapolis. The site is located in the southern half of Section 34 of Grow Township (T.32N., R.24W.). The South Andover site vicinity is shown in Figure 1.

A residential neighborhood exists 1/4 mile north of the site. Development is currently planned to the west and the south of the site. Bunker Lake Boulevard borders the site on the north, and Jay Street on the east. Small businesses along both roads deal in used cars, auto parts, and auto salvage. Several pieces of property within the site are auto salvage yards, and a large portion of the site is buried under a pile of tires and miscellaneous junk. The Waste Disposal Engineering landfill (WDE), which previously accepted hazardous waste, is located 3,000 feet northeast of the site. WDE is a National Priorities List site which is undergoing remedial design.

The site is comprised of several separate parcels of land totaling approximately 50 acres. Various independent storage and disposal activities took place on the site. The parcels of land are shown in Figure 2. The waste storage and disposal activities are detailed in Table 1.

SITE HISTORY

Industrial waste handling activities at the South Andover site are reported to have begun in 1954 with the storage of solvents and inks on the Cecil Heidelberger property. Open pit burning of liquid wastes began on the Batson property in 1970. Chemical waste storage began at the Mistelske property in 1973.

Actions to limit the waste handlers at the various properties began in 1973 when Anoka County officials instructed Cecil Heidelberger to remove and dispose of the chemical wastes stored on the property. Citizen complaints of well contamination prompted investigations by the Minnesota Pollution Control Agency (MPCA). MPCA issued a Citation of Violation to Cecil and Marion Heidelberger in 1976 for the storage of chemical waste. The Heidelbergers discontinued processing waste in early 1977 and stopped accepting waste in 1978.

Actions to regulate other waste handlers at the site occurred in 1980. Notices of Violation were issued by the MPCA to Shirley Heidelberger, Cyril Link, and Charles Mistelske for improper disposal of industrial wastes.

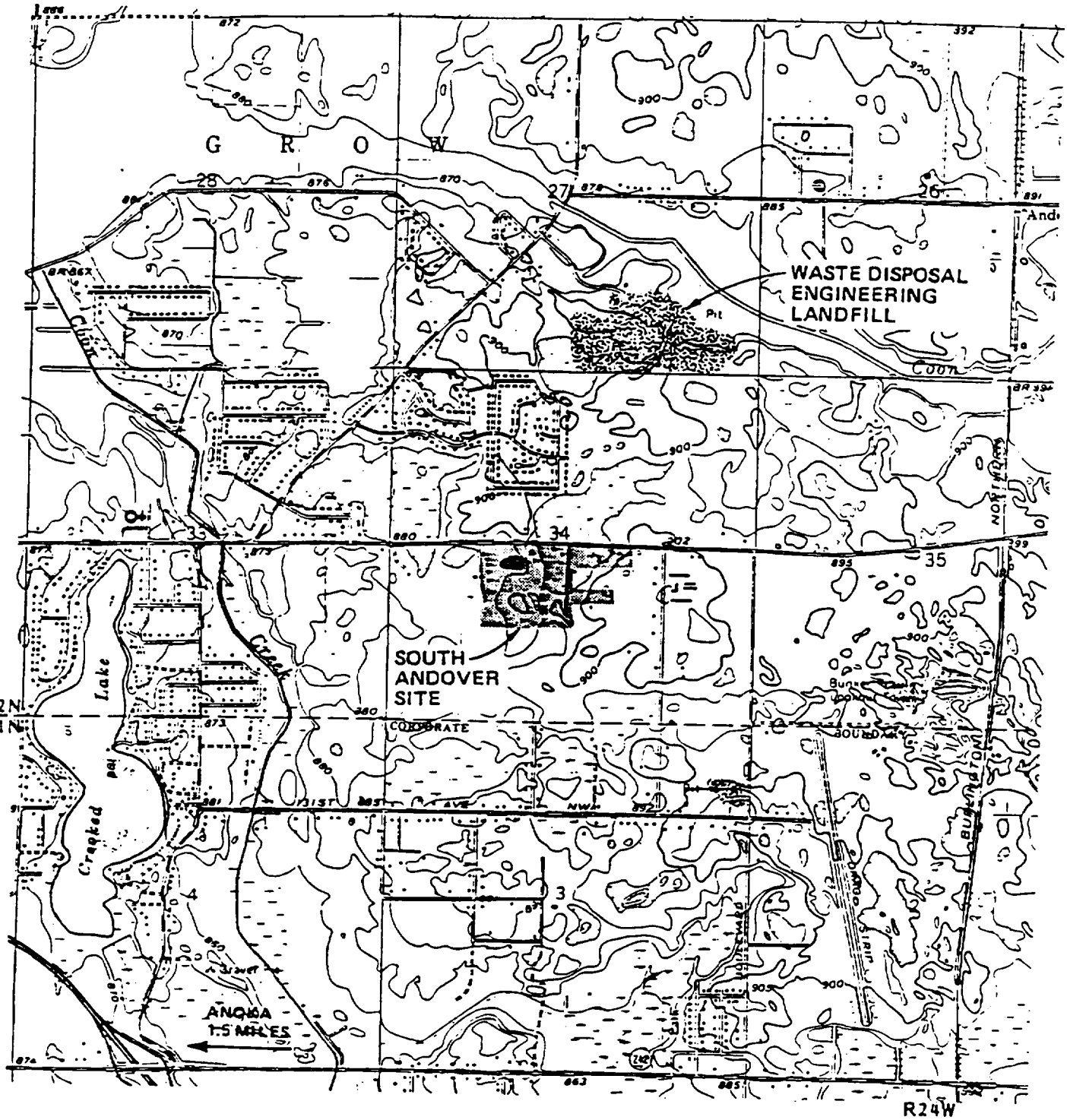

FIGURE 1
LOCATION OF SOUTH ANDOVER SITE
SOUTH ANDOVER

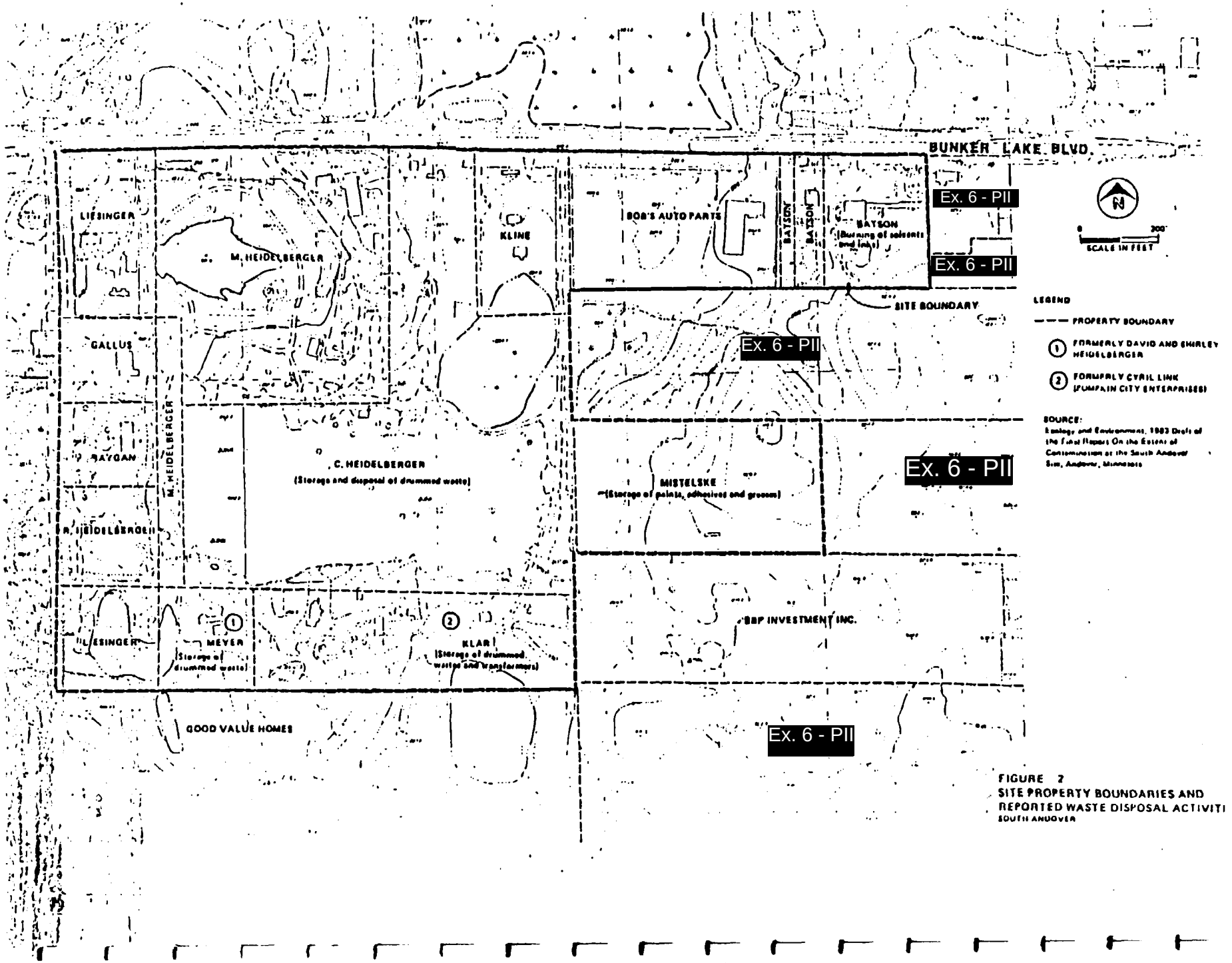

FIGURE 2
SITE PROPERTY BOUNDARIES AND REPORTED WASTE DISPOSAL ACTIVITI
SOUTH ANDOVER

TABLE 1

WASTE LOCATION AND DISPOSAL ACTIVITY

LOCATION	DISPOSAL ACTIVITY
Cecil Heidelberger Property	Chemical wastes were stored and disposed of on the property. A majority of the property is covered with tires and other debris.
Batson Property	Thousands of barrels of solvents and inks were allegedly burned in open pits. A wetland on the property was used as a disposal area prior to filling.
Charles Mistelske Property	The property was used to store approximately 8,300 gallons of paints, adhesives and greases in 1-,2-, and 55-gallon containers.
Meyer Property	The property was used to store approximately 200 drums of chemical waste. Spillage of chemical waste is known to have occurred.
Klar Property	Storage of drummed waste and transformers occurred on the property. An inactive smelting plant, empty drums and miscellaneous debris are present on the site.

Cecil Heidelberger disposed of the contents of approximately 700 drums in 1981 by mixing the contents with waste oil and using the mixture as fuel in an asphalt plant. Approximately 500 additional drums were removed in 1986 by a group of potentially responsible parties (PRPs). Some drums remain onsite.

Several site investigations have been performed at the site. An initial appraisal was performed by Residual Management Technologies (RMT) and PEDCo Environmental in 1979 at the request of U.S. EPA. A follow-up investigation by RMT/PEDCo in 1981 included the installation of 22 monitoring wells. Ecology & Environment, Inc. (E&E) installed 26 additional wells and 22 piezometers in 1981 as part of an expanded FIT groundwater investigation.

An initial remedial investigation (RI), completed January 29, 1988, was performed at the site to characterize the nature and extent of contamination. Soil investigations were limited by the presence of a large volume of tires piled onsite and piles of junked automobiles at various auto salvage yards onsite. The tires on the Cecil Heidelberger property, the majority of the tires, are currently being shredded and removed from the site under a grant from the Minnesota Waste Management Board. The tire removal is scheduled to be completed by Spring 1989. A subsequent RI, looking at contamination of site soils and possible contamination of the lower sand aquifer, is planned for the site following the tire removal.

A feasibility study (FS), completed January 29, 1988, was developed in conjunction with the RI. The FS looked at a variety of alternatives for dealing with the groundwater problem. The alternatives ranged from no action to complete lateral containment of the surficial aquifer with groundwater extraction.

ENFORCEMENT HISTORY

Sixteen parties were notified, by a March 15, 1982 letter from U.S.EPA's Office of Enforcement and Compliance Monitoring (OECM) in Washington, that the U.S. EPA was considering spending public funds at the South Andover site and that they may be liable for money expended by the government. These parties included site owners, site operators and waste generators.

In a July 30, 1985 letter from U.S. EPA Region V, 21 PRPs were notified that U.S. EPA planned to conduct an RI/FS at the site, and that the U.S. EPA would consider an offer by the PRPs to conduct the RI/FS. None of the PRPs indicated that they had the desire and ability to conduct the RI/FS. Negotiations were terminated in an August 29, 1985 memorandum, and the Superfund was used to conduct the RI/FS.

Copies of the Proposed Plan for this operable unit were sent to the PRPs on February 1, 1988. In a February 26, 1988 letter from U.S. EPA Region V, 21 PRPs were notified that the U.S. EPA intended to conduct a remedial action at the site and that the PRPs had 60 days to submit a good faith proposal. No response has been received as of this date.

COMMUNITY RELATIONS HISTORY

Community relations activities at the South Andover site have been handled with direct involvement from the U.S. EPA and the MPCA. The initial contact with the public was in the form of interviews with representatives of the City of Andover, City of Coon Rapids and property owners on or near the site.

Two public meetings have been held for the site. The first meeting was held on September 25, 1985 prior to initiating field activities. The second meeting was held on February 8, 1988 to answer questions and receive comments on this initial groundwater operable unit.

Public involvement and participation on the site has been limited to date. Representatives of the City of Andover and Anoka County have asked for greater involvement. There is a strong interest from these local bodies to facilitate development of the site and the surrounding area. Concern has also been expressed regarding the impact of this site when combined with the presence and remedial actions planned for the WDE site.

SCOPE OF OPERABLE UNIT

This response action is an initial groundwater operable unit and is consistent with Section 300.68(c) of the National Contingency Plan (NCP). This initial groundwater operable unit is being implemented to protect public health and the environment by controlling the migration of contaminated groundwater. The operable unit addresses known areas of groundwater contamination in the surficial aquifer. The U.S. EPA and MPCA feel the possible migration of contaminants from the surficial aquifer off the site or into the lower aquifer are the major concern posed by the site. This operable unit was initiated to deal with these concerns.

The operable unit is fully consistent with all future site work, including the subsequent RI/FS planned for Spring 1989. In addition, it is believed that the gradients established by the extraction well system may be beneficial to the subsequent RI by aiding in the location of "hot spots" which have not been detected. The extraction well system will be incorporated into any subsequent remedial action decisions at the site.

It was determined that the soils do not pose a risk which needs to be addressed as part of the present operable unit. A subsequent RI/FS is

planned for the site following the tire removal presently scheduled to be completed by Spring 1989. Because the soil investigation has not been completed, it was determined that soil removal or capping at the present time could interfere with the subsequent RI/FS, may not be consistent with the final remedy and may not be cost effective. For these reasons, an interim soil remedy was determined to be unnecessary and inappropriate at the present time.

SITE CHARACTERISTICS

The initial RI focused on the surficial aquifer and portions of the site which were clear of tires and other debris. The results of the RI can be broken down into three areas: 1) groundwater, 2) soils, and 3) surface water and sediments.

Multiple waste handling operations occurred between 1954 and 1981 on several different properties within the general site boundaries. Because of this, there is not one source area, but multiple source areas which include locations where drums were stored, where wastes were discharged to the ground, and where wastes were allegedly burned.

As a part of the initial RI, potential risks from contaminated groundwater and exposed soil locations on the site were calculated based on present site use conditions and on possible future residential or commercial development conditions. Both carcinogenic and noncarcinogenic risks were calculated. Risks were not calculated for surface water and sediment locations at this time, but will be included in the subsequent RI.

The carcinogenic risks are theoretical quantifications, and are reported as excess lifetime cancer risks. Excess lifetime cancer risk is defined as the incremental increase in the probability of getting cancer compared to the probability if no exposure occurred. For example, a $1x10^{-6}$ excess lifetime cancer risk represents an exposure that could result in one extra cancer case per million people exposed. Noncarcinogenic risks are determined by comparing potential doses of contaminants by site visitors to contaminant specific reference doses. The reference dose is an estimate of an exposure level that would not be expected to cause adverse effects when exposure occurs.

The analytical results from the remedial investigation and the risk assessment can be found in the RI Report for the South Andover site completed January 29, 1988. A brief summary of the results is presented below.

Groundwater Contamination

The site is underlain by a surficial sand aquifer, a middle aquitard, a lower sand aquifer, a till unit and a bedrock aquifer. The lateral flow in the surficial aquifer was found to radiate in a generally westwardly

direction from the eastern portion of the site. Water level measurements in the well nests indicate a dominant downward component of flow in both the surficial aquifer and the middle aquitard. Residence time of groundwater in the surficial aquifer and the aquitard are less than 10 years and 28 to 70 years respectively. The potentiometric surface of the lower sand aquifer indicates lateral flow southwest across the site.

Groundwater samples were collected from 50 monitoring wells and 8 residential wells on or near the site. Elevated levels of a number of organic and inorganic compounds were detected in shallow monitor wells on site. The highest detected contaminant concentrations are shown in Table 2. Only one contaminant was detected in the lower sand aquifer, and it was only detected in one well which contained 97 ppb methylene chloride. The methylene chloride may be a lab contaminant as opposed to actually being present in the well. Additional RI work is planned for the lower sand aquifer. Residential well sampling by Anoka County and the MPCA indicated that one residential well on-site, which was drawing from the surficial aquifer, was found to be contaminated. This well was ordered to be abandoned by the MPCA.

The contaminants are found in zones of discrete contamination rather than in a continuous plume. This is indicative of the multiple waste handling and disposal operations which occurred on the site.

The contaminated surficial aquifer exceeds a number of maximum contaminant levels as set by the Safe Drinking Water Act and pose incremental cancer risks of greater than $1x10^{-6}$. The groundwater does not pose an imminent risk to the population because the upper aquifer is not currently used as a source of drinking water on or near the site. However, because there is a downward gradient through the aquifer separating the upper and lower sand aquifers, the upper sand aquifer is a possible source of contamination to the lower sand aquifer which serves as a regional drinking water source. There is a potential for an increase in the incremental cancer risk of greater than $1x10^{-6}$ if wells are set in the upper aquifer as a result of future development of the site or if the lower aquifer becomes contaminated. In addition to the cancer risk, use of the contaminated groundwater would exceed the reference dose for bis(2-ethylhexyl)phthalate and acetone.

Soil Contamination

A complete surface and subsurface soil characterization could not be performed at the site due to the presence of the large volume of tires and three active auto junk yards. A limited soil sampling was performed during the RI concentrating on suspected waste storage and disposal areas which were not buried under tires or automobiles.

The soil samples indicated elevated levels of organics and inorganics. For the most part, each contaminant was found at low levels and in a limited number of locations. Under current land use the incremental

TABLE 2

CONTAMINANT LEVELS AND STANDARDS

COMPOUND	HIGHEST DETECTED GROUNDWATER CONCENTRATION (ug/l)	COON CREEK 30-DAY AV. DISCHARGE LIMITS (ug/l) (e)	GROUNDWATER DRINKING WATER STANDARDS (ug/l)	POTW DISCHARGE LIMITS (ug/l)
1,1,1-Trichloroethane	330	830	200 (a)	5000 (f)
1,1,2-Trichloroethane	37	900	6.11 (b)	5000 (f)
1,1-Dichloroethane	12	-	-	10,000 (f)
1,2-Dichloroethane	2	2140	3.8 (b)	15,000 (f)
1,1-Dichloroethene	20	-	-	10,000 (f)
1,2-Dichloroethylene	9	1880	70 (a,b)	10,000 (f)
2-Hexanone	75	-	-	15,000 (e)
4-Methyl-2-Pentanone	18	16,970	-	15,000 (e)
Acetone	170,000	1,270,000	-	15,000 (e)
Chlorobenzene	4	200	60 (b)	1000 (f)
Ethylbenzene	18	2410	680 (a,b)	10,000 (f)
Methylene Chloride	1600	6430	350 (c)	15,000 (e)
Tetrachloroethylene	20	150	6.9 (b)	10,000 (f)
Toluene	3200	1010	2000 (a,b)	15,000 (e)
Trichloroethylene	3	1360	5 (a)	10,000 (f)
Vinyl Chloride	12	86	0.15 (b)	15,000 (e)
Xylenes	22	320	440 (a,b)	15,000 (e)
Benzoic Acid	7	-	-	15,000 (e)
Bis(2-Ethylhexyl)Phthalate	2200	10	21,000 (d)	10,000 (f)
Diethyl Phthalate	1	4340	434,000 (d)	10,000 (f)
Di-n-butyl Phthalate	24	-	-	10,000 (f)
Di-n-octyl Phthalate	3	-	-	15,000 (e)
Isophorone	25	9750	5200 (d)	15,000 (e)
2-Methyl Phenol	21	-	-	15,000 (e)
4-Methyl Phenol	56	-	-	15,000 (e)
N-Nitrosodiphenylamine	6	10	71.1 (b)	10,000 (f)
Phenol	6	2550	280 (c)	15,000 (e)
Arsenic	17	400	50 (a,b)	100 (f)
Cadmium	256	-	5 (b)	1000 (f)
Chromium	127	-	120 (b)	10,000 (f)
Copper	673	-	1300 (b)	8000 (f)
Lead	23	220	20 (a,b)	100 (f)
Nickel	168	2720	150 (b)	1000 (f)
Zinc	8120	3060	-	30 (f)

(a) Based on Federal Safe Drinking Water Act Primary Maximum Contaminant Level
(b) Based on State of Minnesota Recommended Allowable Drinking Water Limits
(c) Based on Federal Office of Drinking Water Health Advisories (Relative Source Contribution) for long-term exposure (to be considered only)
(d) Based on Federal Clean Water Act Water Quality Criteria for Human Health adjusted for Toxicity Protection (to be considered only)
(e) Based on MPCA Division of Water Quality proposed effluent limitation
(f) Based on Threshold in inhibitory effect for activated sludge plants U.S.EPA/530-SW-86-004 (to be considered only)

cancer risk posed by the soils is less than $1x10^{-6}$. The levels of lead in three of the soil samples could result in lead intakes which exceed the reference dose. Under future residential or commercial development, the cancer risk would exceed $1x10^{-6}$. Future use scenarios of light commercial/industrial development and residential development had incremental cancer risks of $4x10^{-5}$ and $1x10^{-4}$ respectively. Under both of these development scenarios, three soil samples had lead levels which could result in intakes of lead greater than the reference dose.

Surface Water and Sediment Contamination

Six surface water and sediment samples were collected from ponded water locations on the site. No pesticides or volatile organic compounds were found in any of the samples. Phenol phthalates and benzoic acid were detected in the samples. Naphthalene was detected in one sample. Elevated levels of inorganics were also detected.

The surface water bodies are not used for drinking water or recreation. Therefore, the surface water and sediments were not dealt with at this time. They will be considered during the overall site RI/FS.

ALTERNATIVES EVALUATION

The major objective of the feasibility study (FS) was to evaluate the need for an initial groundwater measure and possible actions which could be undertaken. As discussed above, this operable unit will not address soil remediation. This will be addressed in the subsequent RI/FS. Due to the limited scope of the RI/FS, which examined the threat to public health and the environment posed by the contaminated surficial aquifer, alternatives were formulated to achieve the following four goals:

- Minimize the potential for direct contaminant consumption;
- Control contaminant migration to the lower sand aquifer;
- Control contaminant migration to surface water; and
- Provide measures that will be consistent with the final site recommendations.

A comprehensive list of appropriate remedial technologies was identified for groundwater control. These technologies were screened based on the characteristics of the site and the characteristics of the contaminants. The technologies which survived the initial screening were further screened based on effectiveness, implementability and cost. Cost was only used between alternative technologies providing similar degrees of protection and treatment.

Technologies which satisfied the screening requirements were combined to form remedial action alternatives. Alternatives which could not guarantee consistency with future site work were dropped from consideration at this point in the evaluation process. The remaining alternatives ranged in scope from no action through complete lateral

containment of the surficial aquifer with groundwater extraction. The four alternatives developed are detailed below.

Alternative 1 - No Action

The no-action alternative is required by the National Contingency Plan (NCP) to be considered through the detailed analysis. It provides a baseline for comparison of other alternatives. Under the no-action alternative, no remedial measures would be undertaken at the South Andover site at the present time. The choice of the no action alternative at this time would not affect the U.S. EPA's and the MPCA's plans to perform a subsequent RI/FS at the South Andover site and is completely consistent with all future site work.

Alternative 2 - Alternative Water Supply

The alternative water supply alternative has the following three major components:

- Provide municipal water to private well users on or near the site;
- Monitor groundwater movement at the site; and
- Place restrictions on new wells on or near the site.

Connection to the municipal water supply would provide uncontaminated water to residences currently using their own private wells. Municipal water hookups would be provided to the eight residences sampled during the RI. Residential wells in both the surficial and lower aquifers will be properly abandoned to eliminate conduits for future migration of contaminants into the lower aquifer. This alternative would not affect future site work.

Groundwater monitoring will be used to detect lateral and vertical migration of contaminants. The monitoring will be coordinated with future site investigations. The well restrictions would eliminate the chance of new wells being installed in a contaminated aquifer.

Alternative 3 - Groundwater Extraction

The groundwater extraction alternative has the following four major components:

- Extract groundwater from the surficial aquifer;
- Provide municipal water to private well users on or near the site;
- Monitor groundwater movement at the site; and
- Place restrictions on new wells on or near the site.

The extraction wells would be located in or slightly downgradient of known contaminated groundwater areas. The wells would pump approximately 20 to 50 gpm (total). The extraction well system would control the horizontal migration of groundwater offsite and limit the vertical migration of contaminants into the lower aquifer by withdrawing the contaminated groundwater found in the surficial aquifer. The exact number and location of the wells will be determined during the remedial design process. Effects on the WDE extraction well system will be taken into consideration at this time.

The municipal water supply, groundwater monitoring, and restrictions on wells are the same as described in Alternative 2.

This alternative will not interfere with future site work. In addition, the gradients imposed by the extraction well system may be helpful in locating unknown areas of contamination.

Alternative 4 - Lateral Containment

The lateral containment option has the following five major components:

- Install a slurry wall around the site;
- Extract groundwater from the surficial aquifer;
- Provide municipal water to private well users on or near the site;
- Monitor groundwater movement at the site; and
- Place restrictions on new wells on or near the site.

This alternative incorporates all aspects of Alternative 3 with the addition of a circumferential slurry wall. The slurry wall will further limit horizontal groundwater contaminant migration and exclude clean water recharge from the surrounding aquifer. The entire site would be surrounded by the slurry wall which would average 30 feet in depth, 3 feet in width, and be approximately 5,800 feet long.

With a reasonable amount of coordination between the development of the workplan for the subsequent field work and the design of the slurry wall, this alternative should not affect future site work. This alternative, however, may limit future development to some extent.

Groundwater Discharge Options

Alternatives 3 and 4 involve groundwater extraction. It is necessary to provide for a discharge option for the extracted groundwater for both of these alternatives. Three possible discharge options were developed. The discharge options are as follows:

- Direct discharge to Coon Creek;
- Onsite treatment of groundwater with discharge to Coon Creek; and

- Discharge to the Metropolitan Waste Control Commission (MWCC) publically-owned treatment works (POTW).

The choice of groundwater discharge option will depend on preliminary work performed during the remedial design (RD) process. Information needed to make the final decision would include actual flow rates from the extraction wells, confirmation of the levels of acetone, methylene chloride and bis (2-ethylhexyl) phthalate present in the surficial aquifer, the National Pollution Discharge Elimination System (NPDES) permit requirements and possible interactions with the remedial action at the WDE site.

Direct discharge of the extracted groundwater to Coon Creek would require an NPDES permit. The NPDES permit sets specific contaminant discharge limits for the discharged waters. The discharge limits would be established by the State of Minnesota and would take into consideration the size and flow rate of Coon Creek, contaminant levels in Coon Creek from other sources and the uses of Coon Creek.

The levels of contaminants found in the surficial aquifer onsite currently exceed two of the proposed discharge limitations to Coon Creek provided by the MPCA. These compounds are toluene and bis (2-ethylhexyl) phthalate. The toluene level only exceeds the proposed discharge limitations in one monitoring well. The actual discharge level of toluene, when the discharge of all the extraction wells are combined, is expected to be below the discharge limitations. In this case, no treatment prior to discharging may be needed. The level of bis (2-ethylhexyl) phthalate significantly exceeds the proposed limitations, but has not been confirmed and may be a laboratory or sampling contaminant. The presence of this compound will be checked prior to determining the discharge option. The cost of the direct discharge is $160,000. A detailed breakdown of the cost is shown in Table 3.

If the NPDES discharge limits are exceeded by the extracted groundwater, onsite treatment of groundwater prior to discharging to Coon Creek would be provided as needed to meet proposed NPDES discharge limits established by the MPCA. A possible system was analyzed in the FS which would remove inorganic, volatile organic and base/neutral organic contamination through the use of an inorganic metal precipitator, an anthracite-greensand filter, an air stripper, and a granulated activated carbon system. This system is anticipated to meet a "best available technology economically achievable" criteria for the treatment of groundwater. Additional sample results during the remedial design may indicate parts of the system are unnecessary. This option would require significant operation and maintenance. Therefore, the maximum present worth cost of an onsite treatment system is $1,700,000. A detailed breakdown of the cost is shown in Table 3.

TABLE 3

COST SUMMARY

ASSEMBLED ALTERNATIVE	CAPITAL COST	REPLACEMENT COST	OPERATION & MAINT.	PRESENT WORTH
Alternative 1 NO ACTION	$0	$0	$0	$0
Alternative 2 ALTERNATIVE WATER SUPPLY	$65,000	$0	$48,000	$520,000
Alternative 3 GROUNDWATER EXTRACTION	$290,000	$50,100	$48,000	$760,000
Alternative 4 LATERAL CONTAINMENT	$3,000,000	$50,100	$48,000	$3,500,000

DISCHARGE OPTIONS	CAPITAL COST	REPLACEMENT COST	OPERATION & MAINT.	PRESENT WORTH
DISCHARGE TO COON CREEK	$160,000	$0	$0	$160,000
ON-SITE TREATMENT - DISCHARGE TO COON CREEK	$430,000	$32,000	$140,000	$1,700,000
DISCHARGE TO POTW	$26,000	$0	$31,000	$320,000

The discharge to a POTW option would entail sending the extracted groundwater to the MWCC wastewater treatment system. The onsite sanitary sewer lines could be used for this purpose. The MWCC POTW has adequate capacity and is in compliance with all of its discharge permits. The highest level for each of contaminants found in the surficial aquifer onsite meet the pretreatment limits for the POTW with the exception of acetone and zinc. The levels of acetone and zinc that will be present in the combined discharge of the extraction wells are expected to meet the pretreatment standards. The addition of the discharge stream is expected to have little if any effect on the MWCC treatment system due to the low contaminant levels and flow rates. The present worth cost for this option is $320,000. A detailed breakdown of the cost is presented in Table 3.

SUMMARY OF COMPARATIVE ANALYSIS OF ALTERNATIVES

The four alternatives assembled were evaluated based on the following nine criteria:

- Overall protection of human health and the environment;
- Compliance with all federal and state applicable or relevant and appropriate requirements (ARARs);
- Reduction of toxicity, mobility or volume;
- Short term effectiveness;
- Long term effectiveness;
- Implementability;
- Cost;
- Community acceptance; and
- State acceptance.

A summary of the relative performance of the alternatives with respect to each of the nine criteria is provided in this section.

Alternatives 2, 3 and 4 would all be effective in protecting public health from ingestion and inhalation of the contaminants detected in the upper aquifer and possibly present in the lower aquifer. By providing municipal water to homes in the vicinity of the site, potential exposure to contaminated groundwater is eliminated. Additionally, Alternatives 3 and 4 provide a level of current and future protection to the environment by limiting contaminant migration offsite or into the lower aquifer through extraction of contaminated groundwater from the surficial aquifer. Alternative 2 does not provide protection to environmental receptors. Alternative 1 does not provide protection to human health or the environment.

Compliance with ARARs dealing with cleanup levels are not necessary for operable units. However, while the operable unit does not have to meet these ARARs, the final remedy will. Therefore, it is desirable that this remedy meet all ARARs.

The primary ARARs for this initial groundwater operable unit are the maximum concentration limits (MCLs) under the Safe Drinking Water Act (SDWA). MCLs are applicable where the water will be provided directly to 25 or more people or will be supplied to 15 or more service connections. MCLs are relevant and appropriate where surface water or groundwater is or may otherwise be used for drinking water. Alternatives 1 and 2 do not address the contaminated groundwater and, therefore, do not meet the SDWA ARARs. No reasonable grounds exist at the present time to justify a waiver of this requirement at the present time for Alternatives 1 and 2. Alternatives 3 and 4 meet the SDWA's MCLs by removing the contaminated groundwater in the surficial aquifer which has been found to exceed the MCLs. Also considered ARARs for the groundwater operable unit are the RCRA groundwater protection standards. These use background, MCLs or alternate concentration limits (ACLs) as the cleanup level. The criteria for choosing between background, MCLs and ACLs are detailed In 40 CFR Part 264.94.

Because the operable unit is being implemented for the purpose of controlling contaminant migration as opposed to restoring the surficial aquifer, the extraction well system will operate until the completion of the subsequent RI/FS regardless of future contaminant levels. Final cleanup levels will be established as a part of the subsequent RI/FS.

Additional ARARs, which are related to discharge options, would need to be met if either Alternatives 3 or 4 were chosen. These include the Clean Water Act, which covers discharges to surface water bodies, the Clean Air Act, which covers air emissions and POTW pretreatment requirements, which cover contaminant levels being discharged to a POTW. The relevant ARARs will be met by the discharge option chosen.

The criterion dealing with the reduction of toxicity, mobility or volume of contaminants only considers reductions due to treatment. Alternatives 1 and 2 do not incorporate any treatment. These alternatives, therefore, do not reduce toxicity, mobility or volume. Alternatives 3 and 4 would involve treatment if either the discharge to POTW option or the onsite treatment with discharge to Coon Creek option is chosen. Both of these discharge options involve treatment which would significantly reduce mobility and volume. If direct discharge to Coon Creek is chosen, neither Alternative 3 nor 4 would involve treatment.

Alternatives 2, 3 and 4 provide a high degree of effectiveness in the short term in achieving prompt protection of human health with no significant adverse effects resulting from the implementation of the remedy. The hook-up to municipal water supplies would not require any significant time delays and is very effective in protecting the public from any potential risks due to consumption of contaminated groundwater.

Alternatives 3 and 4 are protective of the environment in the short term. The anticipated implementation timeframe may be somewhat longer for Alternative 4 due to the time required to design and construct a slurry wall. The no action alternative is not adequately protective of human health or the environment.

Alternatives 2, 3 and 4 are effective in providing long term protection of human health. The hook-up to municipal water eliminates the need to use groundwater on or near the site, but does not address the contamination present in the shallow aquifer or the threat to the lower aquifer. Alternatives 3 and 4 provide a moderate level of long term effectiveness with regard to protection of the environment by controlling contaminant migration. Neither Alternative 3 or 4 eliminates the downward flow gradient through the aquitard or removes contaminants already present in the aquitard, but both decrease the volume of downward flow from the surficial aquifer and the volume of contaminants present in the upper aquifer that pose a threat to the lower aquifer. Long term issues will be addressed more fully in the a subsequent RI/FS. The no action alternative is not adequately protective of human health and the environment.

The implementability of each alternative is based on the technical feasibility, administrative feasibility and the availability of services and materials for the alternative. All of the alternatives are technically feasible. They all involve technologies which have been used regularly in the past and have a demonstrated performance record. All of the alternatives are administratively feasible. Alternatives 3 and 4 would require obtaining a NPDES permit if a surface water discharge is used. Approval of the MWCC would be necessary if the POTW discharge is chosen for Alternative 3 or 4. Alternative 4 may require additional steps and time delays during design and in obtaining access and clearing junk automobiles from around the site prior to the construction of a slurry wall. The services and materials required for each alternative are expected to be readily available.

There are no costs associated with Alternative 1, the no action alternative. Alternative 2 has a total present worth cost of $520,000. Alternative 3 has a total present worth cost of $760,000. Alternative 4 has a total present worth cost of $3,500,000. Alternatives 3 and 4 would have the additional costs associated with the chosen discharge option. A summary of the costs for each alternative is provided in Table 3. Alternative 4 is not felt to offer significant increases in protectiveness to public health and the environment, short term effectiveness or long term effectiveness for the extra cost.

Limited comments were received from the community regarding the various alternatives considered. The comments received indicated the communities concern regarding the discharge options which were considered in the event a groundwater extraction alternative was chosen. These comments indicated a general opposition from the community, including

representatives from Anoka County, to a discharge to Coon Creek. Representatives from the City of Andover expressed concern regarding any discharge to the City's sewer system due to the volume limits set by the MWCC for the City and the resulting displacement of potential future development.

The State of Minnesota, through the MPCA, has been actively involved in the RI/FS process for the South Andover site. The MPCA concurs with the U.S. EPA's selected alternative. The selected alternative must be presented to Minnesota's Citizen Review Board prior to the State's commitment to fund 10 percent of the remedial action.

SELECTED ALTERNATIVE

Based on available data and analysis conducted to date, the U.S. EPA selects Alternative 3 as the most appropriate solution for meeting the goals of the initial groundwater operable unit at the South Andover site. The characteristics of Alternative 3 that are considered most important are:

- The alternative provides immediate protection to human health from the potential threats associated with consumption of groundwater from the site.

- The alternative limits migration of groundwater offsite and controls migration of contaminants into the aquitard and lower aquifers.

- The alternative provides for management of surface water quality through monitoring of contaminant levels in the surficial aquifer and possible surface water discharges.

- The alternative is consistent with additional site actions and will be compatible with the final site remedy.

Clean-up Levels

The initial groundwater operable unit is being implemented for the purpose of controlling contaminant migration not restoration of the surficial aquifer to drinking water standards. Therefore, no cleanup levels are being established at this time. The extraction system will operate until the completion of the subsequent RI/FS. At that time, the groundwater operable unit will be incorporated into the overall site remedy and clean-up levels will be set. The levels to be set are expected to meet all Federal and State ARARs.

Due to the discontinuous and possibly intermittent nature of the contamination, continuous extraction of the groundwater would provide a more reliable migration control system than one which would pump only

when analytical data indicates a contaminant specific or risk specific action level was exceeded. The continuous extraction is also supported by the predominately downward gradient which exists through the aquitard. By increasing the horizontal gradient through the remainder of the study, the chances of capturing contaminants, prior to them entering the aquitard, is increased.

A second important advantage of continuous extraction is that extraction could significantly aid the subsequent RI in locating potential sources of contamination. Previous efforts, using monitor wells and soil gas analysis, did not locate any source areas of high concentration in groundwater or soil. The gradients caused by the extraction wells will potentially draw in pockets of high contamination and facilitate the pinpointing of the source areas.

Operation and Maintenance

The recommended alternative requires a certain degree of annual operation and maintenance (O&M) activity to ensure that groundwater will be extracted and treated to meet the clean-up levels. The degree of O&M cannot be determined until the discharge option is selected. Direct discharge to Coon Creek and discharge to the POTW would both require monitoring of the discharge contaminant levels. An O&M plan will need to be developed during remedial design after the groundwater discharge option has been chosen.

A groundwater monitoring plan will also need to be developed and implemented to determine if contaminants have migrated offsite or into the lower aquifer. This can be incorporated into the subsequent RI/FS work planned for the site.

All O&M responsibilities will be covered as specified in Section 104(c) of SARA. The O&M plan will be reviewed at the completion of the subsequent RI/FS and be incorporated into the final remedy.

STATUTORY DETERMINATIONS

The U.S. EPA and MPCA believe that this remedy will satisfy the statutory requirements of providing protection of human health and the environment, attaining applicable or relevant and appropriate requirements of other environmental statutes, will be cost-effective, and will utilize permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable. The choice of discharge option for the extracted groundwater will determine whether this operable unit will satisfy the preference for treatment as a principal element.

Protection of Human Health and the Environment

The selected remedy provides adequate protection of human health and the environment by preventing consumption of contaminated groundwater through the provision of an alternate water supply, limiting offsite migration if contaminated groundwater and protecting the deeper aquifer from becoming contaminated by the implementation of a groundwater extraction system.

Additional controls on exposure are achieved through restrictions on new wells on or near the site and through monitoring of groundwater at the site.

Attainment of Applicable or Relevant and Appropriate Requirements

This remedy will ensure that drinking water to be supplied to current private well users will attain MCLs under the SDWA and that the discharge from the groundwater extraction system will meet NPDES limitations under the Clean Water Act if discharged to Coon Creek.

Cost-Effectiveness

This alternative affords a high degree of overall effectiveness in not only protecting existing well users against exposure to contaminated groundwater through the provision of an alternate water supply, but also in halting further migration of the contaminated groundwater offsite and into the lower drinking water aquifer through the extraction system. The present worth cost of this action will range from $920,000 to $2,460,000 depending on the discharge option selected during design. This compares with the $3,500,000 required to construct a slurry wall around the site. U.S. EPA believes the costs of the selected remedy are proportionate to the overall effectiveness it affords such that it represents a reasonable value for the money.

Utilization of Permanent Solutions and Alternative Treatment Technologies or Resource Recovery Technologies to the Maximum Extent Practicable

U.S. EPA believes this remedy is the most appropriate solution for meeting the goals of the initial groundwater operable unit at the South Andover site providing the best balance among the evaluation criteria for the alternatives evaluated. This remedy provides effective protection in both the short- and long-term to potential human and environmental receptors, protects the deeper aquifer from becoming contaminated, is readily implemented, is cost effective and is consistent with future response actions that may be undertaken at the site.

Preference for Treatment as a Principal Element

Due to the limited scope of this remedy, which is not the final response action for any of the principal threats posed by the site, the statutory

preference for treatment may not be met. The choice of discharge option during design will determine if the preference is achieved. Subsequent actions are planned, however, that will definitively address the principal threats.

SCHEDULE

The remedial action start is one of the 175 sites comprising a statutory goal for remedial action starts by October 1989. The following are the key milestones for implementation of the remedial action in the event that RD/RA negotiations are not successful.

Approve Remedial Action (execute ROD)	March 1988
Initiate Remedial Design	June 1988
Complete Remedial Design	June 1989
Initiate Remedial Action (Award Contract)	September 1989

FUTURE ACTION

A detailed study of a large portion of the site was impossible due to the large volume of tires and junk automobiles present onsite. The tires are currently being shredded onsite and sent offsite. The operation is taking place under a grant from the Minnesota Waste Management Board and is scheduled to be completed by Spring 1989.

A subsequent RI/FS is planned for the site following the tire removal. The subsequent RI/FS will study and determine appropriate final groundwater remediation and source control measures.

SOUTH ANDOVER SITE
ANDOVER, MINNESOTA

RESPONSIVENESS SUMMARY

The United States Environmental Protection Agency (U.S. EPA) recently held a public comment period, February 1 - March 7, 1988, for interested parties to comment on the U.S. EPA's January 29, 1988 Feasibility Study (FS) and Proposed Plan for the initial groundwater operable unit for the South Andover site. At the beginning of the public comment period, the U.S. EPA announced its recommended alternative for the initial groundwater operable unit.

The purpose of this responsiveness summary is to document U.S. EPA's responses to comments received during the public comment period. All of the comments summarized in this documemt were considered by U.S. EPA in its final decision.

This responsiveness summary is divided into the following sections:

I. RESPONSIVENESS SUMMARY OVERVIEW - This section briefly outlines the proposed remedial alternatives evaluated in the FS, including the recommended alternative.

II. SUMMARY OF COMMENTS ON THE OPERABLE UNIT - This section summarizes both written and oral comments received from interested parties concerning the initial groundwater operable unit for the South Andover site.

III. SUMMARY OF ADDITIONAL COMMENTS RECEIVED - This section summarizes both written and oral comments received from interested parties but were not directed at the initial groundwater operable unit. These comments dealt with issues such as the subsequent RI/FS activity planned for the site.

I. RESPONSIVENESS SUMMARY OVERVIEW

A. Recommended Alternative

The feasibility study identified and evaluated alternatives for dealing with the contaminated surficial aquifer at the South Andover site. The alternatives were screened and evaluated based on the nine criteria detailed in the Summary of Remedial Alternatives.

The four alternatives which were carried into the detailed analysis were:

1. No Action
2. Alternative Water Supply
3. Groundwater Extraction
4. Complete Lateral Containment

U.S. EPA's recommendation was Alternative 3 - Groundwater Extraction. The major components of the selected remedy are as follows:

- Extract groundwater from the surficial aquifer;
- Provide municipal water to private well users on or near the site;
- Monitor groundwater movement at the site; and
- Place restrictions on new wells on or near the site.

The lower aquifers and surface soil contamination at the site will be dealt with in the subsequent RI/FS.

B. Public Comments on the Remedial Alternatives

Two representatives of the City of Andover, one representative of Anoka County and one private citizen submitted formal written comments to U.S. EPA during the public comment period. In addition, a number of oral comments were received from representatives from the City of Andover, Anoka County and private citizens at the public meeting held on February 8, 1988. The comments received covered this operable unit as well as subsequent work planned for the site.

II. SUMMARY OF COMMENTS ON THE OPERABLE UNIT

The following section summarizes written and oral comments received from interested parties. Many of the comments were edited for clarity or when multiple parties made a similar comment.

COMMENT:

Any air stripping required for onsite treatment of groundwater should be located away from residential areas.

U.S. EPA's RESPONSE:

U.S. EPA agrees that protection of human health in all areas including residential areas is a primary concern. The location of the air stripper will be carefully selected if the onsite treatment option is chosen. The location will need to consider human health and engineering concerns. Any discharge from an onsite air stripper will be monitored regularly. The levels of contaminants emitted from the air stripper will not pose a threat to human health.

COMMENT:

The treatment center should be located in the middle of the site.

U.S. EPA's RESPONSE:

A number of factors need to be considered in choosing the location of any possible treatment location. These include protection of public health, engineering considerations and access. The location of any treatment center will be determined during the design stage if onsite treatment is chosen.

COMMENT:

Contaminated surface soils should be removed to prevent contaminant migration to groundwater.

U.S. EPA's RESPONSE:

Current investigation efforts have been unable to locate areas of soil contamination significant enough to be considered sources of groundwater contamination. Part of the subsequent RI/FS work planned is to locate potential source areas.

COMMENT:

A definitive time table for the corrective action is needed, stating specific actions to be performed.

U.S. EPA's RESPONSE:

A detailed time schedule is not available at the current time. The potentially responsible parties (PRPs) have 60 days within which to present a good faith proposal to the U.S. EPA to perform the remedial action chosen. If a good faith proposal is made, the negotiation period may be extended for an additional 60 days. If negotiations are unsuccessful, the

U.S. EPA or the Minnesota Pollution Control Agency (MPCA) will procure a contractor to design the recommended alternative. It is the U.S. EPA's intention to keep all interested parties up to date with the progress at the site.

COMMENT:

Can sewer lines penetrate the slurry wall if one is constructed? If so, what would the City of Andover's liabilities be?

U.S. EPA's RESPONSE:

Yes, sewer and water lines can go through the slurry wall. However, special considerations would be made during the design of the slurry wall to prevent leakage from occurring around the lines. Factors to be considered are the location of the pipes entering the slurry wall and groundwater conditions. The chance of leakage around and infiltration into the sewer and water lines could decrease the integrity of the slurry wall. However, U.S. EPA is not recommending a slurry wall at this site.

The City of Andover and all other parties would need to limit construction immediately around the site so as not to damage the wall. If negligent activities occur, all parties involved may be liable for costs incurred.

COMMENT:

As an alternative to deed restrictions, the Federal, State, Local and private bodies should work together to: 1) Remove all tires as soon as possible to allow completion of the final FS, 2) Remove contaminated soils, 3) Combine the sewer and water facilities for the newly developed commercial park buildings, and locate the cleanup wells to utilize these facilities using a joint effort to allow simultaneous cleanup and development, and 4) Remove existing buildings or hook them up to municipal water and sewer.

U.S. EPA's RESPONSE:

The U.S. EPA has considered these suggestions. However, U.S. EPA does not believe it is in the best interest of public health and the environment to delay implementation of the extraction well system, the hook-up to municipal water, and the restriction on drinking water wells until the final RI/FS is completed. U.S. EPA, in conjunction with the State of Minnesota, is attempting to expedite the tire removal so the subsequent investigations can be completed. Soil removal options will be considered as part of the subsequent work at the site. The City's desire to have the South Andover property developed in the future will be considered when determining the overall site remedy.

COMMENT:

The discharge of extracted groundwater to the Andover sewer system could have a negative effect on the City's development capabilities by using up allotted volume. Perhaps the discharge could be hooked up to the City of Coon Rapids' sewer system.

U.S. EPA's RESPONSE:

The U.S. EPA respects the concerns of the City of Andover regarding the impact on development posed by the possible discharge to the City's sewer system. This impact, as well as the possibility of using Coon Rapids' system, will be considered prior to choosing the discharge option. U.S. EPA and MPCA will coordinate and involve the affected local governments.

COMMENT:

There is a concern that the discharge to Coon Creek from the South Andover site, when combined with the proposed discharge from the WDE site, might create problems such as high runoff rates, high sediment levels and increased turbidity.

U.S. EPA's RESPONSE:

The U.S. EPA is agrees with these concerns and will work closely with the surface water sections within U.S. EPA and the MPCA to minimize all impacts on Coon Creek if the option to discharge to Coon Creek is chosen. The discharge must not exceed any State water quality criteria and must meet the requirements of the National Pollution Discharge Elimination System (NPDES) permit which will need to be obtained if a Coon Creek discharge is chosen.

COMMENT:

The choice of discharging to Coon Creek may delay the permitting process for both the WDE and the South Andover site.

U.S. EPA's RESPONSE:

The U.S. EPA is interested in moving forward on both the WDE and the South Andover site. Every effort will be made to prevent one site from affecting the timing of activities at the other. If it appears that substantial time delays in permitting will occur it will be considered in choosing the discharge option. It is U.S. EPA's intention, however, to choose the most cost-effective option which is protective of public health and the environment.

COMMENT:

At the discharge point, the flow from the discharge should be parallel to the flow of the creek.

U.S. EPA's RESPONSE:

The discharge system will be designed in a manner which will minimize potential negative impacts on the creek. Options such as having the discharge run parallel to the flow of the creek will definitely be considered if the discharge to Coon Creek option is chosen.

COMMENT:

The extracted groundwater should not be discharged into the wetlands.

U.S. EPA's RESPONSE:

The U.S. EPA agrees. The option of discharging to the wetlands was eliminated in the FS report.

COMMENT:

Any discharge to Coon Creek should be properly treated prior to the discharge.

U.S. EPA's RESPONSE:

The U.S. EPA agrees. If the discharge to Coon Creek is chosen, an NPDES permit will need to be obtained. This permit will specify what contaminant levels can exist in the discharge. The extracted groundwater will need to be treated to the degree necessary to meet the permit levels.

COMMENT:

There is a fear among the people in the area that discharging water from the South Andover site, treated or untreated, into Coon Creek could be dangerous.

U.S. EPA's RESPONSE:

The U.S. EPA understands the concerns of the people in the area and wants to reassure them that any action taken by U.S. EPA will be protective of public health and the environment. An NPDES permit will be required if a discharge to Coon Creek is chosen. The permit will take into consideration

creek volume, existing contamination levels, and discharge flow rates in determining acceptable discharge levels which will be protective to the public and the environment.

COMMENT:

There is a concern that the Coon Creek discharge option might jeopardize the WDE cleanup project.

U.S. EPA's RESPONSE:

The U.S. EPA is firmly committed to moving forward on both the South Andover and the WDE remediations. The impact of a Coon Creek discharge from the South Andover site on the WDE site will be considered prior to choosing the discharge option. Discussions with Federal and State representatives working on the WDE site indicate that the two projects should not interfere with each other.

COMMENT:

Actions should be taken to coordinate with the WDE project to prevent overburdening the creek.

U.S. EPA's RESPONSE:

The actions planned for the two projects will be coordinated. Part of the process for obtaining an NPDES permit is the consideration of other sources of contamination to the receiving surface water body (Coon Creek) and the overall load on the receiving body. The discharge levels authorized by the permit will be protective of public health and the environment.

COMMENT:

How will the pumping at the WDE site affect the migration of contaminants from the South Andover site?

U.S. EPA's RESPONSE:

Hydrogeologists working on both the WDE and South Andover site feel the two pumpout systems will not have any effect on each other.

COMMENT:

All actions except the "no action alternative" include deed restrictions on properties around the site, dealing with construction below grade and the

installation of drinking water wells. This seems unnecessary because no data indicates offsite migration of contaminants. If there is a risk or a potential risk, they should be dealt with onsite.

U.S. EPA's RESPONSE:

Restrictions on below grade construction and drinking water wells were discussed under Alternatives 2, 3 and 4. Only the restriction on drinking water wells was incorporated into the chosen alternative. The U.S. EPA prefers to deal with all risks and potential risks onsite, but believes the restriction planned for drinking water wells near the site is justified for the protection of public health. The well restrictions can be incorporated into the local requirement that all new developments to provide municipal water.

COMMENT:

Deed restrictions on surrounding properties are unfair and would have a negative impact on property values in the area. Measures to control and cleanup pollution should be done on the site.

U.S. EPA's RESPONSE:

The U.S. EPA understands the desire to avoid deed restrictions on offsite properties and to keep all cleanup work onsite. However, U.S. EPA's primary concern is the protection of human health. U.S. EPA, therefore, feels the restriction on drinking water wells are justified. The only deed restriction specified in this Record of Decision (ROD) is the ban on the installation of drinking water wells. The restriction is similar to the local requirement that all new developments provide municipal water. This restriction, therefore, should not have a significant effect on property values.

COMMENT:

A requirement that all future buildings in the area, in particular Good Value Homes, install certain venting to protect against gas migration from the site may affect saleability.

U.S. EPA's RESPONSE:

The U.S. EPA is not requiring any additional venting on new development at this time. A threat from gas migration from the site has not been shown at this time and it is anticipated that the extraction well system will serve as additional protection from this potential threat. The U.S. EPA

considered the option of venting as a protective measure, but concluded that the requirement of the vents could not be justified until the risk of gas migration was further investigated. This will be dealt with during the subsequent site work.

COMMENT:

The need for deed restrictions needs to be investigated in greater detail prior to imposing the restrictions.

U.S. EPA's RESPONSE:

The only deed restriction recommended in this action is the ban on the installation of drinking water wells on or near the site. This restriction is similar to existing local regulations which require all new developments to provide municipal water. The U.S. EPA believes the well restrictions are well supported in the FS. U.S. EPA agrees that further investigation is needed prior to imposing the additional restrictions, such as the requirement for venting systems on below grade construction, discussed in the FS, and is not implementing them at this time. The necessity of the additional restrictions will be studied during subsequent work at the site.

COMMENT:

U.S. EPA should define what is, and what is not, subject to development on the Good Value Homes property.

U.S. EPA's RESPONSE:

The U.S. EPA does not currently have the information necessary to say which areas on the Good Value Homes property are environmentally safe for development. This will be investigated during the subsequent site work. The U.S. EPA and MPCA have been willing and are willing to meet with representatives of Good Value Homes to discuss the planned development and what the representatives of Good Value Homes can do to determine the risk posed by potential gas migration.

COMMENT:

The City of Andover has created a Tax Increment Financing District (TIF) for the redevelopment and cleanup of junkyard districts. If deed restrictions of any sort would be put on the site properties, a negative impact to the programs goals may occur.

U.S. EPA's RESPONSE:

The U.S. EPA appreciates the City's concern regarding the impact of deed restrictions of the TIF. The U.S. EPA's primary concern, however, is protection of public health. Based on this concern, the U.S. EPA believes it is justified in imposing restrictions on drinking water wells on or near the site as a part of this operable unit. Based on the information gathered during the subsequent investigations, and any subsequent remedial actions, the well restrictions may be removed in the future. The well restrictions are similar to current local regulations requiring all new developments to provide municipal water and, therefore, should not have a substantial effect on development.

COMMENT:

The maintenance cost of the pump out system appears unreasonably low.

U.S. EPA's RESPONSE:

The cost estimates are based on experience from work on previous sites and from contacting vendors familiar with the processes. The estimates are felt to be in the plus 50%/minus 30% cost range specified in the feasibility study guidance. More detailed cost estimates will be generated during design.

COMMENT:

The cost of the municipal water connection seems low. The estimate does not include the extension of water mains which may be needed.

U.S. EPA's RESPONSE:

During the FS, it was determined that no extension of water mains would be required for the recommended actions. The costs of connecting the private well users to municipal water was based on experience from work on other sites and is believed to fall into the estimate range specified in the feasibility study guidance.

III. SUMMARY OF ADDITIONAL COMMENTS RECEIVED

The following section summarizes written and oral comments received from interested parties. These comments do not deal specifically with the proposed action. Many of the comments were edited for clarity or when multiple parties made a similar comment.

COMMENT:

The U.S. EPA should expedite all additional work on the site.

U.S. EPA's RESPONSE:

It is the goal of the U.S. EPA to complete the RI/FS process for the South Andover site and initiate the final remedy as soon as possible. The U.S. EPA is currently working with The MPCA and the Minnesota Waste Control Board to expedite the tire removal to allow completion of the investigation.

COMMENT:

The downward gradient in the southeast corner of the site, near well 1, should be defined as soon as possible.

U.S. EPA's RESPONSE:

Well 1 is located on the southwest corner of the site, not the southeast. The downward gradient at this location as well as additional work on the lower sand aquifer will be investigated during the subsequent field work. It is the goal of U.S. EPA and MPCA to complete the subsequent work as soon as possible.

COMMENT:

There are not as many tires on the South Andover site as U.S. EPA claims. It is possible to reach any point on the site by simply moving the tires. U.S. EPA has no reason to use the tires as an excuse for delaying more active and positive action at the site.

U.S. EPA's RESPONSE:

A large percentage of the site work could not be performed during the initial field work due to the large volume of tires. The number of tires onsite has been reduced since that time. However, enough of the site is still covered to prevent some of the activities planned for the site from being completed. This includes geophysical work such as electromagnatometry or ground penetrating radar. In addition, due to the size of the site, much of the soil sampling will be conducted by visually locating areas of contamination. This cannot be done with the amount of tires still present.

COMMENT:

Future site work is planned for the lower sand aquifer and the aquitard. The current report, however, does not project any time schedule for such activities. It would be helpful to know the timing and scope of these activities.

U.S. EPA's RESPONSE:

A detailed schedule for these activities has not yet been prepared. There are still questions regarding when the tire removal will be sufficiently complete to allow the subsequent work planned for the site. The subsequent fieldwork at the South Andover site is tentatively scheduled to begin in the spring of 1989. The U.S. EPA will make the information available to the public once a schedule has been determined.

COMMENT:

The soil gas issue should be dealt with onsite with vents or whatever is necessary.

U.S. EPA's RESPONSE:

The issue of potential soil gas problems will be studied in the subsequent work planned for the site. All possible options will be considered during the subsequent FS. Another public comment period will be held prior to choosing a course of action.

COMMENT:

The communication between U.S. EPA, MPCA, local governments and the public has been a disappointment throughout the project.

U.S. EPA's RESPONSE:

U.S. EPA agrees that greater communication between all concerned parties is desirable and beneficial. It is U.S. EPA's intention to improve the communication among all concerned parties throughout the remainder of the project by providing information in a timely manner.

COMMENT:

A citizen expressed concern stating that the City of Andover had diverted storm water into a ditch on her property. She also stated that the City had pumped groundwater that smelled like sewer water onto her property. She feels the City has been taking advantage of her.

U.S. EPA's RESPONSE:

The issue presented is not associated with the South Andover site or other Superfund site. U.S. EPA, therefore, is not in a position to comment on, or become involved in a private citizen's individual issues.

APPENDIX B

TECHNICAL MEMORANDUM
SOIL BORING/WELL INSTALLATION PROGRAM

MEMORANDUM

DATE: October 30, 1990

TO: Dave Voight, Site Manager
South Andover Superfund Site

FROM: Tom Puchalski, Hydrogeologist

SUBJECT: EPA ARCS Region V Program
Donohue Project No. 20022

South Andover Design Investigation

INTRODUCTION

Field activities performed for the South Andover Design Investigation involved the drilling and sampling of six borings, installation of six groundwater monitoring wells, abandonment of four groundwater monitoring wells, the repair of one protective casing cover, the development of all newly installed wells, purging and sampling of several existing groundwater monitoring wells, sampling of newly installed wells, and sampling of residential wells near the site. This memo describes drilling, sampling, and well installation activities.

Well installation activities began on August 21, 1990, and were completed September 17, 1990. Soil borings, sampling, well installation, and well development were completed by Exploration Technology, Inc. (ETI), (Eden Prairie, Minnesota) under the supervision of a Donohue & Associates, Inc., hydrogeologist. A ETI subcontractor, Steven's Well Drilling, drilled two 50-foot, 12-inch diameter borings for double-cased wells described below. Field documentation, including borings logs, time logs, field notes, atmospheric monitoring logs, well development logs, and well installation diagrams were relinquished to the site manager at the completion of drilling activities.

Three types of drill rigs were used during field activities on this site. Most of the drilling and sampling was done using a Central Mine Equipment (CME) 750 drill rig. Some of the shallow wells were drilled using a CME 550, and two large diameter boreholes (12-inch) were drilled to the top of the aquitard at approximately 50 feet using a subcontracted water well rig.

PROCEDURES

Observation Wells

Borings drilled for observation well installations at locations B6A-R and W23A-R were drilled with 4-1/4 inch inside diameter (I.D.) hollow-stem augers and continuously sampled. Three-inch outside diameter (O.D.) stainless steel

split spoons were used when samples were collected for chemical analysis. Samples not intended for chemical analysis were collected with a 2-inch O.D. standard steel split spoons were used. All samples were field screened for contamination immediately after collection using a photoionization detector (PID).

Field screening of samples was accomplished by slowly running the probe of the PID along the entire length of the sample after the split spoon was broken open. No detections were registered during PID scans of samples retrieved during the Design Investigation. The air quality above the borehole was also periodically monitored using the PID and lumidor gasponder. No detections were registered on the instruments within the breathing zone for volatiles, hydrogen sulfide, % oxygen, and Lower Explosive Limit (LEL).

Observation wells were installed so that the screen would intersect the water table with 3 feet of screen above the water table. These installations ranged from 15 feet for well W23A and 22 feet for well W6A-R. Shallow and intermediate wells were installed in 8-inch diameter boreholes. Deep wells were installed in 6-inch diameter boreholes.

Well construction materials consisted of schedule 5, Type 304, 2-inch I.D., stainless steel riser and 10-foot, continuous wrap, 0.010-inch slot, stainless steel screens (Wesco). The well riser was terminated 2 to 3 feet above the ground surface. A sand pack (Unimi Granusil No. 20 silica sand) was installed in the annular space around the well screen from the boring bottom to 1 to 3 feet above the top of the well screen. A bentonite seal was installed from the top of the filter pack to 2 to 3 feet above the filter pack. A bentonite slurry was used for this seal in intermediate (W6B-R, W7B-R) and deep (W1-CR, W7C) wells. Bentonite seals in wells W23A-R and W6A-R consisted of bentonite pellets (Enviroplug No. 8), which were hydrated a minimum of 1/2 hour. The remainder of the annular space was grouted by tremie pipe with cement/bentonite grout Grout mixtures contained Northwestern Type I or Lehigh Type IA air-entrained portland cement and less than 2 percent by weight Wyo-Gel Naturalgel-powdered bentonite. Locking 8-foot (for intermediate and deep piezometers) or 5-foot (for observation wells) steel protective covers were installed into the cement/bentonite grout. A concrete collar was formed to hold the protective casing in place.

Intermediate Wells

Intermediate piezometers W7B-R and W6B-R were installed near the bottom of the upper sand aquifer at depths of 55 and 50 feet, respectively. Hollow-stem augers (4-1/4 inch I.D.) producing an 8-inch diameter borehole were used for these well installations. Well installation materials and construction methods were the same as described for observation wells, except a 5-foot screen was used.

Deep Double-Cased Wells

Deep piezometers W1C-R and W7C were installed below the lacustrine aquitard near the top of the lower sand aquifer. Double-cased well installation methods were used during these installations to prevent potential cross-contamination between the upper and lower sand aquifers. Steven's Well Drilling, a subcontractor to Exploration Technology, used a water well drilling rig to drill 12 inch diameter boreholes for the installation of outer well casings.

Drilling activities at W1C-R began by drilling and sampling through 4-1/4 inch I.D. hollow stem augers to a depth of 55 feet. The lacustrine aquitard was encountered at 52.0 feet. The original auger borehole was overdrilled with a 12 inch diameter bit by the water well rig. Eight inch diameter steel casing was installed in the overdrilled boring and driven an additional 1.5 feet into the aquitard. The annular space between the 12 inch borehole and the 8 inch casing was grouted using a cement-bentonite grout.

After chemical sampling to the aquitard in boring B-7BR, the boring for the installation of W7C was blind-drilled with a 12 inch hole, 3 feet into the aquitard to a depth of 58-feet. Eight inch steel casing was installed and driven an additional two feet to a depth of 60-feet. The annular space between the boring wall and 8 inch casing was filled with cement bentonite grout. Both outer casing installations were undisturbed for several days to allow the annular space grout to set.

Six-inch temporary casing was telescoped through the outer eight inch casing to stabilize the boring during drilling and sampling in the aquitard and lower sand units at deep well locations. The boring was advanced using mud rotary methods and a 5-7/8 inch tricone roller bit. Drilling mud was flushed from the borehole with clear water prior to the well installation. The six inch temporary casing was back-hammered out of the boring during well installation. Well installation methods and materials were identical to those used for intermediate wells.

Well Abandonment

Four existing groundwater wells which were installed during previous site investigations were abandoned. All abandonments were completed to the requirements of State of Minnesota regulations. Three water table wells, B6A, W23A, and W11A, required abandonment. After pulling the protective casing, W11A was overdrilled with 4-1/4 inch I.D. hollow-stem augers to the measured bottom of the well screen. The annular space remaining after overdrilling was grouted by tremie pipe as the augers were removed.

After grouting the inside of the riser and screen by tremie pipe, the casing was pulled from the ground at all three shallow well locations. Grout consisted of approximately 7 gallons of water for every 94-pound bag of portland cement and 2 pounds of bentonite powder. Boreholes were backfilled with grout to be level with the ground surface.

Well W1C was abandoned by initially tremieing cement/bentonite from an obstruction in the well at 10 feet. Five feet of 8-inch outer casing was pulled from the ground. The remaining 2-inch stainless well riser was cut off 2 feet below ground surface and backfilled to ground level with cement bentonite.

Field Modifications

Two field modifications were required during boring, sampling, and well installation activities. At boring B7B-R the sampling interval was changed from continuous to 5-foot at depths below 10 feet. Sampling at 5-foot intervals was continued from a depth of 10 feet to the total depth of 58 feet in boring B7B-R. This modification was necessary due to the blow back of "flowing sands" into the augers. To retrieve samples free of blow-back sand it was necessary to flush the hollow stem augers with water. Flushing was most effectively accomplished at 5-foot intervals concurrent with adding auger flights. Since stratigraphy was apparently consistent at these sampling depths, and no evidence of chemical contamination was present, it is assumed that no significant stratigraphic or information on chemical contamination was missed due to this sampling modification.

A second field modification was a change from collecting three suites of samples per borehole for chemical analysis, to retaining six suites of samples in nested well locations (W7B-R, W7C and W6A-R, W6B-R). Due to the destruction of two of three available stainless steel split spoon samplers during sampling activities only four suites of samples were collected for the W6A-R and W6B-R nest. The remaining stainless split spoon was saved to sample the lowest portion of these boreholes at the expense of missing two chemical sample intervals higher up in the borehole. No evidence of chemical contamination was detected in this borehole, as determined by PID scanning of the samples.

ARCS/R/SANDOVER/AT6

APPENDIX C

SOIL BORING LOGS

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COMPUTER AIDED DESIGN/DRAFTING

BORING LOG

SITE: South Andover
PROJECT NO. 20022.002

SOIL BORING NO. B-6A-R
Sheet 1 of 1

DRILLING METHOD: 4¼ HSA
TYPE OF RIG: CME 550
FOREMAN: Dan North
ASSISTANT: Jimmy Callicoat
GEOL./ENG'R: Tom Puchalski
LOG BY: TEP

WATER LEVEL READINGS

DATE	TIME	DEPTH	
			W.D.
			A.C.R.
			HRS. A.D.
			HRS. A.D.

GROUND SURFACE ELEV.:
DATE START:
DATE COMPLETE: 8/23/90
DATE ABANDONED:
COORDINATES:
NORTH:
EAST:

DEPTH TO CHANGES IN STRATA	DEPTH IN FEET	SAMPLING DATA NO.	T	A	R	PENETRATION 1st	2nd	3rd	N	USCS	SOIL DESCRIPTION	DRILLING COMMENTS
		1				6	10	19	33	SP	D. 10YR 5/3 Brn fr gra SAND, ¼" black streaks FILL moist; Tire chunks as 1.5' FILL	Hna=0 9:30 Sam; VOA 0-2' 9:3; CCHD 0-2' 9:42
								14		SP	Black; 10YR 4/2 Dk grayish brown SAND	
		2				8	6	7	16	SP	MD, 10YR 5/4 Yllwish brn SAND fr gra, moist; Outwash	Hna=0 9:40
								9				
	5	3				7	9	9	17	SP	MD, 10YR 6/4 Lt Yllwish brn SAND fr gra, moist; Outwash	Hna=0 9:47 Sam; Hna=0.5 BH 0-A
								8				BH { 20.5 HCL=00; LEL=00 CO=00
		4				8	7	7	14	SP	MD, 10YR 6/4 Lt Yllwish brn SAND, fr gra, moist; non coh Outwash	Hna=0 9:50 Sam
								7				
		5				4	5	6	12	SP	MD, 10YR 7/3 Very Pale Brn fr gra SAND moist, non coh Outwash	Hna=0 9:59 Sam; LEL=00; BH { % O2=21.0 CO=00 H2S=00
								6				
	10					7	11	11	24	SP	MD, 10YR 6/4 Lt Yllwish Brn fr gra SAND moist; not coh, changes to mdgra 11.5-11.8' fr gra 11.8-12'	VOA - 10-12 10; COMP - 10-12 10
								13			trace ½" clay, small gvl, sharp Outwash	Hna=0 10:12 Sam
						8	11	6	11	SP	MD, 10YR 6/3 Pale Brn fr gra SAND fr gra, stratified, one ¼" black layer at 12.4' moist	Hna=0 10:20 Sam
								5	▼		mdgra 10YR 7/6 Yllw SAND, non coh Outwash	Geotech 10:22 B
						2	5	5	12	SP	MD, 5YR 4/6 Yllwish red fr gra SAND in upper 4" changing to 10YR 7/2 Lt gray SAND - fr gra 10% red gra trace ½" sharp small gvl saturated Outwash	Hna=0 10:29 - B; LEL=002; BH { %O2=21.0 CO=00 H2S=00 EAD=000 } 10:30
	15							7				
						2	0	6	11	SP	MD, 5Y 5/2 Olive gray layered fr SAND stratified with darker div & black layers ½" thick mica flakes throughout, non coh, saturated Outwash	Hna=0 10:46 Sample
								5				
						2	2	7	25	SP	MD, 5Y 5/2 Olive gray fr SAND color change to 5Y 5/1 gray SAND at 21' saturated Outwash	Hna=0 11:03 - Sample
								18				
	20					5	8	2	6	SP	fr 5Y 4/1 Dk gray fr gra SAND ¼" band of black silt at 21.3', mica flakes throughout	Hna=0 1329 - Sample
								4				
						16	19	16	23	SP	MD SAND as above - only 2-3" recovery	
								7				
						20	69	53	81	SP	MD 5Y 5/1 Gray SAND fr gra	Hna=0 Sample; VOA 24-26
	25							28				COMP 24-26

E.O.B. 26.0' 1330 Paint thinner odor

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COMPUTER AIDED DESIGN/DRAFTING

BORING LOG

SITE: South Andover PROJECT NO. 20022.002

SOIL BORING NO. B6B-2

DRILLING METHOD: HSA 4¼
FOREMAN: Dan North
ASSISTANT: Jimmy Cullicoat
GEOL./ENG'R: Tom Puchalski
LOG BY: TFP

WATER LEVEL READINGS

DATE	TIME	DEPTH	
			W.D.
			S.C.R.
			A.C.R.
			HRS. A.D.
			HRS. A.D.

GROUND SURFACE ELEV.
PHYSICAL SETTING:
DATE START: 8/24/90
DATE COMPLETE: 8/24/90

DEPTH TO CHANGES IN STRATA	DEPTH IN FEET	SAMPLING DATA NO.	T	A	R	PENETRATION 1st	2nd	3rd	N	USCS	SOIL DESCRIPTION	COMMENTS
	24	1	3"			25	36	19	42	SM	D, 5Y 5/1 Gray SILTY SAND, [illegible] coh, sat, 20%	935 Borehole - Hmu=0 CO=0ppm LEL=0 O2=20.5
											S.LT 80% fn gra SAND	
								23		ML	5Y 5/1 Gray SILT, low coh, sat	Hmu=1 938 Not enough sample for collection
	26	2	2"			5	6	4	14	ML	5Y, 5Y 5/1 Gray SILT stratified, mod coh, 10% clay, saturated LACUSTRINE	Hmu = Not functioning correctly - Now Hmu=0
								10				955
	28	3				8	27	13	26	SM	MD, 5Y 5/1 Gray SILTY SAND, non coh, sat 20% silt fn gra	956 Hmu=0 - Sample
								13		ML	5Y 5/1 Gray SILT, stratified, LACUSTRINE	
	30	4				26	19	12	28	SM	MD, 5Y 5/1 Gray SILTY SAND, non coh, sat 20% silt fn gra sand, trace ½" gvl-sbang, Outwash	Hmu=0 - Sample 1009
								16				
	32	5				19	33	29	61	SM	VD, 5Y 5/1 Gray SILTY SAND, non coh, sat 20% silt Outwash	Borehole LEL 001 10:2 SO_2 20.1 CO 000 H2S 000
								29				
	34	6				5	3	6	13	SM	D, 10YR 4/1 Dark Gray SILTY SAND 10% sin gvl ¼-½" sbang, sat Outwash	Hmu=0 1050
								7				
	36	7				26	22	4	20	SP	MD, 5Y 5/1 Gray SAND, fn gra, non coh, sat	Hmu=0 1114
										SP	Medium gra. fens Outwash	
								16			fn gra lean SILTY SAND Till	
	38	8				8	10	20	46	SM	D, 5Y 5/1 Gray SILTY SAND, non coh, sat	
								7		SM		
	40	9				2	0	2	6	SM	L, 10YR 4/2 Dk grayish brn SILTY SAND, low coh, 20% SILT 10% ¼" sbang gvl, sat Till	Hmu=0 1111
								4				
	42	10				24	36	16	52	SP	D, 5Y 5/2 Grayish Brown SAND, fn gra, sat co gra shod sand Outwash	No Hmu Available
								22		SM	Grayish Brn SILTY SAND, fn gra, to ¼" sbang gvl, 20% silt, saturated Till	
	44	11				32	50	30	82	SP	VD, 10YR 5/3 Brown fn gra SAND OUTWASH	No Hmu Available
											co gra SP	
	46	12				9	18	20	80	SP	10YR 5/2 Grayish Brown fn gra SAND to ½" sbang gvl, sat, OUTWASH	Hmu=0 1545
										SP	As above Outwash	
								51		ML	10YR 4/2 Dk Grayish Brn SILT, saturated	
	48	13				7	16	20	36	SP	H, 10YR 5/2 Grayish Brn SAND Outwash	Hmu=0 1610
								17		ML	10YR 4/2 Dk Grayish Brn SILT	
	50	14				13	19	20	67	ML	10YR 4/2 Dk Grayish Brn SILT, low coh, moist, stratified LACUSTRINE	Hmu=0 1634 VOA = 1635

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BORING LOG

SOIL BORING NO. B68-R

SITE: South Andover PROJECT NO. 20022.002

DRILLING METHOD: 4¼ HSA
FOREMAN: Rob Cahoe
ASSISTANT: Jimmy Callicoat
GEOL./ENG'R. Tom Puchalski
LOG BY: TEP

WATER LEVEL READINGS

DATE	TIME	DEPTH	
			W.D.
			S.C.R.
			A.C.R.
			HRS. A.D.
			HRS. A.D.

GROUND SURFACE ELEV.
PHYSICAL SETTING:
DATE START: 8/24/90
DATE COMPLETE: 8/24/90

DEPTH TO CHANGES IN STRATA	DEPTH IN FEET	SAMPLING DATA NO.	T	A	R	PENETRATION 1st	2nd	3rd	N	USCS	SOIL DESCRIPTION	COMMENTS
	53	15				18	32	50 6.5	50+	ML	M, 10YR 4/2 Dk Grayish Brn SILT low col, moist, non plas, ~~trace~~ LACUSTRINE	Hom=0 1654 Sampler
	54										E.OB. 1700, SS to 54.0' HSA to 50.0' 8/24/90 TEP	

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BORING LOG

SITE: S. Andover PROJECT NO. 20022.002 SOIL BORING NO. B-7B-R

DRILLING METHOD: HSA 4¼
FOREMAN: Greg Scallon
ASSISTANT: Jim Gallicoat
GEOL./ENG'R: Tom Pielvalski
LOG BY: TP

WATER LEVEL READINGS

DATE	TIME	DEPTH	
			W.D.
			S.C.R.
			A.C.R.
			HRS. A.D.
			HRS. A.D.

GROUND SURFACE ELEV.
PHYSICAL SETTING:
DATE START: 8/27/90
DATE COMPLETE:

DEPTH TO CHANGES IN STRATA	DEPTH IN FEET	SAMPLING DATA NO.	T	A	R	PENETRATION 1st	2nd	3rd	N	USCS	SOIL DESCRIPTION	COMMENTS
		1				1	2	2	4	SM	VL, 10YR 3/2 Very Dark Grayish brown SILTY SAND, non coh, moist, mets 20% SILT 80% fn Sand Outwash	Hm = 0.1 1000 VOA CCMT 1000
								2				
	2					2	2	3	5	SP	L, 10YR 5/6 Yellowish Brn SAND fn grn, 10% silt non coh, moist Outwash	Hm=0 1013 Simple
								3				
	4					3	3	5	11	SP	MD, 10YR 5/6 Yellowish Brn SAND fn grn, non coh, moist Outwash Hm=0 1021	Borehole CC 0 10CS 2.0 LEC 0 MS 0
								6				
	6					3	2	2	4	SP	VL, 10YR 6/4 Yellowish Brn SAND fn grn, non coh moist, Outwash	Hm=0 1025
								2				
	8					4	2	3	5	SP	L 10YR 6/3 Pale Brn SAND fn grn, occasional high moisture layers ¼" bands, non coh, moist Outwash	Hm=0 1028
								3				
	10											
	12											
	14					5	5	5	11	SP	MD 10YR 6/3 Pale Brn SAND major, moist non coh Outwash	Hm=0 1042 Simple
								6				
	16											
	18											
	20					5	7	8	15	SP	VL 10YR 6/3 Pale Brn SAND fn grn moist non coh, tr ¼-½" strong gvl. Outwash	Hm=0 1044 Simple
								3				
	22											
	24					3	5	5	9	SP	L, 10YR 3/2 Very Dk Grayish Brn SAND, fn grn Borehole sc to rounded, trace ½" gvl strong 10YR 5/3 Brn SAND as above	CC 0 7CS 0.2 LEC 0 MS 0
								4				
	26										GEOTECH 24-26 Hm=0 1058 Sample	Hm=0 1051

CC 0
7CS 0.2
LEC 0
MS 0

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BORING LOG

SITE: S. ANDOVER PROJECT NO. 20022.002

SOIL BORING NO. B-7B-R

DRILLING METHOD:
FOREMAN:
ASSISTANT:
GEOL./ENG'R.
LOG BY:

WATER LEVEL READINGS

DATE	TIME	DEPTH	
			W.D.
			S.C.R.
			A.C.R.
			HRS. A.D.
			HRS. A.D.

GROUND SURFACE ELEV.
PHYSICAL SETTING:
DATE START: 8/27/90
DATE COMPLETE: 8/27/90

DEPTH TO CHANGES IN STRATA	DEPTH IN FEET	SAMPLING DATA NO.	T	A	R	PENETRATION 1st	2nd	3rd	N	USCS	SOIL DESCRIPTION	COMMENTS
	28											
	30					3	6	8	17	SP	MD 10YR 5/3 Brown SAND with fr gra, co sand increasing with depth, non calc, saturated	Hm=0 1121
								9		GW	Range from coarse to 1/2" gravel 10/20/70 fr/cc/gvl well graded gravel silty SAND 6:/4c SND/SILT	
	32											
	34					13	13	14	29	SP	MD 10YR 5/3 Brn SAND 60% 30% 1/2" gvl	Hm=0 1128 Sample
								15		SP ML	No GVL COLOR CHANGE TO 10YR 5/1 Gray 5Y 5/1 Gray SILT, stratified	VCA 1128 COMP
	36											
	38											
	40					11	23	34	53	SM	MD 5Y 5/1 Gray SILTY SAND 20% silt low calc, saturated	Hm=0 1200
								29		ML	5Y 5/1 Gray SILT	
	42											
	44					6	6	15	20	SP	MD, 5Y 5/1 Gray SAND coarse and larger	Hm=0 1312 VCA COMP 1312
	46							17		SM	Fr gra SILTY SAND trace organics Weak layers stratified 5Y 5/1 Gray wet	
	48											
	50					0	0	1	2	SM	[illegible] Fr gra SILTY SAND 20% silt low calc saturated	Hm=0 1355
								1				
	52											
	54											

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BORING LOG

SITE: South Andover PROJECT NO. 20077.007

SOIL BORING NO. B-7B-R

DRILLING METHOD: HSA 4¼
FOREMAN: Greg Scallon
ASSISTANT: Jim Callicoat
GEOL. ~~ENG'R~~: Tom Puchalski
LOG BY: TP

WATER LEVEL READINGS

DATE	TIME	DEPTH	
			W.D.
			S.C.R.
			A.C.R.
			HRS. A.D.
			HRS. A.D.

GROUND SURFACE ELEV.
PHYSICAL SETTING:
DATE START: 8/27/90
DATE COMPLETE: 8/27/90

DEPTH TO CHANGES IN STRATA	DEPTH IN FEET	SAMPLING DATA NO.	T	A	R	PENETRATION 1st	2nd	3rd	N	USCS	SOIL DESCRIPTION	COMMENTS
	54					9	10	14	37	SM	D. olive gray 5Y 4/2 fn SILTY SAND 20% slt tr sm gv	Hmm=0 1436 XCR
								23		ML	10YR 4/2 Dk grayish brn SILT, stratified low cohs, non plas, saturated LACUSTRINE	COMP
	56					10	17	34	51	ML	H 10YR 4/2 Dk grayish brn SILT, stratified low cohs, non plas, sat LACUSTRINE	
								37				
	58										EOB 1452 SC to 58' HSA to 56' TEP 8/27/90	
	60											

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BORING LOG

SITE: South Andover PROJECT NO. 200.22-002 SOIL BORING NO. B-7C

DRILLING METHOD: Tricone 5 7/8
FOREMAN: Greg Scallon
ASSISTANT: Jim Gallicoat
GEOL./ENGR: Tom Puchalski
LOG BY: TP

WATER LEVEL READINGS

DATE	TIME	DEPTH	
			W.D.
			S.C.R.
			A.C.R.
			HRS. A.D.
			HRS. A.D.

GROUND SURFACE ELEV.
PHYSICAL SETTING:
DATE START: 9/6/90
DATE COMPLETE: 9/7/90

DEPTH TO CHANGES IN STRATA	DEPTH IN FEET	SAMPLING DATA NO.	T	A	R	PENETRATION 1st	2nd	3rd	N	USCS	SOIL DESCRIPTION	COMMENTS
	58					13	25	50				61.0 Blind drilling to 58.0 by water well rig.
						38	9/6/90					
	60											
	62	3" BS 2' blows				13	25	50	75	ML	H 10YR 4/2 Dark Grayish Brn SILT 20% Clay, 2-3" sbrd gvl, nonplas, loose, TILL moist	Only attempted 18" sample Hum=0 1300
	63-65											
	64					24	40	14	31	ML	H 10YR 4/2 Dk Grayish Brn SILT with 10% clay, large - 2" gvl sbrd, moist, nonplas, loose	Hum=0 1544 GEOTECH 64'-65'
		3" Brown				16	14	17 13	25	CL	H, 10YR 4/2 Dk Grayish Brn SILTY CLAY TILL, low plas, low cohesion, moist, trace 1/8-1/2" sbrd gvl TILL	Hum=0 1634 Sample VCA (GEOTECH) 64.5'
	66					16	14	20				
		Shelby				NO RECOVERY					Attempt Shelby tube	
	68										End of Test 1740	
		3" Good				25	30	44	115	CL	H, 10YR 4/2 Dk Grayish Brn SILTY CLAY, low plas, low cohesion, moist, trace 1/4-1/2" sbrd gvl TILL	Hum=0 930 Sample
	70							71				
		3" Good				24	22	42			NO RECOVERY	
	72							42				
						25	25	32	66	SM	M, 10YR 4/2 Dk Grayish Brn SILTY SAND to gvl, nonplas, loose, moist, trace clay	Hum=0 1012 Sample
	74							30		ML	10YR 4/2 Dk Grayish Brn SILT	
										ML	Stratified SILT 2.5Y 4/2 Dk Grayish Brn LACUSTRINE	
						14	16	24	49	ML	H, 2.5Y 4/2 Dk Grayish Brn SILT, stratified, nonplas, low cohesion, LACUSTRINE	Hum=0 1030 Sample
	76							45				
						15	22	26	65	ML	H, 10YR 4/1 Dk Gray SILT, stratified to 3" and bottom 4" saturated, nonplas, low cohesion, LACUSTRINE 10% Clay	Hum=0 1115 Sample
	78							39				
						10	12	17	28	ML	H, 10YR 4/1 Dark Gray SILT as above	Hum=0 1116 Sample
	80							18	35			
						24	34	37	68	ML	H, 10YR 4/1 Dk Gray SILT stratified, moist, nonplas, low cohesion, 10% Clay trace 1/4" sbrd gvl LACUSTRINE	Hum=0 1200 Sample
	82							39				
						12	15	30	45	ML	As above	Hum=0 1215 Sample
	84							75				

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COMPUTER AIDED DESIGN/DRAFTING

BORING LOG

SITE: South Gardiner PROJECT NO. 20022.002

SOIL BORING NO. B-7C

DRILLING METHOD: 5 7/8" tricone
FOREMAN: Greg Scallon
ASSISTANT: Jim Callicoat
GEOL./ENG'R: Tom Puchalski
LOG BY: TP

WATER LEVEL READINGS

DATE	TIME	DEPTH	
			W.D.
			S.C.R.
			A.C.R.
			HRS. A.D.
			HRS. A.D.

GROUND SURFACE ELEV.
PHYSICAL SETTING:
DATE START: 9/7/90
DATE COMPLETE:

DEPTH TO CHANGES IN STRATA	DEPTH IN FEET	SAMPLING DATA NO.	T	A	R	PENETRATION 1st	2nd	3rd	N	USCS	SOIL DESCRIPTION	COMMENTS
	86		3"			18	29	33	81	ML	H, 10 YR 4/2 Dk Grayish Brn SILT 10% Clay non plas, low cohe, moist LACUSTRINE	Hum=0 1400
								48				
	88		3"			11	12	15	47	ML	VD 10 YR 4/2 Dk Grayish Brn SILT 20% Clay, non plas, low coh, moist LACUSTRINE	Hum=0 1404
								39			massive	
	90		Shelby							ML	Shelby tube 1422 89-91' 100% Recovery	Hum=0 1440 CEL=000 CO=000 SO_2=31.0 H_2S=000
	92		3"			11	11	17	37	ML	H, 10YR 4/2 Dk Grayish Brn SILT 10-20% clay non plas, low coh, moist occasional 1/4" bands of 7.5YR 4/2 Brown Silty Clay massive LACUSTRINE	Hum=0 1505
								20				
	94		3"			15	20	18	39	ML	As above	Hum=0 1517
								18				
	96		3"			15	15	18	33	ML	As Above	Hum=0 1529
								18		CL	10YR 5/2 Grayish Brn SILTY CLAY 1/4" 7.5YR 4/2 Brn Silty Clay bands 1" apart, moist loose, stiff LACUSTRINE	
	98		3"			17	27	33	48	CL	H, 10 YR 5/2 Grayish Brn SILTY CLAY	Hum=0 1603
								35				
	100		2"			30	37	31	70	CL	As above	
								39		SM	VD, 7.5YR 4/2 Dark Brown SILTY SAND with gravel & trace clay 10% 2"-1/2" sub-rounded, hard, moist	Hum=0 1633
	102		3"			30	34	63	133	SM	Sat Saturated VD 10YR 4/3 Dark Brown SILTY SAND, 10% 1/2" gvl stoney, sat 20% silt 10% clay,	GEOTECH 100-101' Hum=0 1700 VOA Cam 102-103' 1703
								60				
	104		2"			7	10	30	61	SM	VD 10YR 4/3 Dk Brn SILTY SAND 20% silt trace 1/2" stoney gvl, sat, non coh,	Hum=0 1711
								31				
	106		2"			22	16	19	37	SM	D, 10YR 4/3 Dk Brn SILTY SAND, fine grained, 20% silt, trace clay, trace >2" to 1/2" stone gvl, moist w/ water	Hum=0 1745
								15				
	108										Eq 55 to 107' 5 7/8" to 115' 6" casing to 64.0' 1756 9/7/90	
	110										Blind drilled to 113' for well installation on 9/7 hole cleared 0/8 KC - caved to 111.0'	
	112											

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BORING LOG

SITE: S. Andover PROJECT NO. 20037.002

SOIL BORING NO. WIC-R

DRILLING METHOD: 4¼ HSA
FOREMAN: Dan North
ASSISTANT: Jimmy Callicoat
GEOL./ENG'R: TEP
LOG BY: TEP

WATER LEVEL READINGS

DATE	TIME	DEPTH	
			W.D.
			S.C.R.
			A.C.R.
			HRS. A.D.
			HRS. A.D.

GROUND SURFACE ELEV.
PHYSICAL SETTING: SW corr
DATE START: 8/20/90
DATE COMPLETE: 8/22/90

DEPTH TO CHANGES IN STRATA	DEPTH IN FEET	SAMPLING DATA NO.	T	A	R	PENETRATION 1st	2nd	3rd	N	USCS	SOIL DESCRIPTION	COMMENTS Hnw / H_2S / O_2 / LEL
		1	8"ss			3	3	7	13	SP	MD, 10YR 3/3 Dk brn SAND, fn grn, moist ~~lacustrine~~ top 3", outwash	0 - Sample 9:10, VOA - 9:10 - 0-2', COMP 9:22 0-2'
								6				
		2	8"ss			2	2	2	6	SP	L, 10YR 4/4 Dk Ylwish Brn SAND, fn grn, moist ~~lacustrine~~ outwash	Hnw=0 9:25 Sample
								4				
	5	3	3"ss			10	7	10	19	SP	MD, 10YR 6/6 Brnish Ylw SAND fn grn, damp ~~lacustrine~~ outwash	Hnw=0 9:31 - Sample H_2S = -000
								9				8288 Bardge % O_2 20.6 CO=000 LEL - 012 RAD=0
		4	8"ss			3	6	8	17	SP	MD, 10YR 6/6 Brnish Ylw SAND color strat. Red with 10YR 5/4 Ylwish Brn fn grn damp ~~lacustrine~~ outwash	Hnw=0 9:47 - Sample
								9				
		5				20	10	11	25	SP	MD, 10YR 6/4 Lt Ylwish Brn SAND color strat. fine with 5YR 5/6 Ylwish Red ½" layers moist to wet, fn grn, ~~lacustrine~~ outwash	Hnw=0 10:10 - Sample
								14				
	10	6				4	6	7	17	SP	MD, 10YR 6/4 Lt Ylwish Brn SAND, saturated fn grn ½" - 4" layers of black fn grn SAND ~~lacustrine~~ outwash	Hnw=0 10:13 - Sample
								9				
		7				7	5	5	11	SP	MD, 10YR 5/6 Ylwish Brn SAND, fn grn, sat COLOR CHANGE AT 13.5' 10YR 6/1 Lt Grey ~~lacustrine~~ outwash	Hnw=0 10:24 - Sample
								6				
	15	8				3	6	10	21	SP	MD, 10YR 7/1 Lt Grey fn grn SAND Hnw=0 10:35	Borehole Hnw=0 0:29 Sample H_2S = -000 CO = 000 % LEL = -012 % O_2 = 20.5
								11				
		9				14	24	28	65	SP	MD 10YR 6/2 Lt Brnish Grey fn grn SAND, sat 10% md grn	Hnw=0 11:10
								37				
		10				13	9	14	28	SP	MD 10YR 5/2 Grey ish Brn fn grn SAND, sat 10% md grn 10YR 5/6 Ylwish Brn fn SAND layer ½" thick 6" from screen tip	Hnw=0 11:20
								14				
	20	11				11	29	78	118	SP	MD 10YR 6/2 Lt Brnish Grey fn grn SAND, sat, ~~lacustrine~~ 10% md grn outwash	Hnw=0 1431 - Sample Borehole=0 1425
								5½" 100			GEOTECH 1437 20-22'	
		12				8	13	36	120	SP	MD, 10YR 6/2 Lt brownish grey fn grn SAND sat, ~~lacustrine~~ outwash	Borehole 1434 Hnw=0 1451 Sample H_2S 001 CO 000 % LEL -013 % O_2 19.5
								84				
	25	13				19	55	72	141	SP	MD 10YR 6/2 Lt brnish grey fn grn SAND 10% md sat, ~~lacustrine~~ outwash	Hnw=0 1459
								69				
		14				13	37	54	142	SP	As above Hnw=0 1527	
								88				

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BORING LOG

SITE: South Andover
PROJECT NO. 20022.002

SOIL BORING NO. W1C-R ~~B-1C-R~~
Sheet 2 of 3

DRILLING METHOD: 4¼ HSA
TYPE OF RIG: CME 550
FOREMAN: Dan North / Greg Sullivan
ASSISTANT: Jimmy Collicoat
GEOL./ENG'R: Tom Puchalski
LOG BY: TP

WATER LEVEL READINGS

DATE	TIME	DEPTH	
			W.D.
			A.C.R.
			HRS. A.D.
			HRS. A.D.

GROUND SURFACE ELEV.:
DATE START:
DATE COMPLETE:
DATE ABANDONED:
COORDINATES:
NORTH:
EAST:

DEPTH TO CHANGES IN STRATA	DEPTH IN FEET	SAMPLING DATA NO.	T	A	R	PENETRATION 1st	2nd	3rd	N	USCS	SOIL DESCRIPTION	DRILLING COMMENTS
		15				18	5	8	9	SP	VD. 10 YR 6/2 Lt brownish gray fn grn SAND, sat, LACUSTRINE	Hnu=0 1630 Sample
								10	0		OUTWASH	
	30											
		16				11	22	35	6	SP	VD. 10 YR 5/1 Gray fn grn SAND, sat, trace dk gray silt in ¼" bands Outwash	Hnu=0 1635 Sample H_2S=.001 CO=.000 CO_2=.012 Qz
								10	6/21			
		17				11	22	25	6	SP	VD. 10 YR 6/2 Lt brownish gray fn grn SAND sat, LACUSTRINE trace ½" strong brown coarse sand	Qz=21.2
								27			OUTWASH	
						5			1	SP	VL. 10 YR 4/1 Dk gray SAND trace silt, sat Outwash	Hnu=0 1775 Spoon fell after one blow.
	35					TR						
						5	8	13	22		MD. 10 YR 4/1 Dk gray SAND trace silt, sat Outwash	Hnu=0 1740
								9		ML	10 YR 4/1 Dk gray SILT, sat LACUSTRINE trace ¼" dipping slopes small gr	Hnu=0 1740
						16	9	10	22	SP	10 YR 4/1 Dk gray SAND as above Outwash	Hnu=0 1750
								12		ML	Dk gray SILT as above	
	40											
						12	22	24	40	ML	D. 10 YR 4/1 Dk gray SILT, lacustrine GEOTECH	Hnu=0 1832 40-42 1835
								26				
	42											
						15	55	32/50		SP	VD 10 YR 4/1 Dk gray SAND Outwash	Hnu=0 1906
										SM	10 YR 4/1 Dk gray SILTY SAND, fn grn, low con, sat	Pull Augers 8½
	44											Restart Hole 9½
						9	33	50/4"	83	SP	VD 10 YR 4/1 Dk gray SAND, non cah saturated	Hnu=0 1440 Sample 44-45.5 VBA Cor
										SM	Fn grn SILTY SAND 60% sand 40% SILT 10 YR 4/1 Dk gray	
	46					15	26	36	83	SP	VD. 10 YR 4/2 Grayish brown SAND, non cah, sat, fn grn	1514 Hnu=0
										SM	10 YR 4/2 Dk grayish brown SILTY SAND	
								47				
	48					10	29	67	121	SM	VD. 10 YR 4/2 Dk grayish brown SILTY SAND low con saturated 67% fn grn sand 33% silt	1525 Hnu=0
								54				
	50					15	26	36	69	SM	VD. 10 YR 4/2 Dk grayish brown SILTY SAND low con sat	1610 Hnu=0
								43				
	52									ML	10 YR 4/2 Dark grayish Brn SILT, moist	

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BORING LOG

SITE: South Cleveland PROJECT NO. 20079.007

SOIL BORING NO. WICR

DRILLING METHOD: HSA, 4 1/4" to 58'
FOREMAN: Greg Scallan
ASSISTANT: Dim Gallicoat
GEOL./ENG'R: Tom Puchalski
LOG BY: TEP

WATER LEVEL READINGS

DATE	TIME	DEPTH	
			W.D.
			S.C.R.
			A.C.R.
			HRS. A.D.
			HRS. A.D.

GROUND SURFACE ELEV.
PHYSICAL SETTING:
DATE START: 8/26/90
DATE COMPLETE:

DEPTH TO CHANGES IN STRATA	DEPTH IN FEET	SAMPLING DATA NO.	T	A	R	PENETRATION 1st	2nd	3rd	N	USCS	SOIL DESCRIPTION	COMMENTS
	52					5	6	8	24	ML	VST, 10YR 4/1 Dark Gray SILT, low cohesion, stratified, saturated LACUSTRINE	1636 Hum=0 GEOTECH 52-53
								16				
	54									ML	Poor Recovery - < 6" Did not keep for geotech analysis. Same as above	1648 Push Sample by
	56					10	8	8	15	ML	SE, 10YR 4/1 Dark Gray SILT, low cohesion, stratified, saturated LACUSTRINE	Hum=0 1730
								7			STOP 8/26/90 1730 SS to 58.0'	
	58					11	8	12	27	ML	VST, 10YR 4/1 Dark Gray SILT, 30% clay, non plastic, low cohesion, sat LACUSTRINE	Start 9/1/90 1405 Hum=0 1531
								15				
	60					6	6	8	17	CL	VST, 10YR 4/1 Dark Gray SILTY CLAY 60% Clay/Silt, low plas, low cohesion, stratified, sat LACUSTRINE	Hum=0 1532 Total C = 0.00 CO_2 = 0.00 H_2S = 0.00 CO = 0.00 1532 1542
								9				
	62					3	4	5	10		Push Shelby Tube 1540 No Recovery - Fell Out Bottom - Pounded Spoon	
								5		CL	10YR 4/1 Dark Gray SILTY CLAY 60% Clay/Silt, low plas, low cohesion, sat LACUSTRINE Push Shelby Tube 1620 100% Recovery	GEOTECH 63-64' 1616
	64											
	66					10	13	21	40	ML	10YR 4/1 Dark Gray SILT, non plas, sat, cohesion, LACUSTRINE VD 10YR 4/1 Dark Gray SILT, non plas, low cohesion, sat LACUSTRINE	Hum=0 1642
								19				
	68										END OF DAY 9/1/90	
		55				17	22	27	56	ML	VD [illegible] LACUSTRINE	Hum=0 1805
								29				
	70											
		55				14	22	29	82	ML	VD [illegible] LACUSTRINE	Hum=0 [illegible]
								53				
	72											
		55				21	26	35	74	ML	VD 10YR 4/1 Dk Gray SILT, non plas, low cohesion, sat, stratified LACUSTRINE	Hum=0 [illegible]
								39				
	74											
		55				16	24	29	61	ML	VD 10YR 4/1 Dk Gray SILT, non plas, low cohesion, sat, stratified LACUSTRINE	Hum= 847
								33				
	76											
		50				14	23	37	65	ML	As above	Hum=0 946
								33				
	78											
		55				17	22	26	48	ML	VD 10YR 4/1 Dk Gray SILT, non plas, low cohesion, sat, stratified LACUSTRINE	Hum=0 926

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BORING LOG

SITE: South Andover PROJECT NO. 20072.002

SOIL BORING NO. WIC-R. ~~BLC-R~~

DRILLING METHOD: 5 7/8" tricone
FOREMAN: Greg Scallon
ASSISTANT: Jim Callicoat
GEOL./ENG'R: Tom Puchalski
LOG BY: TEP

WATER LEVEL READINGS

DATE	TIME	DEPTH	
			W.D.
			S.C.R.
			A.C.R.
			HRS. A.D.
			HRS. A.D.

GROUND SURFACE ELEV.
PHYSICAL SETTING:
DATE START: 8/9/10/90
DATE COMPLETE:

DEPTH TO CHANGES IN STRATA	DEPTH IN FEET	SAMPLING DATA NO.	T	A	R	PENETRATION 1st	2nd	3rd	N	USCS	SOIL DESCRIPTION	COMMENTS
	80	8"	SS			13	17	19	56	ML	H, 10YR 4/1 Dk Gray SILT some, low cohesion, non plas stratified 5YR 4/2 1/2" thick clay layers-blocky at 8.0', 8.1', 8.5' 8.8'	Hum=0 934
	82	8"	SS			13	13	20	56	ML	H, 10YR 4/1 Dk Gray SILT, 1/2" thick clay layers & 4" apart clay layers blocky silt massive to stratified near clay layers, low coh, non plas, saturated LACUSTRINE	Hum=0 1000
	84	8"	SS			24	26	27	76	ML	As above	Hum=0 1136
	86	8"	SS			4	4	7	22	SM	MD, 10YR 4/3 Dark Grayish Brown SILTY SAND fine to crs 15-20% silt trace 1/2" stained gvl Saturated	Hum=0 1140
	88	8"	SS			23	29	27	76	SM	VD, 10YR 4/2 Dark Grayish Brown SILTY SAND 80/20 fn sand/small gvl trace 2" stained gvl Saturated	Hum=0 1205 NOA COMP 1210
	90	4"	SS			40	65	50/5"		SM	VD 10YR 4/2 Dk Grayish Brn SILTY SAND 80/20 fn sand/small gvl trace 3" or larger gvl Split spoon to 92 Overdrill to 95' E.O.B. 1241 9/10/90 SEP Cased to 90' [illegible]	
	92											
	94											
	96											
	98											
	100											

Sheet ___ of ___

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COMPUTER AIDED DESIGN/DRAFTING

BORING LOG

SITE: South Andover PROJECT NO. 00022.002 SOIL BORING NO. ~~B-23A~~ W23A-R

DRILLING METHOD: HSA - Split Spoon
FOREMAN: Paul Sbornitini
ASSISTANT: Jay Rose
GEOL./ENG'R. Lewis Richardson
LOG BY:

WATER LEVEL READINGS

DATE	TIME	DEPTH	
9-17	1500	6.5	W.D. (added 8 gallons)
9-17	1525	3.8	S.C.R.
			A.C.R.
			HRS. A.D.
			HRS. A.D.

GROUND SURFACE ELEV.
PHYSICAL SETTING: Flat, Small Trees East wet
DATE START: 9-17-90
DATE COMPLETE:

DEPTH TO CHANGES IN STRATA	DEPTH IN FEET	SAMPLING DATA NO.	T	A	R	PENETRATION 1st	2nd	3rd	N	USCS	SOIL DESCRIPTION	COMMENTS
	1	① 3" SS				3	5	6	11	SM	Med Dense 10YR 5/2 silty fine sand, few organics, dense, trace fine sand, no pebbles or gravel	Fill
	2							13				Fill Material
	3		2" SS			8	10	13	26		And Dense 10YR 2/1 + N 2/0 silty fine sand with few organics, common pebbles & gravel asphalt-like material, strong	
	4							13				
	5		2" SS			1	2	3	6	SW	Gravel > silty fine sand, some constituents, large cobbles at 4'	
	6							3			N 2/0 silt and 35% undecomposed organic matter, moist, no coarse material, wetland soil, slightly cohesive	Water at 4.5' ▼
	7	② 3" SS				1	2	6	13		Med Dense	
	8							7		SP	10YR 5/2 poorly graded fine sand with med sand (glacial) moist	
	9		2" SS			3	3	3	7		Loose 5Y 5/1 Med sand poorly graded, saturated with fine sand, layered no coarse material	
	10							4				
	11		2" SS			7	7	8	15		Med Dense 5Y 4/1 silty poorly graded med fine sand, no coarse sand, trace gravel, saturated, coarse sand increases at 12' increase pebbles	
	12							7				
	13	③ 3" SS				6	9	12	21	SW	Med Dense	
	14							15		SP	5Y 4/3 poorly graded fine sand, layered, saturated no coarse or fine material, no organics	
	15										End hole at 14' in layered sand	
	16										Added 25 gallons to remove or prevent heaving sand.	

APPENDIX D

MINNESOTA DEPARTMENT OF HEALTH WELL INSTALLATION FORMS

STATE OF MINNESOTA — DEPARTMENT OF HEALTH

WATER WELL RECORD
Minnesota Statutes 156A.01-08

MINNESOTA UNIQUE WELL NO. for Water Sample: 462340

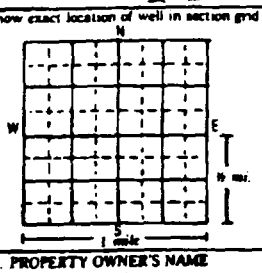
1. LOCATION OF WELL

County Name: Anoka

Township Name	Township Number	Range Number	Section No.	Fraction
Grow	32 N/S	24 E/W	34	¼ ¼ ¼

Numerical Street Address and City of Well Location or Distance from Road Intersection: 2050 ½ Bunker Lk. Rd. Andover, mn.

Show exact location of well in section grid with "X"

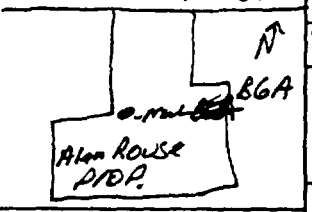


Addition Name

Block Number

Lot Number

Sketch map of well location



2. PROPERTY OWNER'S NAME: Alan Rouse

Mailing Address if different than property address indicated above:

Ex. 6 - PII

3. FORMATION LOG

FORMATION LOG	COLOR	HARDNESS OF FORMATION	FROM	TO
F. Sand	Brown		0	26

Use a second sheet, if needed

4. WELL DEPTH (completed): 22 ft.

Date of Completion: 9-10-90

5. DRILLING METHOD
☐ Cable Tool ☐ Reverse ☐ Driven ☐ Dug
☐ Hollow Rod ☐ Air ☐ Bored ☐ ____
☐ Rotary ☐ Jetted ☒ Power Auger

6. DRILLING FLUID: None

7. USE
☐ Domestic ☒ Monitoring ☐ Heat Pump
☐ Irrigation ☐ Public ☐ Industry
☐ Test Well ☐ Municipal ☐ Commercial
☐ Air Conditioning ☐ ____

8. CASING ☒ Stainless
☐ Black ☐ Threaded
☐ Galv. ☐ Welded
☐ Plastic ☐

HEIGHT: Above/Below Surface 2 ft.
Drive Shoe? Yes ___ No ___

2 in. to 12 ft. Weight ___ lbs./ft.
___ in. to ___ ft. Weight ___ lbs./ft.
___ in. to ___ ft. Weight ___ lbs./ft.

HOLE DIAM.
8 in. to 26 ft.
___ in. to ___ ft.
___ in. to ___ ft.

9. SCREEN
Make: Wesco
Type: SS Diam.: 2"
Slot/Gauze: 0.010 Length: 10'
Set between 12 ft. and 22 ft.
FITTINGS:
Or open hole from ___ ft. to ___ ft.

10. STATIC WATER LEVEL
___ ft. ☒ below ☐ above land surface Date Measured ___

11. PUMPING LEVEL (below land surface)
NA ft. after ___ hrs. pumping ___ g.p.m.
___ ft. after ___ hrs. pumping ___ g.p.m.

12. HEAD WELL COMPLETION
☐ Pitless adapter manufacturer ___ Model ___
☐ Basement offset ☒ At least 12" above ground
☐ Plastic casing protection ___

13. WELL GROUTED? ☒ Yes ☐ No
☒ Neat Cement ☐ Bentonite ☐ ____
Grout material: neat cement from 2 to 4 ft. cu. yds. ___

14. NEAREST SOURCES OF POSSIBLE CONTAMINATION
___ feet ___ direction ___ type
Well disinfected upon completion? ☐ Yes ☐ No

15. PUMP
Date installed: NA ☐ Not installed
Manufacturer's name ___
Model number ___ HP ___ Volts ___
Length of drop pipe ___ ft. Capacity ___ g.p.m.
Material of drop pipe ___
Type ☐ Submersible ☐ L.S. Turbine ☐ Reciprocating
☐ Jet ☐ Centrifugal ☐ ____

16. ABANDONED WELLS
Unused well on property? ☐ Yes ☐ No unknown
Sealed ☐ Permanent ☐ Temporary ☐ Not sealed

17. REMARKS, ELEVATION, SOURCE OF DATA, etc.

well # B6A

18. WATER WELL CONTRACTOR CERTIFICATION
This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

DPRA INC. (License Business Name) M0054 (License No.)
Address: E-1500 1st National Bank Bldg. St. Paul
Signed: [signature] (Authorized Representative) Date ___
ETI (Name of Driller) Date ___

IMPORTANT:
FILE WITH DEED – WELL OWNER COPY

462340

HE-01205-03 (Rev. 9/88)

5/74 30M
7/76 30M
7/78 30M
2/82 10M

STATE OF MINNESOTA DEPARTMENT OF HEALTH

WATER WELL RECORD

Minnesota Statutes 156A.01-.08

MINNESOTA UNIQUE WELL NO. for Water Sample: 462311

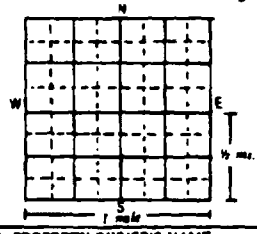
1. LOCATION OF WELL

County Name: Anoka

Township Name: Grow | Township Number: 32 N/S | Range Number: 24 E/W | Section No.: 34 | Fraction: ¼ ¼ ¼

Numerical Street Address and City of Well Location or Distance from Road Intersection: 2050 ½ Bunker LK. Rd. Andover, mn.

Show exact location of well in section grid with "X." Sketch map of well location. Bunker LK. Rd.



Addition Name

Block Number

Lot Number

2. PROPERTY OWNER'S NAME: Alan Rouse

Mailing Address if different than property address

Ex. 6 - PII

3. FORMATION LOG	COLOR	HARDNESS OF FORMATION	FROM	TO
Silty Sand	Gray		0	48
Silt	Brown		48	54

Use a second sheet, if needed

4. WELL DEPTH (completed): 50 ft. | Date of Completion: 9-10-90

5. DRILLING METHOD: ☐ Cable Tool ☐ Reverse ☐ Driven ☐ Dug ☐ Hollow Rod ☐ Air ☐ Bored ☐ ____ ☐ Rotary ☐ Jetted ☒ Power Auger

6. DRILLING FLUID: none

7. USE: ☐ Domestic ☒ Monitoring ☐ Heat Pump ☐ Irrigation ☐ Public ☐ Industry ☐ Test Well ☐ Municipal ☐ Commercial ☐ Air Conditioning ☐ ____

8. CASING: ☒ Steel ☐ Black ☐ Threaded ☐ Galv. ☐ Welded ☐ Plastic ☐

HEIGHT. Above/Below Surface ____ ft. Drive Shoe? Yes ____ No ____

____ in. to 45 ft. Weight ____ lbs./ft.

____ in. to ____ ft. Weight ____ lbs./ft.

____ in. to ____ ft. Weight ____ lbs./ft.

HOLE DIAM.: 8 in. to 54 ft.

9. SCREEN: Make Wesco; Type SS; Diam. 2"; Slot/Gauge 0.010; Length 5'; FITTINGS.; Set between 45 ft. and 50 ft.

Or open hole from ____ ft. to ____ ft.

10. STATIC WATER LEVEL: ____ ft. ☒ below ☐ above land surface. Date Measured ____

11. PUMPING LEVEL (below land surface): N/A ft. after ____ hrs. pumping ____ g.p.m.

____ ft. after ____ hrs. pumping ____ g.p.m.

12. HEAD WELL COMPLETION: ☐ Pitless adapter manufacturer ____ Model ____ ☐ Basement offset ☒ At least 12" above ground ☐ Plastic casing protection ____

13. WELL GROUTED? ☒ Yes ☐ No

☒ Neat Cement ☐ Bentonite ☐ ____

Grout material: Neat cement from 3 to 42 ft. cu. yds. ____

14. NEAREST SOURCES OF POSSIBLE CONTAMINATION: ____ feet ____ direction ____ type

Well disinfected upon completion? ☐ Yes ☐ No

15. PUMP: Date installed N/A ☐ Not installed

Manufacturer's name ____

Model number ____ HP ____ Volts ____

Length of drop pipe ____ ft. Capacity ____ g.p.m.

Material of drop pipe ____

Type: ☐ Submersible ☐ L.S. Turbine ☐ Reciprocating ☐ Jet ☐ Centrifugal ☐ ____

16. ABANDONED WELLS: Unused well on property? ☐ Yes ☐ No unknown

Sealed ☐ Permanent ☐ Temporary ☐ Not sealed

17. REMARKS, ELEVATION, SOURCE OF DATA, etc.

well # BGB

18. WATER WELL CONTRACTOR CERTIFICATION

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

DARA INC. — License Business Name

M0054 — License No.

Address: E-1500 1st National Bank Bld. St. Paul

Signed: Martin R. Berrell — Authorized Representative

ETI — Name of Driller

Date ____

IMPORTANT: 462311

5/74 30M
7/78 30M

STATE OF MINNESOTA DEPARTMENT OF HEALTH

WATER WELL RECORD

Minnesota Statutes 156A.01-.08

MINNESOTA UNIQUE WELL NO. for Water Sample: 462311

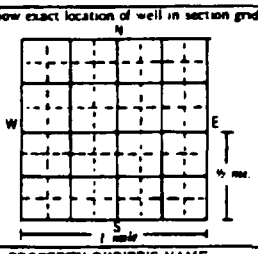
1. LOCATION OF WELL

County Name: Anoka

Township Name: Grow | Township Number: 32 N S | Range Number: 24 E W | Section No.: 34 | Fraction: ¼ ¼ ¼

Numerical Street Address and City of Well Location or Distance from Road Intersection: 2050½ Bunker Lk. Rd Andover, MN.

Show exact location of well in section grid with "X."

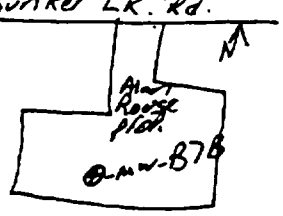


Addition Name

Block Number

Lot Number

Sketch map of well location.



2. PROPERTY OWNER'S NAME: Alan Rouse

Mailing Address if different than property address indicated above:

Ex. 6 - PII

3. FORMATION LOG

FORMATION LOG	COLOR	HARDNESS OF FORMATION	FROM	TO
Silty Sand	Grayish/Brown		0	58

Use a second sheet, if needed

4. WELL DEPTH (completed): 55 ft. | Date of Completion: 9-10-90

5. DRILLING METHOD: ☐ Cable Tool ☐ Reverse ☐ Driven ☐ Dug ☐ Hollow Rod ☐ Air ☐ Bored ☐ ____ ☐ Rotary ☐ Jetted ☒ Power Auger

6. DRILLING FLUID: none

7. USE: ☐ Domestic ☒ Monitoring ☐ Heat Pump ☐ Irrigation ☐ Public ☐ Industry ☐ Test Well ☐ Municipal ☐ Commercial ☐ Air Conditioning ☐ ____

8. CASING: X Stainless ☒ Threaded ☐ Galv ☐ Welded ☐ Plastic ☐

HEIGHT Above/Below Surface 2.0 ft. Drive Shoe? Yes ___ No ___

2 in. to 50 ft. Weight ___ lbs./ft.

___ in. to ___ ft. Weight ___ lbs./ft.

___ in. to ___ ft. Weight ___ lbs./ft.

HOLE DIAM: 8 in. to 58 ft.; ___ in. to ___ ft.; ___ in. to ___ ft.

9. SCREEN: Make nesco; Type SS; Diam. 2"; Slot/Gauze 0.010; Length 5'; Set between 50 ft. and 55 ft.

FITTINGS

Or open hole from ___ ft. to ___ ft.

10. STATIC WATER LEVEL: ___ ft. ☒ below ☐ above land surface. Date Measured ___

11. PUMPING LEVEL (below land surface): NA ft. after ___ hrs. pumping ___ g.p.m.; ___ ft. after ___ hrs. pumping ___ g.p.m.

12. HEAD WELL COMPLETION: ☐ Pitless adapter manufacturer ___ Model ___ ☐ Basement offset ☒ At least 12" above ground ☐ Plastic casing protection ___

13. WELL GROUTED? ☒ Yes ☐ No

☒ Neat Cement ☐ Bentonite ☐ ____

Grout material: neat cement from 3 to 47 ft. cu. yds. ___

14. NEAREST SOURCES OF POSSIBLE CONTAMINATION: ___ feet ___ direction ___ type

Well disinfected upon completion? ☐ Yes ☐ No

15. PUMP: Date installed NA ☐ Not installed

Manufacturer's name ___

Model number ___ HP ___ Volts ___

Length of drop pipe ___ ft. Capacity ___ g.p.m.

Material of drop pipe ___

Type: ☐ Submersible ☐ L.S. Turbine ☐ Reciprocating ☐ Jet ☐ Centrifugal ☐ ____

16. ABANDONED WELLS: Unused well on property? ☐ Yes ☐ No unknown

Sealed ☐ Permanent ☐ Temporary ☐ Not sealed

17. REMARKS, ELEVATION, SOURCE OF DATA, etc.

well # B7B

18. WATER WELL CONTRACTOR CERTIFICATION

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

DRA INC — License Business Name | M0054 — License No.

Address: E-1500 1st National Bank Bld. St. Paul

Signed: [signature] — Authorized Representative

ETI — Name of Driller | Date ___

IMPORTANT: 462344

S/74 30M
7/76 30M
7/78 30M

STATE OF MINNESOTA DEPARTMENT OF HEALTH

WATER WELL RECORD

Minnesota Statutes 156A.01-08

MINNESOTA UNIQUE WELL NO. for Water Sample: 462343

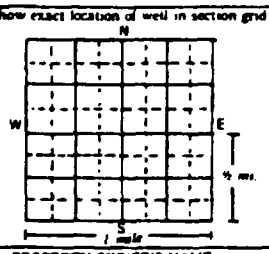
1. LOCATION OF WELL

County Name: Anoka

Township Name: Grow | Township Number: 32 N | Range Number: 24 E | Section No.: 34 | Fraction: ¼ ¼ ¼

Numerical Street Address and City of Well Location or Distance from Road Intersection: 2050's Bunker Lk. Rd. Andover, mn

Show exact location of well in section grid with "X."

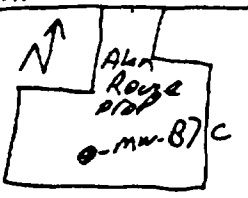


Addition Name

Block Number

Lot Number

Sketch map of well location.



2. PROPERTY OWNER'S NAME: Alan Rouse

Mailing Address if different than property address: Ex. 6 - PII

3. FORMATION LOG	COLOR	HARDNESS OF FORMATION	FROM	TO
Silty Sand	Gray/Brown		0	62
Silt	Gray/Brown		62	69
Silty Clay	Dk. Brown		69	73
Silty Sand	Dk. Brown		73	77
Silt	Gray		77	96
Silty Clay	Dk. Gray		96	100
Silty Sand	Dk. Brown		100	113

Use a second sheet, if needed

4. WELL DEPTH (completed): 105.5 ft. | Date of Completion:

5. DRILLING METHOD: ☐ Cable Tool ☐ Reverse ☐ Driven ☐ Dug ☐ Hollow Rod ☐ Air ☐ Bored ☐ ____ ☐ Rotary ☐ Jetted ☒ Power Auger

6. DRILLING FLUID: none

7. USE: ☐ Domestic ☒ Monitoring ☐ Heat Pump ☐ Irrigation ☐ Public ☐ Industry ☐ Test Well ☐ Municipal ☐ Commercial ☐ Air Conditioning ☐ ____

8. CASING: ☒ Stainless ☐ Black ☐ Threaded ☐ Galv. ☐ Welded ☐ Plastic ☐

HEIGHT Above-Below: Surface 2 ft. Drive Shoe? Yes ___ No ___

2 in. to 105.5 ft. Weight ___ lbs./ft.

___ in. to ___ ft. Weight ___ lbs./ft.

___ in. to ___ ft. Weight ___ lbs./ft.

HOLE DIAM.: 8 in. to 113 ft.

9. SCREEN: Make ~~Johnson~~ WESCO | Type SS | Diam. 2" | Slot/Gauze 0.010 | Length 5' | Set between 100.5 ft. and 105.5 ft. | FITTINGS: | Or open hole from ___ ft. to ___ ft.

10. STATIC WATER LEVEL: ___ ft. ☒ below ☐ above land surface | Date Measured ___

11. PUMPING LEVEL (below land surface): N/A ft. after ___ hrs. pumping ___ g.p.m.

___ ft. after ___ hrs. pumping ___ g.p.m.

12. HEAD WELL COMPLETION: ☐ Pitless adapter manufacturer ___ Model ___ ☐ Basement offset ☒ At least 12" above ground ☐ Plastic casing protection ___

13. WELL GROUTED? ☒ Yes ☐ No

☒ Neat Cement ☐ Bentonite ☐ ___

Grout material: neat cement from 3 to 97 ft. cu. yds. ___

14. NEAREST SOURCES OF POSSIBLE CONTAMINATION: ___ feet ___ direction ___ type

Well disinfected upon completion? ☐ Yes ☐ No

15. PUMP: Date installed N/A ☐ Not installed

Manufacturer's name ___

Model number ___ HP ___ Volts ___

Length of drop pipe ___ ft. Capacity ___ g.p.m.

Material of drop pipe ___

Type: ☐ Submersible ☐ L.S. Turbine ☐ Reciprocating ☐ Jet ☐ Centrifugal ☐ ___

16. ABANDONED WELLS: Unused well on property? ☐ Yes ☐ No unknown

Sealed ☐ Permanent ☐ Temporary ☐ Not sealed

17. REMARKS, ELEVATION, SOURCE OF DATA, etc.

well # B 7C

18. WATER WELL CONTRACTOR CERTIFICATION

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

DPRA INC — License Business Name | M0054 — License No.

Address: E-1500 1st National Bank Bld. St. Paul

Signed: Mitchell Bennett — Authorized Representative | Date ___

ETJ — Name of Driller | Date ___

IMPORTANT: 462343

S/74 30M
7/76 30M

STATE OF MINNESOTA DEPARTMENT OF HEALTH

WATER WELL RECORD

Minnesota Statutes 156A.01-08

MINNESOTA UNIQUE WELL NO. for Water Sample: 462345

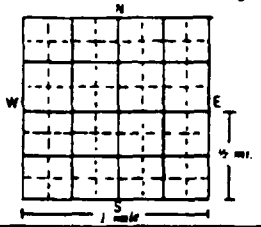
1. LOCATION OF WELL

County Name: Anoka

Township Name	Township Number	Range Number	Section No.	Fraction
Grow	32 N/S	24 E/W	34	¼ ¼ ¼

Numerical Street Address and City of Well Location or Distance from Road Intersection: 2050½ Bunker Lk. Rd. Andover, mn.

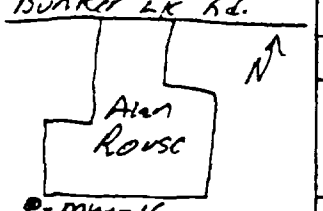
Show exact location of well in section grid with "X". Sketch map of well location.



Addition Name

Block Number

Lot Number



2. PROPERTY OWNER'S NAME: City of Andover

Mailing Address if different than property address indicated above: 1685 NW Crosstown Blvd. Andover, mn. 55304

3. FORMATION LOG

FORMATION LOG	COLOR	HARDNESS OF FORMATION	FROM	TO
Silty Sand	Brown		0	51
Silt	Gray		51	86
Silty Sand	Dk. Brown		86	95

Use a second sheet, if needed

4. WELL DEPTH (completed): 92.3 ft. Date of Completion: 9-10-90

5. DRILLING METHOD: ☐ Cable Tool ☐ Reverse ☐ Driven ☐ Dug ☐ Hollow Rod ☐ Air ☐ Bored ☐ ____ ☐ Rotary ☐ Jetted ☒ Power Auger

6. DRILLING FLUID: none

7. USE: ☐ Domestic ☒ Monitoring ☐ Heat Pump ☐ Irrigation ☐ Public ☐ Industry ☐ Test Well ☐ Municipal ☐ Commercial ☐ Air Conditioning ☐ ____

8. CASING: X 6 turn BSS; ☐ Black ☐ Threaded ☐ Galv ☐ Welded ☐ Plastic ☐ ____; HEIGHT Above/Below Surface 3 ft.; Drive Shoe? Yes ____ No ____

2 in. to 88.3 ft. Weight ____ lbs./ft.

____ in. to ____ ft. Weight ____ lbs./ft.

____ in. to ____ ft. Weight ____ lbs./ft.

HOLE DIAM.: 8 in. to 95 ft.; ____ in. to ____ ft.; ____ in. to ____ ft.

9. SCREEN: Make Johnson; Type SS; Slot/Gauze 0.010; Set between 88.3 ft. and 92.3 ft.; Diam. 2"; Length 5'; FITTINGS:; Or open hole from ____ ft. to ____ ft.

10. STATIC WATER LEVEL: ____ ft. ☒ below ☐ above land surface; Date Measured ____

11. PUMPING LEVEL (below land surface): NA ft. after ____ hrs. pumping ____ g.p.m.; ____ ft. after ____ hrs. pumping ____ g.p.m.

12. HEAD WELL COMPLETION: ☐ Pitless adapter manufacturer ____ Model ____; ☐ Basement offset; ☒ At least 12" above ground; ☐ Plastic casing protection ____

13. WELL GROUTED? ☒ Yes ☐ No

☒ Neat Cement ☐ Bentonite ☐ ____

Grout material: neat cement from 3 to 85 ft. cu. yds. ____

14. NEAREST SOURCES OF POSSIBLE CONTAMINATION: ____ feet ____ direction ____ type

Well disinfected upon completion? ☐ Yes ☐ No

15. PUMP: Date installed NA ☐ Not installed

Manufacturer's name ____

Model number ____ HP ____ Volts ____

Length of drop pipe ____ ft. Capacity ____ g.p.m.

Material of drop pipe ____

Type: ☐ Submersible ☐ L.S. Turbine ☐ Reciprocating ☐ Jet ☐ Centrifugal ☐ ____

16. ABANDONED WELLS: Unused well on property? ☐ Yes ☐ No Unknown

Sealed ☐ Permanent ☐ Temporary ☐ Not sealed

17. REMARKS, ELEVATION, SOURCE OF DATA, etc.

well # W1C

18. WATER WELL CONTRACTOR CERTIFICATION

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

DPRH INC. (License Business Name) M0054 (License No.)

Address: E-1500 1st National Bank Bld. St. Paul, mn.

Signed: Walter R. Benson (Authorized Representative)

ETI (Name of Driller) Date ____

IMPORTANT: WELL OWNER COPY 462345

S-74 30M
7-76 30M

STATE OF MINNESOTA DEPARTMENT OF HEALTH

WATER WELL RECORD

Minnesota Statutes 156A.01-.08

MINNESOTA UNIQUE WELL NO. for Water Sample: 465238

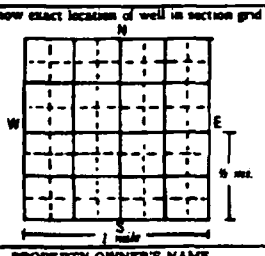
1. LOCATION OF WELL

County Name: Anoka

Township Name: Grow | Township Number: 32 N/S | Range Number: 24 E/W | Section No.: 34 | Fraction: ¼ ¼ ¼

Numerical Street Address and City of Well Location or Distance from Road Intersection: 2050 ½ Bunker Lk. Rd. Andover mn.

Show exact location of well in section grid with "X."

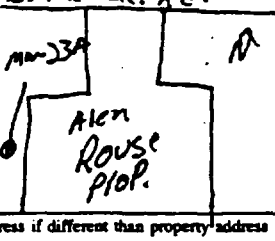


Addition Name

Block Number

Lot Number

Sketch map of well location.



2. PROPERTY OWNER'S NAME: City of Andover

Mailing Address if different than property address indicated above: 1685 N.W. Crosstown Blvd. Andover, mn 55304

3. FORMATION LOG	COLOR	HARDNESS OF FORMATION	FROM	TO
Silty F. Sand			0	15

Use a second sheet, if needed

4. WELL DEPTH (completed): 15 ft. | Date of Completion: 9-17-90

5. DRILLING METHOD: ☐ Cable Tool ☐ Reverse ☐ Driven ☐ Dug ☐ Hollow Rod ☐ Air ☐ Bored ☐ ____ ☐ Rotary ☐ Jetted ☒ Power Auger

6. DRILLING FLUID: none

7. USE: ☐ Domestic ☒ Monitoring ☐ Heat Pump ☐ Irrigation ☐ Public ☐ Industry ☐ Test Well ☐ Municipal ☐ Commercial ☐ Air Conditioning ☐ ____

8. CASING: x Stainless ☐ Black ☐ Threaded ☐ Galv. ☐ Welded ☐ Plastic ☐ ____

HEIGHT: Above/Below Surface 2 ft. Drive Shoe? Yes ____ No ____

2 in. to 5 ft. Weight ____ lbs./ft.

____ in. to ____ ft. Weight ____ lbs./ft.

____ in. to ____ ft. Weight ____ lbs./ft.

HOLE DIAM.: 8 in. to 15 ft.; ____ in. to ____ ft.; ____ in. to ____ ft.

9. SCREEN: Or open hole from ____ ft. to ____ ft.

Make: Johnson

Type: SS Diam.: 2"

Slot/Gauze: 0.010 Length: 10' FITTINGS

Set between 5 ft. and 15 ft.

10. STATIC WATER LEVEL: ____ ft. ☒ below ☐ above land surface Date Measured ____

11. PUMPING LEVEL (below land surface): NA ft. after ____ hrs. pumping ____ g.p.m.

____ ft. after ____ hrs. pumping ____ g.p.m.

12. HEAD WELL COMPLETION: ☐ Pitless adapter manufacturer ____ Model ____ ☐ Basement offset ☒ At least 12" above ground ☐ Plastic casing protection ____

13. WELL GROUTED? ☒ Yes ☐ No

☒ Neat Cement ☐ Bentonite ☐ ____

Grout material: neat cement from 1 to 3 ft. cu. yds. ____

14. NEAREST SOURCES OF POSSIBLE CONTAMINATION: ____ feet ____ direction ____ type

Well disinfected upon completion? ☐ Yes ☐ No

15. PUMP: Date installed: NA ☐ Not installed

Manufacturer's name ____

Model number ____ HP ____ Volts ____

Length of drop pipe ____ ft. Capacity ____ g.p.m.

Material of drop pipe ____

Type: ☐ Submersible ☐ L.S. Turbine ☐ Reciprocating ☐ Jet ☐ Centrifugal ☐ ____

16. ABANDONED WELLS: Unused well on property? ☐ Yes ☐ No Unknown

Sealed ☐ Permanent ☐ Temporary ☐ Not sealed

17. REMARKS, ELEVATION, SOURCE OF DATA, etc.

W-23A

18. WATER WELL CONTRACTOR CERTIFICATION

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

DPRA INC — License Business Name | M0054 — License No.

Address: E-1500 1st National Bank Bld. St. Paul

Signed: Martin R. Bennett — Authorized Representative

ETI — Name of Driller | Date

IMPORTANT: FILE WITH DEED — WELL OWNER COPY 465238

HE-01205-03 (Rev. 9/88)

8/74 30M
7/78 30M
7/79 30M
2/82 10M

APPENDIX E

WELL CONSTRUCTION DIAGRAMS

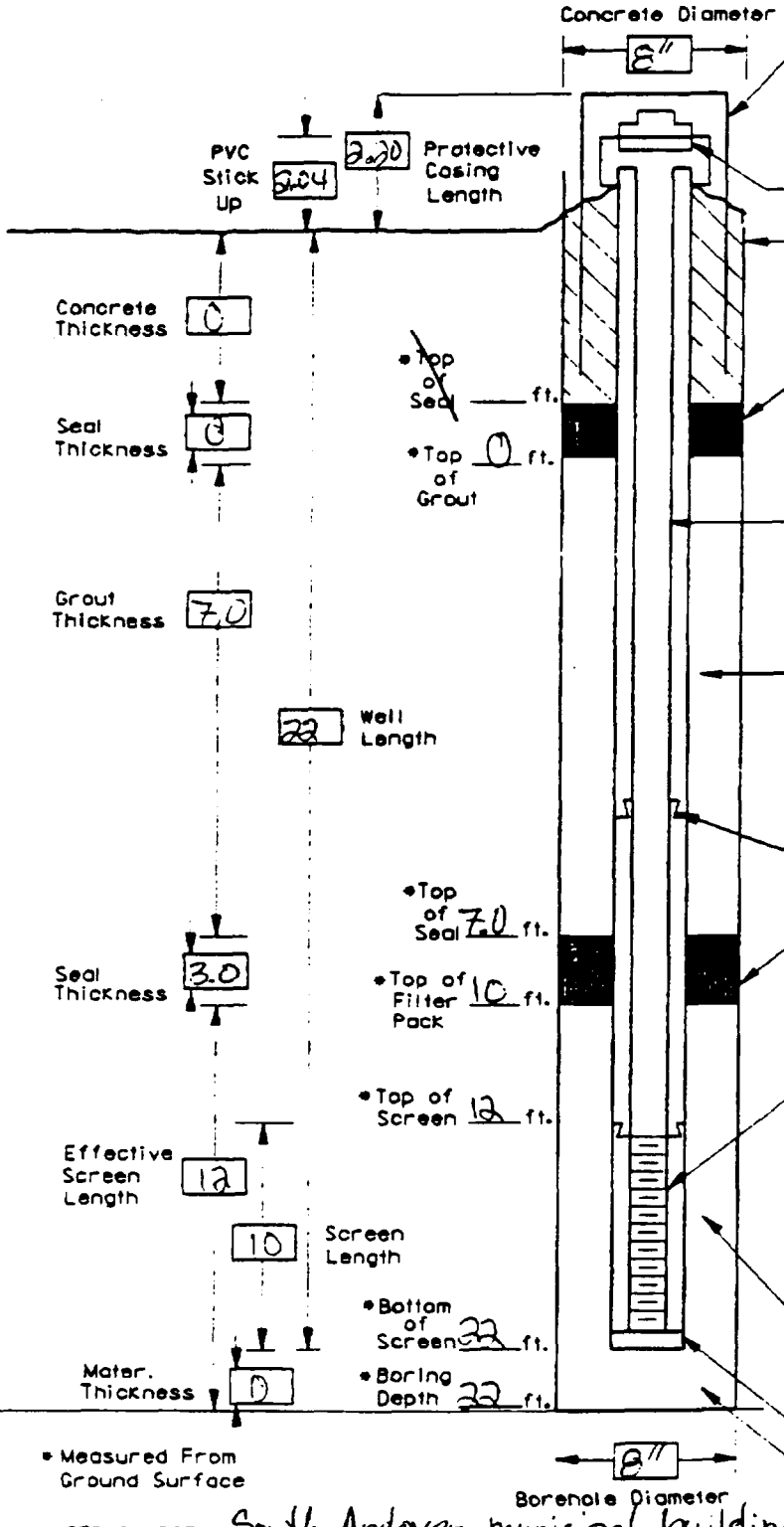
Form 102

Donohue

Engineers & Architects
COMPUTER AIDED DESIGN/DRAFTING

Water Table Well Installation Diagram

Site: South Andover Date: 8/23/90
Inspected By: TOM PUCHALSKI Project No. 20022.002 Well No. B6AtR
Driller/Contractor Don North / ETI



* Measured From Ground Surface

PROTECTIVE CASING
Type Steel Vented Yes/No Type Steel Eff
Diameter 4" Locked Yes Master
Length 7' Key * 3002

GUARD POSTS

CAP OR PLUG Vented Yes/No Type PVC

CONCRETE COLLAR
Cement ____ lbs. + Water ____ gal. ____
Total Quantity ____ gal.
Manufacturer ____

UPPER SEAL No Upper Seal Installed
Powder/Granular/Pellets Quantity ____ gal.
Hydrated ____ gal., Time ____
Manufacturer ____

PIPE Type Stainless Schedule 5 Type 304
O.D. 2.0 " I.D. 1.7 " "
Length/Sec. 10 No. Of Sec. 1/2
Manufacturer WESCO

GROUT Type Cement/Bentonite < 2% Bentonite
Mix 282 lbs. of portland cement +
5 lbs. of bentonite mixture +
Water 18 gals. Total Quant. 127 gal.
Manufacturers Lehigh Type IA Portland
WYO GEL NATURAL GEL

JOINTS Flush Threaded Yes/No
Teflon Taped Yes/No O-Ring Yes/No
Manufacturer WESCO

LOWER SEAL Enviroplug No. 8
Powder/Pellets Quantity Wyo-Ben Inc gal.
Hydrated 1 gal., Time 1/2 hour
Manufacturer WYO-BEN Billings, Mont

SCREEN Continuous Wrap
Type Stainless Steel Schedule 5 Type 304
Length/Sec. 10 No. of Sec. 1
O.D. 2.0 " I.D. 1.7 "
Slot Size No. 10 .010 No. Slots/ft. ____
Manufacturer WESCO Houston, TX Goodin Pipe St. Paul, MN

FILTER PACK Type(s) Unimin Granusil #20
Source Tamarack Materials Bloomington, MN Volume 2 1/3 bags 16 gal.
Manufacturer Unimin Corporation

PLUG OR CAP Type Box X plate Length —

MATERIAL

WATER SOURCE South Andover municipal building

Notes: ____

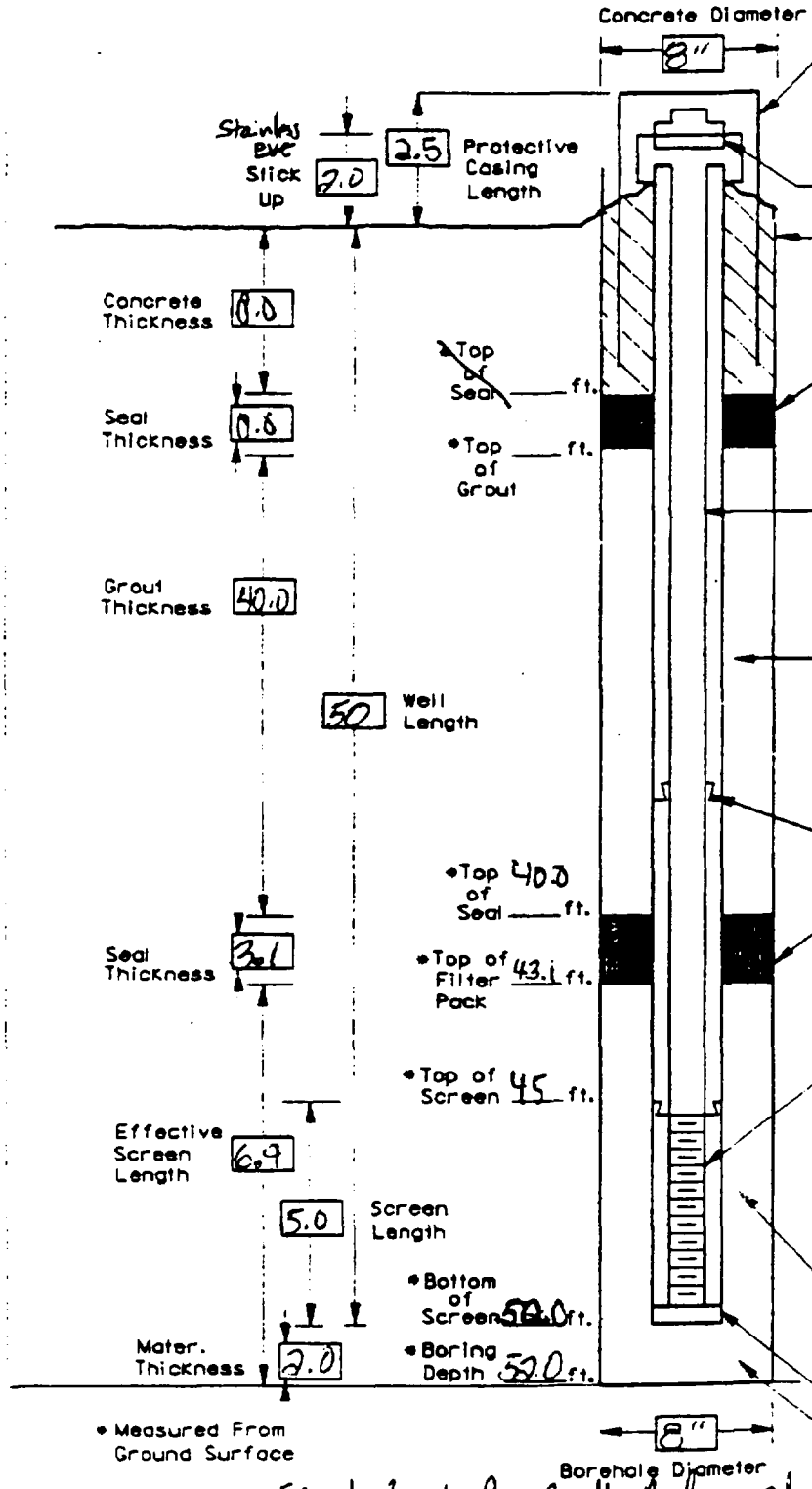
Form 1C

Donohue

Engineers & Architects
COMPUTER AIDED DESIGN/DRAFTING

Water Table Well Installation Diagram

Site: South Andover Date: 8/25/90
Inspected By: Tom Puchalski Project No. 20022.007 Well No. ~~#~~ 6B-R
Driller/Contractor Rich Cahoy / ETI



* Measured From Ground Surface

PROTECTIVE CASING — Type Steel Vented Yes/No Diameter 4" Locked Master Length 7 ft Key * 2002

GUARD POSTS — Type Steel 8'

CAP OR PLUG — Vented Yes/No Type PVC

CONCRETE COLLAR — Cement ____ lbs. + Water ____ gal. ____ Total Quantity ____ gal. Manufacturer ____

UPPER SEAL — No Upper Seal Required
Powder/Granular/Pellets Quantity ____ gal. Hydrated ____ gal., Time ____ Manufacturer ____

PIPE — Type Stainless Steel Schedule 5 Type 304
O.D. 2.0" I.D. 1.7" Length/Sec. 10' No. Of Sec. 4 Manufacturer WESCO 5', 2' 1, 1

GROUT — Type Cement/Bentonite *
Mix 282 lbs. of portland cement + 6 lbs. of bentonite + Water 20 gals. Total Quant. 52 gal.
Manufacturers portland-Lehigh bentonite Wyogel

JOINTS — Flush Threaded Yes/No
Teflon Taped Yes/No O-Ring Yes/No
Manufacturer DuPont PTFE TAPE WESCO O-R

LOWER SEAL — 22 lbs bentonite 5 gallons
~~Powder/Pellets~~ Slurry Quantity water = 6 gal. Hydrated ____ gal., Time 1½ hrs
Manufacturer WYOGEL

SCREEN — Continuous Wrap
Type Stainless Steel Schedule 5 Type 304
Length/Sec. TEP 5' No. of Sec. 1
O.D. 2" I.D. 1.7"
Slot Size No. 10 0.010 No. Slots/ft. ____
Manufacturer WESCO

FILTER PACK — Type(s) Unimin Granusil #20
Source TAMARCK MATERIALS Volume 14.5 gal.
Manufacturer Unimin Corp

PLUG OR CAP — Type Box X plate Length —

MATERIAL — Formation SILT

WATER SOURCE Fire hydrant for South Andover at intersection of Thrush St NW & 136 Ave

Notes: * 2nd batch 120 lbs portland 10 gallons H_2O 5 lbs bentonite, 3rd batch 20 gallons water 282 lbs cement 6 lbs bentonite 4th batch: Same as 3rd, 5th same 6th same 20 bags portland

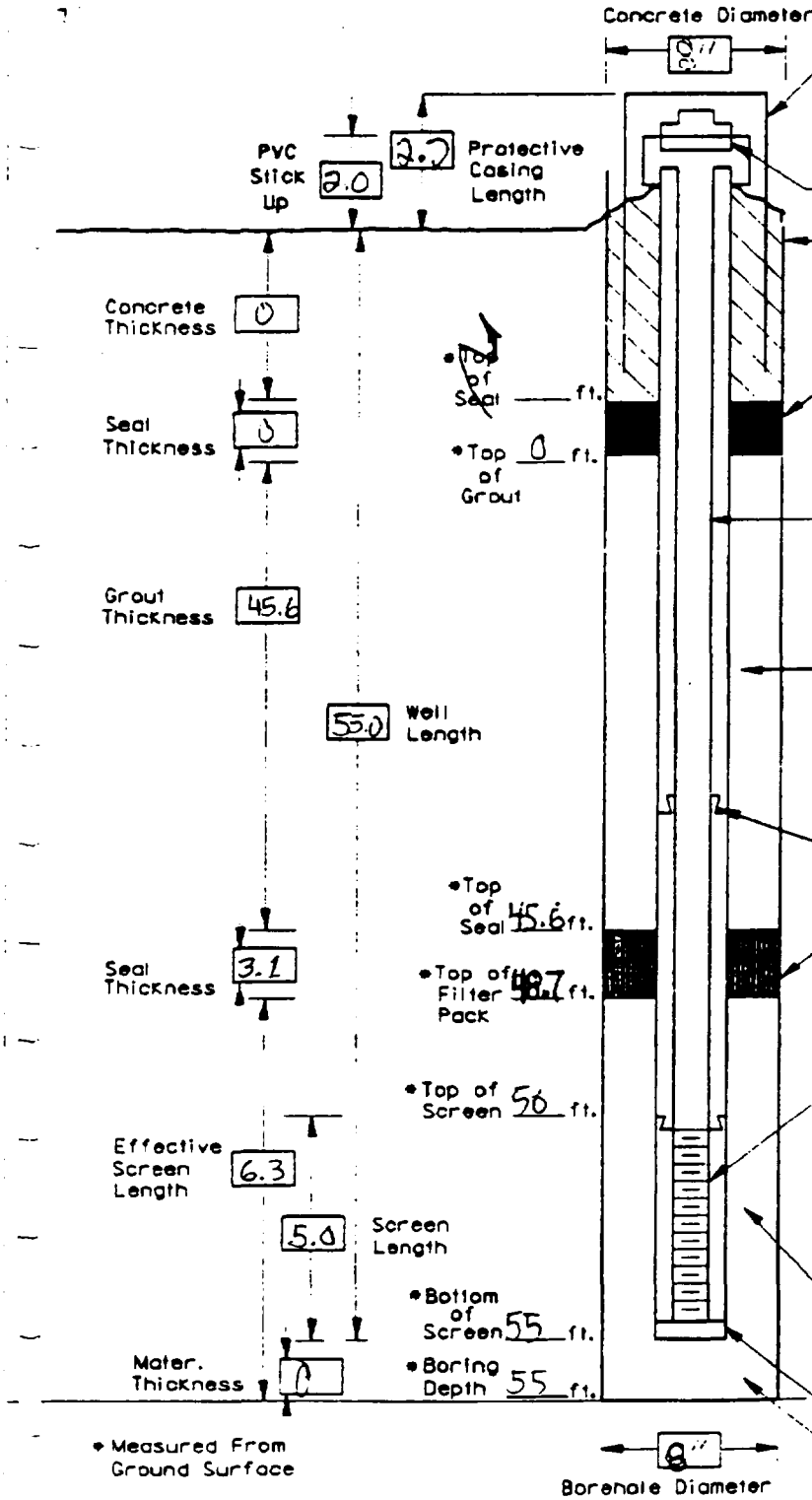
Form 102

Donohue

Engineers & Architects
COMPUTER AIDED DESIGN/DRAFTING

Water Table Well Installation Diagram

Site: South Andover Date: 8/27/90
Inspected By: TOM DUCHALSKI Project No. 26022.002 Well No. W7B-R
Driller/Contractor Greg Scullen / EFT



* Measured From Ground Surface

PROTECTIVE CASING
Type Steel Vented Yes/No Type Steel
Diameter 4" Locked Yes
Length 2' Key * 3002 - Master

GUARD POSTS

CAP OR PLUG Vented Yes/No Type DIC

CONCRETE COLLAR
Cement ____ lbs. + Water ____ gal. ____
Total Quantity ____ gal.
Manufacturer ____

UPPER SEAL
Powder/Granular/Pellets Quantity ____ gal.
Hydrated ____ gal., Time ____
Manufacturer ____

PIPE Type Stainless Steel Schedule 5 Type 304
O.D. 2.0" I.D. 1.7"
Length/Sec. 10' No. Of Sec. ____
Manufacturer WESCO

GROUT Type Cement/Bentonite
Mix 94 lbs. of Portland +
10 lbs. of bentonite +
Water 70 gals. Total Quant. 100 gal.
Manufacturers Lehigh-Cement Naturalgel-Bentonite

JOINTS Flush Threaded Yes/No
Teflon Taped Yes/No O-Ring Yes/No
Manufacturer ____

LOWER SEAL Bentonite slurry
Powder/Pellets Quantity 20 lb bentonite 15 gal.
Hydrated ____ gal., Time ____
Manufacturer WYOBEN

SCREEN Continuous Wire
Type Stainless Steel Schedule 5 Type 304
Length/Sec. 5 No. of Sec. ____
O.D. 2.0" I.D. 1.7"
Slot Size No. 10 No. Slots/ft. ____
Manufacturer WESCO

FILTER PACK Type(s) Unimin Granusil #20
Source Tomacks Materials Volume 7 gal.
Manufacturer Unimin Corporation

PLUG OR CAP Type Box X plate Length ____

MATERIAL Formation Sand

WATER SOURCE Hydrant at intersection of Thrush St NW & 136 Ave NW

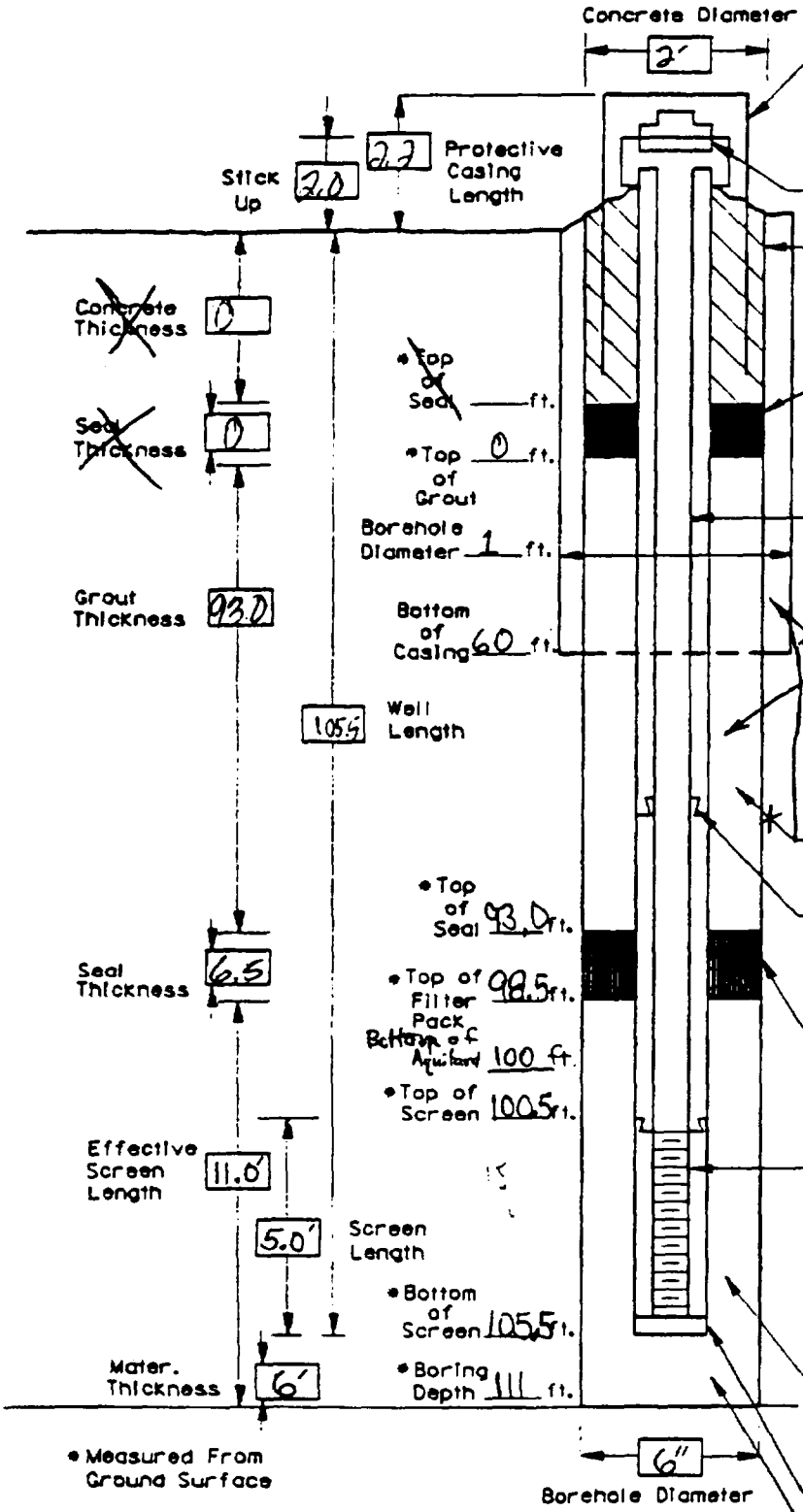
Notes: ____

Donohue Engineers & Architects
COMPUTER AIDED DESIGN/DRAFTING

DOUBLE CASING WELL/PIEZOMETER INSTALLATION DIAGRAM

Form

Site: South Andover Date: 9/8/90
Inspected By: Tom Puchalski Project No. 3C022.002 Well No. ~~A~~ B 7C
Driller/Contractor Greg Scallon/ETI



PROTECTIVE CASING
Type Steel Vented Yes/No Diameter 4" Locked Yes Master Length 5' Key # 2002

GUARD POSTS
Type Steel 8 ft.

CAP OR PLUG Vented Yes/No Type PVC

CONCRETE COLLAR
Cement ____ lbs. + Water ____ gal. ____
Total Quantity ____ gal.
Manufacturer ____

UPPER SEAL
Powder/Granular/Pellets Quantity ____ gal.
Hydrated ____ gal., Time ____
Manufacturer ____

PIPE Type Stainless Schedule 5 Type 304
O.D. 2.0" I.D. 1.7"
Length/Sec. 10 No. Of Sec. 10
Manufacturer ____

GROUT Type Cement / Bentonite
Mix 94 lbs. of Portland +
2 lbs. of bentonite +
Water ____ gals. Total Quant. ____ gal.
Manufacturers ____

OUTSIDE GROUT Type Cement / < 2% bentonite
AMOUNT ____

JOINTS Flush Threaded Yes/No
Teflon Taped Yes/No O-Ring Yes/No
Manufacturer DuPont

LOWER SEAL Bentonite Slurry
Powder/Pellets Quantity 27 lbs powder gal.
Hydrated 15 gal., Time ____
Manufacturer ____

SCREEN Continuous Wrap
Type Stainless Type 304 Schedule 5
Length/Sec. 10 / 5 No. of Sec. 1
O.D. 2.0" I.D. 1.7"
Slot Size No. 10 No. Slots/ft. ____
Manufacturer WESCO

FILTER PACK Type(s) Unimin Granusil #20
Source Tamarks Materials Volume 24 cu.
Manufacturer Unimin Corporation

PLUG OR CAP Type Box X plate Length —

MATERIAL Excavation Sand

WATER SOURCE Hydrant at Thrush NW & 36 NW

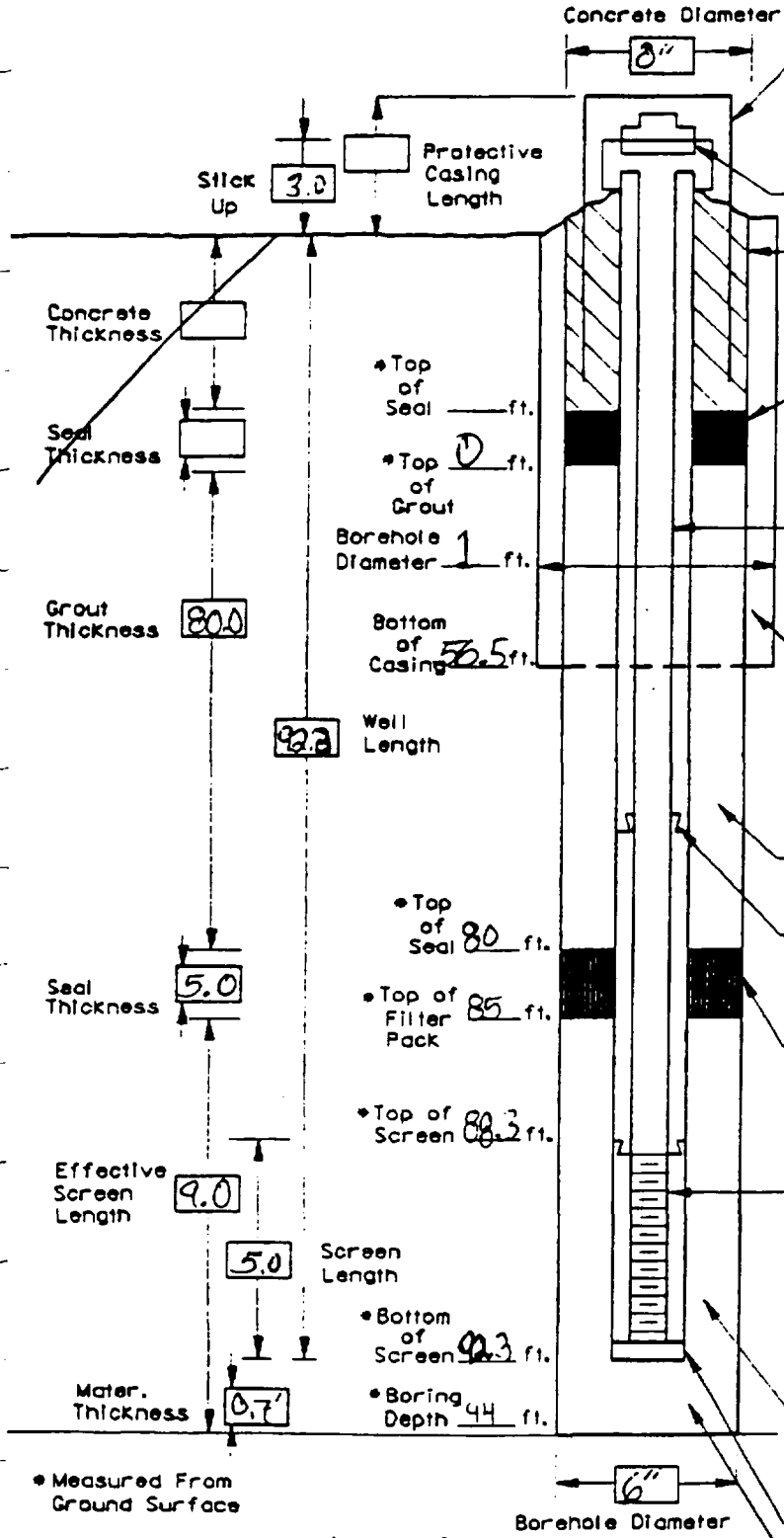
Notes: ____

Donohue Engineers & Architects
COMPUTER AIDED DESIGN/DRAFTING

DOUBLE CASING WELL/PIEZOMETER INSTALLATION DIAGRAM

Form

Site: South Andover Date: 9/10 - 9/11/91
Inspected By: Tom Pilyacski Project No. 2002-002 Well No. W1C-R
Driller/Contractor



PROTECTIVE CASING
Type Steel Vented Yes/No
Diameter 4" Locked Yes
Length 7' Key * 2002

GUARD POSTS
Type Steel 8 Master

CAP OR PLUG Vented Yes/No Type PVC

CONCRETE COLLAR
Cement ____ lbs. + Water ____ gal. ____
Total Quantity ____ gal.
Manufacturer

UPPER SEAL
Powder/Granular/Pellets Quantity ____ gal.
Hydrated ____ gal., Time
Manufacturer

PIPE Type Stainless Schedule 5 Type 304
O.D. 2.0 " I.D. 1.7 "
Length/Sec. 10 No. Of Sec. 9
Manufacturer WESCO

GROUT Type Cement/Bentonite
Mix 13.16 lbs. of portland cement
28 lbs. of bentonite
Water 84 gals. Total Quant. 166 gal.
Manufacturers

OUTSIDE GROUT Type Cement/Bentonite
AMOUNT ≈ 130 gallons

JOINTS Flush Threaded Yes/No
Teflon Taped Yes/No O-Ring Yes/No
Manufacturer

LOWER SEAL 25 lbs bentonite 15 gallons water
~~Powder/Pellets~~ Quantity ____ gal.
Hydrated ____ gal., Time
Manufacturer

SCREEN Continuous Wrap
Type Stainless Steel Schedule 5 Type 304
Length/Sec. 5 No. of Sec. 1
O.D. 2.0 " I.D. 1.7 "
Slot Size ____ No. Slots/ft.
Manufacturer

FILTER PACK Type(s) Unimin Granular Silica #20
Source Tamack Materials Volume 12 gal.
Manufacturer Unimin Corp.

PLUG OR CAP Type Box X Plate Length

MATERIAL Silica Sand #20

WATER SOURCE Hydrant at Thrush St NW & 136 Ave NW

Donohue

Engineers & Architects

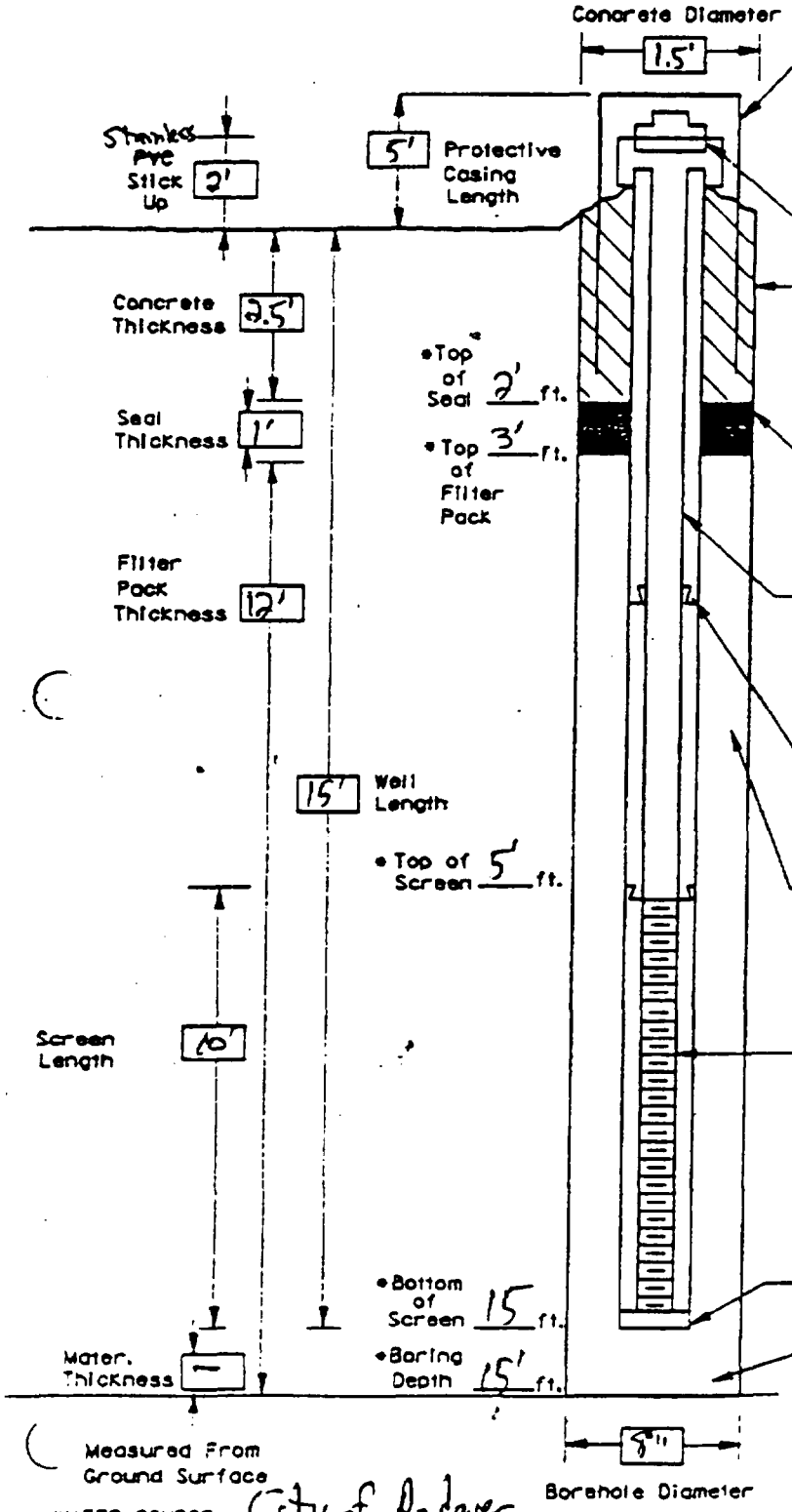
Water Table Well Installation Diagram

Form 101

Site: South Andover Date: 9-17-90

Inspected By: Dave Richardson Project No. 20070.002 Well No. 23A-R

Driller/Contractor ETI



PROTECTIVE CASING
Type Steel Vented Yes/No Type Cap
Diameter 4" Locked Yes
Length 5' Key #

GUARD POSTS

CAP OR PLUG Vented Yes/No Type PVC

CONCRETE COLLAR
Cement 68 lbs. + Water 2 gal.
Total Quantity ____ gal.
Manufacturer Northwestern

SEAL Envirotec No. 8
Powder/Granular Pellets Quantity 16 lbs gal.
Hydrated 2 gal., Time 1642
Manufacturer Wyo-Ben

PIPE Type Stainless Schedule 40
O.D. 2 1/4" I.D. 2 pvc
Length/Sec. 10' No. Of Sec. 1
Manufacturer Wesco

JOINTS Flush Threaded Yes/No
Teflon Taped Yes/No O-Ring Yes/No
Manufacturer Wesco

FILTER PACK Type(s) #20-02130
Source Unimin Corp - 100 lb bags
Volume 300 lbs gal.
Manufacturer Unimin

SCREEN
Type Stainless Schedule 40
Length/Sec. 10' No. of Sec. 1
O.D. 2 1/4" I.D. 2"
Slot Size .010 No. Slots/ft.
Manufacturers Wesco

CAP OR PLUG Type Stainless Length 0.3

MATERIAL Native

WATER SOURCE City of Andover

Notes:

APPENDIX F

MINNESOTA DEPARTMENT OF HEALTH WELL ABANDONMENT RECORDS

ABANDONED WELL RECORD

MINNESOTA UNIQUE WELL NO. (leave blank if not known)

1. LOCATION OF WELL — 23A

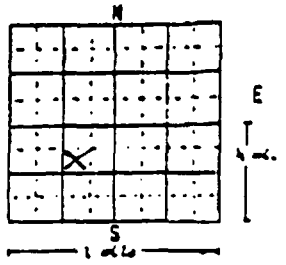
County Name: ANOKA

Township Name	Township Number	Range Number	Section No.	Fraction	4. WELL DEPTH (completed)	Date Sealed
ANDOVER	32 N or S	24 E or W	34	SW NE SW	14.16 ft.	AUGUST 29, 1990

Numerical Street Address and City of Well Location or Distance from Road Intersection

2050 BUNKER LAKE BOULEVARD

Show exact location of well (in section grid with "X")



Sketch map of well location

2. PROPERTY OWNER'S NAME

Mailing Address if different than property address indicated above

3. FORMATION LOG — If not known, indicate formation log from new well or nearby well.

FORMATION LOG	COLOR	HARDNESS OF FORMATION	FROM	TO

16. REMARKS, ELEVATION, SOURCE OF DATA - CASINGS REMOVED, CASINGS PERFORATED, ETC.

TREMIED CEMENT - BENTONITE GROUT (48 lbs Portland Cement - 1 lb bentonite - 3 gallons WATER) INTO WELL. AFTER GROUT WAS TREMIED INTO ~~HOL~~ WELL RISER AND SCREEN WERE PULLED. THE BORING COLLAPSED TO A DEPTH OF 4.0 FEET, THE REMAINING OPEN BOREHOLE WAS FILLED WITH GRANULAR BENTONITE

5. DRILLING METHOD (If known)
1 ☐ Cable tool 4 ☐ Reverse 7 ☐ Driven 10 ☐ Dug
2 ☐ Hollow Rod 5 ☐ Air 8 ☐ Bored 11 ☐ _____
3 ☐ Rotary 6 ☐ Jetted 9 ☒ Power Auger

6. OBSTRUCTIONS
Well obstructed ☐ Yes ☒ No
Obstructions removed ☐ Yes ☐ No If obstructions cannot be removed, contact MDH before sealing.

7. USE
1 ☐ Domestic 4 ☒ Monitoring 6 ☐ Heat Loop
2 ☐ Irrigation 5 ☐ Public 9 ☐ Industry
3 ☐ Test Well 8 ☐ Municipal 10 ☐ Commercial
7 ☐ Air Conditioning 11 ☐ _____

8. CASING(S)
1 ☐ Black 4 ☐ Threaded 7 ☐ _____
2 ☐ Galv. 5 ☐ Welded
3 ☐ Plastic 6 ☐ Stainless Steel
_____ in. to _____ ft.
_____ in. to _____ ft.

9. SCREEN
☐ Screened well from ____ ft. to ____ ft. (If known)
☐ Open Hole from ____ ft. to ____ ft.

10. STATIC WATER LEVEL
_____ ft. ☐ below ☐ above land surface Date Measured _____

11. WELLHEAD COMPLETION
1 ☐ Pitless Adapter 4 ☐ Pound Buried
2 ☐ Basement offset 5 ☐ _____
3 ☐ Well Pit

12. GROUTING INFORMATION
1 ☐ Neat Cement 2 ☐ Bentonite 3 ☐ _____
Grout material _____ from ____ to ____ ft. cu. yds ____

13. NEAREST SOURCES OF CONTAMINATION
____ feet _____ direction _____ type
Well disinfected before sealing? ☐ Yes

14. PUMP ☐ Removed ☒ Not Present
Type: 1 ☐ Submersible 3 ☐ L.S. Turbine 5 ☐ Reciprocating
2 ☐ Jet 4 ☐ Centrifugal 6 ☐ _____

15. EXISTING WELLS (Please sketch locations of abandoned and active wells in remarks section or on back.)
Other unused well(s) on property? ☐ Yes ☐ No
Abandoned: ☐ Permanent ☐ Temporary ☐ Not sealed

17. WATER WELL CONTRACTORS CERTIFICATION
This well was sealed under my jurisdiction and this report is true to the best of my knowledge and belief.

Licensee Business Name _____ License No. _____

Address _____

Signed _____ Date _____

_____ Date _____
Name of Driller

OFFICIAL ABANDONED WELL RECORD (May be used for Property Transfer)

IMPORTANT: FILE WITH MDH

ABANDONED WELL RECORD

MINNESOTA UNIQUE WELL NO. (Leave blank if not known)

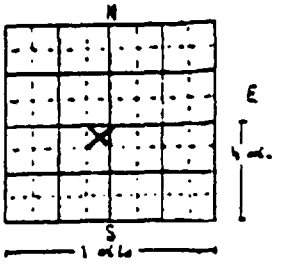
1. LOCATION OF WELL B-6B

County Name ANOKA

Township Name	Township Number	Range Number	Section No.	Fraction
ANDOVER	32 N or S	24 E or W	34	NE NE SW (¼ ¼ of ¼)

Numerical Street Address and City of Well Location or Distance from Road Intersection
500 Ft S. of BUNKER LAKE BOULEVARD (2050)
970 Ft W. OF JAY STREET

Show exact location of well (in section grid with "X")



Sketch map of well location

2. PROPERTY OWNER'S NAME

Mailing Address if different than property address indicated above

3. FORMATION LOG If not known, indicate formation log from new well or nearby well.

FORMATION LOG	COLOR	HARDNESS OF FORMATION	FROM	TO
SAND (SP-SM)	BR		0	40
SILT (ML)	RED		40	70
SAND (SP)	BR		70	

4. WELL DEPTH (completed) 24.0 ft. Date sealed 8-29-90

5. DRILLING METHOD (If known)
1 ☐ Cable tool 4 ☐ Reverse 7 ☐ Driven 10 ☐ Dug
2 ☐ Hollow Rod 5 ☐ Air 8 ☐ Bored 11 ☐ ____
3 ☐ Rotary 6 ☐ Jetted 9 ☒ Power Auger

6. OBSTRUCTIONS
Well obstructed ☐ Yes ☒ No
Obstructions removed ☐ Yes ☐ No If obstructions cannot be removed, contact MDH before sealing.

7. USE
1 ☐ Domestic 4 ☒ Monitoring 6 ☐ Heat Loop
2 ☐ Irrigation 5 ☐ Public 8 ☐ Industry
3 ☐ Test Well 6 ☐ Municipal 10 ☐ Commercial
7 ☐ Air Conditioning 11 ☐ ____

8. CASING(S)
1 ☐ Black 4 ☐ Threaded 7 ☐ ____
2 ☒ Galv. 5 ☐ Welded
3 ☐ Plastic 6 ☐ Stainless Steel
1¼ in. to 20 ft.
____ in. to ____ ft.

9. SCREEN
☒ Screened well from 20 ft. to 24 ft. (If known)
☐ Open Hole from ____ ft. to ____ ft.

10. STATIC WATER LEVEL
____ ft. ☐ below ☐ above land surface Date Measured ____

11. WELLHEAD COMPLETION
1 ☐ Pitless Adapter ☐ Found Surface
2 ☐ Basement offset ☒ STEEL PROTECTOR
3 ☐ Well Pit BENTONITE CAP

12. GROUTING INFORMATION
1 ☐ Neat Cement 3 ☐ Bentonite 5 ☐ ____
Grout material ____ from ____ to ____ ft. cu. yds ____

13. NEAREST SOURCES OF CONTAMINATION
____ feet ____ direction ____ type
Well disinfected before sealing? ☐ Yes

14. PUMP ☐ Removed ☒ Not Present
Type: 1 ☐ Submersible 3 ☐ L.S. Turbine 5 ☐ Reciprocating
2 ☐ Jet 4 ☐ Centrifugal 6 ☐ ____

15. EXISTING WELLS (Please sketch locations of abandoned and active wells in remarks section or on back.)
Other unused well(s) on property? ☐ Yes ☒ No
Abandoned: ☐ Permanent ☐ Temporary ☐ Not sealed

16. REMARKS, ELEVATION, SOURCE OF DATA - CASINGS REMOVED, CASINGS PERFORATED, ETC.

WELL FILLED WITH 8.0 GALLONS
OF CEMENT BENTONITE GROUT

17. WATER WELL CONTRACTORS CERTIFICATION
This well was sealed under my jurisdiction and this report is true to the best of my knowledge and belief.

Licensee Business Name ____ License No. ____
Address ____
Signed ____ Date ____
____ Date ____
Name of Driller

OFFICIAL ABANDONED WELL RECORD (May be used for Property Transfer)

IMPORTANT: FILE WITH MDH

ABANDONED WELL RECORD

MINNESOTA UNIQUE WELL NO. (leave blank if not known)

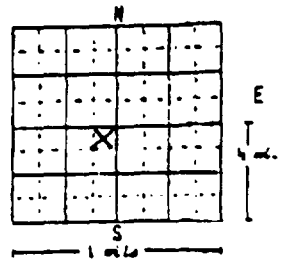
1. LOCATION OF WELL B-6A

County Name ANOKA

Township Name	Township Number	Range Number	Section No.	Fraction ¼ ¼ of ¼
ANDOVER	32 (N) or S	24 (E) or W	34	NE NE SW

Numerical Street Address and City of Well Location or Distance from Road Intersection
500 FT S. OF BUNKER LAKE BOULEVARD (2050) 970 FT W. OF JAY STREET

Show exact location of well (in section grid with "X")



Sketch map of well location

2. PROPERTY OWNER'S NAME

Mailing Address if different than property address indicated above

3. FORMATION LOG If not known, indicate formation log from new well or nearby well.

FORMATION LOG	COLOR	HARDNESS OF FORMATION	FROM	TO
SAND (SP-SM)	GR BR		0	40
SILT (ML)	RD BR		40	70
SAND SP	BR		70	

16. REMARKS, ELEVATION, SOURCE OF DATA - CASINGS REMOVED, CASINGS PERFORATED, ETC.

HAD TO EXCAVATE TO LOCAT B-6A RISER. RISER & SCREEN FILLED WITH 4 GALLONS OF CEMENT BENTONITE GROUT. STEEL PROTECTOR AND 8 FT OF RISER PULLED FROM HOLE WELL POINT STUCK IN GROUND

4. WELL DEPTH (completed) 19.0 ft.

Date sealed AUGUST 29, 1990

5. DRILLING METHOD (if known)
1 ☐ Cable tool 4 ☐ Reverse 7 ☐ Driven 10 ☐ Dug
2 ☐ Hollow Rod 5 ☐ Air 8 ☐ Bored 11 ☐ ____
3 ☐ Rotary 6 ☐ Jetted 9 ☒ Power Auger

6. OBSTRUCTIONS
Well obstructed ☐ Yes ☒ No
Obstructions removed ☐ Yes ☐ No If obstructions cannot be removed, contact MDH before sealing.

7. USE
1 ☐ Domestic 4 ☒ Monitoring 6 ☐ Heat Loop
2 ☐ Irrigation 5 ☐ Public 9 ☐ Industry
3 ☐ Test Well 6 ☐ Municipal 10 ☐ Commercial
7 ☐ Air Conditioning 11 ☐ ____

8. CASING(S)
1 ☐ Black 4 ☐ Threaded 7 ☐ ____
2 ☒ Galv. 5 ☐ Welded
3 ☐ Plastic 6 ☐ Stainless Steel
1¼ in. to 15.0 ft.
____ in. to ____ ft.

9. SCREEN
☒ Screened well from 15 ft. to 19 ft. (if known)
☐ Open Hole from ____ ft. to ____ ft.

10. STATIC WATER LEVEL
____ ft. ☐ below ☐ above land surface Date Measured ____

11. WELLHEAD COMPLETION
1 ☐ Pitless Adapter 4 ☐ Pound Surface
2 ☐ Basement offset 5 ☐ STEEL PROTECTOR
3 ☐ Well Pit BENTONITE CAP

12. GROUTING INFORMATION
1 ☐ Neat Cement 3 ☐ Bentonite 4 ☒ ____
Grout material ____ from ____ to ____ ft. cu. yds. ____

13. NEAREST SOURCES OF CONTAMINATION
____ feet ____ direction ____ type
Well disinfected before sealing? ☐ Yes

14. PUMP ☐ Removed ☒ Not Present
Type: 1 ☐ Submersible 3 ☐ L.S. Turbine 5 ☐ Reciprocating
2 ☐ Jet 4 ☐ Centrifugal 6 ☐ ____

15. EXISTING WELLS (Please sketch locations of abandoned and active wells in remarks section or on back.)
Other unused well(s) on property? ☐ Yes ☒ No
Abandoned: ☐ Permanent ☐ Temporary ☐ Not sealed

17. WATER WELL CONTRACTORS CERTIFICATION
This well was sealed under my jurisdiction and this report is true to the best of my knowledge and belief.

Licensee Business Name License No.

Address

Signed ____ Date ____

____ Date ____
Name of Driller

OFFICIAL ABANDONED WELL RECORD (May be used for Property Transfer)

IMPORTANT: FILE WITH MDH

ABANDONED WELL RECORD

MINNESOTA UNIQUE WELL NO. (Leave blank if not known)

1. LOCATION OF WELL: WELL W-1C

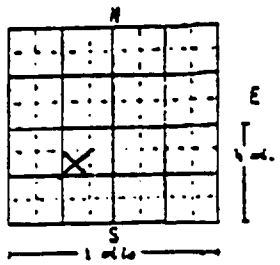
County Name: ANOKA

Township Name	Township Number	Range Number	Section No.	Fraction
ANDOVER	32 N or S	24 E or W	34	SW NE SW (¼ of ¼)

Numerical Street Address and City of Well Location or Distance from Road Intersection

APPROX 1300 Ft S. OF BUNKER LAKE BOULEVARD
2020 Ft W of JAY STREET

Show exact location of well (in section grid with "X")



Sketch map of well location

2. PROPERTY OWNER'S NAME

Mailing Address if different than property address indicated above

3. FORMATION LOG (If not known, indicate formation log from new well or nearby well.)

FORMATION LOG	COLOR	HARDNESS OF FORMATION	FROM	TO

16. REMARKS, ELEVATION, SOURCE OF DATA - CASINGS REMOVED, CASINGS PERFORATED, ETC.

Attempted to pass grout tremie down riser, however, could not pass obstruction at ± 10.0 ft. Grout was tremied from that depth and the well riser cut off 2.0 ft below ground surface.

GROUT MIX
2 BAGS (94lbs) Portland Cement
15 GALLONS WATER
2 lbs of bentonite powder

4. WELL DEPTH (completed): ft.

Date sealed: AUGUST 28, 1990

5. DRILLING METHOD (If known)
1 ☐ Cable tool 4 ☐ Reverse 7 ☐ Driven 10 ☐ Dug
2 ☐ Hollow Rod 5 ☐ Air 8 ☐ Bored 11 ☐ ____
3 ☐ Rotary 6 ☐ Jetted 9 ☐ Power Auger

6. OBSTRUCTIONS
Well obstructed ☒ Yes ☐ No
Obstructions removed ☐ Yes ☒ No If obstructions cannot be removed, contact MDH before sealing.

7. USE
1 ☐ Domestic 4 ☒ Monitoring 8 ☐ Heat Loop
2 ☐ Irrigation 5 ☐ Public 9 ☐ Industry
3 ☐ Test Well 6 ☐ Municipal 10 ☐ Commercial
7 ☐ Air Conditioning 11 ☐ ____

8. CASING(S)
1 ☐ Black 4 ☐ Threaded 7 ☐ ____
2 ☐ Galv. 5 ☐ Welded
3 ☐ Plastic 6 ☐ Stainless Steel
____ in. to ____ ft.
____ in. to ____ ft.

9. SCREEN
☐ Screened well from ____ ft. to ____ ft. (If known)
☐ Open Hole from ____ ft. to ____ ft.

10. STATIC WATER LEVEL
____ ft. ☐ below ☐ above land surface Date Measured ____

11. WELLHEAD COMPLETION
1 ☐ Pitless Adapter 4 ☐ Pound Surface
2 ☐ Basement offset 5 ☐ ____
3 ☐ Well Pit

12. GROUTING INFORMATION
1 ☐ Neat Cement 2 ☐ Bentonite 3 ☒ CEMENT-BENTONITE
Grout material ____ from ____ to ____ ft. cu. yds ____

13. NEAREST SOURCES OF CONTAMINATION
____ feet ____ direction ____ type
Well disinfected before sealing? ☐ Yes

14. PUMP ☐ Removed ☒ Not Present
Type: 1 ☐ Submersible 2 ☐ L.S. Turbine 3 ☐ Reciprocating
4 ☐ Jet 5 ☐ Centrifugal 6 ☐ ____

15. EXISTING WELLS (Please sketch locations of abandoned and active wells in remarks section or on back.)
Other unused well(s) on property? ☐ Yes ☐ No
Abandoned: ☐ Permanent ☐ Temporary ☐ Not sealed

17. WATER WELL CONTRACTORS CERTIFICATION
This well was sealed under my jurisdiction and this report is true to the best of my knowledge and belief.

Licensed Business Name ____ License No. ____
Address ____
Signed ____ Date ____
____ Date ____
Name of Driller

OFFICIAL ABANDONED WELL RECORD (May be used for Property Transfer)

IMPORTANT: FILE WITH MDH

ABANDONED WELL RECORD

MINNESOTA UNIQUE WELL NO. (leave blank if not known)

1. LOCATION OF WELL B-3A

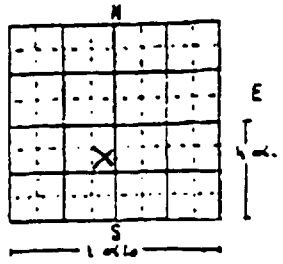
County Name ANOKA

Township Name	Township Number	Range Number	Section No.	Fraction
ANDOVER	32 N or S	24 E or W	34	SE NE SW (¼ of ¼ of ¼)

Numerical Street Address and City of Well Location or Distance from Road Intersection

APPROX 750 FT S OF BUNKER LAKE BLVD
670 Ft W OF JAY ROAD

Show exact location of well (in section grid with "X")



Sketch map of well location

2. PROPERTY OWNER'S NAME

Mailing Address if different than property address indicated above

3. FORMATION LOG (If not known, indicate formation log from new well or nearby well.)

FORMATION	COLOR	HARDNESS OF FORMATION	FROM	TO

16. REMARKS, ELEVATION, SOURCE OF DATA - CASINGS REMOVED, CASINGS PERFORATED, ETC.

GROUND ELEV. 902.8
RISER ELEV. 904.48

4. WELL DEPTH (completed) 25.0 ft. Date sealed

5. DRILLING METHOD (If known)
1 ☐ Cable tool 4 ☐ Reverse 7 ☐ Driven 10 ☐ Dug
2 ☐ Hollow Rod 5 ☐ Air 8 ☐ Bored 11 ☐ ____
3 ☐ Rotary 6 ☐ Jetted 9 ☒ Power Auger

6. OBSTRUCTIONS
Well obstructed ☐ Yes ☒ No
Obstructions removed ☐ Yes ☐ No If obstructions cannot be removed, contact MDH before sealing.

7. USE
1 ☐ Domestic 4 ☒ Monitoring 6 ☐ Heat Loop
2 ☐ Irrigation 5 ☐ Public 9 ☐ Industry
3 ☐ Test Well 6 ☐ Municipal 10 ☐ Commercial
7 ☐ Air Conditioning 11 ☐ ____

8. CASING(S)
1 ☐ Black 4 ☐ Threaded 7 ☐ ____
2 ☒ Galv. 5 ☐ Welded
3 ☐ Plastic 6 ☐ Stainless Steel
1¼ in. to 21.0 ft.
____ in. to ____ ft.

9. SCREEN
☐ Screened well from 21 ft. to 25 ft. (If known)
☐ Open Hole from ____ ft. to ____ ft.

10. STATIC WATER LEVEL
____ ft. ☐ below ☐ above land surface Date Measured ____

11. WELLHEAD COMPLETION
1 ☐ Pitless Adapter 4 ☐ Pound Surface
2 ☐ Basement offset 5 ☐ ____
3 ☐ Well Pit

12. GROUTING INFORMATION
1 ☐ Neat Cement 3 ☐ Bentonite 4 ☐ ____
Grout material ____ from ____ to ____ ft. cu. yds ____

13. NEAREST SOURCES OF CONTAMINATION
____ feet ____ direction ____ type
Well disinfected before sealing? ☐ Yes

14. PUMP ☐ Removed ☒ Not Present
Type: 1 ☐ Submersible 3 ☐ L.S. Turbine 5 ☐ Reciprocating
2 ☐ Jet 4 ☐ Centrifugal 6 ☐ ____

15. EXISTING WELLS (Please sketch locations of abandoned and active wells in remarks section or on back.)
Other unused well(s) on property? ☐ Yes ☐ No
Abandoned: ☐ Permanent ☐ Temporary ☐ Not sealed

17. WATER WELL CONTRACTORS CERTIFICATION
This well was sealed under my jurisdiction and this report is true to the best of my knowledge and belief.

License Business Name License No.

Address

Signed ____ Date ____

____ Date ____
Name of Driller

OFFICIAL ABANDONED WELL RECORD (May be used for Property Transfer)

IMPORTANT: FILE WITH MDH

ABANDONED WELL RECORD

1. LOCATION OF WELL -B-38

MINNESOTA UNIQUE WELL NO. (Leave Blank if Not Known)

County Name ANOKA

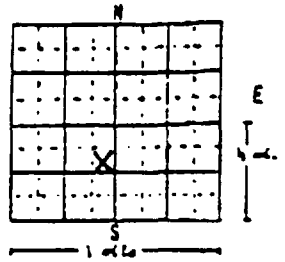
Township Name	Township Number	Range Number	Section No.	Fraction
ANDOVER	32 N or S	24 E or W	34	SE NE SW (¼ ¼ of ¼)

4. WELL DEPTH (completed) ft. | Date sealed

Numerical Street Address and City of Well Location or Distance from Road Intersection
APPROX 750 Ft S. of BUNKER LAKE BOULEVARD (2050)
670 FT W. of JAY ROAD

Show exact location of well (in section grid with "X")

Sketch map of well location



5. DRILLING METHOD (if known)
1 ☐ Cable tool 4 ☐ Reverse 7 ☐ Driven 10 ☐ Dug
2 ☐ Hollow Rod 5 ☐ Air 8 ☐ Bored 11 ☐ _____
3 ☐ Rotary 6 ☐ Jetted 9 ☒ Power Auger

6. OBSTRUCTIONS
Well obstructed ☐ Yes ☒ No
Obstructions removed ☐ Yes ☐ No If obstructions cannot be removed, contact MGH before sealing.

7. USE
1 ☐ Domestic 4 ☐ Monitoring 6 ☐ Heat Loop
2 ☐ Irrigation 5 ☐ Public 9 ☐ Industry
3 ☐ Test Well 8 ☐ Municipal 10 ☐ Commercial
7 ☐ Air Conditioning 11 ☐ _____

2. PROPERTY OWNER'S NAME

Mailing Address if different than property address indicated above

8. CASING(S)
1 ☐ Black 4 ☐ Threaded 7 ☐ _____
2 ☒ Galv. 5 ☐ Welded
3 ☐ Plastic 6 ☐ Stainless Steel
1¼ in. to 30 ft.
_____ in. to _____ ft.

3. FORMATION LOG — If not known, indicate formation log from new well or nearby well.

FORMATION LOG	COLOR	HARDNESS OF FORMATION	FROM	TO

9. SCREEN
☒ Screened well from 30 ft. to 35 ft. (If known)
☐ Open Hole from ____ ft. to ____ ft.

10. STATIC WATER LEVEL
_____ ft. ☐ below ☐ above land surface Date Measured _____

11. WELLHEAD COMPLETION
1 ☐ Pitless Adapter 4 ☐ Found Buried
2 ☐ Basement offset 5 ☒ STEEL PROTECTOR PIPE & BENTONITE PELLET CAP
3 ☐ Well Pit

16. REMARKS, ELEVATION, SOURCE OF DATA - CASINGS REMOVED, CASINGS PERFORATED, ETC.

GROUND ELEV.

RISER ELEV.

12. GROUTING INFORMATION
1 ☐ Neat Cement 3 ☐ Bentonite 2 ☒ CEMENT-BENTONITE
Grout material _____ from ____ to ____ ft. cu. yds ____

13. NEAREST SOURCES OF CONTAMINATION
____ feet _____ direction _____ type
Well disinfected before sealing? ☐ Yes

14. PUMP ☐ Removed ☒ Not Present
Type: 1 ☐ Submersible 3 ☐ L.S. Turbine 5 ☐ Reciprocating
2 ☐ Jet 4 ☐ Centrifugal 6 ☐ _____

15. EXISTING WELLS (Please sketch locations of abandoned and active wells in remarks section or on back.)
Other unused well(s) on property? ☐ Yes ☐ No
Abandoned: ☐ Permanent ☐ Temporary ☐ Not sealed

17. WATER WELL CONTRACTORS CERTIFICATION
This well was sealed under my jurisdiction and this report is true to the best of my knowledge and belief.

License Business Name License No.

Address

Signed _____ Date

_____ Date
Name of Driller

OFFICIAL ABANDONED WELL RECORD (May be used for Property Transfer)

IMPORTANT: FILE WITH MGH

ABANDONED WELL RECORD

MINNESOTA UNIQUE WELL NO. (leave blank if not known)

1. LOCATION OF WELL

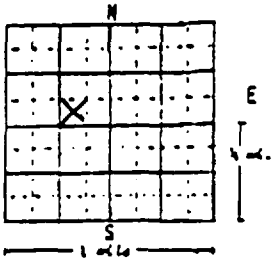
County Name: ANOKA

Township Name	Township Number	Range Number	Section No.	Fraction ¼ ¼ of ¼	4. WELL DEPTH (completed)	Date sealed
ANDOVER	32 N or S	24 E or W	34	SW SE NW	32.0 ft.	

Numerical Street Address and City of Well Location or Distance from Rose Intersection

APPROX 275 Ft N of BUNKER LAKE BOULEVARD (2050)
1820 FT W OF JAY STREET INTERSECTION

Show exact location of well (in section grid with "X")



Sketch map of well location

2. PROPERTY OWNER'S NAME

Mailing Address if different than property address indicated above

3. FORMATION LOG (If not known, indicate formation log from new well or nearby well.)

FORMATION LOG	COLOR	HARDNESS OF FORMATION	FROM	TO
SAND (SP)	BROWN		0	40
SILT (ML)	RED		40	70
SAND (SP)	BR		70	

16. REMARKS, ELEVATION, SOURCE OF DATA - CASINGS REMOVED, CASINGS PERFORATED, ETC.

5. DRILLING METHOD (If known)
1 ☐ Cable tool 4 ☐ Reverse 7 ☐ Driven 10 ☐ Dug
2 ☐ Hollow Rod 5 ☐ Air 8 ☐ Bored 11 ☐ _____
3 ☐ Rotary 6 ☐ Jetted 9 ☒ Power Auger

6. OBSTRUCTIONS
Well obstructed ☐ Yes ☒ No
Obstructions removed ☐ Yes ☐ No If obstructions cannot be removed, contact MDH before sealing.

7. USE
1 ☐ Domestic 4 ☒ Monitoring 6 ☐ Heat Loop
2 ☐ Irrigation 5 ☐ Public 9 ☐ Industry
3 ☐ Test Well 6 ☐ Municipal 10 ☐ Commercial
7 ☐ Air Conditioning 11 ☐ _____

8. CASING(S)
1 ☐ Black 4 ☐ Threaded 7 ☐ _____
2 ☒ Galv. 6 ☐ Welded
3 ☐ Plastic 8 ☐ Stainless Steel

_____ in. to _____ ft.
_____ in. to _____ ft.

9. SCREEN
☒ Screened well from ____ ft. to ____ ft. (If known)
☐ Open Hole from ____ ft. to ____ ft.

10. STATIC WATER LEVEL
_____ ft. ☐ below ☐ above land surface Date Measured _____

11. WELLHEAD COMPLETION
1 ☐ Pitless Adapter 4 ☐ Pound Surface
2 ☐ Basement offset 5 ☐ _____
3 ☐ Well Pit

12. GROUTING INFORMATION
1 ☐ Neat Cement 3 ☐ Bentonite 4 ☐ _____
Grout material _____ from ____ to ____ ft. cu. yds. ____

13. NEAREST SOURCES OF CONTAMINATION
____ feet _____ direction _____ type
Well disinfected before sealing? ☐ Yes

14. PUMP ☐ Removed ☒ Not Present
Type: 1 ☐ Submersible 3 ☐ L.S. Turbine 5 ☐ Reciprocating
2 ☐ Jet 4 ☐ Centrifugal 6 ☐ _____

15. EXISTING WELLS (Please sketch locations of abandoned and active wells in remarks section or on back.)
Other unused well(s) on property? ☐ Yes ☒ No
Abandoned: ☐ Permanent ☐ Temporary ☐ Not sealed

17. WATER WELL CONTRACTORS CERTIFICATION
This well was sealed under my jurisdiction and this report is true to the best of my knowledge and belief.

_____ License Business Name License No.

Address _____

Signed _____ Date _____

_____ Date _____
Name of Driller

OFFICIAL ABANDONED WELL RECORD (May be used for Property Transfer)

IMPORTANT: FILE WITH MDH

ABANDONED WELL RECORD

1. LOCATION OF WELL W-28

MINNESOTA UNIQUE WELL NO. (Leave blank if not known)

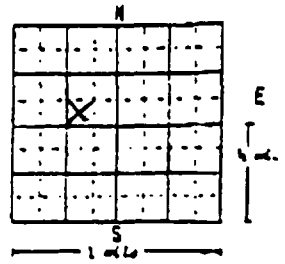
County Name ANOKA

Township Name	Township Number	Range Number	Section No.	Fraction ¼ ¼ of ¼	4. WELL DEPTH (completed)	Date sealed
ANDOVER	32 N or S	24 E or W	34	SW SE NW	50.0 ft.	

Numerical Street Address and City of Well Location or Distance from Road Intersection

APPROX 275 FT N. of BUNKER LAKE BOULEVARD
& 1820 FT W. OF JAY STREET INTERSECTION

Show exact location of well (in section grid with "X")



Sketch map of well location

5. DRILLING METHOD (if known)
1 ☐ Cable tool 4 ☐ Reverse 7 ☐ Driven 10 ☐ Dug
2 ☐ Hollow Rod 5 ☐ Air 8 ☐ Bored 11 ☐ _____
3 ☐ Rotary 6 ☐ Jetted 9 ☒ Power Auger

6. OBSTRUCTIONS
Well obstructed ☐ Yes ☒ No
Obstructions removed ☐ Yes ☐ No If obstructions cannot be removed, contact MDH before sealing.

7. USE
1 ☐ Domestic 4 ☒ Monitoring 6 ☐ Heat Loop
2 ☐ Irrigation 5 ☐ Public 9 ☐ Industry
3 ☐ Test Well 8 ☐ Municipal 10 ☐ Commercial
7 ☐ Air Conditioning 11 ☐ _____

2. PROPERTY OWNER'S NAME

Mailing Address if different than property address indicated above

8. CASING(S)
1 ☐ Black 4 ☐ Threaded 7 ☐ _____
2 ☒ Galv. 6 ☐ Welded
3 ☐ Plastic 8 ☐ Stainless Steel
_____ in. to _____ ft.
_____ in. to _____ ft.

3. FORMATION LOG — If not known, indicate formation log from new well or nearby well.

FORMATION LOG	COLOR	HARDNESS OF FORMATION	FROM	TO
SAND (SP)			0	40
SILT (ML)			40	70
SAND (SP			70	

9. SCREEN
☒ Screened well from 45 ft. to 50 ft. (if known)
☐ Open Hole from ____ ft. to ____ ft.

10. STATIC WATER LEVEL
_____ ft. ☐ below ☐ above land surface Date Measured _____

11. WELLHEAD COMPLETION
1 ☐ Pitless Adapter 4 ☐ Pound Surface
2 ☐ Basement offset 5 ☐ _____
3 ☐ Well Pit

12. GROUTING INFORMATION
1 ☐ Neat Cement 3 ☐ Bentonite 5 ☐ _____
Grout material _____ from ____ to ____ ft. cu. yds ____

13. NEAREST SOURCES OF CONTAMINATION
____ feet _____ direction _____ type
Well disinfected before sealing? ☐ Yes

14. PUMP ☐ Removed ☒ Not Present
Type: 1 ☐ Submersible 3 ☐ L.S. Turbine 5 ☐ Reciprocating
2 ☐ Jet 4 ☐ Centrifugal 6 ☐ _____

15. EXISTING WELLS (Please sketch locations of abandoned and active wells in remarks section or on back.)
Other unused well(s) on property? ☐ Yes ☐ No
Abandoned: ☐ Permanent ☐ Temporary ☐ Not sealed

16. REMARKS, ELEVATION, SOURCE OF DATA - CASINGS REMOVED, CASINGS PERFORATED, ETC.

17. WATER WELL CONTRACTORS CERTIFICATION
This well was sealed under my jurisdiction and this report is true to the best of my knowledge and belief.

_____ Licensed Business Name _____ License No.

Address _____

Signed _____ Date _____

_____ Date _____
Name of Driller

OFFICIAL ABANDONED WELL RECORD (May be used for Property Transfer)

IMPORTANT: FILE WITH MDH

ABANDONED WELL RECORD

MINNESOTA UNIQUE WELL NO. (leave blank if not known)

1. LOCATION OF WELL W-2C

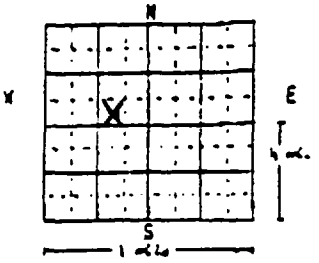
County Name ANOKA

Township Name	Township Number	Range Number	Section No.	Fraction	4. WELL DEPTH (completed)	Date sealed
ANDOVER	32 N or S	24 E or W	34	SW SE NW	107 ft.	

Numerical Street Address and City of Well Location or Distance from Road Intersection

APPROX 275 Ft N. of BUNKER LAKE BOULEVARD (2050) & 1820 Ft W. of Jay Street Intersection

Show exact location of well (in section grid with "X")



Sketch map of well location

2. PROPERTY OWNER'S NAME

Mailing Address if different than property address indicated above

3. FORMATION LOG — If not known, indicate formation log from new well or nearby well.

FORMATION	COLOR	HARDNESS OF FORMATION	FROM	TO
SAND (SP-SM)	BR		0	84
SILT (ML)	RED BR		84	94
SAND (SP)	GRAY		94	107

16. REMARKS, ELEVATION, SOURCE OF DATA - CASINGS REMOVED, CASINGS PERFORATED, ETC.

5. DRILLING METHOD (if known)
1 ☐ Cable tool 4 ☐ Reverse 7 ☐ Driven 10 ☐ Dug
2 ☐ Hollow Rod 5 ☐ Air 8 ☐ Bored 11 ☐ _____
3 ☐ Rotary 6 ☐ Jetted 9 ☒ Power Auger

6. OBSTRUCTIONS
Well obstructed ☐ Yes ☒ No
Obstructions removed ☐ Yes ☐ No If obstructions cannot be removed, contact MDH before sealing.

7. USE
1 ☐ Domestic 4 ☒ Monitoring 6 ☐ Heat Loop
2 ☐ Irrigation 5 ☐ Public 9 ☐ Industry
3 ☐ Test Well 6 ☐ Municipal 10 ☐ Commercial
7 ☐ Air Conditioning 11 ☐ _____

8. CASING(S)
1 ☐ Black 4 ☐ Threaded 7 ☐ _____
2 ☒ Galv. 5 ☐ Welded
3 ☐ Plastic 6 ☐ Stainless Steel
_____ in. to _____ ft.
_____ in. to _____ ft.

9. SCREEN
☐ Screened well from 92 ft. to 107 ft. (if known)
☐ Open Hole from ____ ft. to ____ ft.

10. STATIC WATER LEVEL
_____ ft. ☐ below ☐ above land surface Date Measured _____

11. WELLHEAD COMPLETION
1 ☐ Pitless Adapter 4 ☐ Pound Buried
2 ☐ Basement offset 5 ☐ _____
3 ☐ Well Pit

12. GROUTING INFORMATION
1 ☐ Neat Cement 3 ☐ Bentonite 5 ☒ CEMENT-BENT.
Grout material AS ABOVE from 0 to 89 ft. cu. yds ____

13. NEAREST SOURCES OF CONTAMINATION
____ feet _____ direction _____ type
Well disinfected before sealing? ☐ Yes

14. PUMP ☐ Removed ☒ Not Present
Type: 1 ☐ Submersible 3 ☐ L.S. Turbine 5 ☐ Reciprocating
2 ☐ Jet 4 ☐ Centrifugal 6 ☐ _____

15. EXISTING WELLS (Please sketch locations of abandoned and active wells in remarks section or on back.)
Other unused well(s) on property? ☐ Yes ☒ No
Abandoned: ☐ Permanent ☐ Temporary ☐ Not sealed

17. WATER WELL CONTRACTORS CERTIFICATION
This well was sealed under my jurisdiction and this report is true to the best of my knowledge and belief.

License Business Name _____ License No. _____

Address _____

Signed _____ Date _____

_____ Date _____
Name of Driller

OFFICIAL ABANDONED WELL RECORD (May be used for Property Transfer)

IMPORTANT: FILE WITH DNR

ABANDONED WELL RECORD

1. LOCATION OF WELL -W-HA

MINNESOTA UNIQUE WELL NO. (leave blank if not known)

County Name ANOKA

Township Name	Township Number	Range Number	Section No.	Fraction
ANDOVER	32 N or S	24 E or W	34	¼ ¼ of ¼

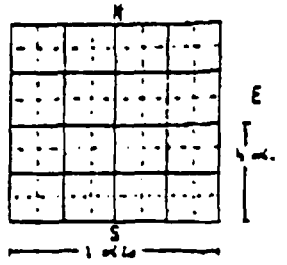
4. WELL DEPTH (completed) 21.0 ft. Date sealed

Numerical Street Address and City of Well Location or Distance from Road Intersection

2050 N BUNKER LAKE BLVD

Show exact location of well (in section grid with "X")

Sketch map of well location



5. DRILLING METHOD (if known)
1 ☐ Cable tool 4 ☐ Reverse 7 ☐ Driven 10 ☐ Dug
2 ☐ Hollow Rod 5 ☐ Air 8 ☐ Bored 11 ☐ _____
3 ☐ Rotary 6 ☐ Jetted 9 ☒ Power Auger

6. OBSTRUCTIONS
Well obstructed ☐ Yes ☒ No
Obstructions removed ☐ Yes ☐ No If obstructions cannot be removed, contact MDH before sealing.

7. USE
1 ☐ Domestic ☒ Monitoring 6 ☐ Heat Loop
2 ☐ Irrigation 5 ☐ Public 9 ☐ Industry
3 ☐ Test Well 6 ☐ Municipal 10 ☐ Commercial
7 ☐ Air Conditioning 11 ☐ _____

2. PROPERTY OWNER'S NAME

Mailing Address if different than property address indicated above

8. CASING(S)
1 ☐ Black 4 ☐ Threaded 7 ☐ _____
2 ☒ Galv. 5 ☐ Welded
3 ☐ Plastic 6 ☐ Stainless Steel
_____ in. to _____ ft.
_____ in. to _____ ft.

3. FORMATION LOG — If not known, indicate formation log from new well or nearby well.

FORMATION LOG	COLOR	HARDNESS OF FORMATION	FROM	TO

9. SCREEN
☒ Screened well from 16 ft. to 21 ft. (if known)
☐ Open Hole from ____ ft. to ____ ft.

10. STATIC WATER LEVEL
_____ ft. ☐ below ☐ above land surface Date Measured _____

11. WELLHEAD COMPLETION
1 ☐ Pitless Adapter 4 ☐ Found Buried
2 ☐ Basement offset 5 ☒ CONCRETE SECURED PROTECTOR
3 ☐ Well Pit

16. REMARKS, ELEVATION, SOURCE OF DATA - CASINGS REMOVED, CASINGS PERFORATED, ETC.

12. GROUTING INFORMATION
1 ☐ Neat Cement 2 ☐ Bentonite 3 ☐ _____
Grout material _____ from ____ to ____ ft. cu. yds ____

13. NEAREST SOURCES OF CONTAMINATION
____ feet _____ direction _____ type
Well disinfected before sealing? ☐ Yes

14. PUMP ☐ Removed ☒ Not Present
Type: 1 ☐ Submersible 3 ☐ L.S. Turbine 5 ☐ Reciprocating
2 ☐ Jet 4 ☐ Centrifugal 6 ☐ _____

15. EXISTING WELLS (Please shows locations of abandoned and active wells in remarks section or on back.)
Other unused well(s) on property? ☐ Yes ☒ No
Abandoned: ☐ Permanent ☐ Temporary ☐ Not sealed

17. WATER WELL CONTRACTORS CERTIFICATION
This well was sealed under my jurisdiction and this report is true to the best of my knowledge and belief.

Licensed Business Name License No.

Address

Signed _____ Date _____

_____ Date _____
Name of Driller

OFFICIAL ABANDONED WELL RECORD (May be used for Property Transfer)

IMPORTANT: FILE WITH MDH

APPENDIX G

TECHNICAL MEMORANDUM
SLUG TESTING AND HYDRAULIC CHARACTERIZATION

MEMORANDUM

DATE: January 16, 1991

TO: Dave Voight

FROM: Peter Rzepecki

SUBJECT: EPA ARCS Region V Contract No. 68-W8-0093
EPA Work Assignment No. 13-5N45
Donohue Project No. 20022

Hydraulic Conductivity Testing

INTRODUCTION

Twelve rate-of-recovery (slug) tests were conducted on six monitoring wells to determine aquifer local hydraulic conductivity. Tests were performed on October 23-24, 1990, by Steve Slocum and Peter Rzepecki.

These tests were conducted utilizing a pressure transducer to measure water level changes over time in the well. The wells tested and analysis results are shown in Table 1. Data and interpretation of data is presented in computer printouts and graphs attached. The "depth of water" column contains transducer readings. The "drawdown" column represents an absolute value of the difference between initial transducer reading (static water level) and consecutive transducer readings.

FIELD ACTIVITIES

All wells had falling and raising head tests performed on them. Falling head tests are those in which a stainless steel slug is lowered into the well, displacing the water column upward. Measurements of water column height versus time is then made as the water column falls back toward the equilibrium level. The rate of decline is directly proportional to the hydraulic conductivity of the formation around the well screen. The rising head tests are those in which the equilibrium water level has been allowed to reestablish itself, or nearly so, after the slug has been placed into the water (usually after a falling head test is completed). The slug is then rapidly removed from the well causing the water level to drop below equilibrium. Measurements are then taken as the water level rises back to equilibrium.

DATA EVALUATION

The rate-of-recovery tests were analyzed utilizing the Bouwer and Rice method (1976). This analysis is applicable to fully or partially penetrating wells in unconfined aquifers or confined aquifers with leaky confining beds. This is generally the case for the six wells tested. Data reduction and analyses were done using a computer program by Howard Trussell of Donohue.

Table 1 presents the resulting hydraulic conductivities. The rising head data is preferable for wells where the static water level falls within the screened interval, as in water table wells (Bouwer, 1989). Because both sets of data were available, both rising and falling head data were analyzed for all wells to compare values. As Table 1 indicates with an exception for W-23-A the values are similar.

The quality of the data proved to be good (see attached figures), and obtained estimates seem to be reliable. The introduced values of aquifer thickness (estimated aquifer depth) are rough estimates, but calculated K-value is not especially sensitive to this parameter, and resulting differences in K are insignificant. It is noteworthy that the small diameter of all the tested wells makes the results of tests especially vulnerable to aquifer heterogeneities. Calculated hydraulic conductivities represent the very local conditions around the well screens.

The effective screen length for wells with water table crossing the screen was calculated based on static water level. The actual changes in effective screen length during slug test are accounted for by introducing into calculations coefficients A, B, and C (Bouwer, 1989).

REFERENCES

Bouwer, H. 1989, The Bouwer and Rice Slug Test-An Update, Groundwater, Vol. 27, No. 3.

Bouwer, H. and Rice, R.C., 1976, A Slug Test for Determining Hydraulic Conductivity of Unconfined Aquifers with Completely or Partially Penetrating Wells, Water Resources, Vol 12, No. 3.

Attach: Computer Generated Printouts and Graphs
Infield Hydraulic Conductivity Slug Test Forms

ARCS/R/SANDOVER/AT6

TABLE 1.

SOUTH ANDOVER - DRAFT SITE INVESTIGATION PLAN
SUMMARY OF RATE-OF-RECOVERY TESTS

Date of test	Well Number	Hydraulic Conductivity (cm/sec) (1) Falling Head	Rising Head
10-24-90	W-1-C	1.12E-03	1.10E-03
10-24-90	W-6-A	2.13E-02	1.61E-02
10-24-90	W-6-B	3.37E-05	2.52E-05
10-23-90	W-7-B	2.16E-05	1.85E-05
10-23-90	W-7-C	5.30E-04	5.23E-04
10-24-90	W-23-A	8.68E-04	4.55E-03

(1) - Analyzed using the Bouwer and Rice method (1976).

Donohue ENGINEERS ARCHITECTS SCIENTISTS

INFIELD HYDRAULIC CONDUCTIVITY SLUG TEST

SHEET 7 OF ___

PROJECT NO.: 20022 003

SITE: South Andover

WELL NUMBER: W-1-C

LOGGER ID NUMBER: 07

CLIENT: ___

WELL DRILLED BY: ___

DATE TEST PERFORMED: 3:15PM

TIME TEST PERFORMED: 10/24/90

TOP OF PIPE ELEVATION: ___

OBSERVATION WELL/PIEZOMETER (circle): ___

FALL/RISE TEST (circle) ___

FORMATION WELL SCREENED IN: ___

STATIC WATER LEVEL (T.C.P.): 21.21

TOTAL DEPTH OF WELL: 46.15

DEPTH OF WATER IN WELL: ___

INITIAL TRANSDUCER WATER LEVEL: ~~21.21~~ 7.54

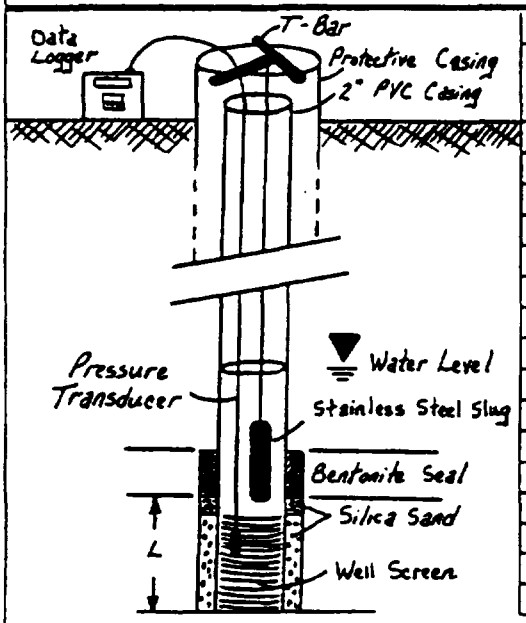
STATIC TRANSDUCER WATER LEVEL: ___

DIAMETER OF BOREHOLE: 6"

DIAMETER OF PIPE: 2"

SCREEN LENGTH: 5'

EFFECTIVE SCREEN LENGTH* "L": ___



*"L" length is less than the sand pack length if the water table intersects sand pack, where "L" will equal distance between water table and bottom of sand pack.

SILOG II LOGGING SEQUENCE

SEGMENT NUMBER	NUMBER OF READINGS	INTERVAL (SEC.)	SEGMENT DURATION (SEC.)	ELAPSED TIME (SEC.)
1				
2				
3				
4				
5	10	60		
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				

PRESSURE TRANSDUCER PSI: 05

STAINLESS STEEL SLUG LENGTH: 4'

NOTES: ___

TEST PERFORMED BY: ___ DATE: ___

LOGGER DOWNLOADED BY: ___ DATE: ___

CALCULATIONS BY: ___ DATE: ___

COMPUTER FILE NAME: ___

Donohue ENGINEERS ARCHITECTS SCIENTISTS

INFIELD HYDRAULIC CONDUCTIVITY SLUG TEST

SHEET 8 OF ___

PROJECT NO.: 20022.003

SITE: South Andover

WELL NUMBER: W-1-C

LOGGER ID NUMBER: 08

CLIENT: ___

WELL DRILLED BY: ___

DATE TEST PERFORMED: 10/24/90

TIME TEST PERFORMED: 3:40 PM

TOP OF PIPE ELEVATION: ___

OBSERVATION WELL/PIEZOMETER (circle): ___

FALL/RISE TEST (circle) ___

FORMATION WELL SCREENED IN: ___

STATIC WATER LEVEL (T.C.P.): 21.21

TOTAL DEPTH OF WELL: ___

DEPTH OF WATER IN WELL: ___

INITIAL TRANSDUCER WATER LEVEL: 7.55

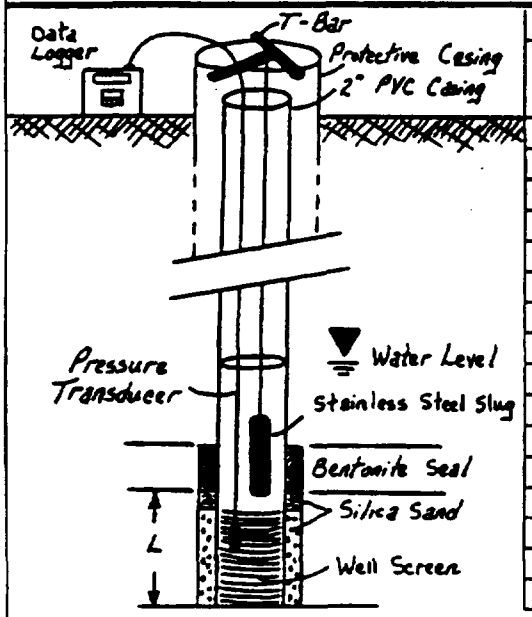
STATIC TRANSDUCER WATER LEVEL: ___

DIAMETER OF BOREHOLE: 6"

DIAMETER OF PIPE: 2"

SCREEN LENGTH: 5'

EFFECTIVE SCREEN LENGTH* "L": ___



*"L" length is less than the sand pack length if the water table intersects sand pack, where "L" will equal distance between water table and bottom of sand pack.

SILOG II LOGGING SEQUENCE

SEGMENT NUMBER	NUMBER OF READINGS	INTERVAL (SEC.)	SEGMENT DURATION (SEC.)	ELAPSED TIME (SEC.)
1	30	1		
2	18	5		
3	16	15		
4	8	30		
5	10	60		
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				

PRESSURE TRANSDUCER PSI: 05

STAINLESS STEEL SLUG LENGTH: 4'

NOTES: ___

TEST PERFORMED BY: [illegible] DATE: 10/24/90

LOGGER DOWNLOADED BY: ___ DATE: ___

CALCULATIONS BY: ___ DATE: ___

COMPUTER FILE NAME: ___

18 pts ✓

Donohue ENGINEERS ARCHITECTS SCIENTISTS

INFIELD HYDRAULIC CONDUCTIVITY SLUG TEST

SHEET 3 OF ___

PROJECT NO.: 20022.003

SITE: South Indover

WELL NUMBER: ~~W~~ B-6A-R

LOGGER ID NUMBER: 03

CLIENT: ___

WELL DRILLED BY: ___

DATE TEST PERFORMED: 10/24/90

TIME TEST PERFORMED: 12:45 PM

TOP OF PIPE ELEVATION: ___

OBSERVATION WELL/PIEZOMETER (circle): ___

FALL/RISE TEST (circle) ___

FORMATION WELL SCREENED IN: ___

STATIC WATER LEVEL (T.C.P.): 16.70

TOTAL DEPTH OF WELL: 25.05

DEPTH OF WATER IN WELL: ___

INITIAL TRANSDUCER WATER LEVEL: 7.57

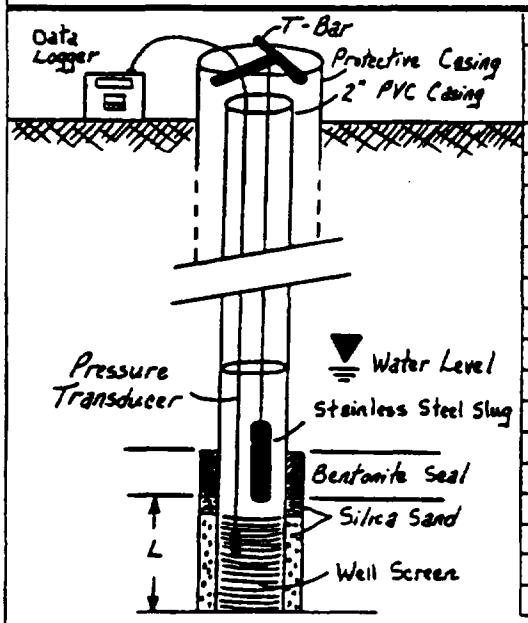
STATIC TRANSDUCER WATER LEVEL: ___

DIAMETER OF BOREHOLE: 8"

DIAMETER OF PIPE: 2"

SCREEN LENGTH: 10'

EFFECTIVE SCREEN LENGTH* "L": ___



*"L" length is less than the sand pack length if the water table intersects sand pack, where "L" will equal distance between water table and bottom of sand pack.

SILOG II LOGGING SEQUENCE

SEGMENT NUMBER	NUMBER OF READINGS	INTERVAL (SEC.)	SEGMENT DURATION (SEC.)	ELAPSED TIME (SEC.)
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				

PRESSURE TRANSDUCER PSI: 05

STAINLESS STEEL SLUG LENGTH: 4'

NOTES: ___

TEST PERFORMED BY: [illegible] DATE: 10/24/90

LOGGER DOWNLOADED BY: ___ DATE: ___

CALCULATIONS BY: ___ DATE: ___

COMPUTER FILE NAME: ___

22 pts. ✓

Donohue ENGINEERS ARCHITECTS SCIENTISTS

INFIELD HYDRAULIC CONDUCTIVITY SLUG TEST

SHEET 4 OF ___

PROJECT NO.: 20022.003

SITE: South Andover

WELL NUMBER: ~~70~~ B - 6A - R

LOGGER ID NUMBER: 04

CLIENT: ___

WELL DRILLED BY: ___

DATE TEST PERFORMED: 10/24/90

TIME TEST PERFORMED: 1:05

TOP OF PIPE ELEVATION: ___

OBSERVATION WELL/PIEZOMETER (circle): ___

FALL/RISE TEST (circle) ___

FORMATION WELL SCREENED IN: ___

STATIC WATER LEVEL (T.C.P.): 16.70

TOTAL DEPTH OF WELL: 25.05

DEPTH OF WATER IN WELL: ___

INITIAL TRANSDUCER WATER LEVEL: 7.58

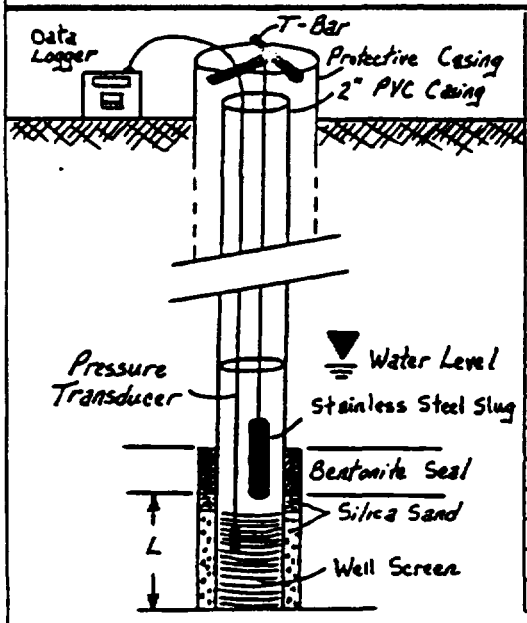
STATIC TRANSDUCER WATER LEVEL: ___

DIAMETER OF BOREHOLE: 8"

DIAMETER OF PIPE: 2"

SCREEN LENGTH: 10'

EFFECTIVE SCREEN LENGTH* "L": ___



*"L" length is less than the sand pack length if water table intersects sand pack, where "L" is distance between water table and top of sand pack.

SILOG II LOGGING SEQUENCE

SEGMENT NUMBER	NUMBER OF READINGS	INTERVAL (SEC.)	SEGMENT DURATION (SEC.)	ELAPSED TIME (SEC.)
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				

PRESSURE TRANSDUCER PSI: 05

STAINLESS STEEL SLUG LENGTH: 4'

NOTES: ___

[illegible]: [illegible] DATE: 10/24/90

LOGGER [illegible]: ___ DATE: ___

[illegible]: ___

Donohue ENGINEERS ARCHITECTS SCIENTISTS

INFIELD HYDRAULIC CONDUCTIVITY SLUG TEST

SHEET 11 OF ___

PROJECT NO.: 20022.003

SITE: South Andover

WELL NUMBER: ~~D~~ B-6B-R

LOGGER ID NUMBER: 01

CLIENT: ___

WELL DRILLED BY: ___

DATE TEST PERFORMED: 10/24/90

TIME TEST PERFORMED: 11:45 AM

TOP OF PIPE ELEVATION: ___

OBSERVATION WELL/PIEZOMETER (circle): ___

FALL/RISE TEST (circle) ___

FORMATION WELL SCREENED IN: ___

STATIC WATER LEVEL (T.C.P.): 17.27

TOTAL DEPTH OF WELL: 51.93

DEPTH OF WATER IN WELL: ___

INITIAL TRANSDUCER WATER LEVEL: 7.57

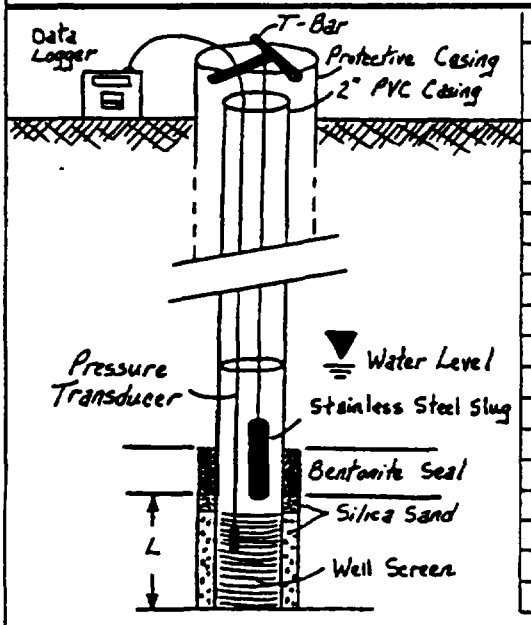
STATIC TRANSDUCER WATER LEVEL: ___

DIAMETER OF BOREHOLE: 8"

DIAMETER OF PIPE: 2"

SCREEN LENGTH: 5'

EFFECTIVE SCREEN LENGTH* "L": ___



*"L" length is less than the sand pack length if the water table intersects sand pack, where "L" will equal distance between water table and bottom of sand pack.

SILOG II LOGGING SEQUENCE

SEGMENT NUMBER	NUMBER OF READINGS	INTERVAL (SEC.)	SEGMENT DURATION (SEC.)	ELAPSED TIME (SEC.)
1	30	01	30	30
2	18	05	90	120
3	16	15	240	360
4	08	30	240	600
5	05	60	300	900
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				

PRESSURE TRANSDUCER PSI: ___

STAINLESS STEEL SLUG LENGTH: ___

9
16
15
80
16
40

NOTES: ___

[illegible]: [illegible] / [illegible]

LOGGER DOWNLOADED BY: ___

COMPUTER FILE NAME: ___

Donohue ENGINEERS ARCHITECTS SCIENTISTS

INFIELD HYDRAULIC CONDUCTIVITY SLUG TEST

SHEET 2 OF ___

PROJECT NO.: 28022.003

SITE: South Andover

WELL NUMBER: ~~02~~ B-6B-R

LOGGER ID NUMBER: 02

CLIENT: ___

WELL DRILLED BY: ___

DATE TEST PERFORMED: 10/24/90

TIME TEST PERFORMED: 12:15 PM

TOP OF PIPE ELEVATION: ___

OBSERVATION WELL/PIEZOMETER (circle): ___

FALL/RISE TEST (circle) ___

FORMATION WELL SCREENED IN: ___

STATIC WATER LEVEL (T.C.P.): 17.27

TOTAL DEPTH OF WELL: 51.93

DEPTH OF WATER IN WELL: ___

INITIAL TRANSDUCER WATER LEVEL: 7.67

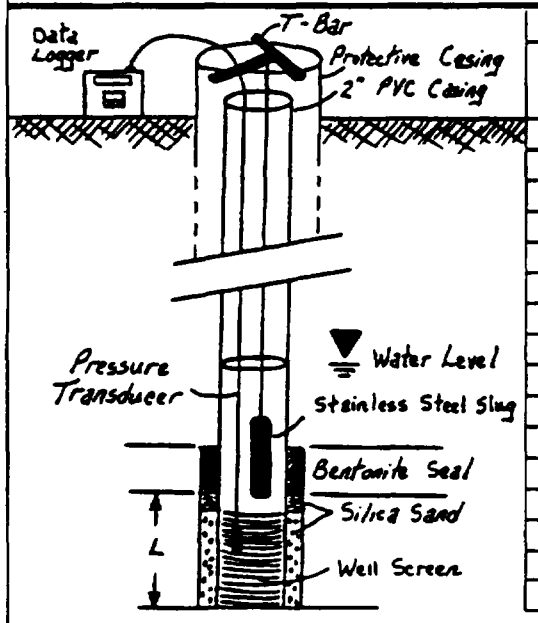
STATIC TRANSDUCER WATER LEVEL: ___

DIAMETER OF BOREHOLE: 8"

DIAMETER OF PIPE: 2"

SCREEN LENGTH: 5'

EFFECTIVE SCREEN LENGTH* "L": ___



*"L" length is less than the sand pack length if the water table intersects sand pack, where "L" will equal distance between water table and bottom of sand pack.

SILOG II LOGGING SEQUENCE

SEGMENT NUMBER	NUMBER OF READINGS	INTERVAL (SEC.)	SEGMENT DURATION (SEC.)	ELAPSED TIME (SEC.)
1	30	01	30	30
2	18	05	90	120
3	16	15	240	360
4	08	30	240	600
5	05	60	300	900
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				

PRESSURE TRANSDUCER PSI: 5

STAINLESS STEEL SLUG LENGTH: 4'

NOTES: ___

TEST PERFORMED BY: [illegible] DATE: 10/24/90

LOGGER DOWNLOADED BY: ___ DATE: ___

CALCULATIONS BY: ___ DATE: ___

COMPUTER FILE NAME: ___

Donohue ENGINEERS ARCHITECTS SCIENTISTS

INFIELD HYDRAULIC CONDUCTIVITY SLUG TEST

SHEET 3 OF ___

PROJECT NO.: 20022.003

SITE: South Anchorage

WELL NUMBER: ~~7~~ 3 - 7 - B

LOGGER ID NUMBER: 3 + 4

CLIENT: ARCS

WELL DRILLED BY: ___

DATE TEST PERFORMED: 10/23/90

TIME TEST PERFORMED: 3:45

TOP OF PIPE ELEVATION: ___

OBSERVATION WELL/PIEZOMETER (circle): ___

FALL/RISE TEST (circle) ___

FORMATION WELL SCREENED IN: ___

STATIC WATER LEVEL (T.C.P.): ~25.07

TOTAL DEPTH OF WELL: ___

DEPTH OF WATER IN WELL: ___

INITIAL TRANSDUCER WATER LEVEL: 7.71

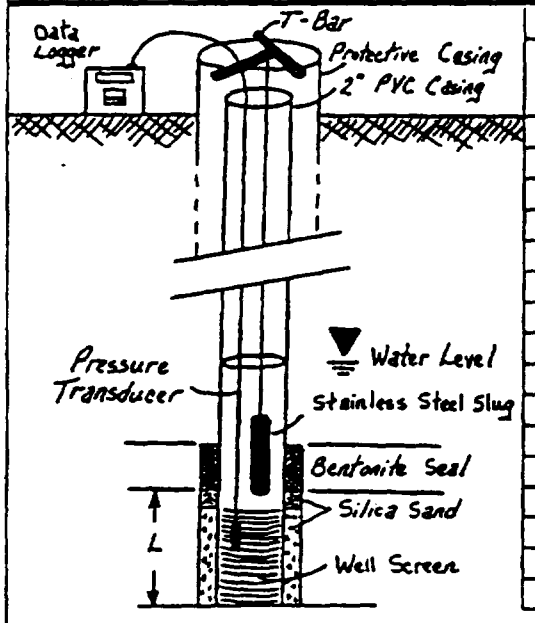
STATIC TRANSDUCER WATER LEVEL: ___

DIAMETER OF BOREHOLE: ___

DIAMETER OF PIPE: 2"

SCREEN LENGTH: ___

EFFECTIVE SCREEN LENGTH* "L": ___



SILOG II LOGGING SEQUENCE

SEGMENT NUMBER	NUMBER OF READINGS	INTERVAL (SEC.)	SEGMENT DURATION (SEC.)	ELAPSED TIME (SEC.)
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				

*"L" length is less than the sand pack length if the water table intersects sand pack, where "L" will equal distance between water table and bottom of sand pack.

PRESSURE TRANSDUCER PSI: ___

STAINLESS STEEL SLUG LENGTH: ___

NOTES: Communication problem: ie. - "Start" Re-start w/ 10:60 initial reading 8.14' Elapsed time 40 sec. to re-start

[illegible] 10/23/90

DATE: ___

BY: ___

Donohue ENGINEERS ARCHITECTS SCIENTISTS

INFIELD HYDRAULIC CONDUCTIVITY SLUG TEST

SHEET 4 OF ___

PROJECT NO.: 20032.003

SITE: 5 ANDOVER

WELL NUMBER: ~~W~~ B-7-B

LOGGER ID NUMBER: 05

CLIENT: ___

WELL DRILLED BY: ___

DATE TEST PERFORMED: ___

TIME TEST PERFORMED: ___

TOP OF PIPE ELEVATION: ___

OBSERVATION WELL/PIEZOMETER (circle): ___

FALL/RISE TEST (circle) ___

FORMATION WELL SCREENED IN: ___

STATIC WATER LEVEL (T.C.P.): ___

TOTAL DEPTH OF WELL: ___

DEPTH OF WATER IN WELL: ___

INITIAL TRANSDUCER WATER LEVEL: 7.92

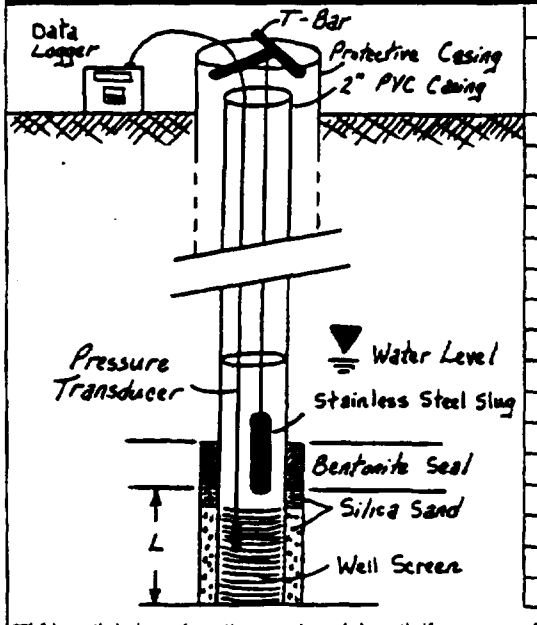
STATIC TRANSDUCER WATER LEVEL: ___

DIAMETER OF BOREHOLE: ___

DIAMETER OF PIPE: ___

SCREEN LENGTH: ___

EFFECTIVE SCREEN LENGTH* "L": ___



*"L" length is less than the sand pack length if the water table intersects sand pack, where "L" will equal distance between water table and bottom of sand pack.

SILOG II LOGGING SEQUENCE

SEGMENT NUMBER	NUMBER OF READINGS	INTERVAL (SEC.)	SEGMENT DURATION (SEC.)	ELAPSED TIME (SEC.)
1	30	01		
2	18	05		
3	16	15		
4	8	30		
5	20	60		
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				

PRESSURE TRANSDUCER PSI: ___

STAINLESS STEEL SLUG LENGTH: ___

NOTES: ___

TEST PERFORMED BY: ___ DATE: ___

LOGGER DOWNLOADED BY: ___ DATE: ___

CALCULATIONS BY: ___ DATE: ___

COMPUTER FILE NAME: ___

Donohue ENGINEERS ARCHITECTS SCIENTISTS

INFIELD HYDRAULIC CONDUCTIVITY SLUG TEST

SHEET 1 OF ___

PROJECT NO.: 20022.003

SITE: South Andover

WELL NUMBER: ~~B~~ B-7-C

LOGGER ID NUMBER: ___

CLIENT: ARCS

WELL DRILLED BY: ___

DATE TEST PERFORMED: 10/23/90

TIME TEST PERFORMED: 2:45 PM

TOP OF PIPE ELEVATION: ___

OBSERVATION WELL/PIEZOMETER (circle): ___

FALL/RISE TEST (circle) Fall

FORMATION WELL SCREENED IN: ___

STATIC WATER LEVEL (T.C.P.): 34.55

TOTAL DEPTH OF WELL: ___

DEPTH OF WATER IN WELL: ___

INITIAL TRANSDUCER WATER LEVEL: 7.38

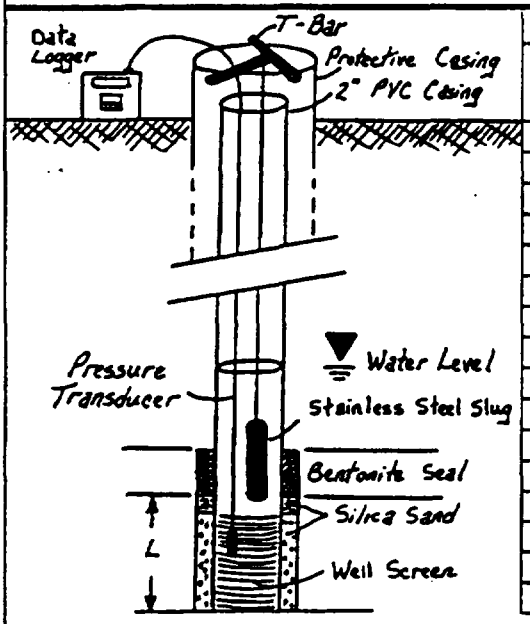
STATIC TRANSDUCER WATER LEVEL: ___

DIAMETER OF BOREHOLE: ___

DIAMETER OF PIPE: 2"

SCREEN LENGTH: ___

EFFECTIVE SCREEN LENGTH* "L": ___



*"L" length is less than the sand pack length if the water table intersects sand pack, where "L" will equal distance between water table and bottom of sand pack.

SILOG II LOGGING SEQUENCE

SEGMENT NUMBER	NUMBER OF READINGS	INTERVAL (SEC.)	SEGMENT DURATION (SEC.)	ELAPSED TIME (SEC.)
1	120	1	120	120
2	20	5	100	220
3	10	10	100	320
4	15	15	225	545
5	12	30	360	905
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				

PRESSURE TRANSDUCER PSI: 5psi

STAINLESS STEEL SLUG LENGTH: 4'

NOTES: ___

[illegible]: [signature] DATE: 10/23/90

[illegible]OADED BY: ___ DATE: ___

[illegible]AME: ___

Donohue ENGINEERS ARCHITECTS SCIENTISTS

INFIELD HYDRAULIC CONDUCTIVITY SLUG TEST

SHEET 2 OF ___

PROJECT NO.: 20022.003

SITE: South Andover

WELL NUMBER: LW B-7-C

LOGGER ID NUMBER: 03

CLIENT: ___

WELL DRILLED BY: ___

DATE TEST PERFORMED: 10/23/90

TIME TEST PERFORMED: 3:15

TOP OF PIPE ELEVATION: ___

OBSERVATION WELL/PIEZOMETER (circle): ___

FALL/RISE TEST (circle) ___

FORMATION WELL SCREENED IN: ___

STATIC WATER LEVEL (T.C.P.): ___

TOTAL DEPTH OF WELL: ___

DEPTH OF WATER IN WELL: ___

INITIAL TRANSDUCER WATER LEVEL: 7.25

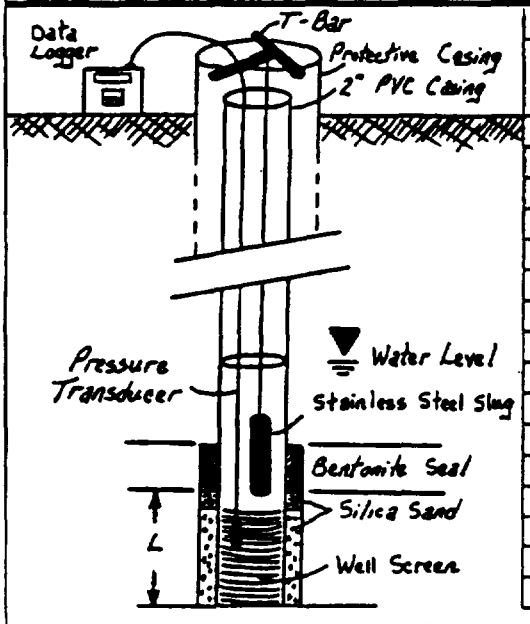
STATIC TRANSDUCER WATER LEVEL: ___

DIAMETER OF BOREHOLE: ___

DIAMETER OF PIPE: 2"

SCREEN LENGTH: ___

EFFECTIVE SCREEN LENGTH* "L": ___



SILOG II LOGGING SEQUENCE

SEGMENT NUMBER	NUMBER OF READINGS	INTERVAL (SEC.)	SEGMENT DURATION (SEC.)	ELAPSED TIME (SEC.)
1	30	1	30	30
2	18	5	90	120
3	16	15	240	360
4	8	30	240	600
5	5	60	300	900
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				

*"L" length is less than the sand pack length if the water table intersects sand pack, where "L" will equal distance between water table and bottom of sand pack.

PRESSURE TRANSDUCER PSI: 5

STAINLESS STEEL SLUG LENGTH: 4'

NOTES: ___

TEST PERFORMED BY: [illegible] DATE: 10/23/90

LOGGER DOWNLOADED BY: ___ DATE: ___

CALCULATIONS BY: ___ DATE: ___

COMPUTER FILE NAME: ___

15 pts

Donohue ENGINEERS ARCHITECTS SCIENTISTS

INFIELD HYDRAULIC CONDUCTIVITY SLUG TEST

SHEET 5 OF ___

PROJECT NO.: 20022.003

SITE: South Andover

WELL NUMBER: W-23-A

LOGGER ID NUMBER: 05

CLIENT: ___

WELL DRILLED BY: ___

DATE TEST PERFORMED: 10/24/90

TIME TEST PERFORMED: 2:05 PM

TOP OF PIPE ELEVATION: ___

OBSERVATION WELL/PIEZOMETER (circle): ___

FALL/RISE TEST (circle) ___

FORMATION WELL SCREENED IN: ___

STATIC WATER LEVEL (T.C.P.): 7.38

TOTAL DEPTH OF WELL: 16.92

DEPTH OF WATER IN WELL: ___

INITIAL TRANSDUCER WATER LEVEL: 7.57

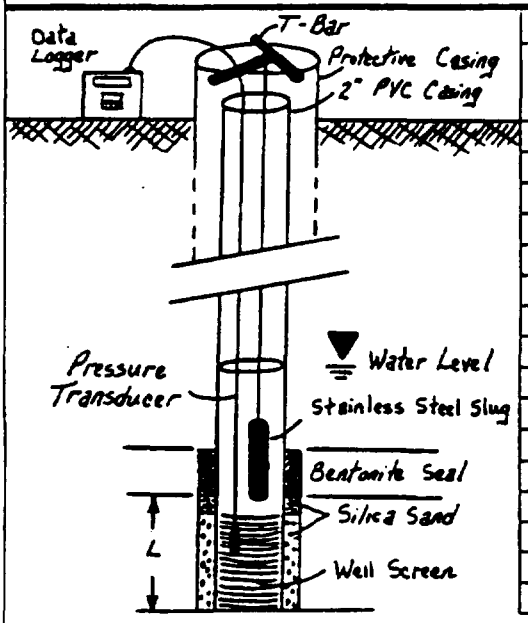
STATIC TRANSDUCER WATER LEVEL: ___

DIAMETER OF BOREHOLE: ___

DIAMETER OF PIPE: 2"

SCREEN LENGTH: ___

EFFECTIVE SCREEN LENGTH* "L": ___



*"L" length is less than the sand pack length if the water table intersects sand pack, where "L" will equal distance between water table and bottom of sand pack.

SILOG II LOGGING SEQUENCE

SEGMENT NUMBER	NUMBER OF READINGS	INTERVAL (SEC.)	SEGMENT DURATION (SEC.)	ELAPSED TIME (SEC.)
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				

PRESSURE TRANSDUCER PSI: 05

STAINLESS STEEL SLUG LENGTH: 41

NOTES: ___

TEST PERFORMED BY: [illegible] DATE: 10/24/90

LOGGER DOWNLOADED BY: ___ DATE: ___

CALCULATIONS BY: ___ DATE: ___

COMPUTER FILE NAME: ___

Donohue ENGINEERS ARCHITECTS SCIENTISTS

INFIELD HYDRAULIC CONDUCTIVITY SLUG TEST

SHEET 6 OF ___

PROJECT NO.: 20022.003

SITE: South Andover

WELL NUMBER: W-23-A

LOGGER ID NUMBER: 06

CLIENT: ___

WELL DRILLED BY: ___

DATE TEST PERFORMED: 10/24/90

TIME TEST PERFORMED: 2:35PM

TOP OF PIPE ELEVATION: ___

OBSERVATION WELL/PIEZOMETER (circle): ___

FALL/RISE TEST (circle) ___

FORMATION WELL SCREENED IN: ___

STATIC WATER LEVEL (T.C.P.): 7.38

TOTAL DEPTH OF WELL: 16.92

DEPTH OF WATER IN WELL: ___

INITIAL TRANSDUCER WATER LEVEL: 7.56

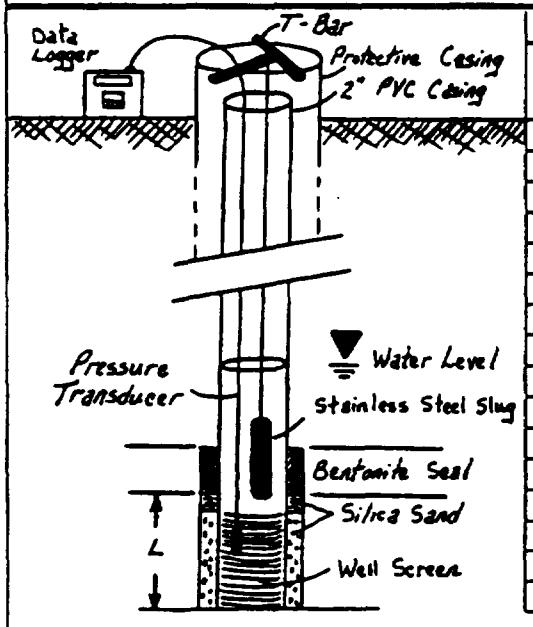
STATIC TRANSDUCER WATER LEVEL: ___

DIAMETER OF BOREHOLE: ___

DIAMETER OF PIPE: 2"

SCREEN LENGTH: ___

EFFECTIVE SCREEN LENGTH* "L": ___



*"L" length is less than the sand pack length if the water table intersects sand pack, where "L" will equal distance between water table and bottom of sand pack.

SILOG II LOGGING SEQUENCE

SEGMENT NUMBER	NUMBER OF READINGS	INTERVAL (SEC.)	SEGMENT DURATION (SEC.)	ELAPSED TIME (SEC.)
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				

PRESSURE TRANSDUCER PSI: 05

STAINLESS STEEL SLUG LENGTH: 4'

NOTES: ___

TEST PERFORMED BY: [illegible] DATE: 10/24/90

LOGGER DOWNLOADED BY: ___ DATE: ___

CALCULATIONS BY: ___ DATE: ___

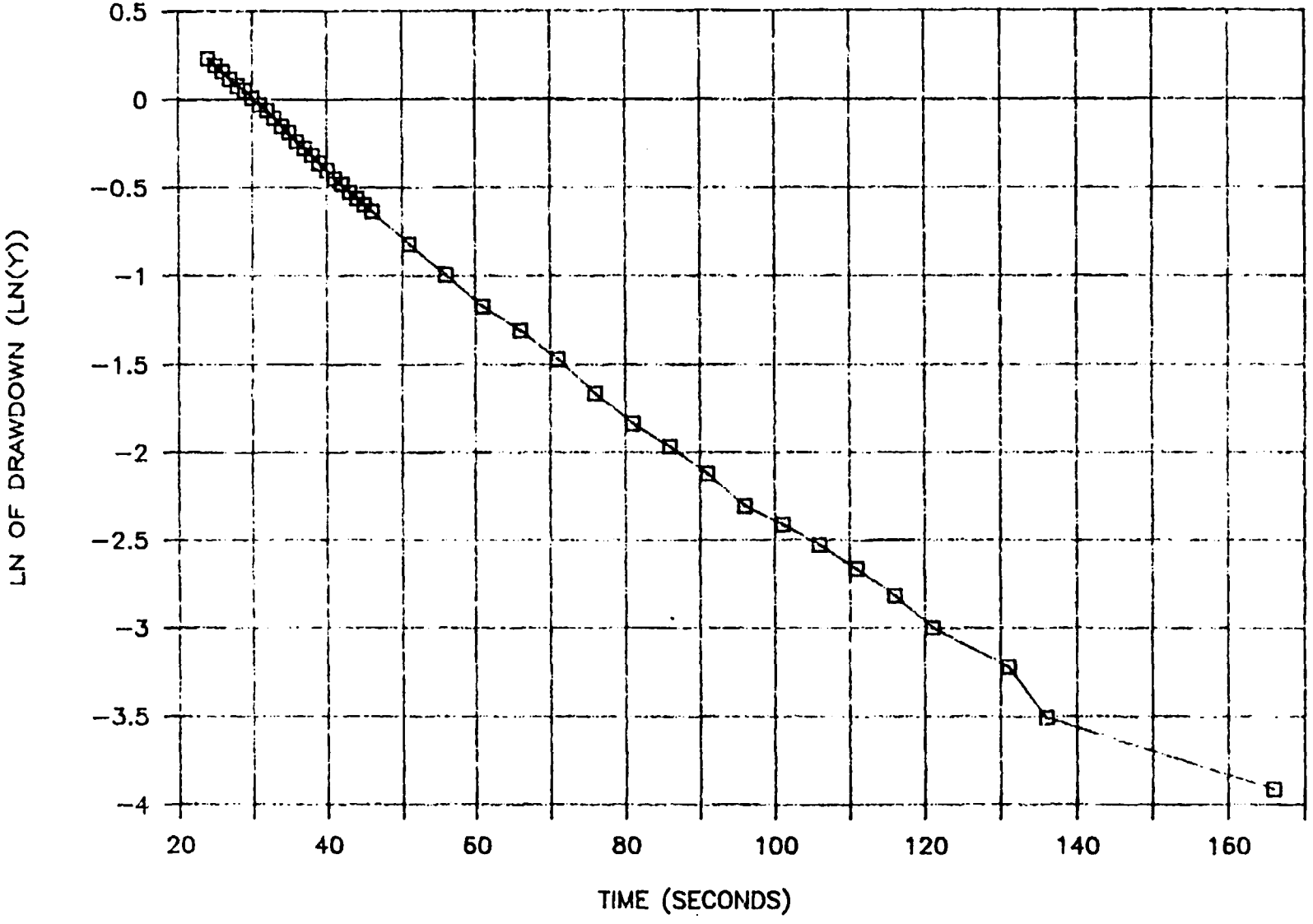
COMPUTER FILE NAME: ___

BOUWER AND RICE METHOD FOR INTERPRETATION OF SLUG TESTS: FOR UNCONFINED AND LEAKY CONFINED AQUIFERS.
TO UTILIZE THIS WORKSHEET, ENTER YOUR DATA AT LOCATIONS MARKED BY AN "*".
PROGRAM CAN INCLUDE EFFECTS OF SANDPACK DEWATERING (ASSUMING WATER IS RISING WITHIN THE SANDPACK).

#	*TIME min (X)	*DEPTH TO WATER Ft.	DRAWDOWN (Y)	TIME sec (X')	LN (Y)	
1		9.17	1.630	1.00	0.4886	*PROJECT NAME :SOUTH ANDOVER - DESIGN INVESTIGATION
2		8.80	1.260	24.00	0.2311	*PROJECT NO :20022.002
3		8.75	1.210	25.00	0.1906	*WELL NO :W-1-C (FALLING HEAD TEST)
4		8.71	1.170	26.00	0.1570	*ANALYST :PETER RZEPECKI
5		8.66	1.120	27.00	0.1133	*DATE COLLECTED :10-24-90
6		8.62	1.080	28.00	0.0770	*RISER PIPE (ID): (2 r sub c) = 1.7 in. = 0.0708 (radius in ft.)
7		8.59	1.050	29.00	0.0488	*EFFECTIVE SCREEN DIAMETER: (2 r sub w) = 6.0 in. = 0.2500 (radius in ft.)
8		8.55	1.010	30.00	0.0100	*EFFECTIVE SCREEN LENGTH: (L) = 9.00 Ft.
9		8.51	0.970	31.00	-0.0305	*MAX DRAWDOWN (IN SUBSET): (Ymax) = 1.63 Ft.
10		8.48	0.940	32.00	-0.0619	*STATIC WATER LEVEL: (SWL) = 7.54 Ft.
11		8.44	0.900	33.00	-0.1054	*DEPTH FROM SWL TO EFF. SCREEN BOTTOM: (H) = 75.79 Ft.
12		8.40	0.860	34.00	-0.1508	*EST. AQUIFER DEPTH (SWL TO AQUIFER BOTTOM): (D) = 75.79 Ft.
13		8.37	0.830	35.00	-0.1863	*INCLUDE SANDPACK DEWATERING (ENTER 1 IF YES, 0 IF NO)? 0
14		8.33	0.790	36.00	-0.2357	*SANDPACK'S SPECIFIC YIELD (Sy) = 0.10
15		8.30	0.760	37.00	-0.2744	BOUWER AND RICE CURVE COEFFICIENTS:
16		8.27	0.730	38.00	-0.3147	RATIO OF L/(r sub w) = 36.00
17		8.24	0.700	39.00	-0.3567	--LOG OF L/(r sub w) = 1.5563
18		8.21	0.670	40.00	-0.4005	FOR PARTIALLY PENETRATING WELLS--
19		8.18	0.640	41.00	-0.4463	A = 2.64
20		8.16	0.620	42.00	-0.4780	B = 0.36
21		8.13	0.590	43.00	-0.5276	FOR FULLY PENETRATING WELLS--
22		8.11	0.570	44.00	-0.5621	C = 2.08
23		8.09	0.550	45.00	-0.5978	--EVALUATION OF LN(Re/(r sub w)):
24		8.07	0.530	46.00	-0.6349	CONST.1 = 0.1925
25		7.98	0.440	51.00	-0.8210	CONST.2 = ERR =(MAX. OF 6.0)= ERR
26		7.91	0.370	56.00	-0.9943	LN(Re/(r sub w)) = 4.00
27		7.85	0.310	61.00	-1.1712	EFFECTIVE r sub c (for sandpack dewatering) = 0.0708
28		7.81	0.270	66.00	-1.3093	(1/T)(LN(Yo/Yt)) (SLOPE) = -3.31E-02 sec^(-1)
29		7.77	0.230	71.00	-1.4697	
30		7.73	0.190	76.00	-1.6607	HYDRAULIC CONDUCTIVITY (K) = 3.69E-05 ft/sec <========== 1.12E-03 cm/sec <========== Regression Output:
31		7.70	0.160	81.00	-1.8326	
32		7.68	0.140	86.00	-1.9661	
33		7.66	0.120	91.00	-2.1203	
34		7.64	0.100	96.00	-2.3026	Constant 9.46E-01
35		7.63	0.090	101.00	-2.4079	Std Err of Y Est 0.0663
36		7.62	0.080	106.00	-2.5257	R Squared 0.9960
37		7.61	0.070	111.00	-2.6593	No. of Observations 39
38		7.60	0.060	116.00	-2.8134	Degrees of Freedom 37
39		7.59	0.050	121.00	-2.9957	
40		7.58	0.040	131.00	-3.2189	X Coefficient(s) -3.31E-02
41		7.57	0.030	136.00	-3.5066	Std Err of Coef. 0.0003
42		7.56	0.020	166.00	-3.9120	
43		7.55	0.010	1156.00	-4.6052	

RATE OF RECOVERY TEST: WELL W-1-C

FALLING HEAD TEST



BOUWER AND RICE METHOD FOR INTERPRETATION OF SLUG TESTS: FOR UNCONFINED AND LEAKY CONFINED AQUIFERS.
TO UTILIZE THIS WORKSHEET, ENTER YOUR DATA AT LOCATIONS MARKED BY AN "*".
PROGRAM CAN INCLUDE EFFECTS OF SANDPACK DEWATERING (ASSUMING WATER IS RISING WITHIN THE SANDPACK).

#	*TIME min (X)	*DEPTH TO WATER Ft.	DRAWDOWN (Y)	TIME sec (X')	LN (Y)
1		6.24	1.300	1.00	0.2624
2		6.29	1.250	29.00	0.2231
3		6.34	1.200	30.00	0.1823
4		6.39	1.150	31.00	0.1398
5		6.43	1.110	32.00	0.1044
6		6.47	1.070	33.00	0.0677
7		6.51	1.030	34.00	0.0296
8		6.55	0.990	35.00	-0.0101
9		6.59	0.950	36.00	-0.0513
10		6.62	0.920	37.00	-0.0834
11		6.65	0.890	38.00	-0.1165
12		6.69	0.850	39.00	-0.1625
13		6.72	0.820	40.00	-0.1985
14		6.75	0.790	41.00	-0.2357
15		6.77	0.770	42.00	-0.2614
16		6.81	0.730	43.00	-0.3147
17		6.83	0.710	44.00	-0.3425
18		6.86	0.680	45.00	-0.3857
19		6.88	0.660	46.00	-0.4155
20		6.90	0.640	47.00	-0.4463
21		6.93	0.610	48.00	-0.4943
22		6.95	0.590	49.00	-0.5276
23		6.97	0.570	50.00	-0.5621
24		6.99	0.550	51.00	-0.5978
25		7.01	0.530	52.00	-0.6349
26		7.02	0.520	53.00	-0.6539
27		7.04	0.500	54.00	-0.6931
28		7.06	0.480	55.00	-0.7340
29		7.08	0.460	56.00	-0.7765
30		7.15	0.390	61.00	-0.9416
31		7.21	0.330	66.00	-1.1087
32		7.26	0.280	71.00	-1.2730
33		7.30	0.240	76.00	-1.4271
34		7.34	0.200	81.00	-1.6094
35		7.37	0.170	86.00	-1.7720
36		7.39	0.150	91.00	-1.8971
37		7.41	0.130	96.00	-2.0402
38		7.43	0.110	101.00	-2.2073
39		7.45	0.090	106.00	-2.4079
40		7.46	0.080	111.00	-2.5257
41		7.47	0.070	116.00	-2.6593
42		7.48	0.060	121.00	-2.8134
43		7.49	0.050	126.00	-2.9957
44		7.50	0.040	136.00	-3.2189
45		7.51	0.030	141.00	-3.5066
46		7.52	0.020	161.00	-3.9120
47		7.53	0.010	176.00	-4.6052
48		7.54	0.000	251.00	ERR

*PROJECT NAME :SOUTH ANDOVER - DESIGN INVESTIGATION
*PROJECT NO :20022.002
*WELL NO :W-1-C (RISING HEAD TEST)
*ANALYST :PETER RZEPECKI
*DATE COLLECTED :10-24-90
*RISER PIPE (ID): (2 r sub c) = 1.7 in. = 0.0708 (radius in ft.)
*EFFECTIVE SCREEN DIAMETER: (2 r sub w) = 6.0 in. = 0.2500 (radius in ft.)
*EFFECTIVE SCREEN LENGTH: (L) = 9.00 Ft.
*MAX DRAWDOWN (IN SUBSET): (Ymax) = 1.30 Ft.
*STATIC WATER LEVEL: (SWL) = 7.54 Ft.
*DEPTH FROM SWL TO EFF. SCREEN BOTTOM: (H) = 75.79 Ft.
*EST. AQUIFER DEPTH (SWL TO AQUIFER BOTTOM): (D) = 75.79 Ft.
*INCLUDE SANDPACK DEWATERING (ENTER 1 IF YES, 0 IF NO)? 0
*SANDPACK'S SPECIFIC YIELD (Sy) = 0.10

BOUWER AND RICE CURVE COEFFICIENTS:
RATIO OF L/(r sub w) = 36.00
—LOG OF L/(r sub w) = 1.5563
FOR PARTIALLY PENETRATING WELLS—
A = 2.64
B = 0.36
FOR FULLY PENETRATING WELLS—
C = 2.08

—EVALUATION OF LN(Re/(r sub w)):
CONST.1 = 0.1925
CONST.2 = ERR =(MAX. OF 6.0)= ERR
LN(Re/(r sub w)) = 4.00

EFFECTIVE r sub c (for sandpack dewatering) = 0.0708
(1/T)(LN(Yo/Yt)) (SLOPE) = -3.23E-02 sec^(-1)

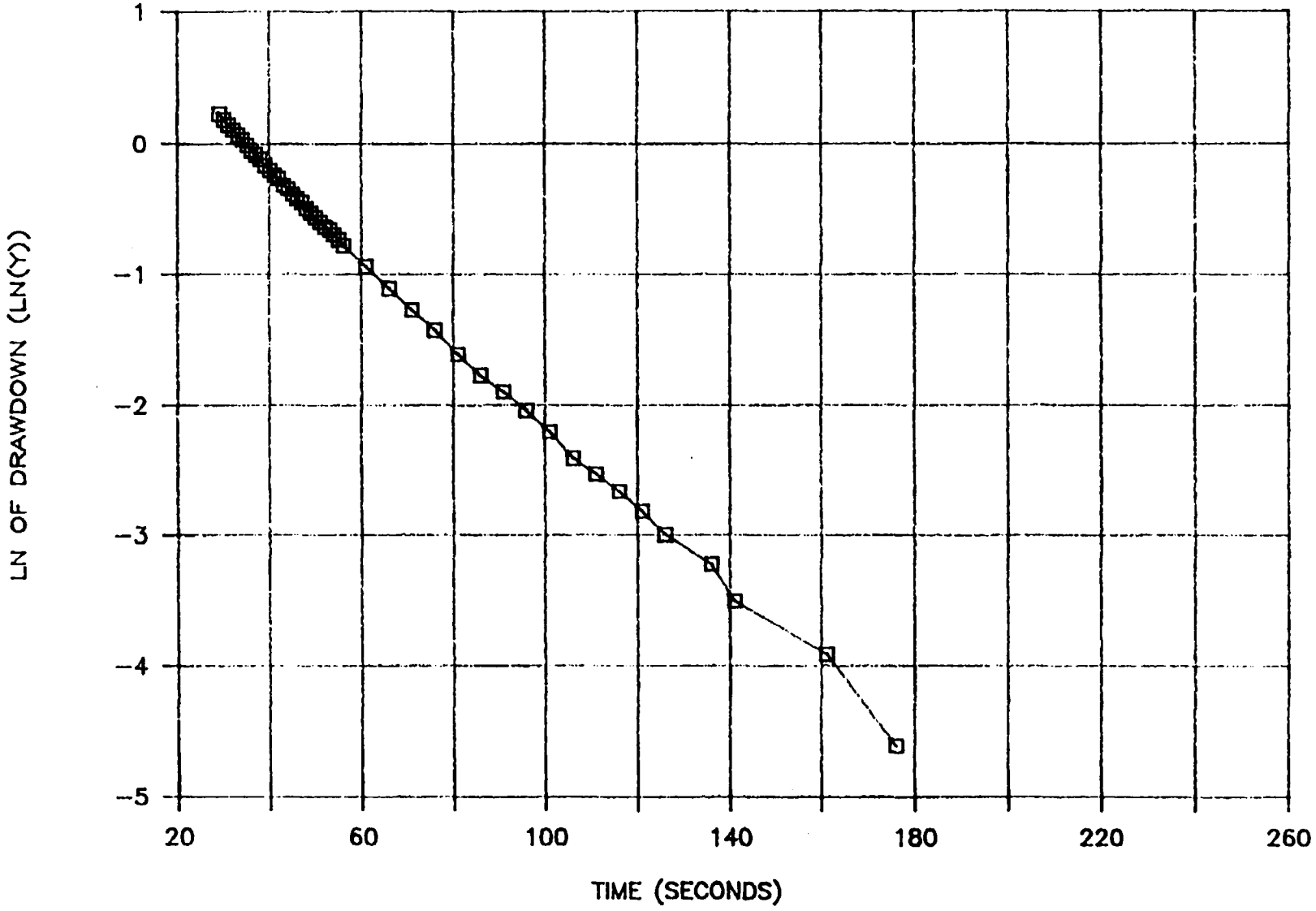
HYDRAULIC CONDUCTIVITY (K) = 3.59E-05 ft/sec <==========
1.10E-03 cm/sec <==========

Regression Output:

Constant	1.08E+00
Std Err of Y Est	0.0527
R Squared	0.9982
No. of Observations	46
Degrees of Freedom	44
X Coefficient(s)	-3.23E-02
Std Err of Coef.	0.0002

RATE OF RECOVERY TEST: WELL W-1-C

RISING HEAD TEST

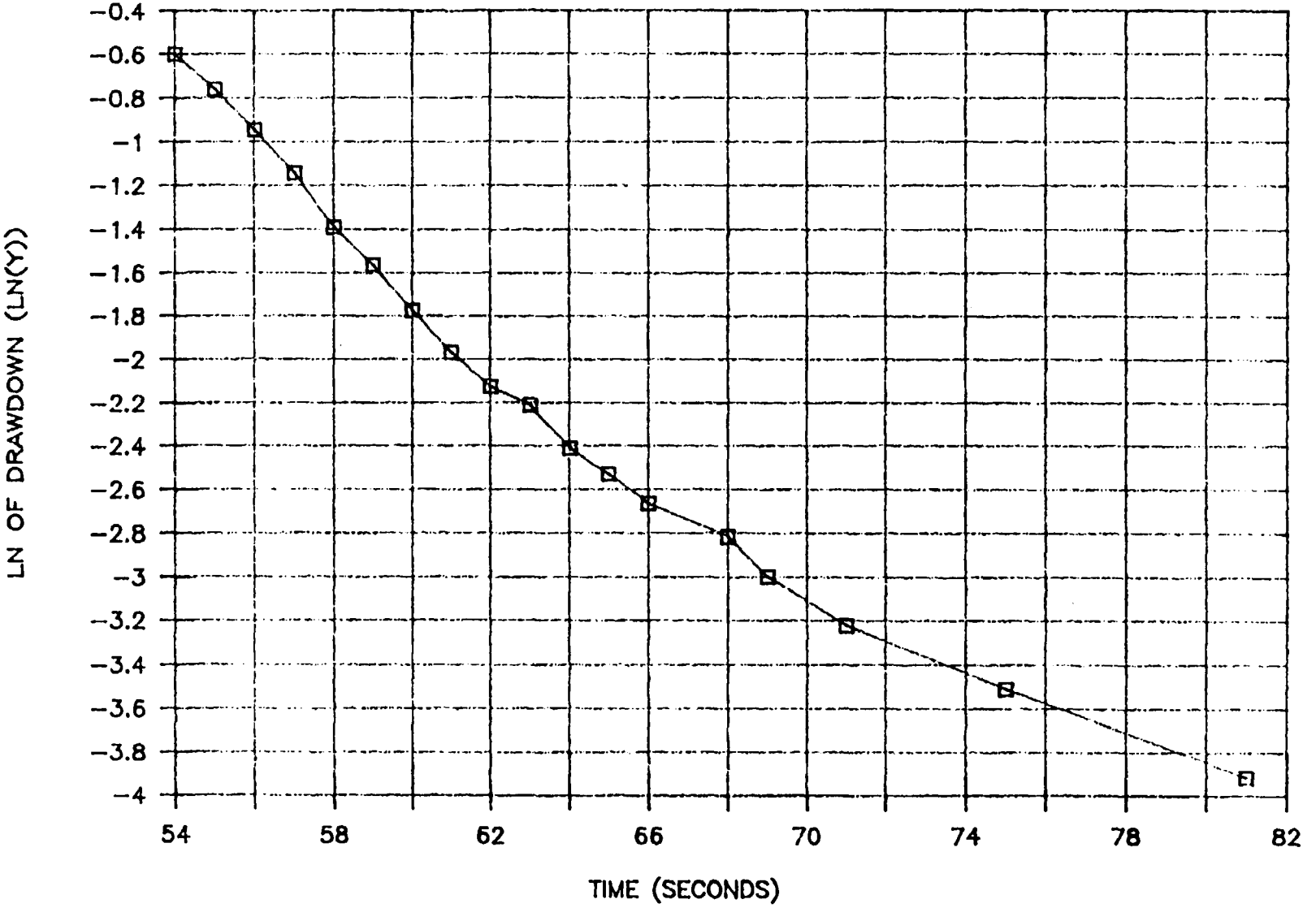


BOUWER AND RICE METHOD FOR INTERPRETATION OF SLUG TESTS: FOR UNCONFINED AND LEAKY CONFINED AQUIFERS.
TO UTILIZE THIS WORKSHEET, ENTER YOUR DATA AT LOCATIONS MARKED BY AN "*".
PROGRAM CAN INCLUDE EFFECTS OF SANDPACK DEWATERING (ASSUMING WATER IS RISING WITHIN THE SANDPACK).

#	*TIME min (X)	*DEPTH TO WATER Ft.	DRAWDOWN (Y)	TIME sec (X')	LN (Y)	
1		8.39	0.820	1.00	-0.1985	*PROJECT NAME :SOUTH ANDOVER - DESIGN INVESTIGATION
2		8.12	0.550	54.00	-0.5978	*PROJECT NO :20022.002
3		8.04	0.470	55.00	-0.7550	*WELL NO :W-6-A (FALLING HEAD TEST)
4		7.96	0.390	56.00	-0.9416	*ANALYST :PETER RIEPECKI
5		7.89	0.320	57.00	-1.1394	*DATE COLLECTED :10-24-90
6		7.82	0.250	58.00	-1.3863	*RISER PIPE (ID): (2 r sub c) = 1.7 in. = 0.0708 (radius in ft.)
7		7.78	0.210	59.00	-1.5606	*EFFECTIVE SCREEN DIAMETER: (2 r sub w) = 8.0 in. = 0.3333 (radius in ft.)
8		7.74	0.170	60.00	-1.7720	*EFFECTIVE SCREEN LENGTH: (L) = 7.34 Ft.
9		7.71	0.140	61.00	-1.9661	*MAX DRAWDOWN (IN SUBSET): (Ymax) = 0.82 Ft.
10		7.69	0.120	62.00	-2.1203	*STATIC WATER LEVEL: (SWL) = 7.57 Ft.
11		7.68	0.110	63.00	-2.2073	*DEPTH FROM SWL TO EFF. SCREEN BOTTOM: (H) = 7.37 Ft.
12		7.66	0.090	64.00	-2.4079	*EST. AQUIFER DEPTH (SWL TO AQUIFER BOTTOM): (D) = 20.00 Ft.
13		7.65	0.080	65.00	-2.5257	*INCLUDE SANDPACK DEWATERING (ENTER 1 IF YES, 0 IF NO)? 1
14		7.64	0.070	66.00	-2.6593	*SANDPACK'S SPECIFIC YIELD (Sy) = 0.20
15		7.63	0.060	68.00	-2.8134	BOUWER AND RICE CURVE COEFFICIENTS:
16		7.62	0.050	69.00	-2.9957	RATIO OF L/(r sub w) = 22.02
17		7.61	0.040	71.00	-3.2189	—LOG OF L/(r sub w) = 1.3428
18		7.60	0.030	75.00	-3.5066	FOR PARTIALLY PENETRATING WELLS--
19		7.59	0.020	81.00	-3.9120	A = 2.16
20		7.58	0.010	886.00	-4.6052	B = 0.30
21			7.570		2.0242	FOR FULLY PENETRATING WELLS—
22			7.570		2.0242	C = 1.58
23			7.570		2.0242	—EVALUATION OF LN(Re/(r sub w)):
24			7.570		2.0242	CONST.1 = 0.3553
25			7.570		2.0242	CONST.2 = 3.6347 =(MAX. OF 6.0)= 3.6347
26			7.570		2.0242	LN(Re/(r sub w)) = 1.99
27			7.570		2.0242	EFFECTIVE r sub c (for sandpack dewatering) = 0.1620
28			7.570		2.0242	(1/T)(LN(Yo/Yt)) (SLOPE) = -1.97E-01 sec^(-1)
29			7.570		2.0242	
30			7.570		2.0242	HYDRAULIC CONDUCTIVITY (K) = 6.98E-04 ft/sec <==========
31			7.570		2.0242	2.13E-02 cm/sec <==========
32			7.570		2.0242	
33			7.570		2.0242	Regression Output:
34			7.570		2.0242	Constant 1.01E+01
35			7.570		2.0242	Std Err of Y Est 0.0240
36			7.570		2.0242	R Squared 0.9983
37			7.570		2.0242	No. of Observations 9
38			7.570		2.0242	Degrees of Freedom 7
39			7.570		2.0242	
40			7.570		2.0242	X Coefficient(s) -1.97E-01
41			7.570		2.0242	Std Err of Coef. 0.0031
42			7.570		2.0242	
43			7.570		2.0242	

RATE OF RECOVERY TEST: WELL W-6-A

FALLING HEAD TEST



BOUWER AND RICE METHOD FOR INTERPRETATION OF SLUG TESTS: FOR UNCONFINED AND LEAKY CONFINED AQUIFERS.

TO UTILIZE THIS WORKSHEET, ENTER YOUR DATA AT LOCATIONS MARKED BY AN "*".

PROGRAM CAN INCLUDE EFFECTS OF SANDPACK DEWATERING (ASSUMING WATER --

#	*TIME min (X)	*DEPTH TO WATER Ft.	DRAWDOWN (Y)	TIME sec (X')	LN (Y)	
1		6.69	0.880	1.00	-0.1278	*PROJECT
2		6.87	0.700	39.00	-0.3567	*PROJECT
3		7.00	0.570	40.00	-0.5621	*WELL NO
4		7.10	0.470	41.00	-0.7550	*ANALYST
5		7.18	0.390	42.00	-0.9416	*DATE COLL
6		7.24	0.330	43.00	-1.1087	*RISER PIPE
7		7.29	0.280	44.00	-1.2730	*EFFECTIVE S
8		7.33	0.240	45.00	-1.4271	*EFFECTIVE SL
9		7.36	0.210	46.00	-1.5606	*MAX DRAWDOWN
10		7.39	0.180	47.00	-1.7148	*STATIC WATER
11		7.41	0.160	48.00	-1.8326	*DEPTH FROM SWL
12		7.43	0.140	49.00	-1.9661	*EST. AQUIFER DE
13		7.45	0.120	50.00	-2.1203	*INCLUDE SANDPAC
14		7.47	0.100	51.00	-2.3026	*SANDPACK'S SPEC
15		7.48	0.090	52.00	-2.4079	
16		7.49	0.080	53.00	-2.5257	
17		7.50	0.070	54.00	-2.6593	
18		7.51	0.060	55.00	-2.8134	
19		7.52	0.050	57.00	-2.9957	
20		7.53	0.040	58.00	-3.2189	
21		7.54	0.030	61.00	-3.5066	
22		7.55	0.020	63.00	-3.9120	
23		7.56	0.010	71.00	-4.6052	
24		7.57	0.000	876.00	ERR	
25			7.570		2.0242	
26			7.570		2.0242	
27			7.570		2.0242	
28			7.570		2.0242	
29			7.570		2.0242	
30			7.570		2.0242	
31			7.570		2.0242	
32			7.570		2.0242	
33			7.570		2.0242	
34			7.570		2.0242	
35			7.570		2.0242	
36			7.570		2.0242	
37			7.570		2.0242	
38			7.570		2.0242	
39			7.570		2.0242	
40			7.570		2.0242	
41			7.570		2.0242	
42			7.570		2.0242	
43			7.570		2.0242	

dius in ft.)

ius in ft.)

BOUWER AND RICE C

RATIO OF L/(r sub w) = 22.02

--LOG OF L/(r sub w) = 1.3428

FOR PARTIALLY PENETRATING WELLS--

A = 2.16

B = 0.30

FOR FULLY PENETRATING WELLS--

C = 1.58

--EVALUATION OF LN(Re/(r sub w)):

CONST.1 = 0.3558

CONST.2 = 3.6371 =(MAX. OF 6.0)= 3.6371

LN(Re/(r sub w) = 1.98

EFFECTIVE r sub c (for sandpack dewatering) = 0.1620

(1/T)(LN(Yo/Yt)) (SLOPE) = -1.49E-01 sec^(-1)

HYDRAULIC CONDUCTIVITY (K) = 5.30E-04 ft/sec <==========

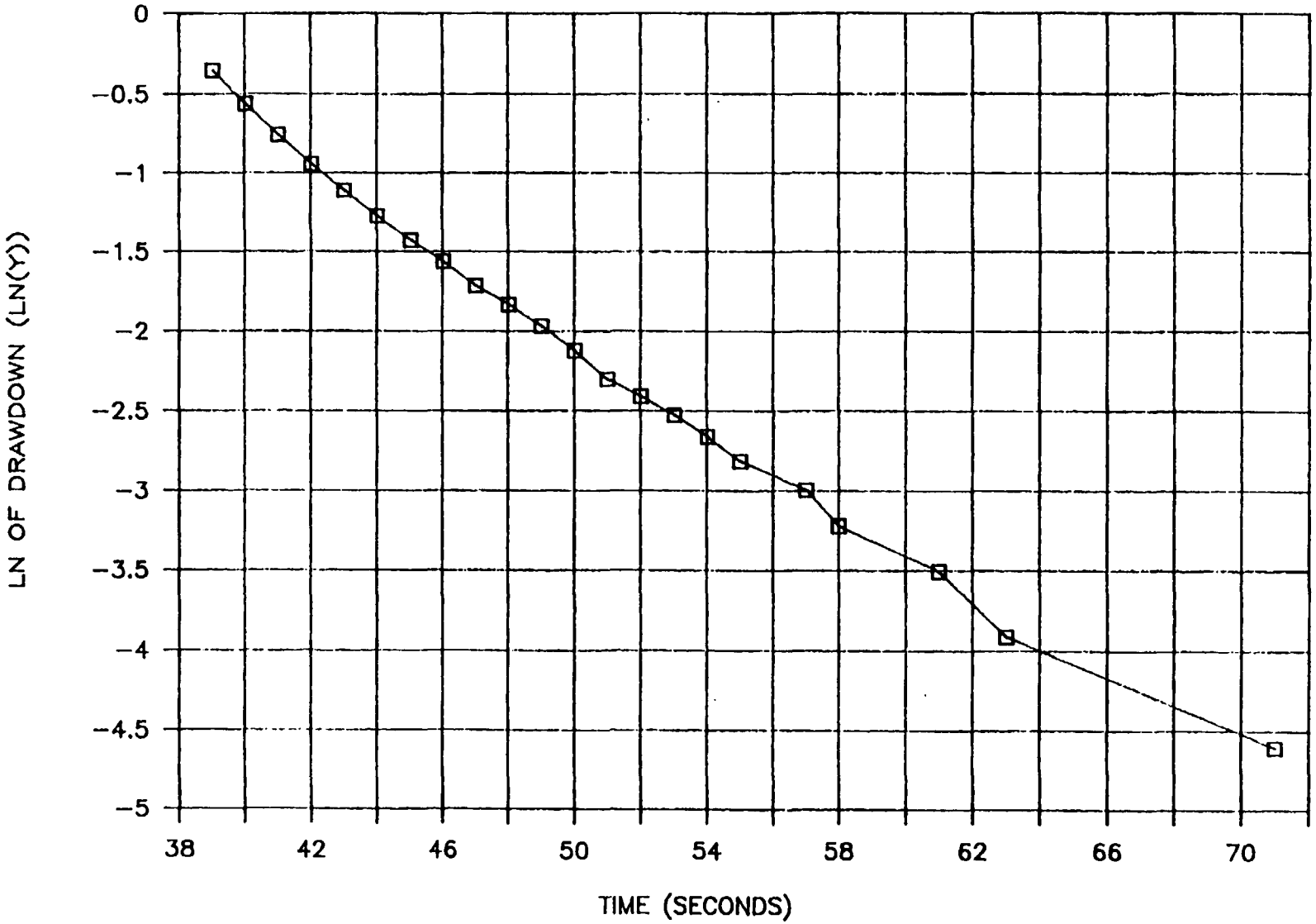
1.61E-02 cm/sec <==========

Regression Output:

Constant	5.36E+00
Std Err of Y Est	0.0503
R Squared	0.9958
No. of Observations	17
Degrees of Freedom	15
X Coefficient(s)	-1.49E-01
Std Err of Coef.	0.0025

RATE OF RECOVERY TEST: WELL W-6-A

RISING HEAD TEST



BOUWER AND RICE METHOD FOR INTERPRETATION OF SLUG TESTS: FOR UNCONFINED AND LEAKY CONFINED AQUIFERS.
TO UTILIZE THIS WORKSHEET, ENTER YOUR DATA AT LOCATIONS MARKED BY AN "*".
PROGRAM CAN INCLUDE EFFECTS OF SANDPACK DEWATERING (ASSUMING WATER IS RISING WITHIN THE SANDPACK).

#	*TIME min (X)	*DEPTH TO WATER Ft.	DRAWDOWN (Y)	TIME sec (X')	LN (Y)
1		8.93	1.390	1.00	0.3293
2		8.89	1.350	57.00	0.3001
3		8.82	1.280	60.00	0.2469
4		8.81	1.270	62.00	0.2390
5		8.79	1.250	63.00	0.2231
6		8.78	1.240	67.00	0.2151
7		8.77	1.230	77.00	0.2070
8		8.76	1.220	86.00	0.1989
9		8.75	1.210	91.00	0.1906
10		8.74	1.200	96.00	0.1823
11		8.73	1.190	101.00	0.1740
12		8.72	1.180	106.00	0.1655
13		8.71	1.170	116.00	0.1570
14		8.70	1.160	121.00	0.1484
15		8.69	1.150	126.00	0.1398
16		8.68	1.140	131.00	0.1310
17		8.67	1.130	141.00	0.1222
18		8.66	1.120	146.00	0.1133
19		8.65	1.110	156.00	0.1044
20		8.64	1.100	161.00	0.0953
21		8.61	1.070	166.00	0.0677
22		8.59	1.050	186.00	0.0488
23		8.58	1.040	201.00	0.0392
24		8.55	1.010	216.00	0.0100
25		8.53	0.990	231.00	-0.0101
26		8.52	0.980	246.00	-0.0202
27		8.50	0.960	261.00	-0.0408
28		8.48	0.940	276.00	-0.0619
29		8.46	0.920	291.00	-0.0834
30		8.45	0.910	306.00	-0.0943
31		8.43	0.890	321.00	-0.1165
32		8.41	0.870	336.00	-0.1393
33		8.40	0.860	351.00	-0.1508
34		8.38	0.840	366.00	-0.1744
35		8.36	0.820	381.00	-0.1985
36		8.35	0.810	396.00	-0.2107
37		8.32	0.780	411.00	-0.2465
38		8.29	0.750	441.00	-0.2877
39		8.26	0.720	471.00	-0.3285
40		8.23	0.690	501.00	-0.3711
41		8.21	0.670	531.00	-0.4005
42		8.18	0.640	561.00	-0.4463
43		8.16	0.620	591.00	-0.4780

*PROJECT NAME :SOUTH ANDOVER - DESIGN INVESTIGATION
*PROJECT NO :20022.002
*WELL NO :W-6-8 (FALLING HEAD TEST)
*ANALYST :PETER RZEPECKI
*DATE COLLECTED :10-24-90
*RISER PIPE (ID): (2 r sub c) = 1.7 in. = 0.0708 (radius in ft.)
*EFFECTIVE SCREEN DIAMETER:(2 r sub w) = 8.0 in. = 0.3333 (radius in ft.)
*EFFECTIVE SCREEN LENGTH: (L) = 8.90 Ft.
*MAX DRAWDOWN (IN SUBSET): (Ymax) = 1.39 Ft.
*STATIC WATER LEVEL: (SWL) = 7.54 Ft.
*DEPTH FROM SWL TO EFF. SCREEN BOTTOM: (H) = 36.73 Ft.
*EST. AQUIFER DEPTH (SWL TO AQUIFER BOTTOM): (D) = 40.00 Ft.
*INCLUDE SANDPACK DEWATERING (ENTER 1 IF YES, 0 IF NO)? 0
*SANDPACK'S SPECIFIC YIELD (Sy) =

BOUWER AND RICE CURVE COEFFICIENTS:
RATIO OF L/(r sub w) = 26.70
—LOG OF L/(r sub w) = 1.4265
FOR PARTIALLY PENETRATING WELLS—
A = 2.32
B = 0.32
FOR FULLY PENETRATING WELLS—
C = 1.73

—EVALUATION OF LN(Re/(r sub w)):
CONST.1 = 0.2339
CONST.2 = 2.2834 =(MAX. OF 6.0)= 2.2834
LN(Re/(r sub w) = 2.87

EFFECTIVE r sub c (for sandpack dewatering) = 0.0708
(1/T)(LN(Yo/Yt)) (SLOPE) = -1.37E-03 sec^(-1)

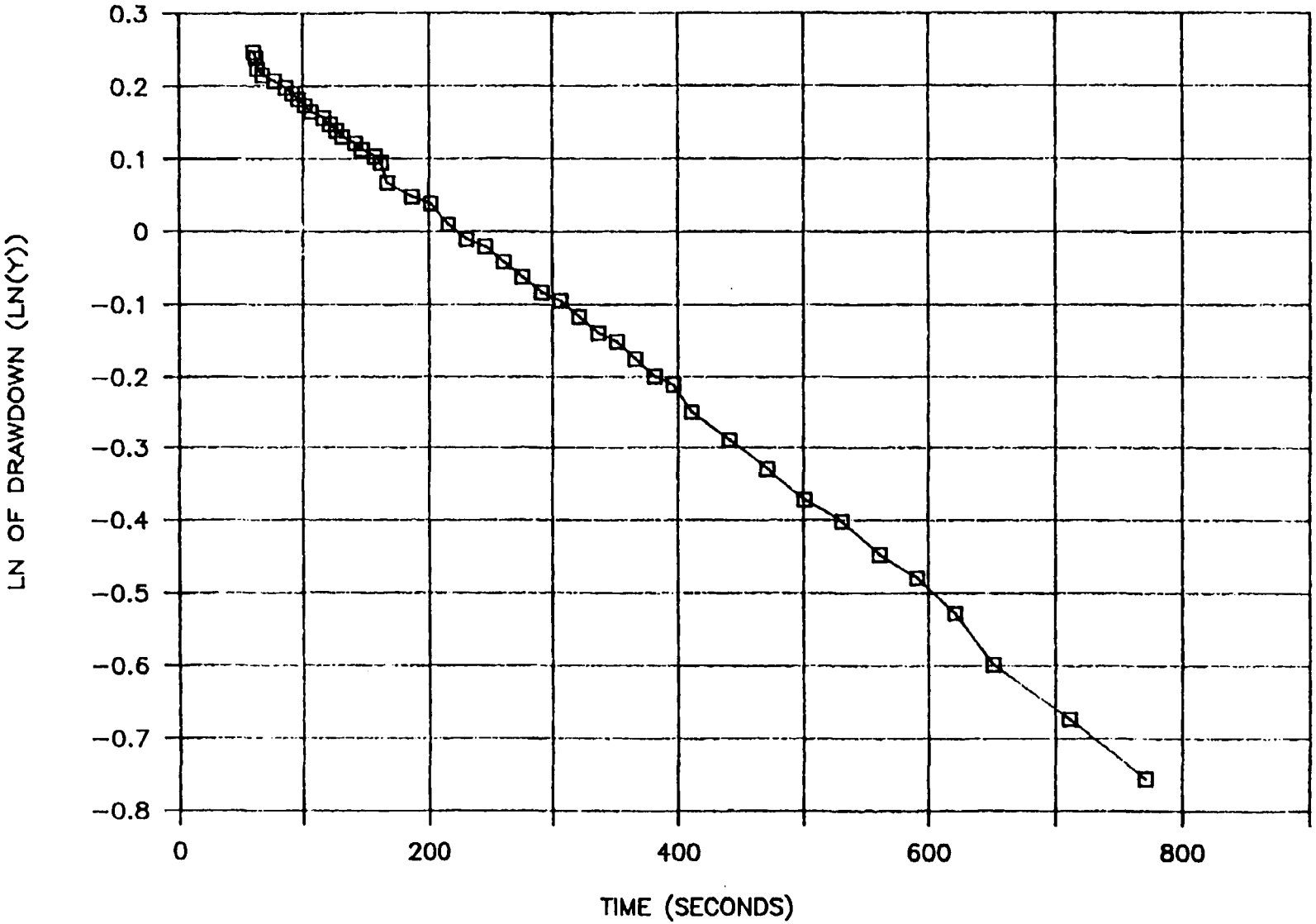
HYDRAULIC CONDUCTIVITY (K) = 1.11E-06 ft/sec <==========
3.37E-05 cm/sec <==========

Regression Output:

Constant	3.14E-01
Std Err of Y Est	0.0088
R Squared	0.9989
No. of Observations	41
Degrees of Freedom	39
X Coefficient(s)	-1.37E-03
Std Err of Coef.	0.0000

RATE OF RECOVERY TEST: WELL W-6-B

FALLING HEAD TEST

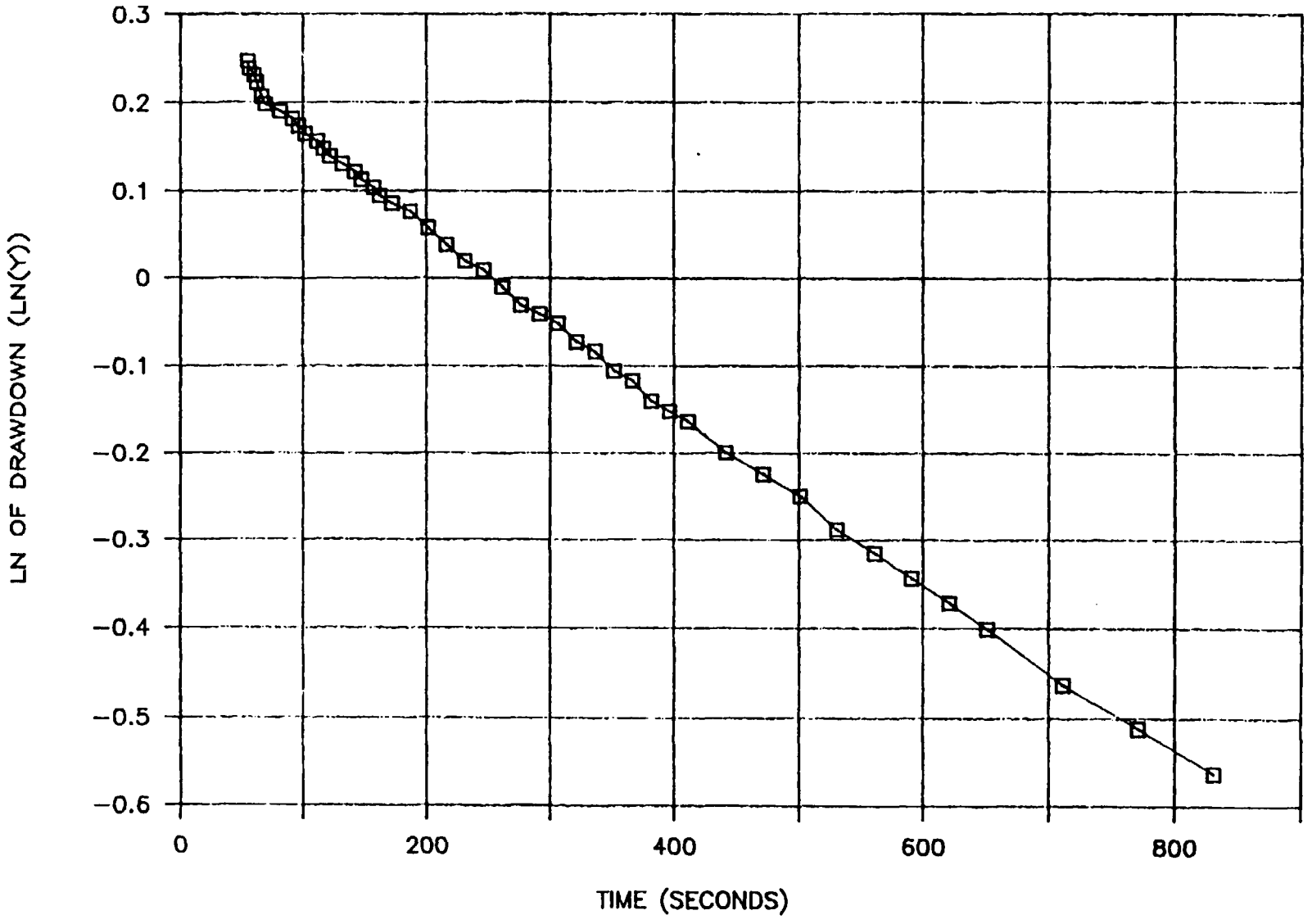


BOUWER AND RICE METHOD FOR INTERPRETATION OF SLUG TESTS: FOR UNCONFINED AND LEAKY CONFINED AQUIFERS.
TO UTILIZE THIS WORKSHEET, ENTER YOUR DATA AT LOCATIONS MARKED BY AN "*".
PROGRAM CAN INCLUDE EFFECTS OF SANDPACK DEWATERING (ASSUMING WATER IS RISING WITHIN THE SANDPACK).

#	*TIME min (X)	*DEPTH TO WATER Ft.	DRAWDOWN (Y)	TIME sec (X')	LN (Y)	
1		6.25	1.290	1.00	0.2546	*PROJECT NAME :SOUTH ANDOVER - DESIGN INVESTIGATION
2		6.26	1.280	55.00	0.2469	*PROJECT NO :20022.002
3		6.27	1.270	56.00	0.2390	*WELL NO :W-6-B (RISING HEAD TEST)
4		6.28	1.260	60.00	0.2311	*ANALYST :PETER RIEPECKI
5		6.29	1.250	62.00	0.2231	*DATE COLLECTED :10-24-90
6		6.31	1.230	66.00	0.2070	*RISER PIPE (ID): (2 r sub c) = 1.7 in. = 0.0708 (radius in ft.)
7		6.32	1.220	69.00	0.1989	*EFFECTIVE SCREEN DIAMETER:(2 r sub w) = 8.0 in. = 0.3333 (radius in ft.)
8		6.33	1.210	81.00	0.1906	*EFFECTIVE SCREEN LENGTH: (L) = 8.90 Ft.
9		6.34	1.200	91.00	0.1823	*MAX DRAWDOWN (IN SUBSET): (Ymax) = 1.29 Ft.
10		6.35	1.190	96.00	0.1740	*STATIC WATER LEVEL: (SWL) = 7.54 Ft.
11		6.36	1.180	101.00	0.1655	*DEPTH FROM SWL TO EFF. SCREEN BOTTOM: (H) = 36.73 Ft.
12		6.37	1.170	111.00	0.1570	*EST. AQUIFER DEPTH (SWL TO AQUIFER BOTTOM): (D) = 40.00 Ft.
13		6.38	1.160	116.00	0.1484	*INCLUDE SANDPACK DEWATERING (ENTER 1 IF YES, 0 IF NO)? 0
14		6.39	1.150	121.00	0.1398	*SANDPACK'S SPECIFIC YIELD (Sy) =
15		6.40	1.140	131.00	0.1310	BOUWER AND RICE CURVE COEFFICIENTS:
16		6.41	1.130	141.00	0.1222	RATIO OF L/(r sub w) = 26.70
17		6.42	1.120	146.00	0.1133	---LOG OF L/(r sub w) = 1.4265
18		6.43	1.110	156.00	0.1044	FOR PARTIALLY PENETRATING WELLS—
19		6.44	1.100	161.00	0.0953	A = 2.32
20		6.45	1.090	171.00	0.0862	B = 0.32
21		6.46	1.080	186.00	0.0770	FOR FULLY PENETRATING WELLS—
22		6.48	1.060	201.00	0.0583	C = 1.73
23		6.50	1.040	216.00	0.0392	---EVALUATION OF LN(Re/(r sub w)):
24		6.52	1.020	231.00	0.0198	CONST.1 = 0.2339
25		6.53	1.010	246.00	0.0100	CONST.2 = 2.2834 =(MAX. OF 6.0)= 2.2834
26		6.55	0.990	261.00	-0.0101	LN(Re/(r sub w)) = 2.87
27		6.57	0.970	276.00	-0.0305	EFFECTIVE r sub c (for sandpack dewatering) = 0.0708
28		6.58	0.960	291.00	-0.0408	(1/T)(LN(Yo/Yt)) (SLOPE) = -1.02E-03 sec^(-1)
29		6.59	0.950	306.00	-0.0513	
30		6.61	0.930	321.00	-0.0726	HYDRAULIC CONDUCTIVITY (K) = 8.25E-07 ft/sec <==========|
31		6.62	0.920	336.00	-0.0834	2.52E-05 cm/sec <==========|
32		6.64	0.900	351.00	-0.1054	
33		6.65	0.890	366.00	-0.1165	Regression Output:
34		6.67	0.870	381.00	-0.1393	Constant 2.62E-01
35		6.68	0.860	396.00	-0.1508	Std Err of Y Est 0.0077
36		6.69	0.850	411.00	-0.1625	R Squared 0.9987
37		6.72	0.820	441.00	-0.1985	No. of Observations 40
38		6.74	0.800	471.00	-0.2231	Degrees of Freedom 38
39		6.76	0.780	501.00	-0.2485	
40		6.79	0.750	531.00	-0.2877	X Coefficient(s) -1.02E-03
41		6.81	0.730	561.00	-0.3147	Std Err of Coef. 0.0000
42		6.83	0.710	591.00	-0.3425	
43		6.85	0.690	621.00	-0.3711	

RATE OF RECOVERY TEST: WELL W-6-B

RISING HEAD TEST



BOUWER AND RICE METHOD FOR INTERPRETATION OF SLUG TESTS: FOR UNCONFINED AND LEAKY CONFINED AQUIFERS.
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#	*TIME min (X)	*DEPTH TO WATER Ft.	DRAWDOWN (Y)	TIME sec (X')	LN (Y)
1		9.14	1.430	1.00	0.3577
2		9.05	1.340	2.00	0.2927
3		9.03	1.320	3.00	0.2776
4		9.02	1.310	4.00	0.2700
5		9.01	1.300	6.00	0.2624
6		9.00	1.290	8.00	0.2546
7		8.99	1.280	10.00	0.2469
8		8.98	1.270	11.00	0.2390
9		8.97	1.260	14.00	0.2311
10		8.96	1.250	19.00	0.2231
11		8.95	1.240	22.00	0.2151
12		8.94	1.230	24.00	0.2070
13		8.93	1.220	31.00	0.1989
14		8.91	1.200	36.00	0.1823
15		8.90	1.190	41.00	0.1740
16		8.89	1.180	46.00	0.1655
17		8.88	1.170	51.00	0.1570
18		8.86	1.150	56.00	0.1398
19		8.85	1.140	63.00	0.1310
20		8.84	1.130	68.00	0.1222
21		8.83	1.120	73.00	0.1133
22		8.82	1.110	83.00	0.1044
23		8.81	1.100	88.00	0.0953
24		8.80	1.090	93.00	0.0862
25		8.79	1.080	98.00	0.0770
26		8.78	1.070	103.00	0.0677
27		8.77	1.060	113.00	0.0583
28		8.75	1.040	133.00	0.0392
29		8.73	1.020	148.00	0.0198
30		8.71	1.000	163.00	0.0000
31		8.69	0.980	178.00	-0.0202
32		8.68	0.970	193.00	-0.0305
33		8.66	0.950	208.00	-0.0513
34		8.64	0.930	223.00	-0.0726
35		8.63	0.920	238.00	-0.0834
36		8.62	0.910	253.00	-0.0943
37		8.61	0.900	268.00	-0.1054
38		8.60	0.890	283.00	-0.1165
39		8.58	0.870	298.00	-0.1393
40		8.57	0.860	313.00	-0.1508
41		8.56	0.850	328.00	-0.1625
42		8.55	0.840	343.00	-0.1744
43		8.54	0.830	358.00	-0.1863

*PROJECT NAME :SOUTH ANDOVER - DESIGN INVESTIGATION
*PROJECT NO :20022.002
*WELL NO :W-7-B (FALLING HEAD TEST)
*ANALYST :PETER RZEPECKI
*DATE COLLECTED :10-23-90
*RISER PIPE (ID): (2 r sub c) = 1.7 in. = 0.0708 (radius in ft.)
*EFFECTIVE SCREEN DIAMETER:(2 r sub w) = 8.0 in. = 0.3333 (radius in ft.)
*EFFECTIVE SCREEN LENGTH: (L) = 6.30 Ft.
*MAX DRAWDOWN (IN SUBSET): (Ymax) = 1.43 Ft.
*STATIC WATER LEVEL: (SWL) = 7.71 Ft.
*DEPTH FROM SWL TO EFF. SCREEN BOTTOM: (H) = 31.93 Ft.
*EST. AQUIFER DEPTH (SWL TO AQUIFER BOTTOM): (D) = 40.00 Ft.
*INCLUDE SANDPACK DEWATERING (ENTER 1 IF YES, 0 IF NO)? 0
*SANDPACK'S SPECIFIC YIELD (Sy) =

BOUWER AND RICE CURVE COEFFICIENTS:
RATIO OF L/(r sub w) = 18.90
—LOG OF L/(r sub w) = 1.2765
FOR PARTIALLY PENETRATING WELLS—
A = 2.06
B = 0.30
FOR FULLY PENETRATING WELLS—
C = 1.48

—EVALUATION OF LN(Re/(r sub w)):
CONST.1 = 0.2411
CONST.2 = 3.1868 =(MAX. OF 6.0)= 3.1868
LN(Re/(r sub w) = 2.50

EFFECTIVE r sub c (for sandpack dewatering) = 0.0708
(1/T)(LN(Yo/Yt)) (SLOPE) = -7.20E-04 sec^(-1)

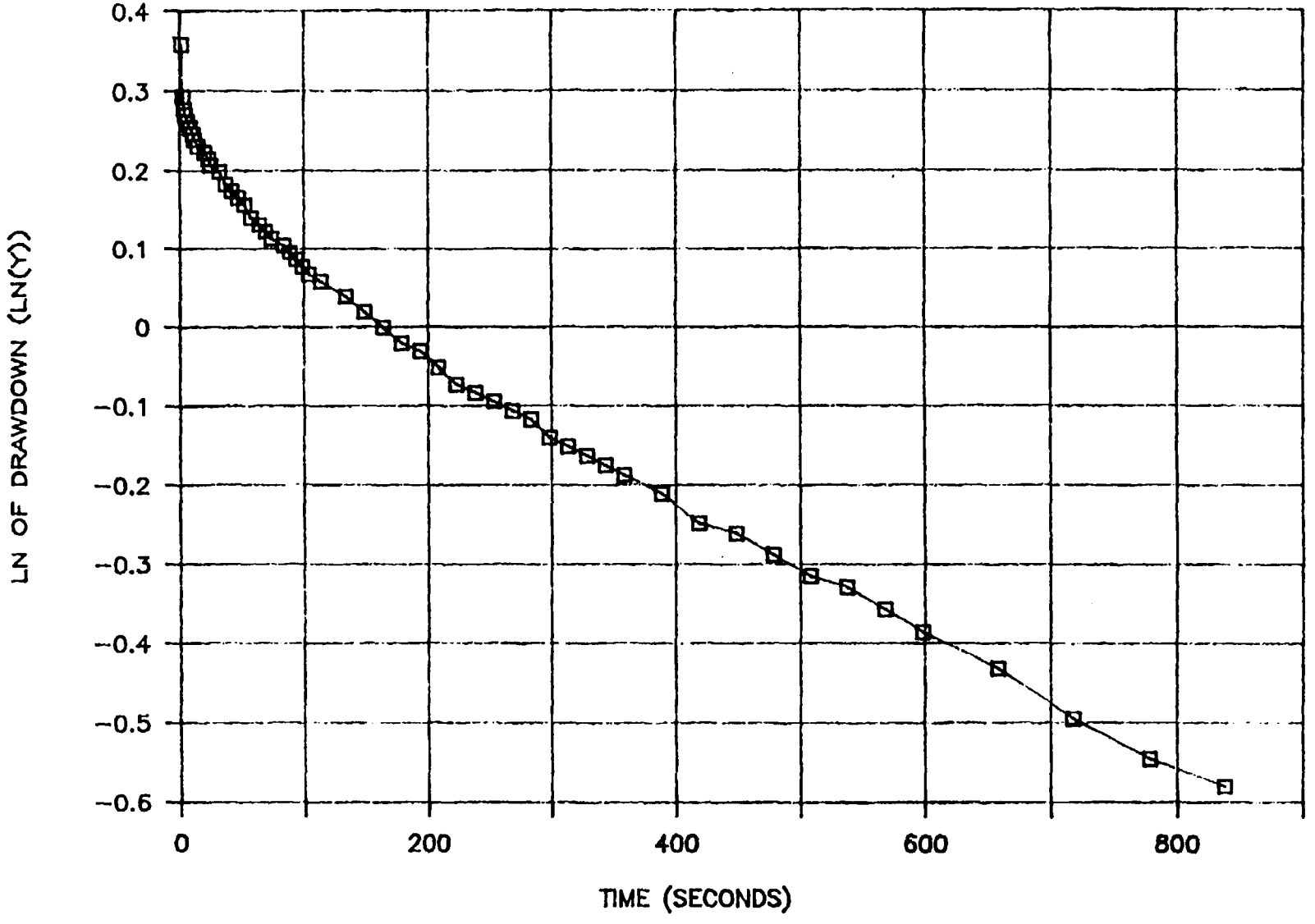
HYDRAULIC CONDUCTIVITY (K) = 7.16E-07 ft/sec <==========
2.18E-05 cm/sec <==========

Regression Output:

Constant	2.67E-01
Std Err of Y Est	0.0114
R Squared	0.9942
No. of Observations	30
Degrees of Freedom	28
X Coefficient(s)	-7.20E-04
Std Err of Coef.	0.0000

RATE OF RECOVERY TEST: WELL W-7-B

FALLING HEAD TEST



BOUWER AND RICE METHOD FOR INTERPRETATION OF SLUG TESTS: FOR UNCONFINED AND LEAKY CONFINED AQUIFERS.
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#	*TIME min (X)	*DEPTH TO WATER Ft.	DRAWDOWN (Y)	TIME sec (X')	LN (Y)
1		6.52	1.190	1.00	0.1740
2		6.54	1.170	2.00	0.1570
3		6.55	1.160	60.00	0.1484
4		6.56	1.150	62.00	0.1398
5		6.57	1.140	64.00	0.1310
6		6.58	1.130	66.00	0.1222
7		6.59	1.120	67.00	0.1133
8		6.60	1.110	71.00	0.1044
9		6.61	1.100	73.00	0.0953
10		6.62	1.090	77.00	0.0862
11		6.63	1.080	81.00	0.0770
12		6.65	1.060	91.00	0.0583
13		6.66	1.050	101.00	0.0488
14		6.67	1.040	106.00	0.0392
15		6.68	1.030	116.00	0.0296
16		6.69	1.020	121.00	0.0198
17		6.70	1.010	136.00	0.0100
18		6.71	1.000	146.00	0.0000
19		6.72	0.990	151.00	-0.0101
20		6.73	0.980	166.00	-0.0202
21		6.74	0.970	191.00	-0.0305
22		6.75	0.960	206.00	-0.0408
23		6.76	0.950	221.00	-0.0513
24		6.77	0.940	236.00	-0.0619
25		6.78	0.930	251.00	-0.0726
26		6.79	0.920	266.00	-0.0834
27		6.80	0.910	281.00	-0.0943
28		6.81	0.900	296.00	-0.1054
29		6.82	0.890	311.00	-0.1165
30		6.83	0.880	326.00	-0.1278
31		6.84	0.870	341.00	-0.1393
32		6.85	0.860	356.00	-0.1508
33		6.87	0.840	386.00	-0.1744
34		6.88	0.830	416.00	-0.1863
35		6.89	0.820	446.00	-0.1985
36		6.91	0.800	476.00	-0.2231
37		6.92	0.790	506.30	-0.2357
38		6.94	0.770	536.00	-0.2614
39		6.95	0.760	566.00	-0.2744
40		6.97	0.740	596.00	-0.3011
41		6.98	0.730	626.00	-0.3147
42		6.99	0.720	656.00	-0.3285
43		7.02	0.690	716.00	-0.3711
44		7.05	0.660	776.00	-0.4155

*PROJECT NAME :SOUTH ANDOVER - DESIGN INVESTIGATION
*PROJECT NO :20022.002
*WELL NO :W-7-8 (RISING HEAD TEST)
*ANALYST :PETER RZEPECKI
*DATE COLLECTED :10-23-90
*RISER PIPE (ID): (2 r sub c) = 1.7 in. = 0.0708 (radius in ft.)
*EFFECTIVE SCREEN DIAMETER:(2 r sub w) = 8.0 in. = 0.3333 (radius in ft.)
*EFFECTIVE SCREEN LENGTH: (L) = 6.30 Ft.
*MAX DRAWDOWN (IN SUBSET): (Ymax) = 1.19 Ft.
*STATIC WATER LEVEL: (SWL) = 7.71 Ft.
*DEPTH FROM SWL TO EFF. SCREEN BOTTOM: (H) = 31.93 Ft.
*EST. AQUIFER DEPTH (SWL TO AQUIFER BOTTOM): (D) = 40.00 Ft.
*INCLUDE SANDPACK DEWATERING (ENTER 1 IF YES, 0 IF NO)? 0
*SANDPACK'S SPECIFIC YIELD (Sy) =

BOUWER AND RICE CURVE COEFFICIENTS:
RATIO OF L/(r sub w) = 18.90
---LOG OF L/(r sub w) = 1.2765
FOR PARTIALLY PENETRATING WELLS--
A = 2.06
B = 0.30
FOR FULLY PENETRATING WELLS--
C = 1.48

---EVALUATION OF LN(Re/(r sub w)):
CONST.1 = 0.2411
CONST.2 = 3.1868 =(MAX. OF 6.0)= 3.1868
LN(Re/(r sub w) = 2.50

EFFECTIVE r sub c (for sandpack dewatering) = 0.0708
(1/T)(LN(Yo/Yt)) (SLOPE) = -6.12E-04 sec^(-1)

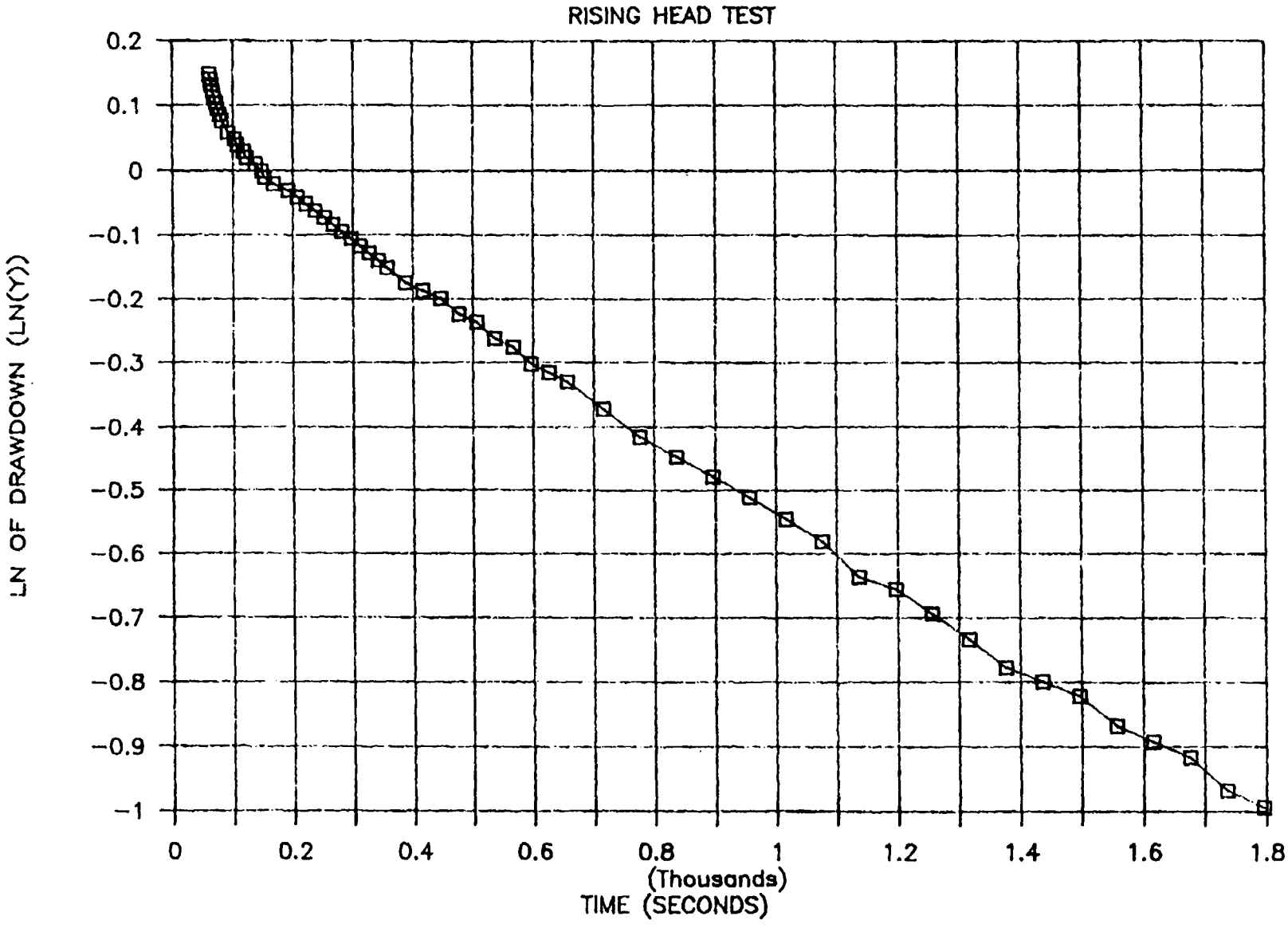
HYDRAULIC CONDUCTIVITY (K) = 6.09E-07 ft/sec <==========
1.86E-05 cm/sec <==========

Regression Output:

Constant	7.89E-02
Std Err of Y Est	0.0127
R Squared	0.9983
No. of Observations	48
Degrees of Freedom	46
X Coefficient(s)	-6.12E-04
Std Err of Coef.	0.0000

45		7.07	0.640	836.00	-0.4463
46		7.09	0.620	896.00	-0.4780
47		7.11	0.600	956.00	-0.5108
48		7.13	0.580	1016.00	-0.5447
49		7.15	0.560	1076.00	-0.5798
50		7.18	0.530	1136.00	-0.6349
51		7.19	0.520	1196.00	-0.6539
52		7.21	0.500	1256.00	-0.6931
53		7.23	0.480	1316.00	-0.7340
54		7.25	0.460	1376.00	-0.7765
55		7.26	0.450	1436.00	-0.7985
56		7.27	0.440	1496.00	-0.8210
57		7.29	0.420	1556.00	-0.8675
58		7.30	0.410	1616.00	-0.8916
59		7.31	0.400	1676.00	-0.9163
60		7.33	0.380	1736.00	-0.9676
61		7.34	0.370	1796.00	-0.9943

RATE OF RECOVERY TEST: WELL W-7-B



BOUWER AND RICE METHOD FOR INTERPRETATION OF SLUG TESTS: FOR UNCONFINED AND LEAKY CONFINED AQUIFERS.
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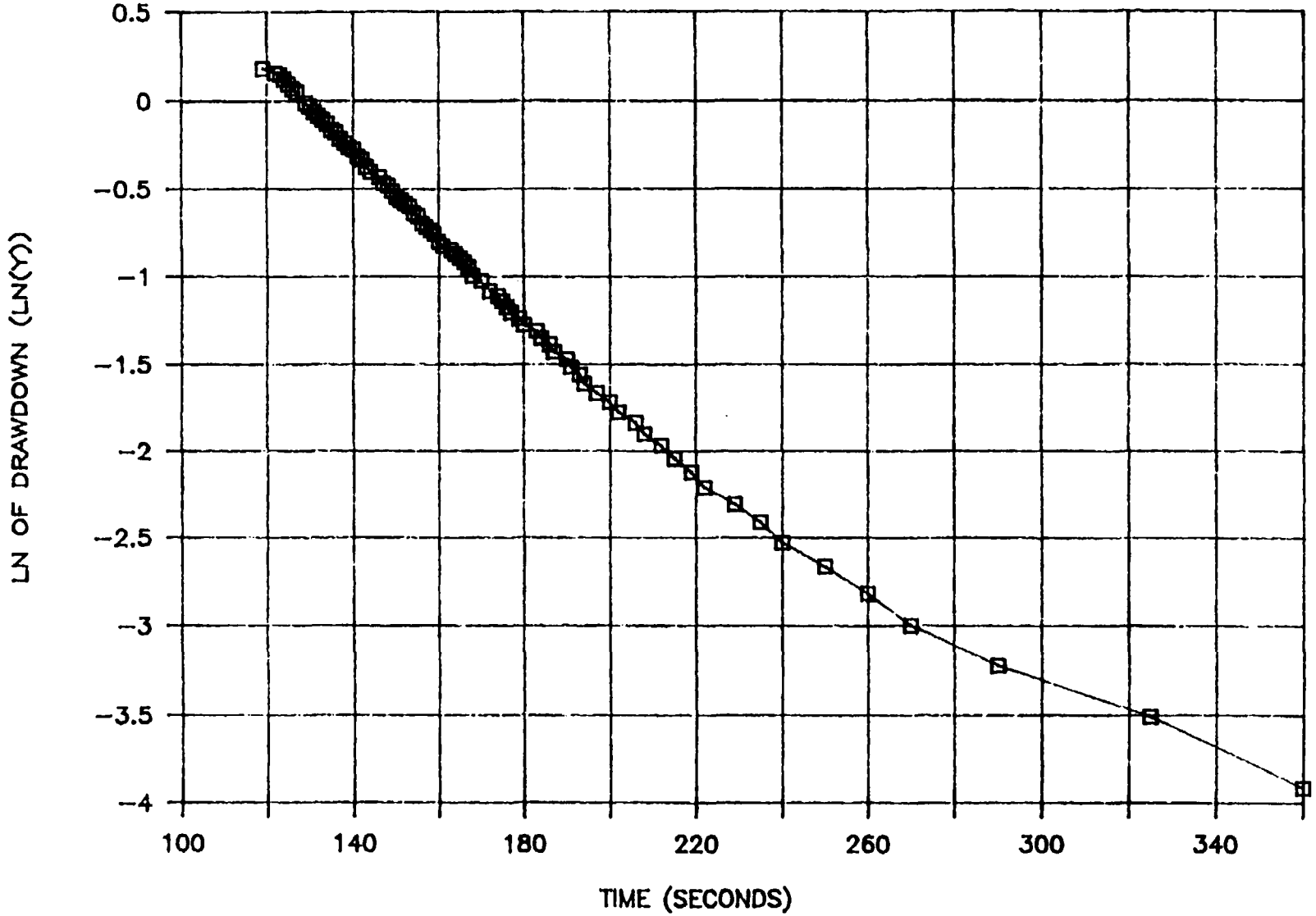
#	*TIME min (X)	*DEPTH TO WATER Ft.	DRAWDOWN (Y)	TIME sec (X')	LN (Y)	
						*PROJECT NAME :SOUTH ANDOVER - DESIGN INVESTIGATION
						*PROJECT NO :20022.002
						*WELL NO :W-7-C (FALLING HEAD TEST)
1		8.59	1.320	59.00	0.2776	*ANALYST :PETER RZEPECKI
2		8.47	1.200	119.00	0.1823	*DATE COLLECTED :1-23-90
3		8.44	1.170	122.00	0.1570	*RISER PIPE (ID): (2 r sub c) = 1.7 in. = 0.0708 (radius in ft.)
4		8.43	1.160	123.00	0.1484	*EFFECTIVE SCREEN DIAMETER:(2 r sub w) = 6.0 in. = 0.2500 (radius in ft.)
5		8.40	1.130	124.00	0.1222	*EFFECTIVE SCREEN LENGTH: (L) = 12.50 Ft.
6		8.37	1.100	125.00	0.0953	*MAX DRAWDOWN (IN SUBSET): (Ymax) = 1.32 Ft.
7		8.34	1.070	126.00	0.0677	*STATIC WATER LEVEL: (SWL) = 7.27 Ft.
8		8.32	1.050	127.00	0.0488	*DEPTH FROM SWL TO EFF. SCREEN BOTTOM: (H) = 76.45 Ft.
9		8.26	0.990	129.00	-0.0101	*EST. AQUIFER DEPTH (SWL TO AQUIFER BOTTOM): (D) = 80.00 Ft.
10		8.24	0.970	130.00	-0.0305	*INCLUDE SANDPACK DEWATERING (ENTER 1 IF YES, 0 IF NO)? 0
11		8.21	0.940	131.00	-0.0619	*SANDPACK'S SPECIFIC YIELD (Sy) =
12		8.19	0.920	132.00	-0.0834	
13		8.17	0.900	133.00	-0.1054	BOUWER AND RICE CURVE COEFFICIENTS:
14		8.15	0.880	134.00	-0.1278	RATIO OF L/(r sub w) = 50.00
15		8.12	0.850	135.00	-0.1625	—LOG OF L/(r sub w) = 1.6990
16		8.11	0.840	136.00	-0.1744	FOR PARTIALLY PENETRATING WELLS—
17		8.08	0.810	137.00	-0.2107	A = 3.09
18		8.06	0.790	138.00	-0.2357	B = 0.44
19		8.04	0.770	139.00	-0.2614	FOR FULLY PENETRATING WELLS—
20		8.03	0.760	140.00	-0.2744	C = 2.63
21		8.00	0.730	141.00	-0.3147	
22		7.99	0.720	142.00	-0.3285	—EVALUATION OF LN(Re/(r sub w)):
23		7.96	0.690	143.00	-0.3711	CONST.1 = 0.1922
24		7.94	0.670	144.00	-0.4005	CONST.2 = 2.6532 =(MAX. OF 6.0)= 2.6532
25		7.92	0.650	146.00	-0.4308	LN(Re/(r sub w) = 3.60
26		7.90	0.630	147.00	-0.4620	
27		7.89	0.620	148.00	-0.4780	EFFECTIVE r sub c (for sandpack dewatering) = 0.0708
28		7.87	0.600	149.00	-0.5108	(1/T)(LN(Yo/Yt)) (SLOPE) = -2.40E-02 sec^(-1)
29		7.85	0.580	150.00	-0.5447	
30		7.84	0.570	151.00	-0.5621	HYDRAULIC CONDUCTIVITY (K) = 1.74E-05 ft/sec <==========
31		7.83	0.560	152.00	-0.5798	5.30E-04 cm/sec <==========
32		7.82	0.550	153.00	-0.5978	
33		7.80	0.530	154.00	-0.6349	Regression Output:
34		7.79	0.520	155.00	-0.6539	Constant 3.08E+00
35		7.77	0.500	156.00	-0.6931	Std Err of Y Est 0.0181
36		7.76	0.490	157.00	-0.7133	R Squared 0.9991
37		7.75	0.480	158.00	-0.7340	No. of Observations 68
38		7.74	0.470	159.00	-0.7550	Degrees of Freedom 66
39		7.72	0.450	160.00	-0.7985	
40		7.71	0.440	161.00	-0.8210	X Coefficient(s) -2.40E-02
41		7.70	0.430	163.00	-0.8440	Std Err of Coef. 0.0001
42		7.69	0.420	164.00	-0.8675	
43		7.68	0.410	165.00	-0.8916	

44		7.67	0.400	166.00	-0.9163
45		7.66	0.390	167.00	-0.9416
46		7.64	0.370	168.00	-0.9943
47		7.63	0.360	170.00	-1.0217
48		7.62	0.350	171.00	-1.0498
49		7.61	0.340	172.00	-1.0788
50		7.60	0.330	174.00	-1.1087
51		7.59	0.320	175.00	-1.1394
52		7.58	0.310	176.00	-1.1712
53		7.57	0.300	177.00	-1.2040
54		7.56	0.290	179.00	-1.2379
55		7.55	0.280	180.00	-1.2730
56		7.54	0.270	183.00	-1.3093
57		7.53	0.260	184.00	-1.3471
58		7.52	0.250	186.00	-1.3863
59		7.51	0.240	187.00	-1.4271
60		7.50	0.230	190.00	-1.4697
61		7.49	0.220	191.00	-1.5141
62		7.48	0.210	193.00	-1.5606
63		7.47	0.200	194.00	-1.6094
64		7.46	0.190	197.00	-1.6607
65		7.45	0.180	200.00	-1.7148
66		7.44	0.170	202.00	-1.7720
67		7.43	0.160	206.00	-1.8326
68		7.42	0.150	208.00	-1.8971
69		7.41	0.140	212.00	-1.9661
70		7.40	0.130	215.00	-2.0402
71		7.39	0.120	219.00	-2.1203
72		7.38	0.110	222.00	-2.2073
73		7.37	0.100	229.00	-2.3026
74		7.36	0.090	235.00	-2.4079
75		7.35	0.080	240.00	-2.5257
76		7.34	0.070	250.00	-2.6593
77		7.33	0.060	260.00	-2.8134
78		7.32	0.050	270.00	-2.9957
79		7.31	0.040	290.00	-3.2189
80		7.30	0.030	325.00	-3.5066
81		7.29	0.020	360.00	-3.9120
82		7.28	0.010	520.00	-4.6052
83		7.27	0.000	715.00	ERR

RATE OF RECOVERY TEST: WELL W-7-C

FALLING HEAD TEST



BOUWER AND RICE METHOD FOR INTERPRETATION OF SLUG TESTS: FOR UNCONFINED AND LEAKY CONFINED AQUIFERS.
TO UTILIZE THIS WORKSHEET, ENTER YOUR DATA AT LOCATIONS MARKED BY AN "*".
PROGRAM CAN INCLUDE EFFECTS OF SANDPACK DEWATERING (ASSUMING WATER IS RISING WITHIN THE SANDPACK).

#	*TIME min (X)	*DEPTH TO WATER Ft.	DRAWDOWN (Y)	TIME sec (X')	LN (Y)
1		5.92	1.350	1.00	0.3001
2		5.96	1.310	2.00	0.2700
3		6.00	1.270	3.00	0.2390
4		6.03	1.240	4.00	0.2151
5		6.07	1.200	5.00	0.1823
6		6.10	1.170	6.00	0.1570
7		6.14	1.130	7.00	0.1222
8		6.17	1.100	8.00	0.0953
9		6.19	1.080	9.00	0.0770
10		6.23	1.040	10.00	0.0392
11		6.26	1.010	11.00	0.0100
12		6.28	0.990	12.00	-0.0101
13		6.31	0.960	13.00	-0.0408
14		6.33	0.940	14.00	-0.0619
15		6.35	0.920	15.00	-0.0834
16		6.38	0.890	16.00	-0.1165
17		6.40	0.870	17.00	-0.1393
18		6.43	0.840	18.00	-0.1744
19		6.45	0.820	19.00	-0.1985
20		6.47	0.800	20.00	-0.2231
21		6.49	0.780	21.00	-0.2485
22		6.51	0.760	22.00	-0.2744
23		6.53	0.740	23.00	-0.3011
24		6.55	0.720	24.00	-0.3285
25		6.57	0.700	25.00	-0.3567
26		6.59	0.680	26.00	-0.3857
27		6.61	0.660	27.00	-0.4155
28		6.63	0.640	28.00	-0.4463
29		6.65	0.620	29.00	-0.4780
30		6.72	0.550	62.00	-0.5978
31		6.79	0.480	67.00	-0.7340
32		6.85	0.420	72.00	-0.8675
33		6.90	0.370	77.00	-0.9943
34		6.95	0.320	82.00	-1.1394
35		6.98	0.290	87.00	-1.2379
36		7.02	0.250	92.00	-1.3863
37		7.05	0.220	97.00	-1.5141
38		7.07	0.200	102.00	-1.6094
39		7.09	0.180	107.00	-1.7148
40		7.11	0.160	112.00	-1.8326
41		7.13	0.140	117.00	-1.9661
42		7.14	0.130	122.00	-2.0402
43		7.15	0.120	127.00	-2.1203
44		7.17	0.100	132.00	-2.3026
45		7.19	0.080	142.00	-2.5257
46		7.20	0.070	147.00	-2.6593
47		7.21	0.060	162.00	-2.8134
48		7.22	0.050	177.00	-2.9957
49		7.23	0.040	192.00	-3.2189

*PROJECT NAME :SOUTH ANDOVER - DESIGN INVESTIGATION
*PROJECT NO :20022.002
*WELL NO :W-7-C (RISING HEAD TEST)
*ANALYST :PETER RZEPECKI
*DATE COLLECTED :1-23-90
*RISER PIPE (ID): (2 r sub c) = 1.7 in. = 0.0708 (radius in ft.)
*EFFECTIVE SCREEN DIAMETER:(2 r sub w) = 6.0 in. = 0.2500 (radius in ft.)
*EFFECTIVE SCREEN LENGTH: (L) = 12.50 Ft.
*MAX DRAWDOWN (IN SUBSET): (Ymax) = 1.35 Ft.
*STATIC WATER LEVEL: (SWL) = 7.27 Ft.
*DEPTH FROM SWL TO EFF. SCREEN BOTTOM: (H) = 76.45 Ft.
*EST. AQUIFER DEPTH (SWL TO AQUIFER BOTTOM): (D) = 80.00 Ft.
*INCLUDE SANDPACK DEWATERING (ENTER 1 IF YES, 0 IF NO)? 0
*SANDPACK'S SPECIFIC YIELD (Sy) =

BOUWER AND RICE CURVE COEFFICIENTS:
RATIO OF L/(r sub w) = 50.00
—LOG OF L/(r sub w) = 1.6990
FOR PARTIALLY PENETRATING WELLS—
A = 3.09
B = 0.44
FOR FULLY PENETRATING WELLS—
C = 2.63

—EVALUATION OF LN(Re/(r sub w)):
CONST.1 = 0.1922
CONST.2 = 2.6532 =(MAX. OF 6.0)= 2.6532
LN(Re/(r sub w) = 3.60

EFFECTIVE r sub c (for sandpack dewatering) = 0.0708
(1/T)(LN(Yo/Yt)) (SLOPE) = -2.37E-02 sec^(-1)

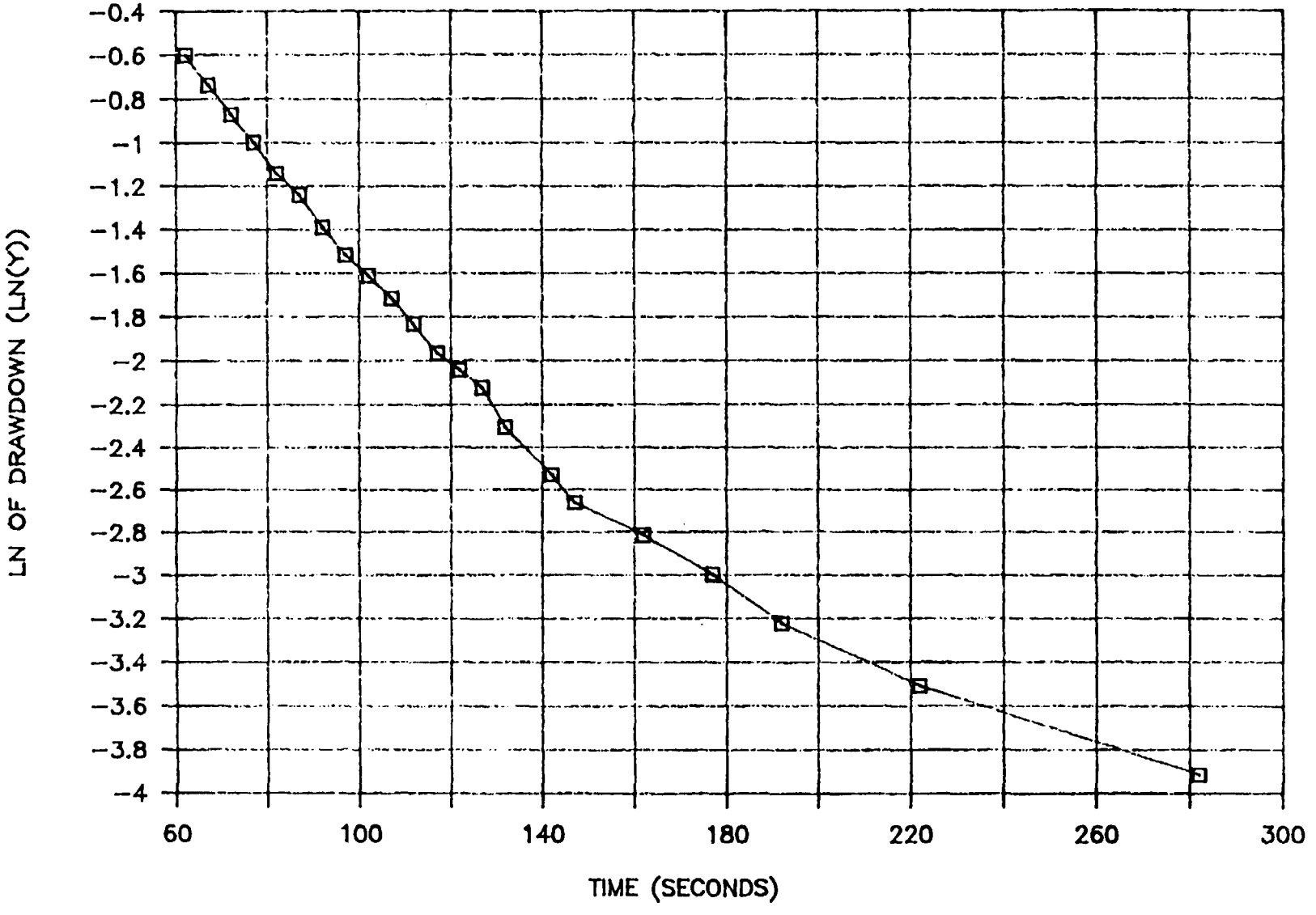
HYDRAULIC CONDUCTIVITY (K) = 1.72E-05 ft/sec <==========
5.23E-04 cm/sec <==========

Regression Output:

Constant	8.30E-01
Std Err of Y Est	0.0280
R Squared	0.9981
No. of Observations	17
Degrees of Freedom	15
X Coefficient(s)	-2.37E-02
Std Err of Coef.	0.0003

RATE OF RECOVERY TEST: WELL W-7-C

RISING HEAD TEST



BOUWER AND RICE METHOD FOR INTERPRETATION OF SLUG TESTS: FOR UNCONFINED AND LEAKY CONFINED AQUIFERS.
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PROGRAM CAN INCLUDE EFFECTS OF SANDPACK DEWATERING (ASSUMING WATER IS RISING WITHIN THE SANDPACK).

#	*TIME min (X)	*DEPTH TO WATER Ft.	DRAWDOWN (Y)	TIME sec (X')	LN (Y)
1		8.47	1.200	1.00	0.1823
2		8.04	0.770	35.00	-0.2614
3		7.90	0.630	36.00	-0.4620
4		7.81	0.540	37.00	-0.6162
5		7.76	0.490	38.00	-0.7133
6		7.72	0.450	39.00	-0.7985
7		7.69	0.420	40.00	-0.8675
8		7.67	0.400	41.00	-0.9163
9		7.65	0.380	42.00	-0.9676
10		7.64	0.370	43.00	-0.9943
11		7.63	0.360	44.00	-1.0217
12		7.62	0.350	45.00	-1.0498
13		7.61	0.340	46.00	-1.0788
14		7.60	0.330	48.00	-1.1087
15		7.59	0.320	51.00	-1.1394
16		7.58	0.310	65.00	-1.1712
17		7.57	0.300	1170.00	-1.2040
18			7.270		1.9838
19			7.270		1.9838
20			7.270		1.9838
21			7.270		1.9838
22			7.270		1.9838
23			7.270		1.9838
24			7.270		1.9838
25			7.270		1.9838
26			7.270		1.9838
27			7.270		1.9838
28			7.270		1.9838
29			7.270		1.9838
30			7.270		1.9838
31			7.270		1.9838
32			7.270		1.9838
33			7.270		1.9838
34			7.270		1.9838
35			7.270		1.9838
36			7.270		1.9838
37			7.270		1.9838
38			7.270		1.9838
39			7.270		1.9838
40			7.270		1.9838
41			7.270		1.9838
42			7.270		1.9838
43			7.270		1.9838

*PROJECT NAME :SOUTH ANDOVER - DESIGN INVESTIGATION
*PROJECT NO :20022.002
*WELL NO :W-23-A (FALLING HEAD TEST)
*ANALYST :PETER RZEPECKI
*DATE COLLECTED :10-24-90
*RISER PIPE (ID): (2 r sub c) = 2.0 in. = 0.0833 (radius in ft.)
*EFFECTIVE SCREEN DIAMETER:(2 r sub w) = 8.0 in. = 0.3333 (radius in ft.)
*EFFECTIVE SCREEN LENGTH: (L) = 9.00 Ft.
*MAX DRAWDOWN (IN SUBSET): (Ymax) = 1.35 Ft.
*STATIC WATER LEVEL: (SWL) = 7.27 Ft.
*DEPTH FROM SWL TO EFF. SCREEN BOTTOM: (H) = 9.00 Ft.
*EST. AQUIFER DEPTH (SWL TO AQUIFER BOTTOM): (D) = 20.00 Ft.
*INCLUDE SANDPACK DEWATERING (ENTER 1 IF YES, 0 IF NO)? 0
*SANDPACK'S SPECIFIC YIELD (Sy) =

BOUWER AND RICE CURVE COEFFICIENTS:
RATIO OF L/(r sub w) = 27.00
—LOG OF L/(r sub w) = 1.4314
FOR PARTIALLY PENETRATING WELLS—
A = 2.33
B = 0.32
FOR FULLY PENETRATING WELLS—
C = 1.74

—EVALUATION OF LN(Re/(r sub w)):
CONST.1 = 0.3338
CONST.2 = 3.4965 =(MAX. OF 6.0)= 3.4965
LN(Re/(r sub w)) = 2.17

EFFECTIVE r sub c (for sandpack dewatering) = 0.0833
(1/T)(LN(Yo/Yt)) (SLOPE) = -3.41E-02 sec^(-1)

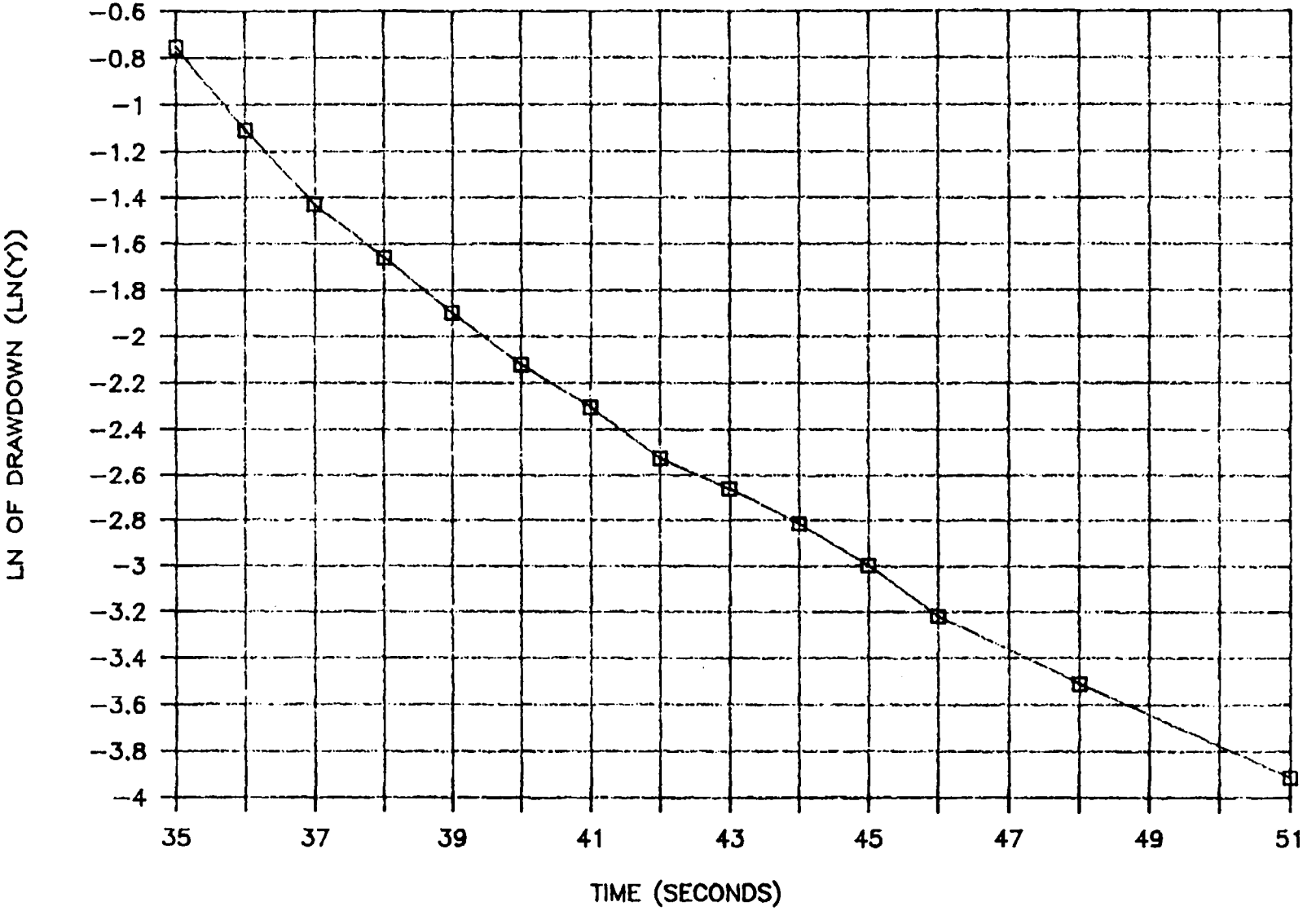
HYDRAULIC CONDUCTIVITY (K) = 2.85E-05 ft/sec <==========
8.68E-04 cm/sec <==========

Regression Output:

Constant	4.83E-01
Std Err of Y Est	0.0117
R Squared	0.9794
No. of Observations	7
Degrees of Freedom	5
X Coefficient(s)	-3.41E-02
Std Err of Coef.	0.0022

RATE OF RECOVERY TEST: WELL W-23-A

FALLING HEAD TEST



BOUWER AND RICE METHOD FOR INTERPRETATION OF SLUG TESTS: FOR UNCONFINED AND LEAKY CONFINED AQUIFERS.
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PROGRAM CAN INCLUDE EFFECTS OF SANDPACK DEWATERING (ASSUMING WATER IS RISING WITHIN THE SANDPACK).

#	*TIME min (X)	*DEPTH TO WATER Ft.	DRAWDOWN (Y)	TIME sec (X')	LN (Y)	
1		6.50	1.070	1.00	0.0677	*PROJECT NAME :SOUTH ANDOVER - DESIGN INVESTIGATION
2		6.80	0.770	26.00	-0.2614	*PROJECT NO :20022.002
3		7.04	0.530	27.00	-0.6349	*WELL NO :W-23-A (RISING HEAD TEST)
4		7.19	0.380	28.00	-0.9676	*ANALYST :PETER RZEPECKI
5		7.29	0.280	29.00	-1.2730	*DATE COLLECTED :10-24-90
6		7.36	0.210	30.00	-1.5606	*RISER PIPE (ID): (2 r sub c) = 2.0 in. = 0.0833 (radius in ft.)
7		7.41	0.160	31.00	-1.8326	*EFFECTIVE SCREEN DIAMETER: (2 r sub w) = 8.0 in. = 0.3333 (radius in ft.)
8		7.44	0.130	32.00	-2.0402	*EFFECTIVE SCREEN LENGTH: (L) = 9.00 Ft.
9		7.47	0.100	33.00	-2.3026	*MAX DRAWDOWN (IN SUBSET): (Ymax) = 0.77 Ft.
10		7.49	0.080	34.00	-2.5257	*STATIC WATER LEVEL: (SWL) = 7.57 Ft.
11		7.50	0.070	35.00	-2.6593	*DEPTH FROM SWL TO EFF. SCREEN BOTTOM: (H) = 9.00 Ft.
12		7.52	0.050	36.00	-2.9957	*EST. AQUIFER DEPTH (SWL TO AQUIFER BOTTOM): (D) = 20.00 Ft.
13		7.53	0.040	37.00	-3.2189	*INCLUDE SANDPACK DEWATERING (ENTER 1 IF YES, 0 IF NO)? 0
14		7.54	0.030	40.00	-3.5066	*SANDPACK'S SPECIFIC YIELD (Sy) =
15		7.55	0.020	43.00	-3.9120	
16		7.56	0.010	51.00	-4.6052	
17		7.57	0.000	1163.00	ERR	

BOUWER AND RICE CURVE COEFFICIENTS:

RATIO OF L/(r sub w) = 27.00

—LOG OF L/(r sub w) = 1.4314

FOR PARTIALLY PENETRATING WELLS--

A = 2.33

B = 0.32

FOR FULLY PENETRATING WELLS--

C = 1.74

—EVALUATION OF LN(Re/(r sub w)):

CONST.1 = 0.3338

CONST.2 = 3.4965 =(MAX. OF 6.0)= 3.4965

LN(Re/(r sub w) = 2.17

EFFECTIVE r sub c (for sandpack dewatering) = 0.0833

(1/T)(LN(Yo/Yt)) (SLOPE) = -1.79E-01 sec^(-1)

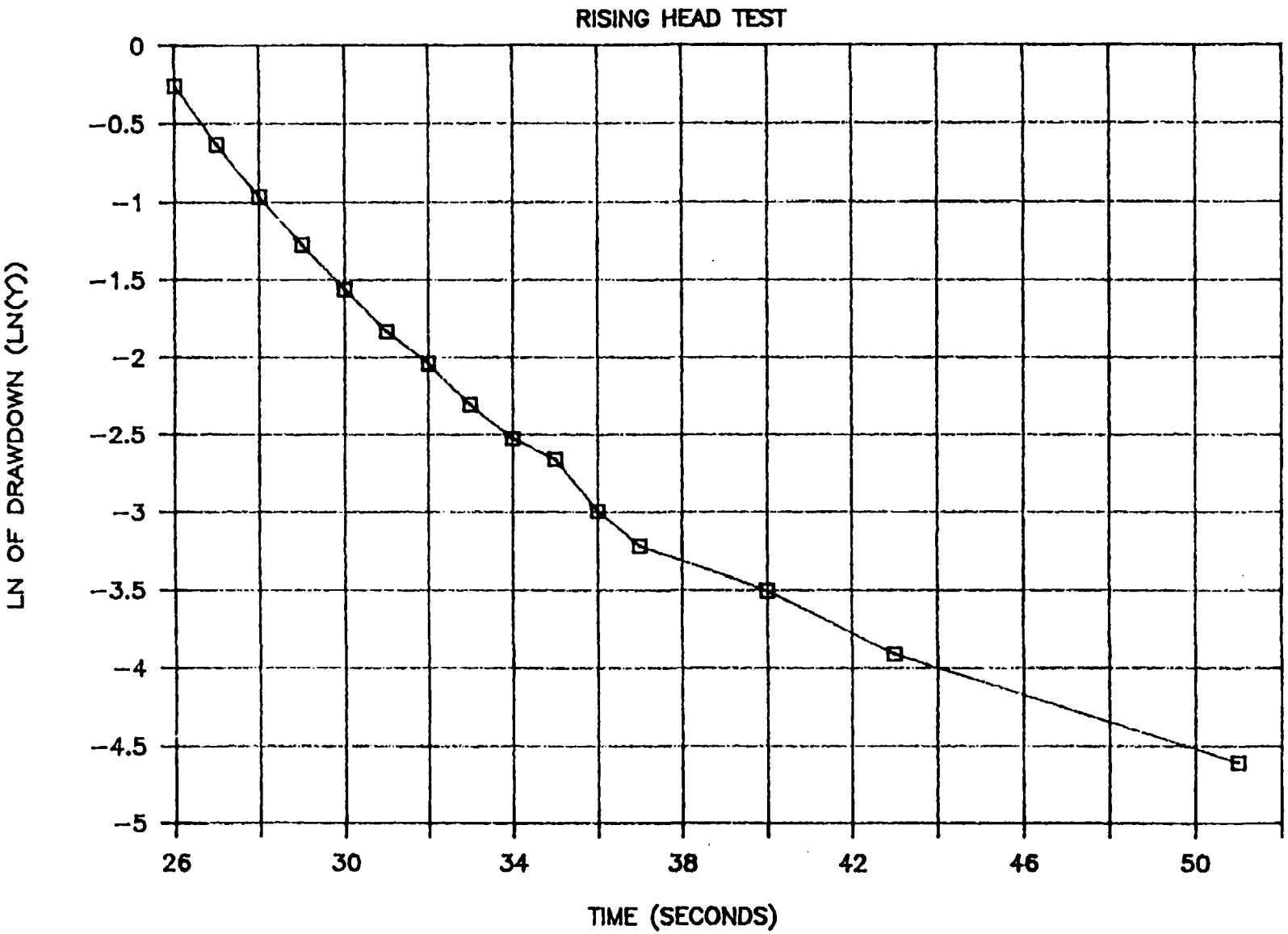
HYDRAULIC CONDUCTIVITY (K) = 1.49E-04 ft/sec <==========

4.55E-03 cm/sec <==========

Regression Output:

Constant	3.81E+00
Std Err of Y Est	0.3458
R Squared	0.9276
No. of Observations	15
Degrees of Freedom	13
X Coefficient(s)	-1.79E-01
Std Err of Coef.	0.0138

RATE OF RECOVERY TEST: WELL W-23-A



APPENDIX H

TECHNICAL MEMORANDUM
GROUNDWATER SAMPLING PROGRAM

MEMORANDUM

DATE: July 16, 1991

TO: D. Voight
Project Files, South Andover Superfund
Site Design Investigation

CC: R. Gau - Project Manager
M. Crosser - TSQAM

FROM: Environmental Staff

SUBJECT: EPA ARCS Region V Contract No. 68-W8-9003
EPA Work Assignment No. 13-5N45
Donohue Project No. 20022.003

South Andover Design Investigation

GROUNDWATER SAMPLING PROGRAM

Sampling of groundwater from monitoring wells and residential water supply wells at the South Andover site took place between September 21, 1990 and November 8, 1990. During this time period, a total of 2 monitoring wells and 4 residential wells were sampled as part of the South Andover Design Investigation (DI). Several different sampling events were required to complete the sampling of these wells. This memorandum was drafted using information compiled from field notes for the different sampling events, and summarizes the methods and procedures used during well sampling. Modifications or deviations from procedures specified in the DI Final Site Investigation Plan are also discussed.

A listing of the wells sampled during the South Andover DI are given in Table 1. Sampling dates are included to assist in differentiating between sampling events.

Residential Wells

Four residential wells in the area of the South Andover site were sampled during September 1990. Residential wells were sampled directly from the tap after allowing the tap to run for 5 minutes. Residential well water samples were collected for analyses including: Volatile Organic Compounds (VOC), Base Neutral Analysis (BNA), Polychlorinated Biphynels (PCBs), pesticides, metals and cyanide. During interviews with residents, it was determined that water softeners or other water treatment systems were not used at the residential well sample locations. Since residential wells water samples were taken directly from the tap no decontamination was required.

TABLE 1

WELLS SAMPLED FOR THE DESIGN INVESTIGATION
SOUTH ANDOVER SITE
July 1991

Monitoring Wells	Well Diameter	Date Sampled
B4C	1 inch	November 5, 1990
B6A-R	2 inch	October 17, 1990
B6B-R	2 inch	October 16, 1990
B7A	1 inch	November 5, 1990
B7B-R	2 inch	October 18, 1990
B7C	2 inch	October 18 and November 5, 1990
B8A	1 inch	November 6, 1990
W1A	1 inch	November 2, 1990
W1B	1 inch	November 1, 1990
W9A	1 inch	October 18, 1990
W15B	2 inch	November 8, 1990
W16A	2 inch	September 23, 1990
W17A	2 inch	October 16, 1990
W19A	2 inch	October 16, 1990
W21A	2 inch	September 22, 1990
W21B	2 inch	September 22, 1990
W23A-R	2 inch	October 17, 1990
W23B	2 inch	October 17, 1990
W23C	2 inch	September 25, 1990
W26A	2 inch	September 25, 1990

Residential Wells	Date Sampled
RW01	September 21, 1990
RW03	September 21, 1990
RW04	September 21, 1990
RW06	September 21, 1990

B/V/AA3

Monitoring Wells

Groundwater samples from monitoring wells were collected during three sampling events. The third sampling event was necessary due to the presence of 1-inch diameter wells which required acquisition of special sampling equipment. Table 1 lists the monitoring wells sampled, well diameters and sampling dates.

In general, all 2-inch diameter wells were sampled during the sampling events occurring in September and October, 1990. A Keck pump was used to purge and collected samples from all 2-inch diameter wells. The Keck pump was decontaminated between wells following the procedure specified in the DI Site Investigation Plan. Decontamination procedures specified included: (1) soap and water wash; (2) tap water rinse; (3) an isopropanol rinse; and (4) two rinses with distilled water. In addition, one gallon of distilled water was pumped through the keck pump before sampling at a different well. A minimum of 5 well volumes was purged prior to sampling.

Modified bailers and a specialized air lift pump were used to sample 1-inch diameter wells. The airlift system consisted of a 0.25 inch air line (fitted with brass nozzle), encased in 0.75 inch PVC pipe which was inserted to the bottom of the well. After installation, the air line was connected to a portable air compressor forcing air down the well and evacuating water via the PVC piping. Water evacuated from the well was collected in a plastic container. While is system was used to sample well W-1A, the air lift system was not used for subsequent wells since this system proved ineffective and the equipment was difficult to decontaminate. As a result, the remaining 1-inch diameter wells were purged and sampled with 1-inch bailers. Bailers were decontaminated using the procedure followed for the Keck pump (described above).

Damage to wells B2B, B9A, and B4A, made sampling impossible. In addition, well B4B could not be located and is thought to have been destroyed by prior construction activities in the area. Wells W15B and B8A were substituted for wells B2B and W8A, to provide additional information that would have been provided by missing or damaged wells.

A 2-inch PVC bailer was used to sample W15B. This bailer was lost in the well during sampling. Although several recovery attempts were made, efforts to retrieve the lost bailer/recovery equipment were unsuccessful. A 2-inch disposable bailer was used to complete sampling at W15B.

Samples collected from all monitoring wells were analyzed for: (1) Volatile Organic Analytes (VOAs), (2) BNAs, (3) Inorganics, (4) Chemical Oxygen Demand (COD), (5) total phosphorous (TP), (6) total suspended solids, and (7) total solids (TS). In addition, samples were collected for PCB/pesticide analyses from wells W7C, W9A, and W23A-R.

Slow recovery did not allow sufficient sample volumes to be recovered for all analyses at several wells. As a result, samples were collected for VOA and inorganic analyses at wells B4C and B7A.

SUMMARY

Twenty-one monitoring wells and four residential water supply wells were sampled as part of the DI. Water samples collected were analyzed for some or all of the following: VOCs, VOAs, metals, BNAs, PCBs, pesticides, cyanide, inorganics, COD, TP, TSS, or TS.

Monitoring wells sampled included both 1-inch and 2-inch diameter wells. The occurrence of 1-inch diameter wells caused problems during sampling which were resolved through the use of specialized sampling equipment. Acquisition of the specialized sampling equipment required the completion of sampling to be delayed and required a third sampling event. Slow recovery resulted in the omission of samples for several analyses at two well locations.

Three wells scheduled to be sampled were found to be damaged and not capable of being sampled. In addition, well B4B could not be located and is thought to have been destroyed by construction activities. Two wells located near and screened similarly to wells lost or damaged were substituted in the sampling program.

B/V/AA3

APPENDIX I

TECHNICAL MEMORANDUM
GEOLOGIC EVALUATION

MEMORANDUM

DATE: July 30, 1991

TO: Dave Voight, Site Manager

CC: Roman Gau, Project Manager
Mike Crosser, TSQAM

FROM: Rob Cannestra

SUBJECT: EPA ARCS Region V Contract No. 68-W8-0093
EPA Work Assignment No. 13-5N45
Donohue Project No. 20022.000

Geologic Evaluation
South Andover Remedial Investigation/Design Investigation

1.0 INTRODUCTION

The South Andover Remedial Investigation and Design Investigation were conducted during the summer of 1990. The purpose of these investigations was to: (1) obtain information to further characterize site geology and hydrogeology; (2) document current groundwater quality; and (3) to obtain information to be used by the U.S. Environmental Protection Agency (EPA) in assessing potential impacts to downgradient receptors. This information will be used to evaluate the present condition of the site, evaluate the extent of contamination observed, and to assist in the identification of remedial actions.

This memorandum will present the geology of the site based on information obtained by Donohue as part of work completed for the Remedial Investigation and Design Investigation. Specifically, the stratigraphy of the site will be defined and physical properties of the stratigraphic units will be described. The geologic information obtained by Donohue was combined with that of earlier investigations (CH2M Hill, 1988; FIT, 1981; RMT/PEDco, 1979) to produce comprehensive geologic cross sections. Since the information taken from earlier investigations was collected by others, Donohue can make no judgements as to its accuracy.

2.0 REGIONAL GEOLOGY

The South Andover site is located in the Anoka Sand Plain physiographic region in east central Minnesota. The landscape of this area strongly reflects the influence of mid to late Wisconsinan glaciation, however, the area has been subject to glacial activity throughout Pleistocene times. Glacial tills and outwash deposits exist as remnants of past glacial activity. Thickness of unconsolidated glacial deposits range from 100 to 300 feet. Following the end of Wisconsinan glacial activity 10,000 to 12,000 years ago, the land surface was modified by fluvial and aeolian processes to create the present landscape.

Two major glacial advances occurred during mid- and late-Wisconsinan Age glaciation. Glacial advances are responsible for the deposition of glacial tills. The earlier Superior Lobe glacial advance deposited the Superior Till. The Superior Till consists of red, silty, clayey sand. As the ice of the Superior Lobe retreated, thick sequences of outwash sands were deposited. As glacial ice continued to retreat, finer grained sediments were deposited in relatively quiet glacial lakes. Subsequent readvance of the glaciers by the Grantsburg sublobe is responsible for the deposition of the Grantsburg till. The Grantsburg till is generally described as a gray, calcareous, silty, clayey sand. As the ice of the Grantsburg sublobe retreated, another sequence of outwash sand was deposited. These gray outwash sands make up what is commonly referred to today as the Anoka Sand Plain. The Anoka Sand Plain covers an area of approximately 850 square miles ranging in thickness from 20 to 60 feet (Farnham, 1956).

Bedrock beneath the unconsolidated glacial deposits consist of sedimentary rock units of Cambrian and Precambrian Age. These rocks are predominantly comprised of sandstone, however, interbedded units of dolomite and siltstone are included. The Jordan Sandstone is the surficial bedrock unit in the region sequentially underlain by the St. Lawrence Formation (dolomite and siltstone), Franconia Formation (sandstone), Ironton-Galesville (sandstone), Eau Claire Formation (siltstone), Mt. Simon Formation (sandstone), and Hinkley and Fond du Lac Formations (sandstones). These sedimentary bedrock units overly a Precambrian Crystalline basement rock complex.

3.0 SITE GEOLOGY

3.1 Previous Investigations

Previous site work completed by CH2M Hill (1988) has identified three major unconsolidated site geologic units at South Andover. The units identified by CH2M Hill are presented in a stratigraphic column prepared by CH2M Hill and included in Figure 2-8. The uppermost unit identified by CH2M Hill (Upper Sand Unit) is an outwash and dune sand deposit which is considered part of the Anoka Sand Plain. This unit ranges from 20 to 50 feet thick in the vicinity of the site. Often a 2- to 7-foot thick silty sand or topsoil layer exists within the upper consolidated unit. Occasionally, black organic silt deposits, representative of swampy depositional environments, occur locally in the upper sand unit.

The upper sand unit is underlain by approximately 50 to 70 feet of glacial and glacio-fluvial silt and clay deposits called the Middle Aquitard. The intermediate aquitard is made up of three subunits which include from top to bottom: (1) a localized, discontinuous, thick gray sandy clay unit (Grantsburg Sublobe till); (2) a sandy silt unit, probably of lacustrine origin; and (3) a lacustrine clay and clayey silt unit. The bottom subunit extends across the site and is the thickest of the three subunits.

A sand unit underlies the intermediate aquitard. The sand unit is composed of silty, fine sand and occasional, localized coarse sand and gravel lenses. Investigators attribute the deposition of this unit to glacial fluvial and ice contact environments. In the vicinity of the South Andover site, this lower sand unit occurs at a depth of 100 feet and may range in thickness from 9 to 35 feet.

The lowermost unconsolidated unit occurring at the site is the Superior Till. The Superior Till is described as red sandy clay glacial till estimated to have a maximum thickness of approximately 5 feet, however, its continuity is undefined. The Superior till unit lies directly over Cambrian bedrock units.

3.2 Donohue Investigation

Soil borings completed in conjunction with the RI and DI investigations completed by Donohue are tabulated in Table 1. DI boring locations are shown on the site location map in Figure 3-1. Evaluation of boring information shows that the site stratigraphy is in general agreement with that previously defined, however, the composition of the aquitard was more clearly defined. Site stratigraphy defined during the RI and DI is summarized in the site hydrostratigraphic column shown in Figure 4-1.

3.2.1 Upper Sand Unit

Shallow and intermediate borings completed for the RI and DI investigations revealed and upper sand unit comprised of sand and silty sand with occasional local gravel lenses or organic deposits (W23A-R). According to the borings completed as part of the RI and DI and geologic cross sections prepared for this memorandum, (Figures 4-2 and 4-3) the thickness of the upper sand aquifer ranged from 23.0 feet (W19A, B, C) to 40.5 feet (BS-08). The average thickness of the upper sand unit calculated is 34 feet. Within the hydrogeology of the site, this unit functions as an aquifer. In general, borings completed for the RI were terminated within the upper sand unit, however, RI borings BS-01, BS-05, and BS-08 did penetrate through into the surface of the underlying unit.

3.2.2 Aquitard

Beneath the upper sand unit is a sequence of silts, silty sands, and clays of glacio-lacustrine origin considered an aquitard. The aquitard is the thickest unit encountered at the site, ranging in thickness from 68 feet (W19C) to 47 feet (W21C). The maximum thickness within the aquitard encountered during a DI boring is 65 feet (B7C).

The aquitard is made up of three less extensive subunits including: (1) an upper discontinuous glacio-lacustrine silt and silty sand subunit which includes lenses of glacial till; (2) a discontinuous glacio-lacustrine silty sand and sand unit; and (3) a basal continuous glacio-lacustrine silty and clay unit. The relationship of these subunits is shown in the west to east and south to north cross sections prepared using borings completed during the DI and previous investigations.

3.2.2.1 Subunit 1

Subunit 1 of the aquitard is discontinuous and ranges in thickness from 0 to 10.5 feet (B6B-R). In general, Subunit 1 is composed of laminated gray silts which indicate deposition in a fairly low energy lacustrine environment. At well nests W1 and B7, Subunit 1 is interbedded with a 1.5-foot thick layer of sand and silty sand, respectively.

At well nests W21, W19, and W15, the top of Subunit 1 is gray sandy clay 3 to 7 feet thick. The sandy clay encountered at these locations is considered to be glacial till, specifically the Grantsburg Till. At locations W19 and W15, lenses of the Grantsburg Till are underlain by the laminated silts characteristic of Subunit A1. At well nest W21, however, the laminated silts are absent and a lens of Grantsburg Till makes up the entire thickness of Subunit 1. The deposition of glacial tills at these locations is attributed to the melting of slabs of glacial ice which floated in a glacial lake to these locations after breaking from a nearby glacier.

Subunit 1 extends across almost the entire site though it pinches out to the north between well nests W19 and W4 and to the northeast between well nests W15 and B1.

3.2.2.2 Subunit 2

Beneath Subunit 1 is a discontinuous silty sand and sand layer. This silty sand and sand unit, Subunit 2, has a maximum thickness of 13.5 feet (B6B-R). Subunit 2 is continuous across the site in the north-south direction as shown in cross section B-B. However, in cross section A-A, which runs southwest to northeast across the site, Subunit 2 is absent at well nest B8 and pinches out in borings in the northeast between well nests W15 and B1 logged during previous investigations.

Silty sands and sands within Subunit 2 are stratified indicating glacio-lacustrine origin. The thickest sequences of Subunit 2 are in locations B6 and B7 where borings and well installations were completed as part of the DI. Wells B6B-R and B7B-R, replacement wells installed as part of the DI, are screened within Subunit 2.

3.2.2.3 Subunit 3

The lowest portion of the aquitard, Subunit 3, is composed of silts and clay. Silts and clays within Subunit 3 are both laminated and unlaminated but are considered lacustrine in origin (CH2M Hill, 1988). Subunit 3 is the thickest subunit within the intermediate aquitard. The thickness of Subunit 3 in borings completed for the DI which penetrate the aquitard ranges from 33 feet (W1C-R) to 45 feet (W7C). In the two geologic cross sections prepared fro the site, Subunit 3 has a maximum thickness of 54 feet at location W19.

A 7-foot thick lens of dark grayish brown silty clay till is reported for DI boring B7C. Directly below the lens of till material in B7C is a 1-foot thick lens of dark gray brown silty sand which is considered to be glacial outwash. The origin of these sediments is uncertain.

3.3 Lower Sand Unit

A lower sand unit was encountered in borings W1C-R and B7C at depths of 86 feet and 100 feet respectively. The lower sand aquifer is composed of dark gray-brown to brown silty sand. This lower sand aquifer was also identified in earlier CH2M Hill studies. Since this aquifer was not fully penetrated during the investigations completed by Donohue, the thickness of the lower sand aquifer was not defined. CH2M Hill (1988) determined that the lower sand unit is 9 to 35 feet thick.

References

CH2M Hill, Inc., 1988, Remedial Investigation Report, Contract No. 68-01-7251, U.S. Environmental Protection Agency.

Farnham, R.S. 1956, Geology of the Anoka Sand Plain in 1956 Annual Meeting Guidebook for Field Trips, G.M. Schwartz, Editor, Geological Society of America.

Residuals Management Technology, Inc., 1981, Technical Assistance to Andover, Preliminary Hydrogeologic Report on the Heidelberger Site, Contract No. 68-01-6005, U.S. Environmental Protection Agency.

ARCS/R/SANDOVER/AT6

TABLE 1
RI AND DI SOIL BORINGS
Andover, Minnesota

Boring No.	Total Depth (Ft.)
B1C-R	92.0
B6A-R	26.0
B6B-R	54.0
B7B-R	58.0
B7C	107.0
B23A-R	15.0
BS-01	40.0
BS-02	14.0
BS-03	10.0
BS-04	10.0
BS-05	34.0
BS-06	12.0
BS-07	10.0
BS-08	46.0
BS-09	10.0
BS-10	10.0
BS-11	10.0
BS-12	8.0
BS-13	14.0
BS-14	10.0
BS-15	8.0

ARCS/R/SANDOVER/AT6

APPENDIX J

TECHNICAL MEMORANDUM
HYDROGEOLOGIC EVALUATION

TECHNICAL MEMORANDUM

DATE: January 14, 1991

TO: Dave Voight, Site Manager

CC: Roman Gau, Project Manager
Mike Crosser, TSQAM

FROM: Rob Cannestra

RE: EPA ARCS Region V Contract No. 68-W8-0093
EPA Work Assignment No. 13-5N45
Donohue Project No. 20022.000

Hydrogeologic Evaluation
South Andover Design Investigation

1.0 INTRODUCTION

1.1 General

The South Andover Design Investigation was conducted during the summer of 1990. The purpose of this work was to (1) obtain information to further characterize site geology and hydrogeology; (2) document current groundwater quality; and (3) generally assess whether downgradient receptors could potentially be exposed to unacceptable human health risks, if identified. It is the intent of the U.S. EPA and the Minnesota Pollution Control Agency to use the information obtained by Donohue to determine the adequacy of an existing Record of Decision (ROD) issued for this site (March 1988).

This memorandum has been prepared to present and discuss the hydrogeological information obtained by Donohue as part of the Design Investigation. Specifically, Donohue will further characterize the hydraulic properties of the geologic units underlying the South Andover site by discussing groundwater flow directions, horizontal and vertical hydraulic gradients for each hydrogeologic unit, and provide an estimate of average linear flow velocities. Finally, this hydrogeologic assessment compares the observations made by Donohue with those reported previously by CH2M Hill (1988) in a previously completed Remedial Investigation (RI) of the South Andover site.

1.2 Background Information

Previous hydrogeologic characterization of the South Andover site was completed by CH2M Hill (1988) as part of a RI under an earlier Remedial Planning/Field Investigation Team (REM/FIT) contract. CH2M Hill defined three hydrogeologic units to be present beneath the South Andover site which were differentiated on the basis of stratigraphy and variations in hydraulic

properties. The three units identified include: (1) the Upper Sand Aquifer; (2) the Middle Aquitard composed of silt, sandy silt, and clay; and (3) the Lower Sand Aquifer. A site stratigraphic column prepared by CH2M Hill, included as Figure 2-8, presents more detailed information on the thickness and components of these units.

Subsequent soil borings completed during the DI by Donohue have provided stratigraphic information of greater detail than was previously available. The improved stratigraphic detail is significant because it allows three subunits to be defined in the lacustrine aquitard which combine to form the aquitard. Since the subunits of the aquitard can be defined separately they are considered separate hydrogeologic units. The presence of three separate hydrogeologic units within the aquitard increases the number of hydrogeologic units to be discussed for the site to five. Thus the five hydrogeologic units discussed at the site include: (1) the Upper Sand Aquifer; (2) Aquitard-Subunit 1; (3) Aquitard-Subunit 2; (4) Aquitard-Subunit 3; and (5) Lower Sand Aquifer. The strategraphy and hydrogeology is summarized in the site hydrostratigraphic colmn shown in Figure 4-1. Additional information on site stratigraphy is provided in the Technical Memorandum evaluating site geology in Appendix A.

2.0 HYDROGEOLOGIC CHARACTERIZATION

2.1 Hydraulic Conductivity Testing

Methods and Procedures

The hydraulic conductivities of the major hydrogeologic units underlying the South Andover site were determined by using both field and laboratory testing methods. Hydraulic properties of both an upper sand aquifer and lower sand aquifer were evaluated by performing in-situ hydraulic conductivity (slug) tests. In addition, laboratory permeability testing was also used to determine the hydraulic properties of an intervening confining unit which separates aquifer systems.

Slug test data was collected by using both rising head and falling head methods at selected well locations. Pressure transducers were placed in each well prior to testing, and changes in water levels were recorded by a data logger. Detailed accounts of field and analytical methods employed for slug testing are included in Technical Memorandum in Appendix G.

Hydraulic conductivity values were calculated from slug test data using the methods of Bower and Rice (1976). The hydraulic conductivities assigned to individual wells are the logarithmic mean of hydraulic conductivities calculated from rising and falling head slug tests conducted on each well.

2.1.1 Upper Sand Aquifer

Slug tests were performed on two water table wells, to determine the hydraulic properties of the surficial aquifer. A memorandum discussing the field procedures, problems or deviations from the work plan during field work

included in Technical Memorandum addressing hydraulic characterization in Appendix G. The raw field data and recovery graphs for each test are included in this Technical Memorandum. The results of slug tests are summarized in Table A and are discussed below. The logarithmic mean hydraulic conductivity of wells B6A-R and W23A in the upper sand aquifer is 6.1 x 10^{-3} cm/sec.

Hydraulic conductivities within the Upper Sand Aquifer determined by Donohue compare well with those previously determined by CH2M Hill, especially if the CH2M Hill slug test of W23B is disregarded. Accuracy within an order of magnitude under the assumptions made for slug test analysis is considered expectable. Differences between hydraulic conductivities observed by CH2M Hill and Donohue may be related to local variations in the physical properties of the aquifer.

2.1.2 Aquitard-Subunit 1

In cross sections prepared by Donohue (Figures 4-2 and 4-3) Aquitard subunit 1 appears laterally extensive but not continuous over the entire site. Though not continuous, this unit does separate two layers of distinctly different hydraulic conductivity (the Upper Sand Aquifer and Aquitard-subunit 2).

Unfortunately, no wells were completed in the Subunit 1 of the Aquitard so slug tests could not be performed. In addition laboratory hydraulic conductivity tests were run on samples taken from depths deeper in the intermediate aquitard. Regardless, since CH2M Hill did not consider this a separate hydrogeologic unit comparison of hydraulic conductivity data is impossible.

2.1.3 Aquitard Subunit-2

Aquitard Subunit 2 is laterally extensive but nevertheless discontinuous across the site. Where Subunit 1 is absent, Subunit 2 potentially grades into the Upper Sand Aquifer. Two wells are completed in Subunit 2 (B6B and B7B). Slug test analysis of these wells shows Subunit 2 to have a mean logarithmic hydraulic conductivity of 2.4 x 10^{-5} cm/sec.

Since CH2M Hill did not identify this as a separate hydrogeologic unit and screen wells accordingly no direct comparison of hydraulic conductivities is possible. However, well W23B is potentially completed in Subunit 2 where the aquitard Subunit 1 is absent. The hydraulic conductivity reported by CH2M Hill for W23B is 4.3 x 10^{-4} cm/sec.

If W23B is considered screened in Subunit 2 of the Aquitard, hydraulic conductivities determined by Donohue at B6B and B7B are comparable to earlier tests by CH2M Hill on W23B. The differences between hydraulic conductivities calculated for these wells approach an order of magnitude difference and are comparable considering the testing methods employed. Differences within an order of magnitude may be attributed to the testing methods or local variations in the physical properties of the geologic units.

TABLE A

MEAN HYDRAULIC CONDUCTIVITY VALUES
1990 DONOHUE & 1988 CH2M HIL INVESTIGATION
South Andover Superfund Site
January, 1991

	Donohue & Associates DI	Method	1988 CH2M Hill RI/FS	Method
Upper Sand Aquifer	6.1×10^{-3} cm/sec	Slug Test (2)	1.7×10^{-3} cm/sec*	Slug Test (6)
Aquitard - Subunit 1	NT	NA	NT	NA
Aquitard - Subunit 2	2.4×10^{-5} cm/sec	Slug Test (2)	NT	NA
Aquitard - Subunit 3	1.4×10^{-6} cm/sec	Lab Falling-Head Permeability (2)	9.2×10^{-6} cm/sec (Upper Zone) 2.3×10^{-6} cm/sec (Lower Zone)	*Lab Triaxial Perm-imeter (6)
Lower Sand Aquifer	7.6×10^{-4} cm/sec	In-situ Slug Test (2)	5.3×10^{-3} 4.1×10^{-3} 4.6×10^{-3} 5.6×10^{-3} 5.7×10^{-3}	Jacob Confined Walton Semi-Confined Hantush Semi-Confined Residual Drawdown (Theis Recovery) Calculated Recovery

NT = Not tested.
NA = Not applicable.

W/A/AF7

2.1.4 Aquitard Subunit-3

The hydraulic conductivity of Subunit 3 was determined by conducting laboratory permeability tests (falling-head) on shelby tube samples collected from depth within the aquitard. Available information indicates that the Subunit 3 is composed of laminated and unlaminated silt and clay. Two lab permeability tests were performed by Donohue on samples taken from Subunit 3. The calculated mean hydraulic conductivity for Subunit 3 is 1.4×10^{-6} cm/sec.

CH2M Hill had also reported that the Middle Aquitard consists of several zones. CH2M Hill recognized an upper clay-poor zone and a lower clay-rich zone, this distinction was based primarily on observed textural and other physical characteristics. CH2M Hill reported that this differentiated was supported by differences in hydraulic conductivity results. CH2M Hill used laboratory triaxial permeability tests to calculate hydraulic conductivities within the upper and lower zones. Unfortunately the depth at which shelby tube samples were collected were not reported by CH2M Hill. Regardless, logarithmic mean hydraulic conductivity values for the upper and lower zones within the intermediate aquitard calculated by CH2M Hill are 9.2×10^{-6} cm/sec and 2.3×10^{-6} cm/sec, respectively.

The mean hydraulic conductivity values for Subunit 3 obtained by Donohue and those obtained by CH2M Hill for the Aquitard are in general agreement (same order of magnitude). Differences in the hydraulic conductivity between the various zones within the Subunit 3 have not been addressed. The inherent uncertainties associated with the testing methods used for hydraulic characterization suggests that the observed differences are minor.

2.1.5 Lower Sand Aquifer

The Lower Sand Aquifer consists of fine sands and silty sand. In-situ hydraulic conductivity (slug) tests were conducted on two wells completed by Donohue within the upper portion of the lower sand aquifer (W1C-R, W7C).

Results obtained by Donohue demonstrate that the hydraulic conductivity within the lower sand aquifer is fairly uniform, ranging from 1.1×10^{-3} cm/sec to 5.3×10^{-4} cm/sec (logarithmic mean = 7.6×10^{-4} cm/sec).

A pump test was conducted by CH2M Hill to determine the hydraulic characteristics of the Lower Sand Aquifer. Pump test results obtained by CH2M Hill employed a variety of widely used pump test evaluation methods (see Table A). The hydraulic conductivity determined by these methods was comparable (5.0×10^{-3} cm/sec).

The hydraulic conductivity values determined by Donohue and CH2M Hill for the lower sand aquifer are similar and fall well within the range normally reported for fine sands. This observed similarity is considered significant since there are inherent limitations associated with slug tests. Slug tests are limited to evaluating hydraulic conductivity of the geologic formation occurring within close proximity to the well screen. In contrast, aquifer

pump tests evaluate hydraulic conductivity on a larger scale, allowing any heterogeneity or anisotropy occurring within the aquifer to be taken into account. The differences in scale between testing methods may be responsible for the observed difference in hydraulic conductivity.

2.2 Groundwater Flow Analysis

Methods and Procedures

Incomplete groundwater level measurements were collected during the sampling of new and select existing monitoring wells in September and October, 1990. A complete round of water level measurements for several wells was attempted (December 1990). Access to wells was restricted at several locations during the December monitoring event due to frozen locks. As a result of missing water level information, water levels obtained during earlier monitoring events were used to supplement the December 1990 data to evaluate groundwater flow direction. Use of water level data from different monitoring events is expected to have little, if any effect on the general groundwater flow direction since review of existing data shows little variation between monitoring events. Supplemental water levels were recorded between September and December 1990, and show fluctuations ranging from less than 0.1 ft to 0.7 ft during this time. Fluctuations of this magnitude are not expected to affect general flow patterns, however, hydraulic gradients may be influenced. Since only one comprehensive monitoring event was completed, no evaluation of seasonal water level fluctuations was possible.

Water level measurements used to construct groundwater flow maps are summarized in Table B. If water levels from monitoring events other than the December 1990 event are included in these tables they are noted. The water elevations presented are referenced to mean sea level (MSL) datum.

Differences exist in ground surface and well elevations observed by Donohue and those previously reported by CH2M Hill due to survey discrepancies in the latter. Donohue resurveyed the site and the elevations reported are considered correct.

Depth to water ranges from 3.64 ft at the north central portion of the site (W4A) to 22.93 ft in the south central portion of the site (B7A). A map showing the configuration of the water table within the upper sand aquifer (TOSA) is presented in Figure 4-4 (see water table on plan sheet). Significant observations pertaining to groundwater flow pathways are summarized below.

2.2.1 Upper Sand Aquifer

Horizontal groundwater movement within the Upper Sand Aquifer is from the northeast towards the west-southwest. Available water elevation data suggests that a water table "high" or mound is present northeast of the site, across Bunker Lake Boulevard. A less distinct water table mound, may also occur in the northeast corner of the site near location W15. At this location, the groundwater elevation in W15B, a base of upper sand aquifer (BOSA) well

TABLE B

GROUNDWATER ELEVATIONS
WATER TABLE OBSERVATION WELLS
South Andover Superfund Site
January, 1991

Well No.	Ground Elevation (Feet)	Top of Riser (Feet)	Casing Elevation (Feet)	Groundwater Elevations Depth to Water (Feet)	Groundwater Elevations Water Elevation (MSL)
W1A	889.0	891.65	891.74	14.41	877.24
W2A				7.30	
W3A	902.8	904.48	904.71		
W4A	883.7	884.41	885.35	4.85	879.56
W5A	890.8	892.82	893.05	12.10	880.72
B6A-R	895.3	897.05	896.71	17.29	879.76
W6A	884.6	886.15	886.17	9.00	868.86
W7A	883.6	885.90	885.90		
W8A	894.7	895.68	896.19	17.30	878.38
W9A	889.6	891.20	891.52	12.65	878.55
W10A	884.3	886.42	889.59		
W11A					
W12A	881.5	884.35	884.44		
W13A	903.9	905.21	905.32		
W14A					
W16A	900.1	901.39	901.46	20.54*	880.85
W17A	885.6	888.56	888.65	8.58	879.98
W18A					
W19A	891.9	893.53	893.75	13.91	879.62
W20A	896.3	897.96	898.05	18.93	879.03
W21A	896.9	898.55	898.66	19.54	879.01
W22A	884.1	885.23	885.41		
W23A-R	883.3	885.21	884.64	N/R	
W24A	898.2	900.17	900.27	21.55	878.62
W25A	900.4	902.38	902.49	23.46	878.92
W26A	888.0	889.84	890.03	9.38*	880.46
B1A	901.0	902.62	902.64	23.01	879.61
B2A					
B3A					
B4A	884.1	886.45	886.37	7.02	879.40
B5A					
B7A	902.1	903.49	903.48	24.32	879.17
B8A	882.4	883.40	884.13	5.53	877.87
B9A	882.0	885.30	885.44	7.75	877.55
B10A	884.0	886.11	886.02	8.35	877.76

* Denotes reading date other than 12/90.

TABLE B (cont.)

GROUNDWATER ELEVATIONS
INTERMEDIATE PIEZOMETERS
(BOTTOM OF UPPER SAND AQUIFER WELLS)
South Andover Superfund Site
January, 1991

Well No.	Ground Elevation (Feet)	Top of Riser (Feet)	Casing Elevation (Feet)	Groundwater Elevations Depth to Water (Feet)	Groundwater Elevations Water Elevation (MSL)
W1B	888.61	892.72	892.71	17.40	875.32
W2B	892.7	893.07	893.33	10.69	882.38
W3B	903.0	904.51	904.63		
W4B	883.8	884.61	884.97	6.75	877.86
W5B	890.8	891.26	892.26	14.51	876.75
W6B					
W7B	883.6	884.51	885.01		
W8B	894.7	895.68	896.34	17.27	878.41
W9B	889.6	891.86	891.87	N/R	
W15B	889.6	891.43	891.53	11.25	880.18
W19B	891.8	894.09	894.15	14.46	879.63
W21B	896.9	898.59	898.65	19.08	879.51
W23B	883.1	885.32	885.44	7.65	877.67
B1B	901.1	902.88	903.13	23.26	879.62
B2B	892.7	893.07	893.33	DAMAGED	
B8B	882.0	885.33	885.23	7.51	877.82
B9B	881.9	885.23	885.30	7.85	877.38
B10B	884.2	885.36	886.03	N/R	

* Denotes reading other than 12/90.

TABLE B (cont.)

GROUNDWATER ELEVATIONS
WELL SCREENED IN THE INTERMEDIATE AQUITARD
South Andover Superfund Site
January, 1991

Well No.	Ground Elevation (Feet)	Top of Riser (Feet)	Casing Elevation (Feet)	Groundwater Elevations Depth to Water (Feet)	Groundwater Elevations Water Elevation (MSL)
B1C	901.8	903.32	903.99	24.64	878.68
B4B	884.4	6.64	6.59	N/R	
B6B-R	895.1	897.44	897.03	17.18*	880.26
B7B-R	902.2	904.64	904.27	25.07	879.57
B8C	882.1	885.17	884.94	10.03	875.14
B10C	884.6	886.27	886.29	8.56	877.71

* Denotes reading other than 12/90.

TABLE B (cont.)

GROUNDWATER ELEVATIONS
DEEP PIEZOMETERS
(TOP OF SAND AQUIFER)
South Andover Superfund Site
January, 1991

Well No.	Ground Elevation (Feet)	Top of Riser (Feet)	Casing Elevation (Feet)	Groundwater Elevations Depth to Water (Feet)	Groundwater Elevations Water Elevation (MSL)
W1C-R	887.5	890.45	889.90	21.25*	869.20
W2C					
W3C					
B7C	902.2	904.67	904.10	34.82*	869.85
W15C	889.7	892.11	892.0	18.10	874.01
W19C	891.6	893.75	893.51	23.62	870.13
W21C	896.9	899.18	898.78	29.46	869.72
W23C	883.3	885.52	885.42	16.08	869.44
B4C	884.2	887.20	887.04	18.19	869.01

* Denotes reading date other than 12/90.

W/A/AD2

indicates an additional mound. Despite the fact that W15B is a BOSA well, rather than a water table observation well, the water elevations in both well types are in general agreement in well nests across the site. However, the presence of a water table mound in the vicinity of nest W15 cannot be confirmed without obtaining water table elevation information from this location. If an additional water table mound were to exist near well nest W15 its presence may cause local distortion of the water table depicted in Figure 4-4.

Horizontal hydraulic gradients within the surface aquifer range from 0.0006 ft/ft to 0.003 ft/ft (avg = 0.0018 ft/ft). As shown in the water table map, the steepest hydraulic gradients occur in the western portion of the site, and generally decrease to the northeast. It is important to realize that steeper average hydraulic gradients may result from the presence of an on-site water table mound or the presence of wetlands which act as a hydraulic sink. Hydraulic gradients for the South Andover site are summarized in Table C.

Average linear groundwater flow velocities have been estimated for each hydraulic unit by using a variation of Darcy's Law as given in Equation 1.

$$\bar{V} = \frac{K\,i}{n} \qquad (1)$$

where:

$\bar{V}$ = Average linear velocity in units of $^{L}/_{t}$
K = Hydraulic conductivity in units of $^{L}/_{t}$
i = Hydraulic gradient
n = Porosity expressed as percent.

Values input into Equation 1 include a conservative porosity value of 0.25 for poorly-sorted sands (Freeze and Cherry, 1979), and a mean hydraulic conductivity of 6.1×10^{-3} cm/sec. The range of hydraulic gradients reported for this unit have been input into Equation 1 to determine minimum and maximum flow velocities. Average horizontal groundwater flow velocities calculated during the DI and the preceding CH2M Hill RI are summarized in Table D.

Horizontal flow velocities of 15 ft/yr to 76 ft/yr (avg = 45 ft/yr) are estimated for the Upper Sand Aquifer. These values are comparable to the 20 ft/yr to 40 ft/yr values calculated by CH2M Hill. It must be noted that the calculated flow velocities are only estimates, based on generalizing assumptions. For instance, since calculated hydraulic conductivities are estimated values, accurate to within an order of magnitude, and average linear velocities are directly proportional to hydraulic conductivity, calculated velocities may also vary by an order of magnitude.

While horizontal groundwater flow has been documented to occur within the surficial aquifer, comparison of average vertical and horizontal gradients (Table C) indicates that vertical flow predominates. Vertical gradients in

TABLE C

HYDRAULIC GRADIENT SUMMARY
South Andover Superfund Site
January, 1991

Hydrogeologic Unit	Range of Horizontal Gradient	Mean Horizontal Gradient	Range of Vertical Gradient	Mean Vertical Gradient
Surficial Upper Sand Aquifer	0.003 to 0.0006	0.0018	-0.010 to +0.085	0.040†
Intermediate Aquitard	+0.075 to 0.134	0.103	NC	NC
Lower Sand Aquifer	.009 to .002 (Steep in Northeast)	.0055	NC	NC

† - Considers observed downward gradients only.
NC - Not enough information to calculate.

W/A/AF8

TABLE D

HORIZONTAL GROUNDWATER FLOW VELOCITIES
1990 DONOHUE AND 1988 CH2M HILL INVESTIGATIONS
South Andover Superfund Site
January, 1991

HYDROSTRATIGRAPHIC UNIT	Average Groundwater Flow Velocities Under Isotropic Conditions Ft/Year	CH2M Hill RI/FS Flow Velocities Ft/Year
Upper Sand Aquifer		
K (horizontal) observed 6.1×10^{-3} cm/sec	15-76	20-40
Aquitard - Subunit 1		
No information on hydraulic conductivity	II	N/A
Aquitard - Subunit 2		
K (horizontal) observed 2.4×10^{-5} cm/sec	II	N/A
Aquitard - Subunit 3		
K (vertical) observed 1.4×10^{-6} cm/sec	3.9-17.6 4.4×10^{-2}	16-125
Lower Sand Aquifer		
K (horizontal) observed 7.6 $\times 10^{-4}$ cm/sec	II	II II

* - Gradients assumed similar to those observed in the upper sand aquifer.
II - Insufficient information to complete calculations.
N/A - Not addressed.

W/A/AF9

TABLE E

VERTICAL GROUNDWATER FLOW VELOCITIES
1990 DONOHUE AND 1988 CH2M HILL INVESTIGATIONS
South Andover Superfund Site
January, 1991

HYDROSTRATIGRAPHIC UNIT	Average Groundwater Flow Velocities Under Isotropic Conditions Ft/Year	Average Groundwater Flow Velocities When Kh/Kv = 3 Ft/Year	CH2M Hill RI/FS Flow Velocities Ft/Year
Upper Sand Aquifer			
K (horizontal) observed 6.1×10^{-3} cm/sec	50 - 2100	25 - 714	3.5 - 230
Aquitard - Subunit 1			
No information on hydraulic conductivity	II	II	N/A
Aquitard - Subunit 2			
K (horizontal) observed 2.4×10^{-5} cm/sec	II	II	N/A
Aquitard - Subunit 3			
K (vertical) observed 1.4×10^{-6} cm/sec	.023 - .044	Not Applicable	0.78 - 2.55
Lower Sand Aquifer			
K (horizontal) observed 7.6 $\times 10^{-4}$ cm/sec	II	II	II

* = Gradients assumed similar to those observed in the upper sand aquifer.
II = Insufficient information to complete calculations.
N/A = Not addressed.

W/A/AF9

the surface aquifer range from -0.010 ft/ft at well nest W8 to +0.085 ft/ft at well nest W4. Negative gradients indicate upward movement while positive gradients indicate downward movement. Downward hydraulic gradients are dominant across the majority of the site. However, upward hydraulic gradients are observed at well nests in the northeast (B1), south-southwest (W8), and north (W19).

Average vertical groundwater flow velocities for the sand surficial aquifer have been estimated by using Equation 1. Calculations were performed to evaluate (1) the most conservative case, and (2) for a more realistic case. The information obtained by Donohue is presented in Table D and discussed below.

Homogenous and isotropic conditions were assumed to exist in the Upper Sand Aquifer present the most conservative case. In addition to the mean hydraulic conductivity, an average porosity of 0.25, and the range of observed downward average vertical hydraulic gradients (.002 to .085) were input into Equation 1. The average observed hydraulic conductivity values was input into Equation 1 to estimate maximum vertical flow rates. The range of vertical groundwater velocities calculated for the upper sand aquifer is 50-2,100 ft/yr.

To present a more realistic case, and allow direct comparison of the results obtained by Donohue with those reported by CH2M Hill, calculations were made using a horizontal to vertical hydraulic conductivity ratio (Kh/Kv) of 3. The reason for using this ratio is two-fold: (1) vertical anisotropy is often observed in natural soils, and (2) a Kh/Kv=3 was used by CH2M Hill. Therefore, a similar approach was taken to allow direct comparison of program results. The estimates of vertical groundwater flow velocities obtained by Donohue (25 ft/yr to 714 ft/yr) are within the order of magnitude range previously reported by CH2M Hill (3.5 ft/yr to 230 ft/yr).

2.2.2 Aquitard Subunit-1

No wells have been completed in Subunit 1 of the Aquitard. Lack of water level information within Subunit 1 precludes calculation of horizontal gradients. In addition, lack of hydraulic conductivity data and horizontal gradients precludes the calculation of horizontal flow velocities. However, in the hydrogeologic setting of the site equipotential lines within the upper portion of the Aquitard are nearly horizontal, indicating that vertical flow dominates.

Since only two wells (B6B, B7B) are screened in Subunit 2 of the Aquitard, information on vertical gradients within the upper aquitard are restricted to well nests containing these wells. Unfortunately, since wells are not screened immediately above Subunit 1 at these locations, it is not possible to calculate vertical gradients across the aquitard. Without hydraulic conductivity and gradient information it is impossible to calculate vertical flow velocities.

2.2.3 Aquitard Subunit-2

Two wells recently completed by Donohue (B6B-R and B7B-R) are the only wells screened in Subunit 2 of the Aquitard. Since only two wells exist in this subunit, the direction of groundwater flow within the subunit (vertical and horizontal) can not be determined. Without information on the direction of groundwater movement it is not possible to calculate hydraulic gradients. Before average flow velocities can be calculated in either vertical or horizontal directions, additional information must be collected to determine the direction of groundwater movement and the magnitude of hydraulic gradients.

2.2.4 Aquitard Subunit-3

Vertical hydraulic gradients across aquitard-subunit 3 can be calculated at well nest B7. The vertical gradient of subunit 3 calculated at well next B7 is 0.19.

No wells have been completed in Subunit 3 of the Aquitard. This lack of wells has precluded estimation of horizontal gradients or horizontal flow velocities. However, at the South Andover site equipotential lines (in cross section) through the lower portion of the Aquitard are essentially horizontal indicating that groundwater movement is chiefly vertical.

Vertical groundwater flow velocities in Aquitard subunit 3 have been calculated using Equation 1. Input parameters included: (1) a conservative porosity value of 0.40 for silt (Freeze and Cherry, 1979), and (2) an average vertical hydraulic conductivity of 1.4×10^{-6} cm/sec. Since vertical hydraulic conductivity was determined by laboratory falling head test methods, no corrections for anisotropy were made. However, some uncertainty remains since laboratory analysis performed on a small sample may not necessarily be representative of the entire unit. Differences between hydraulic conductivities determined in the laboratory and field are common.

Vertical groundwater flow velocity estimated for aquitard subunit 3 is 0.7 ft/yr.

The values obtained by Donohue and CH2M Hill are compared in Table D. This information shows that vertical groundwater flow velocities estimated by Donohue are less than those previously reported by CH2M Hill (0.78 ft/yr to 2.55 ft/yr). This occurrence is largely attributed to the observed difference in hydraulic conductivities and hydraulic gradients calculated by Donohue.

Although interaction between the Upper and Lower Sand Aquifers cannot be fully evaluated without conducting extensive pump testing, the information obtained by Donohue does indicate that the groundwater flow within in the Upper Sand Aquifer, and the Aquitard is predominantly downward. This information suggests that the Upper and Lower Sand Aquifer systems are hydraulically interconnected.

2.2.5 Lower Sand Aquifer

Water elevation data collected from wells completed within the Lower Sand Aquifer has been plotted and contoured in Figure 4-5 to evaluate the direction of groundwater flow. The configuration of the potentiometric surface suggests that groundwater within the Lower Sand Aquifer flows from the northeast west-southwest across the site. This trend is similar to that observed for the upper water table aquifer.

Horizontal hydraulic gradients range from 0.002 ft/ft to 0.009 ft/ft (avg = 0.0055 ft/ft), with the observed gradients generally increasing to the east. The values estimated by Donohue for the Lower Sand Aquifer compare well to the upper value reported by CH2M Hill (0.00076 to 0.006 ft/ft).

Horizontal groundwater flow rates within the Lower Sand Aquifer were also calculated (Equation 1). Input parameters included: (1) a conservative porosity of 0.25 for sand (Freeze and Cherry, 1979), and (2) a mean hydraulic gradient of 0.0055 ft/ft. The observed horizontal hydraulic conductivity values were also input into Equation 1 to estimate minimum and maximum horizontal groundwater flow velocity. Calculated horizontal groundwater flow velocities ranged from 6.3 ft/yr to 28 ft/yr (avg = 17 ft/yr). The values calculated by Donohue are lower than those reported by CH2M Hill (16 to 125 ft/yr). Differences between horizontal flow velocities calculated for each program are due to differences in hydraulic conductivities used in calculation.

Since no wells were completed near the base of the Lower Sand Aquifer it is not possible to calculate the vertical hydraulic gradients within this unit. Consequently, vertical gradients or vertical flow velocity for this unit can not be calculated. Without bedrock wells the interaction between unconsolidated deposits and bedrock units cannot be evaluated.

3.0 SUMMARY

Stratigraphic and hydraulic characterization completed by Donohue as part of the South Andover DI has shown there to be three continuous hydrogeologic units present. These units consist of: (1) the Upper Sand Aquifer, (2) the Aquitard, and (3) the Lower Sand Aquifer. The Aquitard can be further broken down into 3 different subunits, each interpreted to possess different hydrogeologic properties.

Groundwater in the unconfined Upper Sand Aquifer flows from the northeast towards the west-southwest across the site. Horizontal flow velocities within the upper sand aquifer are estimated to range from 15 to 76 ft/yr. Despite the presence of horizontal flow vertical gradients indicate that downward vertical groundwater movement dominates. Estimates of average vertical groundwater flow velocities range from 25 to 2100 ft.

Subunit 1 of the Aquitard was not discussed separately prior to the Donohue investigation. Subunit 1 is considered discontinuous but is present over the majority of the site. Unfortunately, no information on the hydraulic

properties of Subunit 1 is available. Further information on the hydraulic conductivity, and hydraulic gradients within the unit is necessary before average groundwater flow velocities can be calculated.

Subunit 2 of the Aquitard may be in direct connection with the Upper Sand Aquifer if the Subunit 1 is absent. Information available is not sufficient to determine the direction of groundwater movement or hydraulic gradients within Subunit 2. The absence of hydraulic gradients makes estimates of average groundwater flow velocities impossible.

Subunit 3 of the Aquitard remains a significant feature in the hydrogeology of the South Andover site. Subunit 3 appears continuous across the site. Hydraulic conductivity of the aquitard was determined by laboratory permeability testing to be 1.4×10^{-6} cm/sec. Horizontal movement within the aquitard can be considered insignificant due to the strong vertical gradients. Average vertical groundwater flow velocity within the aquitard is estimated at 0.7 ft/yr. The interconnection of aquifers above and below the aquitard can only be evaluated by pump testing.

The Lower Sand Aquifer was characterized to have a mean hydraulic conductivity of 7.6×10^{-4} cm/sec. No vertical gradients nor vertical flow velocities can be calculated since wells necessary to define vertical gradients do no exist in the lower sand aquifer. Horizontal hydraulic gradients were calculated to range from 0.002 to 0.009 and are observed to steepen towards the northeast. Gradients are comparable to those obtained by CH2M Hill, however, gradients calculated by Donohue differ at the lower end of the range. Average horizontal flow velocities calculated for the Lower Sand Aquifer are in good agreement with those obtained by CH2M Hill if the differences due to hydraulic conductivities used in calculating them are taken into account. Average horizontal groundwater velocity in the Lower Sand Aquifer ranges from 6.3 to 28 ft/yr and averages 17 ft/yr.

The hydrogeology defined at the South Andover site is restricted to the unconsolidated glacial deposits. The interaction of unconsolidated glacial units with underlying bedrock units cannot be addressed without additional hydrogeologic monitoring of the bedrock units.

4.0 REFERENCES

Bouwer H., and Rice, R.C., 1976, A Slug Test for Determining Hydraulic Conductivity of Confined Aquifers with Completely or Partially Penetrating Wells: Water Resources REsearch, v. 12, pp. 423-428.

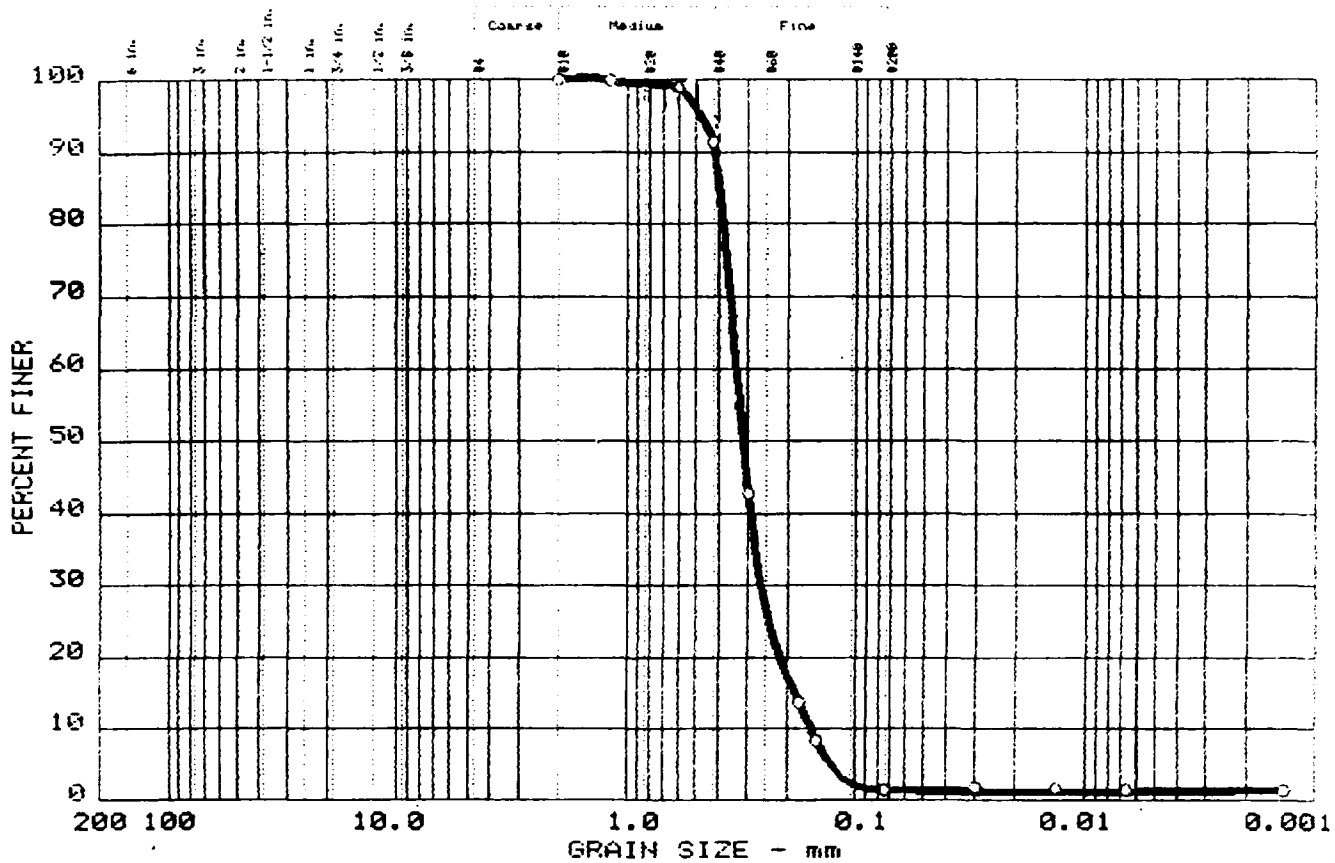
CH2M Hill, Inc., 1988, Final Remedial Investigation Report, Contract No 68-01-7251, U.S. Environmental Protection Agency.

Freeze, R.A. and Cherry, J.A., 1979, Groundwater: Prentice-Hall, Englewood Cliffs, 604 p.

APPENDIX K

GEOTECHNICAL LABORATORY REPORTS

GRAIN SIZE DISTRIBUTION TEST REPORT



Symbol	%+75mm	% GRAVEL	% SAND	% SILT	% CLAY
○	0.0	0.0	98.6	0.2	1.2

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○	--	--	0.40	0.33	0.31	0.262	0.1843	0.1569	1.30	2.1

MATERIAL DESCRIPTION	USCS
○ Brown Fine-Medium SAND, Trace Clay	SP

Project No.: 15091.14
Project: ETI
○ Sample: BORING: B6A SAMPLE: 1 @ 13.0-14.0 FT

Date: 10/02/90

Remarks:
TESTED BY: DWA/MML
ENTERED BY: MML
CHECKED BY: [illegible]
APPROVED BY: CAF

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EWI, Engineering Associates, Inc.

Sheet No.

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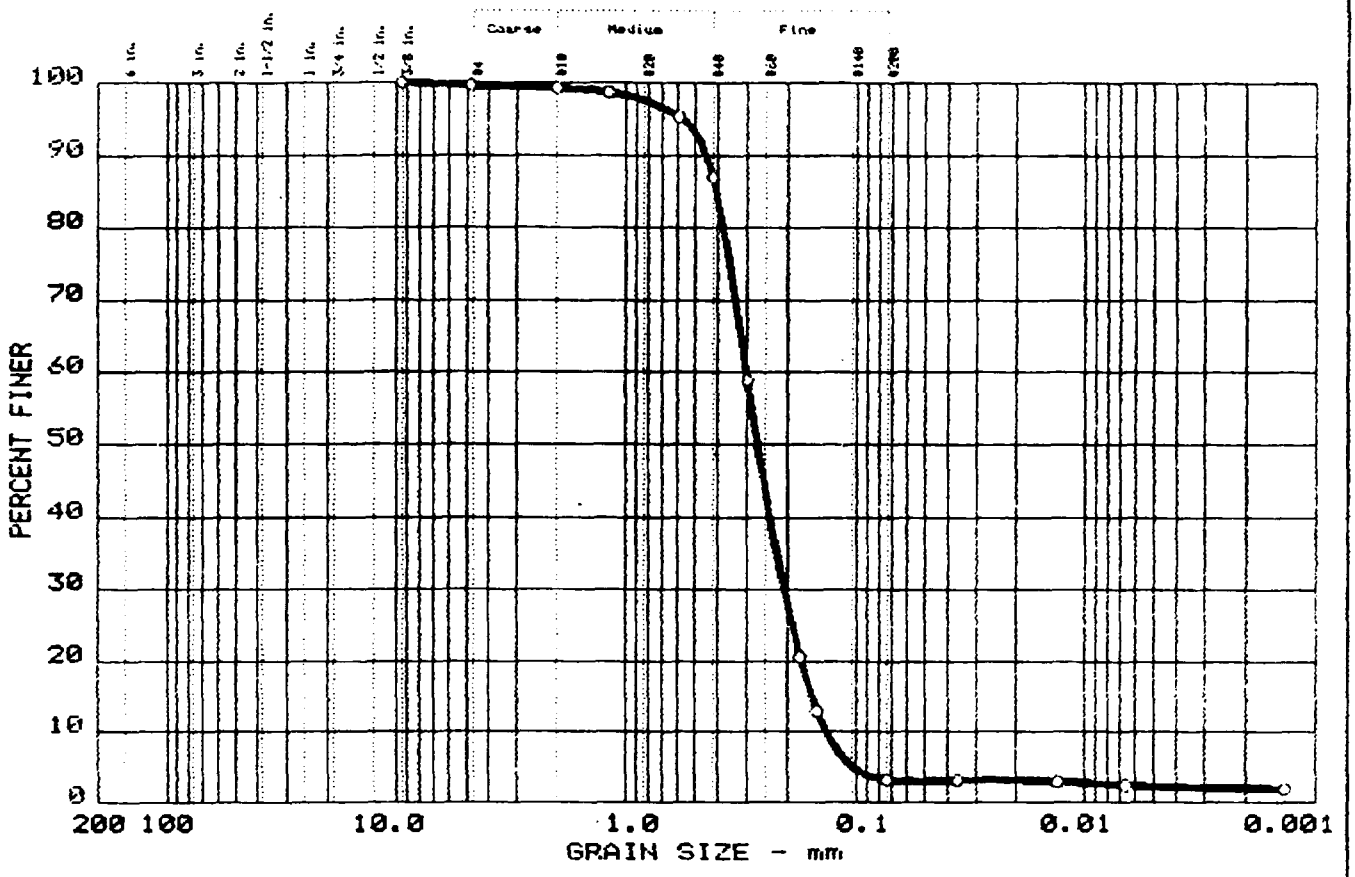

Symbol	%+75mm	% GRAVEL	% SAND	% SILT	% CLAY
○	0.0	0.3	96.5	0.9	2.3

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○	--	--	0.41	0.30	0.27	0.207	0.1569	0.1351	1.05	2.2

MATERIAL DESCRIPTION	USCS
○ Brown Fine-Medium SAND, Trace Clay & Silt	SP

Project No.: 15091.14
Project: ETI
○ Sample: BORING: B7B SAMPLE: 1 @ 24.0-25.0 FT

Date: 10/02/90

Remarks:
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APPROVED BY: CAF

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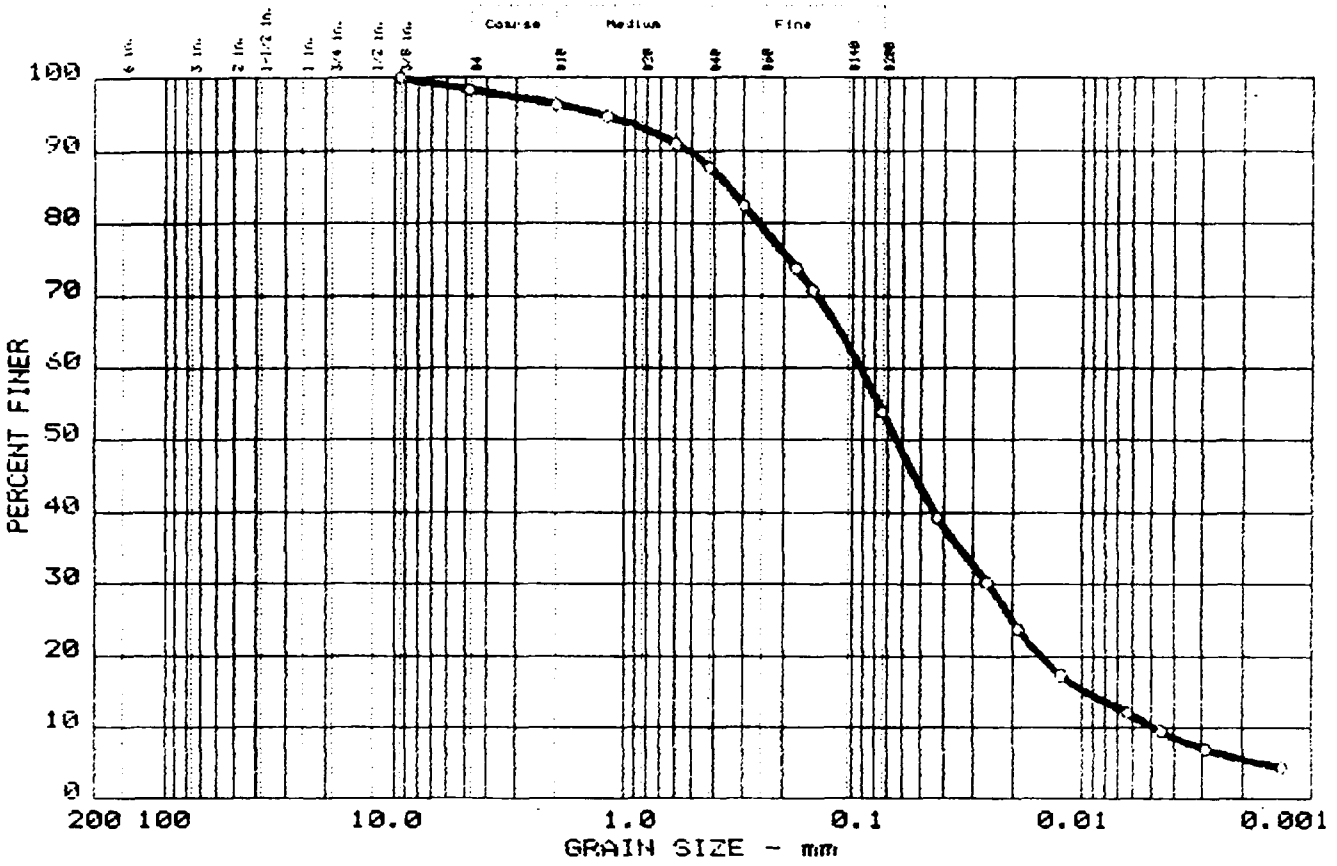

Symbol	%+75mm	% GRAVEL	% SAND	% SILT	% CLAY
○	0.0	1.6	44.5	43.6	10.3

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○	--	--	0.34	0.09	0.06	0.026	0.0095	0.0048	1.49	19.3

MATERIAL DESCRIPTION	USCS
○ Brown Sandy SILT, Little Clay, Trace Gravel	ML

Project No.: 15091.14
Project: ETI
○ Sample: BORING: B7C @ 64.0-65.0 FT

Date: 10/02/90

Remarks:
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APPROVED BY: CAF

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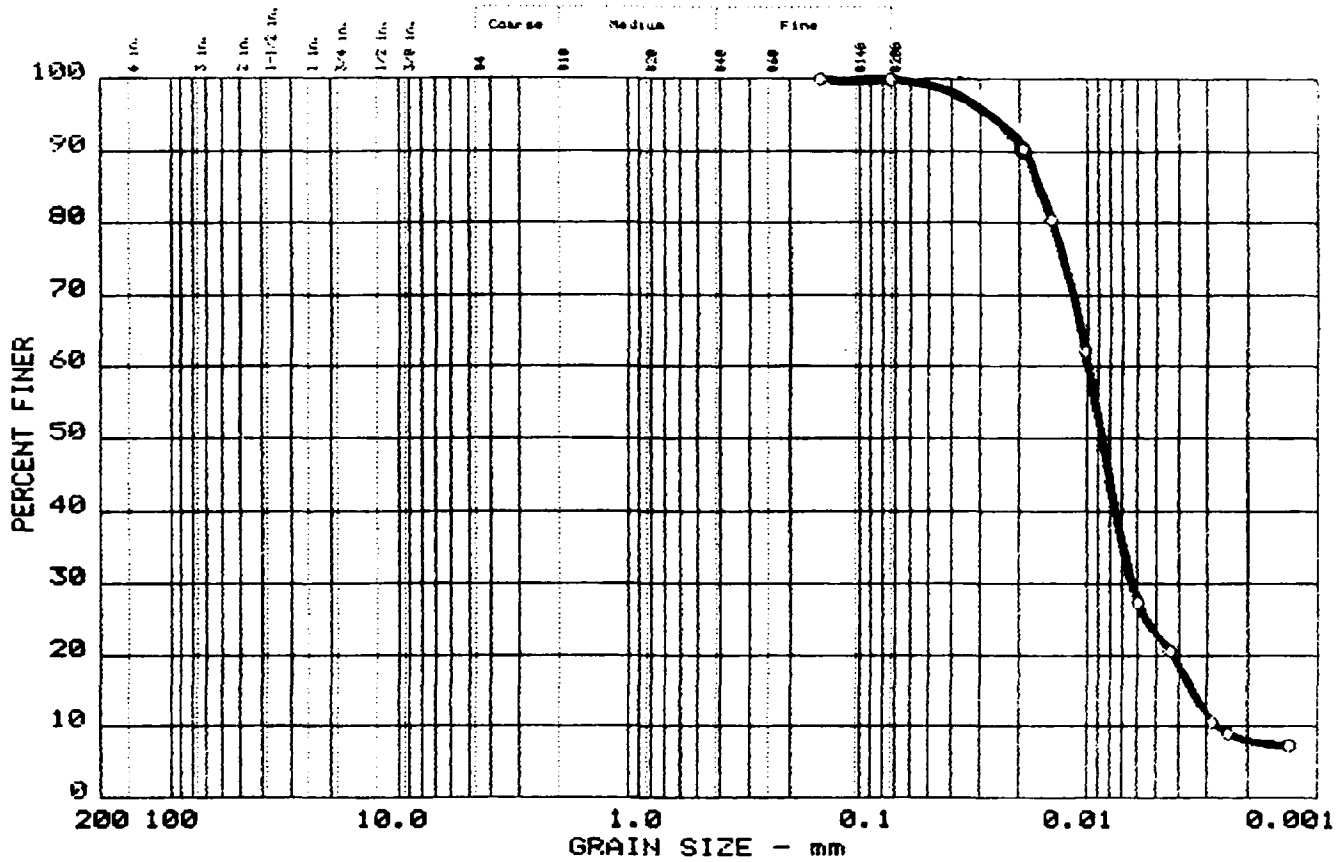

Symbol	%+75mm	% GRAVEL	% SAND	% SILT	% CLAY
○	0.0	0.0	0.0	77.1	22.9

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○	24	1			0.01	0.006	0.0035	0.0027	1.52	3.6

MATERIAL DESCRIPTION	USCS
○ Brown SILT, Some Clay	ML

Project No.: 15091.15
Project: ETI
○ Sample: BORING: B7C @ 89.0-91.0 FT

Date: 10/03/90

Remarks:
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APPROVED BY: CAF

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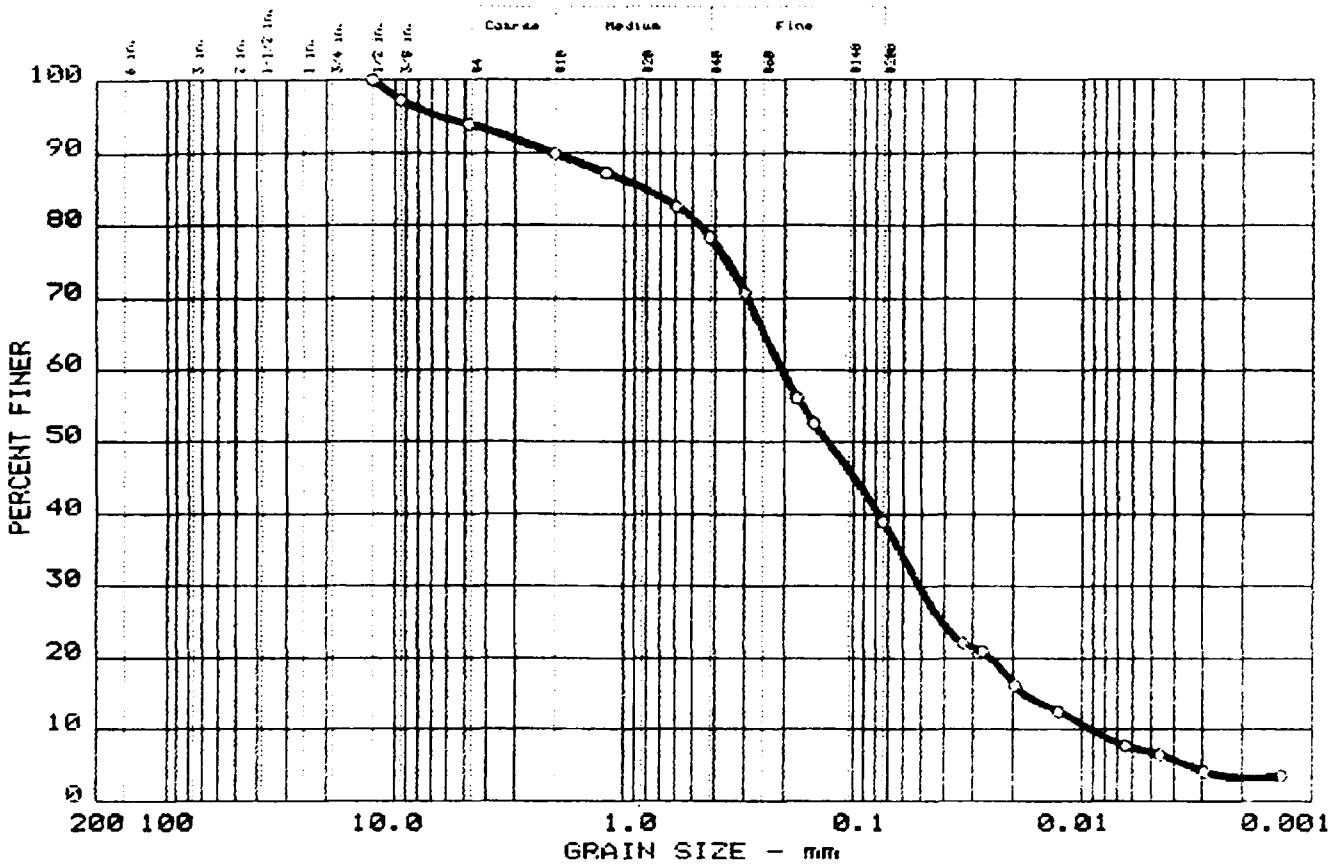

Symbol	%+75mm	% GRAVEL	% SAND	% SILT	% CLAY
○	0.0	6.1	54.9	32.2	6.8

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○	--	--	0.79	0.20	0.13	0.051	0.0178	0.0089	1.45	22.9

MATERIAL DESCRIPTION	USCS
○ Brown Fine-Coarse SAND, Some Silt, Little Clay & Gravel	SM

Project No.: 15091.14
Project: ETI
○ Sample: BORING: B7C @ 100.0-101.0 FT

Date: 10/02/90

Remarks:
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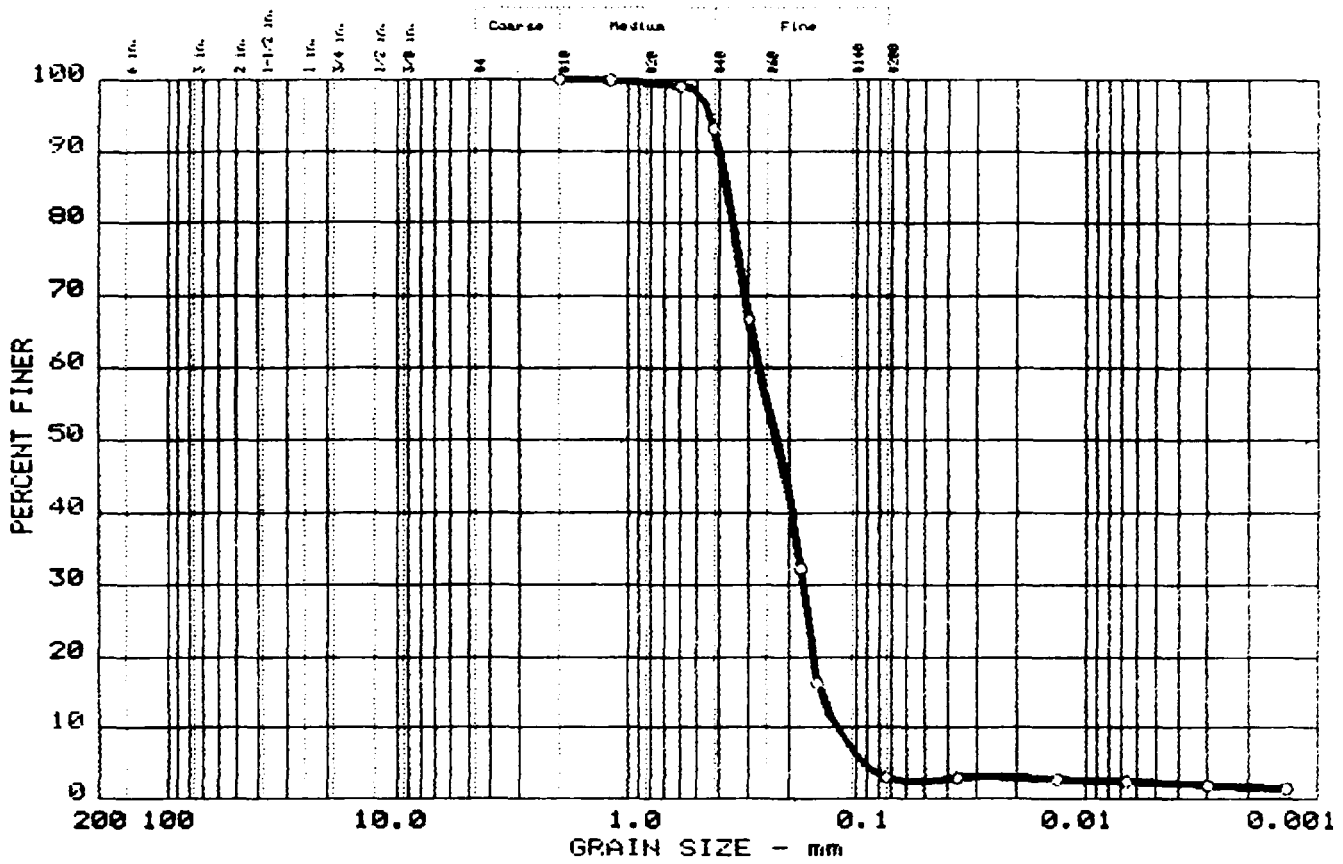

Symbol	%+75mm	% GRAVEL	% SAND	% SILT	% CLAY
○	0.0	0.0	97.0	0.8	2.2

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○	--	--	0.37	0.27	0.23	0.173	0.1454	0.1209	0.92	2.2

MATERIAL DESCRIPTION	USCS
○ Brown Fine-Medium SAND, Trace Clay & Silt	SP

Project No.: 15091.14
Project: ETI
○ Sample: BORING: B1C SAMPLE: 1 @ 20.0-22.0 FT

Date: 10/02/90

Remarks:
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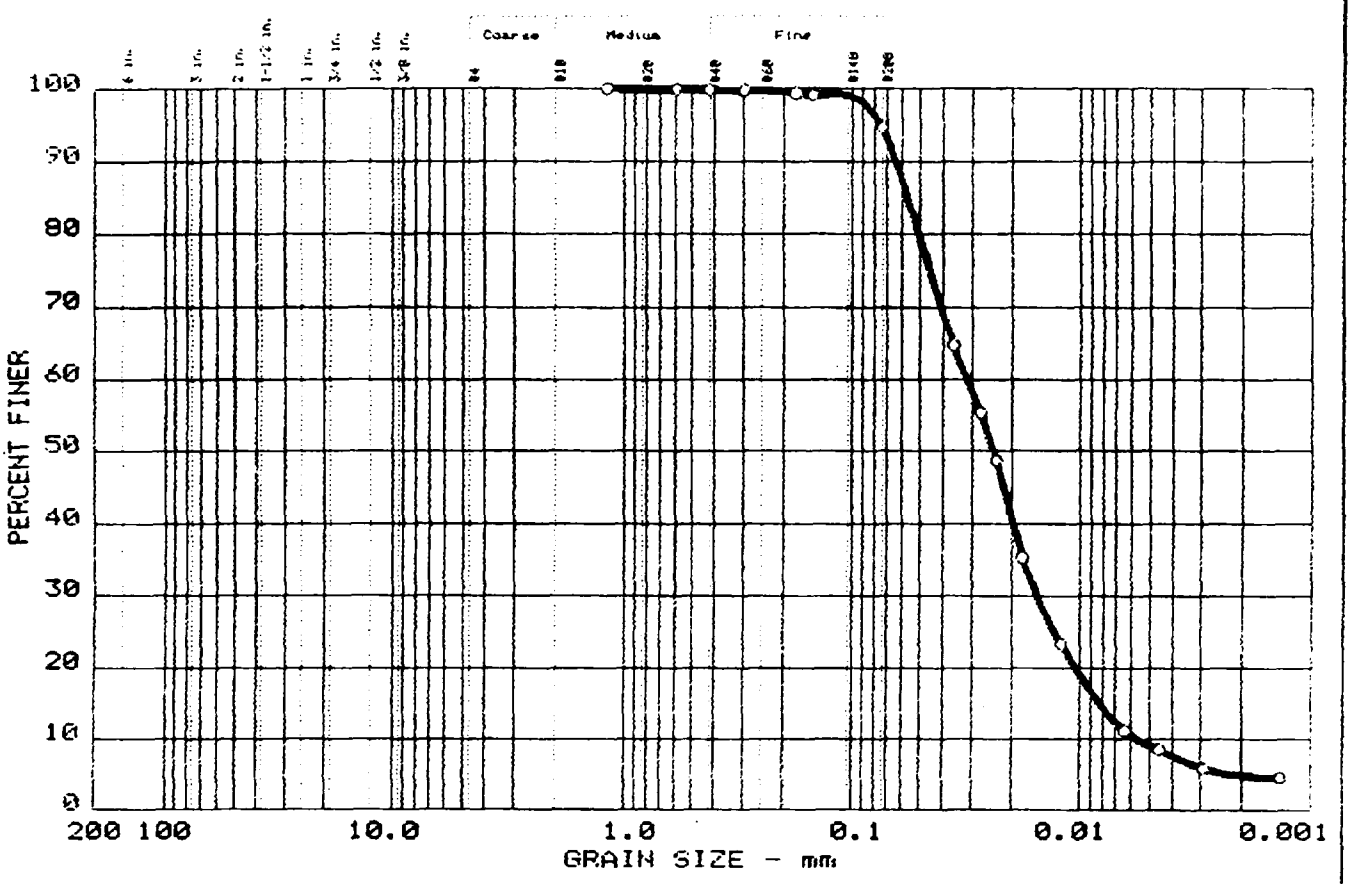

Symbol	%+75mm	% GRAVEL	% SAND	% SILT	% CLAY
○	0.0	0.0	5.3	85.6	9.1

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○	--	--			0.02	0.016	0.0081	0.0056	1.39	5.6

MATERIAL DESCRIPTION	USCS
○ Brown SILT, Little Clay & Sand	ML

Project No.: 15091.14
Project: ETI
○ Sample: BORING: B1CR SAMPLE: 2 @ 40.0-42.0 FT

Date: 10/02/90

Remarks:
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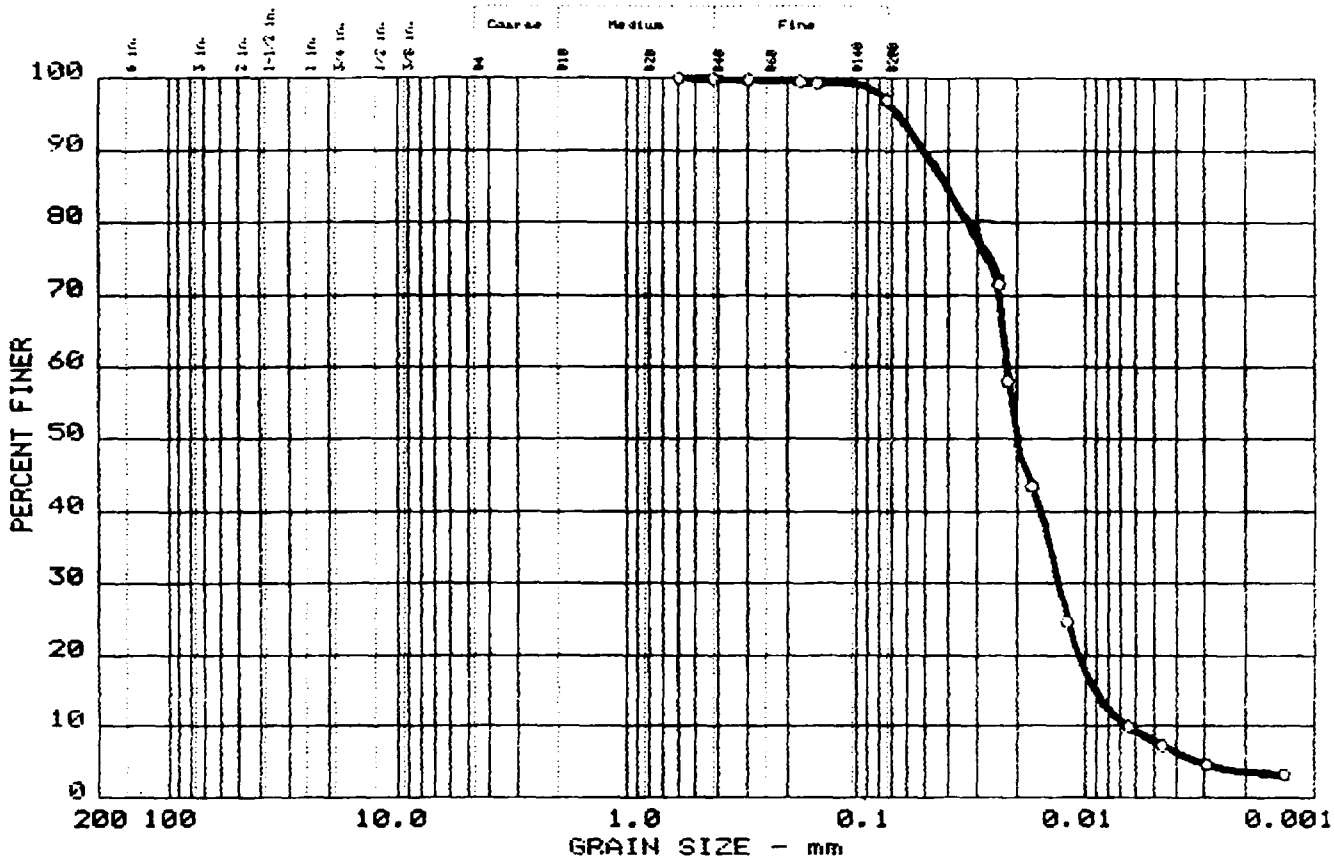

Symbol	%+75mm	% GRAVEL	% SAND	% SILT	% CLAY
○	0.0	0.0	3.1	89.1	7.8

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○	--	--			0.02	0.013	0.0092	0.0065	1.22	3.4

MATERIAL DESCRIPTION	USCS
○ Brown SILT, Little Clay, Trace Sand	ML

Project No.: 15091.14
Project: ETI
○ Sample: BORING: B1CR @ 52.0-53.0 FT

Date: 10/02/90

Remarks:
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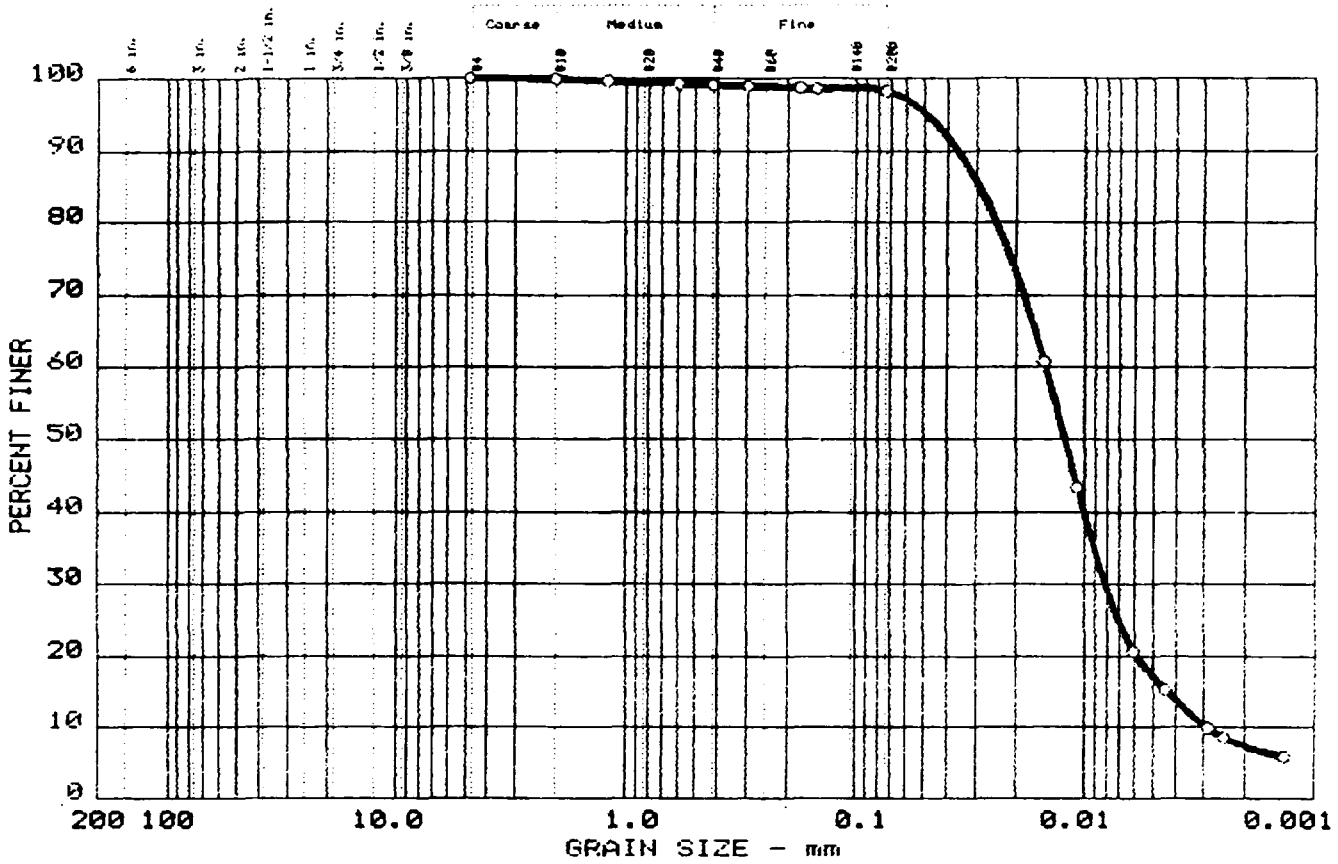

Symbol	%+75mm	% GRAVEL	% SAND	% SILT	% CLAY
○	0.0	0.0	1.8	81.3	16.9

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○	--	--			0.01	0.008	0.0043	0.0029	1.53	5.2

MATERIAL DESCRIPTION	USCS
○ Brown SILT, Some Clay, Trace Sand	ML

Project No.: 15091.14
Project: ETI
○ Sample: BORING: B1CR @ 63.0-64.0 FT

Date: 10/02/90

Remarks:
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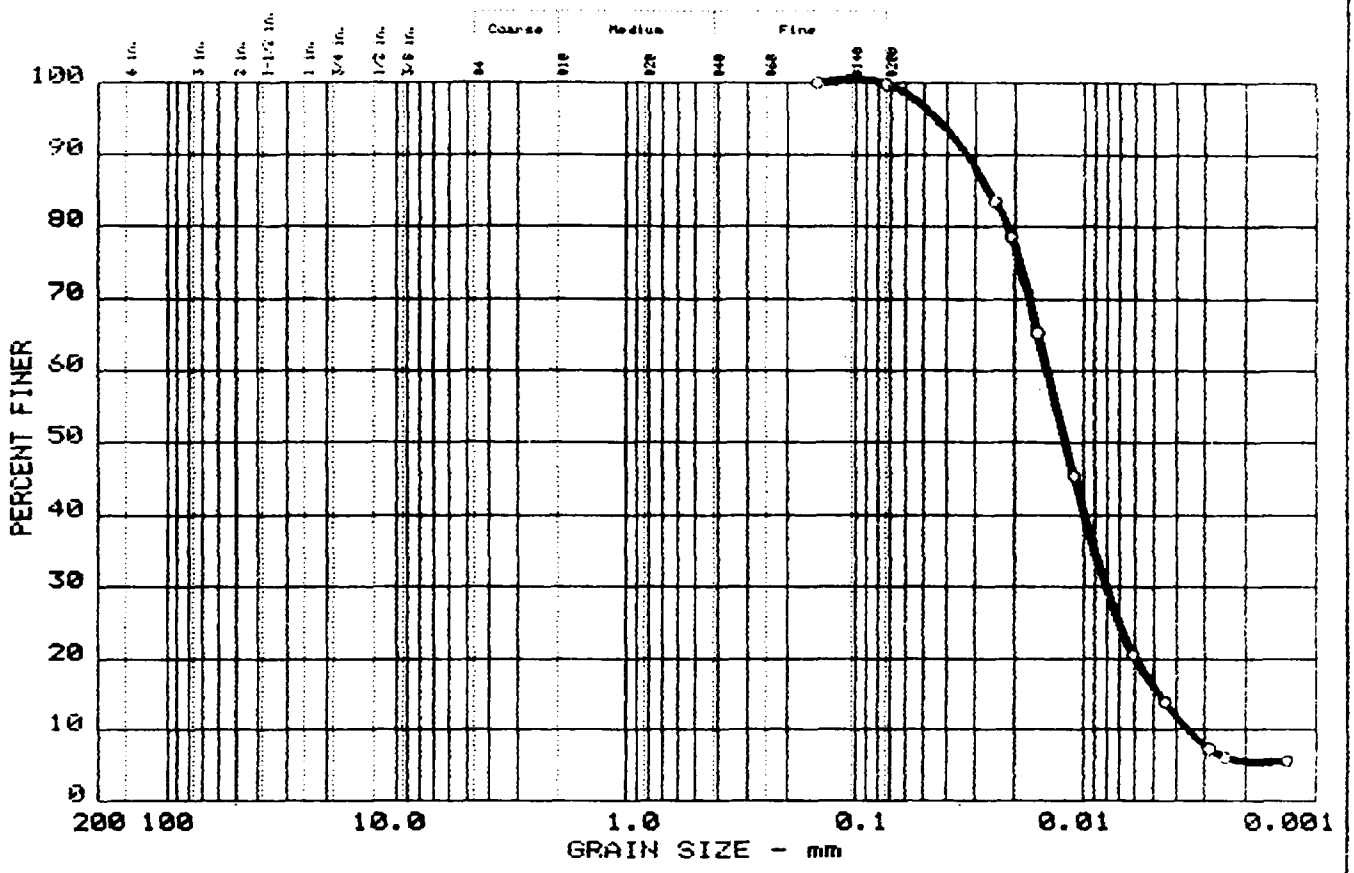

Symbol	%+75mm	% GRAVEL	% SAND	% SILT	% CLAY
○	0.0	0.0	0.1	84.0	15.9

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○	26	0			0.01	0.008	0.0047	0.0035	1.28	4.1

MATERIAL DESCRIPTION	USCS
○ Brown SILT, Some Clay	ML

Project No.: 15091.15
Project: ETI
○ Sample: BORING: B1C @ 64.0-66.0 FT

Date: 10/03/90

Remarks:
TESTED BY: DWA/MML
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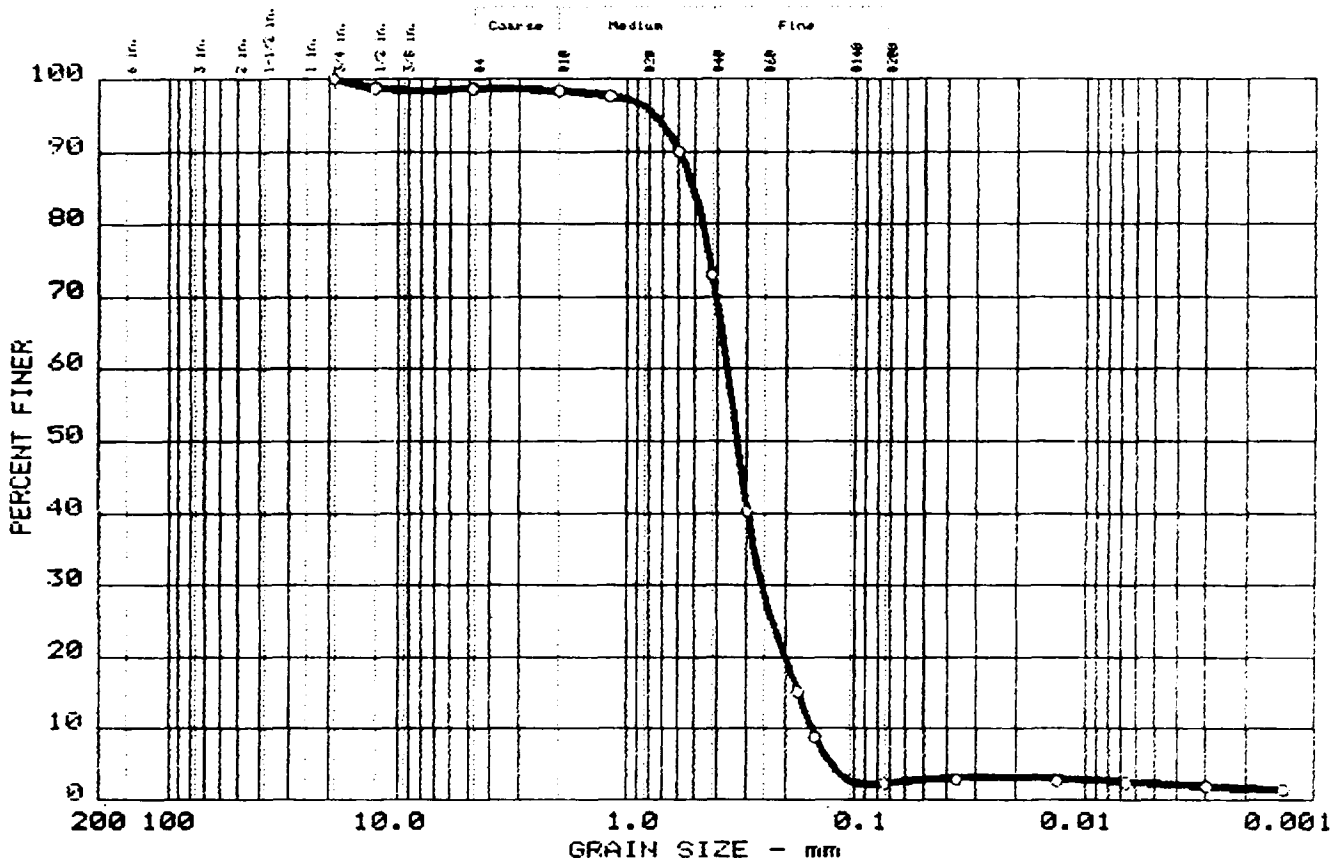
GRAIN SIZE DISTRIBUTION TEST REPORT



Symbol	%+75mm	% GRAVEL	% SAND	% SILT	% CLAY
○	0.0	1.3	96.4	0.0	2.3

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○	--	--	0.51	0.36	0.33	0.255	0.1762	0.1535	1.16	2.4

MATERIAL DESCRIPTION	USCS
○ Brown Fine-Medium SAND, Trace Gravel & Clay	SP

Project No.: 15091.14
Project: ETI
○ Sample: BORING: W23A SAMPLE: 1 @ 12.0-14.0 FT

Date: 10/02/90

GRAIN SIZE DISTRIBUTION TEST REPORT

EWI, Engineering Associates, Inc.

Remarks:

TESTED BY: DWA/MML

ENTERED BY: MML

CHECKED BY: DWA

APPROVED BY: CAF

Sheet No.

EWI

Job No. 15091:15
Date: 10/03/90

FALLING HEAD PERMEABILITY TEST

EWI Engineering Associates, Inc., 8383 Greenway Blvd., Middleton, WI 53562 Phone: (608) 231-6860

PROJECT	ETI
LOCATION	
SAMPLE (a)	BORING: B1C
DEPTH (ft)	64.0-66.0
SOIL DESCRIPTION	Brown SILT, Some Clay (ML)
SAMPLE DIAMETER (cm)	7.4
SAMPLE AREA, A(cm²)	42.6

	INITIAL	FINAL
SAMPLE LENGTH, L(cm)	20.1	20.1
MOISTURE CONTENT, %	27.3	26.3
DRY DENSITY (lb/cu ft)	95.1	95.1
PERCENT COMPACTION	-	-

RUN	COEFFICIENT OF PERMEABILITY, k(cm/sec)
1	2.2E-06
2	1.9E-06
3	2.2E-06
4	2.1E-06
5	2.1E-06
6	2.5E-06
7	2.4E-06
8	2.5E-06
9	2.8E-06
10	2.2E-06
11	2.1E-06
12	1.8E-06

AVERAGE COEFFICIENT OF PERMEABILITY = 2.0E-06 cm/sec
(Based on run numbers 10 through 12)

FORMULA: $k = \frac{2.3aL}{At} \log_{10} \frac{h_0}{h_1}$, Where a = cross-sectional area of standpipe,
t = time for water level to fall from initial height, h_0, to final height, h_1
(All other terms are defined above)

FOOTNOTES: (a) This permeability test was performed on a relatively undisturbed 3-inch diameter Shelby tube sample.

CHECKED BY: DWR DATE: 10/22/90 APPROVED BY: CAF DATE: 10/29/90

EWI

Job No. 15091.15
Date: 10/03/90

FALLING HEAD PERMEABILITY TEST

EWI Engineering Associates, Inc., 8383 Greenway Blvd., Middleton, WI 53562 Phone: (608) 231-6860

PROJECT	ETI
LOCATION	
SAMPLE (a)	BORING: B7C
DEPTH (ft)	89.0-91.0
SOIL DESCRIPTION	Brown SILT, Some Clay (ML)
SAMPLE DIAMETER (cm)	7.4
SAMPLE AREA, A(cm^2)	42.6

	INITIAL	FINAL
SAMPLE LENGTH, L(cm)	19.2	19.2
MOISTURE CONTENT, %	30.0	30.3
DRY DENSITY (lb/cu ft)	92.8	92.8
PERCENT COMPACTION	-	-

RUN	COEFFICIENT OF PERMEABILITY, k(cm/sec)
1	1.1E-06
2	9.7E-07
3	9.2E-07
4	1.1E-06
5	1.1E-06
6	1.1E-06
7	1.1E-06
8	1.0E-06
9	9.9E-07
10	9.3E-07
11	9.4E-07
12	9.8E-07

AVERAGE COEFFICIENT OF PERMEABILITY = 9.5E-07 cm/sec
(Based on run numbers 10 through 12)

FORMULA: $k = \frac{2.3aL}{\Delta t} \log_{10} \frac{h_0}{h_1}$, Where a = cross-sectional area of standpipe,
t = time for water level to fall from initial height, h_0, to final height, h_1
(All other terms are defined above)

FOOTNOTES: (a) This permeability test was performed on a relatively undisturbed 3-inch diameter Shelby tube sample.

CHECKED BY: DWR DATE: 10/22/90 APPROVED BY: CAF DATE: 10/29/90

EWI

APPENDIX L

TECHNICAL MEMORANDUM
CHEMICAL SAMPLING RESULTS COMPARISON

MEMORANDUM

DATE: May 2, 1991

TO: Dave Voight, Site Manager

CC: Roman Gau, Project Manager
Mike Crosser, TSQAM

FROM: Sarah Levin

RE: EPA ARCS Region V Contract No. 68-W8-0093
EPA Work Assignment No. 13-5N45
Donohue Project No. 20022.000

Chemical Sampling Results Comparison
South Andover Design Investigation

1.0 INTRODUCTION

Subsurface investigations conducted by CH2M Hill at the South Andover First Operable Unit RI included chemical sampling of surficial soils, pilot boring soils, and new and existing monitoring wells. This memorandum compares the data collected by CH2M Hill with the 1990 Design Investigation.

2.0 SOILS

A summary of organic compounds detected in 1990 DI soil boring samples is presented in Table 4-2. Sample W23A-R (6-8 feet) contained the highest frequency and concentration of volatile organic compounds (VOCs). This sample contained methylene chloride (13,000 ppb), acetone (3,200 ppb), and 4-methyl-2-pentanone (5,100 ppb). No VOCs, however, were detected at other sampling intervals at the same location. Acetone was also detected at relatively high levels at B6AR (24-24 feet) (530 ppb) and W1C-R (0-2 feet) (2,000 ppb). Low levels of VOCs were detected in six other samples, and no VOCs were detected in four samples. The occurrences of methylene chloride may be field or lab induced contamination and may not be indicative of site contamination.

The highest frequency and concentrations of semi-volatile organic compounds (SVOCs) were detected at B6A-R (0-2 feet). The majority of SVOCs detected at this location are polyaromatic hydrocarbons (PAHs). B6A-R (0-2 feet) also contained benzoic acid (10,000 ppb), fluorene (1,200 ppb), fluoranthene (1,000 ppb), bis(2-ethylhexyl)phthalate (590 ppb) and 4,4'-DDT (20 ppb). Naphthalene, diethylphthalate, and butyl benzyl phthalate were detected in B6A-R at the deeper depth intervals. Bis(2-ethylhexyl)phthalate was also detected in seven other boring samples.

Organic chemicals detected in pilot borings completed during the CH2M Hill study are summarized in Table 2-2. Pilot boring samples analyzed by CH2M Hill detected five of the six VOCs detected during the DI. The 1985 data for methylene chloride and acetone are most likely attributable to field or lab induced contamination. Several other VOCs detected during the 1985 investigation were not found in any DI samples. Similarly, four SVOCs detected by CH2M Hill were not identified during the DI. All four of these SVOCs, however, were also detected in the associated blanks, implying that the contamination is not site related. The only SVOCs detected during both investigations was bis (2-ethylhexyl) phthalate. One 1985 pilot boring sample contained a pesticide (beta BHC) not found in DI soils.

A summary of inorganic compounds detected in DI soil sample locations is presented in Table 4-3. Antimony was not detected in any of the boring samples. This confirms data from CH2M Hill's pilot boring samples. Table 2-2 of the report summarizes elevated concentrations of inorganics detected in 1985 surficial soil samples. Antimony, however, was detected in three composite surficial soil samples during the first operable unit RI. Arsenic was detected in all but one DI soil boring. CH2M Hill did not detect arsenic in any soil samples. The DI data does not contradict the 1985 data, however, because the detection limits used during analysis of the earlier samples were an order of magnitude greater than the ones used during the DI. Cadmium, which was detected in only one 1985 composite surficial soil sample and in no 1985 pilot boring samples, was detected at low levels in three DI samples. Selenium was detected only at W23A-R (6-8 feet). It was not detected by CH2M Hill. The 1985 selenium detected limit, however, was greater than the level found at W23A-R. Although silver was detected in many of the 1985 composite surficial soil samples, it was not detected in any boring samples taken during the 1985 RI or the 1990 DI. Finally, cyanide was detected during the DI at one location (W23-R) at two depth intervals. Cyanide was not detected in any of CH2M Hill's soil samples.

CH2M Hill established background levels for five inorganic compounds: barium, chromium, copper, lead, and zinc. Background levels for other inorganic compounds were not determined due to variant nature of these elements in soil. The only background level exceeded in the 1985 pilot boring samples was the one for lead in W21 (90 ft.). No DI samples exceed the levels set by CH2M Hill for barium, chromium, or copper. The background levels were exceeded for both lead and zinc in B6A-R (0-2 feet) and W23A-R (0-2 feet).

The soils data for both organic and inorganic compounds is discussed in further detail in Chapter 4 of the Second Operable Unit RI Report (Donohue, 1991).

3.0 GROUNDWATER

Organic compounds detected above regulatory standards during the 1985 CH2M Hill investigation are summarized in Table 2-4. Those detected during the Design Investigation are presented in summary tables in Chapter 4 of this report. Samples taken from the earlier investigation contained concentrations

of vinyl chloride, methylene chloride, acetone, trans-1,2-dichloroethylene, trichloroethylene, 1,1,2-trichloroethane, tetrachloroethylene, toluene, and bis(2-ethylhexyl)phthalate (BEHP) which exceed RALs or MCLs. The RAL for BEHP was also exceeded in samples taken from the lower sand aquifer and one residential well. No samples analyzed during the Design Investigation contained concentrations of organic compounds greater than the regulatory standards.

Detected inorganic compounds are summarized in Chapter 2 for the CH2M Hill investigation and in Chapter 4 for the Design Investigation. Both sampling events found elevated concentrations of iron, manganese, and zinc in the upper sand aquifer. All RAL exceedances for zinc, however, occurred in wells constructed of galvanized materials. CH2M Hill data from upper sand aquifer wells also contained concentrations of cadmium, nickel, and vanadium greater then RALs or MCLs. Design Investigation analyses do not confirm that these levels have been exceeded. Additionally, exceedances of standards for arsenic, selenium, and thallium were detected in the 1990 investigation which were not found in the earlier study.

In 1985, groundwater taken from the lower aquifer exceeded RALs for lead, manganese and zinc in one galvanized well, W2C. During the Design Investigation, four deep wells contained concentrations of arsenic greater than the RAL and one well, W23, contained an elevated level of lead. It should be noted that the detection limit for arsenic during the CH2M Hill investigation was fifty times greater than the RAL. Elevated levels of arsenic, therefore, may have gone undetected.

The third source of groundwater analyzed during both studies was on-site residential wells. During January, 1986, water from all six residential well contained elevated levels of manganese. Four wells exceeded the RALs for iron and zinc; two wells exceeded the cobalt RAL; and two wells exceeded the lead RAL. RW008, which is screened in the upper sand aquifer, contained elevated concentrations of vanadium, cadmium, chromium, and nickel in addition to elevated levels mentioned above. None of the wells tested during January, 1986, contained concentrations of organics exceeding standards. During June, 1986, RW008 was resampled. Only two RALs, bis(2-ethylhexyl) phthalate (which was not detected five months beforehand) and manganese, were exceeded during the second sampling event. In 1990, only one exceedance, the RAL for iron in RW04, was reported. RW008, the well exhibiting the highest contaminant concentrations in the CH2M Hill investigation, was not sampled during the Design Investigation.

The data from the different sampling events, therefore, do not agree well. These discrepancies may be due to differences in sampling methods, analytical procedures, natural attenuation and dilution in groundwater, or seasonal variation of water quality.

ARCS/R/SANDOVER/AT6

APPENDIX M

ANALYTICAL RESULTS FOR SOIL AND GROUNDWATER

TABLE M-1
VOLATILE ORGANICS ANALYSIS RESULTS
BORING SOIL
SOUTH ANDOVER DESIGN INVESTIGATION
1990

	SAMPLE ID:	B6AR	B6AR	B6AR	B6BR	B7B	B7B
	DEPTH:	0-2	10-12	24-26	50-52	0-2	34-36
	AGENCY SAMPLE ID:	EJL12	EJL13	EJL18	EJL23	EJL33	EJL34
	DATE SAMPLED:	23-AUG-90	23-AUG-90	23-AUG-90	24-AUG-90	27-AUG-90	27-AUG-90
COMPOUND							
Chloromethane	UG/KG	19 UJ	11 U	12 UJ	12 UJ	11 U	12 U
Bromomethane	UG/KG	19 UJ	11 U	12 UJ	12 UJ	11 U	12 U
Vinyl Chloride	UG/KG	19 UJ	11 U	12 UJ	12 UJ	11 U	12 U
Chloroethane	UG/KG	19 UJ	11 U	12 UJ	12 UJ	11 U	12 U
Methylene Chloride	UG/KG	27 UJ	9 U	30 UJ	9 UJ	7 U	7 U
Acetone	UG/KG	19 UJ	20 U	530 JE	12 UJ	11 U	12 J
Carbon Disulfide	UG/KG	9 UJ	5 U	6 UJ	6 UJ	5 U	6 U
1,1-Dichloroethene	UG/KG	9 UJ	5 U	6 UJ	6 UJ	5 U	6 U
1,1-Dichloroethane	UG/KG	9 UJ	5 U	6 UJ	6 UJ	5 U	6 U
1,2-Dichloroethene(total)	UG/KG	9 UJ	5 U	6 UJ	6 UJ	5 U	6 U
Chloroform	UG/KG	9 UJ	5 U	6 UJ	6 UJ	5 U	6 U
1,2-Dichloroethane	UG/KG	9 UJ	5 U	6 UJ	6 UJ	5 U	6 U
2-Butanone	UG/KG	19 UJ	11 U	12 UJ	12 UJ	11 UJ	12 UJ
1,1,1-Trichloroethane	UG/KG	9 UJ	5 U	6 UJ	6 UJ	5 U	6 U
Carbon Tetrachloride	UG/KG	9 UJ	5 U	6 UJ	6 UJ	5 U	6 U
Vinyl Acetate	UG/KG	19 UJ	11 U	12 UJ	12 UJ	11 U	12 U
Bromodichloromethane	UG/KG	9 UJ	5 U	6 UJ	6 UJ	5 U	6 U
1,2-Dichloropropane	UG/KG	9 UJ	5 U	6 UJ	6 UJ	5 U	6 U
cis-1,3-Dichloropropene	UG/KG	9 UJ	5 U	6 UJ	6 UJ	5 U	6 U
Trichloroethene	UG/KG	9 UJ	5 U	6 UJ	6 UJ	5 U	6 U
Dibromochloromethane	UG/KG	9 UJ	5 U	6 UJ	6 UJ	5 U	6 U
1,1,2-Trichloroethane	UG/KG	9 UJ	5 U	6 UJ	6 UJ	5 U	6 U
Benzene	UG/KG	9 UJ	5 U	6 UJ	6 UJ	5 U	6 U
trans-1,3-Dichloropropene	UG/KG	9 UJ	5 U	6 UJ	6 UJ	5 U	6 U
Bromoform	UG/KG	9 UJ	5 U	6 UJ	6 UJ	5 U	6 U
4-Methyl-2-pentanone	UG/KG	19 UJ	11 U	12 UJ	12 UJ	11 U	12 U
2-Hexanone	UG/KG	19 UJ	11 U	12 UJ	12 UJ	11 U	12 U
Tetrachloroethene	UG/KG	9 UJ	5 U	6 UJ	6 UJ	5 U	6 U
1,1,2,2-Tetrachloroethane	UG/KG	9 UJ	5 U	6 UJ	6 UJ	5 U	6 U

TABLE M-1
VOLATILE ORGANICS ANALYSIS RESULTS
BORING SOIL
SOUTH ANDOVER DESIGN INVESTIGATION
1990

	SAMPLE ID:	B6AR	B6AR	B6AR	B6BR	B7B	B7B
	DEPTH:	0-2	10-12	24-26	50-52	0-2	34-36
	AGENCY SAMPLE ID:	EJL12	EJL13	EJL18	EJL23	EJL33	EJL34
	DATE SAMPLED:	23-AUG-90	23-AUG-90	23-AUG-90	24-AUG-90	27-AUG-90	27-AUG-90
COMPOUND							
Toluene	UG/KG	2 J	5 U	6 UJ	1 J	4 J	14
Chlorobenzene	UG/KG	9 UJ	5 U	6 UJ	6 UJ	5 U	6 U
Ethyl Benzene	UG/KG	9 UJ	5 U	6 UJ	6 UJ	5 U	6 U
Styrene	UG/KG	9 UJ	5 U	6 UJ	6 UJ	5 U	6 U
Xylenes (Total)	UG/KG	10	5 U	6 UJ	6 UJ	5 UJ	6 UJ
Acrolein	UG/KG						
Acrylonitrile	UG/KG						

TABLE M-1
VOLATILE ORGANICS ANALYSIS RESULTS
BORING SOIL
SOUTH ANDOVER DESIGN INVESTIGATION
1990

	SAMPLE ID:	B7B	B7B	B7B	W1CR	W1CR	W1CR
	DEPTH:	44-46	44-46	54-56	0-2	44-45.5	88-89
	AGENCY SAMPLE ID:	EJL37	EJL38	EJL43	EJL05	EJL30	EJL84
	DATE SAMPLED:	27-AUG-90	27-AUG-90	27-AUG-90	22-AUG-90	26-AUG-90	10-SEP-90
COMPOUND							
Chloromethane	UG/KG	12 U	12 U	11 U	11 U	12 U	12 UJ
Bromomethane	UG/KG	12 U	12 U	11 U	11 U	12 U	12 UJ
Vinyl Chloride	UG/KG	12 U	12 U	11 U	11 U	12 U	12 UJ
Chloroethane	UG/KG	12 U	12 U	11 U	11 U	12 U	12 UJ
Methylene Chloride	UG/KG	6 U	6 U	6 U	7 U	9 B	6 UJ
Acetone	UG/KG	12 U	5 U	11 UJ	2000 E	4 UJ	15 UJ
Carbon Disulfide	UG/KG	6 U	6 U	6 U	5 U	6 U	6 UJ
1,1-Dichloroethene	UG/KG	6 U	6 U	6 U	5 U	6 U	6 UJ
1,1-Dichloroethane	UG/KG	6 U	6 U	6 U	5 U	6 U	6 UJ
1,2-Dichloroethene(total)	UG/KG	6 U	6 U	6 U	5 U	6 U	6 UJ
Chloroform	UG/KG	6 U	6 U	6 U	5 U	6 U	6 UJ
1,2-Dichloroethane	UG/KG	6 U	6 U	6 U	5 U	6 U	6 UJ
2-Butanone	UG/KG	12 U	12 U	11 UJ	11 U	12 UJ	12 UJ
1,1,1-Trichloroethane	UG/KG	6 U	6 U	6 U	5 U	6 U	6 UJ
Carbon Tetrachloride	UG/KG	6 U	6 U	6 U	5 U	6 U	6 UJ
Vinyl Acetate	UG/KG	12 U	12 U	11 U	11 U	12 U	12 UJ
Bromodichloromethane	UG/KG	6 U	6 U	6 U	5 U	6 U	6 UJ
1,2-Dichloropropane	UG/KG	6 U	6 U	6 U	5 U	6 U	6 UJ
cis-1,3-Dichloropropene	UG/KG	6 U	6 U	6 U	5 U	6 U	6 UJ
Trichloroethene	UG/KG	6 U	6 U	6 U	5 U	6 U	6 UJ
Dibromochloromethane	UG/KG	6 U	6 U	6 U	5 U	6 U	6 UJ
1,1,2-Trichloroethane	UG/KG	6 U	6 U	6 U	5 U	6 U	6 UJ
Benzene	UG/KG	6 U	6 U	6 U	5 U	6 U	6 UJ
trans-1,3-Dichloropropene	UG/KG	6 U	6 U	6 U	5 U	6 U	6 UJ
Bromoform	UG/KG	6 U	6 U	6 U	5 U	6 U	6 UJ
4-Methyl-2-pentanone	UG/KG	12 U	12 U	11 U	11 UJ	12 U	12 UJ
2-Hexanone	UG/KG	12 U	12 U	11 UJ	11 U	12 U	12 UJ
Tetrachloroethene	UG/KG	6 U	6 U	6 U	5 U	6 U	6 UJ
1,1,2,2-Tetrachloroethane	UG/KG	6 U	6 U	6 U	5 U	6 U	6 UJ

TABLE M-1
VOLATILE ORGANICS ANALYSIS RESULTS
BORING SOIL
SOUTH ANDOVER DESIGN INVESTIGATION
1990

	SAMPLE ID:	B7B	B7B	B7B	W1CR	W1CR	W1CR
	DEPTH:	44-46	44-46	54-56	0-2	44-45.5	88-89
	AGENCY SAMPLE ID:	EJL37	EJL38	EJL43	EJL05	EJL30	EJL84
	DATE SAMPLED:	27-AUG-90	27-AUG-90	27-AUG-90	22-AUG-90	26-AUG-90	10-SEP-90
COMPOUND							
Toluene	UG/KG	6 J	2 J	6 U	2 J	6 U	6 UJ
Chlorobenzene	UG/KG	6 U	6 U	6 U	5 U	6 U	6 UJ
Ethyl Benzene	UG/KG	6 U	6 U	6 U	5 U	6 U	6 UJ
Styrene	UG/KG	6 U	6 U	6 U	5 U	6 U	6 UJ
Xylenes (Total)	UG/KG	6 U	6 U	6 UJ	5 U	6 UJ	6 UJ
Acrolein	UG/KG						
Acrylonitrile	UG/KG						

TABLE M-1
VOLATILE ORGANICS ANALYSIS RESULTS
BORING SOIL
SOUTH ANDOVER DESIGN INVESTIGATION
1990

	SAMPLE ID:	W23AR	W23AR	W23AR	W23AR
	DEPTH:	0-2	0-2	6-8	12-14
	AGENCY SAMPLE ID:	EJL93	EJL94	EJL95	EJL96
	DATE SAMPLED:	17-SEP-90	17-SEP-90	17-SEP-90	17-SEP-90
COMPOUND					
Chloromethane	UG/KG	11 UJ	11 UJ	950 UJ	12 UJ
Bromomethane	UG/KG	11 UJ	11 UJ	950 UJ	12 UJ
Vinyl Chloride	UG/KG	11 UJ	11 UJ	950 UJ	12 UJ
Chloroethane	UG/KG	11 UJ	11 UJ	950 UJ	12 UJ
Methylene Chloride	UG/KG	5 UJ	5 UJ	470 UJ	6 UJ
Acetone	UG/KG	11 UJ	11 UJ	13000 BJ	97 J
Carbon Disulfide	UG/KG	5 UJ	5 UJ	470 UJ	6 UJ
1,1-Dichloroethene	UG/KG	5 UJ	5 UJ	470 UJ	6 UJ
1,1-Dichloroethane	UG/KG	5 UJ	5 UJ	470 UJ	6 UJ
1,2-Dichloroethene(total)	UG/KG	5 UJ	5 UJ	470 UJ	6 UJ
Chloroform	UG/KG	5 UJ	5 UJ	470 UJ	6 UJ
1,2-Dichloroethane	UG/KG	5 UJ	5 UJ	470 UJ	6 UJ
2-Butanone	UG/KG	11 UJ	11 UJ	950 UJ	12 UJ
1,1,1-Trichloroethane	UG/KG	5 UJ	5 UJ	470 UJ	6 UJ
Carbon Tetrachloride	UG/KG	5 UJ	5 UJ	470 UJ	6 UJ
Vinyl Acetate	UG/KG	11 UJ	11 UJ	950 UJ	12 UJ
Bromodichloromethane	UG/KG	5 UJ	5 UJ	470 UJ	6 UJ
1,2-Dichloropropane	UG/KG	5 UJ	5 UJ	470 UJ	6 UJ
cis-1,3-Dichloropropene	UG/KG	5 UJ	5 UJ	470 UJ	6 UJ
Trichloroethene	UG/KG	5 UJ	5 UJ	470 UJ	6 UJ
Dibromochloromethane	UG/KG	5 UJ	5 UJ	470 UJ	6 UJ
1,1,2-Trichloroethane	UG/KG	5 UJ	5 UJ	470 UJ	6 UJ
Benzene	UG/KG	5 UJ	5 UJ	470 UJ	6 UJ
trans-1,3-Dichloropropene	UG/KG	5 UJ	5 UJ	470 UJ	6 UJ
Bromoform	UG/KG	5 UJ	5 UJ	470 UJ	6 UJ
4-Methyl-2-pentanone	UG/KG	11 UJ	11 UJ	3200 J	12 UJ
2-Hexanone	UG/KG	11 UJ	11 UJ	5100 J	12 UJ
Tetrachloroethene	UG/KG	5 UJ	5 UJ	470 UJ	6 UJ
1,1,2,2-Tetrachloroethane	UG/KG	5 UJ	5 UJ	470 UJ	6 UJ

TABLE M-1
VOLATILE ORGANICS ANALYSIS RESULTS
BORING SOIL
SOUTH ANDOVER DESIGN INVESTIGATION
1990

	SAMPLE ID:	W23AR	W23AR	W23AR	W23AR
	DEPTH:	0-2	0-2	6-8	12-14
	AGENCY SAMPLE ID:	EJL93	EJL94	EJL95	EJL96
	DATE SAMPLED:	17-SEP-90	17-SEP-90	17-SEP-90	17-SEP-90
COMPOUND					
Toluene	UG/KG	5 UJ	5 UJ	470 UJ	6 UJ
Chlorobenzene	UG/KG	5 UJ	5 UJ	470 UJ	6 UJ
Ethyl Benzene	UG/KG	5 UJ	5 UJ	470 UJ	6 UJ
Styrene	UG/KG	5 UJ	5 UJ	470 UJ	6 UJ
Xylenes (Total)	UG/KG	5 UJ	5 UJ	470 UJ	6 UJ
Acrolein	UG/KG				
Acrylonitrile	UG/KG				

TABLE M-2
SEMI-VOLATILE ORGANICS ANALYSIS RESULTS
BORING SOIL
SOUTH ANDOVER DESIGN INVESTIGATION
1990

	SAMPLE ID:	B6AR	B6AR	B6AR	B6BR	B7B	B7B
	DEPTH:	0-2	10-12	24-26	50-52	0-2	34-36
	AGENCY SAMPLE ID:	EJL12	EJL13	EJL18	EJL23	EJL33	EJL34
	DATE SAMPLED:	23-AUG-90	23-AUG-90	23-AUG-90	24-AUG-90	27-AUG-90	27-AUG-90
COMPOUND							
Phenol	UG/KG	2900 U	350 U	410 U	380 U	360 U	390 U
bis(2-Chloroethyl) ether	UG/KG	2900 U	350 U	410 U	380 U	360 U	390 U
2-Chlorophenol	UG/KG	2900 U	350 U	410 U	380 U	360 U	390 U
1,3-Dichlorobenzene	UG/KG	2900 U	350 U	410 U	380 U	360 U	390 U
1,4-Dichlorobenzene	UG/KG	2900 U	350 U	410 U	380 U	360 U	390 U
Benzyl alcohol	UG/KG	2900 U	350 U	410 U	380 U	360 U	390 U
1,2-Dichlorobenzene	UG/KG	2900 U	350 U	410 U	380 U	360 U	390 U
2-Methylphenol	UG/KG	2900 U	350 U	410 U	380 U	360 U	390 U
bis(2-Chloroisopropyl) ether	UG/KG	2900 U	350 U	410 U	380 U	360 U	390 U
4-Methylphenol	UG/KG	2900 U	350 U	410 U	380 U	360 U	390 U
N-Nitrosodinpropylamine	UG/KG	2900 U	350 U	410 U	380 U	360 U	390 U
Hexachloroethane	UG/KG	2900 U	350 U	410 U	380 U	360 U	390 U
Nitrobenzene	UG/KG	2900 U	350 U	410 U	380 U	360 U	390 U
Isophorone	UG/KG	2900 U	350 U	410 U	380 U	360 U	390 U
2-Nitrophenol	UG/KG	2900 U	350 U	410 U	380 U	360 U	390 U
2,4-Dimethylphenol	UG/KG	2900 U	350 U	410 U	380 U	360 U	390 U
Benzoic acid	UG/KG	10000 J	1700 UJ	2000 U	1900 UJ	1700 U	1900 U
bis(2-Chloroethoxy) methane	UG/KG	2900 U	350 U	410 U	380 U	360 U	390 U
2,4-Dichlorophenol	UG/KG	2900 U	350 U	410 U	380 U	360 U	390 U
1,2,4-Trichlorobenzene	UG/KG	2900 U	350 U	410 U	380 U	360 U	390 U
Naphthalene	UG/KG	740 J	350 U	89 J	380 U	360 U	390 U
4-Chloroaniline	UG/KG	2900 U	350 U	410 U	380 U	360 UJ	390 UJ
Hexachlorobutadiene	UG/KG	2900 U	350 U	410 U	380 U	360 U	390 U
4-Chloro-3-methylphenol	UG/KG	2900 U	350 U	410 U	380 U	360 U	390 U
2-Methylnaphthalene	UG/KG	1400 J	350 U	410 U	380 U	360 U	390 U
Hexachlorocyclopentadiene	UG/KG	2900 UJ	350 UJ	410 UJ	380 UJ	360 U	390 U
2,4,6-Trichlorophenol	UG/KG	2900 U	350 U	410 U	380 U	360 U	390 U
2,4,5-Trichlorophenol	UG/KG	14000 U	1700 U	2000 U	1900 U	1700 U	1900 U
2-Chloronaphthalene	UG/KG	2900 U	350 U	410 U	380 U	360 U	390 U

TABLE M-2
SEMI-VOLATILE ORGANICS ANALYSIS RESULTS
BORING SOIL
SOUTH ANDOVER DESIGN INVESTIGATION
1990

SAMPLE ID:		B6AR	B6AR	B6AR	B6BR	B7B	B7B
DEPTH:		0-2	10-12	24-26	50-52	0-2	34-36
AGENCY SAMPLE ID:		EJL12	EJL13	EJL18	EJL23	EJL33	EJL34
DATE SAMPLED:		23-AUG-90	23-AUG-90	23-AUG-90	24-AUG-90	27-AUG-90	27-AUG-90
COMPOUND							
2-Nitroaniline	UG/KG	14000 U	1700 U	2000 U	1900 U	1700 U	1900 U
Dimethylphthalate	UG/KG	2900 U	350 U	410 U	380 U	360 U	390 U
Acenaphthylene	UG/KG	330 J	350 U	410 U	380 U	360 U	390 U
2,6-Dinitrotoluene	UG/KG	2900 U	350 U	410 U	380 U	360 U	390 U
3-Nitroaniline	UG/KG	14000 U	1700 U	2000 U	1900 U	1700 UJ	1900 UJ
Acenaphthene	UG/KG	1800 J	350 U	410 U	380 U	360 U	390 U
2,4-Dinitrophenol	UG/KG	14000 UJ	1700 UJ	2000 UJ	1900 UJ	1700 U	1900 U
4-Nitrophenol	UG/KG	14000 U	1700 U	2000 U	1900 U	1700 U	1900 U
Dibenzofuran	UG/KG	2900 U	350 U	410 U	380 U	360 U	390 U
2,4-Dinitrotoluene	UG/KG	2900 U	350 U	410 U	380 U	360 U	390 U
Diethylphthalate	UG/KG	2900 U	55 J	86 J	380 U	360 U	390 U
4-Chlorophenyl-phenyl ether	UG/KG	2900 U	350 U	410 U	380 U	360 U	390 U
Fluorene	UG/KG	1200 J	350 U	410 U	380 U	360 U	390 U
4-Nitroaniline	UG/KG	14000 U	1700 U	2000 UJ	1900 U	1700 UJ	1900 UJ
4,6-Dinitro-2-methylphenol	UG/KG	14000 UJ	1700 UJ	2000 U	1900 UJ	1700 U	1900 U
N-nitrosodiphenylamine	UG/KG	2900 U	350 U	410 U	380 U	360 U	390 U
4-Bromophenyl-phenylether	UG/KG	2900 U	350 U	410 U	380 U	360 U	390 U
Hexachlorobenzene	UG/KG	2900 U	350 U	410 U	380 U	360 U	390 U
Pentachlorophenol	UG/KG	14000 U	1700 U	2000 U	1900 U	1700 U	1900 U
Phenanthrene	UG/KG	3200	350 U	410 U	380 U	360 U	390 U
Anthracene	UG/KG	900 J	350 U	410 U	380 U	360 U	390 U
Di-n-butylphthalate	UG/KG	2900 U	350 U	410 U	380 U	360 U	390 U
Fluoranthene	UG/KG	1000 J	350 U	410 U	380 U	360 U	390 U
Pyrene	UG/KG	1600 J	350 U	410 UJ	380 U	360 U	390 U
Butylbenzylphthalate	UG/KG	2900 U	350 U	55 J	380 U	360 U	390 U
3,3-Dichlorobenzidine	UG/KG	5900 U	700 U	820 U	770 U	720 U	780 U
Benzo(a)anthracene	UG/KG	530 J	350 U	410 U	380 U	360 U	390 U
Chrysene	UG/KG	670 J	350 U	410 UJ	380 U	360 U	390 U
bis(2-Ethylhexyl)phthalate	UG/KG	590 J	250 J	310 J	690	180 J	210 J

TABLE M-2
SEMI-VOLATILE ORGANICS ANALYSIS RESULTS
BORING SOIL
SOUTH ANDOVER DESIGN INVESTIGATION
1990

	SAMPLE ID:	B6AR	B6AR	B6AR	B6BR	B7B	B7B
	DEPTH:	0-2	10-12	24-26	50-52	0-2	34-36
	AGENCY SAMPLE ID:	EJL12	EJL13	EJL18	EJL23	EJL33	EJL34
	DATE SAMPLED:	23-AUG-90	23-AUG-90	23-AUG-90	24-AUG-90	27-AUG-90	27-AUG 90
COMPOUND							
Di-n-octylphthalate	UG/KG	2900 U	350 U	410 U	380 U	360 U	390 U
Benzo(b)fluoranthene	UG/KG	550 J	350 U	410 U	380 U	360 U	390 U
Benzo(k)fluoranthene	UG/KG	340 JX	350 U	410 U	380 U	360 U	390 U
Benzo(a)pyrene	UG/KG	530 J	350 U	410 U	380 U	360 U	390 U
Indeno(1,2,3-cd)pyrene	UG/KG	2900 U	350 U	410 U	380 U	360 UJ	390 UJ
Dibenzo(a,h)anthracene	UG/KG	2900 U	350 U	410 U	380 U	360 U	390 U
Benzo(g,h,i)perylene	UG/KG	2900 UJ	350 U	410 U	380 U	360 U	390 U
Carbazole	UG/KG						

TABLE M-2
SEMI-VOLATILE ORGANICS ANALYSIS RESULTS
BORING SOIL
SOUTH ANDOVER DESIGN INVESTIGATION
1990

SAMPLE ID:		B7B	B7B	B7B	W1CR	W1CR	W1CR
DEPTH:		44-46	44-46	54-56	0-2	44-45.5	88-89
AGENCY SAMPLE ID:		EJL37	EJL38	EJL43	EJL05	EJL30	EJL84
DATE SAMPLED:		27-AUG-90	27-AUG-90	27-AUG-90	22-AUG-90	26-AUG-90	10-SEP-90
COMPOUND							
Phenol	UG/KG	400 U	400 U	370 U	370 U	390 U	390 U
bis(2-Chloroethyl) ether	UG/KG	400 U	400 U	370 U	370 U	390 U	390 U
2-Chlorophenol	UG/KG	400 U	400 U	370 U	370 U	390 U	390 U
1,3-Dichlorobenzene	UG/KG	400 U	400 U	370 U	370 U	390 U	390 U
1,4-Dichlorobenzene	UG/KG	400 U	400 U	370 U	370 U	390 U	390 U
Benzyl alcohol	UG/KG	400 U	400 U	370 UJ	370 U	390 U	390 U
1,2-Dichlorobenzene	UG/KG	400 U	400 U	370 U	370 U	390 U	390 U
2-Methylphenol	UG/KG	400 U	400 U	370 U	370 U	390 U	390 U
bis(2-Chloroisopropyl) ether	UG/KG	400 U	400 U	370 U	370 U	390 U	390 U
4-Methylphenol	UG/KG	400 U	400 U	370 U	370 U	390 U	390 U
N-Nitrosodinpropylamine	UG/KG	400 U	400 U	370 U	370 U	390 U	390 U
Hexachloroethane	UG/KG	400 U	400 U	370 U	370 U	390 U	390 U
Nitrobenzene	UG/KG	400 U	400 U	370 U	370 U	390 U	390 U
Isophorone	UG/KG	400 U	400 U	370 U	370 U	390 U	390 U
2-Nitrophenol	UG/KG	400 U	400 U	370 U	370 U	390 U	390 U
2,4-Dimethylphenol	UG/KG	400 U	400 U	370 U	370 U	390 U	390 U
Benzoic acid	UG/KG	1900 U	1900 U	1800 UJ	1800 U	1900 U	1900 U
bis(2-Chloroethoxy) methane	UG/KG	400 U	400 U	370 U	370 U	390 U	390 U
2,4-Dichlorophenol	UG/KG	400 U	400 U	370 U	370 U	390 U	390 U
1,2,4-Trichlorobenzene	UG/KG	400 U	400 U	370 U	370 U	390 U	390 U
Naphthalene	UG/KG	400 U	400 U	370 U	370 U	390 U	390 U
4-Chloroaniline	UG/KG	400 UJ	400 UJ	370 UJ	370 U	390 UJ	390 U
Hexachlorobutadiene	UG/KG	400 U	400 U	370 U	370 U	390 U	390 U
4-Chloro-3-methylphenol	UG/KG	400 U	400 U	370 U	370 U	390 U	390 U
2-Methylnaphthalene	UG/KG	400 U	400 U	370 U	370 U	390 U	390 U
Hexachlorocyclopentadiene	UG/KG	400 U	400 U	370 U	370 UJ	390 U	390 U
2,4,6-Trichlorophenol	UG/KG	400 U	400 U	370 U	370 U	390 U	390 U
2,4,5-Trichlorophenol	UG/KG	1900 U	1900 U	1800 U	1800 U	1900 U	1900 U
2-Chloronaphthalene	UG/KG	400 U	400 U	370 U	370 U	390 U	390 U

TABLE M-2
SEMI-VOLATILE ORGANICS ANALYSIS RESULTS
BORING SOIL
SOUTH ANDOVER DESIGN INVESTIGATION
1990

	SAMPLE ID:	B7B	B7B	B7B	W1CR	W1CR	W1CR
	DEPTH:	44-46	44-46	54-56	0-2	44-45.5	88-89
	AGENCY SAMPLE ID:	EJL37	EJL38	EJL43	EJL05	EJL30	EJL84
	DATE SAMPLED:	27-AUG-90	27-AUG-90	27-AUG-90	22-AUG-90	26-AUG-90	10-SEP-90
COMPOUND							
2-Nitroaniline	UG/KG	1900 U	1900 U	1800 U	1800 U	1900 U	1900 U
Dimethylphthalate	UG/KG	400 U	400 U	370 U	370 U	390 U	390 U
Acenaphthylene	UG/KG	400 U	400 U	370 U	370 U	390 U	390 U
2,6-Dinitrotoluene	UG/KG	400 U	400 U	370 U	370 U	390 U	390 U
3-Nitroaniline	UG/KG	1900 UJ	1900 UJ	1800 UJ	1800 U	1900 UJ	1900 U
Acenaphthene	UG/KG	400 U	400 U	370 U	370 U	390 U	390 U
2,4-Dinitrophenol	UG/KG	1900 U	1900 U	1800 U	1800 UJ	1900 U	1900 UJ
4-Nitrophenol	UG/KG	1900 U	1900 U	1800 U	1800 U	1900 U	1900 UJ
Dibenzofuran	UG/KG	400 U	400 U	370 U	370 U	390 U	390 U
2,4-Dinitrotoluene	UG/KG	400 U	400 U	370 U	370 U	390 U	390 U
Diethylphthalate	UG/KG	400 U	400 U	370 U	370 U	390 U	390 U
4-Chlorophenyl-phenyl ether	UG/KG	400 U	400 U	370 U	370 U	390 U	390 U
Fluorene	UG/KG	400 U	400 U	370 U	370 U	390 U	390 U
4-Nitroaniline	UG/KG	1900 UJ	1900 UJ	1800 U	1800 UJ	1900 UJ	1900 U
4,6-Dinitro-2-methylphenol	UG/KG	1900 U	1900 U	1800 U	1800 UJ	1900 U	1900 U
N-nitrosodiphenylamine	UG/KG	400 U	400 U	370 U	370 U	390 U	390 U
4-Bromophenyl-phenylether	UG/KG	400 U	400 U	370 U	370 U	390 U	390 U
Hexachlorobenzene	UG/KG	400 U	400 U	370 U	370 U	390 U	390 U
Pentachlorophenol	UG/KG	1900 U	1900 U	1800 U	1800 U	1900 U	1900 U
Phenanthrene	UG/KG	400 U	400 U	370 U	370 U	390 U	390 U
Anthracene	UG/KG	400 U	400 U	370 U	370 U	390 U	390 U
Di-n-butylphthalate	UG/KG	400 U	400 U	370 U	370 U	390 U	390 U
Fluoranthene	UG/KG	400 U	400 U	370 U	370 U	390 U	390 U
Pyrene	UG/KG	400 U	400 U	370 U	370 UJ	390 U	390 U
Butylbenzylphthalate	UG/KG	400 U	400 U	370 U	370 UJ	390 U	390 U
3,3-Dichlorobenzidine	UG/KG	800 U	800 U	750 U	730 U	780 U	780 U
Benzo(a)anthracene	UG/KG	400 U	400 U	370 U	370 U	390 U	390 U
Chrysene	UG/KG	400 U	400 U	370 U	370 UJ	390 U	390 U
bis(2-Ethylhexyl)phthalate	UG/KG	400 U	400 U	160 J	120 J	180 J	390 U

TABLE M-2
SEMI-VOLATILE ORGANICS ANALYSIS RESULTS
BORING SOIL
SOUTH ANDOVER DESIGN INVESTIGATION
1990

	SAMPLE ID:	B7B	B7B	B7B	W1CR	W1CR	W1CR
	DEPTH:	44-46	44-46	54-56	0-2	44-45.5	88-89
	AGENCY SAMPLE ID:	EJL37	EJL38	EJL43	EJL05	EJL30	EJL84
	DATE SAMPLED:	27-AUG-90	27-AUG-90	27-AUG-90	22-AUG-90	26-AUG-90	10-SEP-90
COMPOUND							
Di-n-octylphthalate	UG/KG	400 U	400 U	370 U	370 U	390 U	390 U
Benzo(b)fluoranthene	UG/KG	400 U	400 U	370 U	370 U	390 U	390 U
Benzo(k)fluoranthene	UG/KG	400 U	400 U	370 U	370 U	390 U	390 U
Benzo(a)pyrene	UG/KG	400 U	400 U	370 U	370 U	390 U	390 U
Indeno(1,2,3-cd)pyrene	UG/KG	400 UJ	400 UJ	370 UJ	370 U	390 UJ	390 U
Dibenzo(a,h)anthracene	UG/KG	400 U	400 U	370 UJ	370 U	390 U	390 U
Benzo(g,h,i)perylene	UG/KG	400 U	400 U	370 U	370 U	390 U	390 U
Carbazole	UG/KG						

TABLE M-2
SEMI-VOLATILE ORGANICS ANALYSIS RESULTS
BORING SOIL
SOUTH ANDOVER DESIGN INVESTIGATION
1990

SAMPLE ID:		W23AR	W23AR	W23AR	W23AR
DEPTH:		0-2	0-2	6-8	12-14
AGENCY SAMPLE ID:		EJL93	EJL94	EJL95	EJL96
DATE SAMPLED:		17-SEP-90	17-SEP-90	17-SEP-90	17-SEP-90
COMPOUND					
Phenol	UG/KG	360 U	350 U	510 U	410 U
bis(2-Chloroethyl) ether	UG/KG	360 U	350 U	510 U	410 U
2-Chlorophenol	UG/KG	360 U	350 U	510 U	410 U
1,3-Dichlorobenzene	UG/KG	360 U	350 U	510 U	410 U
1,4-Dichlorobenzene	UG/KG	360 U	350 U	510 U	410 U
Benzyl alcohol	UG/KG	360 U	350 U	510 U	410 U
1,2-Dichlorobenzene	UG/KG	360 U	350 U	510 U	410 U
2-Methylphenol	UG/KG	360 U	350 U	510 U	410 U
bis(2-Chloroisopropyl) ether	UG/KG	360 U	350 U	510 U	410 U
4-Methylphenol	UG/KG	360 U	350 U	510 U	410 U
N-Nitrosodinpropylamine	UG/KG	360 U	350 U	510 U	410 U
Hexachloroethane	UG/KG	360 U	350 U	510 U	410 U
Nitrobenzene	UG/KG	360 U	350 U	510 U	410 U
Isophorone	UG/KG	360 U	350 U	510 U	410 U
2-Nitrophenol	UG/KG	360 U	350 U	510 U	410 U
2,4-Dimethylphenol	UG/KG	360 U	350 U	510 U	410 U
Benzoic acid	UG/KG	1800 U	1800 U	2500 U	2000 U
bis(2-Chloroethoxy) methane	UG/KG	360 U	350 U	510 U	410 U
2,4-Dichlorophenol	UG/KG	360 U	350 U	510 U	410 U
1,2,4-Trichlorobenzene	UG/KG	360 U	350 U	510 U	410 U
Naphthalene	UG/KG	360 U	350 U	510 U	410 U
4-Chloroaniline	UG/KG	360 U	350 U	510 U	410 U
Hexachlorobutadiene	UG/KG	360 U	350 U	510 U	410 U
4-Chloro-3-methylphenol	UG/KG	360 U	350 U	510 U	410 U
2-Methylnaphthalene	UG/KG	360 U	350 U	510 U	410 U
Hexachlorocyclopentadiene	UG/KG	360 U	350 U	510 U	410 U
2,4,6-Trichlorophenol	UG/KG	360 U	350 U	510 U	410 U
2,4,5-Trichlorophenol	UG/KG	1800 U	1800 U	2500 U	2000 U
2-Chloronaphthalene	UG/KG	360 U	350 U	510 U	410 U

TABLE M-2
SEMI-VOLATILE ORGANICS ANALYSIS RESULTS
BORING SOIL
SOUTH ANDOVER DESIGN INVESTIGATION
1990

	SAMPLE ID:	W23AR	W23AR	W23AR	W23AR
	DEPTH:	0-2	0-2	6-8	12-14
	AGENCY SAMPLE ID:	EJL93	EJL94	EJL95	EJL96
	DATE SAMPLED:	17-SEP-90	17-SEP-90	17-SEP-90	17-SEP-90
COMPOUND					
2-Nitroaniline	UG/KG	1800 U	1800 U	2500 U	2000 U
Dimethylphthalate	UG/KG	360 U	350 U	510 U	410 U
Acenaphthylene	UG/KG	360 U	350 U	510 U	410 U
2,6-Dinitrotoluene	UG/KG	360 U	350 U	510 U	410 U
3-Nitroaniline	UG/KG	1800 U	1800 U	2500 U	2000 U
Acenaphthene	UG/KG	360 U	350 U	510 U	410 U
2,4-Dinitrophenol	UG/KG	1800 U	1800 U	2500 U	2000 U
4-Nitrophenol	UG/KG	1800 U	1800 U	2500 U	2000 U
Dibenzofuran	UG/KG	360 U	350 U	510 U	410 U
2,4-Dinitrotoluene	UG/KG	360 U	350 U	510 U	410 U
Diethylphthalate	UG/KG	360 U	350 U	510 U	410 U
4-Chlorophenyl-phenyl ether	UG/KG	360 U	350 U	510 U	410 U
Fluorene	UG/KG	360 U	350 U	510 U	410 U
4-Nitroaniline	UG/KG	1800 U	1800 U	2500 U	2000 U
4,6-Dinitro-2-methylphenol	UG/KG	1800 U	1800 U	2500 U	2000 U
N-nitrosodiphenylamine	UG/KG	360 U	350 U	510 U	410 U
4-Bromophenyl-phenylether	UG/KG	360 U	350 U	510 U	410 U
Hexachlorobenzene	UG/KG	360 U	350 U	510 U	410 U
Pentachlorophenol	UG/KG	1800 U	1800 U	2500 U	2000 U
Phenanthrene	UG/KG	360 U	350 U	510 U	410 U
Anthracene	UG/KG	360 U	350 U	510 U	410 U
Di-n-butylphthalate	UG/KG	360 U	350 U	510 U	410 U
Fluoranthene	UG/KG	360 U	350 U	510 U	410 U
Pyrene	UG/KG	360 U	350 U	510 U	410 U
Butylbenzylphthalate	UG/KG	360 U	350 U	510 U	410 U
3,3-Dichlorobenzidine	UG/KG	720 U	710 U	1000 U	810 U
Benzo(a)anthracene	UG/KG	360 U	350 U	510 U	410 U
Chrysene	UG/KG	360 U	350 U	510 U	410 U
bis(2-Ethylhexyl)phthalate	UG/KG	360 U	350 U	510 U	410 U

TABLE M-2
SEMI-VOLATILE ORGANICS ANALYSIS RESULTS
BORING SOIL
SOUTH ANDOVER DESIGN INVESTIGATION
1990

	SAMPLE ID:	W23AR	W23AR	W23AR	W23AR
	DEPTH:	0-2	0-2	6-8	12-14
	AGENCY SAMPLE ID:	EJL93	EJL94	EJL95	EJL96
	DATE SAMPLED:	17-SEP-90	17-SEP-90	17-SEP-90	17-SEP-90
COMPOUND					
Di-n-octylphthalate	UG/KG	360 U	350 U	510 U	410 U
Benzo(b)fluoranthene	UG/KG	360 U	350 U	510 U	410 U
Benzo(k)fluoranthene	UG/KG	360 U	350 U	510 U	410 U
Benzo(a)pyrene	UG/KG	360 U	350 U	510 U	410 U
Indeno(1,2,3-cd)pyrene	UG/KG	360 U	350 U	510 U	410 U
Dibenzo(a,h)anthracene	UG/KG	360 U	350 U	510 U	410 U
Benzo(g,h,i)perylene	UG/KG	360 U	350 U	510 U	410 U
Carbazole	UG/KG				

TABLE M-3
PESTICIDE/PCB ANALYSIS RESULTS
BORING SOIL
SOUTH ANDOVER DESIGN INVESTIGATION
1990

	SAMPLE ID:	B6AR	B6AR	B6AR	B6BR	B7B	B7B
	DEPTH:	0-2	10-12	24-26	50-52	0-2	34-36
	AGENCY SAMPLE ID:	EJL12	EJL13	EJL18	EJL23	EJL33	EJL34
	DATE SAMPLED:	23-AUG-90	23-AUG-90	23-AUG-90	24-AUG-90	27-AUG-90	27-AUG-90
COMPOUND							
alpha-BHC	UG/KG	8.9 U	8.4 U	10 U	9.3 U	8.7 U	9.4 U
beta-BHC	UG/KG	8.9 U	8.4 U	10 U	9.3 U	8.7 U	9.4 U
delta-BHC	UG/KG	8.9 U	8.4 U	10 U	9.3 U	8.7 U	9.4 U
gamma-BHC (lindane)	UG/KG	8.9 U	8.4 U	10 U	9.3 U	8.7 U	9.4 U
Heptachlor	UG/KG	8.9 U	8.4 U	10 U	9.3 U	8.7 U	9.4 U
Aldrin	UG/KG	8.9 U	8.4 U	10 U	9.3 U	8.7 U	9.4 U
Heptachlor epoxide	UG/KG	8.9 U	8.4 U	10 U	9.3 U	8.7 U	9.4 U
Endosulfan I	UG/KG	8.9 U	8.4 U	10 U	9.3 U	8.7 U	9.4 U
Dieldrin	UG/KG	18 U	17 U	20 U	19 U	17 U	19 U
4,4-DDE	UG/KG	18 U	17 U	20 U	19 U	17 U	19 U
Endrin	UG/KG	18 U	17 U	20 U	19 U	17 U	19 U
Endosulfan II	UG/KG	18 U	17 U	20 U	19 U	17 U	19 U
4,4-DDD	UG/KG	18 U	17 U	20 U	19 U	17 U	19 U
Endosulfan sulfate	UG/KG	18 U	17 U	20 U	19 U	17 U	19 U
4,4-DDT	UG/KG	20	17 U	20 U	19 U	17 U	19 U
Methoxychlor	UG/KG	89 U	84 U	100 U	93 U	87 U	94 U
Endrin ketone	UG/KG	18 U	17 U	20 U	19 U	17 U	19 U
alpha-Chlordane	UG/KG	89 U	84 U	100 U	93 U	87 U	94 U
gamma-Chlordane	UG/KG	89 U	84 U	100 U	93 U	87 U	94 U
Toxaphene	UG/KG	180 U	170 U	200 U	190 U	170 U	190 U
Aroclor-1016	UG/KG	89 U	84 U	100 U	93 U	87 U	94 U
Aroclor-1221	UG/KG	89 U	84 U	100 U	93 U	87 U	94 U
Aroclor-1232	UG/KG	89 U	84 U	100 U	93 U	87 U	94 U
Aroclor-1242	UG/KG	89 U	84 U	100 U	93 U	87 U	94 U
Aroclor-1248	UG/KG	89 U	84 U	100 U	93 U	87 U	94 U
Aroclor-1254	UG/KG	180 U	170 U	200 U	190 U	170 U	190 U
Aroclor-1260	UG/KG	180 U	170 U	200 U	190 U	170 U	190 U

TABLE M-3
PESTICIDE/PCB ANALYSIS RESULTS
BORING SOIL
SOUTH ANDOVER DESIGN INVESTIGATION
1990

	SAMPLE ID:	B7B	B7B	B7B	W1CR	W1CR	W1CR
	DEPTH:	44-46	44-46	54-56	0-2	44-45.5	88-89
	AGENCY SAMPLE ID:	EJL37	EJL38	EJL43	EJL05	EJL30	EJL84
	DATE SAMPLED:	27-AUG-90	27-AUG-90	27-AUG-90	22-AUG-90	26-AUG-90	10-SEP-90
COMPOUND							
alpha-BHC	UG/KG	9.6 U	9.6 U	9.1 U	8.4 U	9.4 U	9.3 U
beta-BHC	UG/KG	9.6 U	9.6 U	9.1 U	8.4 U	9.4 U	9.3 U
delta-BHC	UG/KG	9.6 U	9.6 U	9.1 U	8.4 U	9.4 U	9.3 U
gamma-BHC (lindane)	UG/KG	9.6 U	9.6 U	9.1 U	8.4 U	9.4 U	9.3 U
Heptachlor	UG/KG	9.6 U	9.6 U	9.1 U	8.4 U	9.4 U	9.3 U
Aldrin	UG/KG	9.6 U	9.6 U	9.1 U	8.4 U	9.4 U	9.3 U
Heptachlor epoxide	UG/KG	9.6 U	9.6 U	9.1 U	8.4 U	9.4 U	9.3 U
Endosulfan I	UG/KG	9.6 U	9.6 U	9.1 U	8.4 U	9.4 U	9.3 U
Dieldrin	UG/KG	19 U	19 U	18 U	17 U	19 U	19 U
4,4-DDE	UG/KG	19 U	19 U	18 U	17 U	19 U	19 U
Endrin	UG/KG	19 U	19 U	18 U	17 U	19 U	19 U
Endosulfan II	UG/KG	19 U	19 U	18 U	17 U	19 U	19 U
4,4-DDD	UG/KG	19 U	19 U	18 U	17 U	19 U	19 U
Endosulfan sulfate	UG/KG	19 U	19 U	18 U	17 U	19 U	19 U
4,4-DDT	UG/KG	19 U	19 U	18 U	17 U	19 U	19 U
Methoxychlor	UG/KG	96 U	96 U	91 U	84 U	94 U	93 U
Endrin ketone	UG/KG	19 U	19 U	18 U	17 U	19 U	19 U
alpha-Chlordane	UG/KG	96 U	96 U	91 U	84 U	94 U	93 U
gamma-Chlordane	UG/KG	96 U	96 U	91 U	84 U	94 U	93 U
Toxaphene	UG/KG	190 U	190 U	180 U	170 U	190 U	190 U
Aroclor-1016	UG/KG	96 U	96 U	91 U	84 U	94 U	93 U
Aroclor-1221	UG/KG	96 U	96 U	91 U	84 U	94 U	93 U
Aroclor-1232	UG/KG	96 U	96 U	91 U	84 U	94 U	93 U
Aroclor-1242	UG/KG	96 U	96 U	91 U	84 U	94 U	93 U
Aroclor-1248	UG/KG	96 U	96 U	91 U	84 U	94 U	93 U
Aroclor-1254	UG/KG	190 U	190 U	180 U	170 U	190 U	190 U
Aroclor-1260	UG/KG	190 U	190 U	180 U	170 U	190 U	190 U

TABLE M-3
PESTICIDE/PCB ANALYSIS RESULTS
BORING SOIL
SOUTH ANDOVER DESIGN INVESTIGATION
1990

	SAMPLE ID:	W23AR	W23AR	W23AR	W23AR
	DEPTH:	0-2	0-2	6-8	12-14
	AGENCY SAMPLE ID:	EJL93	EJL94	EJL95	EJL96
	DATE SAMPLED:	17-SEP-90	17-SEP-90	17-SEP-90	17-SEP-90
COMPOUND					
alpha-BHC	UG/KG	8.6 U	8.5 U	12 U	9.8 U
beta-BHC	UG/KG	8.6 U	8.5 U	12 U	9.8 U
delta-BHC	UG/KG	8.6 U	8.5 U	12 U	9.8 U
gamma-BHC (lindane)	UG/KG	8.6 U	8.5 U	12 U	9.8 U
Heptachlor	UG/KG	8.6 U	8.5 U	12 U	9.8 U
Aldrin	UG/KG	8.6 U	8.5 U	12 U	9.8 U
Heptachlor epoxide	UG/KG	8.6 U	8.5 U	12 U	9.8 U
Endosulfan I	UG/KG	8.6 U	8.5 U	12 U	9.8 U
Dieldrin	UG/KG	17 U	17 U	24 U	20 U
4,4-DDE	UG/KG	17 U	17 U	24 U	20 U
Endrin	UG/KG	17 U	17 U	24 U	20 U
Endosulfan II	UG/KG	17 U	17 U	24 U	20 U
4,4-DDD	UG/KG	17 U	17 U	24 U	20 U
Endosulfan sulfate	UG/KG	17 U	17 U	24 U	20 U
4,4-DDT	UG/KG	17 U	17 U	24 U	20 U
Methoxychlor	UG/KG	86 U	85 U	120 U	98 U
Endrin ketone	UG/KG	17 U	17 U	24 U	20 U
alpha-Chlordane	UG/KG	86 U	85 U	120 U	98 U
gamma-Chlordane	UG/KG	86 U	85 U	120 U	98 U
Toxaphene	UG/KG	170 U	170 U	240 U	200 U
Aroclor-1016	UG/KG	86 U	85 U	120 U	98 U
Aroclor-1221	UG/KG	86 U	85 U	120 U	98 U
Aroclor-1232	UG/KG	86 U	85 U	120 U	98 U
Aroclor-1242	UG/KG	86 U	85 U	120 U	98 U
Aroclor-1248	UG/KG	86 U	85 U	120 U	98 U
Aroclor-1254	UG/KG	170 U	170 U	240 U	200 U
Aroclor-1260	UG/KG	170 U	170 U	240 U	200 U

TABLE M-4
INORGANIC ANALYSIS RESULTS
BORING SOIL
SOUTH ANDOVER DESIGN INVESTIGATION
1990

	SAMPLE ID:	B6AR	B6AR	B6AR	B6BR	B7B	B7B
	DEPTH:	0-2	10-12	24-26	50-52	0-2	34-36
	AGENCY SAMPLE ID:	MEJF12	MEJF13	MEJF18	MEJF23	MEJF33	MEJF34
	DATE SAMPLED:	23-AUG-90	23-AUG-90	23-AUG-90	24-AUG-90	27-AUG-90	27-AUG-90
COMPOUND							
Aluminum	UG/KG	3020.00 J	1290.00 J	988.00 J	4960.00 J	4830.00	3020.00
Antimony	UG/KG	4.30 UJ	4.20 UJ	4.90 UJ	4.80 UJ	5.60 U	6.00 U
Arsenic	UG/KG	1.70 B	0.77 B	0.82 B	1.30 B	1.80 B	1.40 BJ
Barium	UG/KG	36.80 BJ	13.00 BJ	16.50 BJ	31.70 BJ	32.90 B	30.10 B
Beryllium	UG/KG	0.25 B	0.20 U	0.23 U	0.28 B	.28 BJ	.30 BJ
Cadmium	UG/KG	1.00	0.40 U	0.47 U	0.45 U	.87 U	.93 U
Calcium	UG/KG	1180.00	379.00 B	1440.00	14000.00	670.00 B	26000.00
Chromium	UG/KG	5.70	3.30 J	5.30	9.20	4.70	7.80
Cobalt	UG/KG	5.10 B	2.50 BJ	2.00 BJ	5.50 B	2.90 B	4.90 B
Copper	UG/KG	9.00	3.10 B	3.20 B	16.70	5.90 J	3.10 BJ
Iron	UG/KG	5950.00 J	3180.00 J	2060.00 J	9300.00 J	5410.00	5860.00
Lead	UG/KG	69.80	1.40	1.80	2.40	5.00 J	2.50 J
Magnesium	UG/KG	784.00 B	494.00 B	773.00 B	6090.00	729.00 B	9330.00
Manganese	UG/KG	177.00 J	142.00 J	33.30 J	210.00 J	208.00	206.00
Mercury	UG/KG	0.10 U	0.09	0.12 U	0.10 U	.11 U	.12 U
Nickel	UG/KG	6.00 B	3.40 B	4.20 B	11.60	6.10 U	10.30
Potassium	UG/KG	196.00 B	146.00 B	138.00 B	487.00 B	178.00 U	475.00 B
Selenium	UG/KG	0.42 UJ	0.42 UJ	0.47 UJ	0.46 UJ	.65 U	.70 U
Silver	UG/KG	1.60 U	1.60 U	1.90 U	1.80 U	.87 U	.93 U
Sodium	UG/KG	66.40 BJ	47.10 BJ	84.60 B	326.00 B	27.30 U	91.00 B
Thallium	UG/KG	0.42 U	0.42 U	0.47 U	0.46 U	.43 UJ	.47 U
Vanadium	UG/KG	9.20 B	4.90 B	8.20 B	21.30	10.00 B	11.80
Zinc	UG/KG	797.00	8.90 J	9.60 J	19.90	16.70	19.80
Cyanide	UG/KG	1.10 U	1.00 U	1.20 U	1.20 U	1.10 U	1.20 U
Boron	UG/KG						
Lithium	UG/KG						
Molybdenum	UG/KG						
Strontium	UG/KG						
Titanium	UG/KG						

TABLE M-4
INORGANIC ANALYSIS RESULTS
BORING SOIL
SOUTH ANDOVER DESIGN INVESTIGATION
1990

SAMPLE ID:		B7B	B7B	B7B	W1CR	W1CR	W1CR
DEPTH:		44-46	44-46	54-56	0-2	44-45.5	88-89
AGENCY SAMPLE ID:		MEJF37	MEJF38	MEJF43	MEJF05	MEJF30	MEJF84
DATE SAMPLED:		27-AUG-90	27-AUG-90	27-AUG-90	22-AUG-90	26-AUG-90	10-SEP-90
COMPOUND							
Aluminum	UG/KG	1900.00	2310.00	4160.00	2780.00 J	1640.00	6060.00
Antimony	UG/KG	5.50 U	6.40 U	6.30 U	4.40 UJ	6.40 U	10.60 U
Arsenic	UG/KG	.96 B	1.90 B	1.40 BJ	2.20 J	.54 B	0.47 BJ
Barium	UG/KG	16.60 B	19.30 B	30.30 B	25.50 BJ	8.70 B	23.60 BJ
Beryllium	UG/KG	.21 U	.25 U	.24 U	0.23 B	.24 U	0.43 BJ
Cadmium	UG/KG	.84 U	.99 U	.97 U	0.42 U	.98 U	0.68 U
Calcium	UG/KG	20200.00	22400.00	13600.00	681.00 B	4940.00	9170.00
Chromium	UG/KG	4.80	6.40	8.40	3.90 J	5.50	16.60
Cobalt	UG/KG	3.30 B	2.00 U	6.10 B	2.10 BJ	3.30 B	7.70 B
Copper	UG/KG	2.80 BJ	2.70 BJ	9.90 J	4.50 B	5.80 BJ	14.80
Iron	UG/KG	4610.00	5410.00	8890.00	3890.00 J	3370.00	12100.00 J
Lead	UG/KG	1.60 J	1.80 J	1.70 J	3.90	.68 BJ	1.80 J
Magnesium	UG/KG	5840.00	6470.00	5070.00	601.00 B	1420.00	5500.00
Manganese	UG/KG	157.00	166.00	200.00	169.00 J	51.10	192.00
Mercury	UG/KG	.11 U	.12 U	.12 U	0.10 U	.12 U	0.11 U
Nickel	UG/KG	8.30 B	6.90 U	10.80	3.20 B	6.80 U	20.80
Potassium	UG/KG	253.00 B	351.00 B	310.00 B	151.00 B	201.00 U	431.00 BJ
Selenium	UG/KG	.63 U	.74 UJ	.73 U	0.43 UJ	.73 U	0.23 U
Silver	UG/KG	.84 U	.99 U	.97 U	1.70 U	.98 U	0.45 U
Sodium	UG/KG	84.30 B	149.00 B	228.00 B	41.80 BJ	124.00 B	1040.00 BJ
Thallium	UG/KG	.42 U	.50 U	.49 U	0.43 U	.49 U	0.23 U
Vanadium	UG/KG	9.60 B	10.10 B	23.70	6.50 B	9.00 B	26.80
Zinc	UG/KG	12.40	16.50	19.10	13.10 J	8.30	22.50
Cyanide	UG/KG	1.10 U	1.20 U	1.20 U	1.10 U	1.20 U	0.17 U
Boron	UG/KG						
Lithium	UG/KG						
Molybdenum	UG/KG						
Strontium	UG/KG						
Titanium	UG/KG						

TABLE M-4
INORGANIC ANALYSIS RESULTS
BORING SOIL
SOUTH ANDOVER DESIGN INVESTIGATION
1990

SAMPLE ID:		W23AR	W23AR	W23AR	W23AR
DEPTH:		0-2	0-2	6-8	12-14
AGENCY SAMPLE ID:		MEJF93	MEJF94	MEJF95	MEJF96
DATE SAMPLED:		17-SEP-90	17-SEP-90	17-SEP-90	17-SEP-90
COMPOUND					
Aluminum	UG/KG	4050.00 J	4020.00 J	4290.00 J	1380.00 J
Antimony	UG/KG	10.00 UJ	10.00 UJ	15.30 UJ	11.30 UJ
Arsenic	UG/KG	0.87 BJ	0.70 BJ	1.20 BJ	0.48 UJ
Barium	UG/KG	35.60 BJ	38.20 BJ	32.30 BJ	9.40 BJ
Beryllium	UG/KG	0.21 U	0.28 B	0.33 U	0.24 U
Cadmium	UG/KG	1.00 B	0.83 B	0.98 U	0.72 U
Calcium	UG/KG	3360.00 J	3940.00 J	4530.00 J	5750.00 J
Chromium	UG/KG	20.30	18.10	9.80	5.50
Cobalt	UG/KG	3.40 B	3.60 B	2.00 B	2.80 B
Copper	UG/KG	20.00	19.80	9.40	4.40 B
Iron	UG/KG	5850.00 J	6190.00 J	2670.00 J	3020.00 J
Lead	UG/KG	84.50	113.00	4.10 BJ	6.00
Magnesium	UG/KG	999.00 B	966.00 B	1100.00 B	2060.00
Manganese	UG/KG	143.00 J	154.00 J	28.40 J	35.20 J
Mercury	UG/KG	0.11 U	0.10 U	0.16 U	0.12 U
Nickel	UG/KG	6.30 B	5.80 B	5.60 B	3.80 B
Potassium	UG/KG	328.00 BJ	366.00 BJ	298.00 BJ	249.00 BJ
Selenium	UG/KG	0.43 UJ	0.43 UJ	1.60 BJ	0.48 UJ
Silver	UG/KG	0.43 U	0.43 U	0.65 U	0.48 U
Sodium	UG/KG	1010.00 BJ	1010.00 BJ	1650.00 J	1120.00 BJ
Thallium	UG/KG	2.10 UJ	2.10 UJ	3.30 UJ	0.24 U
Vanadium	UG/KG	12.30	10.90	18.40	7.50 B
Zinc	UG/KG	105.00	116.00	13.90	10.90
Cyanide	UG/KG	0.55 BJ	1.55 J	0.24 U	0.18 U
Boron	UG/KG				
Lithium	UG/KG				
Molybdenum	UG/KG				
Strontium	UG/KG				
Titanium	UG/KG				

TABLE M-5
VOLATILE ORGANICS ANALYSIS RESULTS
GROUNDWATER
SOUTH ANDOVER DESIGN INVESTIGATION
1990

	SAMPLE ID:	B6AR	B6AR	B6BR	B6BR	B7BR	RW1
	DEPTH:	-	-	-	-	-	-
	AGENCY SAMPLE ID:	EJM50	EJM51	EJM47	EJM48	EJM56	EJM27
	DATE SAMPLED:	17-OCT-90	17-OCT-90	16-OCT-90	16-OCT-90	18-OCT-90	21-SEP-90
COMPOUND							
Chloromethane	UG/L	10 U	10 U	10 U	10 U	10 U	1.120 U
Bromomethane	UG/L	10 U	10 U	10 U	10 U	10 U	0.380 U
Vinyl Chloride	UG/L	10 U	10 U	10 U	10 U	10 U	0.910 U
Chloroethane	UG/L	10 U	10 U	10 U	10 U	10 U	0.540 U
Methylene Chloride	UG/L	5 UJ	5 UJ	17 UJ	6 UJ	5 UJ	4.000
Acetone	UG/L	8 J	10 U	10 U	10 U	54	2.130 U
Carbon Disulfide	UG/L	5 U	5 U	5 U	5 U	5 U	1.440 U
1,1-Dichloroethene	UG/L	5 U	5 U	5 U	5 U	5 U	0.720 U
1,1-Dichloroethane	UG/L	5 U	5 U	5 U	5 U	5 U	0.270 U
1,2-Dichloroethene(total)	UG/L	5 U	5 U	5 U	5 U	5 U	0.550 U
Chloroform	UG/L	5 U	5 U	5 U	5 U	5 U	0.310 U
1,2-Dichloroethane	UG/L	5 U	5 U	5 U	5 U	5 U	0.370 U
2-Butanone	UG/L	10 U	10 U	10 U	10 U	10 U	2.710 U
1,1,1-Trichloroethane	UG/L	5 U	5 U	5 U	5 U	5 U	0.450 U
Carbon Tetrachloride	UG/L	5 U	5 U	5 U	5 U	5 U	0.270 U
Vinyl Acetate	UG/L	10 U	10 U	10 U	10 U	10 U	3.430 UJ
Bromodichloromethane	UG/L	5 U	5 U	5 U	5 U	5 U	0.330 U
1,2-Dichloropropane	UG/L	5 U	5 U	5 U	5 U	5 U	0.450 U
cis-1,3-Dichloropropene	UG/L	5 U	5 U	5 U	5 U	5 U	0.640 U
Trichloroethene	UG/L	5 U	5 U	5 U	5 U	5 U	0.350 U
Dibromochloromethane	UG/L	5 U	5 U	5 U	5 U	5 U	0.440 U
1,1,2-Trichloroethane	UG/L	5 U	5 U	5 U	5 U	5 U	0.610 U
Benzene	UG/L	5 U	5 U	5 U	5 U	5 U	0.430 U
trans-1,3-Dichloropropene	UG/L	5 U	5 U	5 U	5 U	5 U	0.690 U
Bromoform	UG/L	5 U	5 U	5 U	5 U	5 U	0.430 U
4-Methyl-2-pentanone	UG/L	10 U	10 U	10 U	10 U	10 U	1.340 U
2-Hexanone	UG/L	10 U	10 U	10 U	10 U	10 U	0.360 U
Tetrachloroethene	UG/L	5 U	5 U	5 U	5 U	5 U	0.980 U
1,1,2,2-Tetrachloroethane	UG/L	5 U	5 U	5 U	5 U	5 U	0.610 U

TABLE M-5
VOLATILE ORGANICS ANALYSIS RESULTS
GROUNDWATER
SOUTH ANDOVER DESIGN INVESTIGATION
1990

	SAMPLE ID:	B6AR	B6AR	B6BR	B6BR	B7BR	RW1
	DEPTH:	-	-	-	-	-	-
	AGENCY SAMPLE ID:	EJM50	EJM51	EJM47	EJM48	EJM56	EJM27
	DATE SAMPLED:	17-OCT-90	17-OCT-90	16-OCT-90	16-OCT-90	18-OCT-90	21-SEP-90
COMPOUND							
Toluene	UG/L	5 U	5 U	5 U	5 U	5 U	0.650 U
Chlorobenzene	UG/L	5 U	5 U	5 U	5 U	5 U	0.690 U
Ethyl Benzene	UG/L	5 U	5 U	5 U	5 U	5 U	0.280 U
Styrene	UG/L	5 U	5 U	5 U	5 U	5 U	0.360 U
Xylenes (Total)	UG/L	5 U	5 U	5 U	5 U	5 U	0.170 U
Acrolein	UG/L						
Acrylonitrile	UG/L						

TABLE M-5
VOLATILE ORGANICS ANALYSIS RESULTS
GROUNDWATER
SOUTH ANDOVER DESIGN INVESTIGATION
1990

SAMPLE ID:		RW1	RW1	RW3	RW3	RW4	RW6
DEPTH:		-	-	0-0	0-0	0-0	-
AGENCY SAMPLE ID:		EJM28	EJM29	EJM23	EJM24	EJM25	EJM26
DATE SAMPLED:		21-SEP-90	21-SEP-90	21-SEP-90	18-SEP-90	21-SEP-90	21-SEP-90
COMPOUND							
Chloromethane	UG/L	1.120 U	1.120 U	1.120 U	1.120 U	1.120 U	1.120 U
Bromomethane	UG/L	0.380 U	0.380 U	0.380 U	0.380 U	0.380 U	0.380 U
Vinyl Chloride	UG/L	0.910 U	0.910 U	0.910 U	0.910 U	0.910 U	0.910 U
Chloroethane	UG/L	0.540 U	0.540 U	0.540 U	0.540 U	0.540 U	0.540 U
Methylene Chloride	UG/L	0.980 U	6.000 U	0.980 U	0.980 U	0.980 U	0.980 U
Acetone	UG/L	2.130 U	2.130 U	2.130 U	2.130 U	2.130 U	2.130 U
Carbon Disulfide	UG/L	1.440 U	1.440 U	1.440 U	1.440 U	1.440 U	1.440 U
1,1-Dichloroethene	UG/L	0.720 U	0.720 U	0.720 U	0.720 U	0.720 U	0.720 U
1,1-Dichloroethane	UG/L	0.270 U	0.270 U	0.270 U	0.270 U	0.270 U	0.270 U
1,2-Dichloroethene(total)	UG/L	0.550 U	0.550 U	0.550 U	0.550 U	0.550 U	0.550 U
Chloroform	UG/L	0.310 U	0.310 U	0.310 U	0.310 U	0.310 U	0.310 U
1,2-Dichloroethane	UG/L	0.370 U	0.370 U	0.370 U	0.370 U	0.370 U	0.370 U
2-Butanone	UG/L	2.710 UJR	2.710 UJR	2.710 U	2.710 U	2.170 U	2.170 U
1,1,1-Trichloroethane	UG/L	2.000	0.450 U	0.450 U	0.450 U	0.450 U	0.450 U
Carbon Tetrachloride	UG/L	0.270 U	0.270 U	0.270 U	0.270 U	0.270 U	0.270 U
Vinyl Acetate	UG/L	3.430 UJ	3.430 UJ	3.430 UJ	3.430 UJ	3.430 UJ	3.430 UJ
Bromodichloromethane	UG/L	0.330 U	0.330 U	0.330 U	0.330 U	0.330 U	0.330 U
1,2-Dichloropropane	UG/L	0.450 U	0.450 U	0.450 U	0.450 U	0.450 U	0.450 U
cis-1,3-Dichloropropene	UG/L	0.640 U	0.640 U	0.640 U	0.640 U	0.640 U	0.640 U
Trichloroethene	UG/L	0.350 U	0.350 U	0.350 U	0.350 U	0.350 U	0.350 U
Dibromochloromethane	UG/L	0.440 U	0.440 U	0.440 U	0.440 U	0.440 U	0.440 U
1,1,2-Trichloroethane	UG/L	0.610 U	0.610 U	0.610 U	0.610 U	0.610 U	0.610 U
Benzene	UG/L	0.430 U	0.430 U	0.430 U	0.430 U	0.430 U	0.430 U
trans-1,3-Dichloropropene	UG/L	0.690 U	0.690 U	0.690 U	0.690 U	0.690 U	0.690 U
Bromoform	UG/L	0.430 U	0.430 U	0.430 U	0.430 U	0.430 U	0.430 U
4-Methyl-2-pentanone	UG/L	0.980 U	0.980 U	0.980 U	0.980 U	0.980 U	0.980 U
2-Hexanone	UG/L	1.340 U	1.340 U	1.340 U	1.340 U	1.340 U	1.340 U
Tetrachloroethene	UG/L	0.360 U	0.360 U	0.360 U	0.360 U	0.360 U	0.360 U
1,1,2,2-Tetrachloroethane	UG/L	0.610 U	0.610 U	0.610 U	0.610 U	0.610 U	0.610 U

TABLE M-5
VOLATILE ORGANICS ANALYSIS RESULTS
GROUNDWATER
SOUTH ANDOVER DESIGN INVESTIGATION
1990

	SAMPLE ID:	RW1	RW1	RW3	RW3	RW4	RW6
	DEPTH:	-	-	0-0	0-0	0-0	-
	AGENCY SAMPLE ID:	EJM28	EJM29	EJM23	EJM24	EJM25	EJM26
	DATE SAMPLED:	21-SEP-90	21-SEP-90	21-SEP-90	18-SEP-90	21-SEP-90	21-SEP-90
COMPOUND							
Toluene	UG/L	0.650 U	0.650 U	0.650 U	0.650 U	0.650 U	0.650 U
Chlorobenzene	UG/L	0.690 U	0.690 U	0.690 U	0.690 U	0.690 U	0.690 U
Ethyl Benzene	UG/L	0.280 U	0.280 U	0.280 U	0.280 U	0.280 U	0.280 U
Styrene	UG/L	1000	0.360 U	0.360 U	0.360 U	0.360 U	0.360 U
Xylenes (Total)	UG/L	0.170 U	0.170 U	0.170 U	0.170 U	0.170 U	0.170 U
Acrolein	UG/L			14.700 UJR			
Acrylonitrile	UG/L			9.970 U			

TABLE M-5
VOLATILE ORGANICS ANALYSIS RESULTS
GROUNDWATER
SOUTH ANDOVER DESIGN INVESTIGATION
1990

	SAMPLE ID:	W1CR	W9A	W16A	W16A	W17A	W19A
	DEPTH:	-	-	-	-	-	-
	AGENCY SAMPLE ID:	EJM52	EJM59	EJM34	EJM35	EJM46	EJM45
	DATE SAMPLED:	17-OCT-90	18-OCT-90	23-SEP-90	23-SEP-90	16-OCT-90	16-OCT-90
COMPOUND							
Chloromethane	UG/L	10 U	10 U	10 U	10 U	10 U	10 U
Bromomethane	UG/L	10 U	10 U	10 U	10 U	10 U	10 U
Vinyl Chloride	UG/L	10 U	10 U	10 U	10 U	10 U	10 U
Chloroethane	UG/L	10 U	10 U	10 U	10 U	10 U	10 U
Methylene Chloride	UG/L	10 UJ	6 U	11	5 U	8 UJ	17 UJ
Acetone	UG/L	10 U	30	10 U	10 U	10 U	7 J
Carbon Disulfide	UG/L	5 U	5 U	5 U	5 U	5 U	5 U
1,1-Dichloroethene	UG/L	5 U	5 U	5 U	5 U	5 U	5 U
1,1-Dichloroethane	UG/L	5 U	5 U	5 U	5 U	5 U	5 U
1,2-Dichloroethene(total)	UG/L	5 U	5 U	5 U	5 U	5 U	5 U
Chloroform	UG/L	5 U	5 U	5 U	5 U	5 U	5 U
1,2-Dichloroethane	UG/L	5 U	5 U	5 U	5 U	5 U	5 U
2-Butanone	UG/L	10 U	10 R	10 UJ	10 UJ	10 U	10 U
1,1,1-Trichloroethane	UG/L	5 U	5 U	5 U	5 U	5 U	5 U
Carbon Tetrachloride	UG/L	5 U	5 U	5 U	5 U	5 U	5 U
Vinyl Acetate	UG/L	10 U	10 U	10 U	10 U	10 U	10 U
Bromodichloromethane	UG/L	5 U	5 U	5 U	5 U	5 U	5 U
1,2-Dichloropropane	UG/L	5 U	5 U	5 U	5 U	5 U	5 U
cis-1,3-Dichloropropene	UG/L	5 U	5 U	5 U	5 U	5 U	5 U
Trichloroethene	UG/L	5 U	5 U	5 U	5 U	5 U	5 U
Dibromochloromethane	UG/L	5 U	5 U	5 U	5 U	5 U	5 U
1,1,2-Trichloroethane	UG/L	5 U	5 U	5 U	5 U	5 U	5 U
Benzene	UG/L	5 U	5 U	5 U	5 U	5 U	5 U
trans-1,3-Dichloropropene	UG/L	5 U	5 U	5 U	5 U	5 U	5 U
Bromoform	UG/L	5 U	5 U	5 U	5 U	5 U	5 U
4-Methyl-2-pentanone	UG/L	10 U	10 U	10 U	10 U	10 U	10 U
2-Hexanone	UG/L	10 U	10 UJ	10 U	10 U	10 U	10 U
Tetrachloroethene	UG/L	5 U	5 U	5 U	5 U	5 U	5 U
1,1,2,2-Tetrachloroethane	UG/L	5 U	5 U	5 U	5 U	5 U	5 U

TABLE M-5
VOLATILE ORGANICS ANALYSIS RESULTS
GROUNDWATER
SOUTH ANDOVER DESIGN INVESTIGATION
1990

	SAMPLE ID:	W1CR	W9A	W16A	W16A	W17A	W19A
	DEPTH:	-	-	-	-	-	
	AGENCY SAMPLE ID:	EJM52	EJM59	EJM34	EJM35	EJM46	EJM45
	DATE SAMPLED:	17-OCT-90	18-OCT-90	23-SEP-90	23-SEP-90	16-OCT-90	16-OCT 90
COMPOUND							
Toluene	UG/L	5 U	5 U	5 U	5 U	5 U	5 U
Chlorobenzene	UG/L	5 U	5 U	5 U	5 U	5 U	5 U
Ethyl Benzene	UG/L	5 U	5 U	5 U	5 U	5 U	5 U
Styrene	UG/L	5 U	5 U	5 U	5 U	5 U	5 U
Xylenes (Total)	UG/L	5 U	5 U	5 U	5 U	5 U	5 U
Acrolein	UG/L						
Acrylonitrile	UG/L						

TABLE M-5
VOLATILE ORGANICS ANALYSIS RESULTS
GROUNDWATER
SOUTH ANDOVER DESIGN INVESTIGATION
1990

SAMPLE ID:		W21A	W21B	W21C	W23AR	W23AR	W23B
DEPTH:		-	-	-	-	-	-
AGENCY SAMPLE ID:		EJM31	EJM32	EJM33	EJM54	EJM54DL	EJM53
DATE SAMPLED:		22-SEP-90	22-SEP-90	23-SEP-90	17-OCT-90	17-OCT-90	17-OCT-90
COMPOUND							
Chloromethane	UG/L	10 U	10 U	10 U	10 U	50 U	10 U
Bromomethane	UG/L	10 U	10 U	10 U	10 U	50 U	10 U
Vinyl Chloride	UG/L	10 U	10 U	10 U	10 U	50 U	10 U
Chloroethane	UG/L	10 U	10 U	10 UJ	10 U	50 U	10 U
Methylene Chloride	UG/L	5 U	11	5 U	5 UJ	25 UJ	12 UJ
Acetone	UG/L	10 U	10 U	10 UJ	350 E	400 D	10 U
Carbon Disulfide	UG/L	5 U	5 U	5 U	5 U	25 U	5 U
1,1-Dichloroethene	UG/L	5 U	5 U	5 U	5 U	25 U	5 U
1,1-Dichloroethane	UG/L	5 U	5 U	5 U	5 U	25 U	5 U
1,2-Dichloroethene(total)	UG/L	5 U	1 J	5 U	5 U	25 U	5 U
Chloroform	UG/L	5 U	5 U	5 U	5 U	25 U	5 U
1,2-Dichloroethane	UG/L	5 U	5 U	5 UJ	5 U	25 U	5 U
2-Butanone	UG/L	10 UJ	10 UJ	10 UJ	50	50 U	10 U
1,1,1-Trichloroethane	UG/L	5 U	5 U	5 U	5 U	25 U	5 U
Carbon Tetrachloride	UG/L	5 U	5 U	5 U	5 U	25 U	5 U
Vinyl Acetate	UG/L	10 U	10 U	10 U	10 U	50 U	10 U
Bromodichloromethane	UG/L	5 U	5 U	5 U	5 U	25 U	5 U
1,2-Dichloropropane	UG/L	5 U	5 U	5 U	5 U	25 U	5 U
cis-1,3-Dichloropropene	UG/L	5 U	5 U	5 U	5 U	25 U	5 U
Trichloroethene	UG/L	5 U	4 J	5 U	4 J	25 U	5 U
Dibromochloromethane	UG/L	5 U	5 U	5 U	5 U	25 U	5 U
1,1,2-Trichloroethane	UG/L	5 U	5 U	5 U	5 U	25 U	5 U
Benzene	UG/L	5 U	5 U	5 U	5 U	25 U	5 U
trans-1,3-Dichloropropene	UG/L	5 U	5 U	5 U	5 U	25 U	5 U
Bromoform	UG/L	5 U	5 U	5 U	5 U	25 U	5 U
4-Methyl-2-pentanone	UG/L	10 U	10 U	10 U	8 J	50 U	10 U
2-Hexanone	UG/L	10 U	10 U	10 UJ	10 U	50 U	10 U
Tetrachloroethene	UG/L	5 U	1 J	5 U	5 U	25 U	5 U
1,1,2,2-Tetrachloroethane	UG/L	5 U	5 U	5 U	5 U	25 U	5 U

TABLE M-5
VOLATILE ORGANICS ANALYSIS RESULTS
GROUNDWATER
SOUTH ANDOVER DESIGN INVESTIGATION
1990

	SAMPLE ID:	W21A	W21B	W21C	W23AR	W23AR	W23B
	DEPTH:	-	-	-	-	-	-
	AGENCY SAMPLE ID:	EJM31	EJM32	EJM33	EJM54	EJM54DL	EJM53
	DATE SAMPLED:	22-SEP-90	22-SEP-90	23-SEP-90	17-OCT-90	17-OCT-90	17-OCT-90
COMPOUND							
Toluene	UG/L	5 U	5 U	5 U	5 U	25 U	5 U
Chlorobenzene	UG/L	5 U	5 U	5 U	5 U	25 U	5 U
Ethyl Benzene	UG/L	5 U	8	5 U	5 U	25 U	5 U
Styrene	UG/L	5 U	5 U	5 U	5 U	25 U	5 U
Xylenes (Total)	UG/L	5 U	4 J	1 J	5 U	25 U	5 U
Acrolein	UG/L						
Acrylonitrile	UG/L						

TABLE M-5
VOLATILE ORGANICS ANALYSIS RESULTS
GROUNDWATER
SOUTH ANDOVER DESIGN INVESTIGATION
1990

SAMPLE ID:		W23C	W23C	W26A
DEPTH:		-	-	-
AGENCY SAMPLE ID:		EJM38	EJM43	EJM30
DATE SAMPLED:		24-SEP-90	25-SEP-90	22-SEP-90
COMPOUND				
Chloromethane	UG/L	10 U	10. U	10 U
Bromomethane	UG/L	10 U	10. U	10 U
Vinyl Chloride	UG/L	10 U	10. U	10 U
Chloroethane	UG/L	10 U	10. U	10 UJ
Methylene Chloride	UG/L	24	5. U	5 U
Acetone	UG/L	10 U	14. J	10 UJ
Carbon Disulfide	UG/L	5 U	5. U	5 U
1,1-Dichloroethene	UG/L	5 U	5. U	5 U
1,1-Dichloroethane	UG/L	5 U	5. U	5 U
1,2-Dichloroethene(total)	UG/L	5 U	5. U	5 U
Chloroform	UG/L	5 U	5. U	5 U
1,2-Dichloroethane	UG/L	5 U	5. U	5 UJ
2-Butanone	UG/L	10 UJ	10. UJ	10 UJ
1,1,1-Trichloroethane	UG/L	5 U	1. J	5 U
Carbon Tetrachloride	UG/L	5 U	5. U	5 U
Vinyl Acetate	UG/L	10 U	10. U	10 U
Bromodichloromethane	UG/L	5 U	5. U	5 U
1,2-Dichloropropane	UG/L	5 U	5. U	5 U
cis-1,3-Dichloropropene	UG/L	5 U	5. U	5 U
Trichloroethene	UG/L	5 U	5. U	5 U
Dibromochloromethane	UG/L	5 U	5. U	5 U
1,1,2-Trichloroethane	UG/L	5 U	5. U	5 U
Benzene	UG/L	5 U	5. U	5 U
trans-1,3-Dichloropropene	UG/L	5 U	5. U	5 U
Bromoform	UG/L	5 U	5. U	5 U
4-Methyl-2-pentanone	UG/L	10 U	1.0 J	10 U
2-Hexanone	UG/L	10 U	10. U	10 UJ
Tetrachloroethene	UG/L	5 U	5. U	5 U
1,1,2,2-Tetrachloroethane	UG/L	5 U	5. U	5 U

TABLE M-5
VOLATILE ORGANICS ANALYSIS RESULTS
GROUNDWATER
SOUTH ANDOVER DESIGN INVESTIGATION
1990

	SAMPLE ID:	W23C	W23C	W26A
	DEPTH:	-	-	-
	AGENCY SAMPLE ID:	EJM38	EJM43	EJM30
	DATE SAMPLED:	24-SEP-90	25-SEP-90	22-SEP-90
COMPOUND				
Toluene	UG/L	5 U	5. U	5 U
Chlorobenzene	UG/L	5 U	5. U	5 U
Ethyl Benzene	UG/L	5 U	5. U	5 U
Styrene	UG/L	5 U	5. U	5 U
Xylenes (Total)	UG/L	5 U	5. U	5 U
Acrolein	UG/L			
Acrylonitrile	UG/L			

TABLE M-6
SEMI-VOLATILE ORGANICS ANALYSIS RESULTS
GROUNDWATER
SOUTH ANDOVER DESIGN INVESTIGATION
1990

SAMPLE ID:		B6AR	B6AR	B6BR	B6BR	B7BR	RW1
DEPTH:		-	-	-	-	-	-
AGENCY SAMPLE ID:		EJM50	EJM51	EJM47	EJM48	EJM56	EJM27
DATE SAMPLED:		17-OCT-90	17-OCT-90	16-OCT-90	16-OCT-90	18-OCT-90	21-SEP-90
COMPOUND							
Phenol	UG/L	10 U	10 U	10 U	10 U	20 UJ	0.880 U
bis(2-Chloroethyl) ether	UG/L	10 U	10 U	10 U	10 U	20 UJ	1.040 U
2-Chlorophenol	UG/L	10 U	10 U	10 U	10 U	20 UJ	0.600 U
1,3-Dichlorobenzene	UG/L	10 U	10 U	10 U	10 U	20 UJ	0.770 U
1,4-Dichlorobenzene	UG/L	10 U	10 U	10 U	10 U	20 UJ	0.620 U
Benzyl alcohol	UG/L	10 U	10 U	10 U	10 U	20 UJ	1.520 U
1,2-Dichlorobenzene	UG/L	10 U	10 U	10 U	10 U	20 UJ	1.100 U
2-Methylphenol	UG/L	10 U	10 U	10 U	10 U	20 UJ	1.080 U
bis(2-Chloroisopropyl) ether	UG/L	10 U	10 U	10 U	10 U	20 UJ	0.940 U
4-Methylphenol	UG/L	10 U	10 U	10 U	10 U	20 UJ	1.180 U
N-Nitrosodinpropylamine	UG/L	10 U	10 U	10 U	10 U	20 UJ	1.030 U
Hexachloroethane	UG/L	10 U	10 U	10 U	10 U	20 UJ	2.610 U
Nitrobenzene	UG/L	10 U	10 U	10 U	10 U	20 UJ	0.670 U
Isophorone	UG/L	10 U	10 U	10 U	10 U	20 UJ	0.820 U
2-Nitrophenol	UG/L	10 U	10 U	10 U	10 U	20 UJ	0.430 U
2,4-Dimethylphenol	UG/L	10 U	10 U	10 U	10 U	20 UJ	3.770 U
Benzoic acid	UG/L	50 U	50 U	50 U	50 U	100 UJ	6.340 U
bis(2-Chloroethoxy) methane	UG/L	10 U	10 U	10 U	10 U	20 UJ	1.160 U
2,4-Dichlorophenol	UG/L	10 U	10 U	10 U	10 U	20 UJ	0.310 U
1,2,4-Trichlorobenzene	UG/L	10 U	10 U	10 U	10 U	20 UJ	0.850 U
Naphthalene	UG/L	10 U	10 U	10 U	10 U	20 UJ	0.730 U
4-Chloroaniline	UG/L	10 U	10 U	10 U	10 U	20 UJ	0.780 U
Hexachlorobutadiene	UG/L	10 U	10 U	10 U	10 U	20 UJ	1.800 U
4-Chloro-3-methylphenol	UG/L	10 U	10 U	10 U	10 U	20 UJ	0.580 U
2-Methylnaphthalene	UG/L	10 U	10 U	10 U	10 U	20 UJ	0.660 U
Hexachlorocyclopentadiene	UG/L	10 U	10 U	10 U	10 U	20 UJ	0.870 UJ
2,4,6-Trichlorophenol	UG/L	10 U	10 U	10 U	10 U	20 UJ	1.140 U
2,4,5-Trichlorophenol	UG/L	50 U	50 U	50 U	50 U	100 UJ	0.840 U
2-Chloronaphthalene	UG/L	10 U	10 U	10 U	10 U	20 UJ	0.860 U

TABLE M-6
SEMI-VOLATILE ORGANICS ANALYSIS RESULTS
GROUNDWATER
SOUTH ANDOVER DESIGN INVESTIGATION
1990

	SAMPLE ID:	B6AR	B6AR	B6BR	B6BR	B7BR	RW1
	DEPTH:	-	-	-	-		-
	AGENCY SAMPLE ID:	EJM50	EJM51	EJM47	EJM48	EJM56	EJM27
	DATE SAMPLED:	17-OCT-90	17-OCT-90	16-OCT-90	16-OCT-90	18-OCT-90	21-SEP-90
COMPOUND							
2-Nitroaniline	UG/L	50 U	50 U	50 U	50 U	100 UJ	0.620 U
Dimethylphthalate	UG/L	10 U	10 U	10 U	10 U	20 UJ	18.380 UJ
Acenaphthylene	UG/L	10 U	10 U	10 U	10 U	20 UJ	0.990 U
2,6-Dinitrotoluene	UG/L	10 U	10 U	10 U	10 U	20 UJ	0.430 U
3-Nitroaniline	UG/L	50 U	50 U	50 U	50 U	100 UJ	2.820 UJ
Acenaphthene	UG/L	10 U	10 U	10 U	10 U	20 UJ	0.920 U
2,4-Dinitrophenol	UG/L	50 U	50 U	50 U	50 U	100 UJ	18.730 U
4-Nitrophenol	UG/L	50 U	50 U	50 UJ	50 U	100 UJ	1.020 U
Dibenzofuran	UG/L	10 U	10 U	10 U	10 U	20 UJ	0.750 U
2,4-Dinitrotoluene	UG/L	10 U	10 U	10 UJ	10 U	20 UJ	1.080 U
Diethylphthalate	UG/L	10 U	10 U	10 U	10 U	20 UJ	24.500 U
4-Chlorophenyl-phenyl ether	UG/L	10 U	10 U	10 U	10 U	20 UJ	0.910 UJ
Fluorene	UG/L	10 U	10 U	10 U	10 U	20 UJ	0.540 U
4-Nitroaniline	UG/L	50 U	50 U	50 U	50 U	100 UJ	1.670 U
4,6-Dinitro-2-methylphenol	UG/L	50 U	50 U	50 U	50 U	100 UJ	11.830 UJ
N-nitrosodiphenylamine	UG/L	10 U	10 U	10 U	10 U	20 UJ	2.550 U
4-Bromophenyl-phenylether	UG/L	10 U	10 U	10 U	10 U	20 UJ	0.710 U
Hexachlorobenzene	UG/L	10 U	10 U	10 U	10 U	20 UJ	6.530 U
Pentachlorophenol	UG/L	50 U	50 U	50 U	50 U	100 UJ	1.200 U
Phenanthrene	UG/L	10 U	10 U	10 U	10 U	20 UJ	0.870 U
Anthracene	UG/L	10 U	10 U	10 U	10 U	20 UJ	1.210 U
Di-n-butylphthalate	UG/L	10 U	10 U	10 U	10 U	20 UJ	1.810 U
Fluoranthene	UG/L	10 U	10 U	10 U	10 U	20 UJ	0.830 U
Pyrene	UG/L	10 U	10 U	10 U	10 U	20 UJ	0.680 U
Butylbenzylphthalate	UG/L	10 U	10 U	10 U	10 U	20 UJ	3.050 U
3,3-Dichlorobenzidine	UG/L	20 U	20 U	20 U	20 U	40 UJ	3.640 U
Benzo(a)anthracene	UG/L	10 U	10 U	10 U	10 U	20 UJ	1.020 U
Chrysene	UG/L	10 U	10 U	10 U	10 U	20 UJ	0.810 U
bis(2-Ethylhexyl)phthalate	UG/L	10 U	10 U	10 U	10 U	20 UJ	2.000 U

TABLE M-6
SEMI-VOLATILE ORGANICS ANALYSIS RESULTS
GROUNDWATER
SOUTH ANDOVER DESIGN INVESTIGATION
1990

	SAMPLE ID:	B6AR	B6AR	B6BR	B6BR	B7BR	RW1
	DEPTH:	-	-	-	-	-	-
	AGENCY SAMPLE ID:	EJM50	EJM51	EJM47	EJM48	EJM56	EJM27
	DATE SAMPLED:	17-OCT-90	17-OCT-90	16-OCT-90	16-OCT-90	18-OCT-90	21-SEP-90
COMPOUND							
Di-n-octylphthalate	UG/L	10 U	10 U	10 U	10 U	20 UJ	0.690 U
Benzo(b)fluoranthene	UG/L	10 U	10 U	10 U	10 U	20 UJ	0.560 U
Benzo(k)fluoranthene	UG/L	10 U	10 U	10 U	10 U	20 UJ	0.780 U
Benzo(a)pyrene	UG/L	10 U	10 U	10 U	10 U	20 UJ	0.910 U
Indeno(1,2,3-cd)pyrene	UG/L	10 U	10 U	10 U	10 U	20 UJ	0.540 UJ
Dibenzo(a,h)anthracene	UG/L	10 U	10 U	10 U	10 U	20 UJ	0.660 U
Benzo(g,h,i)perylene	UG/L	10 U	10 U	10 U	10 U	20 UJ	0.750 UJ
Carbazole	UG/L						

TABLE M-6
SEMI-VOLATILE ORGANICS ANALYSIS RESULTS
GROUNDWATER
SOUTH ANDOVER DESIGN INVESTIGATION
1990

SAMPLE ID:		RW1	RW3	RW3	RW4	RW6	W1CR
DEPTH:		-	0-0	0-0	0-0	-	-
AGENCY SAMPLE ID:		EJM28	EJM23	EJM24	EJM25	EJM26	EJM52
DATE SAMPLED:		21-SEP-90	21-SEP-90	18-SEP-90	21-SEP-90	21-SEP-90	17-OCT-90
COMPOUND							
Phenol	UG/L	0.880 U	0.880 U	0.880 U	0.880 U	0.880 U	10 U
bis(2-Chloroethyl) ether	UG/L	1.040 U	1.040 U	1.040 U	1.040 U	1.040 U	10 U
2-Chlorophenol	UG/L	0.600 U	0.600 U	0.600 U	0.600 U	0.600 U	10 U
1,3-Dichlorobenzene	UG/L	0.770 U	0.770 U	0.770 U	0.770 U	0.770 U	10 U
1,4-Dichlorobenzene	UG/L	0.620 U	0.620 U	0.620 U	0.620 U	0.620 U	10 U
Benzyl alcohol	UG/L	1.520 U	1.520 U	1.520 U	1.520 U	1.520 U	10 U
1,2-Dichlorobenzene	UG/L	1.100 U	1.100 U	1.100 U	1.100 U	1.100 U	10 U
2-Methylphenol	UG/L	1.080 U	1.080 U	1.080 U	1.080 U	1.080 U	10 U
bis(2-Chloroisopropyl) ether	UG/L	0.940 U	0.940 U	0.940 U	0.940 U	0.940 U	10 U
4-Methylphenol	UG/L	1.180 U	1.180 U	1.180 U	1.180 U	1.180 U	10 U
N-Nitrosodinpropylamine	UG/L	1.030 U	1.030 U	1.030 U	1.030 U	1.030 U	10 U
Hexachloroethane	UG/L	2.610 U	2.610 U	2.610 U	2.610 U	2.610 U	10 U
Nitrobenzene	UG/L	0.670 U	0.670 U	0.670 U	0.670 U	0.670 U	10 U
Isophorone	UG/L	0.820 U	0.820 U	0.820 U	0.820 U	0.820 U	10 U
2-Nitrophenol	UG/L	0.430 U	0.430 U	0.430 U	0.430 U	0.430 U	10 U
2,4-Dimethylphenol	UG/L	3.770 U	3.770 U	3.770 U	3.770 U	3.770 U	10 U
Benzoic acid	UG/L	6.340 U	6.340 U	6.340 U	6.340 U	6.340 U	50 U
bis(2-Chloroethoxy) methane	UG/L	1.160 U	1.160 U	1.160 U	1.160 U	1.160 U	10 U
2,4-Dichlorophenol	UG/L	0.310 U	0.310 U	0.310 U	0.310 U	0.310 U	10 U
1,2,4-Trichlorobenzene	UG/L	0.850 U	0.850 U	0.850 U	0.850 U	0.850 U	10 U
Naphthalene	UG/L	0.730 U	0.730 U	0.730 U	0.730 U	0.730 U	10 U
4-Chloroaniline	UG/L	0.780 U	0.780 U	0.780 U	0.780 U	0.780 U	10 U
Hexachlorobutadiene	UG/L	1.800 U	1.800 U	1.800 U	1.800 U	1.800 U	10 U
4-Chloro-3-methylphenol	UG/L	0.580 U	0.580 U	0.580 U	0.580 U	0.580 U	10 U
2-Methylnaphthalene	UG/L	0.660 U	0.660 U	0.660 U	0.660 U	0.660 U	10 U
Hexachlorocyclopentadiene	UG/L	0.870 UJ	0.870 UJ	0.870 UJ	0.870 UJ	0.870 UJ	10 U
2,4,6-Trichlorophenol	UG/L	1.140 U	1.140 U	1.140 U	1.140 U	1.140 U	10 U
2,4,5-Trichlorophenol	UG/L	0.840 U	0.840 U	0.840 U	0.840 U	0.840 U	50 U
2-Chloronaphthalene	UG/L	0.860 U	0.860 U	0.860 U	0.860 U	0.860 U	10 U

TABLE M-6
SEMI-VOLATILE ORGANICS ANALYSIS RESULTS
GROUNDWATER
SOUTH ANDOVER DESIGN INVESTIGATION
1990

SAMPLE ID:		RW1	RW3	RW3	RW4	RW6	W1CR
DEPTH:		-	0-0	0-0	0-0	-	-
AGENCY SAMPLE ID:		EJM28	EJM23	EJM24	EJM25	EJM26	EJM52
DATE SAMPLED:		21-SEP-90	21-SEP-90	18-SEP-90	21-SEP-90	21-SEP-90	17-OCT-90
COMPOUND							
2-Nitroaniline	UG/L	0.620 U	0.620 U	0.620 U	0.620 U	0.620 U	50 U
Dimethylphthalate	UG/L	18.380 U	18.380 UJ	18.380 UJ	18.380 UJ	18.380 UJ	10 U
Acenaphthylene	UG/L	0.990 U	0.990 U	0.990 U	0.990 U	0.990 U	10 U
2,6-Dinitrotoluene	UG/L	0.430 U	0.430 U	0.430 U	0.430 U	0.430 U	10 U
3-Nitroaniline	UG/L	2.820 U	2.820 UJ	2.820 UJ	2.820 UJ	2.820 UJ	50 U
Acenaphthene	UG/L	0.920 U	0.920 U	0.920 U	0.920 U	0.920 U	10 U
2,4-Dinitrophenol	UG/L	18.730 U	18.730 U	18.730 U	18.730 U	18.730 U	50 U
4-Nitrophenol	UG/L	1.020 U	1.020 U	1.020 U	1.020 U	1.020 U	50 U
Dibenzofuran	UG/L	0.750 U	0.750 U	0.750 U	0.750 U	0.750 U	10 U
2,4-Dinitrotoluene	UG/L	1.080 U	1.080 U	1.080 U	1.080 U	1.080 U	10 U
Diethylphthalate	UG/L	24.500 U	24.500 U	24.500 U	24.500 U	24.500 U	10 U
4-Chlorophenyl-phenyl ether	UG/L	0.910 UJ	0.910 UJ	0.910 UJ	0.910 UJ	0.910 UJ	10 U
Fluorene	UG/L	0.540 U	0.540 U	0.540 U	0.540 U	0.540 U	10 U
4-Nitroaniline	UG/L	1.670 U	1.670 U	1.670 U	1.670 U	1.670 UJ	50 U
4,6-Dinitro-2-methylphenol	UG/L	11.830 UJ	11.830 UJ	11.830 UJ	11.830 U	11.830 U	50 U
N-nitrosodiphenylamine	UG/L	2.550 U	2.550 U	2.550 U	2.550 UJ	2.550 U	10 U
4-Bromophenyl-phenylether	UG/L	0.710 U	0.710 U	0.710 U	0.710 U	0.710 U	10 U
Hexachlorobenzene	UG/L	6.530 U	6.530 U	6.530 U	6.530 U	6.530 U	10 U
Pentachlorophenol	UG/L	1.200 U	1.200 U	1.200 U	1.200 U	1.200 U	50 U
Phenanthrene	UG/L	0.870 U	0.870 U	0.870 U	0.870 U	0.870 U	10 U
Anthracene	UG/L	1.210 U	1.210 U	1.210 U	1.210 U	1.210 U	10 U
Di-n-butylphthalate	UG/L	1.810 U	1.810 U	1.810 U	1.810 U	1.810 U	10 U
Fluoranthene	UG/L	0.830 U	0.830 U	0.830 U	0.830 U	0.830 U	10 U
Pyrene	UG/L	0.680 U	0.680 U	0.680 U	0.680 U	0.680 U	10 U
Butylbenzylphthalate	UG/L	3.050 U	3.050 U	3.050 U	3.050 U	3.050 U	10 U
3,3-Dichlorobenzidine	UG/L	3.640 U	3.640 U	3.640 U	3.640 U	3.640 U	20 U
Benzo(a)anthracene	UG/L	1.020 U	1.020 U	1.020 U	1.020 U	1.020 U	10 U
Chrysene	UG/L	0.810 U	0.810 U	0.810 U	0.810 U	0.810 U	10 U
bis(2-Ethylhexyl)phthalate	UG/L	0.890 U	0.89 U	0.890 U	0.89 U	1.000 U	10 U

TABLE M-6
SEMI-VOLATILE ORGANICS ANALYSIS RESULTS
GROUNDWATER
SOUTH ANDOVER DESIGN INVESTIGATION
1990

	SAMPLE ID:	RW1	RW3	RW3	RW4	RW6	W1CR
	DEPTH:	-	0-0	0-0	0-0	-	-
	AGENCY SAMPLE ID:	EJM28	EJM23	EJM24	EJM25	EJM26	EJM52
	DATE SAMPLED:	21-SEP-90	21-SEP-90	18-SEP-90	21-SEP-90	21-SEP-90	17-OCT-90
COMPOUND							
Di-n-octylphthalate	UG/L	0.690 U	0.690 U	0.690 U	0.690 U	0.690 U	10 U
Benzo(b)fluoranthene	UG/L	0.560 U	0.560 U	0.560 U	0.560 U	0.560 U	10 U
Benzo(k)fluoranthene	UG/L	0.780 U	0.780 U	0.780 U	0.780 U	0.780 U	10 U
Benzo(a)pyrene	UG/L	0.910 U	0.910 U	0.910 U	0.910 U	0.910 U	10 U
Indeno(1,2,3-cd)pyrene	UG/L	0.540 UJ	0.540 UJ	0.540 UJ	0.540 UJ	0.540 UJ	10 U
Dibenzo(a,h)anthracene	UG/L	0.660 U	0.660 U	0.660 U	0.660 U	0.660 U	10 U
Benzo(g,h,i)perylene	UG/L	0.750 UJ	0.750 UJ	0.750 UJ	0.750 UJ	0.750 UJ	10 U
Carbazole	UG/L						

TABLE M-6
SEMI-VOLATILE ORGANICS ANALYSIS RESULTS
GROUNDWATER
SOUTH ANDOVER DESIGN INVESTIGATION
1990

SAMPLE ID:		W9A	W16A	W16A	W17A	W19A	W21A
DEPTH:		-	-	-	-	-	-
AGENCY SAMPLE ID:		EJM59	EJM34	EJM35	EJM46	EJM45	EJM31
DATE SAMPLED:		18-OCT-90	23-SEP-90	23-SEP-90	16-OCT-90	16-OCT-90	22-SEP-90
COMPOUND							
Phenol	UG/L	10 U	10 U	10 U	10 U	10 U	10 U
bis(2-Chloroethyl) ether	UG/L	10 U	10 U	10 U	10 U	10 U	10 U
2-Chlorophenol	UG/L	10 U	10 U	10 U	10 U	10 U	10 U
1,3-Dichlorobenzene	UG/L	10 U	10 U	10 U	10 U	10 U	10 U
1,4-Dichlorobenzene	UG/L	10 U	10 U	10 U	10 U	10 U	10 U
Benzyl alcohol	UG/L	10 UJ	10 U	10 U	10 U	10 U	10 U
1,2-Dichlorobenzene	UG/L	10 U	10 U	10 U	10 U	10 U	10 U
2-Methylphenol	UG/L	10 U	10 U	10 U	10 U	10 U	10 U
bis(2-Chloroisopropyl) ether	UG/L	10 U	10 U	10 U	10 U	10 U	10 U
4-Methylphenol	UG/L	10 U	10 UJ	10 UJ	10 U	10 U	10 UJ
N-Nitrosodinpropylamine	UG/L	10 U	10 U	10 U	10 U	10 U	10 U
Hexachloroethane	UG/L	10 U	10 U	10 U	10 U	10 U	10 U
Nitrobenzene	UG/L	10 U	10 U	10 U	10 U	10 U	10 U
Isophorone	UG/L	10 U	10 U	10 U	10 U	10 U	10 U
2-Nitrophenol	UG/L	10 U	10 U	10 U	10 U	10 U	10 U
2,4-Dimethylphenol	UG/L	10 U	10 U	10 U	10 U	10 U	10 U
Benzoic acid	UG/L	50 U	50 U	50 U	50 U	50 U	50 U
bis(2-Chloroethoxy) methane	UG/L	10 U	10 U	10 U	10 U	10 U	10 U
2,4-Dichlorophenol	UG/L	10 U	10 U	10 U	10 U	10 U	10 U
1,2,4-Trichlorobenzene	UG/L	10 U	10 U	10 U	10 U	10 U	10 U
Naphthalene	UG/L	10 U	10 U	10 U	10 U	10 U	10 U
4-Chloroaniline	UG/L	10 U	10 UJ	10 UJ	10 U	10 U	10 UJ
Hexachlorobutadiene	UG/L	10 U	10 U	10 U	10 U	10 U	10 U
4-Chloro-3-methylphenol	UG/L	10 U	10 U	10 U	10 U	10 U	10 U
2-Methylnaphthalene	UG/L	10 U	10 U	10 U	10 U	10 U	10 U
Hexachlorocyclopentadiene	UG/L	10 U	10 U	10 U	10 U	10 U	10 U
2,4,6-Trichlorophenol	UG/L	10 U	10 U	10 U	10 U	10 U	10 U
2,4,5-Trichlorophenol	UG/L	50 U	50 U	50 U	50 U	50 U	50 U
2-Chloronaphthalene	UG/L	10 U	10 U	10 U	10 U	10 U	10 U

TABLE M-6
SEMI-VOLATILE ORGANICS ANALYSIS RESULTS
GROUNDWATER
SOUTH ANDOVER DESIGN INVESTIGATION
1990

	SAMPLE ID:	W9A	W16A	W16A	W17A	W19A	W21A
	DEPTH:	-	-	-	-		
	AGENCY SAMPLE ID:	EJM59	EJM34	EJM35	EJM46	EJM45	EJM31
	DATE SAMPLED:	18-OCT-90	23-SEP-90	23-SEP-90	16-OCT-90	16-OCT-90	22-SEP-90
COMPOUND							
2-Nitroaniline	UG/L	50 U	50 U	50 U	50 U	50 U	50 U
Dimethylphthalate	UG/L	10 U	10 U	10 U	10 U	10 U	10 U
Acenaphthylene	UG/L	10 U	10 U	10 U	10 U	10 U	10 U
2,6-Dinitrotoluene	UG/L	10 U	10 U	10 U	10 U	10 U	10 U
3-Nitroaniline	UG/L	50 U	50 UJ	50 UJ	50 U	50 U	50 UJ
Acenaphthene	UG/L	10 U	10 U	10 U	10 U	10 U	10 U
2,4-Dinitrophenol	UG/L	50 UJ	50 U	50 U	50 U	50 U	50 U
4-Nitrophenol	UG/L	50 U	50 U	50 U	50 U	50 U	50 U
Dibenzofuran	UG/L	10 U	10 U	10 U	10 U	10 U	10 U
2,4-Dinitrotoluene	UG/L	10 U	10 U	10 U	10 U	10 U	10 U
Diethylphthalate	UG/L	10 U	10 U	10 U	10 U	10 U	10 U
4-Chlorophenyl-phenyl ether	UG/L	10 U	10 U	10 U	10 U	10 U	10 U
Fluorene	UG/L	10 U	10 U	10 U	10 U	10 U	10 U
4-Nitroaniline	UG/L	50 U	50 UJ	50 UJ	50 U	50 U	50 UJ
4,6-Dinitro-2-methylphenol	UG/L	50 U	50 U	50 U	50 U	50 U	50 U
N-nitrosodiphenylamine	UG/L	10 U	10 U	10 U	10 U	10 U	10 U
4-Bromophenyl-phenylether	UG/L	10 U	10 U	10 U	10 U	10 U	10 U
Hexachlorobenzene	UG/L	10 U	10 U	10 U	10 U	10 U	10 U
Pentachlorophenol	UG/L	50 U	50 U	50 U	50 U	50 U	50 U
Phenanthrene	UG/L	10 U	10 U	10 U	10 U	10 U	10 U
Anthracene	UG/L	10 U	10 U	10 U	10 U	10 U	10 U
Di-n-butylphthalate	UG/L	10 U	10 U	10 U	10 U	10 U	10 U
Fluoranthene	UG/L	10 U	10 U	10 U	10 U	10 U	10 U
Pyrene	UG/L	10 U	10 U	10 U	10 U	10 U	10 U
Butylbenzylphthalate	UG/L	10 U	10 U	10 U	10 U	10 U	10 U
3,3-Dichlorobenzidine	UG/L	20 UJ	20 U	20 U	20 U	20 U	20 U
Benzo(a)anthracene	UG/L	10 U	10 U	10 U	10 U	10 U	10 U
Chrysene	UG/L	10 U	10 U	10 U	10 U	10 U	10 U
bis(2-Ethylhexyl)phthalate	UG/L	10 U	10 U	2 J	5 J	9 J	2 J

TABLE M-6
SEMI-VOLATILE ORGANICS ANALYSIS RESULTS
GROUNDWATER
SOUTH ANDOVER DESIGN INVESTIGATION
1990

	SAMPLE ID:	W9A	W16A	W16A	W17A	W19A	W21A
	DEPTH:	-	-	-	-	-	-
	AGENCY SAMPLE ID:	EJM59	EJM34	EJM35	EJM46	EJM45	EJM31
	DATE SAMPLED:	18-OCT-90	23-SEP-90	23-SEP-90	16-OCT-90	16-OCT-90	22-SEP-90
COMPOUND							
Di-n-octylphthalate	UG/L	10 U	10 U	10 U	10 U	10 U	10 U
Benzo(b)fluoranthene	UG/L	10 U	10 U	10 U	10 U	10 U	10 U
Benzo(k)fluoranthene	UG/L	10 U	10 UJ	10 UJ	10 U	10 U	10 UJ
Benzo(a)pyrene	UG/L	10 U	10 U	10 U	10 U	10 U	10 U
Indeno(1,2,3-cd)pyrene	UG/L	10 U	10 U	10 U	10 U	10 U	10 U
Dibenzo(a,h)anthracene	UG/L	10 U	10 U	10 U	10 U	10 U	10 U
Benzo(g,h,i)perylene	UG/L	10 U	10 U	10 U	10 U	10 U	10 U
Carbazole	UG/L						

TABLE M-6
SEMI-VOLATILE ORGANICS ANALYSIS RESULTS
GROUNDWATER
SOUTH ANDOVER DESIGN INVESTIGATION
1990

SAMPLE ID:		W21B	W21C	W23AR	W23B	W23C	W23C
DEPTH:		-	-	-	-	-	-
AGENCY SAMPLE ID:		EJM32	EJM33	EJM54	EJM53	EJM38	EJM43
DATE SAMPLED:		22-SEP-90	23-SEP-90	17-OCT-90	17-OCT-90	24-SEP-90	25-SEP-90
COMPOUND							
Phenol	UG/L	10 U	10 U	20 UJ	10 U	10 U	10. UR
bis(2-Chloroethyl) ether	UG/L	10 U	10 U	20 UJ	10 U	10 U	10. UR
2-Chlorophenol	UG/L	10 U	10 U	20 UJ	10 U	10 U	10. UR
1,3-Dichlorobenzene	UG/L	10 U	10 U	20 UJ	10 U	10 U	10. UR
1,4-Dichlorobenzene	UG/L	10 U	10 U	20 UJ	10 U	10 U	10. UR
Benzyl alcohol	UG/L	10 U	10 U	20 UJ	10 U	10 U	10. UR
1,2-Dichlorobenzene	UG/L	10 U	10 U	20 UJ	10 U	10 U	10. UR
2-Methylphenol	UG/L	10 U	10 U	20 UJ	10 U	10 U	10. UR
bis(2-Chloroisopropyl) ether	UG/L	10 U	10 U	20 UJ	10 U	10 U	10. UR
4-Methylphenol	UG/L	10 UJ	10 UJ	20 UJ	10 U	10 UJ	10. UR
N-Nitrosodinpropylamine	UG/L	10 U	10 U	20 UJ	10 U	10 U	10. UR
Hexachloroethane	UG/L	10 U	10 U	20 UJ	10 U	10 U	10. UR
Nitrobenzene	UG/L	10 U	10 U	20 UJ	10 U	10 U	10. UR
Isophorone	UG/L	10 U	10 U	20 UJ	10 U	10 U	10. UR
2-Nitrophenol	UG/L	10 U	10 U	20 UJ	10 U	10 U	10. UR
2,4-Dimethylphenol	UG/L	10 U	10 U	20 UJ	10 U	10 U	10. UR
Benzoic acid	UG/L	50 U	50 U	100 UJ	50 U	50 U	50. UJR
bis(2-Chloroethoxy) methane	UG/L	10 U	10 U	20 UJ	10 U	10 U	10. UR
2,4-Dichlorophenol	UG/L	10 U	10 U	20 UJ	10 U	10 U	10. UR
1,2,4-Trichlorobenzene	UG/L	10 U	10 U	20 UJ	10 U	10 U	10. UR
Naphthalene	UG/L	10 U	10 U	20 UJ	10 U	10 U	10. UR
4-Chloroaniline	UG/L	10 UJ	10 UJ	20 UJ	10 U	10 UJ	10. UR
Hexachlorobutadiene	UG/L	10 U	10 U	20 UJ	10 U	10 U	10. UR
4-Chloro-3-methylphenol	UG/L	10 U	10 U	20 UJ	10 U	10 U	10. UR
2-Methylnaphthalene	UG/L	10 U	10 U	20 UJ	10 U	10 U	10. UR
Hexachlorocyclopentadiene	UG/L	10 U	10 U	20 UJ	10 U	10 U	10. UR
2,4,6-Trichlorophenol	UG/L	10 U	10 U	20 UJ	10 U	10 U	10. UR
2,4,5-Trichlorophenol	UG/L	50 U	50 U	100 UJ	50 U	50 U	50. UR
2-Chloronaphthalene	UG/L	10 U	10 U	20 UJ	10 U	10 U	10. UR

TABLE M-6
SEMI-VOLATILE ORGANICS ANALYSIS RESULTS
GROUNDWATER
SOUTH ANDOVER DESIGN INVESTIGATION
1990

SAMPLE ID:		W21B	W21C	W23AR	W23B	W23C	W23C
DEPTH:		-	-	-	-	-	-
AGENCY SAMPLE ID:		EJM32	EJM33	EJM54	EJM53	EJM38	EJM43
DATE SAMPLED:		22-SEP-90	23-SEP-90	17-OCT-90	17-OCT-90	24-SEP-90	25-SEP-90
COMPOUND							
2-Nitroaniline	UG/L	50 U	50 U	100 UJ	50 U	50 U	50. UR
Dimethylphthalate	UG/L	10 U	10 U	20 UJ	10 U	10 U	10. UR
Acenaphthylene	UG/L	10 U	10 U	20 UJ	10 U	10 U	10. UR
2,6-Dinitrotoluene	UG/L	10 U	10 U	20 UJ	10 U	10 U	10. UR
3-Nitroaniline	UG/L	50 UJ	50 UJ	100 UJ	50 U	50 UJ	50. UR
Acenaphthene	UG/L	10 U	10 U	20 UJ	10 U	10 U	10. UR
2,4-Dinitrophenol	UG/L	50 U	50 U	100 UJ	50 U	50 U	50. UR
4-Nitrophenol	UG/L	50 U	50 U	100 UJ	50 U	50 U	50. UR
Dibenzofuran	UG/L	10 U	10 U	20 UJ	10 U	10 U	10. UR
2,4-Dinitrotoluene	UG/L	10 U	10 U	20 UJ	10 U	10 U	10. UR
Diethylphthalate	UG/L	10 U	10 U	20 UJ	10 U	10 U	10. UR
4-Chlorophenyl-phenyl ether	UG/L	10 U	10 U	20 UJ	10 U	10 U	10. UR
Fluorene	UG/L	10 U	10 U	20 UJ	10 U	10 U	10. UR
4-Nitroaniline	UG/L	50 UJ	50 UJ	100 UJ	50 U	50 UJ	50. UR
4,6-Dinitro-2-methylphenol	UG/L	50 U	50 U	100 UJ	50 U	50 U	50. UR
N-nitrosodiphenylamine	UG/L	10 U	10 U	20 UJ	10 U	10 U	10. UR
4-Bromophenyl-phenylether	UG/L	10 U	10 U	20 UJ	10 U	10 U	10. UR
Hexachlorobenzene	UG/L	10 U	10 U	20 UJ	10 U	10 U	10. UR
Pentachlorophenol	UG/L	50 U	50 U	100 UJ	50 U	50 U	50. UR
Phenanthrene	UG/L	10 U	10 U	20 UJ	10 U	10 U	10. UR
Anthracene	UG/L	10 U	10 U	20 UJ	10 U	10 U	10. UR
Di-n-butylphthalate	UG/L	10 U	10 U	20 UJ	10 U	10 U	10. UR
Fluoranthene	UG/L	10 U	10 U	20 UJ	10 U	10 U	10. UR
Pyrene	UG/L	10 U	10 U	20 UJ	10 U	10 U	10. UR
Butylbenzylphthalate	UG/L	10 U	10 U	20 UJ	10 U	10 U	10. UR
3,3-Dichlorobenzidine	UG/L	20 U	20 U	40 UJ	20 U	20 U	20. UR
Benzo(a)anthracene	UG/L	10 U	10 U	20 UJ	10 U	10 U	10. UR
Chrysene	UG/L	10 U	10 U	20 UJ	10 U	10 U	10. UR
bis(2-Ethylhexyl)phthalate	UG/L	10 U	10 U	20 UJ	6 J	1 J	44. R

TABLE M-6
SEMI-VOLATILE ORGANICS ANALYSIS RESULTS
GROUNDWATER
SOUTH ANDOVER DESIGN INVESTIGATION
1990

	SAMPLE ID:	W21B	W21C	W23AR	W23B	W23C	W23C
	DEPTH:	-	-	-	-	-	-
	AGENCY SAMPLE ID:	EJM32	EJM33	EJM54	EJM53	EJM38	EJM43
	DATE SAMPLED:	22-SEP-90	23-SEP-90	17-OCT-90	17-OCT-90	24-SEP-90	25 SEP-90
COMPOUND							
Di-n-octylphthalate	UG/L	10 U	10 U	20 UJ	10 U	10 U	10. UR
Benzo(b)fluoranthene	UG/L	10 U	10 U	20 UJ	10 U	10 U	10. UR
Benzo(k)fluoranthene	UG/L	10 UJ	10 UJ	20 UJ	10 U	10 UJ	10. UR
Benzo(a)pyrene	UG/L	10 U	10 U	20 UJ	10 U	10 U	10. UR
Indeno(1,2,3-cd)pyrene	UG/L	10 U	10 U	20 UJ	10 U	10 U	10. UJR
Dibenzo(a,h)anthracene	UG/L	10 U	10 U	20 UJ	10 U	10 U	10. UR
Benzo(g,h,i)perylene	UG/L	10 U	10 U	20 UJ	10 U	10 U	10. UR
Carbazole	UG/L						

TABLE M-6
SEMI-VOLATILE ORGANICS ANALYSIS RESULTS
GROUNDWATER
SOUTH ANDOVER DESIGN INVESTIGATION
1990

SAMPLE ID:	W26A
DEPTH:	-
AGENCY SAMPLE ID:	EJM30
DATE SAMPLED:	22-SEP-90

COMPOUND		
Phenol	UG/L	10 U
bis(2-Chloroethyl) ether	UG/L	10 U
2-Chlorophenol	UG/L	10 U
1,3-Dichlorobenzene	UG/L	10 U
1,4-Dichlorobenzene	UG/L	10 U
Benzyl alcohol	UG/L	10 U
1,2-Dichlorobenzene	UG/L	10 U
2-Methylphenol	UG/L	10 U
bis(2-Chloroisopropyl) ether	UG/L	10 U
4-Methylphenol	UG/L	10 UJ
N-Nitrosodinpropylamine	UG/L	10 U
Hexachloroethane	UG/L	10 U
Nitrobenzene	UG/L	10 U
Isophorone	UG/L	10 U
2-Nitrophenol	UG/L	10 U
2,4-Dimethylphenol	UG/L	10 U
Benzoic acid	UG/L	50 U
bis(2-Chloroethoxy) methane	UG/L	10 U
2,4-Dichlorophenol	UG/L	10 U
1,2,4-Trichlorobenzene	UG/L	10 U
Naphthalene	UG/L	10 U
4-Chloroaniline	UG/L	10 UJ
Hexachlorobutadiene	UG/L	10 U
4-Chloro-3-methylphenol	UG/L	10 U
2-Methylnaphthalene	UG/L	10 U
Hexachlorocyclopentadiene	UG/L	10 U
2,4,6-Trichlorophenol	UG/L	10 U
2,4,5-Trichlorophenol	UG/L	50 U
2-Chloronaphthalene	UG/L	10 U

TABLE M-6
SEMI-VOLATILE ORGANICS ANALYSIS RESULTS
GROUNDWATER
SOUTH ANDOVER DESIGN INVESTIGATION
1990

SAMPLE ID:	W26A
DEPTH:	-
AGENCY SAMPLE ID:	EJM30
DATE SAMPLED:	22-SEP-90

COMPOUND		
2-Nitroaniline	UG/L	50 U
Dimethylphthalate	UG/L	10 U
Acenaphthylene	UG/L	10 U
2,6-Dinitrotoluene	UG/L	10 U
3-Nitroaniline	UG/L	50 UJ
Acenaphthene	UG/L	10 U
2,4-Dinitrophenol	UG/L	50 U
4-Nitrophenol	UG/L	50 U
Dibenzofuran	UG/L	10 U
2,4-Dinitrotoluene	UG/L	10 U
Diethylphthalate	UG/L	10 U
4-Chlorophenyl-phenyl ether	UG/L	10 U
Fluorene	UG/L	10 U
4-Nitroaniline	UG/L	50 UJ
4,6-Dinitro-2-methylphenol	UG/L	50 U
N-nitrosodiphenylamine	UG/L	10 U
4-Bromophenyl-phenylether	UG/L	10 U
Hexachlorobenzene	UG/L	10 U
Pentachlorophenol	UG/L	50 U
Phenanthrene	UG/L	10 U
Anthracene	UG/L	10 U
Di-n-butylphthalate	UG/L	10 U
Fluoranthene	UG/L	10 U
Pyrene	UG/L	10 U
Butylbenzylphthalate	UG/L	10 U
3,3-Dichlorobenzidine	UG/L	20 U
Benzo(a)anthracene	UG/L	10 U
Chrysene	UG/L	10 U
bis(2-Ethylhexyl)phthalate	UG/L	10 U

TABLE M-6
SEMI-VOLATILE ORGANICS ANALYSIS RESULTS
GROUNDWATER
SOUTH ANDOVER DESIGN INVESTIGATION
1990

SAMPLE ID:	W26A
DEPTH:	-
AGENCY SAMPLE ID:	EJM30
DATE SAMPLED:	22-SEP-90

COMPOUND		
Di-n-octylphthalate	UG/L	10 U
Benzo(b)fluoranthene	UG/L	10 U
Benzo(k)fluoranthene	UG/L	10 UJ
Benzo(a)pyrene	UG/L	10 U
Indeno(1,2,3-cd)pyrene	UG/L	10 U
Dibenzo(a,h)anthracene	UG/L	10 U
Benzo(g,h,i)perylene	UG/L	10 U
Carbazole	UG/L	

TABLE M-7
PESTICIDE/PCB ANALYSIS RESULTS
GROUNDWATER
SOUTH ANDOVER DESIGN INVESTIGATION
1990

SAMPLE ID:		RW1	RW1	RW3	RW3	RW4	RW6
DEPTH:		-	-	0-0	0-0	0-0	-
AGENCY SAMPLE ID:		EJM27	EJM28	EJM23	EJM24	EJM25	EJM26
DATE SAMPLED:		21-SEP-90	21-SEP-90	21-SEP-90	18-SEP-90	21-SEP-90	21-SEP-90
COMPOUND							
alpha-BHC	UG/L	0.0023 U	0.0023 U	0.0023 U	0.0023 U	0.0023 U	0.0023 U
beta-BHC	UG/L	0.0016 U	0.0016 U	0.0016 U	0.0016 U	0.0016 U	0.0016 U
delta-BHC	UG/L	0.0010 U	0.0010 U	0.0010 U	0.0010 U	0.0010 U	0.0010 U
gamma-BHC (lindane)	UG/L	0.0041 U	0.0041 U	0.0041 U	0.0041 U	0.0041 U	0.0041 U
Heptachlor	UG/L	0.0092 U	0.0092 U	0.0092 U	0.0092 U	0.0092 U	0.0092 U
Aldrin	UG/L	0.0018 U	0.0018 U	0.0018 U	0.0018 U	0.0018 U	0.0018 U
Heptachlor epoxide	UG/L	0.0054 U	0.0054 U	0.0054 U	0.0054 U	0.0054 U	0.0054 U
Endosulfan I	UG/L	0.0026 U	0.0026 U	0.0026 U	0.0026 U	0.0026 U	0.0026 U
Dieldrin	UG/L	0.0025 U	0.0025 U	0.0025 U	0.0025 U	0.0025 U	0.0025 U
4,4-DDE	UG/L	0.0038 U	0.0038 U	0.0038 U	0.0038 U	0.0038 U	0.0038 U
Endrin	UG/L	0.0170 U	0.0170 U	0.0170 U	0.0170 U	0.0170 U	0.0170 U
Endosulfan II	UG/L	0.0072 U	0.0072 U	0.0072 U	0.0072 U	0.0072 U	0.0072 U
4,4-DDD	UG/L	0.0011 U	0.0011 U	0.0011 U	0.0011 U	0.0011 U	0.0011 U
Endosulfan sulfate	UG/L	0.0940 U	0.0940 U	0.0940 U	0.0940 U	0.0940 U	0.0940 U
4,4-DDT	UG/L	0.0083 U	0.0083 U	0.0083 U	0.0083 U	0.0083 U	0.0083 U
Methoxychlor	UG/L	0.0160 U	0.0160 U	0.0160 U	0.0160 U	0.0160 U	0.0160 U
Endrin ketone	UG/L	0.0012 U	0.0012 U	0.0012 U	0.0012 U	0.0012 U	0.0012 U
alpha-Chlordane	UG/L	0.0077 U	0.0077 U	0.0077 U	0.0077 U	0.0077 U	0.0077 U
gamma-Chlordane	UG/L	0.0060 U	0.0060 U	0.0060 U	0.0060 U	0.0060 U	0.0060 U
Toxaphene	UG/L	0.2500 U	0.2500 U	0.2500 U	0.2500 U	0.2500 U	0.2500 U
Aroclor-1016	UG/L	0.0490 U	0.0490 U	0.0490 U	0.0490 U	0.0490 U	0.0490 U
Aroclor-1221	UG/L	0.0490 U	0.0490 U	0.0490 U	0.0490 U	0.0490 U	0.0490 U
Aroclor-1232	UG/L	0.0490 U	0.0490 U	0.0490 U	0.0490 U	0.0490 U	0.0490 U
Aroclor-1242	UG/L	0.0490 U	0.0490 U	0.0490 U	0.0490 U	0.0490 U	0.0490 U
Aroclor-1248	UG/L	0.0490 U	0.0490 U	0.0490 U	0.0490 U	0.0490 U	0.0490 U
Aroclor-1254	UG/L	0.0490 U	0.0490 U	0.0490 U	0.0490 U	0.0490 U	0.0490 U
Aroclor-1260	UG/L	0.0490 U	0.0490 U	0.0490 U	0.0490 U	0.0490 U	0.0490 U

TABLE M-7
PESTICIDE/PCB ANALYSIS RESULTS
GROUNDWATER
SOUTH ANDOVER DESIGN INVESTIGATION
1990

	SAMPLE ID:	W15B	W16A	W16A	W23AR	W23C	W23C
	DEPTH:	-	-	-	-	-	-
	AGENCY SAMPLE ID:	EJM71	EJM34	EJM35	EJM54	EJM38	EJM43
	DATE SAMPLED:	08-NOV-90	23-SEP-90	23-SEP-90	17-OCT-90	24-SEP-90	25-SEP-90
COMPOUND							
alpha-BHC	UG/L	.050 U	0.10 U	0.050 U	0.050 UJ	0.050 U	.050 UJ
beta-BHC	UG/L	.050 U	0.10 U	0.050 U	0.050 UJ	0.050 U	.050 UJ
delta-BHC	UG/L	.050 U	0.10 U	0.050 U	0.050 UJ	0.050 U	.050 UJ
gamma-BHC (lindane)	UG/L	.050 U	0.10 U	0.050 U	0.050 UJ	0.050 U	.050 UJ
Heptachlor	UG/L	.050 U	0.10 U	0.050 U	0.050 UJ	0.050 U	.050 UJ
Aldrin	UG/L	.050 U	0.10 U	0.050 U	0.050 UJ	0.050 U	.050 UJ
Heptachlor epoxide	UG/L	.050 U	0.10 U	0.050 U	0.050 UJ	0.050 U	.050 UJ
Endosulfan I	UG/L	.050 U	0.10 U	0.050 U	0.050 UJ	0.050 U	.050 UJ
Dieldrin	UG/L	.100 U	0.20 U	0.10 U	0.10 UJ	0.10 U	.10 UJ
4,4-DDE	UG/L	.100 U	0.20 U	0.10 U	0.10 UJ	0.10 U	.10 UJ
Endrin	UG/L	.100 U	0.20 U	0.10 U	0.10 UJ	0.10 U	.10 UJ
Endosulfan II	UG/L	.100 U	0.20 U	0.10 U	0.10 UJ	0.10 U	.10 UJ
4,4-DDD	UG/L	.100 U	0.20 U	0.10 U	0.10 UJ	0.10 U	.10 UJ
Endosulfan sulfate	UG/L	.100 U	0.20 U	0.10 U	0.10 UJ	0.10 U	.10 UJ
4,4-DDT	UG/L	.100 U	0.20 U	0.10 U	0.10 UJ	0.10 U	.10 UJ
Methoxychlor	UG/L	.50 U	1.0 U	0.50 U	0.50 UJ	0.50 U	.50 UJ
Endrin ketone	UG/L	.100 U	0.20 U	0.10 U	0.10 UJ	0.10 U	.10 UJ
alpha-Chlordane	UG/L	.50 U	1.0 U	0.50 U	0.50 UJ	0.50 U	.50 UJ
gamma-Chlordane	UG/L	.50 U	1.0 U	0.50 U	0.50 UJ	0.50 U	.50 UJ
Toxaphene	UG/L	1.0 U	2.0 U	1.0 U	1.0 UJ	1.0 U	1.0 UJ
Aroclor-1016	UG/L	.50 U	1.0 U	0.50 U	0.50 UJ	0.50 U	.50 UJ
Aroclor-1221	UG/L	.50 U	1.0 U	0.50 U	0.50 UJ	0.50 U	.50 UJ
Aroclor-1232	UG/L	.50 U	1.0 U	0.50 U	0.50 UJ	0.50 U	.50 UJ
Aroclor-1242	UG/L	.50 U	1.0 U	0.50 U	0.50 UJ	0.50 U	.50 UJ
Aroclor-1248	UG/L	.50 U	1.0 U	0.50 U	0.50 UJ	0.50 U	.50 UJ
Aroclor-1254	UG/L	1.0 U	2.0 U	1.0 U	1.0 UJ	1.0 U	1.0 UJ
Aroclor-1260	UG/L	1.0 U	2.0 U	1.0 U	1.0 UJ	1.0 U	1.0 UJ

TABLE M-8
INORGANIC ANALYSIS RESULTS
GROUNDWATER
SOUTH ANDOVER DESIGN INVESTIGATION
1990

	SAMPLE ID:	B4C	B6AR	B6AR	B6BR	B6BR	B7A
	DEPTH:	-	-	-	-	-	-
	AGENCY SAMPLE ID:	MEHD67	MEHD50	MEHD51	MEHD47	MEHD48	MEHD68
	DATE SAMPLED:	05-NOV-90	17-OCT-90	17-OCT-90	16-OCT-90	16-OCT-90	05-NOV-90
COMPOUND							
Aluminum	UG/L	64.00 BJ	31.2 BJ	41.8 BJ	44.1 BJ	27.0 UJ	32.00 U
Antimony	UG/L	59.00 U	45.0 U	45.0 U	45.0 U	45.0 U	59.00 U
Arsenic	UG/L	6.00 U	2.0 U	2.0 U	2.0 U	2.0 U	6.00 U
Barium	UG/L	73.20 B	6.5 B	106 B	132 B	130 B	148.00 B
Beryllium	UG/L	1.00 U	1.3 B	1.0 U	1.0 U	1.0 U	1.00 U
Cadmium	UG/L	2.00 U	5.0 U	5.0 U	5.0 U	5.0 U	2.00 U
Calcium	UG/L	12800.00	1200 B	35300	60400	61600	37200.00
Chromium	UG/L	5.00 U	6.0 U	6.0 U	6.0 U	6.0 U	5.00 U
Cobalt	UG/L	5.00 U	10.0 U	10.0 U	10.0 U	10.0 U	5.00 U
Copper	UG/L	7.00 U	5.0 U	6.6 BJ	5.0 U	5.0 U	7.00 U
Iron	UG/L	12.00 UJ	14.0 U	15.2 B	30.2 B	30.2 B	12.00 UJ
Lead	UG/L	3.00 UJ	1.0 U	1.0 U	1.0 U	1.0 U	3.00 UJ
Magnesium	UG/L	570.00 B	157 B	15500	12200	12400	9360.00
Manganese	UG/L	2.00 U	8.0 U	115	188	188	414.00
Mercury	UG/L	.20 U	0.20 U	0.20 U	0.20 U	0.20 U	.20 U
Nickel	UG/L	12.00 U	9.0 U	11.3 B	9.0 U	9.0 U	12.00 U
Potassium	UG/L	17100.00	122 U	18100	1580 B	1550 B	838.00 B
Selenium	UG/L	4.00 U	2.0 U	2.0 UJ	2.0 UJ	2.0 UJ	4.00 U
Silver	UG/L	3.00 U	4.0 U	4.0 U	4.0 U	4.0 U	3.00 U
Sodium	UG/L	28900.00 J	1290 U	5320	7470	7470	4790.00 BJ
Thallium	UG/L	1.00 UJ	1.0 U	1.0 U	1.0 U	1.0 UJ	1.00 UJ
Vanadium	UG/L	3.00 U	4.0 U	4.0 U	4.0 U	4.0 U	3.00 U
Zinc	UG/L	33.90 J	10.3 BJ	16.6 BJ	7.3 BJ	7.0 B	647.00
Cyanide	UG/L		10.0 U	10.0 U	10.0 U	10.0 U	
Boron	UG/L						
Lithium	UG/L						
Molybdenum	UG/L						
Strontium	UG/L						
Titanium	UG/L						

TABLE M-8
INORGANIC ANALYSIS RESULTS
GROUNDWATER
SOUTH ANDOVER DESIGN INVESTIGATION
1990

	SAMPLE ID:	B7BR	B7C	B7C	B8A	RW1	RW1
	DEPTH:	-	-	-	-	-	-
	AGENCY SAMPLE ID:	MEHD56	MEHD57	MEHD65	MEHD70	90ZD06S58	90ZD06S59
	DATE SAMPLED:	18-OCT-90	18-OCT-90	05-NOV-90	06-NOV-90	21-SEP-90	21-SEP-90
COMPOUND							
Aluminum	UG/L	35.0 BJ	29.7 BJ	55.60 BJ	32.00 U	80.0 U	80.0 U
Antimony	UG/L	45.0 U	45.0 U	59.00 U	59.00 U	2.0 U	2.0 U
Arsenic	UG/L	2.0 U	5.8 B	6.00 B	6.00 U	2.0 U	2.0 U
Barium	UG/L	58.2 B	40.8 B	84.40 B	215.00	28.4	6.0 U
Beryllium	UG/L	1.0 U	1.0 U	1.00 U	1.00 U	1.0 U	1.0 U
Cadmium	UG/L	5.0 U	5.0 U	2.00 U	2.00 U	0.2 U	0.2 U
Calcium	UG/L	26500	33300	29300.00	44000.00	34400.0	500.0 U
Chromium	UG/L	6.0 U	6.0 U	5.00 U	5.00 U	8.0 U	8.0 U
Cobalt	UG/L	10.0 U	10.0 U	5.00 U	5.00 U	6.0 U	6.0 U
Copper	UG/L	5.0 U	5.0 U	7.00 U	7.00 U	6.0 U	6.0 U
Iron	UG/L	14.9 B	14.8 B	27.80 BJ	6740.00 J	708.0 U	80.0 U
Lead	UG/L	1.2 B	1.7 B	3.00 UJ	3.00 U	2.0 U	2.0 U
Magnesium	UG/L	5080	4910 B	4430.00 B	9170.00	7210.0	100.0 U
Manganese	UG/L	61.1	24.8	26.20	1030.00	127.0	5.0 U
Mercury	UG/L	0.20 U	0.20 U	.20 U	.20 U	0.2 U	0.1 U
Nickel	UG/L	9.0 U	9.0 U	12.00 U	29.20 B	15.0 U	15.0 U
Potassium	UG/L	5120	1310 B	973.00 B	25200.00	5000.0 U	5000.0 U
Selenium	UG/L	20.0 UJ	2.0 UJ	4.00 U	14.60	2.0 U	2.0 U
Silver	UG/L	4.0 U	4.0 U	3.00 U	3.00 U	6.0 U	6.0 U
Sodium	UG/L	15300	24500	19900.00 J	11800.00 J	4830.0	1000.0 U
Thallium	UG/L	1.0 U	1.0 U	1.00 UJ	1.00 UJ	2.0 U	2.0 U
Vanadium	UG/L	4.0 U	4.0 U	3.00 U	3.00 U	5.0 U	5.0 U
Zinc	UG/L	8.8 BJ	4.8 BJ	50.40 J	4080.00	40.0 U	40.0 U
Cyanide	UG/L	10.0 U	10.0 U	10.00 U	10.00 U	5 U	5 U
Boron	UG/L					80.0 U	80.0 U
Lithium	UG/L					10.0 U	10.0 U
Molybdenum	UG/L					15.0 U	15.0 U
Strontium	UG/L					60.6	10.0 U
Titanium	UG/L					25.0 U	25.0 U

TABLE M-8
INORGANIC ANALYSIS RESULTS
GROUNDWATER
SOUTH ANDOVER DESIGN INVESTIGATION
1990

	SAMPLE ID:	RW3	RW3	RW4	RW6	W1A	W1B
	DEPTH:	-	-	-	-	-	
	AGENCY SAMPLE ID:	90ZD06S55	90ZD06S54	90ZD06S56	90ZD06S57	MEHD63	MEHD61
	DATE SAMPLED:	21-SEP-90	21-SEP-90	21-SEP-90	21-SEP-90	02-NOV-90	01-NOV-90
COMPOUND							
Aluminum	UG/L	80.0 U	80.0 U	80.0 U	80.0 U	39.20 BJ	32.00 U
Antimony	UG/L	2.0 U	2.0 U	2.0 U	2.0 U	59.00 U	59.00 U
Arsenic	UG/L	2.0 U	2.0 U	2.0 U	2.0 U	6.00 U	6.00 U
Barium	UG/L	16.2	14.5	126.0	12.8	82.00 B	129.00 B
Beryllium	UG/L	1.0 U	1.0 U	1.0 U	1.0 U	1.00 U	1.00 U
Cadmium	UG/L	0.2 U	0.2 U	0.2 U	0.2 U	2.00 U	2.00 U
Calcium	UG/L	30900.0	31000.0 U	67000.0	23800.0	56700.00	76300.00
Chromium	UG/L	8.0 U	8.0 U	8.0 U	8.0 U	5.00 U	3.00 U
Cobalt	UG/L	6.0 U	6.0 U	6.0 U	6.0 U	5.00 U	5.00 U
Copper	UG/L	6.0 U	6.0 U	6.0 U	6.0 U	7.00 U	7.00 U
Iron	UG/L	80.5	80.0 U	3700.0	80.0 U	416.00 J	58.20 BJ
Lead	UG/L	2.0 U	2.0 U	2.0 U	2.0 U	3.00 UJ	3.00 U
Magnesium	UG/L	7910.0	7920.0	12200.0	4770.0	14000.00	18800.00
Manganese	UG/L	22.7 U	22.5	381.0 U	5.0 U	75.90	387.00
Mercury	UG/L	0.3 U	0.2 U	0.2 U	0.2 U	.20 U	.20 U
Nickel	UG/L	15.0 U	15.0 U	20.3 U	15.0 U	12.00 U	12.00 U
Potassium	UG/L	5000.0 U	5000.0 U	5000.0 U	5000.0 U	721.00 U	721.00 U
Selenium	UG/L	2.0 U	2.0 U	2.0 U	2.0 U	4.00 U	4.00 U
Silver	UG/L	6.0 U	6.0 U	6.0 U	6.0 U	3.00 U	3.00 U
Sodium	UG/L	3000.0	2990.0	3200.0 U	2440.0 U	4680.00 BJ	4680.00 BJ
Thallium	UG/L	2.0 U	2.0 U	2.0 U	2.0 U	1.00 UJ	1.00 UJ
Vanadium	UG/L	5.0 U	5.0 U	5.0 U	5.0 U	3.00 U	3.00 U
Zinc	UG/L	40.0 U	40.0 U	166.0 U	59.3	2210.00	601.00
Cyanide	UG/L	5 U	5 U	5 U	5 U	10.00 UR	10.00 UR
Boron	UG/L	80.0 U	80.0 U	80.0 U	80.0 U		
Lithium	UG/L	10.0 U	10.0 U	10.0 U	10.0 U		
Molybdenum	UG/L	15.0 U	15.0 U	15.0 U	15.0 U		
Strontium	UG/L	55.3	55.3	82.5	39.0		
Titanium	UG/L	25.0 U	25.0 U	25.0 U	25.0 U		

TABLE M-8
INORGANIC ANALYSIS RESULTS
GROUNDWATER
SOUTH ANDOVER DESIGN INVESTIGATION
1990

	SAMPLE ID:	W1B	W1CR	W9A	W9A	W15B	W16A
	DEPTH:	-	-	-	-	-	
	AGENCY SAMPLE ID:	MEHD62	MEHD52	MEHD59	MEHD66	MEHD71	MEHD34
	DATE SAMPLED:	01-NOV-90	17-OCT-90	18-OCT-90	05-NOV-90	08-NOV-90	23-SEP-90
COMPOUND							
Aluminum	UG/L	36.40 B	41.8 BJ	59.4 BJ	32.00 U	65.20 BJ	29.00 U
Antimony	UG/L	59.00 U	45.0 U	45.0 U	59.00 U	59.00 U	10.00 U
Arsenic	UG/L	6.00 U	2.6 B	4.1 B	6.00 U	6.00 U	2.00 U
Barium	UG/L	7.00 U	38.6 B	44.9 B	83.10 B	59.80 B	25.30 B
Beryllium	UG/L	1.00 U	1.0 U	1.0 U	1.00 U	1.00 U	1.00 U
Cadmium	UG/L	2.00 U	5.0 U	5.0 U	2.00 U	2.00 U	2.00 U
Calcium	UG/L	297.00 B	36400	32600	27300.00	57800.00	47100.00
Chromium	UG/L	5.00 U	6.0 U	6.0 U	5.00 U	5.00 U	5.00 U
Cobalt	UG/L	5.00 U	10.0 U	10.0 U	5.00 U	5.00 U	4.00 U
Copper	UG/L	7.00 U	5.0 U	5.0 U	7.00 U	7.00 U	3.00 U
Iron	UG/L	12.00 UJ	14.8 B	44.0 B	12.00 UJ	849.00 J	61.10 BJ
Lead	UG/L	3.00 U	1.2 B	1.6 B	3.00 UJ	3.00 UJ	2.00 U
Magnesium	UG/L	52.90 B	7180	4960 B	5130.00	17500.00	9420.00
Manganese	UG/L	2.00 U	40.0	29.7	31.80	194.00	7.00 U
Mercury	UG/L	.20 U	0.20 U	0.20 U	.20 U	.20 U	0.20 U
Nickel	UG/L	12.00 U	9.0 U	9.0 U	12.00 U	12.00 U	5.00 U
Potassium	UG/L	721.00 U	1160 B	1920 B	721.00 U	1340.00 B	780.00 U
Selenium	UG/L	4.00 U	2.0 UJ	2.0 UJ	4.00 U	4.00 U	2.00 U
Silver	UG/L	3.00 U	4.0 U	4.0 U	3.00 U	3.00 U	4.00 U
Sodium	UG/L	643.00 BJ	9440	23300	2880.00 BJ	7410.00 J	2960.00 B
Thallium	UG/L	1.00 UJ	1.0 U	1.0 B	1.00 UJ	1.00 UJ	2.00 UJ
Vanadium	UG/L	3.00 U	4.0 U	4.0 U	3.00 U	3.00 U	3.00 U
Zinc	UG/L	13.30 B	7.0 BJ	8.8 BJ	201.00	44.00 J	19.70 BJ
Cyanide	UG/L	10.00 UR	10.0 U	10.0 U	10.00 U	10.00 UR	10.00 U
Boron	UG/L						
Lithium	UG/L						
Molybdenum	UG/L						
Strontium	UG/L						
Titanium	UG/L						

TABLE M-8
INORGANIC ANALYSIS RESULTS
GROUNDWATER
SOUTH ANDOVER DESIGN INVESTIGATION
1990

SAMPLE ID:		W16A	W17A	W19A	W21A	W21B	W21C
DEPTH:		-	-	-	-	-	-
AGENCY SAMPLE ID:		MEHD35	MEHD46	MEHD45	MEHD31	MEHD32	MEHD33
DATE SAMPLED:		23-SEP-90	16-OCT-90	16-OCT-90	22-SEP-90	22-SEP-90	23-SEP-90
COMPOUND							
Aluminum	UG/L	29.00 U	41.9 BJ	39.6 BJ	29.00 U	29.00 U	29.00 U
Antimony	UG/L	10.00 U	45.0 U	45.0 U	10.00 U	10.00 U	10.00 U
Arsenic	UG/L	2.00 U	2.0 U	2.0 U	2.00 U	78.40	7.20 B
Barium	UG/L	26.40 B	171 B	140 B	39.70 B	31.40 B	25.30 B
Beryllium	UG/L	1.00 U	1.0 U	1.0 U	1.00 U	1.00 U	1.00 U
Cadmium	UG/L	2.00 U	5.0 U	5.0 U	2.00 U	2.00 U	2.00 U
Calcium	UG/L	48100.00	52700	15800	13200.00	59100.00	45600.00
Chromium	UG/L	5.00 U	6.0 U	6.0 U	5.00 U	5.00 U	5.00 U
Cobalt	UG/L	4.00 U	10.0 U	10.0 U	4.00 U	4.00 U	4.00 U
Copper	UG/L	3.00 U	10.7 BJ	5.0 U	3.00 U	3.00 U	3.00 U
Iron	UG/L	23.40 BJ	31.7 B	22.1 B	89.50 BJ	743.00	39.80 BJ
Lead	UG/L	2.00 U	1.4 BJ	1.0 U	4.50 J	2.00 U	3.00 BJ
Magnesium	UG/L	9610.00	10600	3690 B	3140.00 B	13200.00	8620.00
Manganese	UG/L	7.00 U	472	32.0	11.10 B	632.00	26.40
Mercury	UG/L	0.20 U	0.20 U	0:20 U	0.20 U	0.20 U	0.20 U
Nickel	UG/L	5.00 U	9.0 U	9.0 U	5.80 BJ	6.50 BJ	5.00 U
Potassium	UG/L	780.00 U	3740 B	6450	2030.00 B	1990.00 B	780.00 U
Selenium	UG/L	2.00 UJ	2.0 UJ	2.0 UJ	2.00 U	2.00 UJ	2.00 U
Silver	UG/L	4.00 U	4.0 U	4.0 U	4.00 U	4.00 U	4.00 U
Sodium	UG/L	2990.00 B	6960	6240	6090.00	3300.00 B	3580.00 B
Thallium	UG/L	2.00 UJ	1.0 UJ	1.0 U	2.00 UJ	2.00 UJ	2.00 UJ
Vanadium	UG/L	3.00 U	4.0 U	4.0 U	7.40 B	3.00 U	3.00 U
Zinc	UG/L	28.10 J	51.1	45.8	29.50 J	18.10 BJ	18.30 BJ
Cyanide	UG/L	10.00 U	10.0 U	10.0 U	10.00 U	10.00 U	10.00 U
Boron	UG/L						
Lithium	UG/L						
Molybdenum	UG/L						
Strontium	UG/L						
Titanium	UG/L						

TABLE M-8
INORGANIC ANALYSIS RESULTS
GROUNDWATER
SOUTH ANDOVER DESIGN INVESTIGATION
1990

SAMPLE ID:		W23AR	W23B	W23C	W23C	W26A
DEPTH:		-	-	-	-	-
AGENCY SAMPLE ID:		MEHD54	MEHD53	MEHD38	MEHD43	MEHD30
DATE SAMPLED:		17-OCT-90	17-OCT-90	24-SEP-90	25-SEP-90	22-SEP-90
COMPOUND						
Aluminum	UG/L	40.2 BJ	32.6 BJ	72.50 B	41.50 BJ	29.00 U
Antimony	UG/L	45.0 U	45.0 U	10.00 U	47.00 U	10.00 U
Arsenic	UG/L	15.3	2.0 U	4.00 B	1.0 R	2.00 U
Barium	UG/L	94.8 B	155 B	21.50 B	19.80 BJ	60.60 B
Beryllium	UG/L	1.0 U	1.0 U	1.00 U	1.00 U	1.00 U
Cadmium	UG/L	5.0 U	5.0 U	2.00 U	3.00 U	2.00 U
Calcium	UG/L	105000	42000	35800.00	411.00 BJ	8120.00
Chromium	UG/L	6.0 U	6.0 U	5.00 U	2.00 U	5.00 U
Cobalt	UG/L	10.0 U	10.0 U	4.00 U	5.00 U	4.00 U
Copper	UG/L	5.0 U	5.0 U	3.00 U	4.50 BJ	3.00 U
Iron	UG/L	16500	184	438.00	40.90 BJ	49.70 BJ
Lead	UG/L	1.8 BJ	1.0 U	2.00 U	1.00 U	2.00 U
Magnesium	UG/L	8080	9230	6390.00	141.00 BJ	1020.00 B
Manganese	UG/L	814	254	30.90	2.80 B	15.60
Mercury	UG/L	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U
Nickel	UG/L	9.0 U	9.0 U	5.00 U	10.00 U	16.60 BJ
Potassium	UG/L	1420 B	859 B	833.00 B	451.00 BJ	3490.00 B
Selenium	UG/L	2.0 U	2.0 UJ	2.00 UJ	2.00 U	2.20 BJ
Silver	UG/L	4.0 U	4.0 U	4.00 U	2.00 U	4.00 U
Sodium	UG/L	13100	2310 B	5570.00	437.00 BJ	1830.00 B
Thallium	UG/L	1.0 UJ	1.0 U	2.00 UJ	2.60 BJ	10.00 UJB
Vanadium	UG/L	4.0 U	4.0 U	3.00 U	1.00 U	3.00 U
Zinc	UG/L	18.0 BJ	5.0 BJ	18.20 BJ	17.50 BJ	46.30 BJ
Cyanide	UG/L	10.0 U	10.0 U	10.00 U	1.50 U	10.00 U
Boron	UG/L					
Lithium	UG/L					
Molybdenum	UG/L					
Strontium	UG/L					
Titanium	UG/L					

TABLE M-9
WATER QUALITY RESULTS
GROUNDWATER
SOUTH ANDOVER DESIGN INVESTIGATION
1990

SAMPLE ID:		B6AR	B6AR	B6BR	B6BR	B6BR	B7BR
DEPTH:		-	-	-	-	-	-
AGENCY SAMPLE ID:		5643E-31	5643E-32	5643E-29	5643E-30	5643E-30DUP	5643E-36
DATE SAMPLED:		17-OCT-90	17-OCT-90	16-OCT-90	16-OCT-90	16-OCT-90	18-OCT-90
COMPOUND							
COD	MG/L	28.16	25.28 J	21.44 J	21.44 J	21.44 J	10.37
TDS (Total Dissolved Solids)	MG/L	20.0 U	272	249	236	236	137
TP (Total Phosphorus)	MG/L	0.05 U	.065	.106	.104	.108	.108
TSS (Total Suspended Solids)	MG/L	0.50 UJ	3 J	0.50 UJ	1.0 J	0.50 UJ	0.50 UJ

TABLE M-9
WATER QUALITY RESULTS
GROUNDWATER
SOUTH ANDOVER DESIGN INVESTIGATION
1990

	SAMPLE ID:	B7C	B8A	W1A	W1A	W1B	W1B
	DEPTH:	-	-	-	-	-	-
	AGENCY SAMPLE ID:	5643E-37	5643E-44	5643E-26	5643E-42	5643E-40	5643E-41
	DATE SAMPLED:	18-OCT-90	06-NOV-90	25-SEP-90	02-NOV-90	01-NOV-90	01-NOV-90
COMPOUND							
COD	MG/L	6.14	36.48	35.0	32.22	17.94	5.0 U
TDS (Total Dissolved Solids)	MG/L	155	321	20.0 U	305	335	20.0 U
TP (Total Phosphorus)	MG/L	.169	.440	0.05 U	.206	.085	0.05 U
TSS (Total Suspended Solids)	MG/L	22 J	173	1 J	48.0	41.0	0.50 U

TABLE M-9
WATER QUALITY RESULTS
GROUNDWATER
SOUTH ANDOVER DESIGN INVESTIGATION
1990

	SAMPLE ID:	W1CR	W9A	W9A	W15B	W16A	W16A
	DEPTH:	-	-	-	-	-	-
	AGENCY SAMPLE ID:	5643E-33	5643E-39	5643E-43	5643E-45	5643E-20	5643E-21
	DATE SAMPLED:	17-OCT-90	18-OCT-90	05-NOV-90	08-NOV-90	23-SEP-90	23-SEP-90
COMPOUND							
COD	MG/L	18.88 J	6.912	28.58	13.07	0.77	0.50 U
TDS (Total Dissolved Solids)	MG/L	97	158	110	246	201	208
TP (Total Phosphorus)	MG/L	.130	.136	.258 J	.138	.109	.157
TSS (Total Suspended Solids)	MG/L	10 J	17 J	730	557	85 J	45 J

TABLE M-9
WATER QUALITY RESULTS
GROUNDWATER
SOUTH ANDOVER DESIGN INVESTIGATION
1990

SAMPLE ID:		W17A	W19A	W21A	W21B	W21C	W23AR
DEPTH:		-	-	-	-	-	-
AGENCY SAMPLE ID:		5643E-28	5643E-27	5643E-17	5643E-18	5643E-19	5643E-35
DATE SAMPLED:		16-OCT-90	16-OCT-90	22-SEP-90	22-SEP-90	23-SEP-90	17-OCT-90
COMPOUND							
COD	MG/L	48.96 J	26.88 J	3.07		1.15	38.78
TDS (Total Dissolved Solids)	MG/L	240	128	145	293	230	371
TP (Total Phosphorus)	MG/L	.311	.084	.124	.386	.224	.162
TSS (Total Suspended Solids)	MG/L	86 J	20 J	41 J	16 J	14 J	33 J

TABLE M-9
WATER QUALITY RESULTS
GROUNDWATER
SOUTH ANDOVER DESIGN INVESTIGATION
1990

SAMPLE ID:		W23B	W23C	W26A
DEPTH:		-	-	-
AGENCY SAMPLE ID:		5643E-34	5643E-23	5643E-16
DATE SAMPLED:		17-OCT-90	24-SEP-90	22-SEP-90
COMPOUND				
COD	MG/L	6.14	2.3	11.9
TDS (Total Dissolved Solids)	MG/L	165	135	86
TP (Total Phosphorus)	MG/L	.116	.098	1.239
TSS (Total Suspended Solids)	MG/L	0.50 UJ	6 J	165 J