Formerly Utilized Sites Remedial Action Program (FUSRAP)

ADMINISTRATIVE RECORD

for Maywood, New Jersey

U.S. Department of Energy

0489-0613.1

139133

CH2M HILL Engineers Planners Economists Scientists

November 18, 1994

NAE22948.RI.RP

Ms. Angela Carpenter, Project Manager
United States Environmental Protection Agency, Region II
Federal Facilities Section, Room 2930
26 Federal Plaza
New York, New York 10278-0012

Dear Ms. Carpenter:

Subject: Maywood Chemical Company Site, Maywood, Bergen County, New Jersey: Administrative Order on Consent (Index No. II-CERCLA-70104) and Administrative Order (Index No. II-CERCLA-10105) - *Final Remedial Investigation Report*

CH2M HILL, on behalf of Stepan Company, is submitting eight (8) copies of the above *Final Remedial Investigation Report.*

Please call me with any comments or questions at (201) 316-9300.

Sincerely,

CH2M HILL

Mary S. Manto
Project Manager

dac/NJR147/031R147.WP5
cc: J. Bartlett/Stepan Company
C. Riley/Stepan Company

North Atlantic Regional Office
99 Cherry Hill Road, Suite 304
Parsippany, NJ 07054-1102
201.316.9300
FAX 201.334.5847

Final
Remedial Investigation Report

Stepan Company Property
Administrative Order
(Index No. II - CERCLA - 10105)

Sears and Adjacent Properties
Administrative Order On Consent
(Index No. II - CERCLA - 70104)

Prepared For:
United States Environmental Protection Agency
Region II

Prepared By:
CH2M HILL
Parsippany, New Jersey

On Behalf Of:
Stepan Company
Northfield, Illinois
November 1994

STEPAN COMPANY

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Executive Summary

Introduction

This remedial investigation (RI) report presents the results of the investigation and study activities conducted at the Stepan Company and Sears and Adjacent Properties (the study area) by CH2M HILL from August 1991 through November 1992 and the Focused Investigation conducted July 1993 through November 1993. The investigation of the Stepan Company property was conducted under Unilateral Administrative Order (Index No. II-CERCLA-10105) issued by the United States Environmental Protection Agency (EPA) on May 3, 1991. The investigation of the Sears and Adjacent Properties was performed under the terms of the Administrative Order on Consent (Index No. II-CERCLA 70104) entered into by EPA and Stepan Company on September 21, 1987.

The Stepan and Sears and Adjacent Properties (formerly known collectively as the Maywood and Vicinity Properties) consists of eight separate properties formerly owned by the Maywood Chemical Company and located in Maywood, Bergen County, New Jersey (Figure ES-1). The properties cover a total area of approximately 63.0 acres and are shown in Figure ES-2. The current and former name of each property, the current owner, and the approximate acreage is provided in Table ES-1.

Table ES-1
Stepan and Sears and Adjacent Properties

Property Name	Former Name	Current Owner	Approximate Acreage
Stepan Company (Stepan)	-	Stepan Company	19.0
Sears Logistical Center (Sears)	-	Jeco Corporation	27.4
Gulf	-	Cumberland Farms	0.4
Sunoco	-	Sun Refining and Marketing Company	1.7
AMP Realty Associates (AMP)	Federal Express	AMP Realty Co.	1.5
SWS Realty Associates (SWS)	Hunter Douglas	SWS Realty Co.	4.7
Federal Express	AMF Voit	Maurice Weil	4.7
DeSaussure Equipment Company, Inc. (DeSaussure)	-	William DeSaussure	3.6

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LEGEND

PROPERTY LINE

FENCE LINE

N.Y. SUSQUEHANNA & WESTERN RAILROAD

WEST HUNTER AVENUE

MAYWOOD AVENUE

BURIAL SITE 2

BURIAL SITE 1

BURIAL SITE 3

BLDG NO. 78

BLDG NO. 76

BLDG NO. 20

GARAGE

BLDG NO. 15

BLDG NO. 13

BLDG NO. 3

BLDG NO. 1

BLDG NO. 67

BLDG NO. 52

BLDG NO. 4

BLDG NO. 10

BLDG NO. 2

BLDG NO. 10-1

CONCRETE PAD

CONCRETE PAD

CONCRETE PAD

HOT OIL SHED

ELECTRIC BLDG

SEARS BLDG

WATER RESERVOIR BLDG

CONCRETE PAD

DESAUSSURE BLDG

AMP BLDG

SWS BLDG

FEDERAL EXPRESS BLDG

SUNOCO BLDG

GULF BLDG

STATE ROUTE 17

GROVE AVENUE

AVENUE

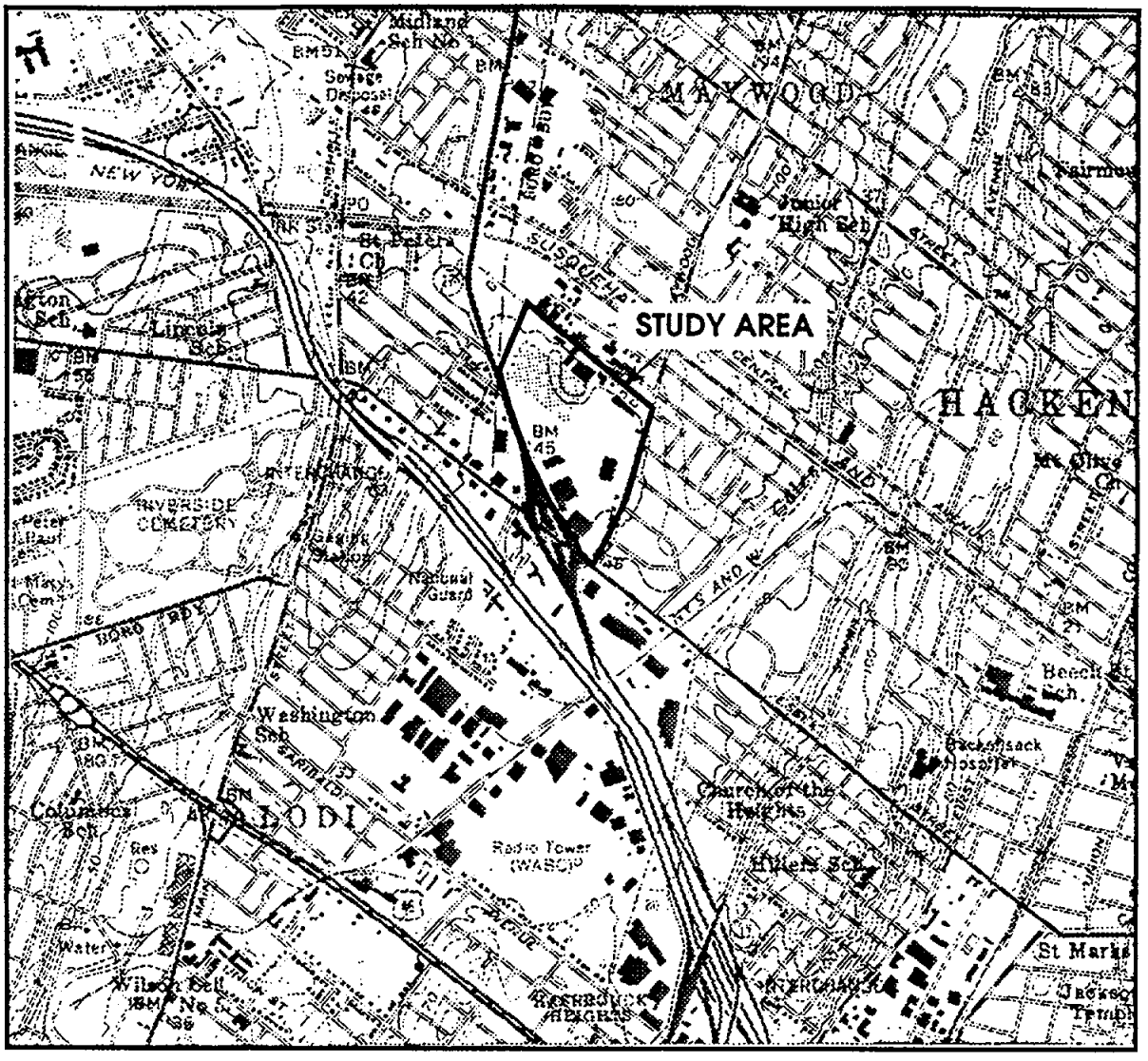
BECKER

0 200 400 600

SCALE 1"=200'

STEPAN COMPANY AND SEARS AND ADJACENT PROPERTIES RI
MAYWOOD, NEW JERSEY

FIGURE ES-2
SITE PLAN



SCALE 1:24000

1 0 1 MILE

1000 0 1000 2000 3000 4000 5000 6000 7000 FEET

1 .5 0 1 KILOMETER

CONTOUR INTERVAL 10 FEET

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Source:
HACKENSACK QUADRANGLE, NJ
7.5 minute series USGS Quadrangle maps, 1955
Photorevised 1981.

STEPAN COMPANY AND SEARS AND ADJACENT PROPERTIES RI
MAYWOOD, NEW JERSEY

Figure ES-1
STUDY AREA
LOCATION MAP

Site History and Past Investigations

The original Maywood Chemical Works was founded in 1895 and initially engaged in a "standard essence" operation involving cerium rare earth, as well as extraction of protein from leather, production of ionones, caffeine extraction, and production of lithium tablets. Later operations (1916-1957), many of which were done under government contract, involved thorium processing from monazite sands. Residues from these processing operations were used as fill in nearby areas of the property.

Stepan Company (then known as Stepan Chemical Company) purchased the property in 1959 and began to clean up thorium wastes on the property in 1963.

A 1980 radiological survey of a portion of the property revealed radiological contamination which was subsequently investigated. Surveys and soils analyses identified Thorium-232 (Th-232) and Radium-226 (Ra-226). Subsequent radiological surveys were carried out by the United States Department of Energy (DOE) under the Formerly Utilized Site Remedial Action Program (FUSRAP). Soil removal from affected residential properties was initiated in July 1984 and materials were stored on a portion of the original Maywood Chemical Company property. This property was designated as the Maywood Interim Storage Site (MISS) and transferred to DOE by Stepan in September 1985. Additional radiological investigations have been performed in the study area and surrounding properties since 1980. As of 1985, this work has been done by DOE through its contractor Bechtel National, Inc. (BNI). Although these investigations have focused on radiological contamination, some limited chemical characterization has also been performed.

In 1986, EPA through its contractor, Ebasco began to characterize chemical, nonradiological contamination on the Stepan property and surrounding areas (Maywood Vicinity Sites). The investigations conducted by DOE and EPA suggest that chemical contamination in soils involves six classes of contaminants: volatiles (mainly non-halogenated industrial solvents or gasoline components), base/neutral/acid extractable compounds (polycyclic aromatic hydrocarbons [PAHs] and phthalates), pesticides (chlorinated), heavy metals, gasoline and fuel oil contaminants, essential and ethereal oils (i.e., a-pinene, d-limonene), and caffeine.

Groundwater monitoring was also conducted by DOE and EPA. DOE's monitoring of wells at the MISS indicated contamination with moderate levels of methylene chloride, bis(2-ethylhexyl)phthalate, and tetrachloroethylene. A few wells showed high concentrations of methylene chloride, bis(2-ethylhexyl)phthalate, benzene, trans-1,2-dichloroethylene, and total organic halide. EPA's 1988 sampling revealed benzene and toluene in one well on the Stepan property. Benzene was, however, not detected in DOE's 1990 sampling of the same well. Most of the organic constituents detected in the MISS wells are organic solvents used as degreasers, dry cleaning agents, or chemical intermediates. In 1985, the first year of annual monitoring by DOE, a well upgradient of the MISS (MISS-4B) on the Stepan property showed the highest

concentrations of organics. Over time, however, these concentrations appear to have decreased and some transport appears to have occurred in a downgradient direction.

In 1990, DOE collected surface water and sediment samples from Westerly Brook upstream of Saddle River and from Lodi Brook. The volatile analysis showed low concentrations of 1,2-dichloroethylene, trichloroethylene, and 1,1,2,2-tetrachloroethane at a sampling location downgradient of the MISS in Westerly Brook. No volatiles were detected downstream of this location, where the brook discharges into the Saddle River. Metals concentrations in sediments were comparable upstream and downstream.

No active municipal water supply wells were identified by a well search within a 1-mile radius of the property. The status of 30 private wells around the site is discussed in further detail on page ES-32.

Field Investigation

The RI field investigation, performed in general accordance with EPA-approved work plans, was composed of an overburden soils investigation, an overburden groundwater investigation, a bedrock groundwater investigation, and a surface water and sediment investigation. The Focused Investigation, performed in general accordance with the EPA-approved RI work plan amendment, was composed of an additional round of groundwater sampling, a source delineation study, a hydraulic evaluation, and an expanded well search. The objectives and components of each investigation are discussed below. A chronology of field investigation activities is presented in Table ES-2. Analytical parameters for each environmental media are shown in Tables ES-3 and ES-4.

Overburden Soils Investigation

The objectives of the overburden soils investigation were as follows:

- To determine the presence and levels of indicator compounds (a-pinene, d-limonene, and caffeine) and chemical constituents in the overburden soils
- To obtain measurements that indicate the vertical and lateral distribution of contaminant concentrations over the study area in order to provide a basis for estimating the areal extent and the depth of the overburden to be remediated
- To measure soil properties affecting the mobility of contaminants in the overburden materials

Table ES-2
Chronology of Field Investigation Activities

August 29, 1991	Groundwater sampling for pH and chlorides to determine stainless steel grade used for well construction
September 3-12, 1991	Surface geophysical investigation at Stepan
September 12-13, 1991	Surface geophysical investigation at DeSaussure
September 18-20, 1991	Surface geophysical investigation at Federal Express
October 29, 1991	Surface geophysical investigation at Gulf
October 31, 1991	Surface geophysical investigation at Sunoco
November 14-15, 1991	Surface geophysical investigation at AMP
December 10-12, 1991	Surface geophysical investigation at Stepan (amended)
December 10-13, 1991	Well rehabilitation and evaluation survey (Stepan)
December 18-19, 1991	Preliminary wetlands delineation (Stepan, Sears and adjacent properties)
December 31, 1991-January 3, 1992	Surface geophysical investigation at SWS
February 10-11, 1992	Construction of decon. pad (Stepan) and mobilization for soil borings (Stepan)
February 12-19, 1992	Soil boring program (Stepan)
February 20-28, 1992	Soil boring program (adjacent properties, excluding Sears)
March 2-4, 1992	Overburden well installation (Stepan)
March 2-17, 1992	Surface geophysical investigation at Sears
March 5-28, 1992	Overburden well installation and bedrock well drilling (Stepan, adjacent properties, excluding Sears)
March 25-April 6, 1992	Test-pitting program (Stepan and Stepan amended property)
March 30-April 22, 1992	Soil boring program, overburden well installation, and bedrock well drilling (Sears)
April 6-15, 1992	Test-pitting program (adjacent properties, excluding Sears)

Table ES-2
Chronology of Field Investigation Activities

April 22-May 1, 1992	Development of overburden wells (Stepan, Sears, and adjacent properties)
April 20-22, 1992	Detailed jurisdictional wetlands delineation (Sears and adjacent properties)
May 4-20, 1992	Test-pitting program (Sears)
May 4-16, 1992	Borehole geophysical logging program (Stepan, Sears, and adjacent properties, excluding Gulf)
May 18-June 2, 1992	Hydraulic packer testing program [Stepan, Sears, and adjacent properties, excluding Gulf (BRMW3) and Federal Exp. (BRMW9)]
May 20-21, 1992	Test-pitting program additional pits required by EPA (Stepan, and adjacent properties)
May 28-June 4, 1992	Bedrock well completion (Stepan, Sears, and adjacent properties, excluding Gulf and Federal Express)
June 1, 1992	Water level measurements
June 8-25, 1992	Bedrock well drilling and completion (Gulf, Federal Exp.); development of bedrock wells (Stepan, Sears, and adjacent properties)
June 22, 1992	Water level measurements
June 22-July 13, 1992	Surveying activities (Stepan, MISS, Sears and adjacent properties)
July 20-24, 1992	Surface water and sediment sampling (Sears and adjacent properties)
July 20-Aug. 4, 1992	Groundwater sampling (Stepan, MISS, Sears, and adjacent properties)
July 28, 1992	Water level measurements
August 4, 1992	Blue material sampling and confirmation of metal detector anomalies requested by EPA (DeSaussure)
August 12-27, 1992	In-situ hydraulic conductivity testing (Stepan, Sears and adjacent properties)
September 9, 1992	Water level measurements
September 10-17, 1992	Continuous water level measurements

Table ES-2
Chronology of Field Investigation Activities

October 2, 1992	Water level measurements
November 5, 1992	Water level measurements
Focused Investigation Activities	
July 19-August 3, 1993	Groundwater sampling (Stepan, MISS, Sears and adjacent properties)
July 26-August 6, 1993	Soil gas program (Stepan)
September 7-17, 1993	Soil boring and hand auger program
October 8-14, 1993	Pressure injection testing
September 20-October 14, 1993	Well installation program
October 24-27, 1993	Bedrock pumping test (Stepan)
November 1-4, 1993	Overburden pumping test (Stepan)
November 15-18, 1993	Bedrock pumping test (Sears)

Table ES-3
Analytical Parameters, Methodologies, and Media Analyzed

Analytical Parameters	Analytical Methods	MEDIA ANALYZED				
		Soil Boring	Sediment	Surface Water	Groundwater	Test P..
Chemical						
TCL VOC	CLP SOW [a]	X	X	X	X	X
TCL semivolatiles, caffeine, a-pinene, and d-limonene	CLP SOW [a]	X	X	X	X	X
TCL pesticides/PCBs	CLP SOW [a]	X	X	X	X	X
TOC	EPA/CE-81 and EPA 415.1 [b]	X [c]	X			
TAL metals and cyanide	CLP SOW [d]	X	X	X	X	X
Lithium	CLP SOW [d]	X [e]	X	X	X	
TCLP VOCs, semivolatiles, herbicides, and pesticides	SW 846 [f]					X
TCLP metals	SW 846 [f]					X
Radiological						
Gross alpha and gross beta	EPA Method 900.0	X	X	X	X	X
Ra-226 and Ra-228	EPA Methods 903.1 and 904.0	X	X	X	X	X
Th-230 and Th-232	Alpha Spectroscopy		X	X	X	X
Total - Thorium	Alpha Scinitillation	X				
U-234, U-235, U-238	Alpha Spectroscopy	X [g]	X	X	X	X
Total uranium	EPA Method 908.1		X [h]			X [i]
Physical						
Atterberg limits (liquid and plastic)	ASTM D4318	X				
Grain size distribution (wash sieve and hydrometer)	ASTM 4222	X				
Moisture content	ASTM D2216-80	X				
X-ray diffraction		X [j]				

[a] Groundwater and surface water samples were analyzed for TCL VOCs according to the method specified in *Superfund Analytical Methods for Low Concentration Water for Organic Analysis*, June 1991, (SAMLCO691).
Soil, sediment, and test pit samples were analyzed for TCL organics according to the method specified in *EPA CLP Statement of Work for Organics Analysis, Multi-Media, Multi-Concentration*, February 1988. Groundwater and surface water samples were also analyzed using this method, for TCL semivolatiles, pesticides, and PCBs only.

[b] *Procedure for Handling Sediment and Water samples* (EPA/CE-81-1) and *Methods for Chemical Analysis of Water and Wastes*, March 1988, (Method 415.1).

[c] TOC analysis was done on only the following three soil boring samples: C31(8 to 10 ft.), C26(0 to 6 ft.), and C24(4 to 6 ft.).

[d] *EPA CLP Statement of Work For Inorganics Analysis, Multi-Media, Multi-Concentration*, March 1990.

[e] Lithium analysis was performed on samples from borings C5 and C20 on Stepan, and on all the borings on Sears.

[f] *Test Methods for Evaluating Soild Waste* (SW846), November 1986. Samples for TCLP VOCs, semivolatiles, pesticides, herbicides, and metals were extracted according to Method SW 846 1311. Analyses of extract was then performed according to SW 846 methods for the analyes of interest.

[g] Total-Thorium analysis was performed because of high radiological levels in samples.

[h] Total-Uranium analysis was performed by the laboratory on one sediment sample.

[i] Total-Uranium analyses were performed by the laboratory on more than half of the test-pit samples; these results were subsequently used by the laboratory to back-calculate isotopic uranium data, assuming uranium, was natural (as opposed to enriched or depleted).

[j] X-ray diffraction was performed on one soil sample only (collected from blue material).

Notes:
TCL = Target Compound List
CLP = EPA Contract Laboratory Program
PCBs = Polychlorinated biphenyls
TAL = Target Analyte List
TCLP = Toxicity Characteristic Leaching Procedure
ASTM = American Society for Testing and Materials
SOW = Statement of Work
VOCs = Volatile organic compounds
TOC = Total organic compound

Table ES–4
Analytical Parameters, Methodologies, and Media Analyzed During Focused Investigation

Analytical Parameters	Analytical Methods	MEDIA ANALYZED DURING FOCUSED INVESTIGATION		
		Soil Boring	Groundwater	Hand Auger
TCL VOC	CLP SOW [a]	X	X	
TCL Semivolatile Organics	CLP SOW [a]	X [b]	X [c]	X
TCL Pesticides [d]	CLP SOW [a]		X	
TAL Metals (total)	CLP SOW [e]		X	
TAL Metals (filtered) [f]	CLP SOW [e]		X	
Cyanide [g] (total)	CLP SOW [e]		X	

[a] Groundwater samples were analyzed for TCL VOCs according to the method specified in *Superfund Analytical Methods for Low Concentration Water for Organic Analysis*, June 1991, (SAMLCO691).
Soil samples were analyzed for TCL organics according to the method specified in *EPA CLP Statement of Work for Organics Analysis, Multi–Media, Multi–Concentration*, February 1988. Groundwater samples were also analyzed using this method, for TCL semivolatiles and pesticides.

[b] Soil borings analyzed for TCL semivolatiles were SG–5, SG–18A, SG–19.

[c] Groundwater samples from Wells B38W01S, B38W02D, B38@18D, and OBMW19 were not analyzed for semivolatile organics.

[d] Pesticides were analyzed for in samples from the following wells: OBMW15, BRMW15, BRMW16, B38W05B and B38W18D.

[e] *EPA CLP Statement of Work For Inorganics Analysis, Multi–Media, Multi–Concentration*, March 1990.

[f] Samples from twenty eight wells were sampled for TAL metals (filtered)

[g] Monitoring wells analyzed for cyanide were B38W12A, B38W12B, BRMW5, BRMW7, BRMW8, BRMW9, BRMW12, OBMW5, OBMW8, OBMW12, and OBMW7.

Notes:
TCL = Target Compound List
CLP = EPA Contract Laboratory Program
TAL = Target Analyte List
SOW = Statement of Work
VOCs = Volatile organic compounds

These objectives were implemented by a soil boring and sampling program in which a total of 44 borings (10 on Stepan and 34 on the Sears and adjacent properties) were installed.

The locations of these borings are shown in Figure ES-3.

Overburden Groundwater Investigation

The objectives of the overburden groundwater investigation were:

- To quantify and characterize the vertical and horizontal extent of groundwater contamination in the overburden
- To estimate the direction and rates of groundwater flow in the overburden
- To measure seasonal fluctuations in the water table
- To evaluate the hydraulic connection between the overburden and the bedrock

The components of the investigation were:

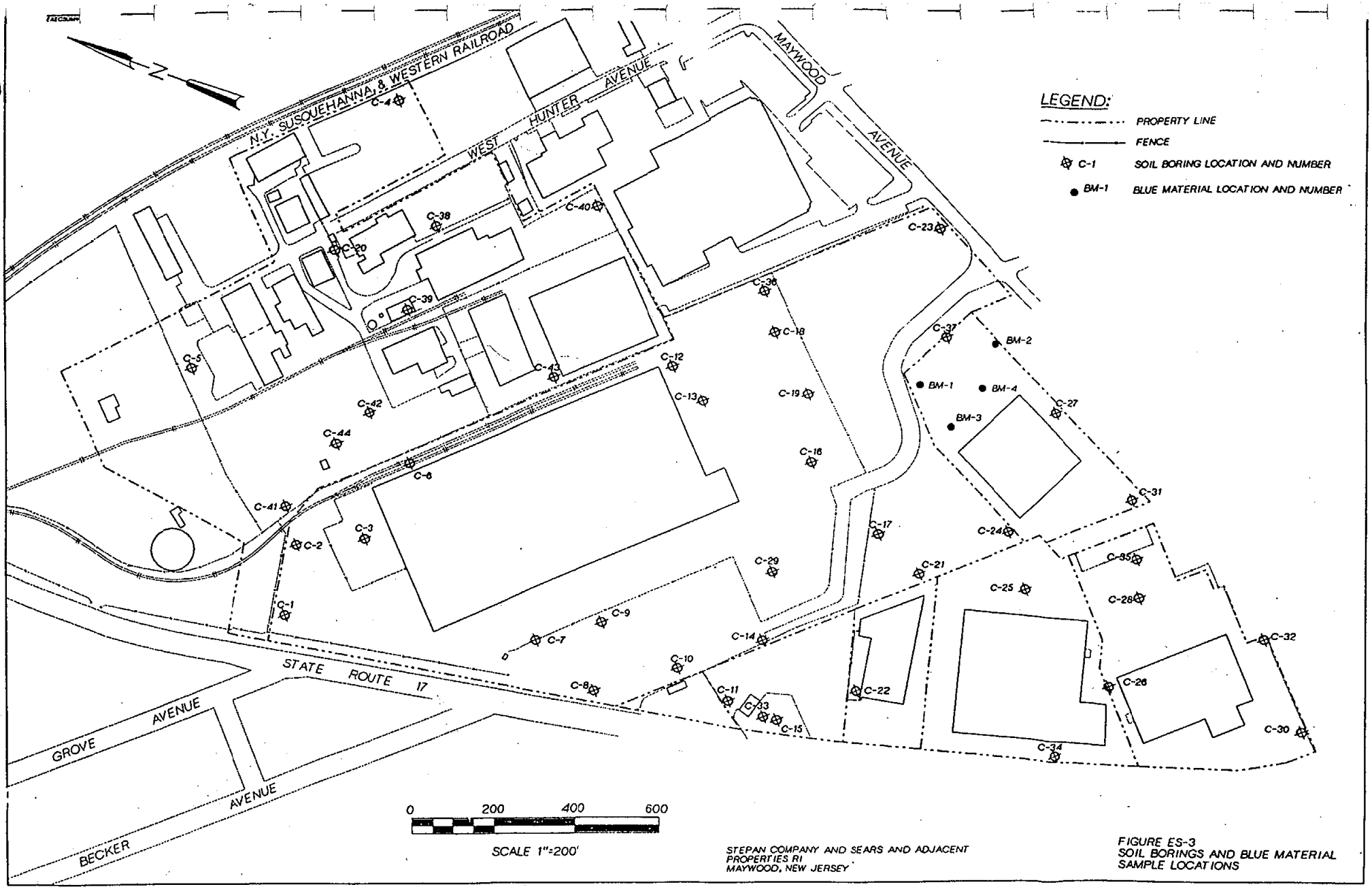
- Selection of groundwater well construction material
- Well rehabilitation and evaluation survey
- Overburden drilling and well construction
- Hydraulic conductivity tests
- Static and continuous water level measurement
- Surveying
- Sampling

A total of 15 overburden monitoring wells (3 on Stepan and 12 on the Sears and adjacent properties) were installed and screened across the water table in the consolidated deposits and/or weathered bedrock. The locations of these wells (including overburden and bedrock monitoring wells installed as part of the Focused Investigation) are shown in Figure ES-4.

Bedrock Groundwater Investigation

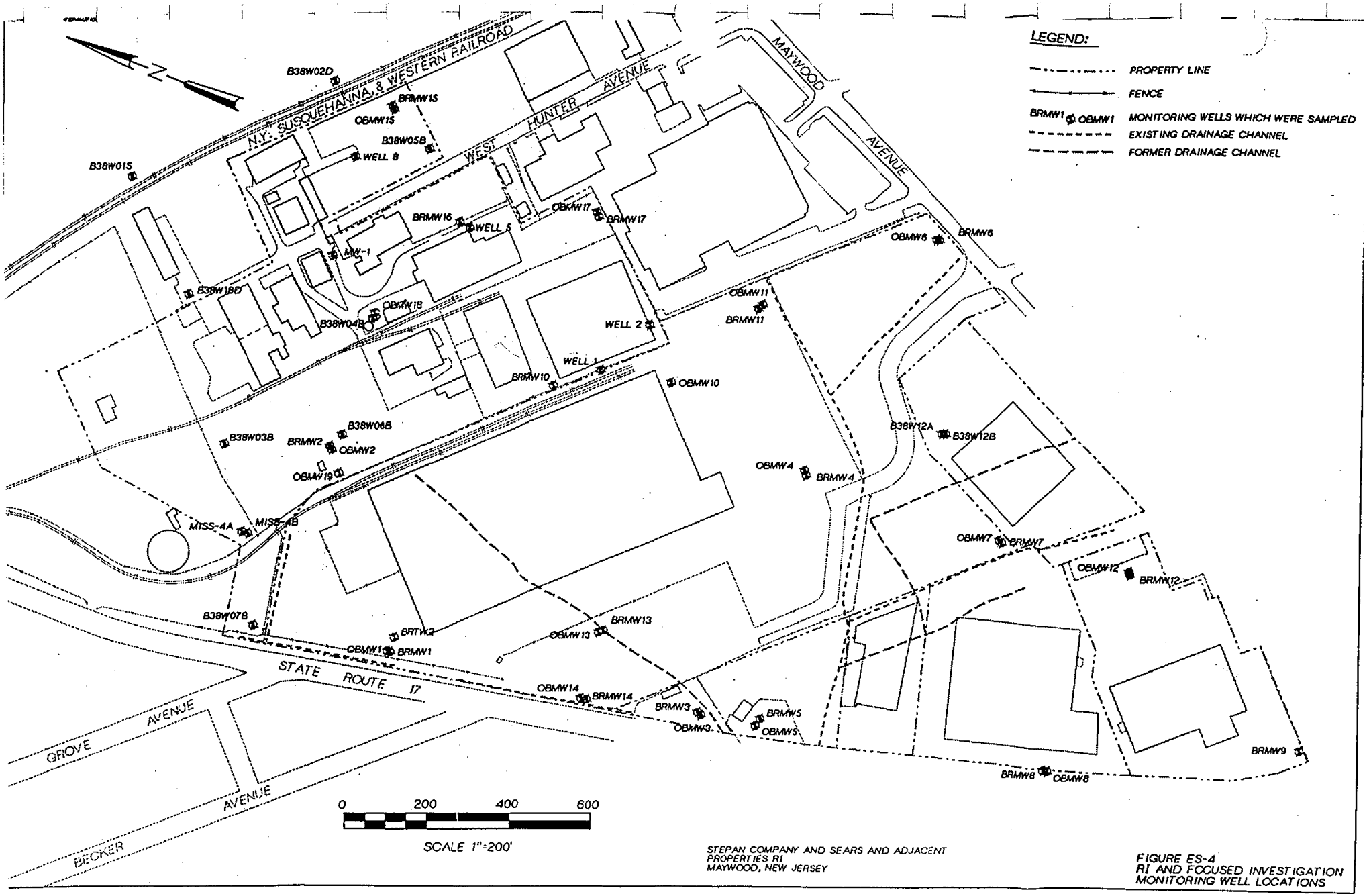
The objectives of the bedrock groundwater investigation were:

- To identify water-bearing zones of the bedrock aquifer and investigate their hydrogeologic characteristics



STEPAN COMPANY AND SEARS AND ADJACENT PROPERTIES RI
MAYWOOD, NEW JERSEY

FIGURE ES-3
SOIL BORINGS AND BLUE MATERIAL SAMPLE LOCATIONS



STEPAN COMPANY AND SEARS AND ADJACENT PROPERTIES RI
MAYWOOD, NEW JERSEY

FIGURE ES-4
RI AND FOCUSED INVESTIGATION
MONITORING WELL LOCATIONS

- To evaluate the degree of hydraulic interconnection between the bedrock aquifer and the overburden water-bearing zone

- To characterize and quantify the horizontal extent of chemical contamination in the upper bedrock aquifer

- To assess groundwater flow patterns in the bedrock and determine if prominent fracture systems affect flow direction and flow rate in different lithologies.

The components of the investigation were:

- Bedrock drilling, coring, and well construction
- Borehole geophysical logging
- Hydraulic pressure injection testing
- Hydraulic conductivity testing
- Static water level measurements
- Continuous water level measurements
- Surveying
- Sampling

Seventeen 2-inch diameter stainless steel bedrock monitoring wells (5 on Stepan and 12 on the Sears and adjacent properties) were installed in the study area at the locations shown in Figure ES-4.

Surface Geophysics and Test Pitting

Surface geophysical surveys were performed on all properties within the study area in an effort to locate and define ferromagnetic containers in the overburden soils. The results and interpretations of these surveys were used to locate test pits for further investigation. The purpose of the test-pit program was to physically investigate anomalous areas of potential buried metal identified during the surface geophysics investigation. A total of 129 test pits was excavated. Samples were collected from 19 of the test pits.

Test pit locations are provided in Figure ES-5.

Surface Water and Sediment Investigation

The objectives of the surface water and sediment investigation were:

- To determine the presence and concentrations of indicator compounds (a-prene, d-limonene, and caffeine) and chemical constituents in sediment and surface water

- Obtain measurements that indicate lateral distribution of containment concentrations over portions of the study area where surface water and sediments occur

These objectives were met by a sampling program that consisted of seven surface water and six sediment samples. Sampling locations were located at the following properties: Sears (4), Federal Express (1), SWS (1), and Sunoco (1).

Focused Investigation

As previously stated, the Focused Investigation consisted of the following activities:

- Additional round of groundwater sampling
- Source delineation study
- Hydrogeologic evaluation
- Expanded well record search

Each of these activities are discussed below.

Additional Round of Groundwater Sampling

The objectives of the additional round of groundwater sampling conducted during the Focused Investigation were:

- To confirm the initial findings of the RI groundwater sampling
- To provide a comprehensive site-wide indication of groundwater contamination
- To support the analysis of the fate and transport of contaminants in groundwater

This sampling program involved the collection of groundwater samples from the same 48 monitoring wells sampled during the RI groundwater sampling event. In addition to these 48 wells, the following wells were also sampled as part of the Focused Investigation: MW1 (Stepan), OBMW1 (Stepan), OBMW19 (Stepan), and BRTW2 (Sears). Wells OBMW18, OBMW19, and BRTW2 were all installed by CH2M HILL during the Focused Investigation for the purpose of source delineation. Well MW1 was installed by Stepan during a previous underground storage tank (UST) investigation. The locations of these wells are shown in Figure ES-4.

Source Delineation Investigation

The source delineation investigation consisted of the following three tasks:

- Soil gas investigation
- Soil boring and hand-auger soil sampling
- Monitoring well construction and sampling

The objectives and components of each of these tasks are described below.

Soil Gas Investigation. The objectives of the soil gas investigation were to:

- Evaluate the presence and lateral extent of volatile organic compound (VOC) contamination in soil around potential source areas
- Aid the evaluation of the lateral extent of VOC contamination in shallow groundwater
- Obtain information on hot-spot soil contamination that may be a source of groundwater contamination by sampling shallow soils in areas of high VOC contamination in soil gas

The soil gas investigation involved the collection of 70 soil gas samples from 71 sampling locations on the Stepan property. Twenty-two of the samples were taken from 23 locations in the Central Tank Farm Area, and 48 samples were taken in the Aromatics and Essential Oils Manufacturing Area. All soil gas samples were tested for the following target compounds: benzene, toluene, ethylbenzene, xylene (BTEX); TVHC; vinyl chloride; total 1,2-DCE; carbon dioxide; oxygen; and methane. Five soil gas samples were also analyzed for naphthalene. The location of these soil gas locations are shown in Figure ES-6.

Soil Boring and Hand-Auger Soil Sampling. The objectives of the soil boring and hand-auger soil sampling were to sample soils in areas on the Stepan property with high VOC or semivolatile organic concentrations to obtain information on hot-spot soil contamination that may be a source of groundwater contamination.

The soil boring and hand-auger soil sampling consisted of the following:

- Installing and sampling 11 soil borings in the Aromatic and Essential Oils Manufacturing Area
- Installing and sampling nine soil borings in the Central Tank Farm Area
- Collecting soil samples from three hand-auger borings to the north, east, and west of boring C-41 (Stepan)

Nineteen of the soil boring samples were analyzed for target compound list (TCL) VOCs. Three of these soil boring samples were also analyzed for TCL semivolatile organics. The three hand-auger soil samples were analyzed for TCL semivolatile organics only. The soil boring and hand-auger sample locations are shown in Figure ES-6.

Monitoring Well Construction and Sampling. The objectives of installing two new overburden wells, OBMW18 and OBMW19, on the Stepan property were to further characterize source areas in the Aromatic and Essential Oils Manufacturing Area (OBMW19) and Central Tank Farm Area (OBMW18). In addition, the bedrock pumping well (BRTW2) at Sears was sampled to provide further delineation of the area.

Groundwater samples from well OBMW18 were analyzed for TCL VOCs, TCL semivolatile organics, and TAL metals (total). Samples from wells OBMW19 and BRTW2 were analyzed for TCL VOCs only. The locations of these wells are shown in Figure ES-4.

Hydrogeologic Evaluation

The objectives of the focused hydrologic evaluation were:

- To characterize the hydrogeologic communication between the overburden aquifer system and the bedrock aquifer system
- To characterize the behavior of groundwater flow in bedrock
- To evaluate the feasibility of groundwater remediation at the site

The components of the hydrogeologic evaluation were:

- Installing eight monitoring and three pumping-test wells
- Pressure injection testing for monitoring well screen selection
- Conducting two 72-hour bedrock pumping tests and one 48-hour overburden pumping test
- Collecting pump-test water quality samples
- Conduct groundwater reinjection tests

Geology and Hydrogeology

The study area is located within the Piedmont Physiographic Province, a north-northeast trending half graben composed primarily of sedimentary rock sequence consisting of sandstones, shales, mudstones, and conglomerates. The overburden is divided into two deposits: the fill and recent age deposits and stratified glacial deposits, and the unstratified glacial deposits and residual soil. Based on boring information, the fill thickness varied from 2 to 12 feet; combined thickness of the fill and recent age deposits and glacial deposits ranged from 0 to 14 feet, and the thickness of unstratified glacial deposits and residual soil varied from 1 to 11.5 feet.

The bedrock underlying the study area consists of sandstones, mudstones, and siltstones representing the Passaic Member of the Brunswick Formation. It appears that the upper portion of the bedrock ranging from 0.5 to 15 feet was moderate to moderately severely weathered.

Groundwater occurs as water table in the overburden soils and under unconfined to semiconfined conditions in the bedrock aquifer. The water table extends through the varying thicknesses of the weathered bedrock zone to the top of the competent bedrock zone and the flow of groundwater in the overburden radiates from the Stepan property roughly in a due south and due west direction. Depending on the location, the bedrock aquifer may be hydraulically connected to the water table. The degree of confinement of the bedrock aquifer appears to depend upon location and depth; the deeper the well, the greater the likelihood of confined conditions. At relatively shallow depths, the bedrock is generally contiguous with the water table.

Systemic fractures, such as partings along the bedding and near-vertical joint sets aligned with the strike of the bedding, provide the principal passage of groundwater flow. Vertical gradients in the bedrock aquifer are not consistently upward or downward.

Nature and Extent of Contamination

Soil analytical results were compared with NJDEPE soil cleanup criteria. No federal cleanup standards currently exist for soils. The organics data were compared to the NJDEPE impact to groundwater soil cleanup criteria and NJDEPE residential direct contact soil cleanup criteria for subsurface and surface soils (as appropriate), with surface soil defined as soil taken from the 0-to-2-foot depth interval, and subsurface soil defined as soil taken from a depth greater than 2 feet. Because there are no NJDEPE impact to groundwater soil cleanup criteria for metals and cyanide, the metals and cyanide analytical data were compared to the residential direct contact soil cleanup criteria, regardless of the depth from which the samples were collected. Results from the groundwater analysis were compared to the NJDEPE Class II-A

groundwater quality criteria, and the April 1992 EPA drinking water regulations and health advisories. Final cleanup criteria will also be based upon the May 1993 Final Risk Assessment conducted by EPA.

Soils and Groundwater

Volatile Organic Compounds (VOCs). Benzene and xylene were the only VOCs detected at levels above the NJDEPE soil cleanup criteria. These two compounds were detected at several locations on Stepan and SWS. Samples from those locations also exhibited the highest total VOCs. The SWS location is near a former gasoline UST. The Stepan locations are in an area that also exhibits groundwater contamination by BTEX. Groundwater from well B38W04B (Stepan) had elevated concentrations of BTEX, cis-1,2-dichlorethene (DCE) and vinyl chloride.

Vinyl chloride and cis-1,2-DCE are also present in elevated concentrations in other bedrock wells at the site.

Benzene was the only VOC detected at levels exceeding the NJDEPE groundwater quality criteria at offsite locations along the hydraulically upgradient boundary of the study area.

Groundwater samples collected during the Focused Investigation sampling contained the same VOCs as were detected during the RI. However, there were several significant differences between the concentrations of VOCs detected during the RI and those detected during the Focused Investigation. TCE was detected at concentrations exceeding the NJDEPE groundwater quality criteria in three wells during the Focused Investigation, but was not detected at all in these wells when they were sampled during the RI. Well B38WO4B (Stepan), which showed concentrations of cis-1,2-DCE, benzene, xylene, and vinyl chloride during the RI, did not have any of these compounds detected during the Focused Investigation. It should be noted that the sample from B38W04B was diluted to the extent that the detection limits for vinyl chloride, benzene, xylene, and 1-2-dichloroethene were 1,000 ppb. In addition, the high volatility of vinyl chloride may also account for the variability in sampling results. However, an elevated concentration of ethylbenzene was detected in the well during the Focused Investigation, but was not detected during the RI. Significant decreases in benzene concentrations from the RI to the Focused Investigation occurred in wells MISS 4B (Stepan) and BRMW2 (Stepan).

Semivolatile Organics. PAHs in soils at levels exceeding the NJDEPE cleanup criteria are present at the 0-to-2-foot depth interval at several borings on Sears and Stepan. Total PAHs at concentrations exceeding 10,000 ppb were found in samples from borings located on DeSaussure, Sears, and Stepan. PAHs, however, do not appear to be impacting groundwater. They are present in samples from only three wells, one of which may be contaminated by gasoline constituents.

Other semivolatile organics (non-PAHs) were found at total concentrations exceeding 1,000 ppb in soil samples from DeSaussure, Sunoco, and Sears. However, individual compounds were not detected at levels above the NJDEPE cleanup criteria at any locations. Pentachlorophenol, bis(2-ethylhexyl) phthalate were the only semivolatile organics detected at concentrations exceeded NJDEPE groundwater quality criteria. Pentachlorophenol was detected in groundwater samples from two wells on the Stepan property, and bis(2-ethylhexyl) phthalate was found in samples from three wells located on the Federal Express, Stepan, and Sears properties.

Caffeine was detected in one soil boring from Stepan and in 11 samples taken from borings at Sears. D-limonene was found in one soil boring sample from Sears, and a-pinene was not detected. Caffeine was detected in groundwater in one offsite well that is located along the hydraulically upgradient boundary of the study area and at one location on Stepan.

Bis(2-ethylhexyl) phthalate was the only semivolatile organic compound that was detected above the groundwater quality criteria during the Focused Investigation sampling. The highest concentration of this compound (100 ppb) was detected in the sample from well MW1 (Stepan).

Pesticides and PCBs. Pesticide compounds (4,4-DDE, 4,4-DDD, and 4,4-DDT) were detected in soil samples taken from borings on Sears and DeSaussure. Pesticides found in groundwater at locations on Stepan (adjacent to the hydraulically upgradient property boundary) and Sears were BHC gamma (Lindane), dieldrin, and heptachlor epoxide. Based on these findings, it appears that pesticides in soils are not affecting groundwater. However, pesticide compounds different from those that were detected in soils were detected in groundwater at levels exceeding the groundwater quality criteria.

Only five wells were sampled for pesticides during the Focused Investigation. Dieldrin, heptachlar epoxide, and total chlorodane were the only pesticides detected at concentrations exceeding the NJDEPE groundwater quality criteria.

PCBs were not detected in any soil or groundwater samples.

Inorganics (Metals and Cyanide). Inorganics were widely distributed in soils. Arsenic, barium, cadmium, lead, selenium, and antimony were all found in soil samples at levels exceeding the NJDEPE soil cleanup criteria. Lithium was found in all samples for which it was analyzed, and cyanide was detected in 12 samples, 5 of which were of blue material found on DeSaussure. Metals were also widely distributed in groundwater, primarily in the samples collected from overburden wells. Aluminum, antimony, arsenic, barium, beryllium, cadmium, chromium, iron, lead, nickel, manganese, and sodium were all detected in groundwater at the site at levels exceeding the NJDEPE groundwater quality criteria. Elevated levels of arsenic, cadmium, chromium, lead, nickel, and manganese exceeding groundwater quality criteria were also detected in onsite wells located along the hydraulically upgradient

portion of the study area. The offsite, upgradient well showed elevated concentrations of cadmium and manganese. It should be noted that analyses were performed on unfiltered groundwater samples. Therefore, the analytical results are for total metals and cyanide. Most metals contamination above levels specified in the standards occurred in samples from overburden wells, possible due to high suspended solids in groundwater. Borings near these wells often demonstrated elevated metals concentrations.

Groundwater samples collected during the Focused Investigation were collected using a low-flow purge/sample method to reduce the amount of sediments in the groundwater samples. Samples from the overburden monitoring wells still contained the highest concentrations of metals and the most exceedances of groundwater quality criteria. However, concentrations of metals in the samples from the Focused Investigation were significantly less than in samples collected during the RI. Exceptions to this are the highly soluble metals such as, calcium, magnesium, sodium, and potassium, which were present at similar concentrations in both RI and Focused Investigation samples.

Only 13 groundwater samples were analyzed for cyanide during the Focused Investigation. Only the sample from well B38W12A (DeSaussure) contained cyanide above the NJDEPE groundwater quality criteria. The cyanide concentration detected during the Focused Investigation was 476 ppb, which is an order of magnitude less than the RI sample.

Surface Water and Sediments

VOCs. VOCs were not found in surface water or sediments at levels above the NJDEPE groundwater quality criteria or soil-cleanup criteria.

Semivolatile Organics. Benzylbutyl phthalate and bis(2 ethylhexyl) phthalate were detected in surface water samples at concentrations exceeding NJDEPE groundwater quality criteria. Five semivolatile organics (PAHs) were detected in sediment above NJDEPE soil cleanup criteria. Seven PAHs were detected at concentrations exceeding NOAA sediment criteria.

Pesticides and PCBs. No pesticides or PCBs were detected in surface water or sediment samples except for Lindane at a concentration below the NJDEPE groundwater quality criteria.

Metals and Inorganics. Lead and cadmium were detected in sediments at concentrations above NJDEPE soil cleanup criteria. Lead and arsenic were detected in some surface water samples at concentrations above the NJDEPE groundwater quality criteria. Aluminum, copper, lead, mercury, and zinc were detected in surface water samples above the Federal Ambient Water Quality Criteria (FAWQCs), and lead and zinc were detected in sediments above National Oceanographic and Atmospheric Administration (NOAA) sediment criteria.

Test Pits

Test-pit samples were tested for TCL and target analyte list (TAL) parameters, and for toxicity characteristic leaching procedure (TCLP) parameters.

TCL VOCs. A cluster of test pits, located in the asphalt/grassy area alongside a culvert on Sears, contained very high total concentrations of VOCs (13,360 ppb to 19,920,000 ppb). This entire area, including test pits TP-106, TP-107, TP-79, TP-85, and TP-84, may be considered as a potential source area for VOCs. TP-87-1 (Sears) also had very high VOC concentrations (105,000 ppb). All samples for which concentrations of VOCs exceeding cleanup criteria were detected were collected from sludges within drums, with the exception of TP-85, which was collected from soils associated with a crushed drum.

Benzene was detected at levels above the NJDEPE cleanup criteria in four test pits on Sears (TP-106, TP-84, TP-85, and TP-87-1). The concentration of benzene was detected at four orders of magnitude greater than the cleanup criteria for benzene in for TP-106, and at two orders of magnitude greater than the cleanup criteria in the other three test pits.

Fourteen volatile organic compounds, in addition to benzene, were detected above cleanup criteria levels in TP-106.

Acetone, benzene, toluene, and xylene were detected at low concentrations in several test pits on Stepan, Sears, and DeSaussure. No VOCs were detected on AMP.

TCL Semivolatile Organics. Semivolatile PAHs were detected in 43 percent of the test pits. TP-25 (Stepan) had the maximum total semivolatile PAHs detected, 8,898,000 ppb, and contained 15 of the 18 PAHs for which the sample was analyzed. The sample was collected from soils associated with a crushed drum, at a depth of 0.6 foot.

Benzo(b)fluoranthene was the only PAH detected above the criteria. It was only detected in the sample from TP-25 (Stepan Amended).

Semivolatile non-PAHs were detected in 74 percent of the test pits (all properties), at generally low concentrations. Concentrations of non-PAHs were below the NJDEPE cleanup criteria at all locations.

Caffeine, d-limonene, and a-pinene were not detected on Stepan. Caffeine was detected in six Sears test pits (eight samples, including two duplicates) and one DeSaussure test-pit sample. D-limonene was detected in two Sears test pits. A-pinene was detected in one Sears test pit. The highest concentration of d-limonene was detected in TP-106, which is the test pit containing 15 VOCs exceeding the NJDEPE soil cleanup criteria.

TCL Pesticides and PCBs. No PCBs were detected in any test-pit samples.

Pesticides were detected in TP-22 (Stepan) and TP-76 (Sears), and concentrations for 4,4'-DDE and 4,4'-DDD in TP-76 exceeded the NJDEPE soil cleanup criteria.

TAL Inorganics (Metals and Cyanide). A variety of inorganics were detected in a high proportion of the test pit samples.

The following metals and cyanide were detected above the NJDEPE cleanup criteria: arsenic, beryllium, cadmium, chromium, copper, lead, mercury, zinc, and antimony.

TCLP Organics. Benzene failed TCLP testing in TP-106 (Sears). Benzene was also detected at this location at four orders of magnitude greater than the levels in the cleanup criteria.

Nitrobenzene failed TCLP testing in TP-22 (Stepan). Total nitrobenzene data for TP-22 was unusable.

TCLP Inorganics. Chromium and selenium failed TCLP testing in TP-22 (Stepan). Total chromium was detected in TP-22 above cleanup criteria levels. Total selenium data for TP-22 was unusable.

The test-pit program was conducted primarily to determine the source of magnetic anomalies observed during the surface geophysics program. Soil samples and samples from within containers (primarily 55-gallon drums) were collected to begin to characterize container contents and determine the impact of released materials on the soil.

Objects ranging from building foundations to scrap metal, including 55-gallon drums in varying conditions, were excavated or uncovered from test pits. Samples of contents were taken from intact containers. Visual observation indicated a wide range of physical properties, which are discussed in Section 4.3.

Analytical data from the test-pit samples indicated that soils have been affected by the buried drums. The contents of the drums contain significant quantities of compounds at high concentrations. Given the results of the analytical data from the test-pit program, however, it would be premature to delineate source areas or hot spots based solely on the test-pit data. Furthermore, soil samples were not collected from all areas adjacent to sampled containers, thereby limiting the ability to delineate specific hot spots.

An analysis of the nature and extent of contamination was performed, attempting to integrate analytical findings with potential source materials and knowledge of historical process and waste disposal operations. In the absence of extensive historical information, an aerial photography survey performed by EPA was used as a

basis for discussion of potential source areas. Potential source materials include the following:

- Petroleum-based fuels in areas of former USTS
- Organic residues in buried drums
- Solvents used near the former Aromatic and Essential Oils Manufacturing Area
- Leather solids filter cake from protein extraction process
- Gypsum from an inorganic chemical manufacturing operation
- Tailings from ore processing and other inorganic residues
- Liquids in bermed areas and lagoons identified in aerial photos

Using the above as a framework, the following conclusions were reached regarding the nature and extent of contamination:

- Areas of BTEX and naphthalene contamination associated with fuel USTs appear to be the source of residual concentrations of these materials in soil and shallow groundwater for several areas on the Stepan, Gulf, and SWS properties.
- Two localized areas of subsurface soil BTEX and acetone contamination were identified on the Stepan property. One of these areas (the former aromatics and essential oils manufacturing area) has impacted overburden groundwater to a limited extent.
- Buried containers containing organic residues with BTEX compounds, ketones, or chlorinated solvents are present on the Sears property. The extent to which these are impacting soils is not defined. Impact to groundwater appears to be minimal.
- An unknown source is contributing to vinyl chloride and DCE in bedrock groundwater on the northwest portion of the Sears property.
- An unknown source appears to be contributing to residual TCE concentrations in bedrock groundwater in the south and east portion of the study area.
- The localized concentrations of high molecular weight PAHs in shallow soils are not migrating into groundwater or surface water.

- The chromium in the leather solids filter cake residue found on the north portion of the Stepan property does not appear to be impacting groundwater.

- Metals, possibly originating from inorganic residues and tailings from ore processing operations, are widely distributed in fill material across the study area. Although localized areas of overburden and groundwater contamination appear to be impacted by the fill material, no identifiable source areas appear to exist.

- Beryllium and manganese are present at levels typical of natural background concentrations in overburden soils. The resulting concentrations in groundwater also appear to be at background concentrations.

- Cyanide contained in the blue material on the DeSaussure property is contributing to low residual concentrations in downgradient bedrock groundwater and nearby surface water. Shallow groundwater underlying the material has also been impacted.

Focused Investigation

Soil Gas. The results of the soil gas sampling are presented in Tracer Research's report found in Appendix Z.

Soil Boring and Hand-Auger. There was excellent correlation between the results of the Focused Investigation soil gas investigation and the results of the soil boring program. The areal extent of VOC contamination defined through the soil gas program was confirmed through soil sample analysis. Soil at several locations in the Aromatic and Essential Oils Manufacturing Area and in the Central Tank Farm Area was found to contain BTEX compounds. The compounds detected were consistent with materials formerly stored in USTs in these areas. At some locations, soil boring results exceeded the NJDEPE impact-to-groundwater soil-cleanup criteria. However, these locations were found to be sharply defined and limited in extent.

Of the samples taken from the Aromatic and Essential Oils Manufacturing Area, from the Central Tank Farm Area, and from the vicinity of boring C-41 and analyzed for semivolatiles, only one from the Central Tank Farm Area exceeded cleanup criteria. However, the criteria exceeded was for residential direct contact with soil (that is, the 0- to 2-foot depth interval). Because the sample was collected in the 3- to 5-foot interval, use of this criterion may not be appropriate in this circumstance.

General Radiological Findings

Hand auger samples of blue material found on DeSaussure contained low levels of Ra-228, Th-230, and Uranium-234 (U-234). The sample collected from the interval below the blue material contained detectable levels of gross alpha and beta radiation, Ra-228, Th-230, U-234, U-235, and U-238. Only U-234 and U-238 were detected at levels above Nuclear Regulatory Commission (NRC) comparison criteria.

Soil boring samples analyzed for radiological constituents identified subsurface radiological contamination on Sears, Stepan, Sunoco, and DeSaussure. Downhole gamma logging results also indicated potential subsurface radiological contamination at select soil boring locations on these properties. Downhole gamma logging results do not indicate the presence of radiological subsurface contamination in soil borings located on AMP, Federal Express, and SWS. Soils on the Gulf and Stepan amended properties could not be assessed because soil borings were not installed on these properties.

In general, extensive areas of elevated radiological readings were observed within the study area.

Surface contamination could not be determined because gamma log results could not be compared to DOE's 11,000-cpm site-specific surface soil guideline.

The thirteen soil boring samples analyzed for radiological parameters contained some radiological constituents at concentrations or estimated concentrations greater than the DOE and/or NRC comparison criteria. Ra-226, Ra-228, U-234, and U-238 were detected in soils at levels above comparison criteria. The maximum concentrations of the radiological analytes were all detected in soil samples collected from boring C-38.

Boring C-38 was intended to be located adjacent to burial site No. 1 (a grassy area on Stepan, west of West Hunter Avenue); however, C-38 may have actually been drilled within the limits of burial site No. 1.

Four of the 20 test-pit samples contained at least one radioisotope at levels above the DOE and NRC comparison criteria. Of these four samples, one was associated with drum contents and three were collected from the surrounding soils. These four test-pit samples were located on Sears. Other test-pit samples collected from within containers, and not associated with soils, contained radioisotopes at concentrations below DOE and NRC comparison criteria.

Although gamma radiation results from test pits were not intended for use in assessing the extent of radiological contamination, gamma results from test pits located on AMP, Federal Express, and SWS are consistent with gamma log results from the soil borings installed on these properties. Test-pit results do not indicate the presence of subsurface radiological contamination at measured locations on these

properties. Gamma radiation measurements collected from test pits on the Stepan amended property were below the DOE reference guideline of 40,000 cpm.

Radiological constituents in unfiltered groundwater samples taken from onsite wells were generally detected at higher concentrations with respect to samples taken from hydraulically upgradient of the study area. Radiological constituents (gross alpha and beta radiation, and uranium) were detected above maximum contaminant levels (MCLs) in several overburden wells; they were not as prevalent in bedrock wells.

Although groundwater within the study area may appear to be impacted by radiological contamination, analytical data was based on unfiltered samples only. Gross alpha, gross beta, and total uranium were detected above the proposed federal primary drinking water standards in unfiltered groundwater samples collected from Stepan, Sears, SWS, and DeSaussure. Targeted thorium and radium isotopes were not detected in groundwater samples above the proposed maximum contaminant levels. Because groundwater samples were not collected on AMP the presence of radiological constituents in groundwater in this area is unknown.

Surface water samples contained detectable levels of gross alpha and beta, Ra-226, Th-230, and U-235. None of the detected radiological parameters were above proposed Safe Drinking Water Act (SDWA) MCLs.

Sediment samples contained detectable levels of gross alpha and beta, Th-230, Th-232, U-234, U-235, and U-238. One sediment sample (SD-3; Sears) contained Ra-226 and Th-232 at levels above DOE's surface soil guidelines. One sediment sample (SD-6; drainage channel between Sears and SWS) contained Ra-226 above DOE's surface soil guideline. Radium-226, Ra-228, and Th-232 were detected at concentrations above DOE's surface soil guidelines in one sediment sample (SD-4 Sears). The other sediment samples (SD-1 and SD-2, Sears; SD-5, Sunoco) did not contain radiological constituents at concentrations above DOE soil guidelines.

Contaminant Fate and Transport

Groundwater

Patterns of contaminant transport in the overburden zone are expected to be controlled by vertical and horizontal variability in soil, causing variations in hydraulic conductivity and aquifer heterogeneity.

Dissolved contaminant migration from the overburden to the bedrock zone is controlled by bedrock stratigraphy and is limited to local areas where the two zones are hydraulically connected.

Patterns of contaminant distribution in the multiunit bedrock aquifers are expected to be highly irregular, due to the complexity of flow in fractured rock. Complex flow in

fractured rock partly results from the variable alignment of preferential flow channels with the prevailing direction of groundwater flow.

Due to the horizontal distances between some monitoring wells, few contaminant distribution patterns could be identified. However, several localized areas with elevated concentrations of VOCs were identified.

Contaminant transport in the overburden is inhibited by attenuation due to organic matter and the tendency for the water table to occur below the top of rock. Contaminant transport in bedrock is characterized by higher velocities and is not attenuated to the same degree as in the overburden due to the scarcity of organic matter.

Elevated levels of organic compounds were found in overburden wells OBMW2, OBMW3, and OBMW4, but were generally more prevalent in bedrock wells.

Several areas of VOC-contaminated soils may be sources of shallow groundwater contamination. These include: soils near well OBMW2 and boring C-44; soils on the north side of Building 10 (Stepan); wastes from container samples from test pit locations TP-84; TP-85, and TP-87 (Sears); soils on the east side of the SWS property near boring C-25; and wastes in buried containers in test pit TP-106.

PAHs in soils do not appear to be impacting groundwater, particularly in paved portions of the study area. Sample results indicate that, even in areas with elevated concentrations of PAHs in soils, PAHs were not detected in groundwater samples from wells near soil boring locations. Low levels of napthalene and 2-methylnapthalene were detected in localized areas of groundwater where BTEX compounds also were detected.

BTEX, TCE, and TCE degradation products are generally more prevalent in bedrock wells than in overburden wells. The presence of benzene at a level four orders of magnitude higher in the overburden well OBMW2 than in bedrock well BRMW2 suggests a significant barrier to contaminant transport to the bedrock zone at this location.

Data collected during the Focused Investigation indicate that metals are not at levels of concern for migration into bedrock, since filtered sample or dissolved concentrations in overburden well samples indicate nondetectable or low concentrations of these parameters. Twenty-eight of the 52 samples collected were also analyzed for filtered TAL metals based on the turbidity (greater than 5 NTUs) of the last well volume purged. The low-flow sampling method used during the Focused Investigation resulted in much lower total metals concentrations due to less silt and sediment in groundwater samples. Analytical results from the filtered samples indicated concentrations similar to those obtained by the low-flow sampling method, confirming that the dissolved metals concentrations are very low. Migration of dissolved metals may be potentially limited in the overburden zone by soil adsorption and chemical transformation to less mobile

forms. Based on the information collected during both the RI and Focused Investigation, specific source areas for groundwater metals contamination have not been delineated.

TCE is expected to have moderate mobility and undergo a biodegradation pathway to other compounds including dichloroethanes, dichloroethylenes, vinyl chloride and chloroethane. Samples taken during the Focused Investigation indicated significantly lower levels of vinyl chloride and cis-1,2-DCE in wells B38W04B and MISS4B than samples collected during the RI. This suggests that a continuing source for these contaminants does not exist in these areas. Variable concentrations suggest that only small, localized zones of these compounds were present near the wells. Focused Investigation results for well BRMW1 were similar to concentrations of vinyl chloride and cis-1,2-DCE that would have been found in the RI, given the elevated detection limit for cis-1,2-DCE. However, no source areas were identified based on the available data. The potential exists for offsite migration of TCE or chlorinated degradation products near wells BRMW1 and BRMW14.

Surface Water and Sediments

BTEX, TCE, TCE degradation products, and PAHs are not expected to contaminate surface water at levels above the NJDEPE groundwater and surface water quality criteria. These compounds were not detected or detected at very low concentrations in overburden groundwater near surface water drainage ditches or wetlands areas.

There does exist the potential for minor lead and arsenic to surface water from elevated concentrations of those metals in nearby surface soils and sediments.

Potential Source Areas

Based on results of the RI and Focused Investigation, soils or waste that are potential sources of shallow groundwater contamination are:

- BTEX compounds in soils near well OBMW2 and boring C-44 (Stepan)
- BTEX compounds in soils on the north-side of Building 10 (Stepan)
- VOCs in a buried container in test pit TP-106 (Sears)
- BTEX compounds in buried containers in test pits TP-84, TP-85, and TP-87 (all on Sears)
- BTEX-contaminated soils on the east side of the SWS property near boring C-25 where a former UST was located

- Cyanide in gypsum material located on the DeSaussure property near well B38W12A

Two portions of the study area have elevated concentrations of chromium in surface soil in the 0- to 3-foot interval. These areas are located near soil boring C-41 (Stepan) and test pit TP-22 (Stepan). Although groundwater wells were not located near boring C-41 or test pit TP-22, groundwater quality downgradient of these areas does not appear to have been affected by chromium.

Well Searches

As part of the RI, a well search was performed to identify potential offsite receptors to groundwater. The well search included the following:

- A 5-mile-radius search for major water-supply well performed by the NJDEPE Bureau of Water Allocation

- A 1-mile-radius search for wells by Well Search Services, Inc.

The RI well search indicated that there were no active municipal-water-supply wells within 1 mile of the site, which alleviated the concern that there may be large public groundwater receptors close to the study area. However, one industrial supply well with a pumping capacity greater than 100,000 gpd was located within 1 mile of the site. The well was registered under Interplast Industries. The well search also indicated that Stepan draws water from the Saddle River for noncontact cooling purposes; no well was registered under Stepan's name. There were also 30 smaller-yield water wells within 1 mile of the site. The exact location, status (whether active or inactive), and current use of each of these wells were not identified during the RI well search, but were investigated during the well search performed as part of the Focused Investigation. A detailed description of the results of the RI well search is provided in Section 1.7.1.

As a follow-up to the RI, an expanded well search was performed under the Focused Investigation, with the following objectives:

- Identification of any additional wells within a 1-mile radius of the site

- Determination of the status of each well and whether any of the smaller-yield wells identified during the RI search are used for drinking water

- Determination of whether the large supply well identified during the RI search is used for drinking water

A total of 50 wells, some active and some inactive, were identified within approximately 1 mile of the study area as a result of the expanded search. A summary of the results follows:

- Of the 30 wells identified during the RI well search, current owners could be identified only for 11. This low percentage may be caused by a change in property owner since the time the well was installed, with the new owner not aware that there is a well on his or her property because the well is not currently in use. Another reason may be an incorrect address and location information in the well permit completed by the driller and provided to the NJDEPE at the time of well installation. These permits were used to provide information on wells within 1 mile of the study area during the RI well search.

- Of the 50 wells identified (including the 11 wells verified from the original well search):

  - 21 are currently inactive

  - 5 are active commercial/industrial wells not used for drinking water

  - 1 is an active commercial and drinking-water well

  - 16 are active domestic wells used for lawn watering, car washing, pools, and other nondrinking uses

  - 7 are active domestic drinking-water wells

- The large water-supply well owned by Interplast and identified during the RI well search supplies cooling water.

Section 1

Introduction

1.1 Purpose of the Remedial Investigation

The purpose of the remedial investigation (RI), conducted by CH2M HILL August 1991 through November 1993, was to determine the nature and extent of chemical contamination at nine sites on the Stepan Company Property (Stepan) and Sears and Adjacent Properties so that remedial action can be planned and implemented. The investigation of Stepan was conducted under Unilateral Administrative Order (Index No. II-CERCLA-10105) issued by the United States Environmental Protection Agency (EPA) on May 3, 1991. The investigation of the Sears and Adjacent Properties was conducted under the terms of the Administrative Order on Consent (Index No. II-CERCLA-70104) entered into by EPA and Stepan Company on September 21, 1987. Previous investigations had yielded some useful chemical information; this RI was designed to supplement that information.

The RI consisted of nine components:

- Overburden soils investigation
- Overburden groundwater investigation
- Bedrock groundwater investigation
- Surface water and sediment characterization
- Geophysical survey
- Test pitting
- Surveying
- Wetlands delineation
- Flood hazard area assessment

On March 11, 1993, CH2M HILL, on behalf of Stepan Company, submitted a draft RI report for the Stepan and Sears and Adjacent Properties to EPA, Region II. EPA provided comments on the RI report in a letter dated May 13, 1993. In the letter, EPA also expressed a desire for delineation of specific potential source areas and further hydrogeologic evaluation. On the basis of information collected during the RI, the following areas and media were chosen for more focused investigations:

- The former gasoline tank area near the guard house
- The central tank farm area
- The aromatic and essential oils manufacturing area
- The soil in the area of boring C-41
- The groundwater within the bedrock at BRMW1

The first four areas are located on the Stepan Company property. In addition, EPA requested a second round of groundwater sampling and a more thorough investigation of offsite wells (commercial, industrial, sanitary, and residential).

The work plan under which the RI had been conducted was amended in June 1993 to accommodate the additional tasks, referred to collectively in this report as the *Focused Investigation*. The Focused Investigation was conducted by CH2M HILL at the Stepan and Sears and Adjacent Properties July through November 1993. The Focused Investigation consisted of the following four components:

- A source delineation study, which included:
  - Soil gas survey
  - Soil boring program
  - Installation and sampling of two monitoring wells in potential source areas
- A hydrogeologic investigation
- A second round of groundwater sampling
- An expanded well search

The field procedures, results, and interpretation of results for each of these components are provided in subsequent sections of this report. All investigation activities were conducted in accordance with the *Remedial Investigation and Feasibility Study (RI/FS) and RI Operations Plan*, in which a work plan is provided for each site and the *RI Work Plan Amendment*.

1.2 Scope and Organization of this Report

The body of this report retains the essence of the March 1993 report. It has been revised and expanded as necessary to address the comments in EPA's letter of May 13, 1993, and to describe the activities of the Focused Investigation. This report is organized as follows:

Section 2—Field Investigation
Section 3—Physical Characteristics of the Study Area
Section 4—Nature and Extent of Contamination
Section 5—Contaminant Fate and Transport
Section 6—Conclusions
Section 7—Recommendations
Section 8—Works Cited

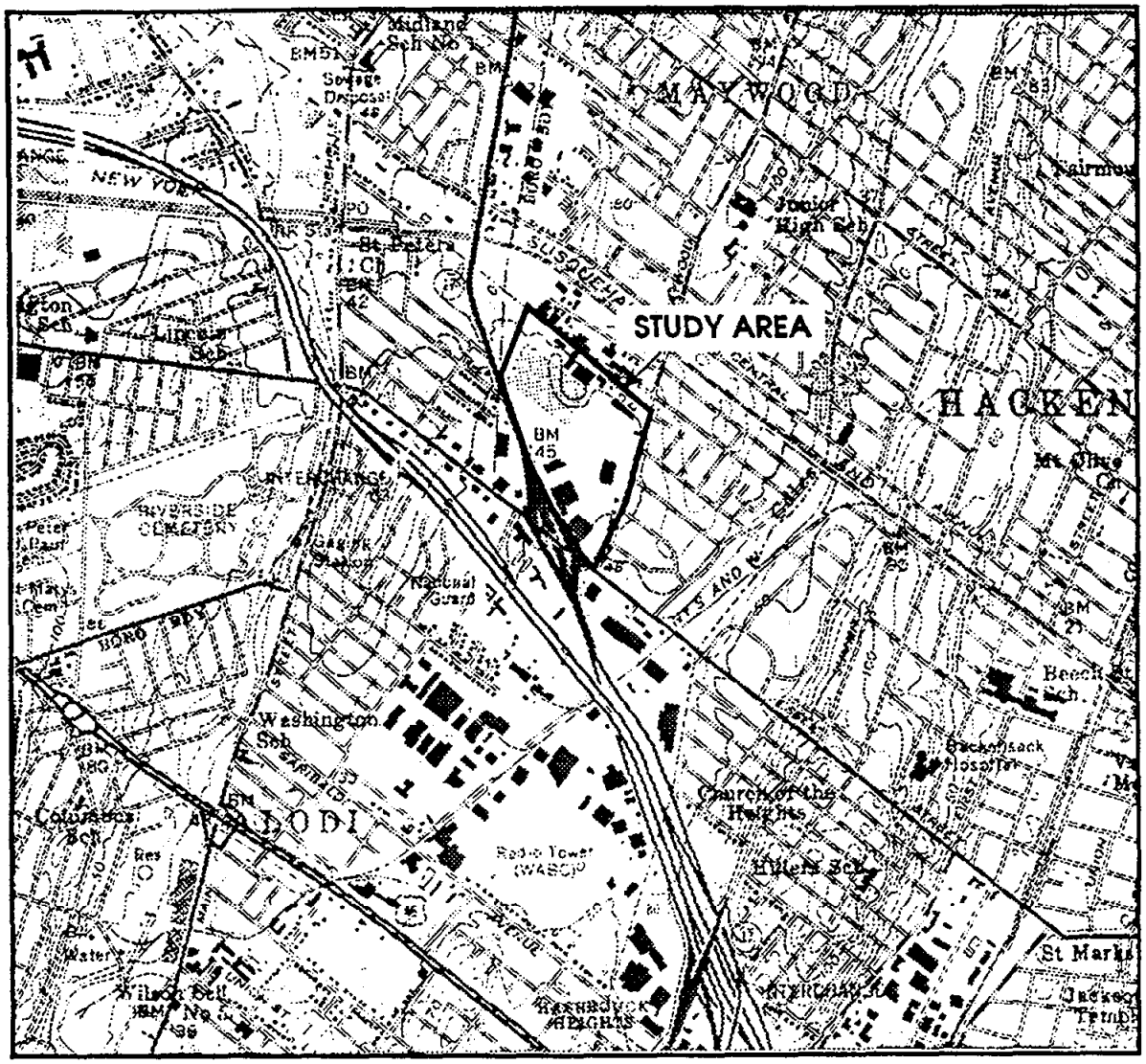
1.3 Site Background

The Stepan and Sears and Adjacent Properties (formerly known collectively as the Maywood Chemical Company Site; referenced in this report as the "study area") consists of eight separate properties formerly owned by the Maywood Chemical Company and located in Maywood, Bergen County, New Jersey (Figure 1-1). These eight properties cover a total area of approximately 63.0 acres and are shown in Figure 1-2. Several of the properties have changed owners since preparation of the original work plan. The current property designations are used throughout the report. The current and former name of each property, the current owners, and the approximate acreage are provided in Table 1-1.

Table 1-1
Stepan and Sears and Adjacent Properties

Current Name of Property	Former Name	Current Owner	Approximate Acreage
Stepan Company (Stepan)	-	Stepan Company	19.0
Sears Logistical Center (Sears)	-	Jeco Corporation	27.4
Gulf	-	Cumberland Farms	0.4
Sunoco	-	Sun Refining and Marketing Company	1.7
AMP Realty Associates (AMP)	Federal Express	AMP Realty Co.	1.5
SWS Realty Associates (SWS)	Hunter Douglas	SWS Realty Co.	4.7
Federal Express	AMF Voit	Maurice Weil	4.7
DeSaussure Equipment Company, Inc. (DeSaussure)	-	William DeSaussure	3.6

Brief summaries of the surface features of each property are presented below. A more detailed discussion of the physical characteristics of the study area is provided in Section 3. A map of surface features is included in this section as Figure 1-3.



SCALE 1:24 000

1 0 1 MILE

1000 0 1000 2000 3000 4000 5000 6000 7000 FEET

1 .5 0 1 KILOMETER

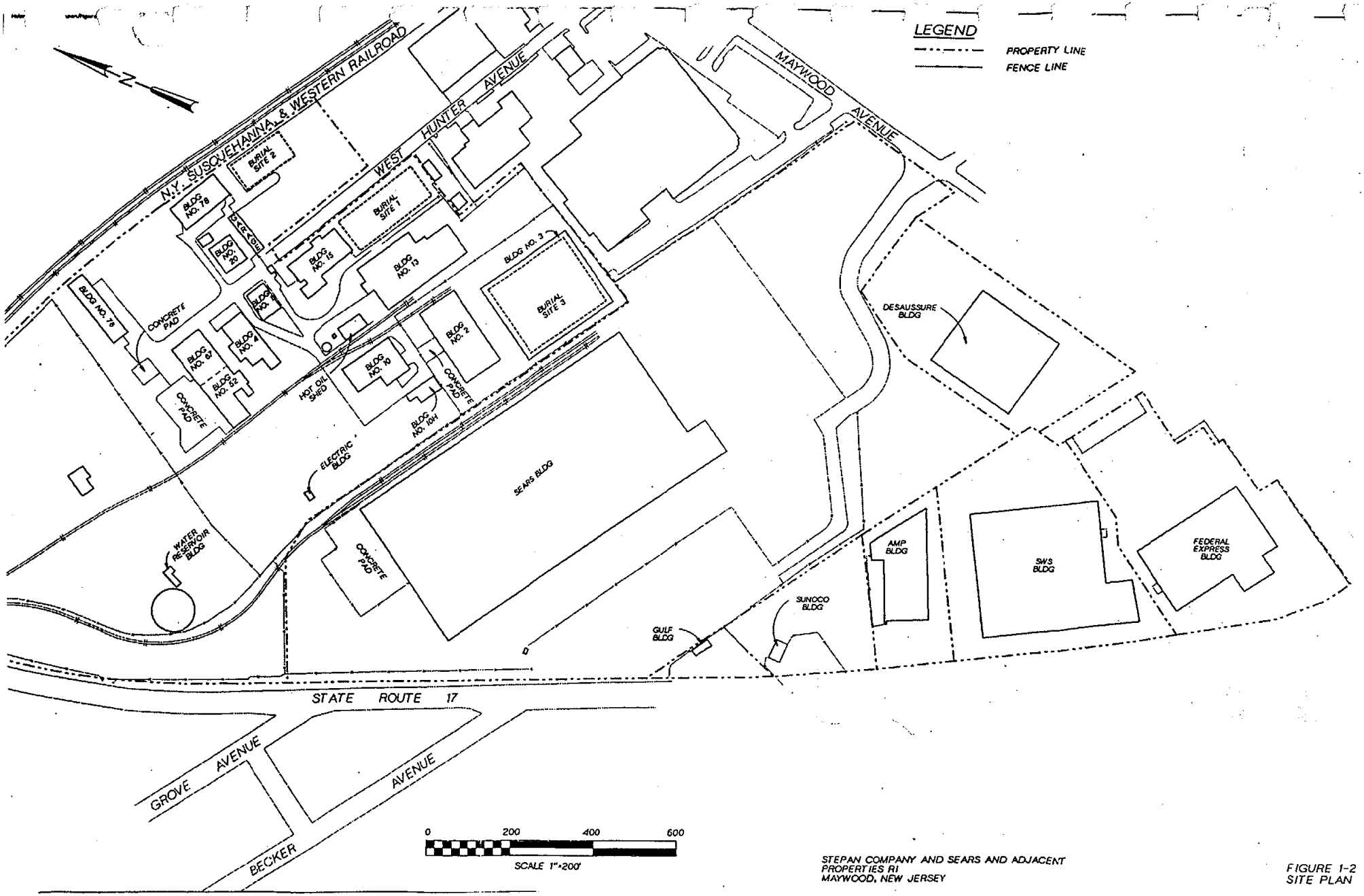
CONTOUR INTERVAL 10 FEET

N

Source:
HACKENSACK QUADRANGLE, NJ
7.5 minute series USGS Quadrangle maps, 1955
Photorevised 1981.

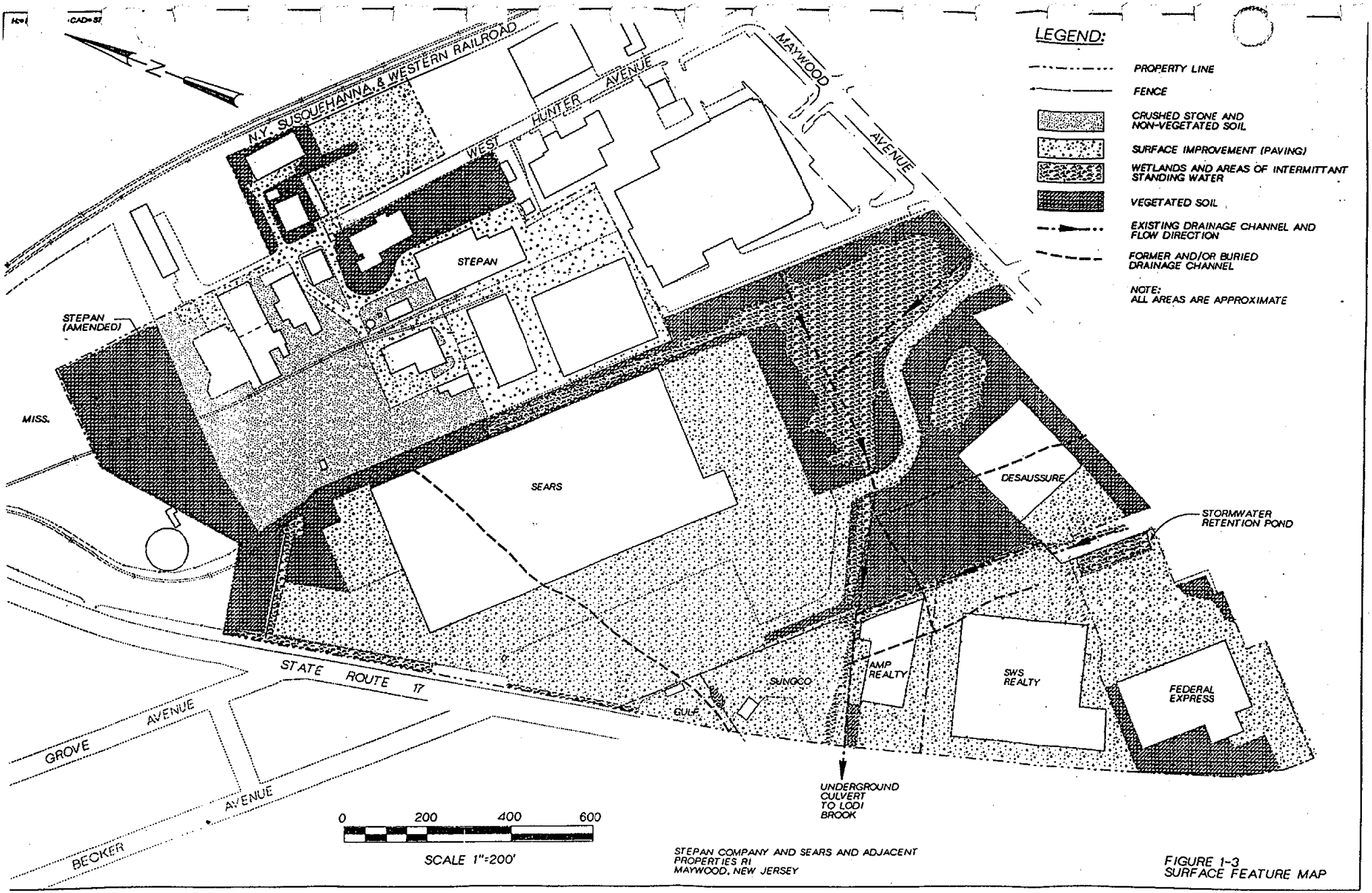
STEPAN COMPANY AND SEARS AND ADJACENT PROPERTIES RI
MAYWOOD, NEW JERSEY

Figure 1-1
STUDY AREA
LOCATION MAP



STEPAN COMPANY AND SEARS AND ADJACENT PROPERTIES RI
MAYWOOD, NEW JERSEY

FIGURE 1-2
SITE PLAN



STEPAN COMPANY AND SEARS AND ADJACENT PROPERTIES RI
MAYWOOD, NEW JERSEY

FIGURE 1-3
SURFACE FEATURE MAP

1.3.1 Stepan Company

Approximately 50 percent of Stepan is covered with structures or with the foundations of former structures, aboveground tank farms, and asphalt paving. Three low-level radiological burial sites are located on the property: one is under the parking lot north of West Hunter Avenue; the second is under the front lawn, just south of West Hunter Avenue; the third is under the building in the southern corner of the Stepan property. Burial site 1 is covered by grass, burial site 2 is paved, and burial site 3 is located below an existing structure (Building 3). The remaining portions of the site are vegetated or covered with crushed stone or nonvegetated soil. Except for burial sites 1 and 2, the entire property is fenced.

1.3.2 Sears

Much of the Sears property is covered by a 6.5-acre warehouse. Approximately 11 acres of the site are paved, and the remaining areas are vegetated. A 3-acre wetland is located on the east side of the warehouse. The low-lying area between the Sears and Stepan properties along the rail spur also is classified as a wetland.

1.3.3 Gulf

The majority of the Gulf property is covered by asphalt paving, an 800-square-foot structure, and two concrete pads, one with gas pumps. A small unpaved area is located along the southeast edge of the property.

1.3.4 Sunoco

Most of the Sunoco property is covered with asphalt paving and is occupied by an 800-square-foot structure and two concrete pads, one with gas pumps. There is a small unpaved area and drainage ditch located in the southern part of the property, along its boundary with the AMP property.

1.3.5 AMP

A 25,000-square-foot combination office-warehouse and a concrete loading pad occupy the AMP property. The entire site is paved, and a drainage channel is located on the northern property boundaries with Sears and Sunoco.

1.3.6 SWS

A 96,000-square-foot office structure occupies about 50 percent of the SWS property. The remainder of the site is paved. A drainage channel is located along the eastern property boundary with Sears.

1.3.7 Federal Express

The majority of the Federal Express property is paved, with the exception of the front lawn, which is located along Route 17. A 50,000-square-foot combination office-warehouse is located on the property. A small pond and unpaved area are located in the northeast part of the property.

1.3.8 DeSaussure

A parking lot and a 52,000-square-foot combination office-warehouse cover approximately 45 percent of the DeSaussure property. The remaining portions of the site are wooded or covered with grass and include a 0.4-acre wetland.

1.3.9 Underground Storage Tanks

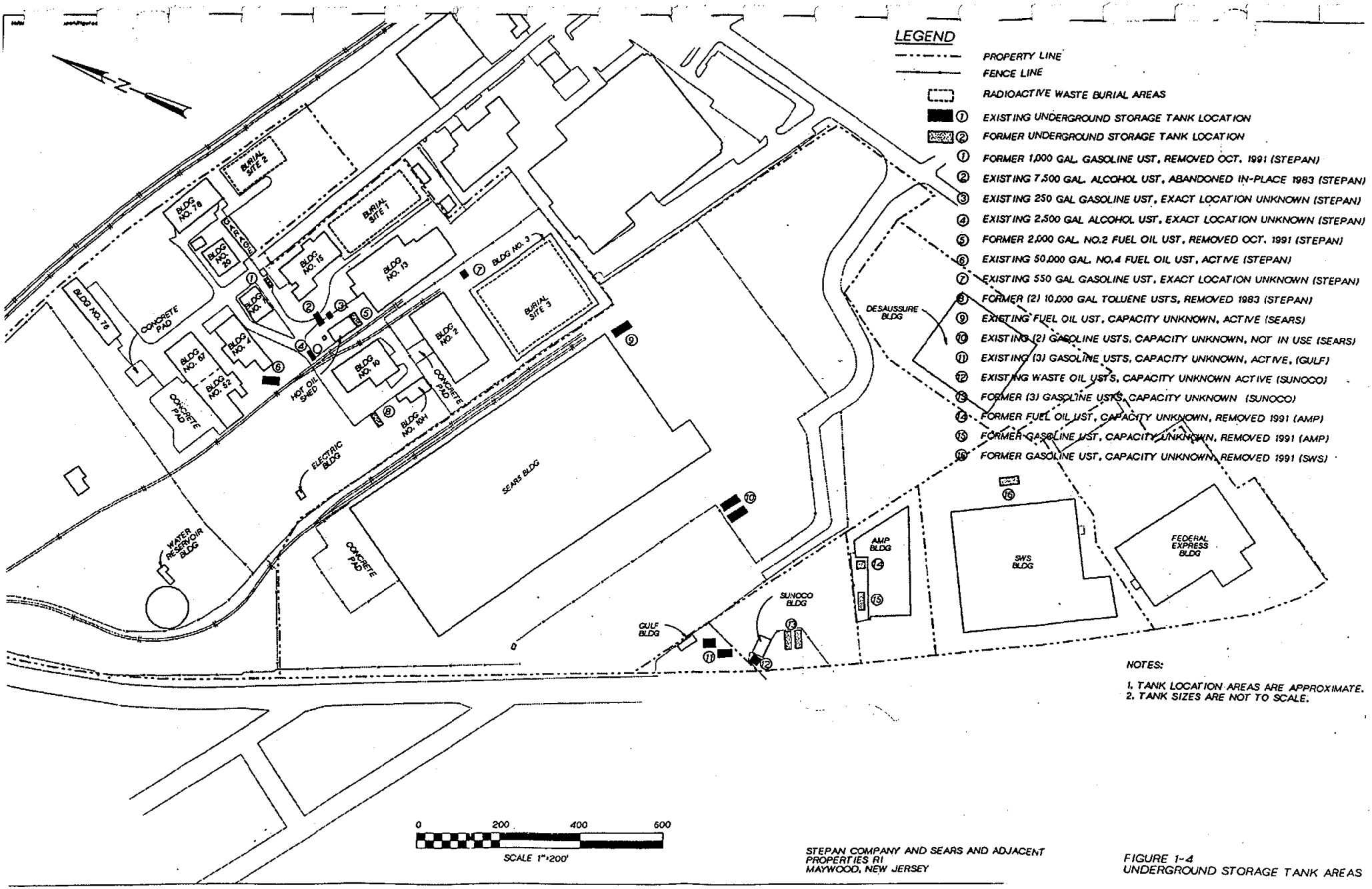
There are 15 underground storage tank (UST) locations within the study area (Figure 1-4). Nine are still in existence, although UST 2 (Stepan), which was used to store alcohols, was abandoned in place in 1983, and UST 10 (Sears), which was used to store gasoline, is no longer in use. Soil and groundwater data from samples collected adjacent to UST 1 (Stepan) and UST 5 (Stepan) are provided in Appendix C. USTs from the remaining eight locations have been removed. No information regarding the removal actions or the condition of the USTs upon removal is available.

1.4 General History

1.4.1 Process Information

The area under investigation is located at the site of the original Maywood Chemical Works, which was founded in 1895. Historical references to the property before 1895 refer to it as a "tile works site." Initial Maywood Chemical Works operations included the use of cerium rare earth in a process referred to as the "standard essence" operation. Early operations also included the extraction of protein from leather as part of the tanning operations, production of ionones, and extraction of caffeine. Lithium tablets also were produced under classified Department of Defense contracts. Descriptions of several of these early operations are provided below.

Various aromatic chemicals were manufactured in the Maywood Plant in two locations. The first location was in buildings located west of building 10. These buildings were removed during the late 1960's. The second manufacturing site was in building 10 itself. The major product was ionone made from either lemongrass oil or geraniol.



NOTES:

1. TANK LOCATION AREAS ARE APPROXIMATE.
2. TANK SIZES ARE NOT TO SCALE.

STEPAN COMPANY AND SEARS AND ADJACENT PROPERTIES RI
MAYWOOD, NEW JERSEY

FIGURE 1-4
UNDERGROUND STORAGE TANK AREAS

Protein extraction operations were initially carried out in buildings located east of the reservoir and behind building 67. These buildings were removed during the early 1960's and these operations were moved to building 67. The main raw material for this process was tanned leather scraps. Other chemicals used in the process were lime, sodium carbonate, coconut fatty acids, phosphorus trichloride, ammonia, sulfur dioxide, ammonium carbonate, and hydrochloric acid. Major products were a polypeptide formulation used in shampoos and a product called maypon 4-C, which was a condensation product of the polypeptide base and fatty acid chloride.

The main lithium salts manufactured were lithium chloride, lithium hydroxide, lithium hydride, lithium metal, and lithium carbonate. Manufacturing sites for these products were buildings 67 and 78. Chemicals used in this process were sodium carbonate, hydrochloric acid, sodium hydroxide, sulfuric acid, and kerosene.

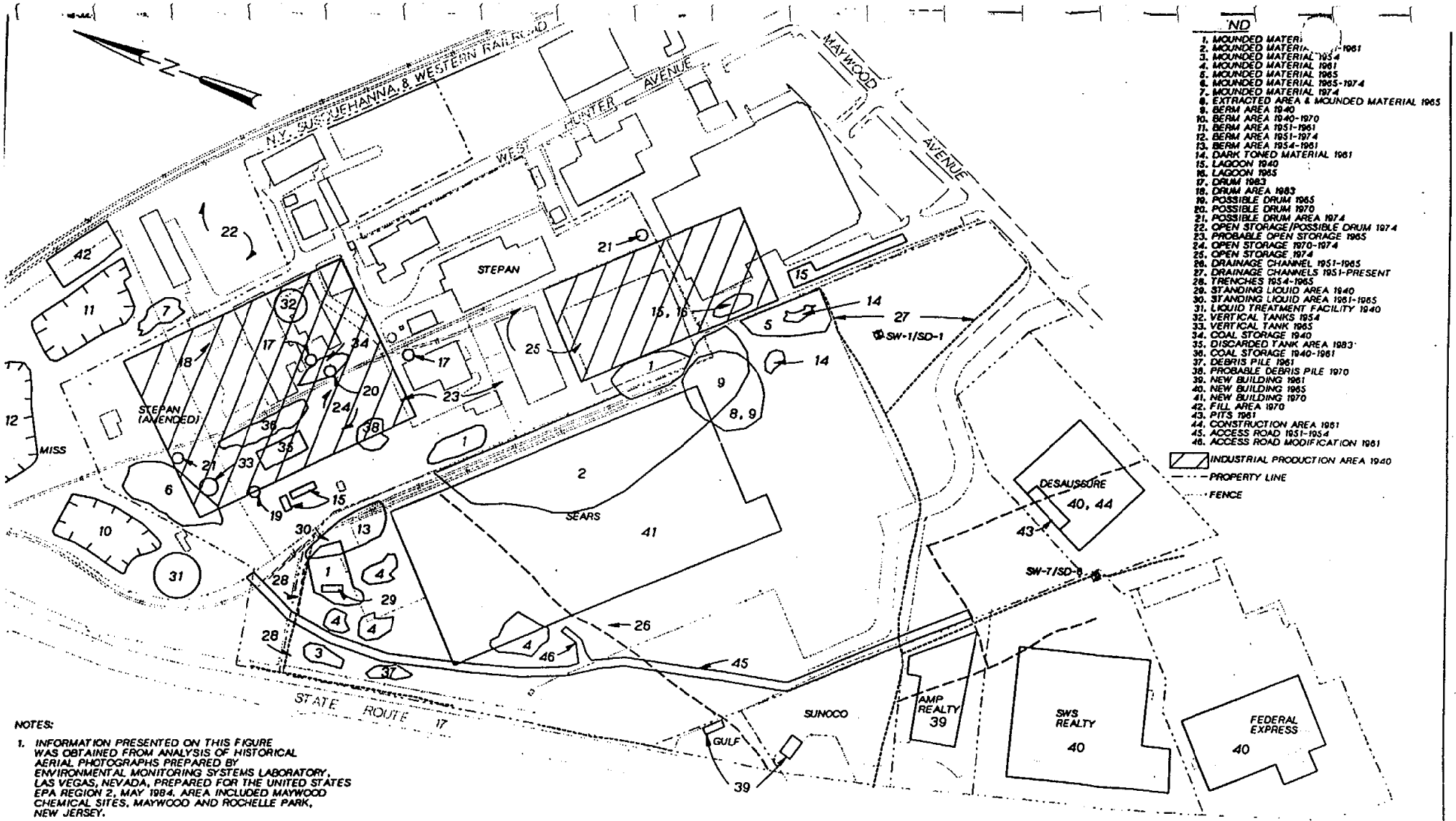
Various surfactant products such as sodium xylene sulfonate were manufactured at the Maywood site from approximately 1960 through 1965 in building 75. This building was located on the site of the present natural products manufacturing building (building 3). Building 75 was removed during 1973 when the new natural products complex was being constructed. Chemicals used in this process were xylene, toluene, fuming sulfuric acid, sodium hydroxide, potassium hydroxide, and ammonium hydroxide.

From 1916 to 1957, Maywood Chemical Works processed thorium from monazite sands for use in manufacturing gas mantles for lighting devices. During this period, a large portion of the work done at Maywood Chemical Works was performed under various government contracts and included use and production of radiological materials. Residues and tailings from these processing operations were used as fill in nearby areas of the property. In 1954, the Atomic Energy Commission (AEC) issued a license to Maywood Chemical Company for possession of source materials (i.e., thorium wastes) stored on the property.

1.4.2 Summary of Aerial Photography Analysis

An analysis of historical aerial photography of the study area was performed by EPA's Environmental Monitoring Systems Laboratory (EMSL) of Las Vegas, Nevada. The analysis was conducted for EPA Region II and the results were presented in EPA's May 1984 report titled *Maywood Chemical Sites Maywood and Rochelle Park, New Jersey*. The material presented in the following sections has been excerpted from this report and summarizes EMSL's analysis.

The aerial photography information for the Stepan, and Sears and Adjacent properties are shown on Figure 1-5. Some of the information contained in EPA's report, and described in this text, could not be included on the figure because it was not clearly discernible, or even visible, on the photographic prints presented in the 1984 report.



NOTES:

1. INFORMATION PRESENTED ON THIS FIGURE WAS OBTAINED FROM ANALYSIS OF HISTORICAL AERIAL PHOTOGRAPHS PREPARED BY ENVIRONMENTAL MONITORING SYSTEMS LABORATORY, LAS VEGAS, NEVADA, PREPARED FOR THE UNITED STATES EPA REGION 2, MAY 1984. AREA INCLUDED MAYWOOD CHEMICAL SITES, MAYWOOD AND ROCHELLE PARK, NEW JERSEY.
2. THE LOCATIONS OF THE INFORMATION PRESENTED ON THIS FIGURE HAVE BEEN APPROXIMATED AND ARE NOT TO SCALE. AREA BOUNDARIES SHOULD NOT BE INFERRED.
3. DATES OF THE ACTUAL PHOTOGRAPHS WERE APRIL 6, 1940, APRIL 7, 1951, MARCH 1, 1954, APRIL 12, 1961, MAY 1, 1965, FEBRUARY 21, 1970, MARCH 25, 1974 AND JUNE 13, 1983.

0 200 400 600

SCALE 1"=200'

STEPAN COMPANY AND SEARS AND ADJACENT PROPERTIES RI
MAYWOOD, NEW JERSEY

FIGURE 1-5
GENERALIZED HISTORICAL AERIAL PHOTOGRAPHY INFORMATION

1.4.2.1 Methodology

EPA searched government and commercial aerial photographic sources to obtain photography of the study area spanning the period from 1940 through 1983. The dates of the aerial photography that were used during the analysis were April 6, 1940; April 7, 1951; March 1, 1954; April 12, 1961; May 1, 1965; February 21, 1970; March 25, 1974; and June 13, 1983.

The analysis was conducted by stereoscopically viewing pairs of transparencies, back lit on a light table. The study area was observed three-dimensionally and at various magnifications, allowing the analyst to search for objects, features, or "signatures" associated with different environmental conditions. The term "signature" refers to a combination of characteristics which indicated a certain object or condition, even though the object itself is not identifiable from the photography. Characteristics included color, tone, shadow, texture, and size.

EPA made prints from coverages which revealed significant changes in the study area. The findings were annotated on overlays to the prints, or to maps of the aerial study area, and descriptions were provided in their report. Due to poor resolution quality of some of the original photography, some objects or features that were identified from the original film and described in the text of the report were not clearly discernible, or even visible, on the photographic prints presented in EPA's report.

The boundaries or areas used during the analysis were determined by observations made from the aerial photography. They do not denote legal property lines or ownership. It should be noted that the Stepan property, the property southeast of Stepan (originally owned by Citro Chemical Company), the MISS property, and the Adjacent properties were not differentiated from each other.

EPA made a distinction between "probable" and "possible" identifications. "Probable" is used when a limited number of discernible signatures allowed the analyst to be reasonably sure of a particular identification. "Possible" is used when few signatures were discernible, and the analyst was only able to infer an identification.

1.4.2.2 Overview of Historical Aerial Photography Analysis

Stepan Property. The property presently occupied by Stepan contained an industrial production facility and a disposal area. The 1940 photographs showed industrial production facilities in the eastern and central portions of the site, a coal storage area next to the railroad spur, and five lagoons along the western property line. Two of the lagoons were identified near the southwestern property boundary on the former Citro Chemical property. Vertical tanks were identified near a liquid treatment facility near the western corner of the site.

The 1951 aerial photographs identified light and dark-toned material near the southwestern boundary, an additional coal storage area west of the 1940 production

area, and possible standing liquid near the northern corner of the Sears site on the Stepan property. An additional bermed area appeared in the western portion of the site in 1954, and four drum storage areas were identified in the 1961 photos. A ground stain was identified near one of the drum storage areas in 1965, as well as a new coal storage area. Four open storage areas and dark-toned material was observed at the eastern end of the facility.

From 1951 to 1961 two to three bermed areas appeared on the west side of the site which is currently referred to as the Maywood Interim Storage Site (MISS). Standing liquid and light- and dark-toned materials were present within and around these bermed areas.

In 1969, debris was present in the western area of the property and by 1983 this same area was revegetated. In 1970, a fill area of light-toned materials and debris was identified along the northern edge of the site, along with a new railroad spur bisecting the bermed area northwest of the liquid treatment facility. Several vertical and horizontal tanks were added to the area north of Sears in 1974. An open storage area north of Sears was also visible.

In 1970 and 1974, parts of the area within the MISS boundaries were used as fill areas. Aerial surveys in 1983 identified additional drums, vertical and horizontal tanks on the property along with two dark-toned ground stains on the east side of the production facility. Several discarded tanks and drum clusters appeared in the western corner south of the railroad spur.

During the earlier years of the aerial study an industrial production facility occupied a large portion of the site. The 1970 photography indicated that buildings were being removed from the site. Some of the building foundations were visible in 1974 and 1983. Drums, above ground tanks, light- and dark-toned material, and coal storage piles were visible around the buildings in the industrial production area. Housekeeping practices on the site appeared to be generally good. The above ground tanks and drums appeared to be in good condition. Some ground stains were visible. No vegetation stress was identified and security fencing around the site first appeared on the 1954 photography.

The area northwest of Sears appeared to have been used as an industrial production facility and a disposal area. The western part of this area (MISS) may have been used for disposal because it contained a bermed area that retained standing liquid and/or light- and dark-toned materials. Lagoons, coal storage piles, and light- and dark-toned materials were identified in other portions of this area. Tanks and/or drums were present in the area throughout the aerial study period. Housekeeping practices associated with these tanks and drums were generally good. Probable drum spillage or leakage was detected in the 1983 photography.

Sears and Adjacent Properties. During the 1940s and 1950s, the Sears and Adjacent Properties was characterized by wooded or open undeveloped land. The 1940 series

showed bermed areas and possible ground staining along the northern edge of the property and a pool of standing liquid in the northwest corner of the site. A ground scarred area appeared south of the pool. Several drainage channels appeared in the 1951 photographs, and, in 1954, a bermed area with standing liquid was visible along the northern corner. The 1954 photos also showed an additional two areas of possible standing liquid and two berms on the north central portion. Standing liquid also appeared in the 1965 photographs, along with a ground stain and standing liquid south of the extraction area.

By 1970, the site had been completely developed and contained many buildings. These buildings currently exist on the Sears and Adjacent Properties. Prior to the construction of the buildings, parts of the site were used for disposal. Two bermed areas that contained standing liquids and ground staining existed on Sears. Light- and dark-toned materials were also visible on Sears. No tanks, drums or vegetation stress was visible on the Sears and Adjacent Properties. Photos taken in 1974 and 1983 did not identify any significant changes from 1970.

1.4.3 Regulatory Chronology

In 1959, Stepan Chemical Company (now known as Stepan Company) purchased the property on which Stepan Company operations are now conducted. Stepan renewed the license issued to Maywood Chemical Company by the AEC and, in 1963, began to clean up piles of thorium wastes on the property. Cleanup and burial of these materials on company property was approved by the AEC.

In 1980, a radiological survey of property formerly owned and remediated by Stepan revealed the presence of radiologic contamination. This discovery prompted surveys and soil sample analyses, which identified the presence of thorium-232 and radium-226 on Stepan property. Findings were reported to the Nuclear Regulatory Commission (NRC) in November 1980.

Subsequent to this discovery, DOE was authorized to investigate and remediate radiological contamination at the site through the Energy and Water Development Appropriations Act of 1984. Through this Act, the Maywood site was assigned to DOE's Formerly Utilized Sites Remedial Action Program (FUSRAP). In 1985, to expedite cleanup of contaminated properties, DOE negotiated access to a 11.7 acre portion of the Stepan property (with the concurrence of the Borough of Maywood through an August, 1984 Memorandum of Understanding) for use as an interim storage facility for contaminated materials. This property, later called the Maywood Interim Storage Site (MISS), was transferred to DOE by Stepan in September 1985.

Since 1980, radiological surveys have been performed on the Stepan property and neighboring properties, including Scanel, Ballod, Sears, and residential properties. Contaminated soil from the Ballod and residential properties have been placed at the MISS by DOE.

In 1985, DOE contracted Bechtel National, Inc., (BNI) to begin investigating the radiological contamination at the MISS and surrounding properties under FUSRAP. In 1985, DOE obtained an emergency New Jersey Pollutant Discharge Elimination System (NJPDES) permit, which required that groundwater monitoring wells be installed at the MISS. DOE has monitored these wells quarterly for radiological and water quality parameters and annually for New Jersey priority pollutants. During the course of DOE's other investigations of the extent of radiological contamination in soil at the MISS and surrounding properties, DOE has also collected samples to support limited chemical characterization.

EPA and NJDEPE continued to be concerned about the potential for chemical contamination and radiological contamination. In 1986, EPA, through its contractor EBASCO, initiated a preliminary characterization of the nonradiological contamination on the Stepan property and the Sears and Adjacent commercial properties (collectively, the Maywood Chemical Company site). This investigation was prompted by findings of investigations performed by DOE that showed chemical contaminants to be commingled with radiological contaminants and to be potentially emanating from Stepan. The properties investigated include those listed in Table 1-1. Information regarding the results of past investigations is provided in Section 1.6.

1.5 Demographics and Land Use

This section provides a summary of demographics and land use in the study area and within 1,000 feet of the study area.

1.5.1 Description of Study Area

The study area includes land within the Borough of Maywood, the Township of Rochelle Park, and the Borough of Lodi. Demographics include municipal information and Bergen County-wide information. Discussion of land use includes municipal information, county-wide information, and details about land use within the study area.

Maywood, Rochelle Park, and Lodi, which are in central Bergen County, are located within 10 miles of New York City. Prominent cultural landmarks include Interstate Route 80 and New Jersey Routes 4, 17, and 46.

1.5.2 Historical Population Trends

As shown in Table 1-2, the total population in the three listed communities and in Bergen County as a whole has been declining since 1970. This population loss has been attributed to a decrease in household size rather than to emigration (Candeub, Flessig, and Associates).

Table 1-2 Historical Population Trends						
Location	**1940**	**1950**	**1960**	**1970**	**1980**	**1990**
Maywood	4,052	8,667	11,460	11,087	9,895	9,473
Lodi	11,552	15,392	23,502	25,163	23,956	22,355
Rochelle Park	2,511	4,483	6,119	6,380	5,603	5,587
Bergen County	409,646	539,139	780,255	897,148	845,385	825,380
Source: Bergen County Department of Planning and Economic Development, Technical Report No. 1.						

1.5.3 Population Density

The population density in all three listed communities significantly exceeds the County's average population density (Table 1-3) and the U.S. average, which is approximately 57 people per square mile.

Table 1-3 Population Density in 1990					
Location	**Population in 1990**	**Location Size in Acres**	**Location Size in Square Miles**	**People per Acre**	**People per Square Mile**
Maywood	9,473	840	1.31	11.28	7,214
Lodi	22,355	1,468	2.29	15.23	9,745
Rochelle Park	5,587	668	1.04	8.36	5,351
Bergen County	825,380	152,775	238.73	5.42	3,457
Source: Bergen County Department of Planning and Economic Development, Technical Report No. 1.					

1.5.4 Daytime Population

The daytime population figures are presented in Table 1-4. These figures reflect the total population plus private employment minus residents who commute to work out of the location.

Table 1-4 Daytime Population						
Location	Population in 1990	Private Sector Employment in 1990	Less Commuters Who Go Out Town (as of 1990)	Estimated Daytime Population in 1990	Estimated Gain or (Loss) in Population	Estimated Percentage of Change in Population
Maywood	9,473	3,506	4,433	8,546	(927)	-9.8%
Lodi	22,355	6,453	10,074	18,734	(3,621)	-16.2%
Rochelle Park	5,587	3,932	2,567	6,952	1,365	24.4%
Bergen County	825,380	396,230	342,837	878,773	53,393	7.8%
Source: Bergen County Department of Planning and Economic Development, Technical Report No. 1.						

1.5.5 Age of Population

The median age of the population has been steadily increasing in the three municipalities (Table 1-5).

Table 1-5 Median Age of Population					
Location	1950	1960	1970	1980	1990
Maywood	32.3	33.5	36.1	37.7	39.4
Lodi	28.8	29.0	29.1	31.6	35.1
Rochelle Park	-------	34.9	37.4	40.5	42.4
Source: Bergen County Department of Planning and Economic Development, Technical Report No. 1.					

The population by age in 1990 is presented in Table 1-6.

Table 1-6
Population by Age in 1990

Age	Maywood	Lodi	Rochelle Park	Bergen County
0-4	531	1,433	278	48,940
5-9	470	1,083	255	45,095
10-14	484	1,062	228	45,621
15-19	502	1,137	291	47,475
20-24	633	1,689	343	55,171
25-29	672	2,489	427	66,507
30-34	798	2,242	409	69,381
35-44	1,466	3,261	751	129,469
45-54	1,042	2,100	575	99,687
55-59	463	1,054	288	44,987
60-64	555	1,136	319	46,688
65 Plus	1,857	3,669	1,423	126,359
Total Male	4,429	10,567	2,541	396,272
Total Female	5,044	11,788	3,046	429,108
Total Population	9,473	22,355	5,587	825,380

Source: Bergen County Department of Planning and Economic Development, Technical Report No. 1.

1.5.6 Capacities for Population Growth

Capacity for population growth in the three communities and in the county was recently assessed on the basis of available land, zoning, and total land remaining that is expected to be absorbed by growth either through development or redevelopment by the year 2010 (Bergen County Department of Planning and Economic Development, Technical Report No. 1). The results are presented in Table 1-7. Of the three communities, Maywood's capacity for population growth is the lowest; only 54 individuals.

Table 1-7 Capacities for Population Growth			
	Population (1987)	Projected Population (2010)	Capacity for Growth (1987-2010)
Maywood	9,646	9,700	54
Lodi	22,682	28,000	5,318
Rochelle Park	5,249	6,600	1,351
Bergen County	825,380	943,005	117,625

1.5.7 Land Use

Figure 1-6 presents a summary of general land use within 1,000 feet of the study area. With the exception of a 0.43-acre neighborhood park located on Duvier Road, there are no public recreational facilities in the study area. There also are no religious facilities, schools, or libraries located within the study area. Whitehall Residence (140-unit housing) and Bristol Manor (180-bed nursing home) are located on the west side of Route 17. A development of high-density garden apartments is located in the southeast part of the study area. More than 50 percent of the land area in Maywood is in residential use, a percentage that is similar to the land use within 1,000 feet of the study area. A detailed summary of land use in the three communities and in Bergen County is presented in Table 1-8.

1.6 Summary of Previous Investigations

The following summary of investigations conducted to date on the Stepan Company and on the Sears and Adjacent Properties emphasizes data on chemical, nonradiological contamination collected in DOE and EPA investigations. The focus of this RI report is chemical contamination. A brief summary of previous radiological investigations also is presented.

1.6.1 Soils

Historical characterization of nonradiological contamination in soils is based on data collected by DOE (1987a, 1987b, 1987c) and by EPA (1988). The DOE data were collected primarily to determine the presence or absence of nonradiological contaminants during the course of DOE's radiological investigations.

DOE. The DOE data show the presence of low levels of contaminants at Sears, Sunoco, and the MISS. These contaminants include volatile organics (methylene chloride, acetone, benzene, and toluene), base neutral/acid extractables (phthalates,

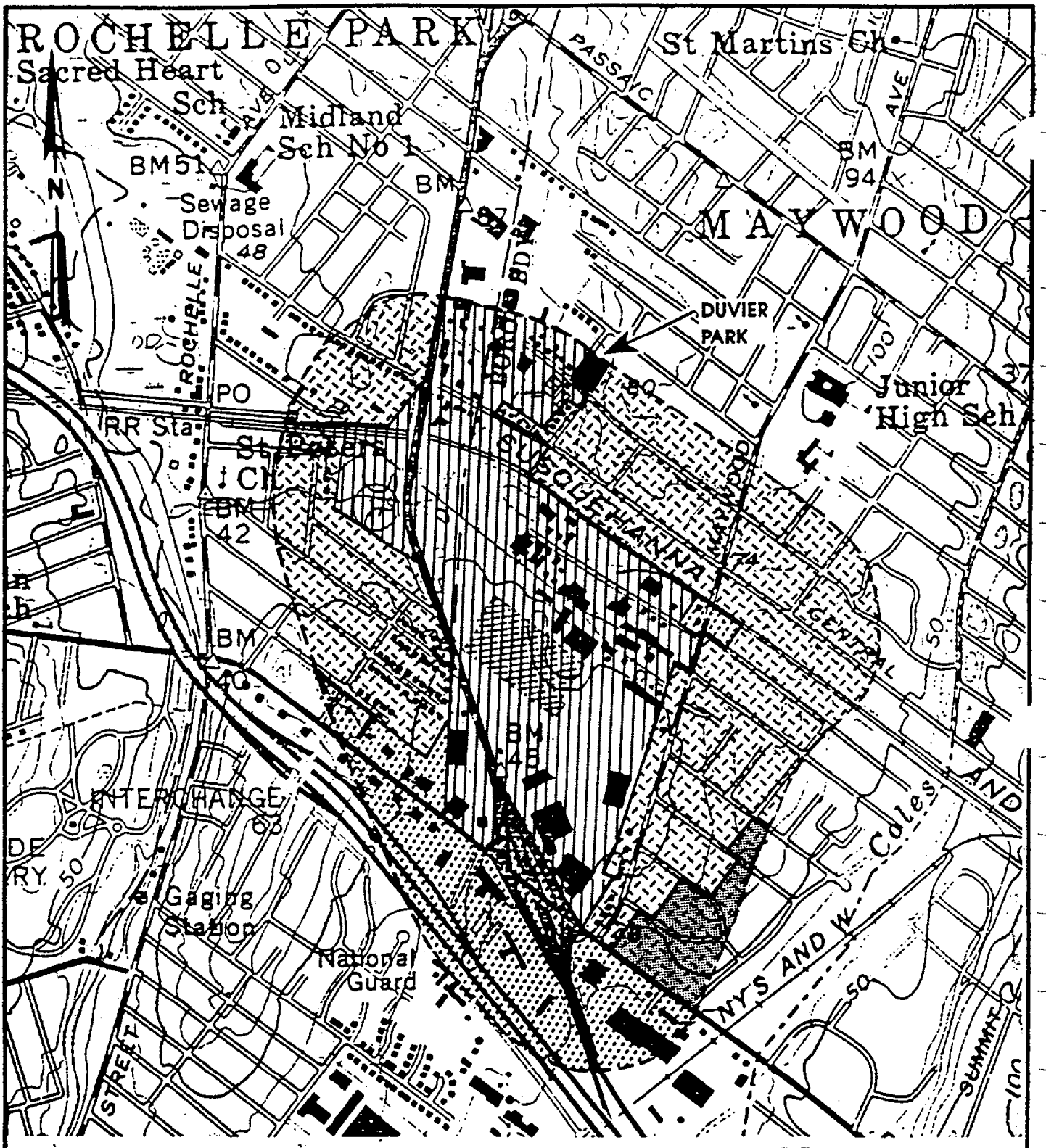


FIGURE 1-6
GENERAL LAND USE

Table 1-8
Land Use

Use	Maywood (acres)	Lodi (acres)	Rochelle Park (acres)	Bergen County (acres)
RESIDENTIAL				
low density (<5 du/acre)	0	0	0	35,815
med density (5-20 du/acre)	405	580	259	24,295
high density (>20 du/acre)	37	33	0	975
Office/Industrial	97	152	68	8,590
Commercial	38	152	64	4,886
Utility/Streets	202	350	123	24,452
Public/Quasi-Public	25	121	14	8,708
Open Space (public & private)	26	19	91	21,531
Undeveloped	10	43	39	18,793
Water	0	18	10	3,739
Total	840	1,468	668	152,784

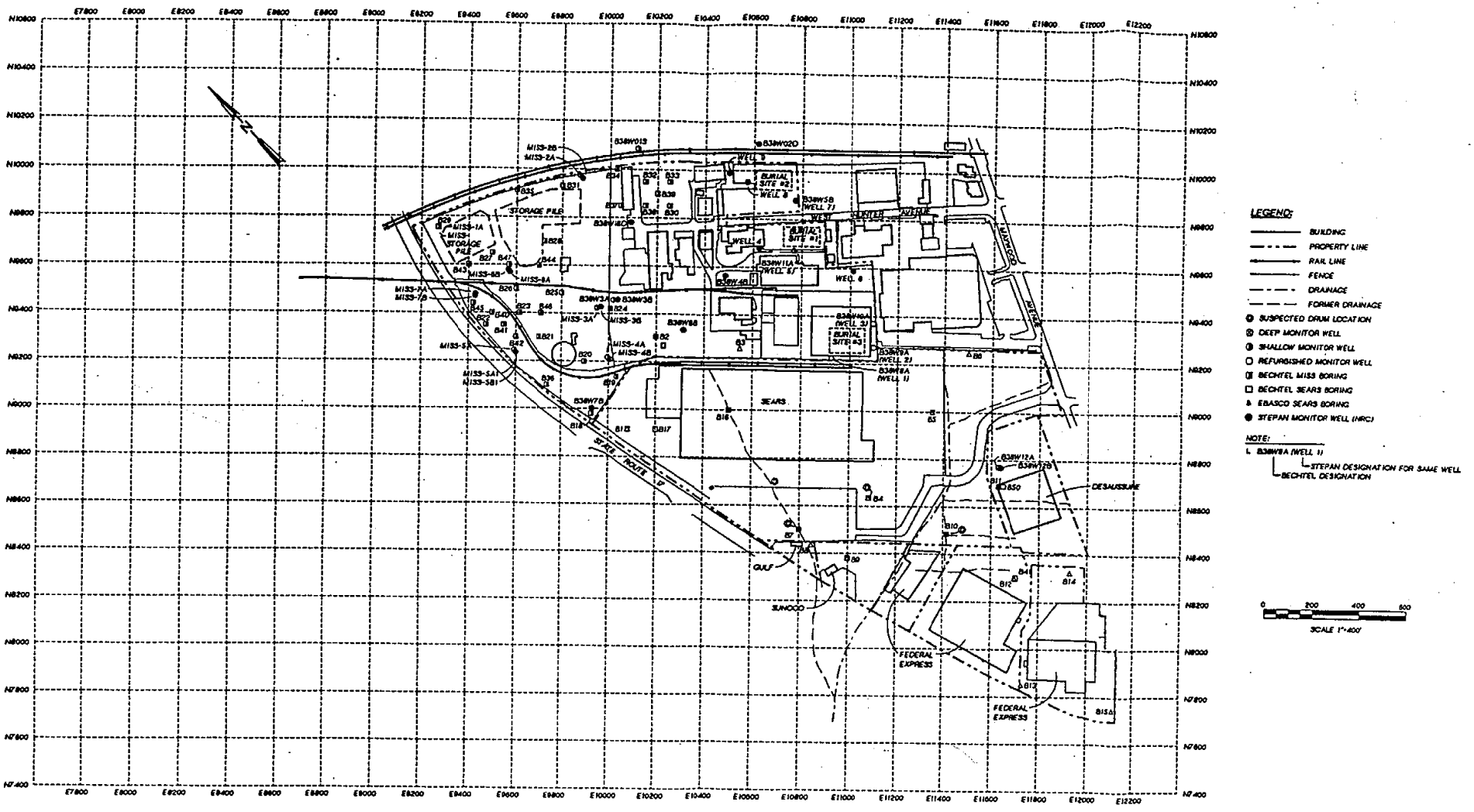
Note: Values from 1982
du = dwelling unit

Source: Bergen County Department of Planning and Economic Development, Technical Report No. 2.

polynuclear aromatic hydrocarbons), and metals (arsenic, cadmium, chromium, lead). However, the data are of limited value and provide only a qualitative indication of contamination. Part of the reason is that samples were taken from soils composited from split-spoon samples collected over 16-foot depths. In addition, holding times on many samples collected for volatile organics analyses were exceeded.

EPA. EPA sampled subsurface soils from August to September 1986 and August to October 1987. The locations sampled are shown in Figure 1-7. Detailed results of sampling are provided in Appendix A. Unlike the DOE samples, the EPA samples were collected from specific depth intervals. However, there were a number of data quality problems such as poor surrogate recoveries, presence of analytes in blanks, and exceeded holding times. Where these problems occurred, they are noted in the data tables in Appendix A.

The soil results from the 1986 sampling effort indicated significant levels of volatile organics in the parts per million (ppm) range, base neutral/acid extractables (24 compounds with some concentration levels at the ppm level), and eight metals



STEPAN COMPANY AND SEARS AND ADJACENT PROPERTIES RI
MAYWOOD, NEW JERSEY

FIGURE 1-7
EXISTING MONITORING WELLS AND SOIL BORING LOCATIONS

varying in concentration up to several hundred ppb. In addition, nine pesticides were detected onsite in levels up to several hundred ppb. Some soil borings also contained gasoline and fuel oil components, various methylated benzenes, caffeine, and essential and ethereal oils (a-pinene and d-limonene).

Methylene chloride, acetone, methyl ethyl ketone, xylene, ethylbenzene, toluene, and benzene were the principal volatile contaminants found in soil borings at the Maywood Chemical Company site.

Acetone and methyl ethyl ketone were found at concentrations ranging from below the detection limited to 5.3 and 15 ppm, respectively. These substances exhibited no generalized distribution pattern across the site although the highest concentrations of both compounds occurred at borehole locations B-2, B-4, and B-12. Methyl ethyl ketone and acetone were detected at each borehole, with the concentrations of methyl ethyl ketone typically increasing with depth.

Concentrations of methylene chloride were greatest near the center of the site, with the highest concentration in boring locations B-4, B-7, and B-12. Methylene chloride was primarily a surficial phenomenon except at boring B-4, where it exhibited increasing concentrations with depth. The maximum methylene chloride value for the site (2.2 ppm) was found at the 9 to 11-foot depth in boring B-4.

Benzene, toluene, xylene, and ethylbenzene exhibited a similar distribution pattern of concentration relative to sample locations. All four compounds exhibited greatest onsite concentrations at mid-depth of borehole B-4 and at the 5 to 7-foot depth of boring B-12 (81 ppm benzene, 9.4 ppm toluene, 120 ppm xylene, and 55 ppm ethylbenzene). In boring B-12, xylene, ethylbenzene, and toluene were present at the surface, but these compounds also showed increasing concentrations with depth in the 5 to 9-foot interval.

Elevated concentrations of 14 base neutral/acid extractables were detected in the soil borings. They were associated with three general classes of compounds: nonnaphthenic polycyclic aromatic hydrocarbons (PAHs), phthalates, and naphthenics. Ten additional base neutral compounds (fluoranthene; benzyl alcohol; benzoic acid; 1,2,4-trichlorobenzene; phenol; 2-methyl phenol; 4-methyl phenol; 2,4-dimethyl phenol; di-n-butylphthalate; and diethylphthalate) typically occurred at concentrations lower than 2 ppm. Most of these additional base neutral compounds were associated with the 14 compounds typically showing high concentrations (up to 50 ppm).

PAHs, phthalates, and naphthenics were surficial phenomena present at their greatest concentrations in boreholes B-1 and B-11. Chrysene and benzo(a)anthracene also showed elevated concentrations in borehole B-5 (0.4 and 0.5 ppm, respectively), and benzo(b)fluoranthene had elevated concentration levels in borehole B-3 (17 ppm).

Phthalate contamination also tended to be a surficial phenomenon of the central grassy area, although concentrations increased with depth at borings B-9 and B-12 for bis(2-ethylhexyl) phthalate.

Naphthalene and 2-methyl naphthalene contamination was also a surficial phenomenon at boring locations B-4 and B-12. Considering that these two compounds are normal constituents of No. 2 fuel oil (diesel), EPA concluded that it is not anomalous or unexpected to see these two compounds at the locations where other fuel oil contaminants were found (see discussion on gasoline and fuel oil components). Therefore, EPA assumed that the naphthalene and 2-methyl naphthalene might have originated from spillage or leakage associated with the USTs.

EPA compared the concentrations of metals in the soil borings to values for natural concentrations of metals in soils as reported in a study by Conner and Shaklette in 1985. Concentrations of arsenic, cadmium, chromium, lead, and mercury were found in the soil borings at levels that exceeded normal background concentrations in soil (Conner and Shacklette) in at least one onsite location. Nickel, beryllium, and zinc were detected but were within normal soil concentration ranges. Onsite metal contamination was primarily a surficial phenomenon, with the greatest concentrations of each metal typically found in the northwestern quadrant of the site.

Chromium was present throughout the site with levels ranging up to several hundred ppm near the surface in the grassy areas adjacent to the Sears and DeSaussure buildings and just north of the Sears building's northern wall, adjacent to the Stepan property line.

Cadmium was detected at elevated concentrations in three areas on the Sears property but not at the Stepan property. The three areas were the northwest corner, the southeast corner, and the central-northeast area. The highest cadmium concentrations, 2.8 to 4.3 ppm, were present in the northwest corner of the site adjacent to the Stepan property line.

Soil boring samples were analyzed for pesticides and polychlorinated biphenyls (PCBs). The analytical results are presented in Appendix A. The nine pesticides detected onsite were alpha-BHC, dieldrin, lindane, endosulfan I, endosulfan sulfate, Aldrin, DDE, DDD, and DDT, with maximum concentrations of 7, 50, 12, 58, 230, 3, 94, 190, and 240 ppb, respectively. Occurrence of pesticides was a surficial phenomenon and generally restricted to the grassy area adjacent to the Sears and DeSaussure buildings.

Gasoline and fuel oil components were detected and consisted primarily of benzene, toluene, xylene, and ethylbenzene. Considering that these four compounds are common octane-boosting additives to gasoline and that their greatest concentrations were found in borehole B-4, which is approximately 30 feet from two USTs (one gasoline, one No. 2 diesel), EPA concluded that the principal source of these

compounds may be the gasoline UST, (Figure 1-4, UST 1) citing the presence of both gasoline components and fuel oil components at depth (3-to-5 and 7-to-9-foot intervals) in borehole B-12 to support this conclusion.

On the basis of generalized patterns of hydrological flow in the area, EPA concluded that the sample intervals stated above would be downgradient of the underground tanks. EPA speculated that surface spillage near the tanks could have been the source of contamination because contaminant levels decrease with depth in borehole B-4.

A-pinene, which is an essential oil, and d-limonene, an ethereal oil, were detected only in the central portion of the site, near the surface of borehole B-4 (1 to 3-foot interval). Caffeine also was detected near the surface of boring B-7; however, EPA rejected this detection for technical reasons (low gas chromatograph/mass spectrometer [GC/MS] EM voltage). EPA tentatively identified A-pinene, d-limonene, and caffeine in the GC/MS library search and considered the results semiquantitative and principally useful in determining presence or absence rather than quantitative concentration. Therefore, no concentration levels were given for any of the compounds. EPA noted that these three compounds are used typically in the food and fragrance industries and are not generally seen in environmental matrices.

Summary. In summary, chemical contamination in the study area, as determined by DOE and EPA, involved six classes of contaminants:

- Volatiles, which were principally nonhalogenated, common industrial solvents or octane-boosting agents related to gasoline
- Base neutral/acid extractable compounds consisting primarily of PAHs--some of which are possibly related to No. 2 fuel oil (diesel)--and phthalates, which are widely used
- Pesticides (principally chlorinated types)
- Heavy metals
- Gasoline and fuel oil contaminants
- Essential oil and ethereal oil (i.e., a-pinene, d-limonene) and caffeine

With the exception of the contamination related to gasoline or fuel oil, which was primarily subsurface in the 3 to 11-foot depth range, all onsite contamination generally occurred in the northwest quadrant of the Sears property and the grassy area of the site adjacent to the Sears and DeSaussure buildings. Because most contaminants were detected near the surface, the contamination is presumed to be the result of surface spillage or the use of contaminated fill.

1.6.2 Groundwater

The historic groundwater information is composed of results of monitoring performed by DOE at the MISS beginning in 1985. DOE monitored MISS wells quarterly for radiological and water quality parameters and annually for New Jersey priority pollutants (BNI, 1986; BNI, 1984; BNI, 1988; BNI, 1989; BNI 1990; BNI, 1991). In addition, in 1988, EPA sampled wells installed by DOE in 1987 and 1988 in the Maywood and vicinity sites. The locations of all wells sampled by DOE and EPA are shown in Figure 1-6.

The DOE data from the MISS groundwater monitoring for the years 1985 to 1987 and 1990 are provided in Appendix B. The results of the sampling performed by EPA in 1988 are also provided in Appendix B.

DOE Groundwater Monitoring at the MISS, 1985-1991. The 1985 sampling showed groundwater to be flowing from northeast to southwest in both the overburden and bedrock aquifer. Most samples from wells at the MISS were found to contain moderate amounts of methylene chloride, bis(2-ethylhexyl)phthalate, and tetrachloroethylene. High concentrations of methylene chloride; bis(2-ethylhexyl)phthalate; benzene; trans-1,2-dichloroethylene; and total organic halide were found in a few wells.

No distinct pattern of chemical concentrations was apparent for the deep wells. In the shallow wells, the highest concentrations were found in well 2A (near the northern boundary of the MISS). Concentrations decreased across the site to the southwest, in the primary direction of groundwater flow. The 1986 data were similar to those for 1985.

In 1987, contaminants such as benzene; trans-1,2-dichloroethylene; trichloroethylene; and tetrachloroethylene were detected at more wells, although at lower concentrations than in the previous two years. Comparison of analytical data from 1987 and 1988 indicates that the contamination may have dissipated. The benzene concentration in well 2B decreased by more than 50 percent, as did the 1,2-dichloroethylene concentration in well 4B. However, the 1989 data for these same and other contaminants significantly increased, particularly tetrachloroethane, from 17 to 58 ppb, in MISS2B; in MISS4B benzene increased to 140 ppb, 1,2-dichloroethene to 750 ppb, vinyl chloride to 340 ppb, and xylene to 1,800 ppb. Newly installed monitoring wells downgradient of the site (B38W14S, B38W14D, B38W15S, and B38W15D) also showed elevated concentrations of VOCs.

In 1990, no volatile compounds were detected at well 2B, but elevated levels of vinyl chloride (180 ppm) appeared at well 4B. One of the offsite, downgradient wells across Route 17, B38W14S, had the highest contamination, with six volatile compounds detected; the maximum concentration found was for tetrachloroethylene at 260 ppb. Metals concentrations were also elevated at the site.

EPA Groundwater Sampling in 1988. Nine wells were sampled by EPA in 1988. In well B38W4B on the Stepan property, benzene and toluene were detected at 15 and 100 ppb, respectively. The DOE sampling for this same well in 1990 showed no benzene, and the concentration of toluene had dropped to 25 ppb.

Summary. Most of the organic contaminants detected during DOE's annual groundwater monitoring program, which was initiated in 1985 at wells on and around the MISS, are solvents and gasoline components. Contaminant concentrations in most wells have fluctuated significantly over time, and although concentrations in some wells seem to have decreased during the 1985-through-1990 time period, downgradient transport appears to have occurred.

1.6.3 Surface Water and Sediment

In 1990, as part of monitoring the MISS, DOE collected surface water and sediment samples from Westerly Brook upstream of Saddle River and from Lodi Brook (Figure 2-10). Surface water was sampled quarterly for pH, specific conductivity, total organic carbon (TOC), total organic halogens (TOX), and metals. Analyses for volatiles and semivolatiles were performed in the third quarter. Sediments were analyzed in the fourth quarter for metals. Results are provided in Appendix B.

Results of Surface Water and Sediment Sampling in 1990. The volatile analyses of surface water showed low but detectable concentrations (less than 50 ppb) of 1,2-dichloroethylene (total), trichloroethylene, and 1,1,2,2,-tetrachloroethane at location 2 in Westerly Brook, downgradient of the MISS. However, no volatiles were detected at Location 1, furthest downstream from the MISS, near Saddle River. Concentrations of metals in sediments were comparable upstream and downstream.

Interpretation of Surface Water and Sediment Results. DOE concluded that the MISS was not contributing to nonradiological degradation of sediment quality, surface water in Lodi Brook, or surface water flowing to the Saddle River. Although volatile compounds were detected in Westerly Brook, the groundwater data may support this conclusion. The chlorinated solvents detected in surface water downgradient of the MISS are similar in type and location to the six volatiles detected in groundwater in 1990, indicating the probability of an onsite source, although a source located downgradient of Route 17 cannot be ruled out.

1.6.4 Tank Closure at Stepan Property

On October 7, 1991, two USTs were removed from Stepan by W.S. King & Son. One 1,000-gallon gasoline UST and one 2,000-gallon No. 2 fuel oil UST were removed. The gasoline tank was formerly located adjacent to the southwest corner of the guard house, which is located at the entrance to Stepan. The fuel oil tank was formerly located near the central portion of Stepan, or approximately 50 feet southeast of monitoring well B38W04B. The two tanks are shown in Figure 1-4 as locations 1 and 5 and in Appendix C.

The following discussion is based upon a report prepared by Environmental Profile Laboratories (EPL) of Toms River, New Jersey.

At the time of the tank removals, no holes or tank pitting, product odors, stained soils, or free product were observed. The excavation was screened with a photoionization detector (PID) that was calibrated to benzene. Screening by the PID did not reveal any "hot spots." Soil samples were collected as outlined in NJDEPE's technical guidance document and in the approved closure plan, according to EPL's report. Soil sampling locations are shown in Figure 2A in Appendix C. The results associated with the soil samples collected on October 7, 1991, from both tank areas are summarized in Tables 1 and 2 in Appendix C.

Because the concentrations of total petroleum hydrocarbon in soil collected from the fuel-oil tank area were elevated with respect to NJDEPE's Bureau of Underground Storage Tank (BUST) cleanup standards, King & Son and EPL returned to Stepan on October 22, 1992, to remove additional contaminated soils. In EPL's mobile laboratory, soil was analyzed onsite for total petroleum hydrocarbons.

The fuel-oil tank excavation was extended to a total depth of approximately 10 feet below grade and was terminated on the western side because the edge of a shed constructed of sheet metal was encountered. In order to maintain the stability of this structure, some contaminated soil was left in place. The amount of contaminated soil removed is unknown. Residual total petroleum hydrocarbon-(TPH)-contaminated soil above NJDEPE standards was left in the soil on the side of the tank area abutting the shed. EPL performed volatile organic analyses on the samples; elevated total petroleum hydrocarbons were found in S-3, S-1-2, and S-2-2. These results are presented in Table 1 in Appendix C.

As required by NJDEPE BUST requirements, a groundwater monitoring well (MW-1) was installed on January 17, 1992, in the area next to the former gasoline tank. The well was sampled on February 5 and March 12, 1992. The various BTEX components were detected in concentrations ranging from 96 ppb for benzene on February 5, 1992, to 2,800 ppb for total xylenes on March 12, 1992. The results are summarized in Table 3 of Appendix C.

A complete copy of the report and laboratory data packages prepared by EPL was submitted to BUST for review.

1.6.5 Radiological Characterizations

In 1980, the NJDEPE and the NRC conducted radiological surveys on the Stepan Company and Ballod properties and confirmed the presence of elevated radiological contamination, primarily by Th-232. Other radiological surveys around this time confirmed the presence of radiological contamination.

In 1983, the EPA conducted radiological surveys of Stepan and Sears and adjacent properties, including Sunoco, Gulf, SWS, DeSaussure, Federal Express, and AMP. With the exception of Federal Express, the EPA surveys identified the presence or potential presence of radiological contamination on each of these properties.

Stepan and Sears. From 1987 through 1991, DOE conducted radiological characterizations of Stepan and Sears and adjacent properties, including the MISS. The characterizations identified radioactive contamination of surface and subsurface soil by thorium, radium, and uranium. Th-232 was identified as the primary contaminant. A brief summary of the results of DOE's radiological characterization is provided below for all properties except Stepan. A comprehensive evaluation of radiological contamination on the Stepan property can be found in DOE's 1992 Remedial Investigation Report. In addition to the radiological contamination in the three burial sites, there are several other areas of surface and subsurface contamination on the Stepan property.

DeSaussure. DOE's 1989 radiological characterization of the DeSaussure property indicated areas of surface and subsurface contamination along the northern, northwestern, and western boundaries of the property. In addition, surface soil contamination was identified along a section of the drainage ditch located in the southwestern corner of the property (DOE, 1989b).

Gulf. In 1989, subsurface soil radiological contamination was identified by DOE throughout the Gulf property. Surface soil radiological contamination was considered limited in extent (DOE, 1989c).

Sunoco. In 1987, DOE identified surface soil radiological contamination in a section of the drainage ditch located along the southeastern corner of the Sunoco property. Subsurface soil contamination was identified as being present over most of the property (DOE, 1987c).

SWS. DOE's 1987 characterization of the SWS property identified surface soil radiological contamination on both the western edge and on the stream bank along the eastern edge of the SWS property. Subsurface contamination was considered a potential along the stream bank, while subsurface soil samples and gamma logging of boreholes did not indicate subsurface soil contamination on the remainder of the SWS property (DOE, 1987d).

Sears. In 1987, surface and subsurface radiological contamination was identified by DOE across the majority of the Sears property. Radiological contamination was also identified in sediment samples, and detectable levels of gross alpha radiation were noted in surface water samples (DOE, 1987b).

MISS. In 1984, DOE began annual environmental compliance monitoring in the MISS and surrounding area. The MISS monitoring programs included sediment and surface water sampling. Annual groundwater sampling was added in 1985. From

1985 to 1990, annual average concentrations of Ra-226, Th-232, and total uranium remained below DOE's derived concentration guidelines (DCGs) in both surface water and groundwater samples (DOE, 1991)[1]. DOE's 1987 characterization of the MISS indicated the presence of radiological contamination in surface and subsurface soils and sediments (DOE, 1987e).

AMP. The 1987 DOE characterization indicated that radiological contamination of surface and subsurface soil was limited to the drainage ditch located along the northeastern boundary of AMP. Analysis of soil boring samples and gamma logging of borings did not identify subsurface radiological contamination elsewhere on the property (DOE, 1987f).

1.7 Well Searches

As part of the RI, a well search was performed to identify potential offsite receptors to groundwater. The well search included the following:

- A 5-mile-radius search for major water-supply well performed by the NJDEPE Bureau of Water Allocation
- A 1-mile-radius search for wells by Well Search Services, Inc.

The RI well search indicated that there were no active municipal-water-supply wells within 1 mile of the site, which alleviated the concern that there may be large public groundwater receptors close to the study area. However, as shown in Figure 1-8, one industrial supply well with a pumping capacity greater than 100,000 gpd was located within 1 mile of the site. The well was registered under Interplast Industries. The well search also indicate that Stepan draws water from the Saddle River for noncontact cooling purposes; no well was registered under Stepan's name. There were also 30 smaller-yield water wells within 1 mile of the site (see Figure 1-9). The exact location, status (whether active or inactive), and current use of each of these wells were not identified during the RI well search but were investigated during the well search performed as part of the focused investigation. A detailed description of the results of the RI well search is provided in Section 1.7.1.

As a follow-up to the RI, an expanded well search was performed under the Focused Investigation, with the following objectives:

- Identification of any additional wells within a 1-mile radius of the site

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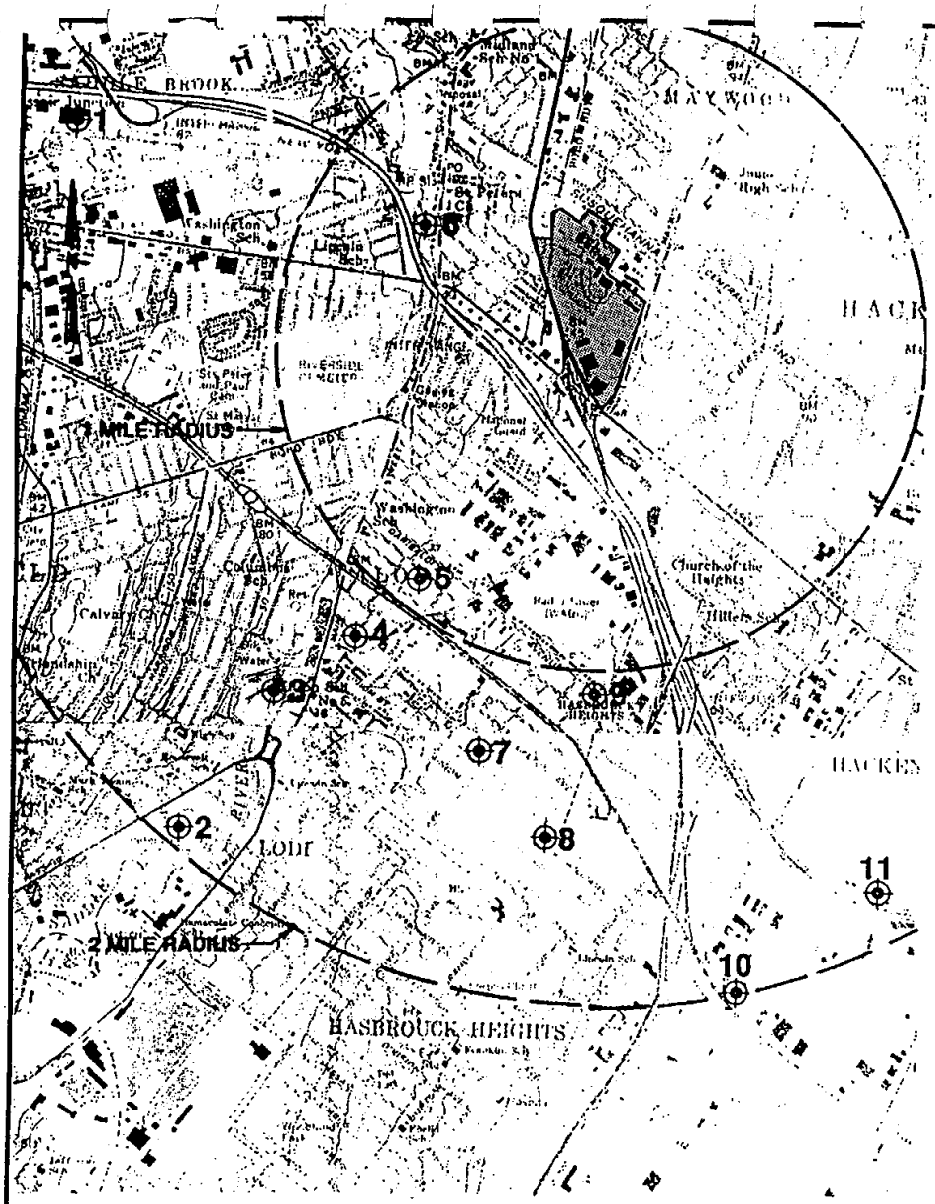
[1]DCGs are public exposure guidelines for radionuclide concentration. DCGs are derived from DOE's 100 millirem/year exposure limit to radionuclides resulting from DOE operations. The guidelines are derived for exposure to individual radionuclides, assuming ingestion of 2 liters of water per day.



WELL	NAME	(WELL DEPTH, PUMP CAPACITY)
1-	PARK 80 ASSOCIATES	(400', 300gpm)
	PARK 80 ASSOCIATES	(300', 0 gpm)
	PARK 80 ASSOCIATES	(300', -)
2-	LODI BOROUGH	(459', 150 gpm)
3-	LODI BOROUGH	(300', 160 gpm)
4-	LODI BOROUGH	(307', 295 gpm)
	LODI BOROUGH	(300', 355 gpm)
	LODI BOROUGH	(332', 355 gpm)
5-	INTERPLAST UNIVERSAL, IND. INC.	(310', 150 gpm)
6-	STEPAN CO.	(Surface Water Intake, 2000 gpm)
7-	LODI BOROUGH	(470', 200 gpm)
8-	LODI BOROUGH	(373', 500 gpm)
9-	LODI BOROUGH	(409', 375 gpm)
10-	TAKASAGO	(445', 70 gpm)
11-	SPINNERIN YARN CO.	(404', 65 gpm)
	SPINNERIN YARN CO.	(400', 50 gpm)
	SPINNERIN YARN CO.	(435', Unknown)
	SPINNERIN YARN CO.	(400', 140 gpm)

Locations are based on the New Jersey State Coordinates

SCALE: 1" = 2000' - 0"

STEPAN COMPANY AND SEARS AND ADJACENT PROPERTIES RI
MAYWOOD, NEW JERSEY

FIGURE 1-8
MAJOR WATER SUPPLY WELLS (>100,000gpd)

ALL WELL LOCATIONS ARE APPROXIMATE

▲ Industrial, commercial, or irrigation wells

● Sanitary or domestic wells

★ Actual well location may be outside a 1-mile radius of the study area

STEPAN COMPANY AND SEARS AND ADJACENT PROPERTIES RI
MAYWOOD, NEW JERSEY

FIGURE 1-9
OTHER WATER WELLS

- Determination of the status of each well and whether any of the smaller-yield wells identified during the RI search are used for drinking water

- Determination of whether the large supply well identified during the RI search is used for drinking water

In order to accomplish these objectives, the following tasks were performed:

- Six municipalities within a 1-mile radius of the site were contacted for information on supply wells registered with or otherwise known to that municipality's health department, department of public works, building department, or other department with such information. The following six municipalities lie within a 1-mile radius of the site: Maywood, Hackensack, Rochelle Park, Garfield, Saddle Brook, and Lodi.

- The Bergen County Department of Health Services was contacted for information on supply wells registered with or otherwise known to the department.

- Water purveyors that supply drinking water to the six municipalities were identified and contacted for information on supply wells. The following two purveyors were contacted: Hackensack Water Company and Passaic Valley Water Commission.

- Tax maps for the six municipalities were reviewed to identify the current addresses and owners of wells identified during the RI well search and during the tasks listed above. For many of the wells identified during the RI search, a single address and owner could not be identified because only an approximate location was available for the wells. In such cases, the owners of properties surrounding the approximate location of the well were contacted in the following task.

- Potential well owners identified during the preceding task were contacted to determine if a well exists on the property, whether the well is active, and what its uses are. This task consisted of consecutively attempting to contact potential well owners by telephone, mail, and in a door-to-door survey.

1.7.1 RI Well Search Results

Major Water Supply Wells. A list of major water supply wells within a 5-mile radius of the study area was provided by the NJDEPE Bureau of Water Allocation. This list includes wells with greater than 100,000-gpd pumping capacity that are listed in water allocation permits and water-use registrations. The computerized search identified one supply well and one surface water intake within a 1-mile radius of the site

(Figure 1-7). The surface water intake is registered under Stepan Company. The supply well, approximately 0.9 miles to the southwest, is a 310-foot-deep well owned by Interplast Universal Industries, Inc.

An additional 16 water withdrawal wells were identified within a 2-mile radius, to the south and west of the Stepan Company and Sears and adjacent properties, which is downgradient in terms of shallow groundwater. The location of these wells is shown on Figure 1-7. The wells are located in the Brunswick Formation and range in depth from 300 to 607 feet. Well pumping capacities range from 50 to 500 gpm. Eight of the 16 wells are inactive and capped municipal wells owned by the Borough of Lodi. Some of the Lodi wells were scheduled for plugging and abandonment in 1993, and others were being used in an EPA remedial investigation.

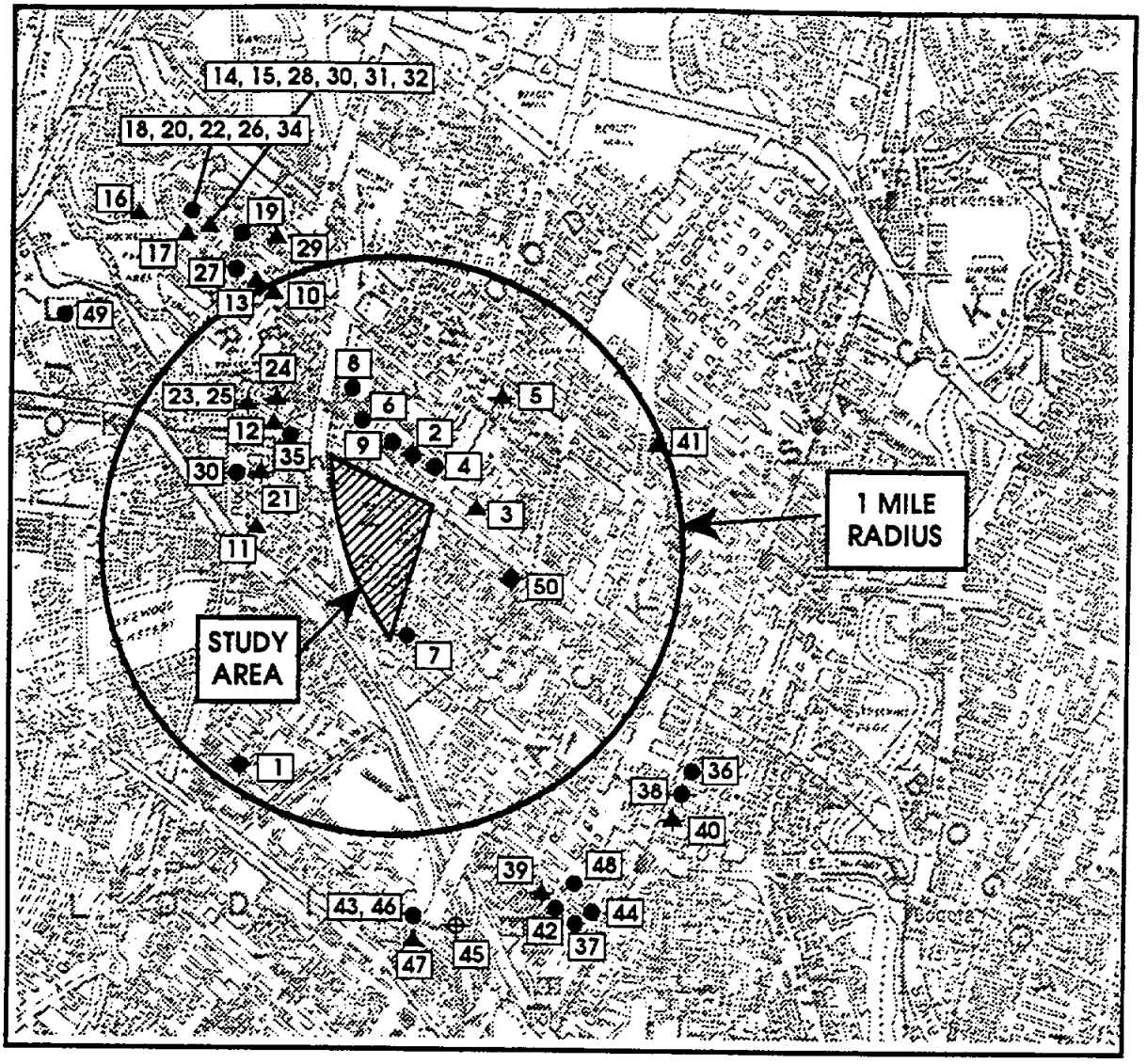
Other Water Wells and Monitoring Wells. Approximately 175 additional monitoring wells or water wells were identified within a 1-mile radius of the study area. The search was completed by Well Search Services, Inc. (Lincroft, New Jersey) using NJDEPE Bureau of Water Allocation files and included wells installed after 1946. Most of the wells are monitoring wells or piezometers with total depths of 100 feet or less. Seventeen industrial, commercial, or irrigation wells were identified (see Figure 1-8), with total depths ranging from 67 to 435 feet. Thirteen domestic or sanitary wells were identified (see Figure 1-8), with total depths ranging from 75 to 305 feet. It should be noted that all wells were located using the New Jersey Atlas Sheet Coordinates. For several of the wells, these coordinates suggested that the wells are within a 1-mile radius of the sites. The well addresses, however, were well outside the 1-mile radius. These wells are marked with an asterisk (*) in Figure 1-9.

1.7.2 Focused Investigation (Expanded) Well Search Results

During the expanded well search, 136 potential well owners were identified. Approximately 25 percent of these were contacted by telephone; questionnaires were sent to the rest. The response to this mailing was approximately 50 percent. The remaining potential well owners were contacted in a door-to-door survey. Of 136 potential well owners, 19 could not be contacted using this approach. Fifteen could not be contacted because the name and/or address of the owner, which was provided by the Tax Department, was incorrect, and the other 4 could not be contacted because there was no one available at the address to provide information, although several visits were made to the address.

A total of 50 wells, some active and some inactive, were identified within approximately 1 mile of the study area as a result of the expanded search. The approximate locations of these wells are shown in Figure 1-10. Table 1-9 summarizes the uses of these wells. A summary of the results follows:

- Of the 30 wells identified during the RI well search, current owners could be identified only for 11. This low percentage may be caused by a change in property owner since the time the well was installed, with



LEGEND

All Well Locations are Approximate.

- ● Inactive
- ◆ Active commercial/industrial
- ⊕ Active commercial/drinking
- ▲ Active domestic non-drinking
- ♣ Active domestic drinking

N

Figure 1-10
LOCATION OF WELLS FOUND IN EXPANDED SEARCH
Sears and Adjacent Properties RI
Maywood, New Jersey

CH2M HILL

Table 1-9 Expanded Well Search–Uses of Identified Wells		
Well No.	**Well Use**	**Survey Method**
Lodi		
1	Industrial: cooling water	D
Maywood		
2	Commercial: plant watering	T
3	Domestic: lawn	T
4	Inactive	T
5	Domestic: drinking	T
6	Inactive	T
7	Commercial: car wash	M
8	Inactive	M
9	Inactive	D
50	Industrial uses	D
Rochelle Park		
10	Domestic: lawn	T
11	Domestic: lawn	T
12	Domestic: pool	T
13	Domestic: laundry, pool, lawn	T
14	Domestic: lawn, car wash	T
15	Domestic: lawn	T
16	Domestic: lawn, pool	T
17	Domestic: lawn	T
18	Inactive	T
19	Inactive	T
20	Inactive	T
21	Domestic: drinking	T

Table 1-9 Expanded Well Search–Uses of Identified Wells		
Well No.	**Well Use**	**Survey Method**
Rochelle Park (continued)		
22	Inactive	M
23	Domestic: drinking	M
24	Domestic: drinking	M
25	Domestic: drinking	M
26	Inactive	M
27	Inactive	M
28	Domestic: lawn	M
29	Domestic: car wash	M
30	Domestic: lawn, car wash	M
31	Domestic: lawn, car wash	M
32	Domestic: lawn, plants watering	M
33	Inactive	M
34	Inactive	D
35	Inactive	D
Hackensack		
36	Inactive	T
37	Inactive	M
38	Commercial: laundromat	M
39	Domestic: drinking	M
40	Domestic: drinking	M
41	Domestic: lawn	M
42	Inactive	M
43	Inactive	M
44	Inactive	M

Table 1-9
Expanded Well Search–Uses of Identified Wells

Well No.	Well Use	Survey Method
Hackensack (continued)		
45	Commercial: drinking	D
47	Domestic: cleaning	D
48	Inactive	D
Saddle Brook		
49	Inactive	T

Notes:
T Well owner contacted by telephone.
M Well owner responded to mail request for information.
D Well owner was contacted during the door-to-door survey.

the new owner not aware that there is a well on his or her property because the well is not currently in use. Another reason may be an incorrect address and location information in the well permit completed by the driller and provided to the NJDEPE at the time of well installation. These permits were used to provide information on wells within 1 mile of the study area during the RI well search.

- Of the 50 wells identified (including the 11 wells verified from the original well search):
  - 21 are currently inactive
  - 5 are active commercial/industrial wells not used for drinking water
  - 1 is an active commercial and drinking-water well
  - 16 are active domestic wells used for lawn watering, car washing, pools, and other nondrinking uses
  - 7 are active domestic drinking-water wells
- The large water-supply well owned by Interplast and identified during the RI well search supplies cooling water.

It should be noted that all active wells located within a 1-mile radius of the site may influence groundwater levels at the site, particularly in bedrock. Of these, the well considered most likely to influence site water levels is well No. 2 located on West Magnolia Avenue. The well owners have indicated that pumping of this well is typically intermittent.

1.7.3 Summary

No active municipal-water-supply wells were identified within a 1-mile radius of the study area, which alleviates the concern that there may be large public groundwater receptors close to the study area. However, 30 water wells were located during the RI well search within a 1-mile radius of the study area. These wells are screened in the Brunswick Formation and range in depth from 40 to 435 feet.

The expanded well search performed under the Focused Investigation confirmed the existence of only 11 of the wells identified during the RI well search. This low number may be a result of changes in property ownership after the well was installed, with the new owner not being aware that there is a well on the property because the well is not currently in use. Another reason may be that the address and location in

the well permit completed by the driller and provided to NJDEPE at the time of well installation were incorrect. These permits were used as information sources for wells within 1 mile of the study area during the RI well search.

A total of 50 wells (including the 11 wells confirmed during the RI well search) study were identified in the expanded well search. Of these, only eight are used for drinking water. The rest are inactive, or used for commercial or industrial supplies, or used for nondrinking domestic uses such as lawn watering and car washing.

The results of the RI and the expanded well searches confirm that groundwater receptors in the area are limited.

Section 2

Field Investigation

2.1 Introduction

Several distinct field activities, summarized below and in Section 2.2, were conducted during the RI from August 29, 1991, to November 5, 1992, and during the Focused Investigation from July 19 to November 18, 1993. In general, activities and objectives described in this section can be assumed to have occurred during the RI (August 1991 through November 1992). Activities that occurred during the Focused Investigation (July through November 1993) are specifically designated as such. A chronology is presented in Table 2-1. All field activities are discussed in this section; however, activities common to the overburden and bedrock groundwater investigations are discussed only once, in Section 2.6, which follows the individual overburden groundwater and bedrock sections.

The following field activities were conducted during the RI:

- Overburden soils investigation
  - Soil boring and sampling program
- Overburden groundwater investigation
  - Selection of groundwater well construction material
  - Well rehabilitation and evaluation survey
  - Overburden drilling and well construction
  - Hydraulic conductivity tests
  - Static and continuous water level measurement
  - Surveying
  - Sampling
- Bedrock groundwater investigation
  - Bedrock drilling, coring, and well construction
  - Borehole geophysical logging
  - Hydraulic pressure injection testing
  - Hydraulic conductivity testing
  - Static and continuous water level measurement
  - Sampling
- Surface water and sediment characterization
  - Sampling

Table 2-1
Chronology of Field Investigation Activities

August 29, 1991	Groundwater sampling for pH and chlorides to determine stainless steel grade used for well construction
September 3-12, 1991	Surface geophysical investigation at Stepan
September 12-13, 1991	Surface geophysical investigation at DeSaussure
September 18-20, 1991	Surface geophysical investigation at Federal Express
October 29, 1991	Surface geophysical investigation at Gulf
October 31, 1991	Surface geophysical investigation at Sunoco
November 14-15, 1991	Surface geophysical investigation at AMP
December 10-12, 1991	Surface geophysical investigation at Stepan (amended)
December 10-13, 1991	Well rehabilitation and evaluation survey (Stepan)
December 18-19, 1991	Preliminary wetlands delineation (Stepan, Sears and adjacent properties)
December 31, 1991-January 3, 1992	Surface geophysical investigation at SWS
February 10-11, 1992	Construction of decon. pad (Stepan) and mobilization for soil borings (Stepan)
February 12-19, 1992	Soil boring program (Stepan)
February 20-28, 1992	Soil boring program (adjacent properties, excluding Sears)
March 2-4, 1992	Overburden well installation (Stepan)
March 2-17, 1992	Surface geophysical investigation at Sears
March 5-28, 1992	Overburden well installation and bedrock well drilling (Stepan, adjacent properties, excluding Sears)
March 25-April 6, 1992	Test-pitting program (Stepan and Stepan amended property)
March 30-April 22, 1992	Soil boring program, overburden well installation, and bedrock well drilling (Sears)
April 6-15, 1992	Test-pitting program (adjacent properties, excluding Sears)

Table 2-1
Chronology of Field Investigation Activities

April 22-May 1, 1992	Development of overburden wells (Stepan, Sears, and adjacent properties)
April 20-22, 1992	Detailed jurisdictional wetlands delineation (Sears and adjacent properties)
May 4-20, 1992	Test-pitting program (Sears)
May 4-16, 1992	Borehole geophysical logging program (Stepan, Sears, and adjacent properties, excluding Gulf)
May 18-June 2, 1992	Hydraulic packer testing program [Stepan, Sears, and adjacent properties, excluding Gulf (BRMW3) and Federal Exp. (BRMW9)]
May 20-21, 1992	Test-pitting program additional pits required by EPA (Stepan, and adjacent properties)
May 28-June 4, 1992	Bedrock well completion (Stepan, Sears, and adjacent properties, excluding Gulf and Federal Express)
June 1, 1992	Water level measurements
June 8-25, 1992	Bedrock well drilling and completion (Gulf, Federal Exp.); development of bedrock wells (Stepan, Sears, and adjacent properties)
June 22, 1992	Water level measurements
June 22-July 13, 1992	Surveying activities (Stepan, MISS, Sears and adjacent properties)
July 20-24, 1992	Surface water and sediment sampling (Sears and adjacent properties)
July 20-Aug. 4, 1992	Groundwater sampling (Stepan, MISS, Sears, and adjacent properties)
July 28, 1992	Water level measurements
August 4, 1992	Blue material sampling and confirmation of metal detector anomalies requested by EPA (DeSaussure)
August 12-27, 1992	In-situ hydraulic conductivity testing (Stepan, Sears and adjacent properties)
September 9, 1992	Water level measurements

Table 2-1
Chronology of Field Investigation Activities

September 10-17, 1992	Continuous water level measurements
October 2, 1992	Water level measurements
November 5, 1992	Water level measurements
Focused Investigation Activities	
July 19-August 3, 1993	Groundwater sampling (Stepan, MISS, Sears and adjacent properties)
July 26-August 6, 1993	Soil gas program (Stepan)
September 7-17, 1993	Soil boring and hand auger program
October 8-14, 1993	Pressure injection testing
September 20-October 14, 1993	Well installation program
October 24-27, 1993	Bedrock pumping test (Stepan)
November 1-4, 1993	Overburden pumping test (Stepan)
November 15-18, 1993	Bedrock pumping test (Sears)
November 19-December 7, 1993	Reinjection of pumping test water at wells BRTW-1, BRTW-2, and OBTW-1.

- Geophysical survey
- Test pitting
- Surveying
- Wetlands delineation
- Flood hazard area assessment

The field investigation work was performed in general accordance with the work plans (CH2M HILL) and the Stepan Quality Assurance project plan (QAPP) (CH2M HILL). Modifications to these plans occasionally occurred as a result of field conditions. These modifications are described in the appropriate sections.

Soil, sediment, surface water, groundwater, and material sampled from test pits were analyzed for the chemical, radiological, and physical parameters shown in Table 2-2 and described in Sections 2.3.6, 2.7.4, 2.8.4, and 2.9.

2.2 Focused Investigation Activities

The following field activities were conducted during the Focused Investigation:

- Groundwater sampling
- Source area delineation
  - Soil gas survey
  - Soil boring sampling
  - Hand auger sampling
  - Installation and sampling of two shallow overburden wells (OBMW18 and OBMW19)
- Hydrogeologic evaluation
  - Overburden and bedrock pump tests
  - Pressure injection testing
- Expanded well search

Soil and groundwater samples collected during the Focused Investigation were analyzed for the chemical parameters shown in Table 2-3 and described in Sections 2.7 and 2.10.

Table 2-2
Analytical Parameters, Methodologies, and Media Analyzed

Analytical Parameters	Analytical Methods	MEDIA ANALYZED				
		Soil Boring	Sediment	Surface Water	Groundwater	Test Pit
Chemical						
TCL VOC	CLP SOW [a]	X	X	X	X	X
TCL semivolatiles, caffeine, a-pinene, and d-limonene	CLP SOW [a]	X	X	X	X	X
TCL pesticides/PCBs	CLP SOW [a]	X	X	X	X	X
TOC	EPA/CE-81 and EPA 415.1 [b]	X [c]	X			
TAL metals and cyanide	CLP SOW [d]	X	X	X	X	X
Lithium	CLP SOW [d]	X [e]	X	X	X	
TCLP VOCs, semivolatiles, herbicides, and pesticides	SW 846 [f]					X
TCLP metals	SW 846 [f]					X
Radiological						
Gross alpha and gross beta	EPA Method 900.0	X	X	X	X	X
Ra-226 and Ra-228	EPA Methods 903.1 and 904.0	X	X	X	X	X
Th-230 and Th-232	Alpha Spectroscopy		X	X	X	X
Total - Thorium	Alpha Scinitillation	X				
U-234, U-235, U-238	Alpha Spectroscopy	X [g]	X	X	X	X
Total uranium	EPA Method 908.1		X [h]			X [i]
Physical						
Atterberg limits (liquid and plastic)	ASTM D4318	X				
Grain size distribution (wash sieve and hydrometer)	ASTM 4222	X				
Moisture content	ASTM D2216-80	X				
X-ray diffraction		X [j]				

[a] Groundwater and surface water samples were analyzed for TCL VOCs according to the method specified in *Superfund Analytical Methods for Low Concentration Water for Organic Analysis*, June 1991, (SAMLCO691).
Soil, sediment, and test pit samples were analyzed for TCL organics according to the method specified in *EPA CLP Statement of Work for Organics Analysis, Multi-Media, Multi-Concentration*, February 1988. Groundwater and surface water samples were also analyzed using this method, for TCL semivolatiles, pesticides, and PCBs only.

[b] *Procedure for Handling Sediment and Water samples* (EPA/CE-81-1) and *Methods for Chemical Analysis of Water and Wastes*, March 1988, (Method 415.1).

[c] TOC analysis was done on only the following three soil boring samples: C31(8 to 10 ft.), C26(0 to 6 ft.), and C24(4 to 6 ft.).

[d] *EPA CLP Statement of Work For Inorganics Analysis, Multi-Media, Multi-Concentration*, March 1990.

[e] Lithium analysis was performed on samples from borings C5 and C20 on Stepan, and on all the borings on Sears.

[f] *Test Methods for Evaluating Soild Waste* (SW846), November 1986. Samples for TCLP VOCs, semivolatiles, pesticides, herbicides, and metals were extracted according to Method SW 846 1311. Analyses of extract was then performed according to SW 846 methods for the analyes of interest.

[g] Total-Thorium analysis was performed because of high radiological levels in samples.

[h] Total-Uranium analysis was performed by the laboratory on one sediment sample.

[i] Total-Uranium analyses were performed by the laboratory on more than half of the test-pit samples; these results were subsequently used by the laboratory to back-calculate isotopic uranium data, assuming uranium, was natural (as opposed to enriched or depleted).

[j] X-ray diffraction was performed on one soil sample only (collected from blue material).

Notes:
TCL = Target Compound List
CLP = EPA Contract Laboratory Program
PCBs = Polychlorinated biphenyls
TAL = Target Analyte List
TCLP = Toxicity Characteristic Leaching Procedure
ASTM = American Society for Testing and Materials
SOW = Statement of Work
VOCs = Volatile organic compounds
TOC = Total organic compound

Table 2–3
Analytical Parameters, Methodologies, and Media Analyzed During Focused Investigation

Analytical Parameters	Analytical Methods	MEDIA ANALYZED DURING FOCUSED INVESTIGATION		
		Soil Boring	Groundwater	Hand Auger
TCL VOC	CLP SOW [a]	X	X	
TCL Semivolatile Organics	CLP SOW [a]	X [b]	X [c]	X
TCL Pesticides [d]	CLP SOW [a]		X	
TAL Metals (total)	CLP SOW [e]		X	
TAL Metals (filtered) [f]	CLP SOW [e]		X	
Cyanide [g] (total)	CLP SOW [e]		X	

[a] Groundwater samples were analyzed for TCL VOCs according to the method specified in *Superfund Analytical Methods for Low Concentration Water for Organic Analysis*, June 1991, (SAMLCO691).
Soil samples were analyzed for TCL organics according to the method specified in *EPA CLP Statement of Work for Organics Analysis, Multi–Media, Multi–Concentration*, February 1988. Groundwater samples were also analyzed using this method, for TCL semivolatile organics and pesticides.

[b] Soil borings analyzed for TCL semivolatile organicswere SG–5, SG–18A, and SG–19.

[c] Groundwater samples from wells B38W01S, B38W02D, B38W18D, OBMW19 and BRTW2 were not analyzed for semivolatile organics.

[d] The following wells were analyzed for pesticides: OBMW15, BRMW15, BRMW16, B38W05B and B38W18D.

[e] *EPA CLP Statement of Work For Inorganics Analysis, Multi–Media, Multi–Concentration*, March 1990.

[f] Samples from twenty–eight wells were sampled for TAL metals (filtered).

[g] The following wells were analyzed for cyanide: B38W12A, B38W12B, BRMW5, BRMW7, BRMW8, BRMW9, BRMW12, OBMW5, OBMW8, OBMW12, and OBMW7.

Notes:
TCL = Target Compound List
CLP = EPA Contract Laboratory Program
TAL = Target Analyte List
SOW = Statement of Work
VOCs = Volatile organic compounds

2.3 Overburden Soil Investigation

2.3.1 Objectives

Overburden soils were investigated because contaminants bound to these soils might be transported to the water table and further transported through the overburden groundwater system. Also, contaminated overburden soils (particularly surficial soils) may pose a human health or ecological risk. The specific objectives of the overburden soils investigation were as follows:

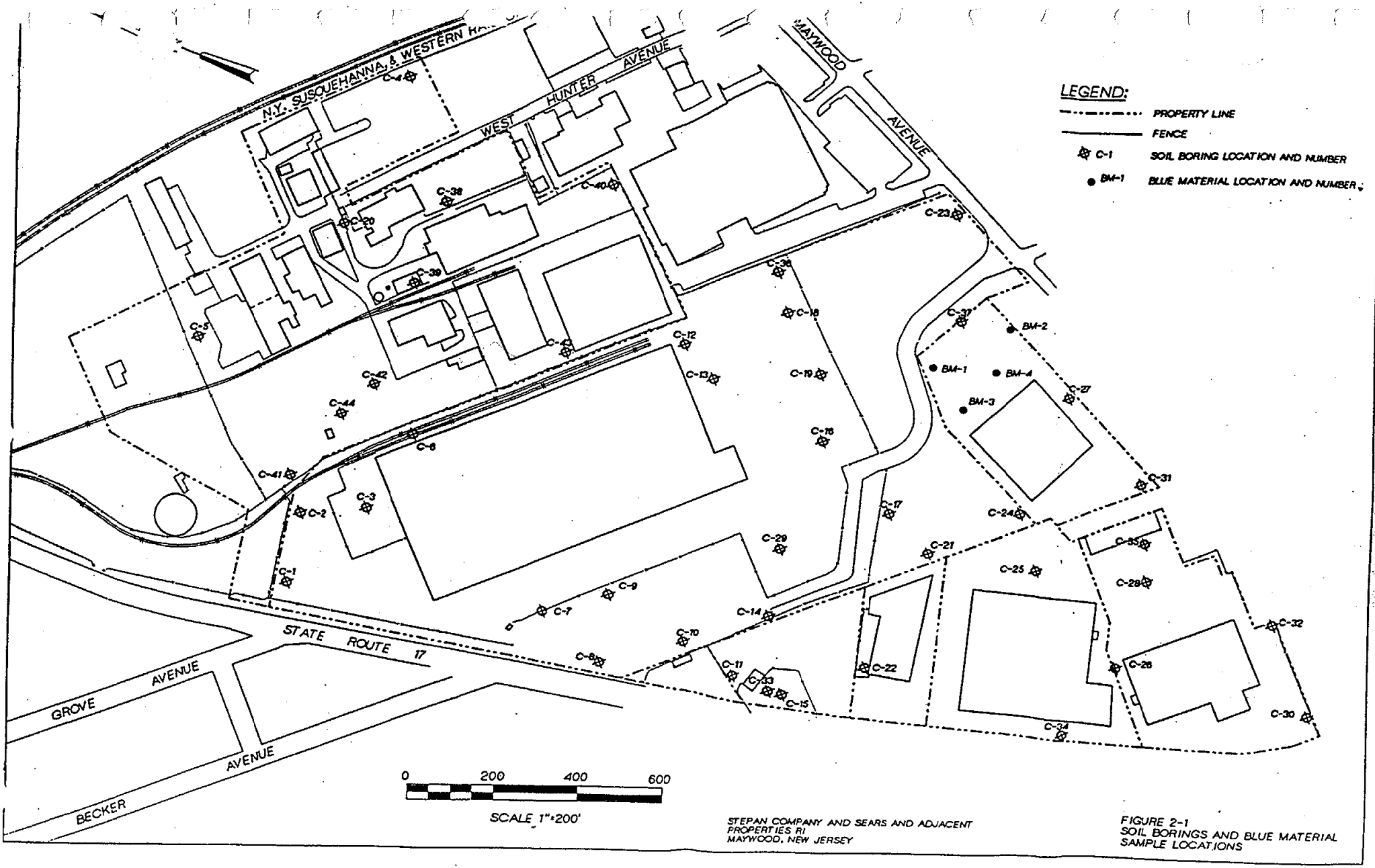
- To determine the presence and levels of indicator compounds and chemical constituents in the overburden soils
- To obtain measurements that indicate the vertical and lateral distribution of contaminant concentrations over the study area in order to provide a basis for estimating the areal extent and the depth of the overburden to be remediated
- To measure soil properties affecting the mobility of contaminants in the overburden materials

The RI focused on overburden soil in which radioactivity did not exceed DOE's action level and therefore was not subject to remediation by DOE. All soil samples and drill cuttings were screened onsite to determine the levels of radiological contamination.

2.3.2 Soil Boring Methodology

Forty-four soil borings were installed from February 11, 1992, through April 8, 1992, on Stepan and Sears and adjacent properties. The locations of these borings are shown on Figure 2-1. Ten borings were installed on Stepan ranging in depth from 3.5 feet (C-5) to 13.7 feet (C-38). Thirty-four borings were installed on the Sears and adjacent properties ranging in depth from 2.0 feet (C-30, Federal Express) to 17.9 feet (C-25, SWS). Drilling services were provided by Environmental Drilling Inc. of West Creek, New Jersey. The justification for soil boring locations and their distribution by property is summarized in Table 2-4.

Of the total 44 soil borings, 35 were advanced using a Mobile B-61 drilling rig using 6¼-inch-inside-diameter hollow-stem augers. Continuous split spoon samples were collected in accordance with American Society of Testing and Materials (ASTM) D1586-84. In general, in order to collect a sufficient quantity of soil, a 3-inch-diameter split spoon was used to collect analytical samples to the depth of soil saturation and 2-inch-outer-diameter split spoons were used below this depth to collect samples for lithologic description; the spoon or auger was advanced until it



STEPAN COMPANY AND SEARS AND ADJACENT PROPERTIES RI
MAYWOOD, NEW JERSEY

FIGURE 2-1
SOIL BORINGS AND BLUE MATERIAL SAMPLE LOCATIONS

Table 2-4
Justification and Distribution of Soil Borings

Soil Boring Number	Corresponding Well(s)	Property Location	Reason for the Location Chosen
C-1	--	Sears	A
C-2	--	Sears	A
C-3	--	Sears	A
C-4	OBMW-15/BRMW-15	Stepan	A
C-5	--	Stepan	D
C-6	--	Sears	B
C-7	--	Sears	A
C-8	OBMW-14/BRMW-14	Sears	D
C-9	OBMW-13/BRMW-13	Sears	A,B
C-10	--	Sears	B,C
C-11	OBMW-3/BRMW-3	Sunoco	B
C-12	OBMW-10	Sears	A
C-13	--	Sears	A
C-14	--	Sears	C
C-15	--	Sunoco	A
C-16	OBMW-4/BRMW-4	Sears	D
C-17	--	Sears	B
C-18	--	Sears	A
C-19	--	Sears	A,B
C-20	--	Stepan	A
C-21	--	Sears	B,C
C-22	--	AMP	A
C-23	OBMW-6/BRMW-6	Sears	D
C-24	OBMW-7/BRMW-7	Sears	B
C-25	--	SWS	B
C-26	--	Federal Express	D
C-27	--	DeSaussure	B
C-28	--	Federal Express	D

Table 2-4
Justification and Distribution of Soil Borings

Soil Boring Number	Corresponding Well(s)	Property Location	Reason for the Location Chosen
C-29	--	Sears	C
C-30	BRMW-9	Federal Express	D
C-31	--	DeSaussure	D
C-32	--	Federal Express	D
C-33	OBMW-5/BRMW-5	Sunoco	A
C-34	OBMW-8/BRMW-8	SWS	D
C-35	OBMW-12/BRMW-12	Federal Express	D
C-36	OBMW-11/BRMW-11	Sears	D
C-37	--	DeSaussure	D
C-38	BRMW-16	Stepan	A
C-39	--	Stepan	C
C-40	OBMW-17/BRMW-17	Stepan	D
C-41	--	Stepan	D
C-42	--	Stepan	A
C-43	BRMW-10	Stepan	A
C-44	OBMW-2/BRMW-2	Stepan	A

Notes:
- A The boring is located on or near the site of potential soil contamination, as suggested by historical aerial photographs, burial grounds, and underground storage tanks.
- B The boring is located in a former surface drainage channel.
- C The boring is located in or near an area where chemical contamination was indicated in previous EPA or DOE investigations.
- D The boring location was chosen to provide areal coverage of the site.

OBMW indicates overburden monitoring well installed during RI.
BRMW indicates bedrock monitoring well installed during RI.

was refused. The size of the split spoon used also depended on what was available for use at the time. Samples were visually described and classified using the Unified Soil Classification System (USCS) per ASTM D2488-84. Soil-boring logs were prepared for each soil boring except the borings in the blue material. The boring logs are provided in Appendix D. The blue material was described as a light blue, soft, wet, clayey-silt. Additional information regarding the blue material is provided in Section 4.2.

A tripod assembly was used on the remaining nine soil borings that were not accessible with the Mobile B61. The tripod assembly was equipped with a portable cathead and, therefore, was not capable of augering. Samples in these borings were acquired by consecutive split spoon advancement. The tripod sampling was limited to shallow depths because saturated conditions were encountered and the boreholes caved in.

2.3.3 Soil Sampling Methodology

One hundred twenty-six soil samples were collected and sent for organic and inorganic chemical analyses as described in Section 2.3.6. Thirteen soil samples were also sent for radiological analysis and three soil samples were sent for physical characterization and TOC analysis.

After the soil boring program was completed, EPA requested that selected soil boring samples from Stepan and Sears also be analyzed for lithium. The samples for lithium analysis were obtained from the laboratory or the field archive of soil boring samples. Fifty-seven soil samples were analyzed for lithium. Five samples were from Stepan and 52 samples were from Sears.

As part of the soil boring program, grab samples of blue material found adjacent to and within the wooded area of the DeSaussure property were collected on three different dates. The blue material sampling locations are designated BM-1 through BM-4 and are shown on Figure 2-1. The grab sample collected on June 1, 1992, was originally designated in the field as BM-2, but was later changed to BM-4 because BM-2 was used as a sample designation in another area on the DeSaussure property. The samples were requested by EPA in order to assess the material's vertical and horizontal extent, and to obtain more comprehensive analytical data of the blue material and the native soils immediately below it.

The RI soil boring procedures followed were in accordance with the work plans (CH2M HILL). These procedures were as follows:

- Soil borings were advanced using a 4¼- or 6¼-inch-inside-diameter hollow-stem augers. Continuous split spoon sampling was conducted every 2 feet from the ground surface to the top of bedrock. Soil samples were collected until saturated conditions or the top of bedrock

were encountered. However, both unsaturated and saturated soils that extended to the top of bedrock were geologically logged.

- Soil samples were collected using 2- or 3-inch-outside-diameter carbon steel split spoons. All split spoons were decontaminated prior to use.

- Soil borings C-2, C-6, C-19, and C-37 were advanced using a tripod rig.

- When the split spoon was retrieved from the borehole, it was opened and the following information was recorded in the field logbook: sample description, depth, time, date, and sample recovery.

- The contents of the split spoon were sliced vertically with a decontaminated stainless steel knife and then scanned for VOCs by either a PID or an Flame Ionization Detector (FID).

- A representative portion of the soil was placed into two 40-ml vials for possible VOC analysis. Samples for possible VOC analysis were not homogenized and vials were packed tightly with soil, leaving as little headspace as possible.

- A 16-ounce nalgene sample jar for headspace screening was filled approximately halfway with soil and was covered with aluminum foil. The headspace sample was then allowed to equilibrate for approximately 10 minutes. The headspace reading was then taken using a PID or FID and recorded in the field logbook. The jar was capped and subsequently used for radiological screening in the field laboratory.

- The soil in the split spoon was scanned in the field for radioactivity by either ESP-1 or ESP-2 model count rate meters in combination with an HP-210 or HP-260 G.M. thin window probe.

- The soil remaining in the split spoon was placed into a stainless steel bowl, covered with aluminum foil, and labeled with the boring number and corresponding depth interval.

- When a soil boring was completed, selected samples were chosen from specific intervals to be sent for chemical analysis, based upon the criteria described in Section 2.3.4.

- Soils from the selected depth-specific intervals were homogenized and placed into sample jars for the following analytical parameters, in the following order: semivolatiles (TCL), caffeine, d-limonene, a-pinene, pesticides/PCBs (TCL), metals (TAL), cyanide (TAL), and radionuclides.

- A soil sample for possible radiological analysis was collected from every depth interval for each soil boring. As required in the work plan, only 10 percent of the total number of samples collected were to be analyzed for radionuclides. The samples sent for radiological analysis were selected at the end of the soil boring program, when all gamma logging was available for evaluation. The selection of the 13 samples that were sent for radiological analysis was based upon the sample selection criteria described in Section 2.3.4.

- When a boring was advanced to the top of bedrock, it was logged for gamma radiation. In general, this was done by placing a temporary, 4- or 6-inch-outside-diameter PVC casing inside the auger, from the ground surface to the bottom of the borehole. The auger was then removed, and gamma logging was performed at 6-inch intervals, using an Eberline Model PRS-1 or PRS-2 count rate meter with an Eberline Model BHP-2 probe.[1] When the gamma logging was completed, the PVC casing was removed, and the borehole was filled with a cement-bentonite grout. At some boring locations, where the depth to groundwater was shallow, the PVC casing could not be secured at the bottom of the borehole because the casing was buoyant. The gamma logging at these locations was then taken directly inside the borehole, without any PVC casing. The gamma readings were recorded in the field logbook and are shown on the soil boring logs in Appendix D. Once the borehole was completed and the gamma readings were collected, the drill cuttings were backfilled into the borehole if they (1) had readings less than 30,000 cpm, (2) had no detectable contamination, and (3) if the borehole was not to be converted into monitoring wells.

- Sample jars were decontaminated by wiping soils from the jars' outside surfaces. Swipe samples to be surveyed for alpha and beta-gamma contamination were then collected from the jars. The sample jars were also directly surveyed for alpha contamination. The survey results were compared to release criteria specified in the site-specific health and safety plan, which were based on DOE's surface radioactivity guides (DOE Order 5480.11). If contamination was detected, the outsides of the jars were re-cleaned and re-surveyed until radiological levels were below the release criteria.

- Samples were screened in the field laboratory by a Tennelec Model 6000 multichannel pulse height analyzer. Screening results provided an approximation of thorium-232 and/or radium-226 levels, expressed in

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[1]The BHP-2 probe is lead shielded, containing a 2 inch x 2 inch NaI scintillation crystal, with a conversion efficiency of 1,115 cpm per 1uR/hour (Ra-226).

pCi/g. This screening was performed to determine whether samples exceeded the DOT shipping criteria of 2,000 pCi/g (total activity), because materials containing radioactivity above the DOT shipping criteria are required to be shipped as limited-quantity radioactive materials. The screening results were also used to inform the analytical laboratories of radioactivity levels in the samples for both health and safety purposes and NRC licensing.

- Samples for all parameters (except radiological) were stored at 4°C until they were shipped; Quality Assurance/Quality Control (QA/QC) requirements were adhered to (i.e., custody seals were used; samples were secured in a locked field trailer). Radiological samples were not refrigerated, but the same QA/QC procedures used for the samples that were shipped for chemical analysis were used for the radiological samples.

The blue material on the DeSaussure property was sampled on February 25, 1992; June 1, 1992; and August 4, 1992. These samples were obtained and analyzed as follows:

- **February 25, 1992.** Sample was collected from the 0.5-to-1.0-foot interval using a decontaminated stainless steel trowel. Sample was homogenized in a stainless steel bowl. Sample was not analyzed for radiological parameters.

- **June 1, 1992.** Sample was collected from the 0.5-to-2.0-foot interval using a shovel and a decontaminated stainless steel trowel. Sample was analyzed by X-ray diffraction only, to determine the mineralogy of the materials.

- **August 4, 1992.** Samples from within and below the blue material were collected from the 0-to-1-foot, 1-to-3-foot, and 3-to-4-foot intervals, using a decontaminated stainless steel hand auger. These samples were analyzed for lithium and radiological parameters.

Blue material samples were also collected during test pitting for toxicity characteristic leaching procedure (TCLP) and radiological analyses. The test-pit sample collection procedures are outlined in Appendix E.

2.3.4 Sample Selection Criteria

The criteria for selecting samples for chemical and radiological analyses are described below.

Chemical Analysis. The chemical analysis criteria were designed to provide a gradient for chemical contamination in each borehole. Three samples are necessary

to show a gradient; however, if bedrock or saturated conditions were encountered at 4 feet or less, then the third sample was not collected. All soil boring samples collected for chemical analyses were taken from the unsaturated zone only. Results of field measurements and headspace screening are presented in Appendix F.

- The first sample was collected from the interval with the highest PID response and/or where visual observation noted contamination.

- The second sample was collected from one or two intervals below the interval from which the first sample was collected (usually the 2-to-4-foot or 4-to-6-foot interval).

- The third sample was collected from an interval that had no PID response and appeared to be visually clean, below the interval of the second sample.

  If there were no PID responses associated with soils collected from a boring, then the following criteria were used to select the depth interval to be sampled and analyzed.

- Visual signs of contamination (such as staining)

- Two-foot interval below the contact between the fill and native soil

- Two-foot interval below different lithologies

Radiological Analysis. Ten percent of the soil boring samples were analyzed for radiological constituents. The following criteria were used to select samples for radiological analysis:

- Sample interval had not been radiologically characterized by the DOE, as indicated by a review of gamma logging and radiological analytical results from previous DOE investigations.

- The radiological activity of the sample, as measured by gamma logging, exceeded the DOE site-specific guideline of 40,000 cpm, which was referenced in the RI work plans. This guideline is an approximate correlation to the DOE subsurface soils cleanup guideline of 15 pCi/g for Th-232.

Assumptions used to compare RI gamma log results to DOE's previous gamma log results are discussed in Section 4. The rationale used to select the samples for radiological analyses is shown in Table 2-5.

Table 2-5
Rationale for Soil Sample Selection for Radioligical Analysis

Property	Boring No.	Depth Interval (ft)	Rationale for Selection
Stepan	C20	(6.5-8.5)	Sample interval had not been radiologically characterized previously by DOE. Previous gamma logging in the vicinity of this boring only went to 5.5 feet, due to borehole stability problems.
	C38	(10-12)	The radiological activity of this sample interval exceeded the DOE action level guideline of 15 pCi/g or 40,000 cpm for 15cm-thick layers below 15 cm.
		(12-14)	Sample interval had not been radiologically characterized previously by DOE. Previous gamma logging in the vicinity of this boring did not reach this depth due to borehole stability problems. This sample interval was also the first interval that appeared to be visibly "clean" native material. Radiological analysis of this interval would help to delineate the depth of contamination from the intervals above, where gray/black sludge material was observed.
DeSaussure	C37	(0-2)	Previous gamma logging data for the property where boring C37 was installed was not found. The gamma logging results from this sample interval also exceeded the DOE action level guideline of 15 pCi/g or 40,000 cpm of radiological activity for 15cm-thick layers below 15 cm.
Sunoco	C15	(3-5)	The radiological activity of this sample interval exceeded the DOE action level guideline of 15 pCi/g or 40,000 cpm for 15cm-thick layers below 15 cm.
Sears	C7	(4-6)	This sample interval was selected because it was the deepest interval from boring C7, which had gamma logging results exceeding the DOE action level guideline of 15 pCi/g or 40,000 cpm of radiological activity. Therefore, this sample interval would help to indicate the extent of radiological contamination.
	C8	(2-4)	The radiological activity of this sample interval exceeded the DOE action level guideline of 15 pCi/g or 40,000 cpm for 15cm-thick layers below 15 cm.
	C9	(0-2)	The radiological activity of this sample interval exceeded the DOE action level guideline of 15 pCi/g or 40,000 cpm for 15cm-thick layers below 15 cm.
	C14	(2-4)	The radiological activity of this sample interval exceeded the DOE action level guideline of 15 pCi/g or 40,000 cpm for 15cm-thick layers below 15 cm.
	C16	(2.5-4.0)	This sample interval was selected because it was the deepest interval from boring C16, which had gamma logging results exceeding the DOE action level guideline of 15 pCi/g or 40,000 cpm of radiological activity. Therefore, this sample interval would help to indicate the extent of radiological contamination.
	C21	(2-4)	This sample interval was selected because it was the deepest interval from boring C21, which had gamma logging results exceeding the DOE action level guideline of 15 pCi/g or 40,000 cpm of radiological activity. Therefore, this sample interval would help to indicate the extent of radiological contamination.
	C24	(2-4)	Previous gamma logging by DOE in the vicinity of this boring did not reach this depth. During the RI, gamma logging could only reach a depth of 2.5 feet due to borehole stability problems. Therefore, this sample interval was analyzed because this depth interval had not been previously characterized by DOE, nor was it characterized during the RI.
	C29	(5-7)	Previous gamma logging by DOE in the vicinity of this boring did not reach this depth. During the RI, gamma logging could only reach a depth of 2.5 feet due to borehole stability problems. Therefore, this sample interval was analyzed because this depth interval had not been previously characterized by DOE, nor was it characterized during the RI.

Geologic Horizons. In addition to the chemical and limited radiological characterization, three soil samples were collected from different geologic horizons in order to determine the physical characteristics of these horizons. These samples were collected from borings C-24 (4 to 6 feet; Sears), C-26 (0 to 6 feet; Federal Express), and C-31 (8 to 10 feet; DeSaussure). The field geologist selected the samples based on the stratigraphy encountered during the soil boring program.

2.3.5 Modifications of Work Plans and QAPP

The following modifications of the work plans (CH2M HILL) and the QAPP (CH2M HILL) occurred during the soil boring program because of field conditions: some soil borings were relocated; sediment samples were not collected during the soil boring program; one of the criteria for selection of samples for radiological analysis was not used; and the blue material was found and sampled on the DeSaussure property, not on the Sears property, as originally expected.

Relocation of Soil Borings. The following borings had to be relocated because accessibility to the drill rig was limited by overhead and subsurface utilities or because saturated conditions associated with wetlands and drainage channels were encountered. The actual locations relative to the planned locations are provided below. Justification for the relocation of these borings was provided to EPA in a letter dated January 17, 1992. EPA subsequently approved the revised soil boring locations.

- Stepan—C-4 (250 feet to the northwest), C-43 (68 feet to the northwest), and C-44 (110 feet to the north).
- DeSaussure—C-37 (90 feet to the west).
- Federal Express—C-32 (85 feet to the south).
- Gulf—C-11 (50 feet to the east and onto Sunoco property; moved closer to drainage channel).
- Sears—C-12 (15 feet to the south), C-19 (65 feet to the northwest), C-21 (20 feet to the northeast), and C-17 (15 feet to the southeast). C-17 was installed on top of the western bank of the drainage channel.

Sediment Sample Collection. The two sediment samples originally planned to be collected at the same time as soil samples from borings C-19 and C-17 (SD-3 and SD-4, Sears) were not collected during the soil boring program. They were collected during one sampling event with all of the other sediment samples, in order to compare all analytical results associated within one media (sediments). The sediments were sampled simultaneously with surface water, in order to determine the impact of potentially contaminated sediment on surface water quality.

Radiological Sample Selection Criteria. The work plan stated that the sample interval exhibiting elevated gamma readings[2] would be selected for radiological analysis. This criteria was not used because it did not indicate whether or not subsurface soils contained Th-232 at levels above DOE's subsurface soils cleanup guideline of 15 pCi/g. Rather, it only provides statistical confidence that soils contain levels of radioactivity greater than background levels. DOE's previously established site-specific 40,000 cpm guideline was used instead, because it was approximately equal to 15 pCi/g Th-232.

Location of the Blue Material. The work plan stated that blue material was observed, during a preliminary site reconnaissance, within a wooded area on Sears. The blue material was actually found on the DeSaussure property and was sampled there.

2.3.6 Analytical Requirements

Soil boring samples selected for chemical analyses were analyzed by either TCT-St. Louis Laboratory in St. Louis, Missouri, or CH2M HILL's laboratory in Montgomery, Alabama. TCT-St. Louis also performed the physical characterization and TOC analysis of soil samples. Core Laboratories of Casper, Wyoming, performed the radiological analyses.

Table 2-3 summarizes analytical parameters for each media and analytical methodologies. The components of the analytical parameters are listed in Table 2-6.

Summaries of preservation methods and sample holding times for all analytical parameters (for both aqueous and solid matrices) are listed in Table 2-7.

The chemical analyses of the selected soil samples consisted of the following:

- TCL organics (VOCs, semivolatiles, pesticides, PCBs)
- TAL inorganics (metals and cyanide)
- Caffeine, d-limonene, and a-pinene
- Lithium (as requested by EPA for selected soil borings)
- TOC

The radiological analyses of the selected soil samples consisted of the following:

- Gross alpha and gross beta radiation
- Radium-226, -228
- Uranium-234, -235, -238
- Total-thorium (by alpha scintillation)

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[2]Elevated was defined as background + (4.66 times the standard deviation of background)

Table 2-6
TCL Organic and TAL Inorganic Analytes

TCL Volatile Organics	TCL Semi-volatile Organics	TCL Pesticides/PCBs	TAL Metals
Acetone	Acenaphthene	Aldrine	Aluminum
Benzene	Acenaphthylene	alpha-BHC	Antimony
Bromodichloromethane	Anthracene	beta-BHC	Arsenic
Bromoform	Benzo(a)anthracene	delta-BHC	Barium
Bromomethane	Benzo(b)fluoranthene	gamma-BHC (Lindane)	Beryllium
2-Butanone	Benzo(k)fluoranthene	Aroclor-1016	Cadmium
Carbon disulfide	Benzo(a)pyrene	Aroclor-1221	Calcium
Carbon tetrachloride	Benzo(g,h,i)perylene	Aroclor-1232	Chromium
Chlorobenzene	Benzoic acid	Aroclor-1242	Cobalt
Chloroethane	Benzyl alcohol	Aroclor-1248	Copper
Chloroform	Bis(2-Chloroisopropyl)ether	Aroclor-1254	Iron
Chloromethane	Bis(2-Chloroethoxy)methane	Aroclor-1260	Lead
Dibromochloromethane	Bis(2-Chloroethyl)ether	alpha-Chlordane	Magnesium
1,1-Dichloroethane	Bis(2-Ethylhexyl)phthalate	gamma-Chlordane	Manganese
1,2-Dichloroethane	4-Bromophenyl-phenylether	4,4'-DDD	Mercury
1,1-Dichloroethene	Butylbenzylphthalate	4,4'-DDE	Nickel
1,2-Dichloroethene (Total)	4-Chloro-3-methylphenol	4,4'-DDT	Potassium
1,2-Dichloropropane	4-Chloroaniline	Dieldrin	Selenium
cis 1,3-Dichloropropene	2-Chloronapthalene	Endosulfan I	Silver
trans 1,3-Dichloropropene	2-Chlorophenol	Endosulfan II	Sodium
Ethyl benzene	4-Chlorophenyl-phenylether	Endosulfan sulfate	Thallium
2-Hexanone	Chrysene	Endrin	Vanadium
4-Methyl-2-pentanone	Di-N-Butylphthalate	Endrin ketone	Zinc
Methylene chloride	Di-N-Octylphthalate	Heptachlor	
Styrene	Dibenzo(a,h)anthracene	Heptachlor epoxide	
1,1,2,2-Tetrachloroethane	Dibenzofuran	Methoxychlor	**OTHER**
Tetrachloroethene	1,2-Dichlorobenzene	Toxaphene	
Toluene	1,3-Dichlorobenzene		Cyanide
1,1,1-Trichloroethane	1,4-Dichlorobenzene		
1,1,2-Trichloroethane	3,3-Dichlorobenzidine		
Trichloroethene	2,4-Dichlorophenol		
Vinyl acetate	Diethylphthalate		
Vinyl chloride	2,4-Dimethylphenol		
Xylenes (Total)	Dimethylphthalate		
	4,6-Dinitro-2-methylphenol		
	2,4-Dinitrophenol		
	2,4-Dinitrotoluene		
	2,6-Dinitrotoluene		
	Fluoranthene		
	Fluorene		
	Hexachlorobenzene		
	Hexachlorobutadiene		
	Hexachlorocyclopentadiene		
	Hexachloroethane		
	Indeno(1,2,3-cd)pyrene		
	Isophorone		
	2-Methylnapthalene		
	2-Methylphenol		
	4-Methylphenol		
	Napthalene		
	2-Nitroaniline		
	3-Nitroaniline		
	4-Nitroaniline		
	Nitrobenzene		
	2-Nitrophenol		
	4-Nitrophenol		
	N-Nitroso-di-n-dipropylamine		
	N-Nitrosodiphenylamine		
	Pentachlorophenol		
	Phenanthrene		
	Phenol		
	Pyrene		
	1,2,4-Trichlorobenzene		
	2,4,5-Trichlorophenol		
	2,4,6-Trichlorophenol		

Table 2–7
Sample Preservation and Holding Time Requirements

Laboratory Analysis	Preservation Requirements		Holding Times[a]
	Aqueous	Solids	
VOC Headspace	NA	None	10 minutes
TCL VOCs	Cool to 4°C; HCl to pH<2	Cool to 4°C	10 days
TCL semivolatiles, pesticides, PCBs, caffeine, d–limonene, and a–pinene	Cool to 4°C	Cool to 4°C	7 days for extraction 40 days for analysis
TAL metals and lithium	Cool to 4°C; HNO_3 to pH<2	Cool to 4°C	6 months, Hg–28 days
Cyanide	Cool to 4°C; NaOH to pH>12	Cool to 4°C	14 Days
TCLP VOCs, semivolatiles, and metals	NA	Cool to 4°C	
Radionuclides	HNO_3 to pH<2	None	6 months
TOC	Cool to 4°C; H_2SO_4 to pH<2	Cool to 4°C	28 days

[a] Holding times were from the date of sample collection.

Notes:
VOCs = Volatile organic compounds
TCL = Target Compound List
PCBs = Polychlorinated biphenyls
TAL = Target Analyte List
TCLP = Toxicity characteristic leaching procedure

The physical characterization of the selected soil samples consisted of the following:

- Atterberg limits (liquid and plastic limits)
- Grain size (by wash sieve and hydrometer)
- Moisture content

2.3.7 Quality Assurance/Quality Control (QA/QC)

QA/QC samples were collected and analyzed to measure:

- Internal consistency of the samples
- Cross-contamination sources
- Decontamination efficiency
- Other sources of contamination
- Accuracy, reproducibility, and precision of the laboratory

Field duplicate samples, equipment rinse blank samples, and matrix spike/matrix spike duplicate (MS/MSD) samples were taken for QA/QC during the soil boring program.

- **Field Duplicate Samples.** Field duplicate samples were collected by filling two sets of sample containers simultaneously. The duplicate sample was analyzed for the same parameters as the initial sample. Duplicate samples were assigned different sample numbers and were not identified as duplicate samples to the laboratory. One field duplicate sample was collected for every 20 or fewer samples sent to each laboratory.

- **Equipment Rinse Blank Samples.** Equipment rinse blank samples were collected from the split spoon and the stainless steel bowl. They were collected by pouring demonstrated analyte-free water over the inside of a decontaminated split spoon into a decontaminated bowl. The rinsate was then poured into sample containers and chemically preserved as necessary. The equipment rinse blank samples were analyzed for the same parameters as the soil boring samples. One equipment rinse blank sample was collected each day.

- **MS/MSD Samples.** MS/MSD samples were obtained by collecting additional sample volume from randomly selected locations. MS/MSD samples were collected at a frequency of one per 20 or fewer samples sent to each laboratory.

2.3.8 Chain-of-Custody

Chain-of-custody was maintained during the soil boring sampling program through use of traffic report/chain-of-custody forms and chain-of-custody seals. The traffic report/chain-of-custody forms were used to track the samples from the time of collection until analysis by the laboratory. The chain-of-custody seals were used to confirm that samples had not been tampered with during sample storage or shipment.

Samples were always kept within the view of sampling personnel or were locked in a secure area (the field trailer).

2.3.9 Field Screening

The chemical and radiological field screening results are summarized in Table 2-8, which presents the VOC headspace concentrations measured by PID and radiological measurements taken by the HP-210/HP-260. The results of the downhole gamma logging are summarized in Table 2-9. Data from the downhole gamma logging are presented in full, in Appendix D. The analytical results from the soil boring program are presented and discussed in Section 4.2.

2.3.10 Decontamination

All sampling equipment (trowels, split spoons, and bowls) and drilling equipment (drilling rigs and augers) was decontaminated in accordance with the procedures specified in the work plans.

Sampling Equipment. Trowels, split spoons, and bowls were steam cleaned and chemically decontaminated prior to and between each use. The chemical decontamination consisted of the following series of chemical rinses:

- Alconox (phosphate-free detergent) and tap water wash
- Tap water rinse
- 10-percent nitric acid rinse
- Deionized water rinse
- Methanol rinse
- Hexane rinse
- Demonstrated analyte-free water rinse

All solvents and acids used for chemical decontamination were of HPLC grade or pesticide grade. The demonstrated analyte-free water was prepared and analyzed by TCT-St. Louis laboratory. No organic or inorganic constituents were detected. The data associated with the analyses of the analyte-free water was provided to EPA on March 24, 1992, and September 4, 1992.

Table 2–8
Soil Boring Sampling – Field Screening Results

Property	Boring No.	Depth Interval (ft)	Maximum PID Scan [a] (ppm)	Maximum Rad Scan [b] (cpm)	Maximum Headspace Reading [a] (ppm)	Remarks
Stepan	C4	(1–3)	1	85	8	
		(3–5) [c]	3	70	9.4	
		(5–7) [c]	3	76	10.0	
		(7–9) [c]	3	67	11.7	
		(9–11)	0	65	12	
	C5	(0–2) [c]	0 [d]	50	0 [d]	
		(2–4) [c]	0 [d]	50	0 [d]	
	C20	(0.5–2.5)	0	76	0	
		(2.5–4.5) [c]	0.2	77	0	
		(4.5–6.5) [c]	103	40	1345	
		(6.5–8.5) [c,e]	75	92	1543	The 7.5–to–8.5–ft. interval contained black stained gravel and exhibited a chemical odor.
	C38	(0–2)	0	78	0	
		(2–4)	0	70	0	
		(4–6)	2	210	2	Hydrogen sulfide odor. Black and gray fill material.
		(6–8)	7	590	17.8	Hydrogen sulfide odor. Black clay fill material with white mottling.
		(8–10) [c]	20 [f]	18600	20	Black sludge material.
		(10–12) [c,e]	0	27400	10	Black sludge material.
		(12–14) [c,e]	0	569	Not taken [g]	Sludge material, with native soil in the 13–to–14–ft. interval.
	C39	(0–2) [c]	0	60	3.2	
		(2–4)	1	57	2.1	
		(4–6) [c]	0	42	2.0	
		(6–8) [c]	0.2	68	3.6	
	C40	(0–2)	0 [d]	Not taken [h]	4.9	
		(2–4) [c]	0 [d]	60	6.8	
		(4–6) [c]	0 [d]	47	10.8	
		(6–8) [c]	0 [d]	45	10.1	
		(8–10) [c]	0 [d]	48	10.8	

Table 2–8
Soil Boring Sampling – Field Screening Results

Property	Boring No.	Depth Interval (ft)	Maximum PID Scan [a] (ppm)	Maximum Rad Scan [b] (cpm)	Maximum Headspace Reading [a] (ppm)	Remarks
Stepan	C41	(0–2) [c]	0 [d]	50	0 [d]	
		(2–4)	0 [d]	80	0 [d]	Streaks of black staining in the soil.
		(4–6) [c]	0 [d]	50	0 [d]	Streaks of black staining in the soil.
		(6–8) [c]	0 [d]	80	0 [d]	
		(8–10)	0 [d]	80	0 [d]	
		(10–12)	1 [d]	75	0 [d]	
		(12–14)	0 [d]	65	0 [d]	
	C42	(0–2)	17	69	111	Similar chemical odors to C20 and C43.
		(2–4)	38	70	108	Gray, black, and orange stained fill material.
		(4–6) [c]	115	47	112	Gray and black sludge material.
		(6–8) [c]	14	85	100	
		(8–10)	0 [d]	35	55	The 8–to–9–ft. interval contained sludge.
		(10–12) [c]	0	58	8.8	
		(12–14)	50 [d]	88	7.0	
		(14–16)	20 [d]	87	18.8 [d]	
	C43	(1–3)	0.4	71	13.8	Black staining within fill material. Similar chemical odor to C20.
		(3–5) [c]	8	40	45	Black staining within fill material.
		(5–7)	0.5	70	3.5	
		(7–9) [c]	0	84	30	
		(9–11)	13	67	31.3	
		(11–13) [c]	35	96	111	
	C44	(0–2)	2.9 [d]	Not taken [h]	21	
		(2–4)	15 [d]	50	211	Soils emitted a chemical odor.
		(4–6) [c]	5 [i]	65	49.9	Soils emitted a chemical odor.
		(6–8) [c]	500 [i]	21	143	Soils emitted a chemical odor.
		(8–10) [c]	20 [i]	70	190	Soils emitted a chemical odor.
		(10–12)	8 [i]	21	26.4	Soils emitted a chemical odor.
Federal Express	C26	(0–2) [c]	1	70	7	
		(2–4) [c]	3	80	9	
		(4–6) [c]	3	65	10	
		(6–8)	0	75	Not taken [j]	

Table 2–8
Soil Boring Sampling – Field Screening Results

Property	Boring No.	Depth Interval (ft)	Maximum PID Scan [a] (ppm)	Maximum Rad Scan [b] (cpm)	Maximum Headspace Reading [a] (ppm)	Remarks
Federal Express	C28	(1–3)	0.5	100	3.1	
		(3–5) [c]	0.7	60	3	
		(5–7) [c]	1	98	3.6	
		(7–9) [c]	1	76	3.4	
	C30	(1–3) [c]	0	56	1.4	Encountered bedrock at 2.5 feet. The 0–to–1–ft. interval was asphalt and trap rock.
	C32	(1–3) [c]	0	55	0.5	The 0–to–1–ft. interval contained asphalt.
		(3–5) [c]	0	70	2.3	
		(5–7) [c]	0	52	1.2	
		(7–9)	0	58	Not taken [h]	
	C35	(1–3)	0.2	83	4	The 0–to–1–ft. interval contained asphalt.
		(3–5) [c]	0.5	73	3	
		(5–7) [c]	2	60	4	
		(7–9) [c]	1	80	1	
SWS	C25	(0.5–2.5) [c]	113	70	600	The 0–to–0.5–ft. interval contained asphalt. Soil from the 0.5–to–2.5–ft. interval was stained and emitted a petroleum odor.
		(2.5–4.5)	1000	60	1520	Sample emitted a petroleum odor.
		(4.5–6.5) [c]	600	60	1680	Sample emitted a petroleum odor.
		(6.5–8.5)	470	65	1450	Sample emitted a petroleum odor.
		(8.5–10.5) [c]	1300	40	3777	Sample emitted a petroleum odor.
	C34	(1–3) [c]	0	65	8	
		(3–5) [c]	0	55	5.6	
		(5–7) [c]	0	70	5.3	
		(7–9)	0	80	5.8	
DeSaussure	C27	(0–2)	0	10	0	The 1.7–to–2–ft. interval contained white fill material.
		(2–4) [c]	0	12	0	Sample contained a soft gray, white, and tan fill material.
		(4–6) [c]	0	17	0	
		(6–8) [c]	0	8	0	

Table 2–8
Soil Boring Sampling – Field Screening Results

Property	Boring No.	Depth Interval (ft)	Maximum PID Scan [a] (ppm)	Maximum Rad Scan [b] (cpm)	Maximum Headspace Reading [a] (ppm)	Remarks
DeSaussure	C31	(0–2)	0.2	80	3	
		(2–4) [c]	0.5	65	1	
		(4–6) [c]	0.5	65	2	
		(6–8) [c]	0.5	70	4.4	
		(8–10)	0	80	1	
	C37	(0–2) [c,e]	0	150	0.5	
		(2–4) [c]	1.0	90	2.2	The 3.5–to–4.0–ft. interval contained gray streaks.
Sunoco	C15	(0–2) [c]	2.1	Not taken [k]	2.5	Due to underground tanks in close proximity to boring, sample was taken from sidewalls after excavation with a shovel.
		(3–5) [c,e]	4.0	500	34.8	Slight petroleum odor. Gray sand with some black fill material. Black fill material exhibited elevated rad readings.
		(5–7) [c]	1.3	60	6.5	
		(7–9)	1.2	55	3.4	
	C33	(1–3) [c]	8	65	4.3	
		(3–5) [c]	3.7	95	3.6	The 4.5–to–5.0–ft. interval contained black organic material similar to the 3–to–5–ft. interval within C15.
		(5–7)	1	65	4.2	
		(7–9) [c]	3	50	7.9	
		(9–11)	0	80	3.3	
Sunoco	C11	(1–3)	0	75	3.3	
		(3–5) [c]	0	45	13.8	
		(5–7) [c]	0	40	5.4	
		(7–9) [c]	0	42	4.8	
		(9–11)	0	55	Not taken [l]	
AMP	C22	(1–3) [c]	1	48	5.6	
		(3–5) [c]	0	69	2.0	
		(5–7) [c]	2	60	3.0	
		(7–9)	2	75	Not taken [l]	
Sears	C1	(1–3) [c]	0 [d]	90	0 [d]	
		(3–5) [c]	0 [d]	60	0 [d]	
		(5–7) [c]	0.3 [d]	50	0 [d]	Soils emitted a petroleum odor.
		(7–9)	15 [d]	70	290 [d]	Soils emitted a petroleum odor.

Table 2–8
Soil Boring Sampling – Field Screening Results

Property	Boring No.	Depth Interval (ft)	Maximum PID Scan [a] (ppm)	Maximum Rad Scan [b] (cpm)	Maximum Headspace Reading [a] (ppm)	Remarks
Sears	C2 [m]	(0–2) [c]	0	60	0	
		(2–4)	0	60	0	Sampled only the 3–to–4–ft. interval.
	C3	(0–2) [c]	0	60	1.6	The 0–to–0.5–ft. interval was concrete. Sample was collected from the 1.5–to–2–ft. interval.
		(2–4) [c]	1.4	60	1.7	
		(4–6)	0.2	Not taken [l]	Not taken [l]	
	C6	(0–2) [c]	0	60	0	Interval contained black gravel (railroad ballast).
		(2–4)	0	Not taken [k]	Not taken [k]	
	C7 [n]	(0–2)	0	60	0	
		(2–4) [c]	4.1	290	2.0	Soils emitted a hydrogen sulfide odor. Soft, black and gray fill material.
		(4–6) [c,e]	1.2	190	2.7	Encountered black and white fill material. Soils emitted a hydrogen sulfide odor.
		(6–8) [c]	0	70	2.9	
	C8	(0–2) [c]	0	130	2.0	
		(2–4) [c,e]	0	47	1.6	The 2–to–3–ft. interval contained slough from interval above. Sample was collected from the 3–to–4–ft. interval.
		(4–6)	0	Not taken [o]	Not taken [o]	
		(6–8)	0	60	3.4	
	C9	(0–2) [c,e]	0.7	100	3.1	
		(2–4)				No recovery.
		(4–6) [c]	1.7	60	22	Some dark staining and pieces of concrete were present.
		(6–8)	2.0	60	Not taken [k]	Soils emitted a petroleum odor.
	C10 [p]	(0–2)	0	400	2.3	The 1–to–2–ft. interval contained white and gray fill material.
		(2–4)	0	100	2.4	
		(4–6) [c]	1.2	100	2.3	
		(6–8) [c]	0	70	1.6	
	C12	(0.5–2.5) [c]	0	60	0.7	The 0.5–to–1–ft. interval contained gravel and asphalt.
		(2.5–4.5) [c]	0	60	1.2	
		(4.5–6.5)				No recovery.
		(6.5–8.5)	0	60	Not taken [k]	

Table 2–8
Soil Boring Sampling – Field Screening Results

Property	Boring No.	Depth Interval (ft)	Maximum PID Scan [a] (ppm)	Maximum Rad Scan [b] (cpm)	Maximum Headspace Reading [a] (ppm)	Remarks
Sears	C13	(1–3) [c]	0 [d]	50	0 [d]	The 2.5–to–3–ft. interval contained black stained soils.
		(3–5) [c]	0 [d]	60	0 [d]	Some black staining.
		(5–7) [c]	0 [d]	60	0 [d]	
		(7–9)	0 [d]	60	0 [d]	
	C14	(0–2)	0	230	1.0	The 0.7–to–1–ft. interval contained fill which was light gray with pale pink streaks.
		(2–4) [c,e]	0.6	200	2.2	The 2–to–3.5–ft. interval contained gray and white fill.
		(4–6) [c]	0	100	2.0	
		(6–8)	0	100	1.9	
	C16 [q]	(0–2)	0	200 [h]	0	The 1.5–to–2–ft. interval contained gray and white fill material.
		(2–4) [c,e]	0	250	0	The 3.5–to–4–ft. interval contained gray and white fill material. Sample emitted a hydrogen sulfide odor.
		(4–6)	0	200	0	
		(6–8)	0	200	0	
	C17 [r]	(0–2) [c]	0	180	0	
		(2–4)	0	130	0	
		(4–6)	0	80	0	
	C18	(0–2) [c]	0	60	0	
		(2–4) [c]	0	60	0	
	C19	(0–2) [c]	0	60	0	Sample contained small amounts of blue material.
		(2–4) [c]	0	60	0	
		(4–6) [c]	0	60	0	
	C21	(0–2) [c]	0	400	0	The 1–to–2–ft. interval contained gray and white fill material.
		(2–4) [c,e]	0	150	0	The 3–to–4–ft. interval contained grayish sand and white fill material.
		(4–6)	0	150	Not taken [k]	Encountered gray sand material.
	C23	(0–2) [c]	0	60	0	
		(2–4)	0	60	0	
		(4–6) [c]	0	60	0	
		(6–8)	0	60	Not taken [k]	
	C24	(0–2)	0	200	0	
		(2–4) [c,e]	0	200	0	
		(4–6) [c]	0	200	0	

Table 2-8
Soil Boring Sampling – Field Screening Results

Property	Boring No.	Depth Interval (ft)	Maximum PID Scan [a] (ppm)	Maximum Rad Scan [b] (cpm)	Maximum Headspace Reading [a] (ppm)	Remarks
Sears	C29	(1–3) [c]	0	250	0	Black fill material with gray mottling.
		(3–5)	0	80	0	Black/brown sludge.
		(5–7) [c,e]	0	200	0	
		(7–9) [c]	0	60	0	Sample emitted a petroleum odor.
	C36	(0–2) [c]	0	60	0	
		(2–4) [c]	0	60	0	
		(4–6) [c]	0	60	0	

[a] PID scan and headspace screening were performed using a Photon PID, except where noted. PID scan measurements often fluctuated as the instrument was moved along the soil in the split spoon. Only the maximum PID readings have been presented in this table.
[b] Radiological scan was performed using an HP–210 or HP–260 probe.
[c] Sample interval sent for chemical analysis.
[d] PID scan and/or headspace screening were performed using an OVM.
[e] Sample interval was sent for radiological analysis.
[f] PID scan and headspace screening were performed using an HNu PID.
[g] Headspace sample spilled before reading was taken.
[h] Instrument was not working properly.
[i] PID scan and headspace screening were performed using an OVA.
[j] Headspace reading not taken because no sample was collected due to shallow bedrock.
[k] Rad scan inadvertently not taken for this sample.
[l] Headspace reading and/or rad scan were not taken because no sample was collected due to the shallow occurrence of groundwater.
[m] The sample from the 3–to–4–ft. interval of boring C2 was sent for chemical analysis.
[n] The samples from the 4–to–5–ft., 5–to–7–ft., and 7–to–8–ft. intervals of boring C7 were sent for chemical analysis.
[o] Headspace and/or rad scan were not taken because the sample was not representative of the interval.
[p] Samples from the 2–to–3–ft., 4–to–6–ft., and 6–to–8–ft. intervals of boring C10 were sent for semivolatile, metals, cyanide, caffeine, d–limonene, and a–pinene analysis. VOC analysis, however, was done only on the sample from the 3–to–4–ft. interval.
[q] The samples from the 1.5–to–2.5–ft., 2.5–to–4.0–ft., and 4.0–to–5.5–ft. intervals of boring C16 were sent for chemical analysis.
[r] The samples from the 2–to–3–ft. and 3–to–4–ft. intervals of boring C17 were sent for chemical analysis.

Table 2-9
Summary of Downhole Gamma Radiation Logging

Soil Boring Location		Surface Gamma-Log Reading	Gamma-Log Reading @ 0.5 ft (BGS)	High Gamma-Log Reading		Comments
ID	Property	(cpm)	(cpm)	> 0.5 ft (BGS) (cpm)	Depth ft (BGS)	
C1	Sears	8,110	9,769	15,934	2	
C2	Sears	3,599	4,240	5,249	1.5	
C3	Sears	19,481	12,286	21,000	1.5	
C4	Stepan	8,357	9,274	15,453	9.5	
C5	Stepan	12,435	8,357	12,261	3	
C6	Sears	10,340	NT	3,987	2	Bore hole collapsed - not able to complete log
C7	Sears	11,534	7,360	247,236	4	
C8	Sears	88,218	92,470	142,962	1.5	
C9	Sears	40,170	20,040	87,146	2	
C10	Sears	128,130	74,902	291,304	2.5	
C11	Sunoco	7,654	13,246	26,543	4	
C12	Sears	8,621	6,868	10,385	8.5	
C13	Sears	9,536	3,864	18,386	3	
C14	Sears	27,692	39,820	247,650	2.5	
C15	Sunoco	11,402	37,297	99,468	4	
C16	Sears	43,059	57,994	72,462	1	
C17	Sears	22,040	88,939	65,198	1	
C18	Sears	5,494	10,448	6,700	1	
C19	Sears	12,213	13,721	23,367	1	
C20	Stepan	15,058	16,200	15,767	1	
C21	Sears	42,158	102,768	335,944	1.5	
C22	AMP	5,058	7,008	11,251	6.5	
C23	Sears	1,804	3,148	4,960	4	
C24	Sears	30,263	42,081	142,599	2	
C25	SWS	5,620	5,865	14,826	5	
C26	Federal Express	6,418	7,673	9,662	4.5	
C27	DeSaussure	5,882	6,073	9,662	8.5	
C28	Federal Express	9,379	12,203	13,303	1	
C29	Sears	24,983	96,207	277,799	1.5	
C30	Federal Express	5,186	7,169	10,792	1.5	
C31	DeSaussure	5,546	6,719	9,678	9	
C32	Federal Express	7,312	7,809	11,238	7	
C33	Sunoco	4,768	5,738	45,216	4	
C34	SWS	8,863	6,818	9,718	9.5	
C35	Federal Express	9,288	9,678	10,292	1	
C36	Sears	2,314	3,530	5,385	1	
C37	DeSaussure	24,979	36,955	48,943	1.5	
C38	Stepan	17,970	25,778	867,544	11	
C39	Stepan	7,428	11,868	13,696	3.5	
C40	Stepan	9,434	11,007	11,661	2.5	
C41	Stepan	15,073	23,066	32,753	1.5	
C42	Stepan	6,059	18,474	47,483	1.5	

Table 2-9
Summary of Downhole Gamma Radiation Logging

Soil Boring Location		Surface Gamma-Log Reading	Gamma-Log Reading	High Gamma-Log Reading		Comments
ID	Property	(cpm)	@ 0.5 ft (BGS) (cpm)	> 0.5 ft (BGS) (cpm)	Depth ft (BGS)	
C43	Stepan	5,682	7,885	20,980	2.5	
C44	Stepan	10,468	22,292	27,063	1.5	

Notes: An Eberline Model PRS-1 or PRS-2 count rate meter was used with an Eberline Model BHP-2 probe. The BHP-2 probe contained a 2 in. x 2 in. NaI

Scintillation crystal encased in a lead shield, and had a conversion effficiency of 1,115 cpm per 1 uR/hour (Ra-226).

cpm = Counts per minute

BGS = Below ground surface

NT = Not taken

Complete downhole gamma radiation logging results for each boring are contained on soil boring logs.

After chemical decontamination, the sampling equipment was allowed to air dry and was wrapped in aluminum foil until use.

Onsite Equipment. To prevent cross-contamination between boreholes, all soil and/or sediment adhering to the drilling rig and augers was removed using a steam cleaner inside a temporary or portable decontamination pad established at each property. All liquid and sediment resulting from this decontamination were contained in drums and are being stored on the properties where the material was generated.

2.3.11 Management of Investigation-Derived Waste

Three types of wastes were generated during the soil boring investigation: soil cuttings, decontamination fluids, and used personal protective equipment (PPE).

Soil Cuttings. Soil cuttings from the drilling operations were contained in DOT-approved 55-gallon steel drums. A label containing the following information was placed on each drum:

- Specific location (soil boring number)
- Property sampled (e.g., Stepan, Sears)
- Media inside drum (i.e., soil)
- Date drum was filled
- Remarks regarding drum contents (e.g., PID readings)

Soil cuttings from each individual soil boring were drummed separately. The filled drums were left in an area on the property where the material was generated. The drum storage area for each property was approved by the property owner or representative.

Decontamination Fluids. Fluids resulting from the decontamination of augers, split spoons, and sampling equipment consisted of rinse water and spent solvents/acids. Spent solvents/acids were collected during the decontamination process and placed in 5-gallon plastic containers. These containers were placed in 55-gallon steel drums. Rinse water from steam cleaning was collected in a sump within the decontamination pad and later pumped into 55-gallon steel drums. Spent solvents/acids were not mixed with the rinse water. All drums generated from decontamination activities were labelled with the same information as the soil cutting drums. The drums were stored on the property where the materials were generated.

Used PPE. Used PPE such as Tyvek suits, booties, and gloves were double-bagged and placed in a solid waste rolloff for the property on which they were used, unless the PPE was visually contaminated or the PPE was radiologically or chemically contaminated (identified by field screening). PPE that was found to be contaminated was drummed, properly labeled, and stored on the property on which it was used.

2.4 Overburden Groundwater Investigation

The field activities associated with the overburden groundwater investigation included the following:

- Selection of groundwater well construction material
- Well rehabilitation and evaluation survey
- Overburden drilling and well construction
- Hydraulic conductivity testing
- Static water level measurements
- Continuous water level measurements
- Surveying

Hydraulic conductivity testing and water level measurement are described in Section 2.6. Surveying is discussed in Section 2.9.3.

The overburden monitoring wells installed during the RI were designated OBMW and the bedrock monitoring wells were designated BRMW. Each of these was followed by a number (OBMW1, BRMW1). The existing wells had already been named and these names were not changed; the prefixes used were "MISS," "B38W," and "Well".

2.4.1 Objectives

Groundwater movement in the overburden provides a potential pathway for contaminant transport into the offsite environment. Historical information presently available suggests that the most likely transport route is downward from the overburden water-bearing zone to the underlying bedrock aquifer. It is also possible that some contaminants are carried offsite by lateral flow in the overburden water-bearing zone, or by discharge from the overburden water-bearing zone to surface drainage areas. To evaluate these potential transport pathways, the overburden groundwater investigation had the following objectives:

- To quantify and characterize the vertical and horizontal extent of groundwater contamination in the overburden
- To estimate the directions and rates of groundwater flow in the overburden
- To measure seasonal fluctuations in the water table
- To evaluate the hydraulic connection between the overburden and the bedrock

2.4.2 Selection of Groundwater Well Construction Material

Stainless steel well casing and screen is required during CERCLA investigations by the EPA Region II guidance document *Standard Operating Procedure for Selecting Ground Water Well Construction Material.* The stainless steel may be either 304- or 316-grade, depending on the chloride concentration and pH of the groundwater. 316-grade is used when chloride concentrations are greater than 1,000 ppm and/or when pH concentrations are below 4.5; 304-grade is used otherwise.

Existing data from a DOE 1987 report (1987e) showed that the lowest pH measured in seven well couplets installed at the MISS was 5.8 to 6.1, at MISS3A. In general, according to this report, the overburden wells had a pH of 5.8 to 6.8 and the bedrock wells had a pH of 6.9 to 9.0. No existing chloride data were available from the DOE study. On the basis of this information, 304-grade stainless steel was preliminary selected; however, 312-grade stainless steel was used. Two existing groundwater wells (MISS3A and 3B) were sampled on August 29, 1991, to confirm this selection.

The samples collected on August 29, 1991, were analyzed by Laboratory Resources Inc. of Westwood, New Jersey. The chloride concentrations for MISS3A and MISS3B were 14.8 ppm and 117 ppm, respectively. The pH concentrations in MISS3A ranged from 5.95 to 6.14; in MISS3B they ranged from 6.1 to 6.5. Because the chloride concentrations were less than 1,000 ppm and the pH concentrations were above 4.5, 304-grade stainless steel well casings and screens were used in the construction of the overburden and bedrock monitoring wells. These results were submitted to EPA in a letter dated October 25, 1991, and were approved by EPA.

2.4.3 Well Rehabilitation and Evaluation Survey

A well rehabilitation and evaluation survey was conducted at Stepan from December 10 to December 13, 1991. The purpose of this survey was to determine if selected NRC monitoring wells, located in the immediate vicinity of the NRC-licensed radiological burial sites, were suitable for collecting representative groundwater samples from the overburden groundwater system, as was proposed during preparation of the work plan for Stepan. (The construction and integrity of some of the NRC wells was questionable.) This approach was agreed on in conversations between Stepan, CH2M HILL, and EPA during preparation of the work plan.

The NRC wells are constructed of PVC. During the preparation of the work plan, EPA had agreed that existing wells constructed of PVC are acceptable for sampling; however, the analytical results were to be qualified during final reporting.

The well rehabilitation and evaluation survey included the following NRC wells:

- Well 1, formerly designated in the work plan as B38W8A, located near the southwest side of Building 3 and Burial Site 3

- Well 2, formerly designated in the work plan as B38W9A, located near the southeast corner of Building 3 and Burial Site 3
- Well 5, formerly designated in the work plan as B38W11A, located near the south side of Burial Site 1
- Well 6, located near the southern corner of Burial Site 1
- Well 8, located near the southwest side of Burial Site 2

The following procedures were used:

- The well was accessed and the general integrity of the well and surface seals inspected.
- The depth to water and bottom depth of the well were determined.
- The screened interval of the well was scrubbed and surged using a dedicated laboratory brush attached to dedicated PVC pipe.
- The well was bailed and/or pumped and changes observed in water quality (pH, specific conductivity, temperature), yield, and recovery.

The results of the survey indicated that all wells except Well 6 were acceptable for sampling. Wells 1, 2, and 5 were capable of being pumped (approximately 0.3 to 0.5 gpm) and produced sufficient quantities of groundwater for sampling. The yield, recovery rate, and the boring log associated with Well 8 indicated that the well is screened across strata with limited water-bearing properties. Because it was unlikely that a new well installed in this area would yield a larger quantity of groundwater than the existing well, a new well was not installed at this location.

Data collected at Well 6 indicated that the PVC well casing or screen may be structurally damaged. During well rehabilitation, gravel and coarse sand were observed within the discharge water. Because the well was not equipped with an inner cap, this material might have been introduced from the surface. Although the well yield was sufficient, the presence of the coarse fragments could have compromised the integrity of groundwater samples collected from the well.

During the survey, it was also determined that Well 6 was not in the location shown in the work plan (near the proposed location of BRMW17). The well is actually located near the southern corner of Burial Site 1. Because a shallow well was needed to supplement the hydrogeological investigation near bedrock well BRMW17, a replacement well (OBMW17) was installed at the location where Well 6 was originally shown. (Stepan had recommended this to EPA in a letter dated January 7, 1992 and received approval.)

A summary of the field data collected during the well rehabilitation and evaluation survey and copies of the NRC well logs are presented in Appendix H.

2.4.4 Overburden Drilling and Monitoring Well Construction

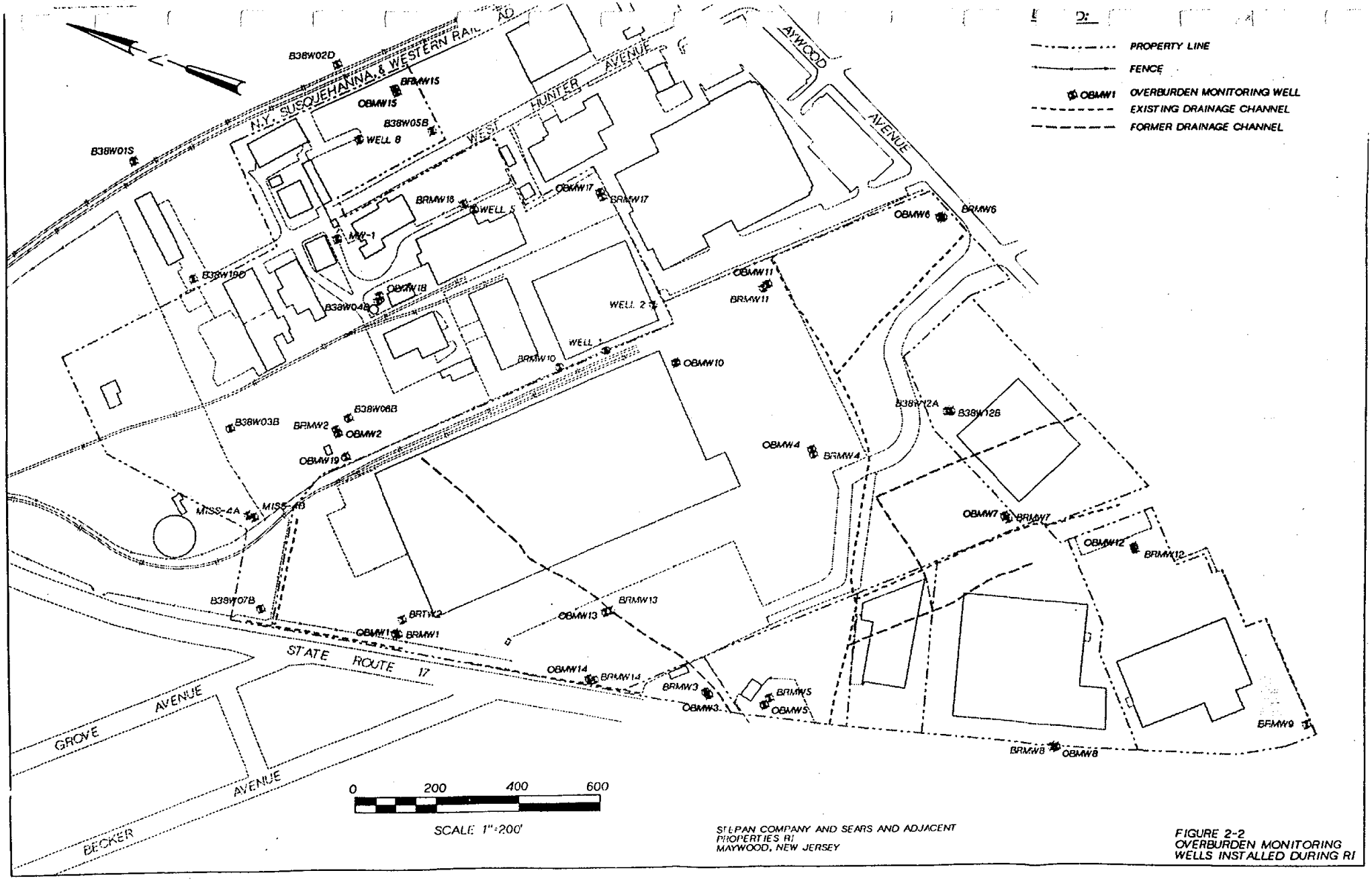
From March 2, 1992, to April 22, 1992, 15 overburden monitoring wells were installed at the study area using a Mobile B-61 or B-80 truck-mounted or all-terrain-vehicle (ATV) drilling rig equipped with 4¼-inch-inside-diameter, 7⅝-inch-outside-diameter hollow-stem augers. Three overburden wells were installed on Stepan and the remaining 12 wells were installed on Sears and adjacent properties. All overburden wells installed during this phase begin with OB and are presented in Figure 2-2 along with all wells sampled and discussed later in this section. Drilling and well installation services were provided by Environmental Drilling of West Creek, New Jersey.

Depending on the first occurrence of groundwater, the depth of the wells varied from 8 feet (OBMW6 and OBMW10, Sears) to 17 feet (OBMW15, Stepan) below the ground surface. The wells were screened across the water table in the unconsolidated deposits and/or weathered bedrock. During the soil boring program the depth to the top of the moderately-to-severely-weathered bedrock zone was determined by split spoon or auger refusal. However, during overburden well drilling, the boreholes were advanced below the depth of split spoon or auger refusal to facilitate the installation of a length of well screen sufficient for representative groundwater sampling of the water table aquifer.

Because groundwater occurred within the bedrock at the OBMW15 (Stepan) location, this well was installed 4 feet into competent rock, which was 7 feet below the top of the moderately-to-severely weathered bedrock zone, using a 5⅞-inch-diameter roller bit. Attempts were made to use a water-rotary drilling method at this location; however, because the borehole was not stable, a mud-rotary drilling method was used.

Although the work plan stated that overburden wells would be drilled using hollow-stem augers, adverse field conditions made this impossible. During the drilling and installation of the overburden wells, conversations were held with EPA and TRC/Alliance (EPA's oversight contractor) regarding the use of drilling muds. The following decision criteria were agreed upon:

- Efforts would be made to use hollow stem augers to drill the overburden wells.
- If the hollow stem auger drilling method was unsuccessful due to groundwater first occurring within the bedrock, then a water-rotary drilling method would be used.
- If the water-rotary drilling method was unsuccessful due to borehole stability problems, then a mud-rotary drilling method would be used. AQUAGEL GOLD SEAL® should be used. If this type of drilling mud



STEPAN COMPANY AND SEARS AND ADJACENT PROPERTIES RI
MAYWOOD, NEW JERSEY

FIGURE 2-2
OVERBURDEN MONITORING WELLS INSTALLED DURING RI

did not remove the drill cuttings from the borehole then QUIK-GEL could be used. [Both AQUAGEL GOLD SEAL® and QUIK-GEL® are registered trademarks of Baroid Technology, Inc. Information regarding these products is included in Appendix I.]

The overburden monitoring wells were fabricated of sections of 2-inch-inside-diameter, schedule 5, type 312-grade stainless steel riser pipe and continuous wire-wrapped, No. 10-slot well screen. All couplings between sections of the stainless steel riser pipe and well screen were flush-threaded. The bottom section of each well was fitted with a threaded stainless steel end-cap.

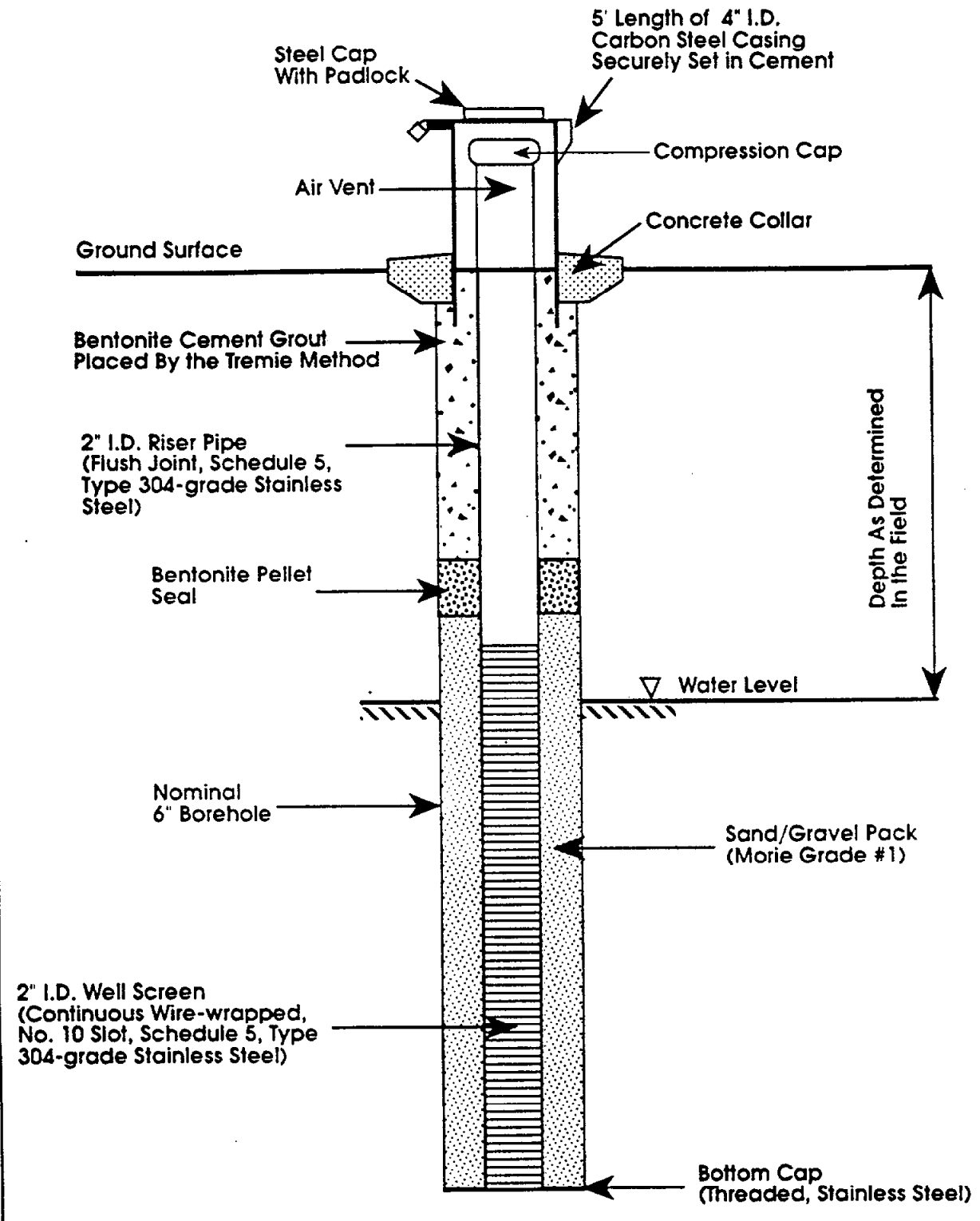
The annular space around the wells was a minimum of 3 inches. The annulus between the well screen and the wall of the borehole was packed with sand (Morie grade No. 1). The sand pack extended 1 to 2.5 feet above the top of the screen. Depending on the location of the top of screen, a 1- or 2-foot-thick bentonite-pellet seal was placed above the sand pack. The pellets were then hydrated with potable water and allowed to set for at least 1 hour before the well installation was completed. The remaining annular space above the bentonite-pellet seal was filled with bentonite-cement grout by the tremie method.

The overburden wells were completed in one of two ways: with either a protective casing extending above the ground surface or with a flush-mounted roadbox. In areas where there is minimal traffic or grass cover (excluding OBMW11 and BRMW11, Sears), a 5-foot length of 4-inch-inside-diameter steel pipe with locking cap assembly was installed. Three of the overburden wells were completed with a protective casing extending above the ground surface: OBMW15 (Stepan), OBMW17 (Stepan), and OBMW11 (Sears). The remaining 12 overburden wells were completed flush with the ground surface.

The second method of well completion was used in areas of heavy traffic. This flush mount method consisted of installing an 8-inch-diameter steel roadbox, approximately at grade, that allows surface water to drain away from the well. The roadbox was set within a 2-foot-square concrete pad. A locking cap assembly, to secure the well, was placed inside the roadbox. All wells installed on Sears with the exception of OBMW11 and BRMW11 were installed using the flushmount method.

All overburden wells were permanently marked with the New Jersey well permit number and well designation, regardless of the types of well completion. Typical overburden well diagrams are shown in Figure 2-3 and Figure 2-4. Completed well construction diagrams and monitoring well records are included in Appendix J. Well construction details for the overburden wells are presented in Table 2-10.

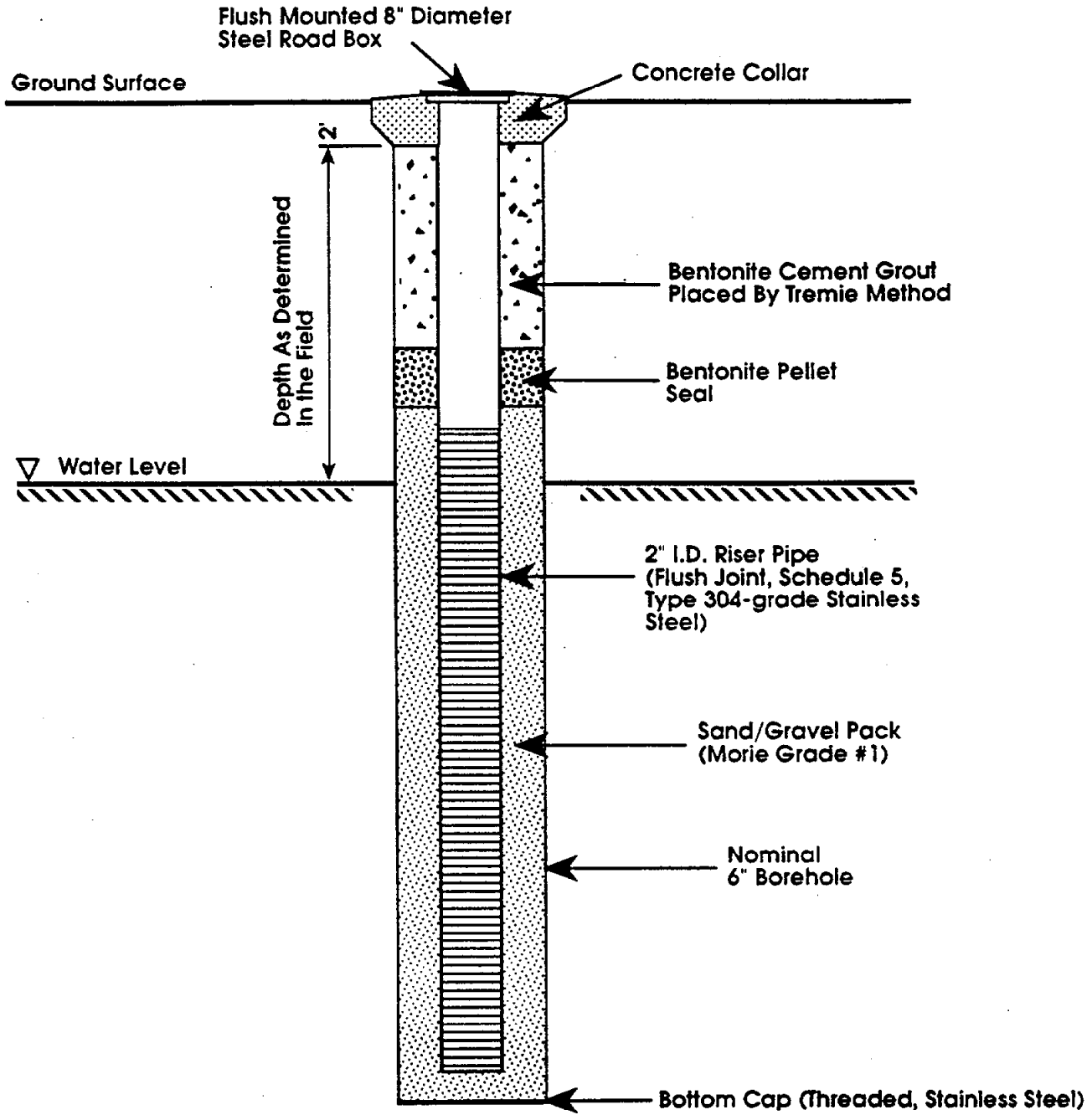
All soils and liquids produced from the overburden well installations were contained in 55-gallon steel drums and are currently being stored on the property where the materials were generated.



Well Screen Lengths Are Variable.
Not to Scale

STEPAN COMPANY AND SEARS AND ADJACENT PROPERTIES RI
MAYWOOD, NEW JERSEY

Figure 2-3
TYPICAL OVERBURDEN MONITORING WELL INSTALLATION
STEPAN COMPANY AND SEARS AND ADJACENT PROPERTIES RI, MAYWOOD, NEW JERSEY



Well Screen Lengths Are Variable.
Not to Scale

STEPAN COMPANY AND SEARS AND ADJACENT PROPERTIES RI
MAYWOOD, NEW JERSEY

Figure 2-4
TYPICAL FLUSH MOUNT
OVERBURDEN MONITORING WELL INSTALLATION
STEPAN COMPANY AND SEARS AND ADJACENT
PROPERTIES RI, MAYWOOD, NEW JERSEY

Table 2-10
Well Construction Details for Overburden and Bedrock Monitoring Wells

WELL LOCATION	Well Total Depth (ft. BGS)	Ground Elevation (ft.MSL)	Top of Riser Elevation (ft. MSL)	Top of Protective Casing Elevation (ft. MSL)	Screen Interval (ft. MSL)		Screen Interval (ft. BGS)		Top of Sand Pack Depth (ft. BGS)	Bottom of Sand Pack Depth (ft. BGS)	Top of Bentonite Seal Depth (ft. BGS)	Bottom of Isolation Casing Depth (ft. BGS)
OBMW1	10.0	49.4	48.82	49.42	46.4	39.4	3.0	10.0	2.0	10.0	1.0	N/A
BRMW1	47.0	49.5	49.08	49.49	12.5	2.5	37.0	47.0	35.0	47.5	33.0	17.5
OBMW2	13.0	54.9	54.40	54.86	51.9	41.9	3.0	13.0	2.5	13.0	2.0	N/A
BRMW2	50.0	54.9	54.61	54.92	23.4	13.4	31.5	41.5	30.0	45.3	26.5	18.5
OBMW3	12.0	47.2	46.80	47.13	42.2	35.2	5.0	12.0	3.0	13.0	2.0	N/A
BRMW3	30.0	46.9	46.67	46.93	26.9	16.9	20.0	30.0	19.0	32.0	18.0	18.5
OBMW4	14.0	46.2	45.96	46.24	42.2	32.2	4.0	14.0	3.0	14.0	2.0	N/A
BRMW4	36.0	46.6	46.33	46.68	20.6	10.6	26.0	36.0	25.0	38.0	23.0	24.0
OBMW5	10.0	46.4	46.13	46.45	43.4	36.4	3.0	10.0	2.0	10.0	1.0	N/A
BRMW5	29.0	46.4	45.97	46.41	27.4	17.4	19.0	29.0	18.0	31.0	16.0	17.0
OBMW6	8.0	48.8	48.94	49.22	45.8	40.8	3.0	8.0	2.0	8.0	1.0	N/A
BRMW6	27.0	49.3	49.06	49.48	32.3	22.3	17.0	27.0	16.0	29.0	14.0	15.0
OBMW7	15.0	45.6	44.95	45.66	40.6	30.6	5.0	15.0	4.0	15.0	2.0	N/A
BRMW7	38.0	45.6	45.11	45.67	17.6	7.6	28.0	38.0	27.0	40.0	25.0	26.0
OBMW8	12.5	45.7	45.55	45.81	40.2	33.2	5.5	12.5	3.0	13.0	2.0	N/A
BRMW8	42.0	45.7	45.17	45.68	13.7	3.7	32.0	42.0	31.0	45.0	29.0	30.0
BRMW9*	23.5	53.3	54.34	54.65	39.8	29.8	13.5	23.5	11.5	24.0	9.0	10.0
OBMW10	8.0	48.5	48.09	48.50	45.5	40.5	3.0	8.0	3.0	9.0	2.0	N/A
BRMW10	40.0	59.4	58.95	59.39	29.4	19.4	30.0	40.0	28.0	42.0	26.0	23.0
OBMW11*	10.0	45.6	48.23	48.54	40.6	35.6	5.0	10.0	4.0	10.0	2.0	3.0
BRMW11*	33.0	45.7	47.79	48.41	22.7	12.7	23.0	33.0	21.0	35.0	19.0	17.0
OBMW12	15.0	47.5	47.27	47.54	42.5	32.5	5.0	15.0	3.0	15.0	2.0	N/A
BRMW12	48.0	47.6	47.23	47.61	9.6	-0.4	38.0	48.0	32.0	50.0	30.0	20.0
OBMW13	14.0	47.7	47.26	47.68	43.7	33.7	4.0	14.0	3.0	15.0	2.0	N/A
BRMW13	33.0	47.6	47.21	47.66	24.6	14.6	23.0	33.0	22.0	35.0	20.0	21.0
OBMW14	14.0	46.5	46.02	46.51	42.5	32.5	4.0	14.0	3.0	15.0	2.0	N/A
BRMW14	37.0	46.6	46.22	46.58	19.6	9.6	27.0	37.0	26.0	39.0	24.0	25.0

Table 2–10
Well Construction Details for Overburden and Bedrock Monitoring Wells

WELL LOCATION	Well Total Depth (ft. BGS)	Ground Elevation (ft.MSL)	Top of Riser Elevation (ft. MSL)	Top of Protective Casing Elevation (ft. MSL)	Screen Interval (ft. MSL)		Screen Interval (ft. BGS)		Top of Sand Pack Depth (ft. BGS)	Bottom of Sand Pack Depth (ft. BGS)	Top of Bentonite Seal Depth (ft. BGS)	Bottom of Isolation Casing Depth (ft. BGS)
OBMW15 [a]	17.0	70.1	72.27	72.55	58.1	53.1	12.0	17.0	10.0	17.0	8.0	3.0
BRMW15 [a]	30.0	70.2	71.63	71.85	50.2	40.2	20.0	30.0	19.0	32.0	17.0	18.0
BRMW16 [a]	30.0	66.9	67.69	68.52	46.9	36.9	20.0	30.0	19.0	32.0	17.0	18.0
OBMW17 [a]	15.0	60.5	63.02	62.70	55.5	45.5	5.0	15.0	3.0	15.0	2.0	3.0
BRMW17 [a]	35.0	60.3	62.04	62.37	35.3	25.3	25.0	35.0	23.0	37.0	21.0	20.0
WELL 1 [a]	*16.0*	58.3	58.82	59.04	*53.3*	*43.3*	*5.0*	*15.0*	*4.0*	*15.0*	*2.0*	*N/A*
WELL 2 [a]	*20.0*	58.7	59.28	59.43	*49.7*	*39.7*	*9.0*	*19.0*	*8.0*	*19.0*	*6.0*	*N/A*
WELL 5 [a]	*13.0*	62.1	62.17	62.60	*57.1*	*50.1*	*5.0*	*12.0*	*4.0*	*12.0*	*2.0*	*N/A*
WELL 8 [a]	*17.0*	73.3	75.08	75.17	*66.3*	*56.3*	*7.0*	*17.0*	*6.0*	*17.0*	*4.0*	*N/A*
B38WO1S [a]	*23.0*	*55.2*	*57.20*	*57.20*	*38.2*	*33.2*	*17.0*	*22.0*	*14.0*	*23.0*	*12.0*	*1.8*
B38WO2D [a]	*43.0*	*75.1*	*78.00*	*78.10*	*38.1*	*33.1*	*37.0*	*42.0*	*13.5*	*43.0*	*9.0*	*1.8*
B38WO3B [a]	*40.5*	56.7	57.96	58.72	*26.8*	*17.1*	*29.8*	*39.5*	*19.8*	*56.3*	*16.8*	*3.0*
B38WO4B [a]	*36.3*	62.8	65.64	66.30	*40.1*	*35.1*	*22.7*	*27.7*	*13.2*	*39.7*	*10.7*	*3.0*
B38WO5B [a]	*44.5*	68.2	70.99	71.45	*45.4*	*35.1*	*22.7*	*33.0*	*18.5*	*49.0*	*16.5*	*3.0*
B38WO6B [a]	*36.4*	55.6	58.04	58.48	*39.5*	*34.5*	*15.9*	*20.9*	*13.5*	*37.5*	*11.0*	*3.0*
B38W7B [a]	*39.2*	52.0	54.55	54.76	*32.9*	*22.6*	*18.5*	*28.8*	*16.0*	*43.2*	*13.0*	*13.0*
B38W12A [a]	*14.8*	47.3	50.03	50.31	*39.8*	*34.8*	*7.4*	*12.4*	*5.4*	*16.2*	*3.0*	*3.0*
B38W12B [a]	*50.3*	47.4	49.63	50.17	*12.8*	*2.4*	*34.5*	*44.9*	*28.2*	*55.0*	*25.2*	*3.0*
B38W18D [a]	*41.0*	58.2	60.24	60.45	*23.2*	*18.2*	*35.0*	*40.0*	*25.0*	*41.2*	*22.5*	*2.6*
MISS 4A [a]	*10.0*	55.2	57.23	57.29	*50.3*	*45.3*	*4.7*	*9.7*	*3.8*	*10.0*	*3.0*	*2.8*
MISS 4B [a,b]	*47.0*	55.3	56.44	56.81								3.5

[a] Well is stickup construction.
[b] Well is open bedrock borehole construction.
Notes:
Ground, top of riser, and top of protective casing elevations were taken from vertical survey conducted by GEOD corporation dated August 1992. (Excluding B38W01S and B38W02D)
ft. BGS = Feet Below Ground Surface.
ft. MSL = Elevation in feet mean sea level.
Wells in the "Well" series, the "B38W" series, and the "MISS" series were installed prior to the RI by DOE or BNI.
Italics = Information was obtained from DOE or BNI well records.

After the overburden wells were installed, the wells were developed from April 22, 1992, to May 1, 1992, by the surge and pump method. A centrifugal pump equipped with ¾-inch-diameter polyethylene pipe was first used to draw fine-grained sediment from the well. Then a 2-inch-diameter rubber surge block was lowered to the bottom of the screen and raised up and down vigorously to induce water to flow into the screen. This alternation was continued during well development until the water was relatively turbidity-free and until pH, specific conductivity, and temperature measurements had stabilized. In cases where well yield was very low (OBMW10, Sears; OBMW11, Sears; and OBMW15, Stepan), wells were developed over several days using a bailer instead of a pump.

2.5 Bedrock Groundwater Investigation

The field activities associated with the bedrock groundwater investigation consisted of the following:

- Bedrock drilling, coring, and well construction
- Borehole geophysical logging
- Hydraulic pressure injection testing
- Hydraulic conductivity testing
- Static water level measurements
- Continuous water level measurements
- Surveying

The field activities that were common to both the bedrock and overburden groundwater investigations (hydraulic conductivity testing and water level measurements) are discussed in Section 2.6. Surveying is discussed in Section 2.9.3.

2.5.1 Objectives

Historical data showed that contamination had been found in the bedrock aquifer beneath the study area. The objectives of the bedrock groundwater investigation were as follows:

- To identify the water-bearing zones of the bedrock aquifer and investigate their hydrogeologic characteristics
- To evaluate the degree of hydraulic interconnection between the bedrock aquifer and the overburden water-bearing zone
- To characterize and quantify the horizontal extent of chemical contamination in the upper bedrock aquifer

- To assess groundwater flow patterns in the bedrock and determine if prominent fracture systems affect flow direction and flow rate in different lithologies

2.5.2 Bedrock Drilling, Coring, and Well Construction

Seventeen 2-inch-diameter stainless steel bedrock monitoring wells were installed from March 5, 1992, to June 25, 1992 (Figure 2-5). Five of the wells were installed on Stepan; these ranged in depth from 30 feet (BRMW15 and BRMW16) to 42 feet (BRMW2). The remaining 12 wells were installed on Sears and adjacent properties; these ranged in depth from 23.5 feet (BRMW9, Federal Express) to 47.5 feet (BRMW1, Sears). The bedrock wells were drilled by water, mud, and air-rotary drilling methods using a Mobile B-61, B-80, or ATV drilling rig. Drilling services were provided by Environmental Drilling Inc. of West Creek, New Jersey.

All bedrock wells except BRMW3 (Gulf) and BRMW9 (Federal Express) were installed according to the procedure in the work plan and as summarized below. Exceptional conditions were encountered at BRMW1 (Sears) and BRMW9 that required deviation from the work plan. These deviations are discussed at the end of this section.

A 6-inch-inside-diameter steel casing was installed in each of the bedrock wells by first advancing a 9⅞-inch-diameter rock roller bit to a minimum of 5 feet into competent bedrock. The steel casing was set inside a nominal 10-inch-diameter borehole and grouted into place with a cement-bentonite grout mixture. The cement-bentonite grout mixture was introduced into the annular space between the borehole and steel casing using the tremie method.

The cement-bentonite grout mixture around the casing was allowed to set overnight before each casing was pressure tested. Pressure testing was used to test the effectiveness of the cement-bentonite grout seal. Pressure testing was performed by first removing all of the cuttings in the casing, then adding at least 3 feet of clean water inside the 6-inch steel casing, placing a hand-tightened fitting equipped with a pressure gauge on the casing, and then pressurizing the casing with nitrogen up to 15 psi and monitoring it for 5 minutes. A pressure drop of less than 1 psi in 5 minutes constituted proof of an adequate seal. Although the work plan stated that a pressure of 20 psi was to be used, 15 psi was determined to be adequate because the depth to which the casing was to be installed (approximately 20 feet below ground surface) was shallower than the depth that was assumed during the preparation of the work plan (approximately 30 feet below ground surface). The results of the pressure testing indicated that all steel casings were effectively grouted into the bedrock. Upon successful completion of the pressure test, a 6-inch-diameter borehole was advanced to a minimum depth of 30 feet below the bottom of the steel surface casing using a 5⅞-inch-diameter rock roller bit by water-rotary and/or mud-rotary drilling methods.

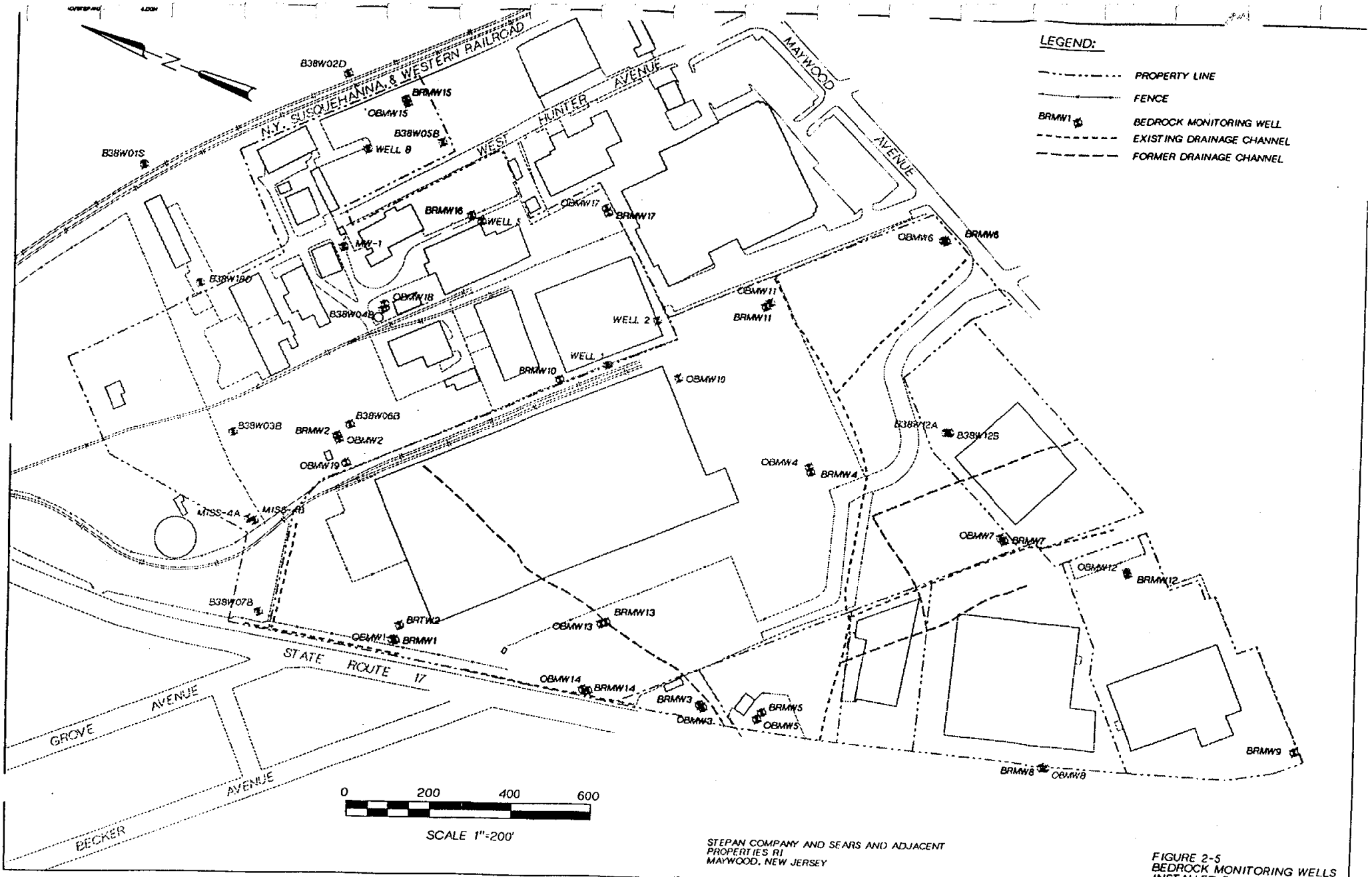


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FIGURE 2-5
BEDROCK MONITORING WELLS INSTALLED DURING RI

Although the work plan stated that the bedrock wells would be drilled using a water-rotary drilling method, adverse field conditions made it necessary to use the mud-rotary method in the interval of the boreholes where the surface casings were installed for all 17 wells and for the interval below the surface casing in BRMW3, BRMW4, BRMW9, and BRMW14.

The following criteria for determining whether water-rotary or mud-rotary methods would be used were agreed to by EPA, TRC/Alliance, and CH2M HILL during the bedrock drilling program:

- The interval of the borehole where the surface casing was to be installed would be drilled using a water-rotary method. However, if overburden soils and the weathered bedrock zone were found to be unstable, a mud-rotary method could be used instead. AQUAGEL GOLD SEAL® was the first choice for drilling mud. If this did not remove the drill cuttings, then QUIK-GEL® drilling mud could be used.

- The 30-foot interval below the surface casing would be drilled using a water-rotary method. However, if the bedrock below the surface casing was found to be extremely unstable, then a mud-rotary method could be used instead (determined case-by-case). AQUAGEL GOLD SEAL® was preferred; however, if extreme adverse field conditions were encountered, then it would be acceptable for the field hydrogeologist to decide to use QUIK-GEL®.

The mud-rotary method, using AQUAGEL GOLD SEAL®, was used to drill the interval of the borehole where the surface casings were installed in all 17 bedrock wells. The water-rotary method was used to drill the 30-foot interval below the surface casing in all bedrock wells except BRMW3 (Gulf), BRMW4 (Sears), BRMW9 (Federal Express), and BRMW14 (Sears). The mud-rotary method, using AQUAGEL GOLD SEAL® and QUIK-GEL®, was used to drill BRMW3, BRMW4, BRMW9, and BRMW14, because field conditions warranted it. However, because incompetent zones within the bedrock were encountered in BRMW3 and BRMW9, these wells were drilled to total depth using an air-rotary drilling method. The specific field conditions relating to these two wells are discussed later in this section.

The work plan stated that bedrock coring was to occur at BRMW9 (Federal Express), BRMW10 (Stepan), BRMW14 (Sears), and BRMW15 (Stepan). However, review of regional geological reports and the position of the proposed bedrock wells resulted in coring at different locations than those proposed in the work plan (BRMW2 [Stepan], BRMW8 [SWS], BRMW13 [Sears] and BRMW17 [Stepan]). The rationale for the original coring locations and their modifications is provided below.

BRMW14/BRMW13. BRMW14 was selected in the work plan for coring to determine whether there is an increased fracture network near the former drainage channel on Sears. However, BRMW14 is approximately 200 feet east of the former

drainage channel. Because BRMW13 was located next to the channel, coring was performed at BRMW13 instead.

BRMW9/BRMW8. BRMW9 was selected in the work plan as one of three locations to provide areal coverage of the bedrock fracture patterns within the Passaic Formation. However, because competent and resistant sandstone was encountered approximately 2 feet below grade at BRMW9, it was considered likely that the occurrence of fractures would be minimal at this location. Therefore, coring was performed at BRMW8, because it was the next closest location.

BRMW10. BRMW10 was selected in the work plan as one of three locations to provide areal coverage of the bedrock fracture patterns within the Passaic Formation. However, because coring is time consuming and BRMW10 was located in an area of Stepan that has work hour limitations, coring was not conducted at this location. Coring was conducted at BRMW17 to provide areal coverage of the bedrock fracture patterns within the Passaic Formation.

BMRW15. BRMW15 was selected in the work plan as one of three locations to provide areal coverage of the bedrock fracture patterns within the Passaic Formation. Specifically, it was chosen because it lies along a perpendicular to the bedrock strike. However, because there was an existing well approximately 130 feet south with coring information available (B38W58), no coring was conducted at BRMW15, and a new location was chosen along the perpendicular (BRMW17).

BRMW17. Because it was not practical to core at BRMW10 due to work hour limitations, coring was conducted at BRMW17 to provide areal coverage of the bedrock fracture patterns within the Passaic Formation. BRMW17 was also added as a coring location because it aligns with BRMW8 and this alignment parallels bedrock strike.

BRMW2. BRMW2 was added as a coring location because it is aligned with BRMW13 and BRMW8 and because this alignment approximately parallels the strike of the bedrock.

After the surface casings were installed at BRMW2, BRMW8, BRMW13, and BRMW17, the boreholes were advance using NX-size conventional coring equipment. Continuous coring was completed to approximately 30 feet below the bottom of the casing. The cores were placed in wooden boxes for storage and analysis by the site hydrogeologist. Information recorded included the core run, length of run, percentage of core recovery, rock quality data (RQD), lithology, fracture orientation, and bedrock discontinuities. Core descriptions were recorded on CH2M HILL standard rock core log forms that conform to information requirements outlined by ASTM D2113-83.

When the coring was completed the borehole was reamed out to 6 inches using a 5⅞-inch rock bit. Each borehole was then developed by pumping potable water into the

borehole until turbidity and sediment were substantially reduced. This phase of development was conducted so subsequent bedrock testing could occur within a relatively sediment-free environment.

Following the completion of bedrock well drilling, borehole geophysical logging was performed in each of the bedrock wells except BRMW9 (Federal Express) and pressure injection (packer) testing was performed in each of the bedrock wells except BRMW3 (Gulf) and BRMW9. Geophysical logging and packer testing are discussed in Sections 2.4.3 and 2.4.4, respectively. The conditions affecting BRMW3 and BRMW9, and the installation of the bedrock monitoring wells, are discussed below.

BRMW3. During the drilling of well BRMW3 (Gulf), an incompetent zone was encountered within the bedrock at approximately 4 feet below the bottom of the steel casing (22.5 feet below ground surface). Loss of drilling fluids occurred and the borehole could not be advanced with the water-rotary methods. Drilling muds proved unsuccessful. A Mobile B-80 drilling rig, equipped to perform air-rotary drilling, was used to complete the drilling. Because the incompetent zone occurred 4 feet below the casing, the well was immediately installed within this highly fractured and weathered zone within the bedrock. As a result, borehole geophysical testing and packer testing were not conducted in this well, and the borehole was not drilled 30 feet below the surface casing.

BRMW9. During the drilling of BRMW9, bedrock was encountered at 2 feet below ground surface and water occurred initially at approximately 25 feet. Because of the shallow occurrence of bedrock and the depth to water, the shallow overburden well (OBMW9) was not installed.

After drilling to 30 feet, all drilling fluids were removed from the borehole. The water level equilibrated at 15 feet below grade. It was decided to screen the zone from 20 to 30 feet because this interval was likely providing water to the borehole.

A 6-inch steel surface casing was installed 10 feet below ground surface (7 feet into competent rock). Because the borehole was already drilled to a depth of 30 feet before the installation of the surface casing, the casing could not be pressure tested. When attempting to conduct geophysical logging within this borehole, it was noted that the total depth of the borehole was only 20 feet below ground. Fragments of incompetent rock had caved in and filled approximately 10 feet of the borehole. A caliper log was run to determine the borehole size. A borehole diameter fluctuating between 9 and 14 inches was recorded for the interval above the caved material. As a result, the borehole had to be redrilled. Because of the size limitations of the packer assembly, packer testing could not be conducted in BRMW9.

BRMW9 was redrilled to 30 feet below ground surface. Attempts to drill the 20-to-30-foot interval were unsuccessful because the borehole would not stay open to allow installation of the well screen. Large rounded fragments of weathered bedrock and gravel were removed from the borehole. The well screen was eventually installed

from 13.5 to 23.5 feet below ground surface. Water was originally encountered at approximately 25 feet and then rose to about 15 feet below ground surface. Approximately 6.5 feet of caved material lies below the bottom of the well. This material acts as a natural sandpack below the screen and allows water to flow into it. The well was completed in the same manner as the other bedrock wells.

Installation. After completion of geophysical logging and packer testing, the bedrock wells were installed. The screen interval in each well was selected based on information obtained during the borehole geophysical logging and packer testing. The interval that exhibited the highest permeability was screened in each well. In cases where permeability data were inconclusive, the screen intervals were selected on the basis of test data from the nearest boreholes. The bedrock monitoring wells were completed using the same specifications as for the overburden wells, except that screened intervals were 10 feet long and centralizers were used to position the stainless steel in the borehole. The bedrock wells were fabricated of sections of 2-inch-inside-diameter, schedule 5, type 304-grade stainless steel riser pipe and continuous wire-wrapped No. 10-slot well screen. For holes where there was a difference between the borehole depth and the screen depth, HOLEPLUG® (graded bentonite) was used to seal the unused portion of the borehole. A 2-foot-thick sand layer was placed between the bottom of the screen and the hole plug to provide a buffer. The sand pack (Morie grade No. 1) was installed 1 to 2 feet above the top of the screen in the bedrock wells, depending on the location of the top of the screen and its proximity to the bottom of the surface casing. Approximately 2 feet of annular bentonite pellet seal was then installed above the sand pack. When the screened zone was directly below the surface casing, a thicker bentonite pellet seal was installed that extended up inside the surface casing. The pellets were then hydrated with potable water and allowed to set for at least 1 hour before the well was completed. The annular space between the well and the surface casing above the bentonite pellet seal was then filled with bentonite-cement grout by the tremie method.

The bedrock wells were completed in one of two ways: with either a protective casing extending above the ground surface or a flush-mounted roadbox. In areas where there is minimal traffic or grass cover (excluding Sears), a 5-foot length of 4-inch-inside-diameter steel pipe with locking cap assembly was installed. Four of the bedrock wells that were completed with a protective casing extending above the ground surface were BRMW9 (Federal Express), BRMW 15 (Stepan), BRMW 17 (Stepan), and BRMW 11 (Sears). The remaining 13 bedrock wells were completed flush with the ground surface.

The second method of well completion was used in areas of heavy traffic. This flush mount method consisted of installing an 8-inch-diameter steel roadbox, approximately at grade, that allows surface water to drain away from the well. The roadbox was set within a 2-foot square, concrete pad. A locking cap assembly, to secure the well, was placed inside the roadbox.

All bedrock wells were permanently marked with the New Jersey well permit number and well designation, regardless of the type of well completion. Typical bedrock well diagrams are shown in Figure 2-6 and Figure 2-7. Completed well construction diagrams and monitoring well records are included in Appendix J. Well construction details for the bedrock wells are presented in Table 2-10.

All soils and liquids produced from the bedrock well installations were contained in 55-gallon steel drums and are currently being stored on the property where the materials were generated.

After all the screens and risers were installed in the bedrock boreholes, the wells were developed using an air-lift system. The air-lift system consisted of a ¾-inch-diameter polyethylene pipe set near the bottom of the well to lift sediment from the well. Discharge water was directed through a tee and collected in 55-gallon steel drums. Parameters measured in the field included temperature, pH, and specific conductivity. Development continued until the parameters stabilized and the purge water was relatively sediment-free. In cases where well yield was very low (BRMW1, BRMW4, BRMW7, and BRMW14; all located on Sears) well development occurred over several days using a bailer.

2.5.3 Borehole Geophysical Logging

CH2M HILL conducted borehole geophysical surveys in 16 of 17 bedrock boreholes from May 4, 1992, to May 16, 1992. BRMW3 (Gulf) was not logged because the borehole was not drilled to the total depth of 30 feet below the steel surface casing due to caving problems while drilling with wet-rotary methods. Geophysical logs conducted during each borehole survey included natural gamma ray, spontaneous potential (SP), long normal (64-inch) and short normal (16-inch) resistivity (LSN), fluid resistivity, temperature, and three-arm caliper.

There were two objectives of the geophysical surveys. The first was to correlate geophysical log signatures to the lithologic data obtained from the bedrock cores from BRMW2 (Stepan), BRMW8 (SWS), BRMW13 (Sears), and BRMW17 (Stepan) in order to compare the lithologic data across the entire study area. The second objective was to locate water-bearing fractures. The data were then used in conjunction with data obtained from hydraulic pressure injection (packer) testing to select screened intervals.

The logging surveys were conducted using two logging tools, a three-armed caliper and a multi-functional logging tool (MFLT). All of the logs were recorded with similar scales and with similar procedures. Briefly, the procedure was as follows:

- The MFLT was placed in the borehole and the temperature and fluid resistivity logs were recorded on the first down run of the borehole to minimize the disturbance of the borehole fluid.

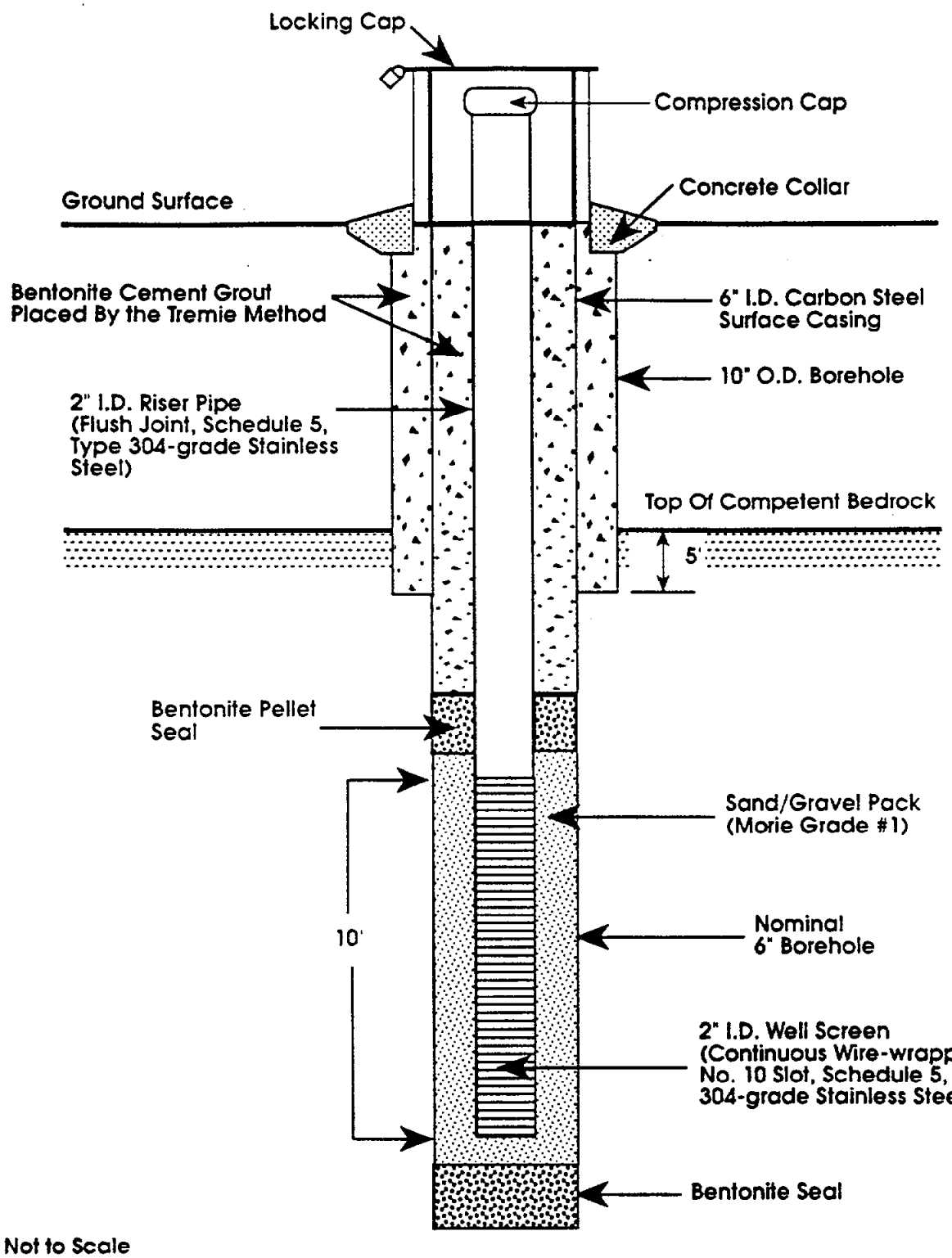

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Figure 2-6
TYPICAL BEDROCK MONITORING WELL INSTALLATION
STEPAN COMPANY AND SEARS AND ADJACENT PROPERTIES RI, MAYWOOD, NEW JERSEY

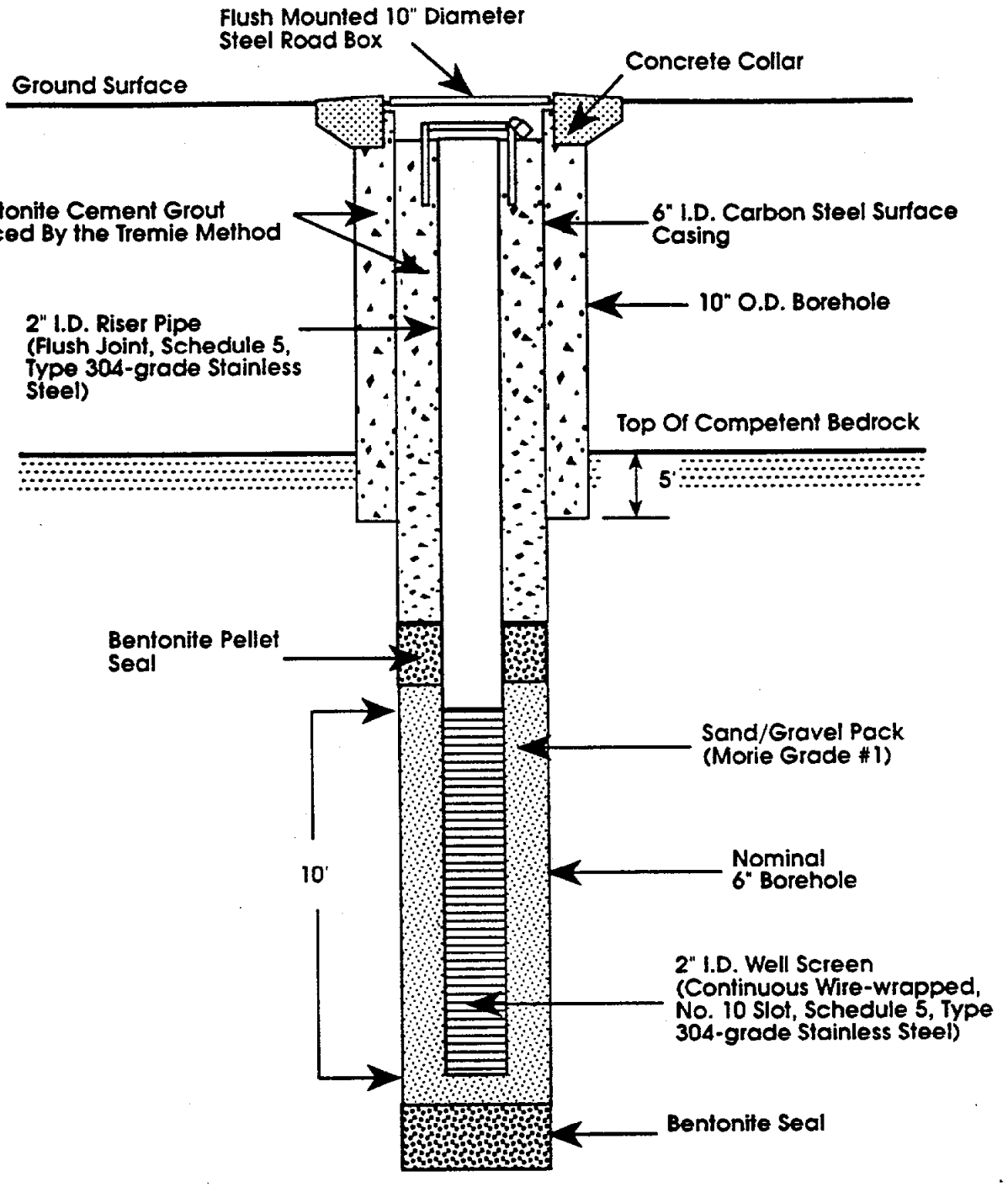

Figure 2-7
TYPICAL FLUSH MOUNT
BEDROCK MONITORING WELL INSTALLATION
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PROPERTIES RI, MAYWOOD, NEW JERSEY

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PROPERTIES RI
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- The natural gamma ray, SP, and LSN resistivity logs were recorded on the subsequent up run of the borehole in order to decrease the steel casing's effect on the SP and LSN resistivity responses.

- The MFLT was removed and the three-armed caliper was placed in the borehole and run to the bottom of the borehole. The diameter of the borehole was then recorded on the up run.

To aid in the field investigation process, additional fluid resistivity and temperature logs were run on BRMW2 and BRMW17 (both on Stepan). These logs were run after the initial logging survey of the wells and after the wells had been stressed by bailing out approximately three casing volumes of borehole fluid. These logs were run to determine if any aquifer contribution to the well could be seen by changes in either or both parameters. A comparison of the logs conducted before and after stressing the well did not indicate any changes in the borehole fluids. It was then assumed that little to no contribution could be observed. Stressing and additional logs were not conducted on the remainder of the wells in the geophysical logging survey because it was assumed they would be similar to the two test logs.

The logging tools were decontaminated between each borehole by using a modified triple rinse method which included an alconox wash, a distilled water rinse, a methanol rinse, and a second distilled water rinse. The logging cable was also decontaminated between each borehole by running the cable, while logging out of the borehole, through a series of wet paper towels. The first towel was saturated with methanol and the second with distilled water.

The geophysical logs were recorded digitally on a computer hard drive and then downloaded to a floppy diskette. The logging unit used was a Century Geophysical Compu-Log II, which was chosen because it allowed the log data to be viewed in a variety of formats, which provides versatility in presenting the data. The log scales were selected to maximize the response curves. The following units were selected: inches for the caliper; American Petroleum Institute (API) units for the natural gamma ray; millivolts for SP; OHM-M for LSN; degrees Fahrenheit for temperature; and OHM-M for fluid resistivity.

As part of the geophysical logging QA/QC program, the logging tools were calibrated within an anticipated range based on site conditions. Calibration takes place across the range by using minimum and maximum calibration values. The following are the calibration procedures used for the surveys:

- Caliper–calibrated daily in the field using standard calibration paddles of 6 inches and 12 inches. Calibration was also verified in each borehole by opening the caliper arms in the 6-inch casing.

- Natural gamma ray–calibrated before the logging surveys, using a standard sleeve with an active source emitting 500 counts per second.

- LSN resistivity—calibrated before the logging surveys at the geophysical logger warehouse, using resistor arrays, based on USGS recommended design, between the measurement electrodes. The range was from 0 OHM-M to 2001 OHM-M.

- SP—calibrated before the logging surveys using a calibration box manufactured by Century Geophysical Corporation. The range was from 0 millivolts to 400 millivolts.

- Temperature—calibrated before logging surveys using water baths of known values. The range was from 5 degrees C to 32 degrees C.

- Fluid resistivity—calibrated before logging surveys using water baths of known values. The range was from 0.3 OHM-M to 50 OHM-M.

Copies of the geophysical signatures are included in Appendix K. Interpretation of the borehole geophysical data is discussed in Section 3.

2.5.4 Hydraulic Pressure Injection Testing

Hydraulic pressure injection testing (packer testing) was conducted from May 18, 1992, to June 2, 1992, in all new bedrock boreholes except BRMW3 (Gulf) and BRMW9 (Federal Express). These two boreholes were not tested for the reasons presented in Section 2.5.2.

The method used was similar to the method described in ASTM D4630-86, which is also outlined in the Bureau of Reclamation Geology Report No. G-97, *Permeability Tests Using Drill Holes and Wells*. The primary objective of the packer testing program was to identify the most permeable zone in the borehole. A secondary objective was to quantify the hydraulic conductivity of discrete intervals within the bedrock.

Packer testing involves the isolation of a test interval within the bedrock borehole using a straddle packer assembly and injecting water under pressure into the test interval. Resulting flow rates are then measured for each constant pressure setting.

Testing was performed using two Baski inflatable packers and a compressed nitrogen source connected by Teflon air lines. The two packers were connected using 1¼-inch-diameter perforated steel pipe. Non-perforated 1¼-inch-diameter steel pipe was used above the top packer, both as an injection line and to support the packer assembly. The packer assembly was designed to isolate pressure transducers within and below the test interval. This was accomplished by using an in-line adapter installed above the top packer and specialized fittings installed in the adapter into which the transducers were connected to transfer tubes from the fittings to the respective test zones. Although the transducers were installed at the adapter, the transfer tubes were completed in the respective test zones, which allowed for pressure monitoring of

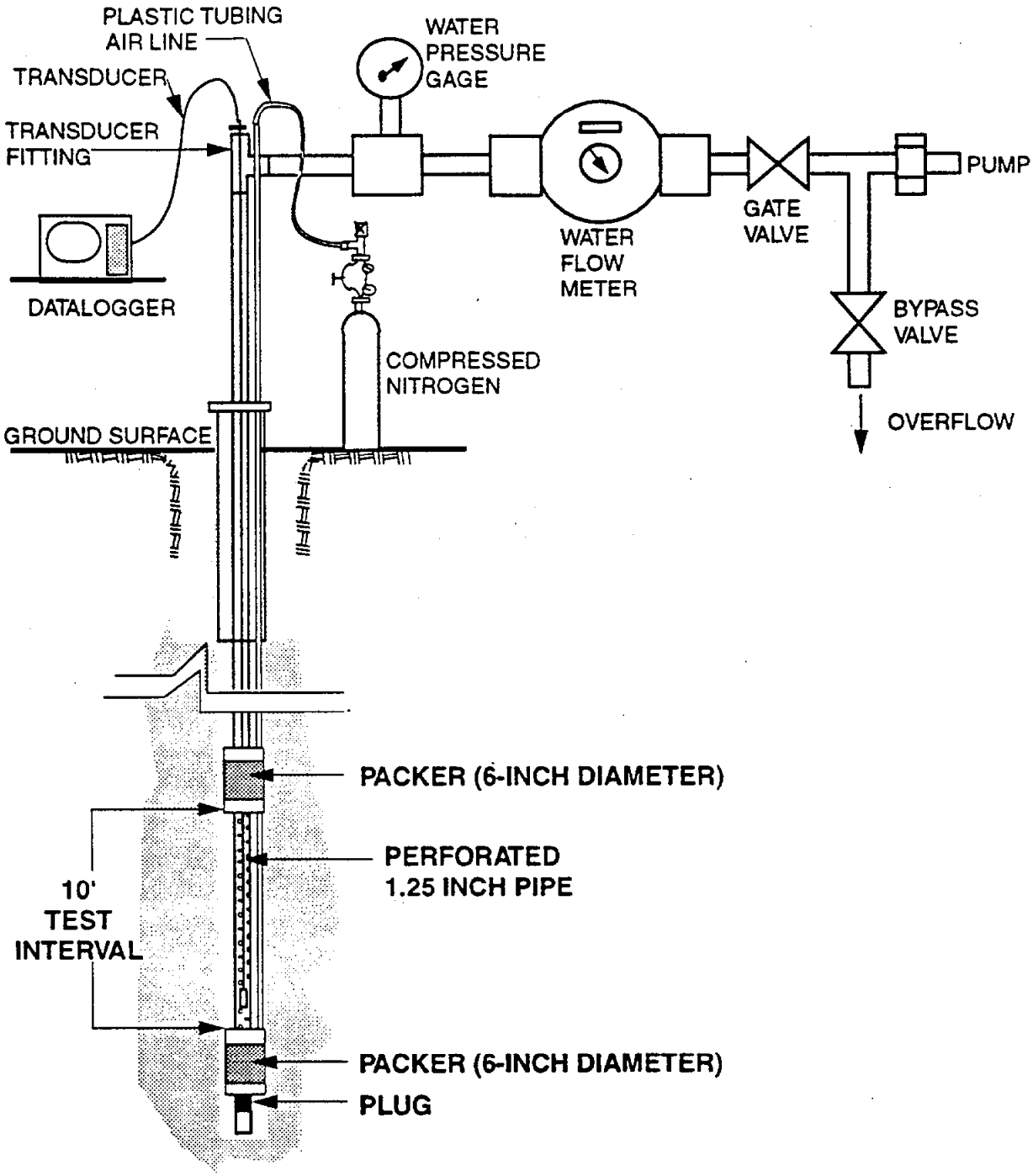
those zones. A pressure transducer was also installed in the interval above the top packer. This transducer was used to determine the effectiveness of the seal provided by the top packer. The transducers were manufactured by Druck Inc. and were connected to a Campbell Scientific micrologger, which allowed direct measurement of pressure conditions in the test zones.

Water was injected in between the packers using a submersible pump lowered in a 500-gallon tank of potable water. A totalizer flowmeter was installed between the tank and the wellhead. The flowmeter was capable of reading flow at an accuracy of 0.1 gallon over a range of 0 to 30 gallons. A tee was installed to allow water discharging from the pump to recirculate into the tank, which allows the operators to regulate the flow and pressure within the packer system. A pressure gauge was installed before the wellhead to check the pressure in the test zone. A schematic of the packer test assembly is shown in Figure 2-8.

The straddle packer assembly was designed to test a 10-foot interval, which is the distance between the bottom of the top packer and the top of the bottom packer. The assembly was left at this distance for the entire program so that three tests could be conducted within each 30 foot interval within each bedrock borehole. Adjusting the length of the straddle packer assembly in between tests would have resulted in fewer intervals being tested in each borehole. The entire open interval of the bedrock boreholes was tested. The first test in each borehole involved the inflation of only the top packer. This resulted in testing the bottom 17 feet of the borehole. Since the entire open interval in the majority of the boreholes was 30 feet, this left approximately 13 feet of borehole that remained to be tested. The general approach after the first interval was tested was to raise the packer assembly half this distance (6.5 feet), then conduct the second test. Finally, the packer assembly was then raised the same distance and the top interval of the borehole was tested. If the bottom interval was the most permeable of the three intervals that were tested, the assembly was lowered back down to the bottom of the borehole and both packers were inflated and the interval was re-tested. This configuration resulted in testing the top 10 feet of the bottom 17 foot section of the borehole.

The following is a brief summary of the procedures used to test the bedrock boreholes. The procedures are presented in the order that they were performed.

- The packer assembly was lowered to approximately 0.5 to 1 foot above the bottom of the borehole.
- The height of the pressure gauge installed above the wellhead was measured with respect to ground surface and the depth to water.
- The top and or bottom packer was inflated and the pressure in the test zone was allowed to stabilize for approximately 5 minutes.



Not to Scale

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Figure 2-8
SCHEMATIC OF PACKER TESTING CONFIGURATION

- The datalogger was activated to record pre-pumping pressures. Potable water was then injected into the test interval.

- After the pressure in the test interval stabilized, flow rates were recorded every minute for 10 to 20 minutes or until consecutive pressure readings were less then 1 psi.

The results of the packer testing program are discussed in Section 3.6.2.

2.6 Field Activities Common to Overburden and Bedrock Groundwater Investigations

The following field activities were common to both the overburden and bedrock groundwater investigations:

- Hydraulic conductivity testing
- Static water level measurement
- Continuous water level measurement
- Sampling

The groundwater sampling program is described in Section 2.7. The surface water and sediment sampling programs are both described in Section 2.8, because they were sampled concurrently.

2.6.1 Hydraulic Conductivity Testing

Hydraulic conductivity (slug) tests were performed from August 12, 1992, to August 27, 1992, in all overburden and bedrock wells installed during the RI. These tests were performed to characterize the hydraulic properties of the overburden and bedrock zones beneath the study area. Results of the slug tests provide order-of-magnitude estimates of the in-situ hydraulic conductivity for a small aquifer volume in the area immediately surrounding the test well. Sets of tests were performed in well couplets screened in intervals within the overburden and fractured bedrock units. From these tests, hydraulic conductivity and limited transmissivity values were determined.

A technical memorandum was prepared describing the hydraulic conductivity testing program. This memorandum describes in detail the field testing methods (i.e., pneumatic displacement and displacement cylinder methods) and data analysis methods (i.e., Bouwer and Rice, and Hvorslev). The memorandum and the recovery curves are presented in Appendix L. Test results and a comparison of these slug test results with pressure injection testing results are presented in Section 3.6.2.

2.6.2 Static Water Level Measurement

In order to determine the direction of groundwater flow and the hydraulic relationships between the overburden and bedrock, several sets of water level measurements were collected during the RI. Water levels were collected from both selected existing wells and wells installed during the field program. Water levels were measured on six separate dates in 1992: June 1, June 22, July 28, September 9, October 2, and November 5. The two sets of water levels collected in June may not be representative of actual groundwater conditions for the following reasons. (1) By June 1, 1992, the majority of the bedrock wells were not completed with screens. Therefore, water level elevations determined from these wells represent the average hydraulic head across a 30-foot interval within the bedrock. (2) Bedrock wells that were completed by June 1 were not developed by that date. All of the overburden wells were installed and developed by June 1.

Water levels collected on June 22, 1992, are considered more representative of groundwater conditions beneath the study area. However, some of the bedrock wells had just been completed with well screen and were not developed by this date.

Water levels collected on July 28, 1992, are considered representative of groundwater conditions and are the most complete set of water level measurements obtained during the RI. All new wells had been installed and developed, and water levels had sufficient time to equilibrate, by this date. Water levels were also collected from selected existing wells on this date, and the elevations of the surface water sampling locations were determined on this date.

Water levels collected on September 9, October 2, and November 5, 1992, are all considered representative of groundwater conditions; however, the water levels were collected from the new wells and only the selective existing wells that did not need access approval from DOE. No surface water elevations were determined on these dates.

The water level data are presented and discussed in Section 3.6.2.

2.6.3 Continuous Water Level Measurement

Continuous water level measurements were recorded from six overburden/bedrock monitoring well couplets. The objective of this testing was to collect enough water level data over time to diagnose responses to natural and human-induced influences. These influences include rainfall, atmospheric pressure, and extraneous pumping in the study area. Of particular significance was the response of the shallow wells to these influences relative to the response of the deep wells. Systematically different response patterns between sets of wells may suggest significantly separate water-bearing zones, for instance.

Campbell Scientific Microloggers and Druck pressure transducers were used to monitor long-term water levels. Barometric pressure readings were collected from a mercury barometer integrated directly with one of the microloggers. The following well couplets were monitored, because they behaved uniquely or they were thought to represent sitewide conditions, for the following reasons:

- OBMW2/BRMW2: There was a considerable head difference between OBMW2 and BRMW2.
- OBMW11/BRMW11: These wells are located in a wetland area that is thought to represent a local groundwater discharge area.
- OBMW12/BRMW12: BRMW12 has the deepest screening interval of the bedrock wells installed. This may explain why OBMW12 and BRMW12 exhibit different water level behaviors.
- OBMW13/BRMW13: These wells are located in the former drainage channel, where the rock is known to be highly fractured.
- OBMW14/BRMW14: The water level in BRMW14 has a history of rising precipitously after the cap is removed.
- OBMW15/BRMW15: Previous water level information had suggested some site pumping might be occurring near the Stepan property.

Monitoring began on Thursday, September 10, 1992, and continued until Thursday, September 17, 1992. Measurements were obtained every 30 minutes in each datalogger for the entire monitoring period. Data are discussed in Section 3.6.2.

2.7 Groundwater Sampling

Groundwater samples were collected from a total of 48 monitoring wells located on Stepan and Sears and adjacent properties. The locations of the wells sampled are shown on Figure 2-9. Thirty-two of these wells were installed during the RI (15 overburden and 17 bedrock wells). Sixteen were existing wells installed during previous investigations (commonly referred to as DOE and NRC wells). Two of the DOE wells are located on the New York Susquehanna and Western railroad right-of-way and were included in the study area. Also presented in Figure 2-9 are four additional wells that were sampled as part of the focused investigation.

Groundwater sampling was conducted July 20 through August 4, 1992. Fifty-one groundwater samples (including duplicate samples) were collected and sent for chemical and radiological analyses.

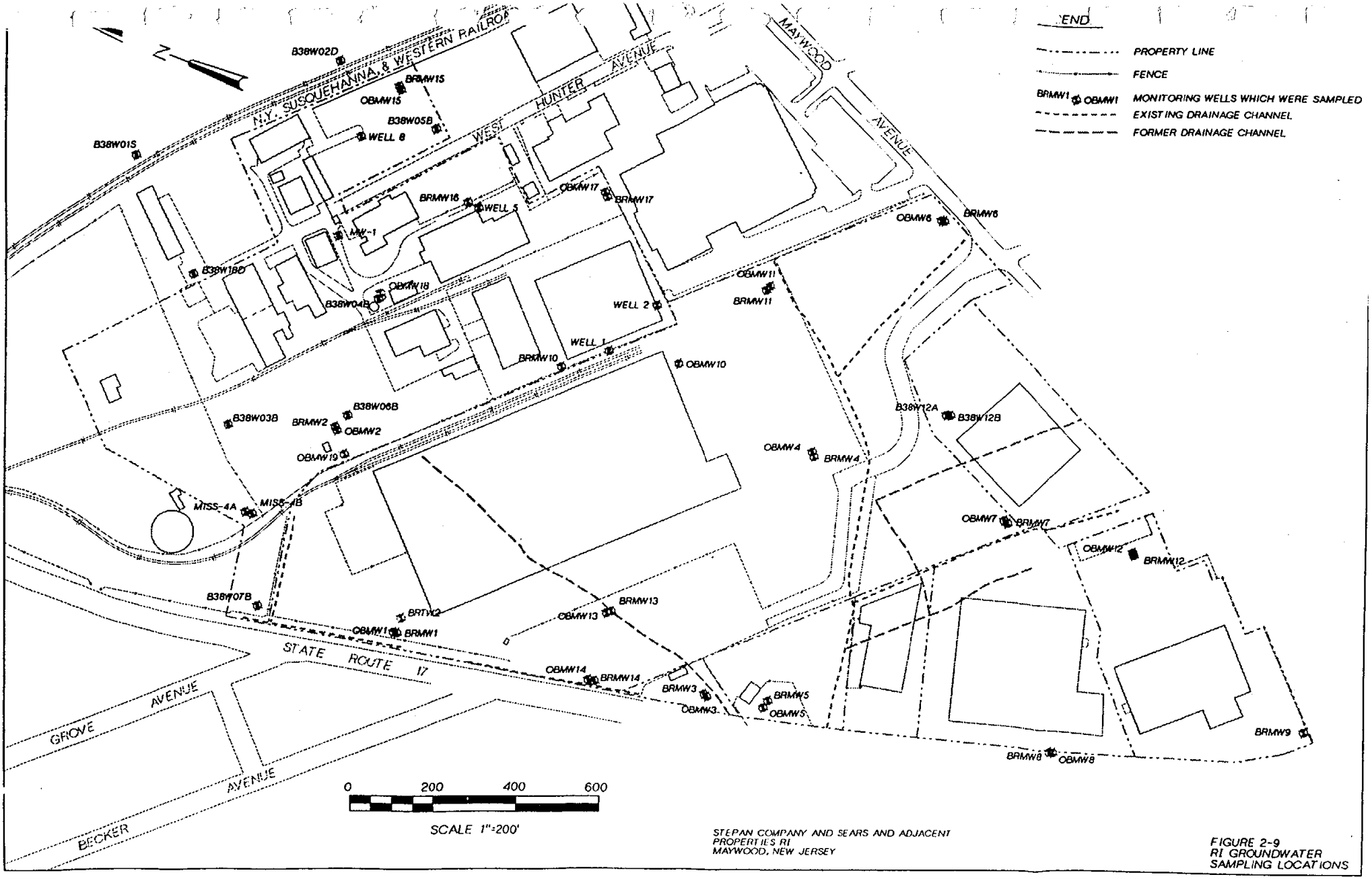

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FIGURE 2-9
RI GROUNDWATER SAMPLING LOCATIONS

The monitoring wells sampled and the properties where they are located are shown in Table 2-11.

The Focused Investigation groundwater samples were collected from the same 48 monitoring wells sampled during the RI groundwater sampling event, with the following exceptions:

- Monitoring well MW1 located on the Stepan property near the guard house at the end of West Hunter Avenue (Figure 2-9) was also sampled.
- Monitoring well MISS 4A could not be sampled because of insufficient well volume.
- Monitoring wells B38W01S, B38W02D, and B38W18D were sampled by BNI, consultants to DOE, during their groundwater sampling program.

The monitoring wells sampled during the Focused Investigation and the properties on which where they are located are shown in Table 2-11.

Focused Investigation groundwater sampling was conducted July 17, 1993, through August 3, 1993. The following number of samples were collected and sent for analysis:

- Fifty-two groundwater samples (including duplicate samples) were collected for TCL VOC and 48 for TCL semivolatile organics analyses.
- Six groundwater samples (including duplicate samples) were collected for TCL pesticides analysis.
- Fifty-two groundwater samples (including duplicate samples) were collected for total TAL metals and 28 filtered TAL metals analysis.
- Thirteen groundwater samples were collected for total cyanide analysis.

Two new overburden monitoring wells (OBMW18 and OBMW19) were installed on the Stepan property and one bedrock pumping well (BRTW2) was installed on the Sears property during the Focused Investigation field activities. Well construction activities for these wells are described in 2.10.1. OBMW18 and OBMW19 were sampled October 20, 1993, and BRTW2 was sampled on November 15, 1993, using the same sampling methods used for the Focused Investigation groundwater sampling conducted in July and August 1993. Well OBMW18 was sampled for TCL VOCs, TCL semivolatile organics, and total TAL metals. Wells OBMW19 and BRTW2 were analyzed for TCL VOCs only.

Table 2-11
Monitoring Well Locations

Well Designation[a]	Property
OBMW1	Sears
BRMW1	Sears
OBMW2	Stepan
BRMW2	Stepan
OBMW3	Gulf
BRMW3	Gulf
OBMW4	Sears
BRMW4	Sears
OBMW5	Sunoco
BRMW5	Sunoco
OBMW6	Sears
BRMW6	Sears
OBMW7	Sears
BRMW7	Sears
OBMW8	SWS
BRMW8	SWS
BRMW9	Federal Express
OBMW10	Sears
BMRW10	Stepan
OBMW11	Sears
BRMW11	Sears
OBMW12	Federal Express
BRMW12	Federal Express
OBMW13	Sears
BRMW13	Sears
OBMW14	Sears
BRMW14	Sears
OBMW15	Stepan
BRMW15	Stepan

Table 2-11
Monitoring Well Locations

Well Designation[a]	Property
BRMW16	Stepan
OBMW17	Stepan
BRMW17	Stepan
Well1	Stepan
Well2	Stepan
Well5	Stepan
Well8	Stepan
B38W01S	Railroad
B38W2D	Railroad
B38W3B	Stepan
B38W4B	Stepan
B38W5B	Stepan
B38W6B	Stepan
B38W7B	Stepan amended property
B38W12A	DeSaussure
B38W12B	DeSaussure
B38W18D	Stepan
MISS4A	Stepan amended property
MISS4B	Stepan amended property
MW1[b]	Stepan
OBMW18[b]	Stepan
OBMW19[b]	Stepan
BRTW-2[b]	Sears

[a]The overburden monitoring wells installed during the RI were designated OBMW, and the bedrock monitoring wells were designated BRMW. Each of these was followed by a number (OBMW1, BRMW1). The existing wells had already been named; these names were not changed.
[b]Well was sampled during the Focused Investigation only.

2.7.1 Objectives

The objectives of the groundwater sampling program were to quantify and characterize the vertical and horizontal extent of groundwater contamination in the overburden and upper bedrock aquifer, and to assist in evaluating the contaminant transport pathways between the overburden groundwater, bedrock groundwater, and surface water.

The objectives of the Focused Investigation groundwater sampling program were to confirm the initial findings of the RI groundwater sampling, provide a comprehensive site-wide picture of groundwater contamination, and support the analysis of the fate and transport of contaminants in groundwater.

2.7.2 Sampling Methodology

The sampling procedures for the groundwater sampling program were based upon the procedures outlined in the work plans (CH2M HILL) and the QAPP (CH2M HILL). Deviations from these plans sometimes occurred because of field conditions. These deviations are summarized in Section 2.7.3. Sampling methodologies used are described below.

The sampling methodology was as follows:

- The well was unlocked, and the protective cap and well cap were removed.
- A headspace reading was taken inside the well casing, using a PID (TMA OVM Model 580B, with 10.6 eV bulb).
- Water level was measured using an electronic water level indicator with an accuracy of ± 0.01 foot. Readings were taken from the top of the outer casing, the top of the inner casing (if present), and from the ground surface.
- The well depth for existing wells was measured if no well logs existed. If well logs existed, the well logs were used to determine the total depth of the well.
- The well volume for each well was calculated using the following equation:

$$\text{Well Volume} = 3.14 \cdot R^2 \cdot H$$

where R = radius of the inner well casing, and
H = height of the water column in the well

- The well was purged to a minimum of three and a maximum of five well volumes, using either a decontaminated 2-inch submersible Grundfos Redi-flow 2® pump, or a peristaltic pump with dedicated silicone tubing.

- Specific conductivity, pH, and temperature measurements were taken at the onset of purging and after each well volume was purged. These parameters and other observations were recorded on the field data sheets.

- When field parameters stabilized to within ± 10 percent, well sampling began.

- If a well was determined to be purged dry, the well was not purged further. Sampling took place within 3 hours of well purging completion in most cases.

- Sampling was completed using a 2-inch-diameter stainless steel bailer with a 3-foot Teflon-coated wire leader and polypropylene rope.

- Samples were collected for the following analyses in the following order: TCL VOCs, TCL semivolatiles, TCL pesticides, TCL PCBs, a-pinene, caffeine, d-limonene, TAL metals (including lithium), cyanide, and radionuclides. Samples collected for metals analysis were not filtered.

- Samples were chemically preserved, if applicable. Table 2-7 provides a summary of the sample preservation requirements.

- Samples were immediately placed in a cooler containing ice and kept at 4 degrees C until shipped to the laboratories.

- Groundwater samples were not screened for radioactivity by the field laboratory, because of potential matrix interferences. Because groundwater samples were not expected to be considered radioactive,[3] groundwater samples were shipped as non-radioactive materials.

The sampling procedures for the Focused Investigation groundwater sampling program were similar to those of the RI sampling procedures. However, because of the turbidity problem with the RI groundwater samples, which resulted in elevated metals concentrations, the purging and sampling method was modified for the Focused Investigation sampling.

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[3]Defined by DOT as total activity greater than 2 x 10^6 pCi/L; 49 CFR 173.403.

The following modified purging and sampling method was used:

- Wells were purged at a slow rate using either a peristaltic, centifical, or submersible pump (depending upon well volume and water level).

- In addition to other field measurements (pH, specific conductance, and temperature), turbidity measurements also were taken after each well volume was purged. If the last well volume purged had turbidity readings greater than 5 NTUs, a sample for filtered metals was collected, in addition to the total metals sample.

- Once purging of a well was completed, samples were collected for the following analyses in the following order: TAL metals (total), TAL metals (filtered), TCL VOCs, TCL semivolatile organics, TCL pesticides, and cyanide.

- Samples for total and filtered metals analysis were collected through a peristaltic pump at a flow rate of 100 ml per minute. The samples for filtered metals were filtered by attaching a 0.45 μm cellulose acetate in-line filter to the peristaltic pump tubing.

- Once metals samples were collected, the peristaltic pump tubing was removed from the well, and a decontaminated stainless steel bailer was used to collect samples for other parameters. Metals samples were not collected with a bailer because sampling with a bailer can stir up sediments in the well, resulting in elevated metals levels.

For a more detailed description of the Focused Investigation groundwater sampling program, refer to the *Remedial Investigation Workplan Amendment*, June 1993.

2.7.3 Modifications of the Work Plans and QAPP

Modifications of the sampling procedures specified in the work plans (CH2M HILL) and in the QAPP (CH2M HILL) for the RI groundwater sampling are outlined below.

- OBMW15 was purged dry after the third well volume was removed. The well did not recover sufficiently on the day it was purged to collect the sample volume required for all analytical parameters. Only samples for VOC analysis were collected on the day it was purged. Samples for all other analytical parameters were collected the following day, without repurging.

- Well 8 was purged dry after only 0.75 gallons were removed. The well did not recover sufficiently on the day it was purged to collect the sample volume required for all analytical parameters. Only samples for

QC analysis were collected on the day it was purged. Samples for all other analytical parameters (except radiological) were collected daily throughout the rest of the groundwater sampling event. Samples for radiological analysis could not be collected because the sample volume was insufficient.

- MISS4A was purged dry after only 0.9 gallons were removed and recovered very slowly. Given the limited sample volume, only samples for VOC and semivolatile analysis were collected on that day. Because of the weekend, sampling continued 2 days later, without repurging. However, after these 2 days, the well was still not fully recovered. After discussion with EPA, sampling of this well was terminated.

- BRMW14 was purged dry after the second well volume was removed. The well did not recover sufficiently on the day it was purged to collect the sample volume required for all analytical parameters. Only samples for VOC analysis were collected on the day it was purged. Samples for all other analytical parameters were collected the following day, without repurging.

- Well 6 (NRC) was not sampled as proposed in the work plan because it was not in satisfactory condition. Well 6 was replaced by OBMW17, and OBMW17 was sampled instead.

- B38W3A (DOE) was not sampled as proposed in the work plan because it could not be located.

- OBMW9 was not installed or sampled, as proposed in the work plan, for the reasons discussed in Section 2.5.2.

A second round of groundwater sampling was not proposed in the work plans (CH2M HILL) or in the QAPP (CH2M HILL). The Focused Investigation groundwater sampling, however, was described in the work plan amendment. Modifications to the work plan amendment are outlined below.

- Well MISS4A could not be sampled because of insufficient well volume.

- All groundwater samples were analyzed for TCL VOCs, TCL semivolatile organics, and TAL metals (total). Selected groundwater samples were analyzed for TCL pesticides, cyanide (total), and TAL metals (filtered).

- Several wells went dry during purging and had to be sampled over several hours or days. These wells were not repurged prior to sampling.

- Samples from wells B38W01S, B38W02D, and B38W18D, which were sampled by BNI for CH2M HILL, were never analyzed for TCL semivolatile organics.

- The sample from well OBMW11 was never analyzed for TCL pesticides. The sample from well B38W05B was analyzed for TCL pesticides instead, by mistake.

2.7.4 Analytical Requirements

Groundwater samples were analyzed for chemical parameters by TCT-St. Louis Laboratory in St. Louis, Missouri, in accordance with the analytical methodologies presented in Table 2-2. Core Laboratories in Casper, Wyoming, performed the radiological analyses in accordance with the analytical methodologies presented in Table 2-2.

Chemical analysis consisted of the following:

- TCL organics (VOCs, semivolatiles, pesticides, and PCBs)
- TAL inorganics (metals and cyanide)
- Caffeine, d-limonene, and a-pinene
- Lithium

Radiological analysis consisted of the following:

- Gross alpha and gross beta radiation
- Ra-226 and Ra-228
- U-234, U-235, and U-238
- Th-230 and Th-232

Focused Investigation groundwater samples were also analyzed for chemical parameters by TCT-St. Louis Laboratory in St. Louis, Missouri, in accordance with the analytical methodologies outlined in Table 2-3.

All wells sampled during the Focused Investigation were analyzed for TCL VOCs, TCL semivolatile organics, and TAL metals (total), except as noted in Section 2.7.3.

Samples were to be collected for TCL pesticides analysis from those wells that had pesticide concentrations above state or federal MCLs during RI sampling. These wells included B38W18D, BRMW15, OBMW15, BRMW16, and OBMW11. During Focused Investigation groundwater sampling, however, the sample from well OBMW11 mistakenly was omitted. A sample from well B38W05B was taken in place of the sample that should have been collected from OBMW11.

Groundwater samples for filtered TAL metals analysis were collected from wells that had turbidity measurements greater than 5 NTU, as previously discussed in Section 2.7.2.

Total cyanide analysis was performed on samples from the following wells: B38W12A, B38W12B, OB/BRMW5, OB/BRMW7, OB/BRMW8, BRMW9, and OB/BRMW12. The locations of the wells to be sampled for cyanide were selected by EPA.

2.7.5 QA/QC

QA/QC samples were collected and analyzed to measure the following:

- Internal consistency of the samples
- Cross-contamination sources
- Decontamination efficiency
- Other sources of contamination
- Accuracy, reproducibility, and precision of the laboratory
- Contamination during collection or shipment

QA/QC samples consisted of field duplicate samples, equipment rinse blank samples, MS/MSD samples, and trip blank samples.

- **Field Duplicate Samples.** Field duplicate samples were collected by filling two sets of sample containers simultaneously. The duplicate samples were then analyzed for the same parameters as the corresponding sample. Duplicate samples were not identified as duplicate samples to the laboratory. One field duplicate sample was collected for every 20 or fewer samples.

- **Equipment Rinse Blank Samples.** Equipment rinse blank samples were collected from the decontaminated sampling equipment (stainless steel bailer). They were collected by pouring demonstrated analyte-free water over the inside of the decontaminated sampling equipment and then pouring the rinsate into sample containers, with chemical preservation as needed. The equipment rinse blank samples were analyzed for the same parameters as the corresponding samples. One equipment rinse blank sample was collected for each decontamination event.

- **MS/MSD Samples.** MS/MSD samples were obtained by collecting additional sample volume from randomly selected locations. One MS/MSD sample was collected for each 20 or fewer samples.

- **Trip Blank Samples.** Trip blank samples were prepared by filling three pre-preserved 40-ml vials with demonstrated analyte-free water. The

trip blanks were then carried in the cooler with the VOC samples collected each day. One trip blank sample was collected per day.

2.7.6 Chain-of-Custody

Chain-of-custody was maintained during the groundwater sampling program through the use of traffic report/chain-of-custody forms and chain-of-custody seals. The traffic report/chain-of-custody forms were used to track the samples from the time of collection until analysis by the laboratory. The chain-of-custody seals were used to confirm that the samples had not been tampered with during sample storage or shipment.

Samples were always kept within the view of sampling personnel, or were locked in a secure area (i.e., the field trailer).

2.7.7 Field Screening

Table 2-12 summarizes pH, specific conductance, and temperature measurements collected during groundwater purging. Table 2-13 summarizes the pH, temperature, specific conductance, and turbidity measurements made during Focused Investigation groundwater sampling. The analytical results from both RI and Focused Investigation groundwater sampling are presented in Section 4.4.

2.7.8 Decontamination

Sampling equipment (bailers and pumps) was chemically decontaminated before each use. Lisano Laboratories of West Paterson, New Jersey, decontaminated the bailers using the following series of chemical rinses:

- Alconox and tap water wash
- Tap water rinse
- 10-percent nitric acid rinse
- Deionized water rinse
- Methanol rinse
- Hexane rinse
- Demonstrated analyte-free water rinse

All solvents and acids used for chemical decontamination were of HPLC or pesticide grade. The demonstrated analyte-free water was prepared and analyzed by TCT-St. Louis laboratory.

After the sampling equipment was chemically decontaminated, it was allowed to air dry and was wrapped in aluminum foil until used.

Table 2-12
Summary of Groundwater Field Measurements

Well Location and Property	Date Purged	Water Level (ft.)	Well Depth (ft.)	Well Dia. (inch)	Well Volume (gal.)	Volume Purged (gal.)	pH	Temp (C)	Specific Cond. (umhos/cm)	Color and Turbidity	Remarks
OBMW1	7/29/92	5.74[1]	10	2	0.6	0 = 0	5.77	22.1	1190	Brown / slightly turbid	Sample collected from this well was very turbid.
Sears		6.32[2]				1 = 0.6	6.17	22.2	1190	Yellow / less turbid	
						2 = 1.2	6.12	23.1	1100	Colorless / clear	
						3 = 2.6	6.18	23.2	1090	Colorless / clear	
BRMW1	7/29/92	5.70[1]	47	2	7	0 = 0	6.50	18.4	1390	Colorless / clear	Well went dry after purging 7 gal. Well was allowed to recover.
Sears		6.10[2]				1 = 7	6.77	19.3	1500	Colorless / clear	Pumped well again at a slower rate. Well went dry again after
						2 = 14	7.22	18.5	1600	Colorless / clear	purging 18 gal. Sampled well once it recovered.
						3 = 18	7.39	18.6	1600	Colorless / clear	
OBMW2	7/22/92	6.08[1]	13	2	1.13	0 = 0	6.31	23.3	2230	Slightly cloudy	Chemical odor emitted from groundwater.
Stepan		6.55[2]				1 = 1.5	6.37	21.6	2980	Slightly cloudy	
						2 = 3.0	6.22	21.6	2710	Slightly cloudy	
						3 = 4.5	6.05	21.7	2710	Slightly cloudy	
BRMW2.	7/22/92	9.34[1]	42	2	5.3	0 = 0	6.76	21.7	1650	Colorless / clear	Chemical odor emitted from groundwater.
Stepan		9.76[2]				1 = 5.5	6.78	19.3	1690	Colorless / clear	
						2 = 11.0	6.68	19.4	1510	Colorless / clear	
						3 = 16.5	6.68	19.4	1510	Colorless / clear	
OBMW3	8/3/92	4.98[1]	12	2	1.1	0 = 0	6.56	23.5	810	Gray-brown / turbid	
Gulf		5.31[2]				1 = 1.2	6.50	23.2	800	Gray-brown / slightly turbid	
						2 = 2.4	6.70	23.9	850	Gray-brown / slightly turbid	
						3 = 3.6	6.87	23.3	800	Gray-brown / slightly turbid	
BRMW3	8/3/92	4.44[1]	30	2	4.12	0 = 0	6.86	19.8	450	Clear	
Gulf		4.71[2]	30.13[1]			1 = 4.2	7.22	19.7	450	Colorless / clear	
						2 = 8.4	7.36	18.8	410	Colorless / clear	
						3 = 12.6	7.43	18.6	410	Colorless / clear	
OBMW4	7/22/92	3.32[1]	14	2	1.74	0 =0	6.30	17.1	1820	Lt. brown / turbid	Hydrogen sulfide odor emitted from groundwater.
Sears		3.72[2]				1 = 1.75	6.70	16.7	1650	Clear / sl. turbid	
						2 = 3.5	6.84	16.2	1700	Lt. black / turbid	
						3 = 5.25	6.99	16.6	1800	Lt. black / turbid	
BRMW4	7/22/92	3.36[1]	36	2	5.32	0 = 0	6.86	15.9	600	Clear	Well went dry prior to purging the third well volume.
Sears		3.70[2]				1 = 5.5	7.17	16.2	600	Clear	
						2 = 11	7.29	16.7	580	Clear / slightly cloudy	
OBMW5	8/3/92	4.88[1]	9.58[1]	2	0.83	0 = 0	6.51	25.1	1500	Light brown / turbid	Oily film observed on purge water from this well.
Sunoco		4.58[2]	9.88[2]			1 = 1.2	6.50	23.8	1490	Light brown / less turbid	
						2 = 2.5	6.55	23.6	1390	Light brown / less turbid	
						3 = 4	6.49	24.5	1390	Lt. brown / slightly turbid	
BRMW5	8/3/92	4.46[1]	29	2	4	0 = 0	6.82	20.4	1000	SL red-brown / turbid	
Sunoco		4.90[2]	29.8[2]			1 = 4	6.76	19.7	950	Clear / slightly turbid	
						2 = 8	6.80	18.4	910	Clear / slightly turbid	
						3 = 12	6.78	18.2	950	Clear / slightly turbid	
OBMW6	7/29/92	4.76[1]	8	2	0.46	0 = 0	6.43	25.4	800	Clear	Well started to go dry after three well volumes were removed,
Sears		5.02[2]	8.22[2]			1 = 0.5	6.63	21.5	650	Clear	but recovered quickly. Well went dry again, after VOC and
						2 = 1.0	6.81	19.8	640	Clear	semivolatile samples were collected.
						3 = 1.5	6.77	20.6	600	Clear	
BRMW6	7/29/92	4.94[1]	27	2	3.51	0 = 0	6.82	19.6	510	Clear	
Sears		5.44[2]	24.4[2]			1 = 3.5	6.95	19.0	510	Clear	
						2 = 7.0	6.93	19.2	580	Clear	
						3 = 10.5	6.92	18.2	580	Clear	

Table 2-12
Summary of Groundwater Field Measurements

Well Location and Property	Date Purged	Water Level (ft.)	Well Depth (ft.)	Well Dia. (inch)	Well Volume (gal.)	Volume Purged (gal.)	pH	Temp (C)	Specific Cond. (umhos/cm)	Color and Turbidity	Remarks
OBMW7 Sears	7/30/92	3.12[1]	15[1] 15.68[2]	2	1.9	0 = 0	6.12	16.3	1050	Brown / very turbid	
						1 = 2	7.20	16.0	750	Brown / very turbid	
						2 = 4	7.11	15.7	750	Brown / very turbid	
						3 = 6	7.09	15.7	720	Light brown / very turbid	
BRMW7 Sears	7/30/92	3	37	2	5.5	0 = 0	9.76	17.9	550	Clear	Well went dry after 5.5 gal.were removed. Well recovered but went dry again after 2 more gals. were removed. Well went dry again after 13 gal. were removed. Once well recovered sample was collected.
						1 = 5.5	10.32	20.4	590	Clear	
						2 = 11.0	11.67	16.4	950	Clear	
OBMW8 SWS	8/3/92	5.62[1] 5.87[2]	12.5 12.22[2]	2	1.035	0 = 0	5.44	20.3	451	Yellow-brown / turbid	The pH reading did not stabilize during the measurement of the first well volume.
						1 = 1.25	5.62	19.3	451	Brown / very turbid	
						2 = 2.5	5.66	18.9	451	Brown / very turbid	
						3 = 3.75	5.93	18.8	470	Brown / very turbid	
BRMW8 SWS	8/3/92	5.46[1] 5.99[2]	42	2	5.87	0 = 0	5.73	17.9	750	Clear	Collected duplicate sample (BRMW8D).
						1 = 6	6.04	17.8	750	Clear	
						2 = 12	6.20	17.7	750	Clear	
						3 = 18	6.38	18.0	750	Clear	
BRMW9 Federal Express	7/31/92	16.50[1] 16.80[2]	24.32[1] 24.64[2]	2	1.3	0 = 0	6.86	22.7	1090	Brown / turbid	
						1 = 1.3	7.28	16.7	620	Colorless / clear	
						2 = 2.6	7.24	16.7	520	Colorless / clear	
						3 = 4.5	7.24	16.4	500	Colorless / clear	
OBMW10 Sears	7/30/92	0.44	7.82	2	1.2	0 = 0	7.65	24.3	750	Slightly brown / cloudy	Well went dry after third volume was purged. Collected samples for VOCs only. On 7/31/92 collected the samples for the remaining analytical parameters.
						1 = 1.5	9.80	25.9	500	Slightly brown / cloudy	
						2 = 3.0	7.59	27.3	800	Slightly brown / cloudy	
						3 = 4.2	7.75	27.2	1200	Brown / turbid	
BRMW10 Stepan	7/28/92	8.16[1] 8.58[2]	40	2	5.2	0 = 0	6.76	20.8	700	Whitish / cloudy	
						1 = 5.5	6.80	19.0	610	Whitish / cloudy	
						2 = 11.0	6.95	18.9	650	Whitish / clear	
						3 = 16.5	7.00	18.7	625	Whitish / clear	
OBMW11 Sears	7/21/92	3.38	10	2	1.1	0 = 0	6.16	21.8	1050	Org. brown / very turbid	
						1 = 1.1	6.83	20.1	730	Lt. brown / sl. turbid	
						2 = 2.2	6.77	18.7	710	Org.-red-brown / turbid	
						3 = 3.3	6.84	18.9	730	Org.-red-brown / turbid	
						4 = 4.5	6.58	21.0	730	Org.-red-brown / turbid	
BRMW11 Sears	7/21/92	3.75	33	2	4.8	0 = 0	6.86	18.7	460	Colorless / clear	
						1 = 4.8	6.83	17.1	510	Colorless / clear	
						2 = 9.6	6.84	16.8	510	Colorless / clear	
						3 = 14.4	6.91	16.9	510	Colorless / clear	
OBMW12 Federal Express	7/31/92	7.38[1] 7.70[2]	15	2	1.2	0 = 0	6.45	19.0	700	Light brown / cloudy	
						1 = 1.25	6.23	19.0	600	Clear	
						2 = 2.5	6.31	18.9	600	Clear / slightly cloudy	
						3 = 4.0	6.42	18.9	650	Brown / cloudy	
BRMW12 Federal Express	7/31/92	6.04[1] 6.60[2]	48	2	6.74	0 = 0	6.45	18.5	400	Clear	
						1 = 7	6.57	17.2	400	Clear	
						2 = 14	6.62	16.6	400	Clear	
						3 = 21	6.72	16.2	400	Clear	

Table 2-12
Summary of Groundwater Field Measurements

Well Location and Property	Date Purged	Water Level (ft.)	Well Depth (ft.)	Well Dia. (inch)	Well Volume (gal.)	Volume Purged (gal.)	pH	Temp (C)	Specific Cond. (umhos/cm)	Color and Turbidity	Remarks
OBMW13 Sears	7/22/92	4.44[1] 4.90[2]	14	2	1.56	0 = 0 1 = 2 2 = 4 3 = 6 4 = 8	6.78 6.76 6.78 6.81 6.82	22.3 21.6 21.7 20.0 20.3	2000 1950 1890 1700 1700	Red brown / turbid Red brown / turbid Red brown / turbid Red brown / less turbid Red brown / less turbid	Chemical odor emitted from well during sampling (3.1 ppm measured with PID in well headspace). A fourth well volume was purged, due to temperature readings not stabilizing. A duplicate sample was taken (OBMW13D).
BRMW13 Sears	7/22/92	4.42[1] 4.90[2]	33	2	4.66	0 = 0 1 = 5 2 = 10 3 = 15	7.29 7.33 7.20 7.05	19.5 18.4 19.3 18.4	490 510 620 640	Colorless / clear Colorless / clear Colorless / clear Colorless / clear	The temperature from the third well volume may be erroneous, due to problems with the meter.
OBMW14 Sears	7/29/92	3.39[1] 3.90[2]	14	2	1.64	0 = 0 1 = 2 2 = 3.5 3 = 5	6.49 6.86 6.81 7.09	25.6 24.5 24.2 24.3	1890 1880 1950 1950	Pale yellow / clear Pale yellow / clear Pale yellow / clear Pale yellow / clear	Duplicate sample was taken for radionuclides only (OBMW14D).
BRMW14 Sears	7/29/92	3.45[1] 3.82[2]	33 37[1]	2	4.75	0 = 0 1 = 4.75 2 = 9.50	7.32 7.52 7.72	20.8 21.4 20.1	600 600 610	Colorless / clear Colorless / clear Colorless / clear	Well purged dry after second well volume. Only samples for VOC could be collected on 7/29/92. Sampling for other analytical parameters was completed 7/30/92. Samples collected 7/30/92 were light brown in color and turbid.
OBMW15 Stepan	7/22/92	15.18[1] 15.44[2]	17	2	0.7	0 = 0 1 = 1 2 = 2 3 = 3	5.76 6.25 6.63 6.89	18.6 15.7 15.7 16.5	440 440 440 440	Colorless / clear Colorless / clear Colorless / clear Colorless / clear	Well went dry after third volume was removed. Well was slow to recover. Only samples for VOC analysis could be taken on 7/22/92. Collected samples for other parameters on 7/23/92. During purging a chemical odor was noticed. Samples from this well were gray/black in color with oily film on surface.
BRMW15 Stepan	7/22/92	14.49[1] 14.72[2]	30	2	2.77	0 = 0 1 = 3 2 = 6 3 = 9	5.63 5.93 5.89 6.17	17.8 15.5 15.5 15.5	400 380 380 390	Colorless / clear Colorless / clear Colorless / clear Colorless / clear	
BRMW16 Stepan	7/27/92	11.93[1] 12.49[2]	30	2	3.1	0 = 0 1 = 3.5 2 = 7.0 3 = 10.5	6.75 6.73 6.69 6.65	19.6 16.4 16.2 16.2	810 690 680 680	Tan / slightly turbid Lt. tan – gray / less turbid Colorless / clear Colorless / clear	
OBMW17 Stepan	7/23/92	8.5	15	2	1.39	0 = 0 1 = 1.5 2 = 3.0 3 = 4.5	5.83 5.82 6.05 6.00	19.3 19.0 18.9 19.0	455 270 300 300	Brown / very turbid Brown / slightly turbid Brown / slightly turbid Slightly brown / sl. turbid	Samples from this well were very turbid.
BRMW17 Stepan	7/23/92	7.72	35[3]	2	5.45	0 = 0 1 = 5.5 2 = 11 3 = 16.5	5.90 5.99 6.27 6.05	16.8 16.6 16.3 16.4	400 390 390 400	Clear Clear Clear Clear	
WELL 1 Stepan	7/28/92	8.77[1] 8.99[2]	14.84[1] 15.05[2]	2	0.99	0 = 0 1 = 1 2 = 2 3 = 3	6.72 6.85 6.86 6.99	20.0 20.7 20.0 19.8	600 650 610 600	Brown / turbid Brown / turbid Brown / turbid Brown / turbid	Collected duplicate sample (Well 1D) for all analytical parameters, except radionuclides.
WELL 2 Stepan	7/28/92	10.18	18.74	2	1.4	0 = 0 1 = 2 2 = 3 3 = 4.5	6.82 6.84 6.84 6.92	23.6 20.3 19.5 20.0	1950 1350 1350 1350	Cloudy / Turbid Slightly cloudy Slightly cloudy Slightly cloudy	Samples from this well were very turbid and black in color, with hydrogen sulfide odor.

Table 2-12
Summary of Groundwater Field Measurements

Well Location and Property	Date Purged	Water Level (ft.)	Well Depth (ft.)	Well Dia. (inch)	Well Volume (gal.)	Volume Purged (gal.)	pH	Temp (C)	Specific Cond. (umhos/cm)	Color and Turbidity	Remarks
WELL 5 Stepan	7/27/92	6.22[1] 6.53[2]	10.14[1]	2	0.6	0 = 0 1 = 0.75 2 = 1.5 3 = 2.25	6.43 6.42 6.47 6.61	23.1 20.9 20.7 20.5	910 1010 1010 1010	Brown / turbid Lt. brown / slightly turbid Brown tint / slightly turbid Clear	Samples from this well were very turbid and brownish/orange in color.
WELL 8 Stepan	7/23/92	14.7	17	2	0.72	0 = 0 1 = 0.75 2 = 1.5	7.09 6.42 DRY	19.0 18.3	700 550	Red-brown / slightly turbid Clear	Well went dry after removing the second well volume. Well recovered 0.2 ft. in 4 hours. Collected samples for VOC analysis 7/24/92, collected samples for semivolatile analysis on 7/27/92 and 7/28/92, collected samples for metals analysis 7/29/92 and 7/31/92. Attempt to collect samples for radionuclide analysis on 7/31/92 but only obtained 25 mL. Did not collect radionuclide sample due to insufficient sample volume. Collected sample for cyanide analysis on 8/5/92.
B38WO1S Railroad	7/28/92	6.64[1] 6.64[2]	25.98[2]	2	3.15	0 = 0 1 = 3.25 2 = 6.50 3 = 9.75	6.38 6.46 6.55 6.63	14.3 14.0 13.2 13.0	2110 1900 1800 1800	Colorless / clear Colorless / clear Colorless / clear Colorless / clear	Water column was stirred up by bailer, resulting in some sediment in samples.
B38WO2D Railroad	7/28/92	19.4[1] 19.9[2]	45.56[2]	2	4.18	0 = 0 1 = 4.5 2 = 9.0 3 = 13.5	6.93 6.67 6.66 6.76	13.8 13.0 13.7 14.3	395 371 370 371	Org.-brown / very turbid Pale org.-brn. / slightly turbid Pale org.-brn. / slightly turbid Pale org.-brn. / slightly turbid	
B38WO3B Stepan	7/27/92	10.66[1] 11.44[2]	42.9[2]	2	5.13	0 = 1 1 = 5.5 2 = 11.0 3 = 16.5	6.60 6.49 6.40 6.35	17.9 16.5 15.2 15.5	1800 2010 2100 2100	Colorless / clear Colorless / clear Colorless / clear Colorless / clear	On 7/23/92 noticed household insecticide odor coming from inside protective steel well cap. Appeared that someone had sprayed insecticide inside well cap.
B38WO4B Stepan	7/27/92	11.44[1] 12.10[2]	36	2	4.43	0 = 0 1 = 5 2 = 10 3 = 15	6.60 6.64 6.65 6.68	25.5 18.9 18.8 18.6	1350 650 790 750	Clear Pale gray / clear Pale gray / clear Pale gray / clear	Small black particles in groundwater from this well. Groundwater appeared black/gray in color and had a chemical odor.
B38WO5B Stepan	7/23/92	14.74	44.5	2	5.4	0 = 0 1 = 5.5 2 = 11.0 3=16.5	6.02 6.21 6.23	16.2 14.8 14.7	395 390 390	Sl. red-brown / sl. turbid Clear, slightly cloudy Clear	Parameters inadvertently were not recorded for the third well volume.
B38WO6B Stepan	7/28/92	10.60[1] 11.06[2]	39.01[1] 39.42[2]	2	4.6	0 = 0 1 = 5 2 = 10 3 = 15	6.55 6.59 6.60 6.60	18.6 17.4 17.6 17.8	1090 1010 1010 1090	Colorless / clear Colorless / clear Colorless / clear Colorless / clear	The water level rose for a few minutes after being uncapped. Groundwater had a chemical odor.
B38W7B Stepan Amended	7/24/92	10.04[1] 10.26[2]	39.2[1]	2	5.11	0 = 0 1 = 5.1 2 = 10.2 3 = 15.3 4 = 20.4	6.53 6.74 6.88 6.94 6.97	17.3 14.2 14.7 13.6 13.7	300 367 379 380 372	Clear Colorless / clear Colorless / clear Colorless / clear Colorless / clear	Small rust colored particles were present in groundwater. Removed a fourth well volume due to temperature not stablizing.
B38W12A DeSaussure	7/30/92	7.66[1] 7.98[2]	17.74[1] 18.04[2]	2	1.64	0 = 0 1 = 1.75 2 = 2.50 3 = 4.25	8.40 8.05 6.74 6.74	19.5 15.5 15.3 15.4	1900 1600 1590 1600	Clear / slightly turbid Clear / slightly turbid Clear / slightly turbid Clear / slightly turbid	Problem with pH meter for initial and first well volume measurements. A new pH meter was used for second and third well volume measurements.

Table 2-12
Summary of Groundwater Field Measurements

Well Location and Property	Date Purged	Water Level (ft.)	Well Depth (ft.)	Well Dia. (inch)	Well Volume (gal.)	Volume Purged (gal.)	pH	Temp (C)	Specific Cond. (umhos/cm)	Color and Turbidity	Remarks
B38W12B DeSaussure	7/30/92	7.07[1] 7.87[2]	52.32[1] 52.90[2]	2	7.5	0 = 0 1 = 7.5 2 = 15.0 3 = 22.5	7.36 7.45 7.38 7.42	15.7 10.5 16.1 15.1	500 490 500 500	Clear Clear Clear Clear	
B38W18D Stepan	7/23/92	6.67[1]	41	4	23.8	0=0 1 = 25 2 = 50 3 = 75 4 = 80	5.62 5.90 5.94 5.98 5.99	17.0 16.0 16.0 15.5 15.4	500 625 525 650 650	Clear Clear Clear Clear Clear	A fourth well volume was purged due to conductivity fluctuation between second and third well volumes.
MISS 4A Stepan Amended	7/24/92	9.23[1] 9.32[2]	10	2	0.42	0 = 0 1 = 0.5	5.73 5.71	16.7 16.3	1010 900	Light brown / slightly turbid Colorless / clear	Well went dry after approx. 0.9 gallons were removed. Collected a sample for VOC analysis and half the sample volume required for semivolatile analysis on 7/24/92. Collected the samples for metals, cyanide, and radionuclide analysis on 7/27/92. On 7/28/92 collected the remaining sample volume for semivolatiles at laboratory's request.
MISS 4B Stepan Amended	7/24/92	11.3[2]	47[3]	4	24.16	0 = 0 1 = 25 2 = 50 3 = 75	6.06 6.11 6.48 6.62	15.6 14.1 14.0 14.2	1000 1090 1000 1050	Colorless / clear Colorless / clear Colorless / clear Colorless / clear	Groundwater from this well had a chemical odor.

[1] Measured from top of inner casing.
[2] Measured from top of outer casing.
[3] Measured from ground surface.

NOTE:
If datum for well depth is not specified, the given well depth was not measured, but was obtained from the boring logs for the well.

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Table 2-13
Summary of Focused Investigation Groundwater Field Measurements

Well Location and Property	Date Purged	Water Level (ft.)	Well Depth (ft.)	Well Dia. (inch)	Well Volume (gal.)	Volume Purged (gal.)	pH	Temp (C)	Specific Cond. (umhos/cm)	Turbidity (NTU's)	Color	Remarks
OBMW1 Sears	7/27/93	6.85	10	2	0.51	0 = 0	6.22	29.0	1450	25.9	Slightly yellow	Filtered metals were collected.
						1 = 0.8	6.79	27.6	1500	18.3	Colorless	
						2 = 1.3	6.46	27.2	1450	18.4	Colorless	
						3 = 2.2	7.44	27.3	1550	106.6	Tan	
						4 = 2.8	6.39	26.7	1600	>200	Tan	
BRMW1 Sears	7/27/93	7.06	47.35	2	6.57	0 = 0	6.60	22.4	2200	27	Slightly yellow	Well went dry after purging 15 gal. Returned 7/28/93 to sample well. Filtered metals collected.
						1 = 6.6	7.15	22.4	2000	12.9	Colorless	
						2 = 13.2	7.12	22.3	2350	23.7	Colorless	
OBMW2 Stepan	7/20/93	6.08'	13	2	(est.) 1.5	0 = 0	6.69	21.7	3050	117	Gray	Chemical odor emitted from groundwater. 4th and 5th volumes taken due to fluctuation in specific conductivity. Filtered metals collected.
						1 = 1.5	6.69	27.2	2800	29.2	Gray	
						2 = 3.0	6.29	24.1	2650	17.4	Colorless	
						3 = 4.5	6.20	23.1	2000	15.6	Gray	
						4 = 6.0	6.25	24.5	2650	12.1	Gray	
						5 = 7.5	6.27	24.9	2700	19.4	Gray/clear	
BRMW2 Stepan	7/20/93	10.15	42	2	5.2	0 = 0	6.83	20.7	1650	9.4	Colorless	Chemical odor emitted from groundwater.
						1 = 5.2	6.93	20.1	1400	0.9	Colorless	
						2 = 10.4	6.76	20.0	1300	0.6	Colorless	
						3 = 15.6	7.02	19.9	1300	0.3	Colorless	
OBMW3 Gulf	8/2/93	6	12.17	2	1	0 = 0	7.21	25.8	700	40.6	Light-brown	Filtered metals collected.
						1 = 1	7.22	24.9	700	8.3	Light-brown	
						2 = 2	7.26	25.2	700	13.2	Colorless	
						3 = 3	7.31	25.4	690	56.7	Light-brown	
BRMW3 Gulf	8/2/93	5.5	30.13	2	4	0 = 0	7.55	25.4	750	33.6	Light gray/light tan	
						1 = 4	7.75	22.2	550	8.37	Colorless	
						2 = 8	7.59	21.9	500	3.65	Colorless	
						3 = 12	7.40	21.5	500	2.2	Colorless	
OBMW4 Sears	7/29/93	4.39	14	2	1.6	0 =0	6.81	20.8	1450	52.6	Gray/black particles	Filtered metals collected.
						1 = 1.6	7.38	18.3	1450	119.4	Gray/black particles	
						2 = 3.2	6.98	17.8	1350	106	Gray/black particles	
BRMW4 Sears	7/29/93	4.63	36	2	5.1	0 = 0	7.56	18.9	500	57.6	Green tint	Well went dry after purging 10.5 gallons. Filtered metals collected.
						1 = 5.25	9.37	16.3	300	34	colorless	
						2 = 10.5	7.39	18.1	500	53	colorless	
OBMW5 Sunoco	8/2/93	5.65	9.58	2	0.64	0 = 0	6.30	26.3	1900	152.1	Light brown	Filtered metals collected.
						1 = 1	6.30	24.8	1800	177	Light brown/black flakes	
						2 = 2	6.38	24.4	1900	33.7	Light brown	
						3 = 3	6.49	25.2	1950	66.2	Light brown	
BRMW5 Sunoco	8/2/93	5.65	29	2	3.8	0 = 0	6.40	24.3	1100	>200	Brown	
						1 = 4	6.54	21.2	1000	14	Colorless	
						2 = 8	6.59	20.5	1100	2.7	Colorless	
						3 = 12	6.89	20.9	1050	1.5	Colorless	
OBMW6 Sears	7/26/93	6.15	8	2	0.3	0 = 0	6.25	20.8	630	29.6	Yellowish	Well went dry before first well volume was removed. Filtered metals collected.
BRMW6 Sears	7/26/93	6.3	27	2	3.4	0 = 0	6.07	20.3	500	81	Colorless	
						1 = 3	6.16	18.2	600	6.4	Colorless	
						2 = 6	6.81	19.1	590	10.4	Colorless	
						3 = 9	7.09	19.3	670	2	Colorless	
						4 = 12	7.19	19.7	670	0.9	Colorless	

Table 2-13
Summary of Focused Investigation Groundwater Field Measurements

Well Location and Property	Date Purged	Water Level (ft.)	Well Depth (ft.)	Well Dia. (inch)	Well Volume (gal.)	Volume Purged (gal.)	pH	Temp (C)	Specific Cond. (umhos/cm)	Turbidity (NTU's)	Color	Remarks
OBMW7 Sears	7/30/93	4.22	15	2	1.75	0 = 0	7.09	23.5	1100	>200	Brown	Filtered metals collected
						1 = 3	7.30	24.7	1000	56	Slightly yellow	
						2 = 4.7	7.27	24.1	1010	20.7	Pale yellow	
						3 = 7	6.99	24.6	1000	178	Brown	
BRMW7 Sears	7/30/93	4.02	37	2	5.5	0 = 0	10.10	20.1	500	4.26	Colorless	Well went dry after 12 gallons were removed.
						1 = 5.5	10.70	19.9	500	3.73	Colorless	Filtered metals collected
						2 = 11.0	8.60	18.1	470	9.67	Colorless	
OBMW8 SWS	8/3/93	7.05	12.5	2	0.9	0 = 0	6.10	21.9	890	>200	Brown/tan	Filtered metals collected.
						1 = 1	6.29	20.5	900	>200	Brown	
						2 = 2	6.21	19.9	850	>200	Brown	
						3 = 3	6.46	20.4	1200	45.1	Light brown	
						4 = 4	6.50	20.8	1175	88.8	Light brown	
BRMW8 SWS	8/3/93	6.75	42.32	2	5.8	0 = 0	6.50	23.3	900	8.56	Colorless	
						1 = 6	6.53	19.5	950	2.46	Colorless	
						2 = 12	6.54	20.9	950	1.3	Colorless	
						3 = 18	6.77	20.3	950	1.55	Colorless	
BRMW9 Federal Express	8/3/93	17.8	24.32	2	1.06	0 = 0	6.92	23.0	1450	>200	Orange	Filtered metals collected.
						1 = 1	7.07	20.6	1250	119	Tan	
						2 = 2	7.19	19.3	1010	>200	Tan	
						3 = 3	7.11	17.5	900	>200	Tan	
						4 = 4	7.18	18.2	750	>200	Tan	
						5 = 5	7.21	18.9	600	-	Tan	
OBMW10 Sears	7/28/93	2.73	7.82	2	0.83	0 = 0	7.40	29.5	1550	35.2	Yellowish	Well went dry after third volume was purged. 7/18/93 collected samples for total and filtered metals only. 7/29/93 collect radionuclides for BNI. 7/30/93 collect samples for VOC's and and semivolatiles.
						1 = 0.9	7.40	28.1	1400	20.1	Yellowish	
						2 = 1.8	7.30	28.0	1300	21.3	Yellowish	
						3 = 2.5	7.20	27.7	1450	101.7	Yellowish	
BRMW10 Stepan	7/21/93	8.95	40	2	5.1	0 = 0	6.43	20.3	900	32.1	Colorless	
						1 = 5.1	6.75	18.4	700	2.3	Colorless	
						2 = 10.2	6.95	18.3	650	2.58	Colorless	
						3 = 15.3	6.98	18.3	700	0.6	Colorless	
OBMW11 Sears	7/28/93	4.45	10	2	0.725	0 = 0	6.43	21.3	750	35	Brown particals	Filtered metals collected.
						1 = 0.75	6.52	20.2	600	>200	Brown particals	
						2 = 1.5	6.73	21.5	800	>200	Brown particals	
						3 = 2.3	6.96	20.9	650	>200	Brown particals	
						4 = 3	7.00	23.4	700	90.7	Clearing	
						5 = 3.7	7.30	20.6	680	53.2	Clearing	
BRMW11 Sears	7/28/93	5.08	33	2	4.55	0 = 0	6.05	20.2	500	0.83	Colorless	
						1 = 5	7.35	17.0	500	0.49	Colorless	
						2 = 10	7.26	18.5	580	0.37	Colorless	
						3 = 15	7.31	18.8	510	0.52	Colorless	
OBMW12 Federal Express	8/2/93	8.67	15	2	1.03	0 = 0	6.99	24.6	900	1.19	Colorless	Filtered metals collected.
						1 = 1	6.52	22.6	850	130.9	Tan	
						2 = 2	6.91	19.6	800	111.6	Tan	
						3 = 3.1	6.76	19.5	850	184.9	Tan	

Table 2-13
Summary of Focused Investigation Groundwater Field Measurements

Well Location and Property	Date Purged	Water Level (ft.)	Well Depth (ft.)	Well Dia. (inch)	Well Volume (gal.)	Volume Purged (gal.)	pH	Temp (C)	Specific Cond. (umhos/cm)	Turbidity (NTU's)	Color	Remarks
BRMW12 Federal Express	8/2/93	7.37	48	2	6.6	0 = 0	–	28.2	650	10.6	Colorless	pH inadvertently not recorded for initial volume. Fourth volume removed due to temperature fluctuation after third well volume.
						1 = 9	7.26	21.0	500	5.2	Colorless	
						2 = 14	6.93	20.1	500	2	Colorless	
						3 = 21	7.22	18.4	520	1.9	Colorless	
						4 = 28	7.23	19.3	500	1.2	Colorless	
OBMW13 Sears	7/27/93	5.25	14	2	1.43	0 = 0	7.32	23.1	1510	–	Yellowish/brown	A fourth well volume was removed due to temperature fluctuation after third well volume. Filtered metals collected. Turbidity inadvertently not recorded for initial volume.
						1 = 1.8	6.66	21.2	1590	94.5	Yellowish/brown	
						2 = 3	6.81	21.0	1510	98.7	Yellowish/brown	
						3 = 5	6.81	22.4	1500	77.9	Yellowish/brown	
						4 = 6.5	6.72	21.5	1550	66	Yellowish/brown	
BRMW13 Sears	7/27/93	5.26	33	2	4.5	0 = 0	7.31	22.6	550	41.8	Yellowish	
						1 = 5	7.28	20.4	500	8.84	Slightly yellow	
						2 = 10	7.25	20.4	500	3	Colorless	
						3 = 15	7.33	20.4	550	1	Colorless	
OBMW14 Sears	7/26/93	4.43	14	2	1.6	0 = 0	6.72	24.7	2400	5.7	Yellow	Conductivity did not stabilize between 2nd and 3rd volume. All other parameters O.K. Will not purge another volume.
						1 = 2	7.02	25.0	1850	4.8	Rust color	
						2 = 3.2	6.88	24.7	2090	6	Rust color	
						3 = 4.8	7.17	24.3	2310	4.5	Rust color	
BRMW14 Sears	7/26/93	4.45	33	2	4.7	0 = 0	6.47	28.4	550	16.7	Pale yellow	7/26/93 the pump malfunctioned after the first volume. Came back 7/27/93 to repurge well. Well went dry after 5 gal. were removed. Sampled well on 7/29/93 due to well not recovering. Filtered metals collected.
						1 = 4.7	7.75	23.8	700	–	Pale yellow	
	7/27/93	21.78			* 4.7	0 = 0	6.86	20.3	650	41.9	Pale yellow	
						1 = 5.0	7.12	19.6	650	19	Pale yellow	
OBMW15 Stepan	7/19/93	16.76	20.1	2	0.54	0 = 0	6.70	16.9	440	113	Rusty	
						1 = 0.6	6.78	16.0	430	5.48	Colorless	
						2 = 1.2	6.86	16.0	435	6.48	Colorless	
						3 = 1.8	7.03	16.0	440	3.25	Colorless	
BRMW15 Stepan	7/19/93	16.08	31	2	2.43	0 = 0	6.30	22.3	440	>200	Rust color	Turbidity meter sample bottle steaming up do to high humidity. Sample is very clear, did not collect for filtered metals.
						1 = 2.5	6.70	19.9	420	83	Colorless	
						2 = 5	6.80	19.5	435	41.4	Colorless	
						3 = 7.5	6.80	19.5	410	11.9	Colorless	
BRMW16 Stepan	7/20/93	13.02	30	2	3.1	0 = 0	6.27	19.4	950	>200	Rusty	7/23/93 collect pesticide sample, which was not collected on 7/20/93 after purging 3 well volumes. No parameters taken.
						1 = 2.93	6.52	19.6	900	30.2	Colorless	
						2 = 5.86	6.73	19.4	850	9.7	Colorless	
						3 = 8.79	6.81	19.5	850	3.1	Colorless	
OBMW17 Stepan	7/23/93	9.5	15	2	0.9	0 = 0	6.68	21.4	475	32.7	Colorless	Filtered metals collected.
						1 = 0.9	7.30	21.5	330	26.6	Colorless	
						2 = 2.1	6.65	21.2	335	23.5	Colorless	
						3 = 4	6.61	21.5	351	22.3	Colorless	
BRMW17 Stepan	7/23/93	9.05	35	2	4.5	0 = 0	–	–	490	9.9	Colorless	pH and temperature inadvertently not recorded for initial reading.
						1 = 4.5	7.03	20.4	500	2	Colorless	
						2 = 9	6.80	20.0	470	3.19	Colorless	
						3 = 13.5	6.75	19.0	452	2.2	Colorless	
WELL 1 Stepan	7/21/93	9.64	14.84	2	0.847	0 = 0	6.91	19.1	700	>200	Brown	Filtered metals collected.
						1 = 1	7.00	18.0	700	19.6	Colorless	
						2 = 2	7.17	18.5	720	20.4	Light brown	
						3 = 3	7.24	18.4	720	31.4	Light brown	

Table 2-13
Summary of Focused Investigation Groundwater Field Measurements

Well Location and Property	Date Purged	Water Level (ft.)	Well Depth (ft.)	Well Dia. (inch)	Well Volume (gal.)	Volume Purged (gal.)	pH	Temp (C)	Specific Cond. (umhos/cm)	Turbidity (NTU's)	Color	Remarks
WELL 2 Stepan	7/21/93	11.15	18.74	2	1.24	0 = 0	7.19	21.5	1490	>200	Gray/brown	Filtered metals collected.
						1 = 1.25	7.00	19.1	1390	12.2	Yellow tint	
						2 = 2.5	7.13	19.5	1350	18.9	Yellow tint	
						3 = 3.75	7.14	20.8	1300	14.44	Green/yellow	
WELL 5 Stepan	7/20/93	7.32	10.14	2	0.5	0 = 0	6.26	24.5	850	9.93	Colorless	
						1 = 0.5	6.45	21.7	1050	5.89	Colorless	
						2 = 1	6.58	21.1	1100	3.02	Colorless	
						3 = 1.5	6.63	20.6	1100	1.36	Colorless	
WELL 8 Stepan	7/19/93	14.82	19.1	2	0.93	0 = 0	–	20.0	900	–	Colorless	Well went dry after removing one well volume. On 7/21/93 observed worker spraying herbicide around the area of the well. 7/22/93 collect samples for VOC analysis. 7/26/93 collect sample for metal analysis. 8/2/93 collect partial sample for semi-volatile analysis before well went dry.
						1 = 1	–	21.0	860	–	Light tan	
B38WO3B Stepan	7/21/93	11.91	42.9	2	5.25	0 = 0	7.28	21.1	1900	22.5	Colorless	Slight organic odor to purge water. Turbidity reading inadvertently not recorded for the third well volume. Filtered metals collected.
						1 = 5.5	7.27	17.3	1900	12.7	Colorless	
						2 = 10.75	7.15	17.5	1950	8.3	Colorless	
						3 = 16	7.14	17.9	2000	–	Colorless	
B38WO4B Stepan	7/29/93	13.95	36	2	3.75	0 = 0	7.10	23.5	1050	30.3	Gray	Oily sheen on the purge water. Filtered metals collected.
						1 = 3.75	7.00	21.8	1050	17.08	Gray	
						2 = 7.5	7.00	19.8	1000	26.5	Gray	
						3 = 11.25	7.00	18.8	900	16.29	Yellow/gray	
B38WO5B Stepan	7/19/93	15.85	44.5	2	5	0 = 0	6.83	20.0	420	24.9	Colorless	
						1 = 5	6.89	17.0	430	5.5	Colorless	
						2 = 10	7.05	16.0	405	1.54	Colorless	
						3 = 15	7.05	15.5	425	1.21	Colorless	
B38WO6B Stepan	7/20/93	11.49	39.01	2	4.48	0 = 0	6.23	24.4	1190	14	Colorless	The high turbidity readings may be do to foam and bubbles in the sample, not sediment in sample.
						1 = 4.5	6.67	21.7	1150	14.4	Colorless	
						2 = 9	6.70	20.3	1050	12	Colorless	
						3 = 13.5	6.68	20.2	1000	40	Colorless	
B38W7B Stepan Amended	7/23/93	11.05	39.2	2	4.6	0 = 0	7.12	20.4	500	140.4	Tan	
						1 = 5	7.41	17.1	450	4.11	Colorless	
						2 = 9.5	7.57	16.2	500	1.28	Colorless	
						3 = 14	7.66	15.8	490	1.06	Colorless	
B38W12A DeSaussure	7/30/93	8.73	17.74	2	1.46	0 = 0	6.50	23.4	2000	19.3	Yellow tint	
						1 = 1.5	6.60	18.3	2000	20.7	Yellow tint	
						2 = 3	7.20	19.1	1900	15.5	Colorless	
						3 = 4.5	6.70	18.4	1950	4.67	Colorless	
B38W12B DeSaussure	7/30/93	8.12	52.32	2	7.5	0 = 0	7.36	18.6	510	31.8	Colorless	Filtered metals collected.
						1 = 7.5	6.68	16.8	510	32.8	Colorless	
						2 = 15.0	6.92	16.7	510	16	Colorless	
						3 = 22.5	7.44	17.6	550	6.6	Colorless	
MISS 4A Stepan Amended	7/22/93	11.6	11.88	2	0.05	0 = 0						Only 0.28 feet of water in well. Considered well dry and will not sample.

Table 2-13
Summary of Focused Investigation Groundwater Field Measurements

Well Location and Property	Date Purged	Water Level (ft.)	Well Depth (ft.)	Well Dia. (inch)	Well Volume (gal.)	Volume Purged (gal.)	pH	Temp (C)	Specific Cond. (umhos/cm)	Turbidity (NTU's)	Color	Remarks
MISS 4B	7/22/93	11.85	47	4	23	0 = 0	5.01	21.3	1800	44.2	Colorless	Groundwater from this well had a chemical odor.
Stepan						1 = 23	6.57	21.5	1200	4.83	Colorless	Small rust colored particles, were in sample. Filtered metals
Amended						2 = 46	7.05	19.1	1000	8.7	Colorless	collected.
						3 = 69	7.07	19.3	1250	4	Colorless	
						4 = 92	6.85	18.6	1200	5.7	Colorless	
MW-1	7/23/93	11.22	19.1	4	5.1	0 = 0	6.83	22.8	1000	9.16	Colorless	Well went dry after second volume was collected. Chemical
Stepan						1 = 5	6.88	21.1	1000	132.7	Tan	odor coming from well.
						2 = 10	7.06	21.5	1100	>200	Cocoa brown	

Modified decontamination of the submersible pumps was conducted on the Stepan Property:

- The outside of the submersible pump, the pump wires, and Teflon leader were scrubbed using a scrub brush and an Alconox and water solution.
- The submersible pump, pump wires, and Teflon leader were placed in a 5-gallon bucket containing an Alconox and tap water solution.
- The submersible pump was turned on, and the Alconox solution was pumped through the inside of the pump.
- The submersible pump was then placed in a 5-gallon bucket containing tap water.
- The pump was turned on, and approximately 10 to 20 gallons of tap water was pumped through the submersible pump.
- The outside of the submersible pump was allowed to air dry.
- The outside of the submersible pump was then rinsed with pesticide-grade methanol and hexane and was air dried.
- The submersible pump, pump wires, and Teflon leader were wrapped in aluminum foil until used.

Methanol and hexane were not pumped through the submersible pump because these chemicals could have damaged the inside of the pump and could have contaminated groundwater samples if the equipment was not thoroughly rinsed. A nitric acid rinse was not used on the submersible pump because it could have damaged both the inside and the outside of the pump as well as the pump wires.

Peristaltic and centrifical pumps, which were used to sample some of the shallower wells, did not require decontamination because they do not come into contact with the groundwater. Only the silicon tubing is contacted by the water; dedicated tubing was used for purging and sampling and was disposed of after each use.

2.7.9 Management of Investigation-Derived Wastes

Three types of wastes were generated during the groundwater sampling programs: groundwater purged from wells, decontamination fluids, and used PPE.

Purge Water. Purge water from the wells was disposed of on the site only when the following conditions, specified in the work plan, were met:

- Disposal would not cause or increase any existing threat to human health and the environment through known exposure routes.
- Disposal would not erode soil, flow off the site, flow onto uncontaminated areas onsite, or flow through contaminated areas into clean areas, either onsite or offsite.
- Water from a contaminated aquifer would not be discharged into an uncontaminated aquifer.
- Disposal was limited to one area of known contamination (at or above action levels for relevant pollutants) or an area as close to the origin of the water as possible.
- Disposal and/or discharge would not significantly add to the contamination of surface soil.

The following conditions also had to be met before purge water could be disposed of on the site:

- The well had to be located in an unpaved area where runoff would not occur. Purge water from wells located on paved or sloped areas was contained.
- The volume of purge water to be disposed of had to be less than 20 gallons.
- The well could not be located in a known contaminated area.
- Disposal of the purge water could not affect other wells in the vicinity.

"Onsite" was defined in this case as the property where the purge water was generated. Purge water was disposed of on the site only after all wells in the immediate vicinity were purged and sampled. The purge water was contained in 5-gallon buckets until purging and sampling was completed; then it was slowly poured next to the well where it was generated.

If purge water could not be disposed of within the conditions listed above, then the water was contained in DOT-approved 55-gallon drums. The filled drums were left on the property where the purge water was generated. All drums were labeled with the following information:

- Specific location (well number)

- Property sampled (e.g., Stepan, Sears)
- Drum contents (i.e., groundwater)
- Date drum was filled
- Remarks regarding drum contents (e.g., PID readings)

Decontamination Fluids. Aqueous wastes from the decontamination of submersible pumps were discharged to the sewer system on the property where they were generated. Solvent wastes from the decontamination of submersible pumps were contained in a 55-gallon drum. All drums generated from decontamination activities were properly labeled with information regarding location and type of material and were stored on the properties on which they were generated.

Used PPE. Used PPE such as Tyvek suits, rubber boot covers, and gloves were double bagged and placed in a solid waste rolloff on the property where they were generated, unless the PPE was very soiled or radiologically or chemically contaminated (as indicated by field screening). PPE that was found to be contaminated was drummed, properly labeled as indicated in the previous section, and stored on the property on which it was used.

2.8 Surface Water and Sediment Sampling

Surface water and sediment were sampled from July 20, 1992, to July 24, 1992. These media were characterized to determine the surface water and sediment quality, and to assess the impact from surface water movement through the drainage channels, which could serve as a potential pathway for contaminant migration from the study area.

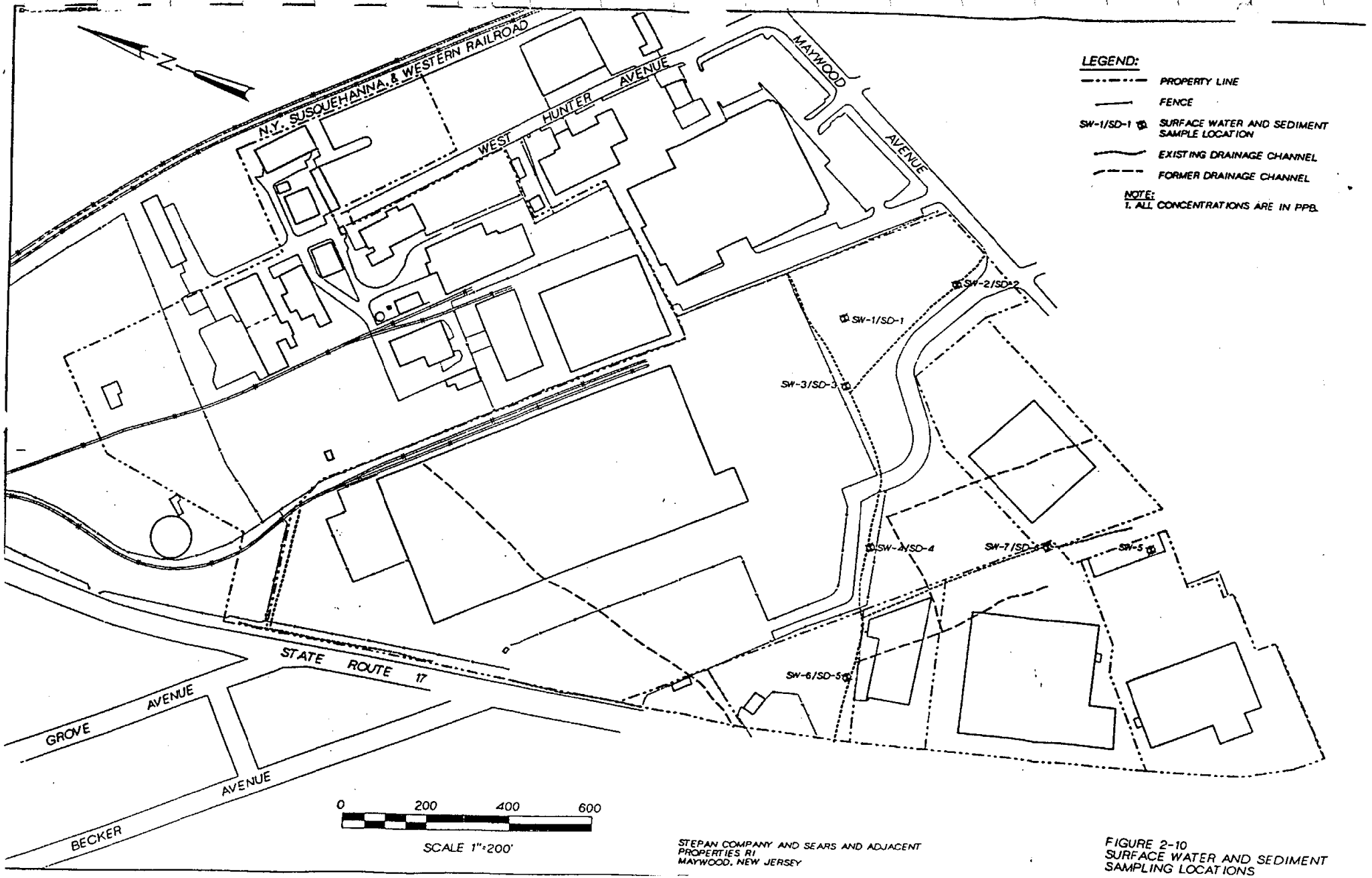
Surface water samples were collected at seven locations, and sediment samples were collected at six corresponding locations (Figure 2-10). Samples of surface water and sediment were collected on the properties listed in Table 2-14.

All surface water samples, except SW-5, and all sediment samples were collected from surface-water drainage channels. Sample SW-5 was collected from the intermittent pond located on the Federal Express property.

2.8.1 Objectives

The objectives of the surface water and sediment sampling program were:

- To characterize the horizontal extent of surface water contamination (chemical and radiological) within existing drainage channels and ponds located on Sears and adjacent properties.



STEPAN COMPANY AND SEARS AND ADJACENT PROPERTIES RI
MAYWOOD, NEW JERSEY

FIGURE 2-10
SURFACE WATER AND SEDIMENT SAMPLING LOCATIONS

Table 2-14 Properties on Which Surface Water and Sediment Were Sampled		
Property	**Surface Water Sample**	**Corresponding Sediment Sample**
Sears	SW-1	SD-1
Sears	SW-2	SD-4
Sears	SW-3	SD-3
Sears	SW-4	SD-4
Federal Express	SW-5	None required
Sunoco	SW-6	SD-5
SWS	SW-7	SD-6

- To determine which compounds (chemical and radiological) are in existing drainage channel sediments.

- To measure soil properties affecting the mobility of chemical and radiological contaminants in the drainage channel sediments.

2.8.2 Sampling Methodology

The sampling procedures followed during the RI were based upon the procedures outlined in the work plans (CH2M HILL) and the QAPP (CH2M HILL). Because of field conditions, deviations from these plans sometimes occurred.

The surface water and sediment sampling methodologies were as follows:

- Field parameter measurements (pH, conductivity, and temperature) were collected at each surface water sampling location and recorded in the field logbook.

- Surface water samples were collected before sediment samples, at locations where both matrices were sampled.

- Personnel collecting samples entered the location from the downstream side, to minimize disturbance and suspension of sediments.

- Sample bottles not pre-preserved were used in collecting the surface water samples by submerging the bottle with the opening facing upstream. Jars laboratory-certified to be decontaminated were used in

collecting and transferring each surface water sample to chemically pre-preserved sample containers at the sample location.

- Sediment samples were collected with a decontaminated stainless steel trowel and placed in a stainless steel bowl.

- Sediment samples for TCL VOC analysis and VOC-headspace screening were collected before the samples were homogenized.

- Sediment samples were homogenized and placed into sample jars for the following analyses in the following order: TCL semivolatiles, caffeine, d-limonene, a-pinene, TCL pesticides and PCBs, TAL metals, lithium, cyanide, and radiological parameters.

- All samples were immediately placed in a cooler containing ice and kept at 4 degrees C until shipped to the laboratories.

- Sample jars were decontaminated by wiping soils from the outside surfaces. The sample jars were then surveyed for transferable alpha and beta-gamma contamination using swipe samples from the jars. The sample jars were also surveyed directly for total (transferable and fixed) alpha contamination. Sample jar survey results were compared to release criteria specified in the site-specific health and safety plan, which were based on DOE's surface radioactivity guides (DOE Order 5480.11). The decontamination procedure was repeated if necessary. Sample jars were not shipped until release criteria were met.

- Surface water and sediment samples were not screened for radioactivity by the field laboratory, because of potential matrix interferences caused by the presence of water. Because surface water samples were not expected to be radioactive[4] surface water samples were shipped as non-radioactive materials. Because of elevated radiation levels observed along some of the drainage channel banks, sediments were considered potentially radioactive[5] and were shipped as "excepted, limited quantity radioactive material." Approximations of activity levels were provided to the analytical laboratories primarily for laboratory NRC-permit compliance purposes.

- Surface water and sediment sampling locations were marked with wooden stakes and flags after sample collection. These locations were included in the study area survey described in Section 2.9.3.

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[4]Defined by DOT as total activity greater than $2x10^6$ pCi/L; 49 CFR 173.403.

[5]Defined by DOT as total activity greater than 2,000 pCi/g; 49 CFR 173.403.

2.8.3 Modifications of the Work Plans and QAPP

The work plan (CH2M HILL) specified that sediment samples SD-3 and SD-4 be collected during the soil boring program, as one of the samples to be collected from each of the soil borings C-19 and C-17, respectively. However, soil borings C-19 and C-17 were moved away from SD-3 and SD-4 because of inadequate drill-rig accessibility. Sediment samples SD-3 and SD-4 were collected at the same time as the other sediment samples, in order to compare all analytical results associated with that media. Sediment samples were taken simultaneously with surface water samples in order to determine the impact of potentially contaminated sediment on the quality of surface water.

Proposed sample location SW-2/SD-2 was dry at the time of sampling, so it was relocated approximately 75 feet east of the originally proposed location, to an area containing water and within the same drainage channel.

2.8.4 Analytical Requirements

Surface water and sediment samples sent for chemical analyses were analyzed by TCT-St. Louis Laboratory in St. Louis, Missouri, in accordance with the analytical methodologies presented in Table 2-2. Core Laboratories in Casper, Wyoming, performed the radiological analyses in accordance with the analytical methodologies presented in Table 2-2.

The chemical analyses consisted of the following:

- TCL organics (VOCs, semivolatiles, pesticides, PCBs)
- TAL inorganics (metals and cyanide)
- Caffeine, d-limonene, and a-pinene
- Lithium
- TOC (sediment samples only)

The radiological analyses consisted of the following:

- Gross alpha and gross beta radiation
- Ra-226 and Ra-228
- U-234, U-235, and U-238
- Th-230 and Th-232

One sediment sample was analyzed for total uranium (described further in Section 4).

2.8.5 QA/QC

QA/QC samples were collected and analyzed to measure the following:

- Internal consistency of the samples
- Cross-contamination sources
- Other sources of contamination
- Decontamination efficiency
- Accuracy, reproducibility, and precision of the laboratory
- Contamination during collection or shipment

Field duplicate samples, equipment rinse blank samples, MS/MSD samples, and trip blank samples were obtained for QA/QC during the surface water and sediment sampling.

- **Field Duplicate Samples.** Field duplicate samples were collected by filling two sets of sample containers simultaneously. The duplicate samples were analyzed for the same parameters as the corresponding sample. Duplicate samples were not identified as duplicate samples to the laboratory. One field duplicate sample was collected per matrix type.

- **Equipment Rinse Blank Samples.** Equipment rinse blank samples were collected from the decontaminated sampling equipment (stainless steel bowl and stainless steel trowel). They were collected by pouring demonstrated analyte-free water over the inside of the decontaminated sampling equipment, and then pouring the rinsate into sample containers, with chemical preservation as needed. Surface water samples were collected directly into the sample container or by using a laboratory-certified decontaminated jar, so equipment blanks were not necessary. The equipment rinse blank samples were analyzed for the same parameters as the corresponding samples. One equipment rinse blank sediment sample was collected per decontamination event.

- **MS/MSD Samples.** MS/MSD samples were obtained by collecting additional sample volume from randomly selected locations. One MS/MSD sample was collected per matrix type.

- **Trip Blank Samples.** Trip blank samples were prepared by filling three pre-preserved 40-ml vials with demonstrated analyte-free water. The trip blanks were carried in the cooler with the samples collected each day. One trip blank sample was collected per day.

2.8.6 Chain-of-Custody

Chain-of-custody was maintained during surface water and sediment sampling through traffic report/chain-of-custody forms and chain-of-custody seals. The traffic report/chain-of-custody forms were used to track the samples from the time of collection until analysis by the laboratory. The chain-of-custody seals were used to confirm that the samples had not been tampered with during sample storage or shipment.

Samples were always kept within the view of sampling personnel, or were locked in a secure area (i.e., the field trailer).

2.8.7 Field Screening Results

pH, specific conductivity, and temperature measurements were collected at surface water sample locations, and VOC headspace readings were collected from sediment samples. These results are summarized in Section 4.

2.8.8 Decontamination

Sampling equipment (trowels and bowls) was chemically decontaminated before and between each use by Lisano Laboratories, in Wayne, New Jersey, using the following series of chemical rinses:

- Alconox and tap water wash
- Tap water rinse
- 10-percent nitric acid rinse
- Deionized water rinse
- Methanol rinse
- Hexane rinse
- Demonstrated analyte-free water rinse

All solvents and acids used for chemical decontamination were of HPLC or pesticide grade. The demonstrated analyte-free water was prepared and analyzed by TCT-St. Louis laboratory.

After sampling equipment was chemically decontaminated it was allowed to air dry and was wrapped in aluminum foil until used.

2.8.9 Management of Investigation-Derived Wastes

The major waste type generated during the surface water and sediment investigation was used PPE. Tyvek suits, rubber boot covers, and gloves were double bagged and placed in a solid waste rolloff on the property where they were generated, unless visually contaminated or radiologically or chemically contaminated (as indicated by

field screening). If PPE was found to be contaminated, it was placed in trash bags and then placed in labeled 55-gallon drums, which are being stored on the property where they were generated.

2.9 Field Activities Common to the Entire Study Area

2.9.1 Geophysical Survey

As part of the RI, surface geophysical investigation surveys were performed at all properties within the study area from September 3, 1991, through March 17, 1992. The purpose of these surveys was to identify potential chemical contamination sources. Specifically, the geophysical investigation was performed in an effort to locate and define ferromagnetic containers in the overburden soils within the study area.

Because of the nature of deposits at the study area, a magnetic survey was determined to be the most effective geophysical method available. The magnetometer identifies areas of buried metal but cannot distinguish drums from other ferrous materials. Therefore, the results of the geophysical investigation were used to select locations for test-pits that were used to characterize the buried metal.

The results and interpretation of these surveys, along with recommended test-pit locations, were provided to EPA in several technical memoranda for review and approval before test-pit activities began. The technical memoranda describe in detail the procedures employed in the data collection; the methods used to interpret the data; the results of the survey, including the interpretation of the data; and the limitations of the results, as well as maps showing the locations of buried metal and recommendations for using the data. Any modifications of the work plans that occurred during the surface geophysical investigation survey or test pit program are presented in the technical memoranda. The technical memoranda are presented in Appendix M.

2.9.2 Test Pitting

The test-pit program was conducted from March 26, 1992, through May 21, 1992. The purpose of the test-pit program was to physically investigate anomalous areas of potential buried metal identified during the surface geophysical investigation. Test pits were excavated to determine the source of magnetic anomalies on the Stepan and Stepan amended, Sears, DeSaussure, Sunoco, AMP, SWS, and Federal Express properties. No test pits were excavated on Gulf because the magnetic anomalies that were identified were due to cultural features or underground storage tanks. A total of 129 test pits were excavated during this program. From 19 test pits, 23 samples (including three field duplicate samples) were collected.

A technical memorandum was prepared detailing the findings of the test-pit program (Appendix E). The technical memorandum presents all aspects of the test pit program except the analytical results associated with test-pit sampling. Test-pit samples were analyzed for both chemical (TCL and TCLP) parameters, as well as radiological parameters; the analytical results are presented in Section 4.3.

2.9.3 Surveying

Surveying activities included the following:

- Establishing horizontal and vertical control networks at the site, including permanent benchmarks, and locating existing topographic features (such as building corners, fence lines, etc.) to fit new locations onto the base map that was presented in the work plan, which was not in the New Jersey State Plane Coordinate System
- Locating and determining elevations of 20 soil borings and 13 wells installed during the Focused Investigation
- Locating 44 soil borings horizontally and vertically
- Locating 46 monitoring wells (32 new wells and 14 existing wells) horizontally and vertically
- Locating seven surface water sample points and six sediment sample points horizontally and vertically
- Locating eight distinct wetland areas horizontally
- Setting two benchmarks on existing headwalls (Sears) in order to determine the elevation of surface water in a drainage channel

The elevation of the top of the inner stainless steel casing and the top of the outer steel protective casing of the monitoring wells, and the benchmarks on the existing headwalls, were measured to 0.01 foot. The elevation of the ground surface for the wells and soil borings, and the top of the water surface and corresponding sediment, was measured to 0.1 foot. The surveyor completed Form Bs for all monitoring wells (Appendix N).

Surveying services were provided by GEOD Corporation of Newfoundland, New Jersey. Work was conducted by New Jersey-licensed surveyors.

Horizontal control and locations were established in the field using Topcon 3B theodolites and electronic measuring devices and FC-1 data collectors. Angles and distances to establish the control points and location points were read four times and two times, respectively.

Vertical control was established by differential leveling using Zeiss self-leveling levels running three wire level loops. Elevations were established at monitoring wells by closed differential leveling loops. Elevations were established at soil boring, surface water, and sediment sample locations by trigonometric leveling methods at the same time horizontal locations were established.

New Jersey State Plane coordinates were established for horizontal control and locations by holding New Jersey State Monuments 3831, 3832, and 7467. Mean sea level elevations were established by holding New Jersey State Monument 7467 after running a three wire level loop between Monument 7467 and Monument 3831 for verification of elevation. The elevation of the two monuments agreed within 0.033 foot.

2.9.4 Wetlands Delineation

A detailed jurisdictional wetlands delineation was conducted at the study area. The purpose of the delineation was to establish a basis for minimizing wetland impacts during investigation and remediation activities. A technical memorandum describing the delineation is included in Appendix O.

The wetlands were delineated on the site on April 20 to 21, 1992, utilizing the three-parameter approach outlined in the *Federal Manual for Identifying and Delineating Jurisdictional Wetlands* (Federal Interagency Committee for Wetland Delineation). A reconnaissance of the entire site was performed. Soil borings were located at areas of noticeable change in vegetation and topography. Locating the extent of the soil types and changes in plant community was difficult because of minimal topographic relief, presence of disturbed soil, and lack of native vegetation. To assist in locating hydric soils and determining the extent of wetland-upland areas, random soil samples were taken with a soil auger within the mowed areas. Federal manual routine data sheets were completed at eight data points; these included information on herbaceous species, shrubs, woody vines, saplings, trees, soil, and hydrology. Photographs were taken at each data point. Data points were numbered and marked in the field with orange and black flagging tied to vegetation or pink wire stakes Wetland boundaries were then identified in the field with numbered pink wire stakes, and pink and black flagging.

2.9.5 Flood Hazard Area Assessment

A flood hazard area assessment was conducted in the study area, which includes the properties shown on Table 2-15. The study area is within the Hackensack River watershed; it encompasses approximately 60 acres.

Table 2-15 Block and Lot Numbers for the Study Area	
Block	**Lot**
124	Lots 31, 32, 40, 47, 48
124	Lot 30
124	Lot 17
124	Lot 1
124	Lot 2
124	Lot 3
124	Lot 4
124	Lot 5

Flood hazard areas were delineated on the basis of a review of Federal Emergency Management Agency (FEMA) flood insurance rate maps.

2.10 Focused Investigation Activities

To respond to EPA's comments on the draft RI report of March 1993 and to address those areas where further investigation was required, the work plan was amended. The scope of work defined in the amended work plan consisted of the following major tasks:

- Groundwater sampling
- Source delineation
- Hydrogeologic evaluation
- Expanded well records search

The groundwater sampling task consisted of resampling of all wells that had been sampled during the initial RI effort. The resampling is discussed in Section 2.7.

The source delineation study was performed to investigate these areas: the Aromatic and Essential Oils Manufacturing Area, the Central Tank Farm Area, and the area around boring C-41. The study included the following:

- Conducting a soil gas survey on the Stepan property
- Installing and sampling 19 soil borings and 3 hand-auger borings

- Sampling of two new monitoring wells at Stepan and the bedrock pumping test well at Sears

Table 2-16 presents field screening results for soil boring samples. All source area delineation activities are discussed in Section 2.10.1.

The hydrogeologic evaluation, which included the installation of three overburden wells and five bedrock wells, pressure injection testing, three subsequent pumping tests, and reinjection testing is discussed in Section 2.10.2.

The expanded well records search consisted of the following subtasks:

- Identification of any additional wells within a 1-mile radius of the site
- Determination of the status and weather any of the smaller-yield wells identified during the RI search are used for drinking water
- Determination as to whether the two large supply wells identified during the RI search are used for drinking water
- Investigation of the yield and depth of the supply well that is registered with NJDEPE under Stepan's name

The expanded well search—also called the Focused Investigation well search—is described at length in Section 1.7.

2.10.1 Source Delineation

Soil Gas Survey. A soil gas investigation was performed at Stepan from July 26 through August 6, 1993, as proposed in the EPA-approved amendment to the RI work plan. This follow-on investigation, part of the Focused Investigation, was conducted within areas designated by CH2M HILL as the Central Tank Farm Area and the Aromatic and Essential Oils Manufacturing Area (Figure 1 in Appendix Z). The soil gas investigation was performed by Tracer Research Corporation (Tracer Research) of Monmouth Junction, New Jersey, and was directed and overseen by CH2M HILL. A copy of Tracer's complete report is provided as Appendix Z.

Objectives

The objectives of the soil gas investigation were to:

- Evaluate the presence and lateral extent of VOC contamination in soil around potential source areas

Table 2-16
Soil Boring Sampling Field Screening Results – Focused Investigation

Property	Boring No.	Depth Interval (ft)	Maximum PID Scan [a] (ppm)	Maximum Rad Scan [b] (cpm)	Maximum Headspace Reading [a] (ppm)	Remarks
Stepan	SG-1	(0-2)	6.6	40-60	75	
		(2-4)	10.0	40-60	66	
		(4-6)	24.2	40-60	167	
		(6-8) [c]	45	40-60	345	
	SG-2	(1-3)	27	80-100	113	
		(3-5) [c]	18.2	1400-1500	18	
		(5-7)	0.5	190-200	8.2	
	SG-3	(1.5-3.5) [c]	37	40-60	137	
		(3.5-5.5)	28	40-60	86.7	
		(5.5-7.5)	29	40-60	252	
	SG-4	(0-2)	0.5	40-60	4.9	PID scan taken from tip of spoon.
		(2-4)	0.5	40-60	22.6	
		(4-6) [c]	23	40-60	49.5	
	SG-5	(1-3)	747	40-60	870	
		(3-5) [c]	951	40-60	1258	Sludgy material. Coal like product.
		(5-7)	482	40-60	739	Sludgy material. Coal like product.
	SG-6	(1-3)	49.1	60-80	142	
		(3-5) [c]	6	60-80	195.5	
		(5-7)	11.7	60-80	124.5	
	SG-7	(0-2)	0	60-80	0.8	
		(2-4) [c]	150	60-80	262	
	SG-8	(1-3)	0	40-60	0.5	
		(3-5) [c]	11.4	20-40	401	
		(5-7)	3.2	20-40	274	
	SG-9	(0-1.5)	0.5	160-180	1	
		(1.5-3.5)	0.0	280-300	7.6	
		(3.5-5.5) [c]	0.5	40-60	20.4	Trace of a volatile organic odor.
		(5.5-7.5)	0.5	40-60	30.5	
	SG-10	(1-3)	48.5	40-60	729	Petroleum like substance at bottom of spoon.
		(3-5)	303	40-60	1067	
		(5-7) [c]	1280	40-60	1279	

Table 2-16
Soil Boring Sampling Field Screening Results – Focused Investigation

Property	Boring No.	Depth Interval (ft)	Maximum PID Scan [a] (ppm)	Maximum Rad Scan [b] (cpm)	Maximum Headspace Reading [a] (ppm)	Remarks
Stepan	SG-11	(1-3)	0.9	60-80	2.7	
		(3-5) [c]	18	40-60	31.5	
		(5-7)	0.9	40-60	22.5	Very little recovery.
	SG-12	(1-3)	0	[d]	7.4	Rad scan inadvertently not taken.
		(3-5) [c]	0	40-60	0	
	SG-13	(0-2)	8	40-60	33.3	Sample collected from 2-4 feet, due to little recovery in 4-6 ft.
		(2-4)	23	20-40	36.9	
		(4-6) [c]	267	40-60	215	
	SG-14	(1-3)	0	40-60	0	
		(3-5) [c]	151	40-60	362	Petroleum odor.
		(5-7)	280	40-60	306	
	SG-15	(0-2)	76	40-60	440	PID scan taken at the tip of the spoon.
		(4-6) [c]	272	40-60	1067	No recovery for the 2-4 foot interval.
	SG-16	(0-2)	0.5	40-60	16	
		(2-4) [c]	8.2	40-60	66	
		(4-6)	0.5	40-60	28	
		(6-8)	0.5	40-60	29	
	SG-17	(1-3)	0	80-100	2.4	
		(3-5)	0	80-100	2.4	
		(5-7) [c]	199	20-40	238	Petroleum like odor.
	SG-18	(1-3)	0	40-60	[e]	Head space inadvertently not taken.
		(3-5) [c]	420	40-60	1274	
		(5-7)	400	40-60	1615	
	SG-18A	(3-5.5) [c]	10	[d]	388	Rad scan not taken. Boring advanced to collect BNAE sample.
	SG-19	(1-3)	0.9	60-80	6.3	
		(3-5) [c]	445	60-80	474	
		(5-7)	345	40-60	433	

[a] PID scan and headspace screening were performed using an Organic Vapor Monitor, Model 580B PID, except where noted. PID scan measurements often fluc
was moved along the soil in the split spoon. Only the maximum PID readings have been presented in this table.
[b] Radiological scan was performed using an HP-210 or HP-260 probe.
[c] Sample interval sent for chemical analysis.
[d] Rad scan inadvertently not taken for this sample.
[e] Headspace inadvertenty not taken for this sample.

- Aid the evaluation of the lateral extent of VOC contamination in shallow groundwater

- Obtain information on hot-spot soil contamination that may be a source of groundwater contamination by sampling shallow soils in areas where VOC contamination in soil gas was high

- Supply data to aid in the effective placement of soil borings and potential groundwater monitoring wells in areas where VOC concentrations in soil gas are high

Methodology. A summary of the methods used during the soil gas investigation and a discussion of the results were compiled in a memorandum submitted to EPA on August 26, 1993. This memorandum is included as Appendix Z.

Soil Boring and Hand-Auger Soil Sampling Program. During the soil boring and hand-auger soil sampling program, the following source areas were investigated on Stepan:

- The Aromatic and Essential Oils Manufacturing Area
- The Central Tank Farm Area
- The area around boring C-41

Objectives. The objectives of the soil boring and hand-auger soil sampling program were to sample soils in areas with high VOC or semivolatile organic concentrations to obtain information on hot-spot soil contamination that may be a source of groundwater contamination.

Sampling Methodology. The soil sampling methods and analysis were similar to the methods used for the February 11 through April 8, 1992, soil boring task summarized in Section 2.3. Deviations from the methods and analysis discussed in Section 2.3 are discussed below.

The Aromatic and Essential Oils Manufacturing Area and the Central Tank Farm Area were investigated by advancing 20 soil borings and two monitoring wells. Placement of soil borings was based on the results of the soil gas investigation. Eleven soil borings and one well were installed in the Aromatic and Essential Oils Manufacturing Area. Nine soil borings were advanced and one monitoring well installed in the Central Tank Farm Area. Whenever possible, borings were located at precisely the same locations established upon interpretation of the soil gas data. The following locations had to be adjusted:

- Boring SG-02 was moved approximately 6 feet northeast to avoid a 6,000-gallon-tank

- Boring SG-11 was moved 5 feet southwest to avoid a storm sewer line

The 20 soil borings (SG-1 through SG-19, plus SG-18A) installed in the Aromatics and Essential Oils area and in the Central Tank Farm Area were advanced to the observed water table. Two additional borings were performed, SG-18A and SG-19, when visual and olfactory evidence indicated that BNAEs probably were present in the area. Drilling services were provided by Kendrick Drilling, Inc. of Chester, New York, between September 13 and 17, 1993. Eighteen of the borings were advanced with a Mobile B-61 drilling rig equipped with 4.25 inch ID hollow-stem augers. Continuous split spoon samples were collected in accordance with ASTM D1586-84. A tripod assembly was used to advance soil boring SG-13 because the Mobile B-61 drill could not access this location. Because the tripod assembly is not capable of advancing augers, continuous splitspoons were collected. In order to minimize the potential for collapse and cross-contamination between intervals, split spoons of successively smaller diameter were driven into the borehole created by the previously driven split spoon. Following completion of sampling, the borings were backfilled or grouted with cement.

Each of the borings was logged for geologic purposes as to color, grain size, texture, and moisture content in accordance with the USCS. Complete boring logs for each of the 20 borings are included as Appendix AA.

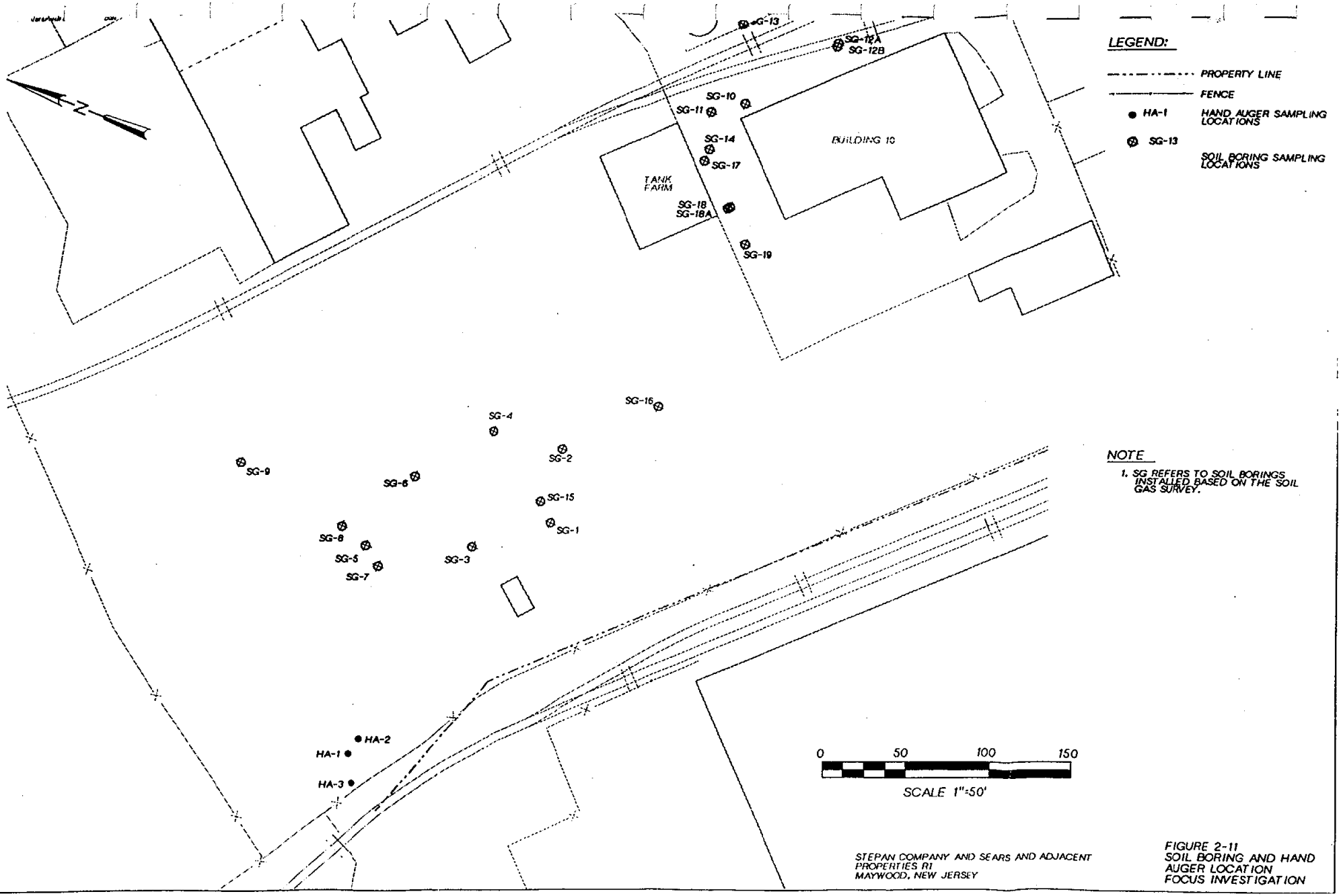
Three hand auger samples were collected near the former C-41 boring on September 7, 1993. The sampling points were approximately 5 feet north, 10 feet east, and 15 feet west of boring C-41. The sample IDs are ST-HA-1 through ST-HA-3. The depth of sample collection was zero to 2 feet BGS. The locations of the 20 soil borings and the shallow hand-auger borings are presented in Figure 2-11.

One sample was collected from each soil boring. Selection was based on the following criteria:

- Interval with the highest PID headspace response
- Interval showing visual signs of contamination (i.e., staining)
- Depth that showed elevated VOC measurements during the soil gas survey
- Interval above the water table (if none of the above criteria applied)

The procedures used during the soil boring and hand-auger sampling effort were similar to those described in Section 2.3.4, with the following exceptions:

- A PID was used to do the VOC scan and the headspace.
- Eight-ounce glass driller jars were used instead of nalgene sample jars for the headspace screening. The jars were capped and stored for future geologic assessment.



NOTE

1. SG REFERS TO SOIL BORINGS INSTALLED BASED ON THE SOIL GAS SURVEY.

STEPAN COMPANY AND SEARS AND ADJACENT PROPERTIES RI
MAYWOOD, NEW JERSEY

FIGURE 2-11
SOIL BORING AND HAND AUGER LOCATION
FOCUS INVESTIGATION

- A Ludlum hand-held meter and pancake probe Model 3 was used to do the field radiological screening.
- If the sample interval was going to be analyzed for BNAs, the remaining soil in the spoon was placed in a stainless steel bowl, homogenized, and placed in an 8-ounce glass sample jar.
- Samples were not collected for radiological analysis.
- Downhole gamma radiation logging was not performed.
- Samples were not screened in the field using a Tennelec model 6000 multichannel pulse height analyzer.

The sampling methodology for the three hand-auger borings was as follows:

- A decontaminated stainless steel hand auger was advanced to 2 feet BGS.
- Soil from the zero-to-2-foot interval was placed in a decontaminated stainless steel bowl.
- The soil was then homogenized.
- Homogenized soil was placed in an 8-ounce jar.
- Samples were then placed in a cooler with ice.
- Sample tracking and manifesting proceeded the same as for other soil samples.

Analytical Requirements. Samples selected for chemical analysis were analyzed by TCT-St. Louis Laboratory. One sample from each of the soil borings (except SG-18A) were submitted for TCL VOC analysis. One sample each from borings SG-5, SG-18A, and SG-19 were analyzed for TCL semivolatile organics.

All of the hand-auger samples were submitted for TCL semivolatile organic analysis.

QA/QC. QA/QC samples were collected in accordance with the methods and procedures discussed in Section 2.3.8.

Decontamination. Sampling and drilling equipment was decontaminated in accordance with the procedures described in Section 2.3.11.

Management of Investigation-Derived Wastes. Three types of waste were generated during the soil sampling program: soil cuttings, decontamination fluids, and used PPE.

Soil cuttings from the soil borings were either drummed or disposed of in the boring. The cuttings were scanned using a PID and a Ludlum Model 3 radiation survey meter. If the soils were determined to be either chemically or radiologically contaminated, they were placed in DOT-approved 55-gallon steel drums and were put back down the boring. Decontamination fluids and used PPE were handled in the same manner as described in Section 2.3.12.

Monitoring Well Construction and Sampling. Two shallow overburden monitoring wells were installed to further characterize source area delineation: one in the Aromatic and Essential Oils Manufacturing Area (OBMW19) and one in the Central Tank Farm Area (OBMW18). In addition, the bedrock pumping well at Sears--BRTW2--was sampled to provide additional delineation in the area.

Objectives. OBMW19 is intended to provide more information on the lateral extent of BTEX contamination in the aromatics area. OBMW18 is intended to evaluate the quality of water in the overburden as a result of elevated concentrations of cis-1,2-DCE, vinyl chloride, and BTEX found in bedrock beneath the Central Tank Farm Area.

Methodology. The wells were installed through 4.25-inch ID hollow-stem augers. Continuous split-spoon samples were collected during construction for geologic purposes. The monitoring wells were constructed with 10 feet of 2-inch ID type 316 stainless-steel riser pipe and 5 to 7 feet of type 304, 0.010-slot, stainless-steel well screen that was set to straddle the water table. Both wells were completed with locking stick-up protective casings. Boring logs are included in Appendix AA. Well construction diagrams are included in Appendix AB. Following construction, each of the wells was developed and pH, conductivity, and temperature measurements were collected until readings had stabilized. Development was performed by surging with bailer and then purging the fluids and sediments. All development water was contained in 55-gallon DOT drums for later disposal.

Groundwater samples were collected from both OBMW18 and OBMW19 on October 20, and BRTW2 on November 15, 1993. Samples obtained from OBMW18 were submitted for analysis of TCL VOC, TCL semivolatile organics, and total TAL metals. Samples obtained from OBMW19 and BRTW2 were submitted for analysis of TCL VOCs only. All sampling methods, QA/QC, and decontamination procedures were conducted as described in Section 2.7.2.

2.10.2 Hydrogeologic Evaluation

Objectives. The focused hydrogeologic evaluation was undertaken to evaluate the feasibility of groundwater remediation at the site by better characterizing the hydrogeologic communication between the overburden aquifer system and the bedrock aquifer system, and the behavior of groundwater flow in bedrock. In particular, the objectives of the evaluation were to determine qualitatively the non-

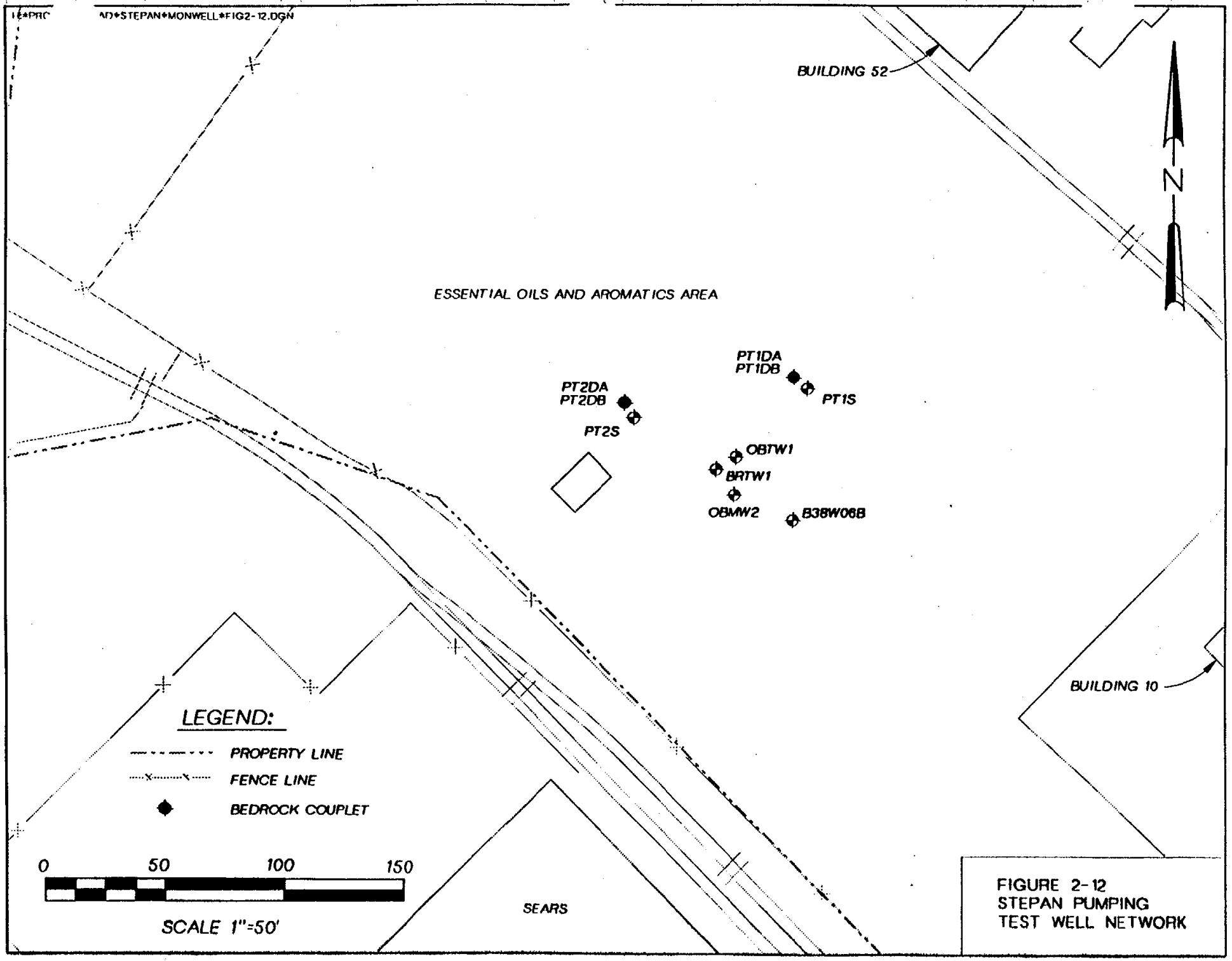


FIGURE 2-12
STEPAN PUMPING
TEST WELL NETWORK

uniformity of the fractured rock aquifer and directional properties of transmissivity and quantify aquifer coefficients from analysis of time-drawdown data.

Methodology. The evaluation required installation of eight monitoring and three pumping-test wells prior to conducting three pumping tests. Pressure injection testing was performed to determine of fracture zones for monitoring-well screen selection. The pumping tests included two 72-hour bedrock pumping tests--one at Stepan and one at Sears--and one 48-hour test in the overburden aquifer at Stepan.

The hydrogeologic evaluation included the following specific elements:

- A preliminary pumping test on wells OBMW2 and BRMW2 to assess the suitability of using the first for a 48-hour overburden pumping test or the second for a 72-hour bedrock pumping test on the Stepan property
- Installation of two observation well triplets (wells PT1-S, PT1D-A, PT1D-B, PT2-S, PT2D-A, PT20-B) for monitoring the above-referenced tests on the Stepan property (see Figure 2-12).
- Installation of test wells OBTW1 and BRTW1 as replacement pumping wells for OBMW2 and BRMW2, respectively, based on results of the preliminary testing
- Implementation of the above-referenced 48-hour overburden and 72-hour bedrock pumping tests at the Stepan property
- Installation of one bedrock test well (BRTW2) and two observation wells (PT2D-A and PT2D-B) on the Sears property just northeast of BRMW1 (see Figure 2-13)
- A third 72-hour pumping test at Sears

Three of the eleven wells drilled during this program were shallow wells. Two of the shallow wells were drilled as shallow offsets to adjacent bedrock wells (PT1-S and PT2-S). The other shallow well is the overburden test well at Stepan, OBTW1. The remaining wells in bedrock were constructed as either couplets for monitoring or as open-hole construction for pumping. Installation and construction of these wells are discussed below. More detail regarding background and objectives is included in the Remedial Investigation Workplan Amendment (Stepan).

Preliminary Pumping Tests. One objective of the pumping test program was to generate useful time-drawdown data from pumping centers to determine aquifer coefficients. The wells selected as pumping test extraction wells were wells that could maximize this objective by assuring the highest possible flow rates for maximum groundwater influence. Preliminary pumping tests were conducted on both OBMW2

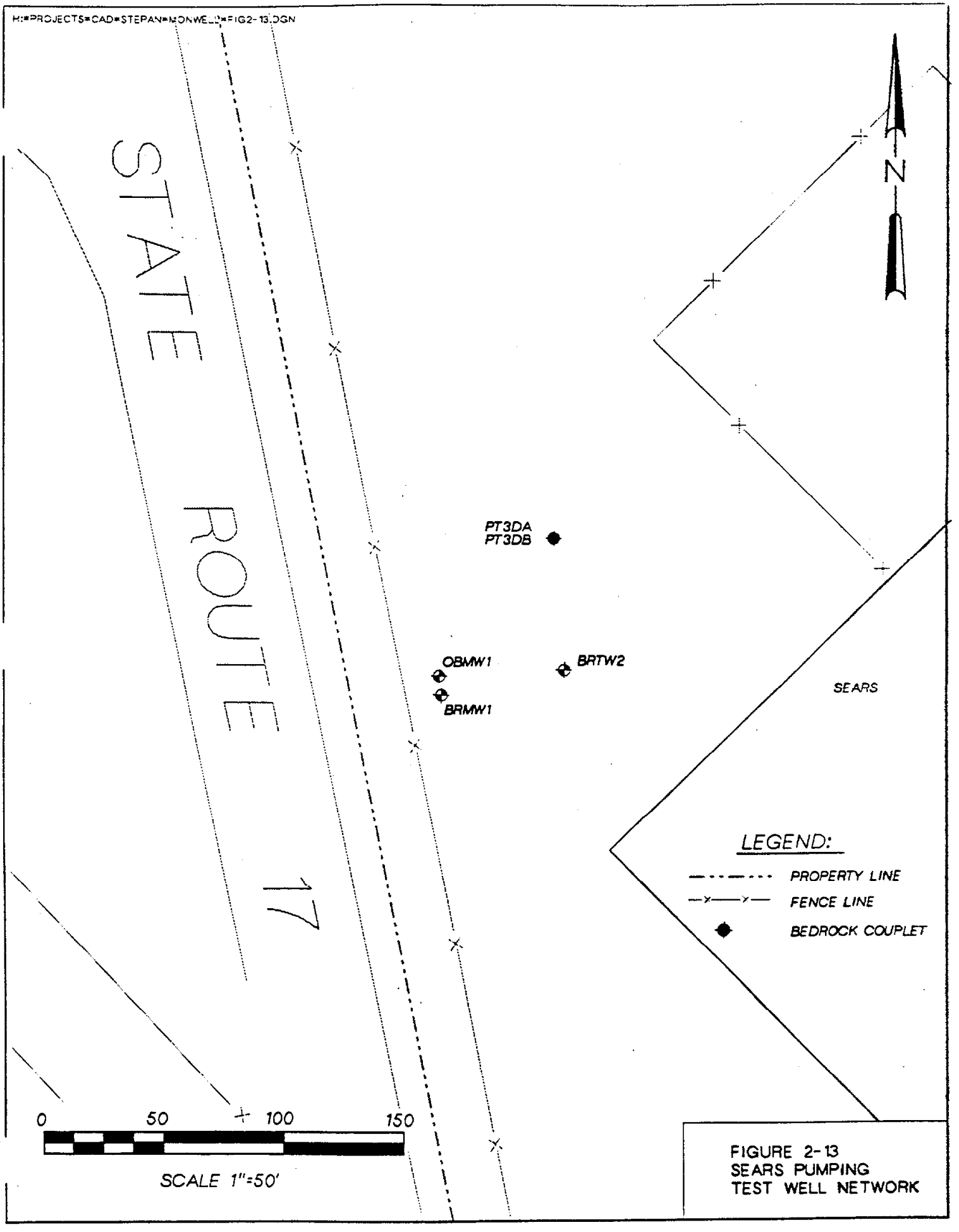


FIGURE 2-13
SEARS PUMPING
TEST WELL NETWORK

and BRMW2 on September 2, 1993. OBMW2 yielded less than 0.25 gpm until it dewatered after 20 minutes of pumping. Because this well was constructed of 2-inch slotted screen in a 6-inch borehole, CH2M HILL recommended installation of a replacement well (OBTW1) that was designed to provide a greater sustained flow rate. Construction of this well is discussed in the following sections.

BRMW2 yielded approximately 8 gpm for a 4-hour period. Although reasonable influence was observed in B38W6B, an adjacent shallow bedrock well, CH2M HILL recommended installation of a replacement well (BRTW1) that was designed to assure maximum influence over a broader area. Construction of this well is discussed in the following sections.

Bedrock Drilling. As shown in Figures 2-12 and 2-13 and explained in detail in the Workplan Amendment, the observation wells were installed at right angles to the bedrock pumping wells (BRTW1, BRTW2) to characterize potential differences in flow along strike and bedding planes. A total of five boreholes were advanced on the two properties to depths of approximately 60 feet BGS. Three of the boreholes were converted to couplets for monitoring. The three couplets included the following piezometers:

- PT1D-A and PT1D-B at Stepan
- PT2D-A and PT2D-B at Stepan
- PT3D-A and PT3D-B at Sears

The remaining two boreholes were left as open-hole construction for test purposes (BRTW1 (Stepan), BRTW2 (Sears)).

Each of the boreholes on the Stepan property were drilled using air-rotary drilling methods. While drilling on Sears property at BRTW2, a a water-rotary drilling method was used to reduce the volume of water generated during drilling. For wells installed using air drilling, an 8-inch-diameter steel casing was installed through the overburden and a minimum of 5 feet into competent bedrock. This casing was installed and tremie-grouted within a temporary 12-inch-diameter steel casing, which was advanced approximately 11 feet into overburden sediments. This temporary casing was needed to stabilize the unconsolidated zone during installation of 8-inch casing. Once the 8-inch casing was grouted, the 12-inch casing was removed. Drilling continued following a 24-hour waiting period to allow the grout to harden. An 8-inch borehole was then advanced to approximately 60 feet using an 8-inch air hammer. A CH2M HILL hydrogeologist classified all rock cuttings according to color, grain size, texture, and mineralogy. While drilling, increases in flow associated with significant water-bearing zones were carefully noted for each borehole. Rock boring logs are included in Appendix AC.

Pressure Injection Testing. Following drilling of the boreholes, packer testing was performed within each of the five open boreholes for identification of significant water-bearing zones. The open boreholes were later converted to BRTW1, BRTW2,

and the three couplets: PT1, PT2, and PT3, as shown in Figures 2-12 and 2-13. This testing was used to select the most significant water-bearing zones for positioning of screen intervals. Pressure injection testing was performed by Earth Data of Exton, Pennsylvania. Except for the packer diameter, the equipment, basic approach, and technique used by Earth Data was consistent with the pressure injection testing performed during the initial phase and described in Section 2.5.4. The packer assembly used during the testing program consisted of two 8-inch OD packers mounted to 1.5-inch-diameter galvanized steel pipe. All pressure or head measurements were made using pressure transducers that were connected to a datalogger and computer for real-time measurements. The configuration of the packer assembly was similar to the schematic presented in Figure 2-8, except the hole was 8 inches in diameter.

No packer tests were conducted in PT1 because an apparent obstruction prevented the two-packer assembly from being lowered below 35 feet. Similar problems were encountered in BRTW2 but were overcome by removing one packer and performing single-packer tests. A summary of the pressure injection program, including the boreholes tested, the test zone intervals, the flow and pressure data obtained from the tests, and the calculations of hydraulic conductivity, are presented in Section 3.7.1

Construction of Bedrock Pumping Wells and Couplets. Two of the five open boreholes were left as open-hole construction to act as pumping test wells (BRTW1 at Stepan and BRTW2 at Sears). The remaining three open boreholes were converted to couplets.

Upon review of the pressure injection testing, screen intervals were selected in the appropriate boreholes for installation of bedrock observation well couplets. The couplets basically consisted of two 2-inch-diameter wells screened at different depths inside of an 8-inch-diameter borehole. Each well of the couplet consisted of a 2-inch ID solid PVC casing and 8 to 10 feet of 2-inch, 0.010-slot PVC well screen. A gravel pack consisting of #1 Morie sand was placed at the bottom of the borehole and extended approximately 2 feet above the well screen. Each well was separated by approximately 5 to 9 feet of bentonite, applied in either pelletized or granular form. Two feet of bentonite was added above the shallow screens, and bentonite-cement grout was installed to grade. All of the couplets and pumping wells were completed with flushmount protective casings that were labeled with permit numbers. Following construction, each of the couplets was developed with a submersible pump to remove fines and increase well yield. Construction diagrams for all bedrock wells are included in Appendix AB.

Construction of Overburden Observation Wells. Shallow offsets PT1S and PT2S were constructed adjacent to bedrock wells couplets at Stepan. Both wells were installed through 4.25-inch ID hollow-stem augers. Each of the wells was completed with 7 to 10 feet of 2-inch, 0.010-slotted PVC well screen and 2-inch PVC riser pipe. A gravel pack consisting of #1 Morie sand was placed at the bottom of the borehole and extended approximately 2 feet above the well screen. Bentonite was installed above

the gravel pack to grade. The wells were completed with flushmount protective casings. Boring logs are included in Appendix AA and well construction diagrams in Appendix AB.

Construction of Overburden Pumping Wells. The overburden pumping well (OBTW1) was installed through a 12-inch-diameter temporary surface casing that was installed to approximately 10 feet below ground using the pneumatic drilling hammer rig. The casing was cleaned out with a 12-inch roller bit that was advanced to approximately 16 feet. Transitional bedrock (residual soil) was encountered at 12 feet. Potable water was pumped through the roller bit to remove fine sediments from the borehole. The pumping well was completed with 12 feet of 6-inch ID, 0.010-slot, continuous wire-wrapped, PVC well screen and 3 feet of 6-inch ID PVC riser pipe. Annular materials were emplaced through the 12 inch casing prior to its removal. The well was completed with a 12-inch flushmount road box with a lockable watertight cap. The construction diagram for OBTW1 is included in Appendix AB.

Development and Investigation-Derived Waste. Following construction, the overburden pumping well and all of the observation wells were developed to remove fine sediments and improve well yield. Development of the shallow wells was performed by pumping with a submersible pump. Each of the five bedrock boreholes initially was developed with the air-rotary drill rig by surging the open holes to remove formation water and drill cuttings. Following well completion, the bedrock couplets were then redeveloped by pumping to assure that residuals from the construction were evacuated and the sandpack had settled.

All drill cuttings from both the Stepan and Sears property well installation program were placed in 55-gallon DOT drums. Each drum was labeled with a unique identification number, its contents, dates on which the material was generated, and location from which derived.

Setup, Instrumentation, and Background Water-Level Monitoring. All measurements during background water-level monitoring and pumping tests were made using Druck pressure transducers connected to Campbell Scientific dataloggers. An onsite barometer was used to record barometric fluctuations during background water-level monitoring as well as during pumping tests. Flow rates were monitored using a Great Lakes paddle wheel flowmeter that was integrated with the datalogger. Conventional flowmeters also were installed to confirm the flow rates. The dataloggers recorded water levels, barometric pressure, and flow rates.

The following wells were monitored during the BRTW1 pumping test:

- Triplets PT1 and PT2 (PT1S, PT1D-A, PT1D-B; PT2S, PT2D-A, PT2D-B)
- B38W6B

- OBTW1 and BRTW1

The same wells were monitored during the OBTW1 test, except BRTW1 was replaced by OBMW2.

The following wells were monitored during the BRTW2 pumping test:

- Couplet PT3 (PT3D-A and PT3D-B)
- OBMW1 and BRMW1
- BRTW2

Background water level data was collected for 72-hour periods prior to each of the Stepan and Sears pumping test. These data were collected prior to the start of both bedrock pumping tests at a frequency of once every 30 minutes and were collected from the same wells that were monitored during the pumping tests.

Pumping Tests. The first pumping test was initiated at BRTW1 and was conducted from October 25 through 28, 1993. An approximate flow rate of 16 gpm was selected during the test. Measurements were recorded at 5-second intervals during the first 5 minutes, 1-minute intervals during the next 2 hours, and 15-minute intervals to the end of the test. Dataloggers were downloaded a minimum of once every 8 hours to safeguard data loss and prepare curves for aquifer analysis.

The second pump test consisted of a 48-hour test at OBTW1. A flow rate of 1.1 gpm was selected on the basis of the preliminary pumping test. This test was run between November 2 and 4, 1993.

The third and last pump test was performed on Sears. The test consisted of a 72-hour test at BRTW2 beginning on November 15 and ending on November 18, 1993. The flow rate during the test approximated 11 gpm.

Each test was followed by a 72-hour recovery period. The same data collection intervals used during the pumping tests were used during the recovery tests. All water generated during the tests was pumped to aboveground storage tanks and was reinjected into the formation it was collected from at the conclusion of the recovery cycle.

All data curves generated during the background monitoring are presented in Appendix AD. Depending on anticipated drawdown in each well, the transducers were lowered variable depths in each well. The mean values for each series is, therefore, somewhat arbitrary. To facilitate comparison of the overburden and bedrock wells with barometric pressure, the deviation from mean values for each series is presented for groups of wells in Appendix AD. Pumping test data curves are presented in Appendix AE, and recovery data curves are presented in Appendix AF. Select curves are matched to type curves for determination of transmissivity and storativity. A summary of the results of this analysis is presented in Section 3.7.

Pumping-Test Water-Quality Sampling. Groundwater samples were collected during each of the bedrock pumping tests at Stepan and Sears. The samples were obtained through a sample cock installed at the wellhead in the pumping-test discharge line. The sample cock consisted of a ball valve mounted in a galvanized Tee installed in the discharge line. Tygon tubing was connected to the ball valve, and the sample was obtained directly from the ball valve after the valve was left open for several minutes to purge. The sample stream was visibly clear of bubbles.

Samples during the Stepan pumping test were obtained at 7 hours, 30 hours, and at 72 hours into the pumping test of BRTW1. Samples during the Sears pumping test were taken at 7 hours, 28 hours, and 72 hours into the pumping test of BRTW2. An additional sample was acquired from BRTW2 prior to the start of the pumping test because this well was never sampled before. Only analysis for TCL volatile organics was performed. Analysis was performed in accordance with the most current EPA CLP statement of work. Except for the sampling technique, QA/QC methods and procedures were followed regarding preservation and shipping of samples. The results of this sampling are summarized in Section 3.7.

Groundwater Reinjection. Groundwater collected during each of the pumping tests was reinjected into the originating formations by an injection system that consisted of a datalogger integrated with a transducer, an electrically actuated ball valve, and a manual control valve. A summary of the injection equipment and program at each of the wells follows.

A total of approximately 80,000 gallons of water was reinjected into BRTW1. This total reflects 3 days of pumping at 16 gpm in addition to the water from the preliminary pumping tests. The water was collected in four tanks, two of them adjacent to the wellhead. Two-inch pipe draining the bottom of both tanks was manifolded together and directed to the electrically actuated valve. From the valve, a 2-inch line ran to the well using through a 2-inch elbow,down into the well. A final 2-inch straight pipe was directed through a well seal and continued down to approximately 7 feet below ground surface (BGS). The well seal provided a watertight seal around the annulus in the event the system backed up or the valve failed. The transducer line, which measured the level of head in the well, ran through the well seal in one of the cable ports, still providing a watertight seal. The datalogger was programmed so that the actuated valve would switch on or off, depending on the level of head in the well. The head conditions were determined largely in the field, after trial and error. In general, the valve was left open until the head rose to approximately 1 foot below grade. To prevent flooding, the valve was then programmed to close and would not reopen until the water level had subsided to a few feet below grade.

Water was reinjected into the formation pumped during the BRTW1 pumping test at an average of 10 gpm. At this rate, the water level in the well rose to approximately 8 feet above the static. The 10 gpm injection rate resulted in an injection specific capacity of 1.2 gpm/ft of recharge. The pumping rate specific capacity after 72 hours

of pumping was 1.8 gpm/ft of drawdown. This differential is not uncommon when reinjecting water. The system was designed to allow recharge at as high a rate as possible without flooding the ground, by cycling on and off. Because of this cycling, the system was probably not operating at 10 gpm consistently, nor at consistent flow rates. The entire recharge did, however, require approximately 5 days.

Injection back into BRTW2 proceeded as discussed for the Stepan site. Because the static water level at Sears is relatively shallow, there was less tolerance, or height, through which the water level could rise during injection without causing flooding. Consequently, recharge proceeded at a slower rate. A total of approximately 50,000 gallons of water was collected during the preliminary testing and pumping test at Sears. Injection flow rates were approximated to reach a maximum of 5 gpm, but as for the BRTW1 reinjection, the injection was designed to cycle on and off and the actual flow rates were variable. Injection of the 50,000 gallons of water took approximately 8 days. This represents an average injection rate of 4.3 gpm.

Injection of water from the overburden pumping tests proceeded as discussed for the previous two injection programs. Water from the overburden test was collected in two 6,000- gallon polyethylene tanks provided by Baker Storage. A total of approximately 4,000 gallons of water was collected from OBTW1 during the preliminary and pumping tests and transferred to both of the 6,000-gallon tanks.

2.10.3 Expanded Well Search

During the Focused Investigation an expanded well search was conducted to determine the number, type, and status of wells within approximately 1 mile of the study area. Details of the expanded well search are provided in Section 1.7.2.

Section 3

Physical Characteristics of the Study Area

3.1 Surface Features

3.1.1 Flood Hazard Areas

A review of the FEMA maps indicated that there are no 100- or 500-year flood hazard areas located within the study area. Therefore, no action regarding flood hazard areas is necessary at this time.

3.1.2 Wetlands

Soils. According to the Bergen County Soil Survey, only Urban Land (Ur) soil type is mapped in the study area. According to the survey, urban land consists of nearly level or gently sloping areas that have been developed for residential, commercial, or industrial use. During development, these areas were leveled or cut and filled and more than 85 percent of the surface covered with impervious materials or buildings. Included in the mapping unit are high density residential areas that are less than 85 percent covered and contain reworked soil material or Udothents. No hydric soil types are mapped in the study area.

Disturbed soil conditions were encountered in the vicinity of data points T2.1, D1, and D2. The upper 18 inches (approximately) of soil, in the vicinity of T2.1 and D1, appeared to be fill material. The fill material consisted of clay loam with limited horizon development and few, if any, mottles or other signs of hydric conditions. A 3-inch layer of organic material was found immediately below the fill material. The organic material consisted of distinguishable vegetative matter. Soil characteristics below the organic layer in the wetland areas displayed hydric indicators such as mottling and gleying. In upland areas, the soil below the organic layer was fairly bright and sandy, with few signs of inundation.

Radioactive material was encountered in the vicinity of T2.1 and D2. The material generally occurred approximately 12 inches BGS near T2.1. This material, though moist, displayed no hydric characteristics. D2 is located within a Palustrine Broad-Leaved Deciduous (PFO1) area on the DeSaussure property. The natural soil in this location is buried under approximately 3.5 feet of bright-blue, silty fill material (see photograph of D2 in Appendix O). The extent of the fill was limited to the PFO1 area. Considering the size of the trees growing in the immediate area, it appears that the fill material has been in place for many decades. The water table in this location was about 8 to 12 inches below the surface. The buried soil displayed strong hydric characteristics.

Wetlands. The NWI map did not show the presence of any wetlands within the study area boundaries. However, the results of the onsite delineation identified Palustrine Emergent (PEM) areas associated with the ditches that traverse the area and two PFO1 areas adjacent to the Maywood Avenue entrance to Sears. These wetlands encompass approximately 4.1 acres of the study area; a map of the delineated wetlands is provided as Figure 3-1.

The PEM wetlands were dominated by common reed (*Phragmites australis*) and, in a few areas, cattails (*Typha latifolia*). In the area of data point T2.1, the vegetation consisted primarily of mowed turf grass mixed with a few sedges and spike grass (*Eleocharis sp.*). The PFO1 wetlands were dominated by mature stands of red maple (*Acer rubrum*), sycamore (*Platanus occidentalis*), American elm (*Ulmus americana*), sweetgum (*Liquidambar styraciflua*), and mowed turf grass. The upland areas on the site are either impervious surfaces or previously filled, mowed turf grass, or otherwise disturbed areas.

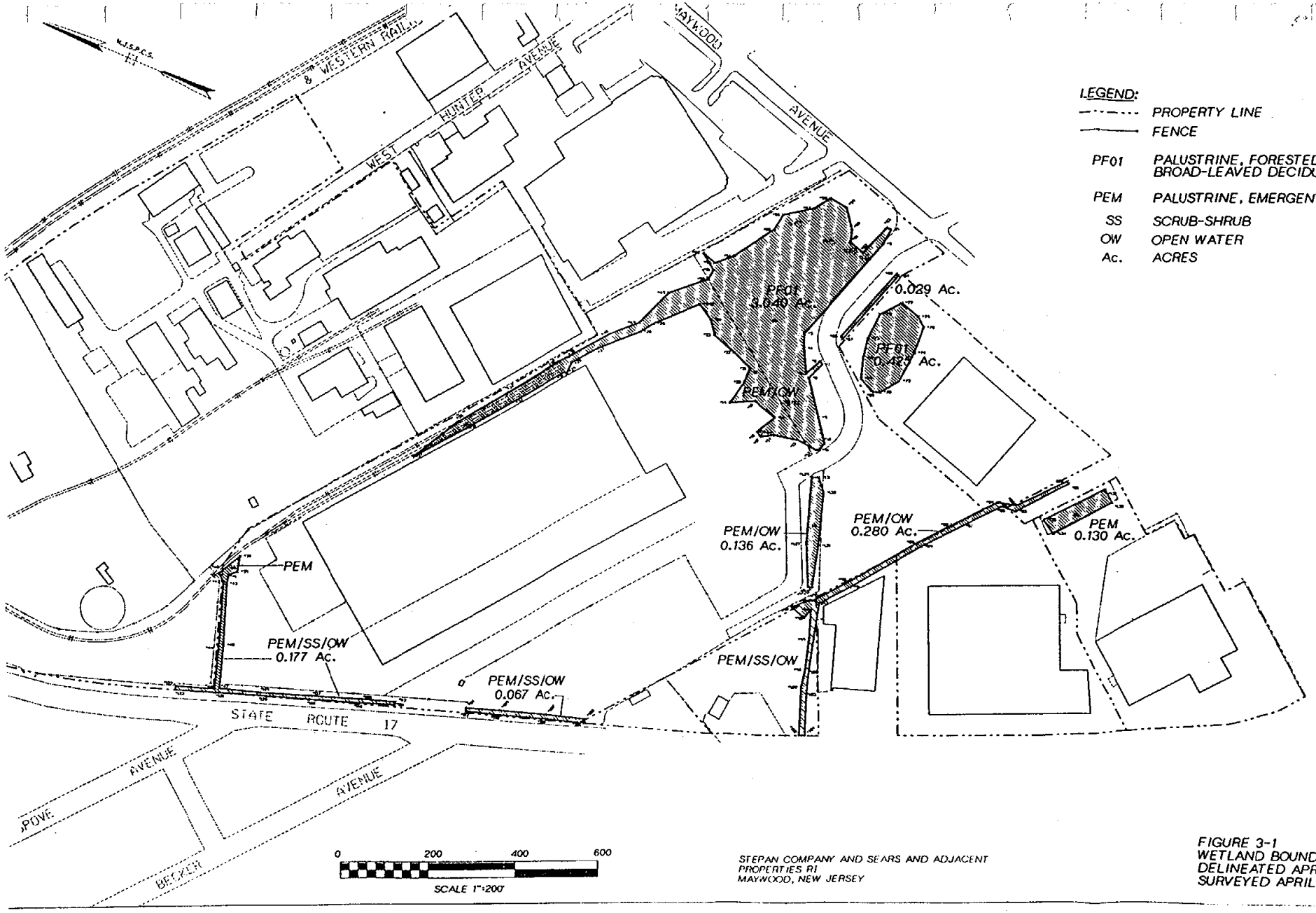
Summary and Conclusions. The majority of the wetlands identified in the study area are PEM, mowed PEM, and PFO1. The hydrologic regime for the site is primarily influenced by runoff and a relatively high water table. The ditches in the area appear to have been put in place for offsite and onsite drainage control. All of the ditches contained flowing water at the time of the delineation.

The NJDEPE requires transition areas around all wetland boundaries. The width of the transition area varies depending upon the type of classification assigned to the wetland by NJDEPE. Because there were no endangered or threatened plant or animal species identified in the area, the wetlands will not be classified as exceptional resource value wetlands. However, the wetlands within the site boundaries may be classified as freshwater wetlands of intermediate or ordinary resource value, and, therefore, may have a 50-foot transition area assigned to them.

3.2 Meteorology

The following meteorologic information was obtained from the *Passaic River Mainstem Report* (Assistant Secretary of the Army).

The RI study area lies on the eastern edge of the Passaic River Basin. The climate of the basin is characteristic of the entire Middle Atlantic Seaboard. Changes in weather conditions are often frequent, with these changes occurring particularly in the spring and fall. Winters are generally moderate, with moderate amounts of snowfall. The basin is subject to moderate summers with hot and sultry mid-summer days and frequent thunderstorms. The rainfall in the basin is moderate and is distributed throughout the year. There are approximately 120 rainy days per year, and relative humidity is high. The average annual temperatures range from 49 degrees Fahrenheit (F) at Charlotteburg to 54 degrees F at Newark. Extreme temperature changes range from -26 degrees F to +108 degrees F. The growing season averages 171 days per



STEPAN COMPANY AND SEARS AND ADJACENT PROPERTIES RI
MAYWOOD, NEW JERSEY

FIGURE 3-1
WETLAND BOUNDARY MAP
DELINEATED APRIL 20-21, 1992
SURVEYED APRIL 22-24, 1992

year. The mean annual relative humidity ranges from 67 percent to 73 percent. Prevailing winds are generally from the northwest at an average annual velocity of approximately 9.7 miles per hour.

The average annual precipitation within the basin is approximately 47.3 inches. Extreme annual precipitation values were observed at 85.99 inches in Paterson in 1882, and 25.26 inches at Morristown in 1930. Monthly precipitation extremes were 25.98 inches in September 1882 in Paterson, and 0.02 inches in Plainfield and Jersey City in June 1949. The distribution of precipitation during the year is fairly uniform, with higher amounts during the summer months.

The average annual snowfall within the basin is approximately 34.2 inches. This is equivalent to about 4 inches of rainfall. The Highland Area is subject to the longest snow season, which is from October through mid-April.

3.3 Regional Geology

The study area is located within the Piedmont Physiographic Province, which is a subdivision of the Appalachian Province. The Piedmont Province is separated from the Highlands Physiographic Province to the west by a northeasterly trending border fault also known as the Ramapo fault. To the east, the Piedmont Province is bordered by generally flat lying sediments of the Coastal Plain Physiographic Province. The contact of the Piedmont Province with the Highlands Province is marked by a steep mountain scarp, as the rocks forming the Highlands Province consist of more resistant metamorphic rocks of Precambrian age. Because of the nature of the rocks, the Highlands Province is a dissected, high relief, mountainous region higher in altitude than the adjacent Piedmont Province.

The Piedmont Province in New Jersey is also known as the Newark Basin, which is a northeast-southwest trending basin formed as a result of extensional rifting during the opening of the Atlantic Ocean (Olsen). The basin is approximately 140 miles long and has its maximum width of 32 miles along the Delaware River (Van Houten). The Piedmont Province is topographically low and smooth in relief, having its highest elevation along the border fault at the western margin and generally sloping southeastward.

The Newark Basin is primarily composed of sedimentary rocks, known as the Newark Group, that consist of sandstones, shales, mudstones, and conglomerates that represent depositional cycles during late Triassic and early Jurassic periods. The sedimentary rocks of the Newark Group lie unconformably on Paleozoic and Precambrian rocks. The sedimentary rocks represent various nonmarine depositional environments. The sandstone and shales were deposited in fluvial, flood, and alluvial fan environments. Conglomerate is found as river channel lag deposits or thick alluvial fan deposits generally along the border fault. Black and grey bioturbated limy shales are indicative of playa lake deposits. These rocks are arranged in fining

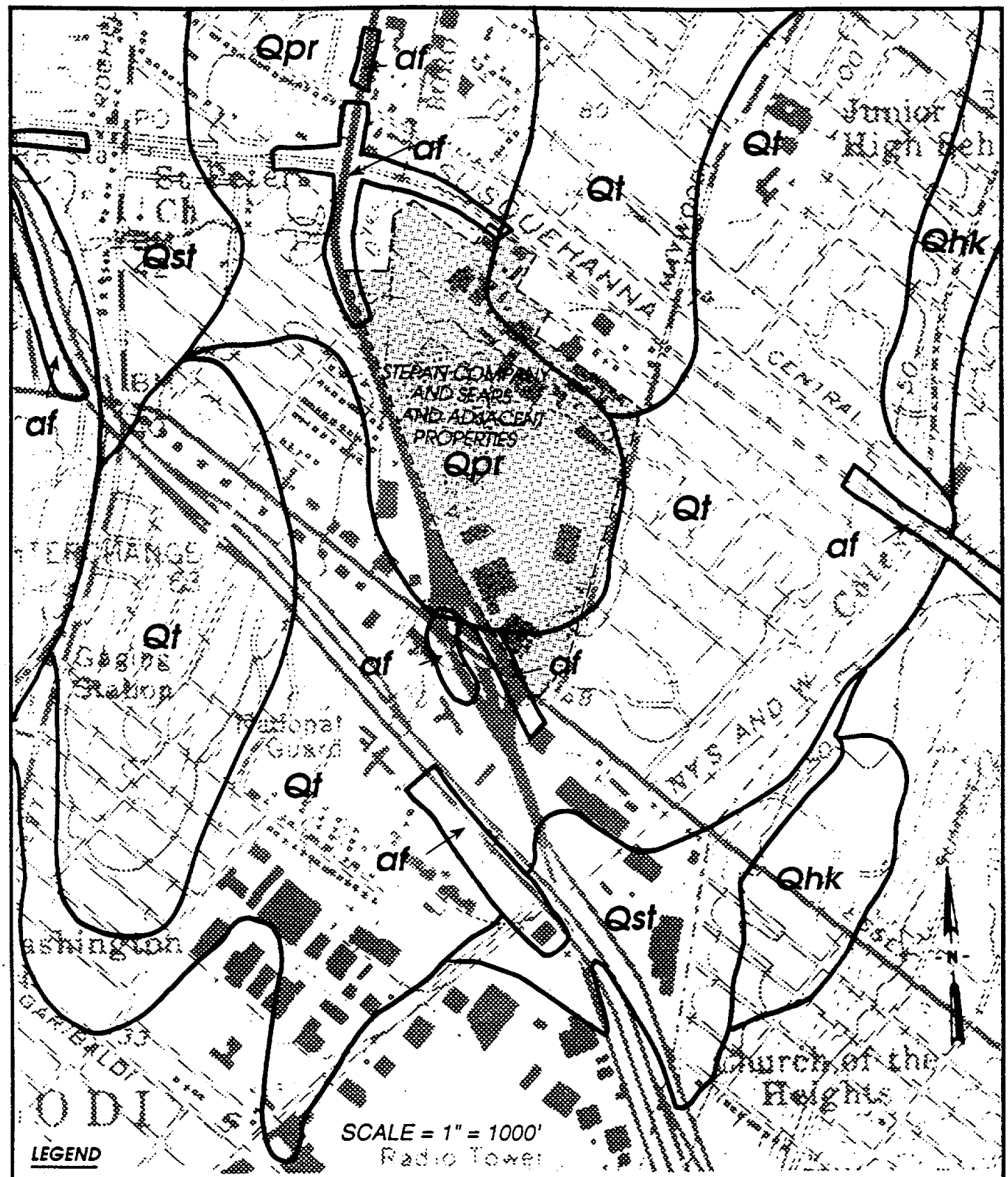
upward cycles up to 320 feet thick. During the Triassic period, the sedimentary sequence was intruded by the igneous basalt sheet lava flows forming the Watchung and Hook Mountains, which contributed to the high topographic points within the generally rolling and undulating plains within the basin. The structure of the Newark Basin and the normal faulting that causes maximum displacement along the northwest edge have contributed to the exposure of the progressively younger rocks toward the northwest. Along the southeastern margin, the basin is overlapped by unconsolidated sediments of the Coastal Plain Province.

The Newark Basin is a north-northeast trending half graben with both the basalt and sedimentary rocks dipping between 7 and 15 degrees to the northwest. The basin is characterized by the presence of regional and local plunging synclinal and anticlinal structures mostly occurring around basalt formations and north-northwest and northeast trending strike-slip faults. The sedimentary rocks are covered with glacial, lacustrine, and fluvial unconsolidated deposits.

3.3.1 Unconsolidated Deposits

The bedrock in the Newark Basin is generally concealed beneath unconsolidated materials that were deposited largely during the last (Wisconsin) glaciation during the Pleistocene Epoch. As the glacier advanced and retreated, it caused realignment of the drainage systems and significantly modified surface topography. As the glacier retreated, crustal downwarping, beneath the glacier, combined with blockage of the drainage by the terminal moraine to the south, caused ponding of the melt water, which formed many retreated lakes such as Lakes Passaic, Paramus, and Hackensack. Lake Hackensack was formed in the area of the present Newark Bay and Hackensack Meadows and extended northward into Rockland County, New York. Such lakes provided the lacustrine depositional environment for varied silts and clays before the outlets were formed that drained the lakes. From the available data (Stanford), it is indicated that Lake Paramus occupied the Saddle River area from Ridgewood to Rutherford (New Jersey) and that it occupied about half of the site south of the railroad tracks located north of the Sears building. According to Stanford, these deposits include deltaic sands and gravels.

The glacial deposits are composed of boulders, gravel, sand, silt, and clay and are mostly derived from the crystalline highlands to the north and the local sedimentary bedrock. The deposits can be generally divided into stratified and unstratified glacial deposits (till) . Till is generally composed of unsorted mixtures of sand, gravel, silt, and clay that were transported by the glacier and deposited directly onto the land surface. Streams of melt water issuing from the stagnating and retreating glacier formed stratified deposits consisting of sand, gravel, silt, and clay. The sediments were transported by water and deposited in contact with the ice or as outwash in floodplains, deltas, and as fine sediments in lakes during and after the retreat of the ice. Figure 3-2 is a map, taken from Stanford, of the glacial deposits in the vicinity of the site.



LEGEND

- Qt - TILL
- af - FILL
- Qpr - GLACIAL LAKE PARAMUS DEPOSITS
- Qst - STREAM TERRACE DEPOSITS
- Qhk - GLACIAL LAKE HACKENSACK

STEPAN COMPANY AND SEARS AND ADJACENT PROPERTIES RI
MAYWOOD, NEW JERSEY

SOURCE: STANFORD N.J.G.S.

FIGURE 3-2
GLACIAL DEPOSITS NEAR THE STUDY AREA
TAKEN FROM THE USGS HACKENSACK N.J. QUADRANGLE
7.5 MINUTE SERIES (TOPOGRAPHIC)

Unstratified Deposits. Till deposits range from light gray, to very pale brown, to yellow or reddish-brown silty sand, sandy silt, or sand with minor silt and clay containing about 5 to 20 percent pebbles, cobbles, and boulders. The sediments are generally unsorted and unstratified and compacted with silt and clay. The gravels are generally subangular to subrounded. Two different till units are found; one of these is a compact (lodgement) till exhibiting a platy, sub-horizontal foliation. The compact till is, in many cases, overlain by a noncompact, more sandy till. The noncompact till may contain as much as 40 percent gravel with thin beds of sorted and stratified sand and gravel. Approximately 50 to 90 percent of the gravel is derived from the local bedrock. Compact till occurs typically in till ramps on hillslopes that faced advancing ice, in drumlins, as sheet deposits on wide lowland areas, and in moraines. Noncompact till is commonly found as a thin discontinuous veneer overlying compact till and bedrock.

According to Stanford's unpublished surficial geological map of the Hackensack quadrangle, till found in the northern part of the study area is known as the Rahway Till. This till is composed of reddish-brown silty sand to clayey silt and was formed from red sandstone and mudstone of the Brunswick Formation. This till is reported to be in contact with glacial lake deposits across the middle of the study area, roughly along the railroad tracks on the north side of the Sears building.

Stratified Deposits. Stratified deposits include kames, which were formed at the ice contacts; coarse outwash deposits; and lake deposits. According to Stanford, glacial Lake Paramus deposits are found across the southern half of the study area. As stated above, its contact with the Rahway Till is along a line that is roughly commensurate with the north side of the Sears building.

Lake Paramus deposits consist of deltaic sands and gravels that can be as thick as 80 feet; lacustrine fan sand and gravel as thick as 20 feet; and lake-bottom silt, clay, and fine sand as thick as 70 feet. The areal extent of Lake Paramus deposits is reported to be from Ridgewood to Rutherford.

3.3.2 Bedrock

The sedimentary rocks of the Newark Group have been divided into three formations on the basis of distinctive lithology: a lower unit, the Stockton Formation; a middle unit, the Lockatong Formation; and an upper unit, the Brunswick Formation. These sediments were deposited in fluvial and lacustrine environments and grade upward from the lower, locally conglomeratic arkose (Stockton Formation) into a reddish-brown mudstone deposit (Brunswick Formation) (Van Houten).

Stockton Formation. The Stockton Formation is largely composed of fluvially deposited gray, red, and buff, medium-to-coarse-grained, feldspar-rich, cross-bedded sandstone with inclusions of red mudstone, siltstone, and fine sandstone. The Stockton is conformably overlain by the Lockatong Formation.

Lockatong Formation. The Lockatong Formation is generally composed of gray and black siltstones and mudstones. Because its color is much darker than that of the overlying Stockton Formation, its contact is very marked. The formation exhibits two distinct types of sedimentary cycles: detrital and chemical. The detrital deposits are represented as mudstones composed of abundant sodium feldspar, illite, and chlorite. The chemical deposits are composed of abundant carbonates. The formation is about 90 feet thick in North Bergen and presumably thickens southward to about 3,750 feet in western New Jersey and adjacent eastern Pennsylvania.

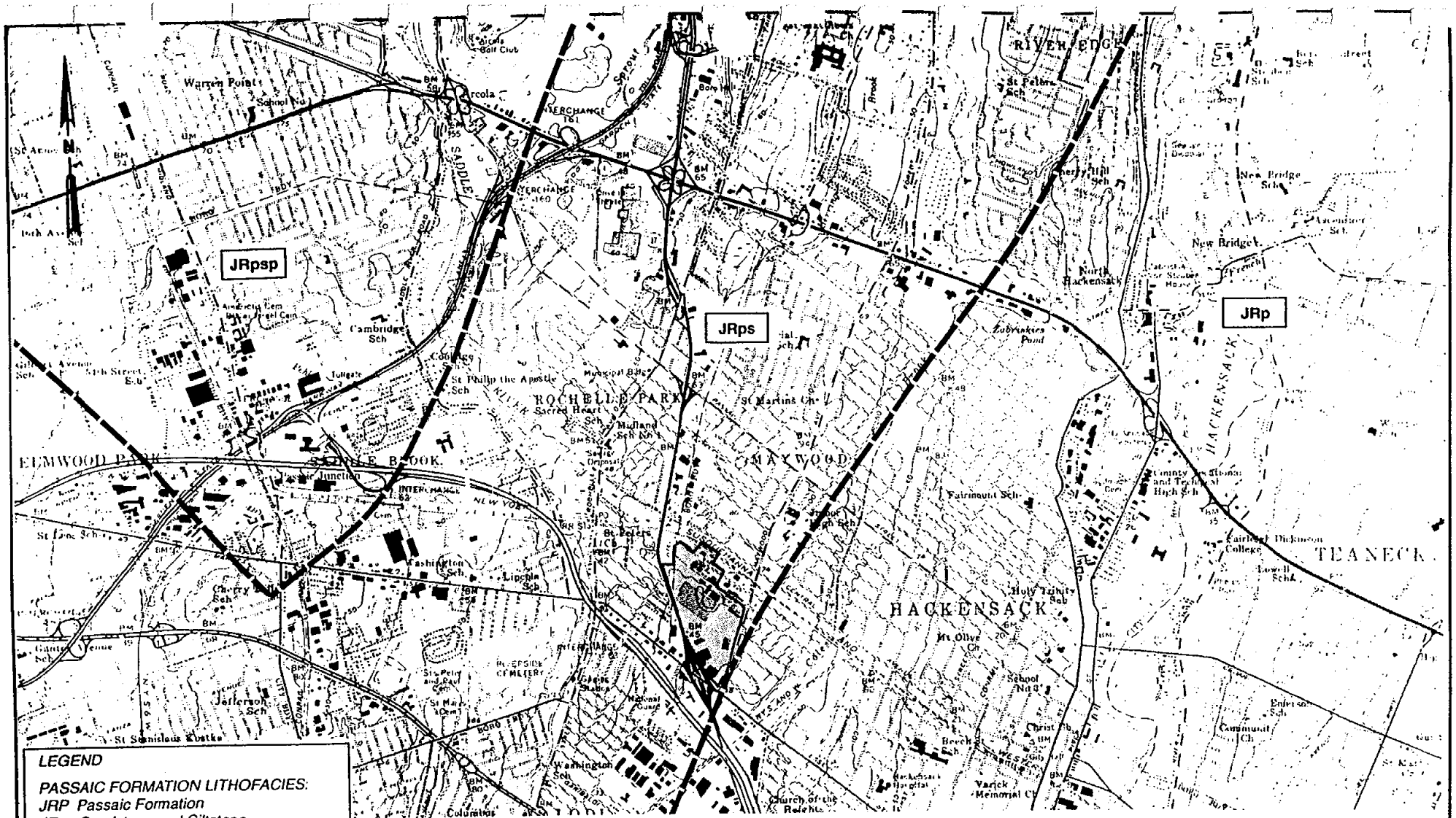
Brunswick Formation. The Lockatong Formation conformably grades into the Brunswick Formation, which consists largely of reddish-brown mudstone, siltstone, sandstone, and conglomerate. Red siltstone and mudstone dominate the sedimentary facies of the Brunswick Formation. The deposits gradually become coarser grained to the north, as evidenced by the presence of sandstone and conglomerate beds in the northern part of the Newark Basin.

Also found within the Brunswick Formation are basalt flows emplaced contemporaneously with the sediments, and post-depositional diabase and gabro sills and dikes. The thickness of the Brunswick Formation in the region of the study area is not known. It has, however, been estimated that in the Newark area, located south of the Saddle River drainage basin, the Brunswick Formation can be as thick as 6,000 to 7,000 feet (Herpers and Barksdale).

Nomenclature for the Brunswick Formation has recently been revised. Olsen has recommended abandoning the use of the Brunswick Formation and subdividing it into nine individual formations with new names. This has been accepted by the United States Geological Survey (USGS), provided these formations can be collectively described as the Brunswick Group. The New Jersey Geological Survey (NJGS) prefers that the Brunswick Formation be retained and recommends the use of the subdivisions to describe members of the formation. Only one of the NJGS subdivisions is present in the study area region: the Passaic Member. The Passaic Member is stratigraphically equivalent to the pre-basalt portion of the Brunswick Formation.

The Passaic Member consists of mudstones, siltstones, sandstones, and conglomerates deposited in chemical and detrital cycles. According to Parker and Houghton (unpublished bedrock geological map of the Hackensack quadrangle), the Passaic Member of the Brunswick Formation is composed of three lithofacies, the Passaic Facies, the Sandstone and Siltstone Facies, and the Sandstone and Pebbly Sandstone Facies. The position, contacts, and orientation of these lithofacies in the study area region are shown in Figure 3-3.

The Passaic Facies. The Passaic Facies is the oldest facies and is characterized as reddish-brown to brownish-purple and grayish-red-argillaceous siltstones, silty mudstones, argillaceous very fine-grained sandstones, and shales. Lake deposits consisting of gray-to-black silty mudstone, gray and greenish-to-purplish-gray



STEPAN COMPANY AND SEARS AND ADJACENT PROPERTIES RI
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FIGURE 3-3
OUTCROP OF THE PASSAIC FORMATION LITHOFACIES NEAR THE STUDY AREA

argillaceous siltstones, black shales, and medium-to-dark-gray argillaceous fine-grained sandstones are abundant in the lower half of the facies and are less common and thinner in the upper half. Red beds occur typically in 10- to 23-foot-thick cyclic playa-lake-mudflat sequences and fining-upward fluvial sequences. Gray lake beds are mostly 6 to 15 feet thick and generally occur in groups of two to five cycles. The Passaic facies has an attitude of approximately 15 degrees east of north, and its contact with the Sandstone and Siltstone Facies, which underlie the site, is about 1,000 feet west of the study area.

The Sandstone and Siltstone Facies. The study area is underlain by the Sandstone and Siltstone Facies of the Passaic Member. This facies is characterized by grayish-red-to-brownish-red, medium-to-fine-grained sandstone beds 1.5 feet to 15 feet thick, with pebble layers or scattered pebbles (mostly quartzite) interbedded with brownish-to-purplish-red coarse-grained siltstone. The siltstone is indistinctly laminated or ripple cross-laminated, irregularly fissile, and calcareous in places (6 to 15 feet), with thick fining-upward cycles of fluvial channel fill and overbank deposits. Some siltstone beds contain desiccation cracks, or root casts, characteristic of fossil soils. The sandstone beds are coarser and thicker in the vicinity of alluvial fan-conglomerate sequences. The maximum thickness in the northern Newark Basin is about 3,610 feet. The average orientation among 10 strike and dip measurements in the area is North 26 degrees East 9 degrees dip northwest.

Sandstone and Pebbly Sandstone Facies. The youngest facies of the Passaic Member near the study area is the Sandstone and Pebbly Sandstone Facies. The contact of this facies with the Sandstone and Siltstone Facies is reported to be about 1 mile northeast of the site. This facies is characterized as a brownish-red, medium-to-coarse-grained, feldspathic sandstone with horizontal planar laminations and low-angle trough cross laminations. The sandstone contains scattered pebble layers, mostly in fining-upward sequences 1.5 to 8 feet thick. Thick sequences have scoured bases and pebble lags. Thin sequences fine upward from fine sandstone to micaceous siltstone. The thickness of this facies is reported to exceed about 2,600 feet in the northern Newark Basin.

3.4 Geology of the Study Area

Activities geologic characterizations, and observations set forth here in Section 3.4 and in Sections 3.4.1 through 3.4.4 stem from the RI. Section 3.4.5 described geologic conditions encountered during the Focused Investigation.

In the study area, 44 soil borings, 129 test pits, and 32 boreholes were drilled to or into the bedrock for well installation in the study area. The data from the exploratory program, as well as field observations and available data, were used to describe the geologic conditions in the study area and to prepare subsurface cross sections across selected locations. Soil boring logs are presented in Appendix D. Rock coring logs

are presented in Appendix P. Monitoring well construction diagrams for shallow overburden and bedrock wells are provided in Appendix J. The cross section lines are shown in Figure 3-4; the cross sections are shown in Figures 3-5 and 3-6.

As described in Section 3.3.2, the Passaic Member of the Brunswick Formation underlies the unconsolidated formations at the site. The subsurface materials encountered during the exploration program can be broadly grouped into three units: Fill and Recent (Holocene) Deposits; Glacial Deposits (including both stratified and unstratified sediments; Pleistocene); and the Bedrock, which represents the Passaic Formation (Triassic-Jurassic).

The fill and recent deposits sometimes graded imperceptibly into the underlying stratified glacial deposits. Difficulty in differentiating the two deposits led to the convention of including all of these relatively loose, well sorted deposits in one unit called the Recent Age deposits and stratified glacial deposits.

Similarly, between the glacial deposits and the underlying bedrock, a layer of residual soil was encountered in the borings at the study area. The residual soil layer is defined here as the soil horizon that resulted from very severely to complete weathering of the upper portions of the underlying bedrock. It consists of sandy and silty material with fragments of the underlying rock formation. It also was demarcated by a relatively sharp increase in blow counts. Because the contact of this layer with the overlying unstratified deposits was difficult to differentiate during the exploratory program, this layer was included with the unstratified deposits (till) in the generalized subsurface cross sections.

3.4.1 Fill and Recent Deposits

Fill materials were encountered in almost every boring, from the surface to depths ranging from 2 feet in C-30 (Federal Express) to 12 feet in C-38 (Stepan). The variation in thickness is attributable to the location of the boring. Boring C-30, for example, is located at the southern boundary of the study area, where bedrock is within about 2 feet of the ground surface and forms a topographic high. Boring C-38 is located near radiological burial site No. 1. Considerable filling has occurred in this area. Fill materials encountered in the borings across the study area, were found to vary from clays to coarse sands containing brick fragments, black and white mottled clay, concrete chips, wood chips, and other miscellaneous materials. However, in some areas of the study area the fill was free of cinder block pieces and wood and concrete chips, which suggests it is more of an engineered fill.

Recent Age Deposits were found below the fill materials and above the glacial deposits. Recent Age deposits consist of sands, silts, clays, and localized peat and were often difficult to differentiate from the fill in areas where engineered fill was placed. This difficulty in differentiation makes it impossible to quantify the thickness of the Recent Age deposits and fill. In the eastern part of the Sears property, marsh deposits (peat and clayey silt) were encountered in four borings (C-16, C-17, C-19,

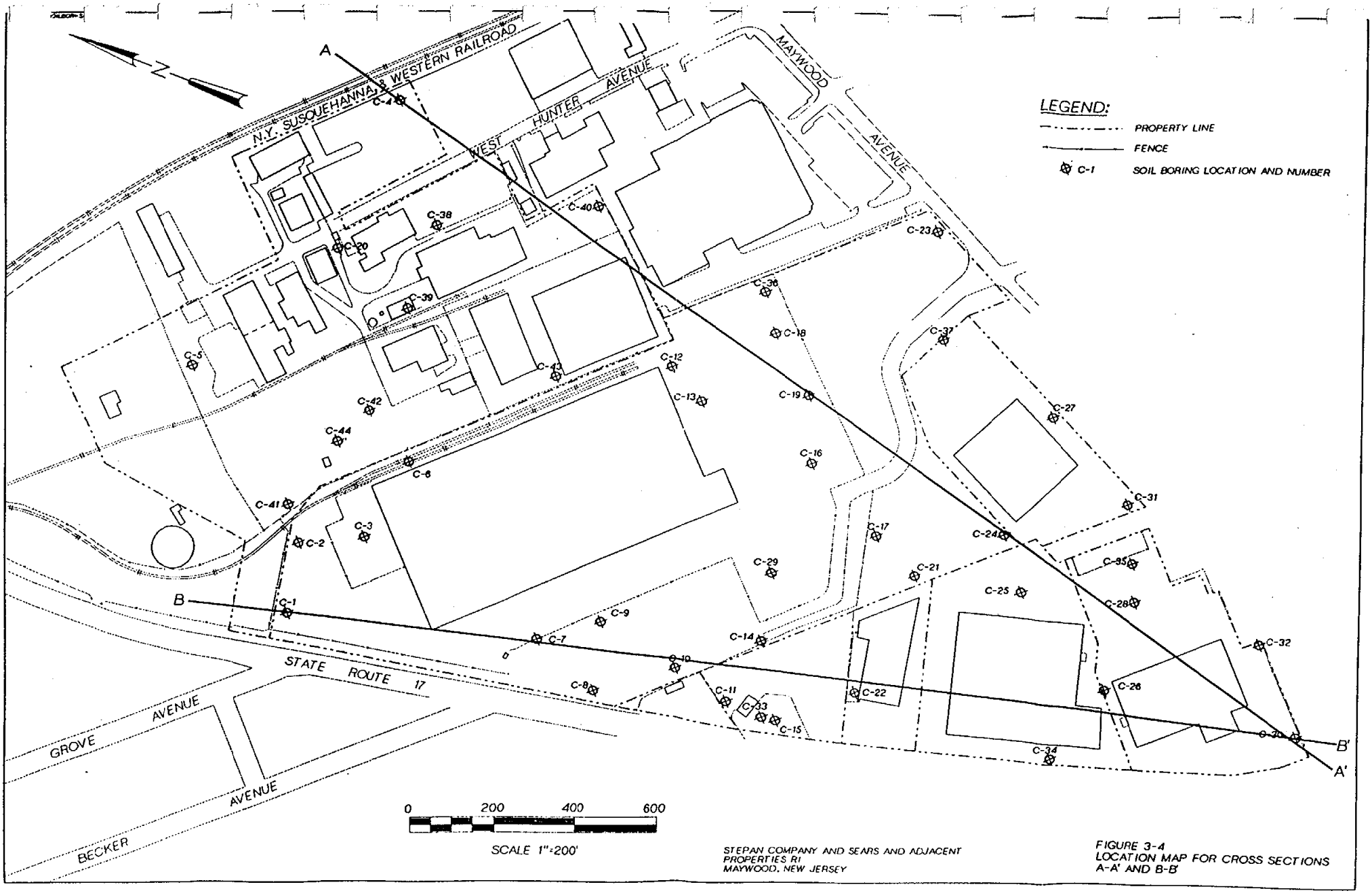
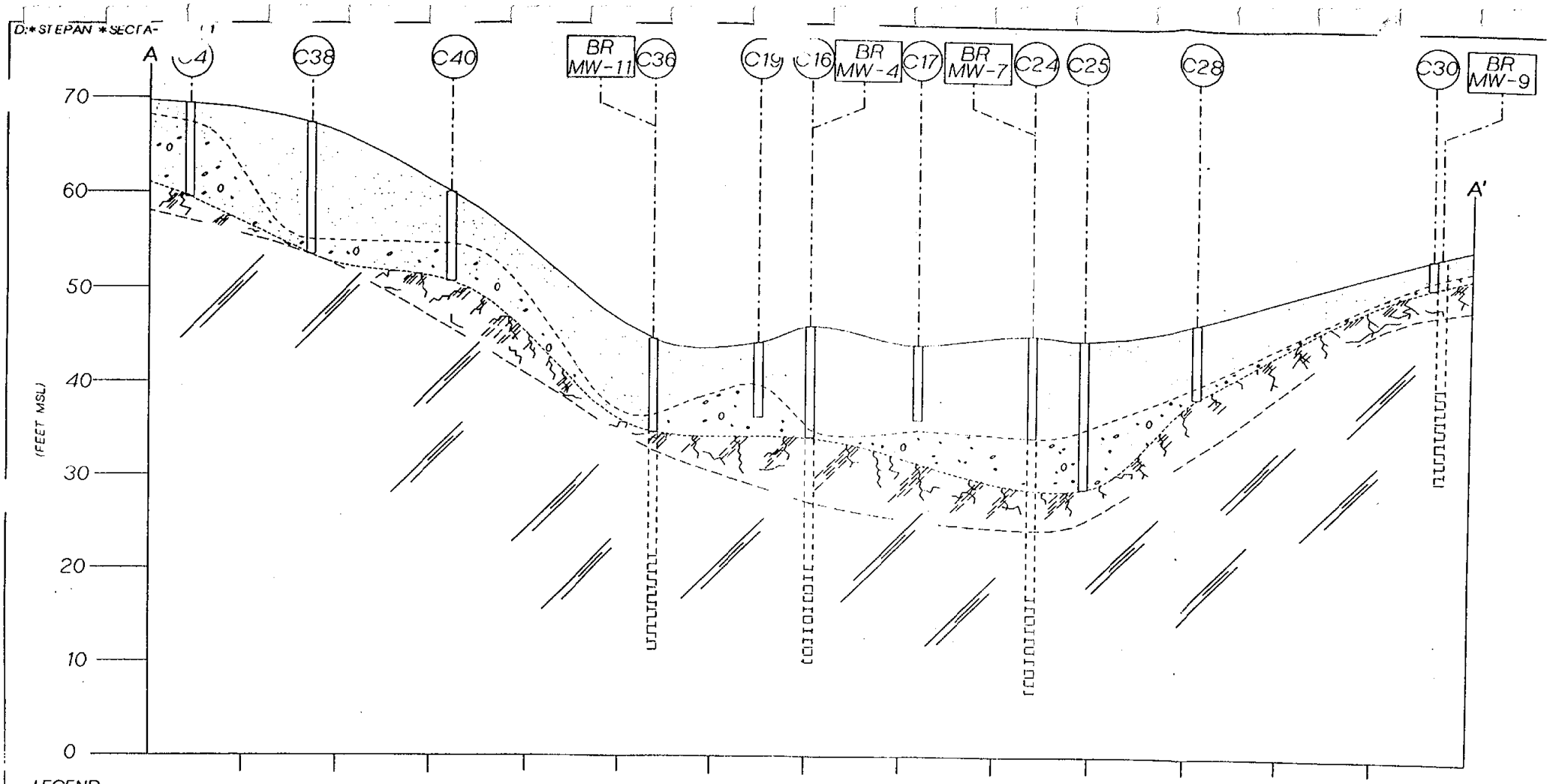


FIGURE 3-4
LOCATION MAP FOR CROSS SECTIONS
A-A' AND B-B'



LEGEND

- RECENT DEPOSITS AND STRATIFIED GLACIAL DEPOSITS
- TILL AND OR RESIDUAL SOIL
- MODERATELY TO SEVERELY WEATHERED ROCK
- RELATIVELY COMPETENT ROCK (REPRESENTS APPARENT DIP)
- BR MW-11 — BEDROCK MONITORING WELL AND SCREEN
- C4 — EXTENT OF SOIL BORING

NOTE: CONTACTS DETERMINED BY BLOW COUNTS, DRILLING SPEEDS, AND LITHOLOGIC DESCRIPTIONS.

VERTICAL SCALE 1 "=10'
HORIZONTAL SCALE 1" =200'

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FIGURE 3-5
CROSS SECTION A-A'
ACROSS STUDY AREA
SHOWING GENERALIZED GEOLOGY

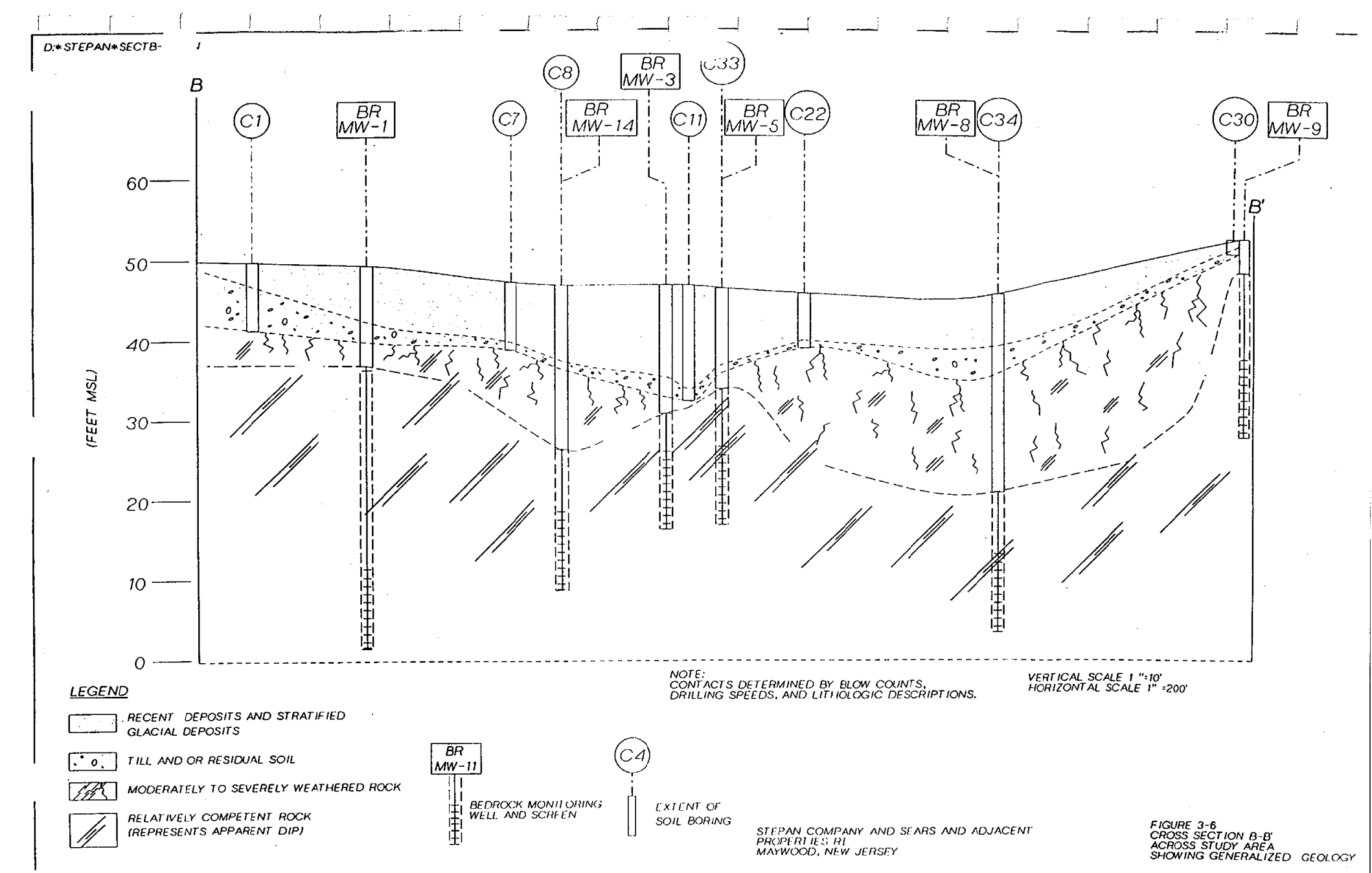

FIGURE 3-6
CROSS SECTION B-B'
ACROSS STUDY AREA
SHOWING GENERALIZED GEOLOGY

and C-36). A 6-inch-thick layer of peat was observed from approximately 3.5 to 4 feet BGS within the wooded area of the DeSaussure property. Gray clayey silt deposits occurred beneath the peat. These marsh deposits are relatively thin (0.5 to 2.5 feet); their extent is limited to the wetland areas identified on the eastern side of the Sears building and the wooded area on DeSaussure.

3.4.2 Glacial Deposits

Deposits of both stratified and unstratified glacial drift were encountered during the soil boring program. On the properties south of Sears, the fill and recent deposits sometimes graded imperceptibly into the underlying stratified glacial deposits. The difficulty in demarcating the exact contact between the two led to the convention of including all of these relatively loose, well sorted, layered deposits as one unit on the subsurface cross sections. On cross sections A-A' and B-B', this unit is referred to as Recent Age deposits and stratified glacial deposits.

According to Figure 3-2, the northern part of the site (north of the railroad tracks along the Sears building) is underlain by Rahway Till. In this area, it was difficult to differentiate the till deposits from the underlying horizon of the residual soil.

As discussed earlier, the residual soil layer was developed from severe to complete weathering of the upper portions of the underlying bedrock. Decomposition of the bedrock from infiltration of relatively highly acidic, highly oxygenated rainwater resulted in transformation of the indurated top of rock to a horizon that exhibits predominantly soil properties. Differential weathering processes dictated by variation in the host rock's grain size, porosity, and mineralogy resulted in a relict bedrock horizon that is alternately indurated and unconsolidated. In many places, the rock fabric is clear and evident but reduced in strength to that of a soil. In other places, the fabric is virtually nondiscernible. In order to prepare cross sections, because of similar properties, the till and residual soil were grouped into one horizon called unstratified glacial deposits (till) and residual soil. The top of this horizon is characteristically indicated by a significant increase in blow counts during split-spoon sampling, dark reddish-brown clay, silt, sand, or siltstone and sandstone. The bottom of this horizon is defined as the depth of auger refusal. The residual soil is underlain by the moderately to severely weathered bedrock of the Passaic Formation.

South of the railroad tracks, where Rahway Till is not present, the stratified drift and deposits of Lake Paramus, overlie the residual soils.

3.4.3 Laboratory Soil Testing Results

During the soil boring program, three soil samples were collected and subsequently tested to determine the physical characteristics of two horizons identified during the RI: Recent Deposits and Stratified Glacial Deposits (C-24, Sears; C-26, Federal

Express) and Till and/or Residual Soil (C-31, DeSaussure). The testing consisted of grain size analysis by wash sieve and hydrometer, atterberg limits, and moisture content.

The results of the laboratory soil testing are presented in Table 3-1. As the results indicate, it is difficult to differentiate the Recent Age deposits horizon and stratified glacial deposits from the till and/or residual soil horizon. The data packages associated with the laboratory testing are included in Appendix Q.

3.4.4 Bedrock (Passaic Formation)

Bedrock, as defined by auger refusal, was encountered as shallow as 2 feet (C-30, Federal Express) to 16 feet (C-25, SWS). The depth to bedrock beneath Stepan ranged from 3.5 feet (C-5) to 15 feet (C-42). The boundary between the bottom of the residual soil and glacial till and the top of bedrock is transitional. For the most part, the contact was well represented by the depth of auger refusal during the soil boring program and is represented as such on the cross sections. It is possible, however, that auger refusal in some cases resulted from a sizable rock fragment within the residual soil and till, which would have caused a false determination of the top of the weathered rock. The top of bedrock shown in cross sections A-A' and B-B' may, therefore, be indicated as higher in some cases than it actually is.

Bedrock drilling was conducted using water or mud rotary-drilling methods after soil augering. During drilling, it was observed that the upper portion of the bedrock generally was weathered from moderate to moderately severe. The thickness of this zone varied from 0.5 feet (BRMW16, Stepan) to 15 feet (BRMW8, Sunoco). The bottom of this weathered zone was defined as the depth after which 5 feet of hard drilling was encountered. The surface casing was also required to be installed 5 feet below competent rock. On cross sections A-A' and B-B', this zone is labeled as moderately to severely weathered rock. Competent bedrock was encountered below this zone.

The contours of the top of rock encountered in borings in the study area are shown in Figure 3-7. The surface is generally a reflection of the topography of the study area. On the basis of ground-surface elevation at the boring locations, it is indicated that an elevation difference of about 31 feet exists across the property between boring location C-4 (Stepan) and C-25 (SWS). The bedrock elevation difference between northern and southern property boundaries at Stepan varies about 11 feet. However, south of the railroad tracks at Sears, an additional drop of about 12 feet in elevation is indicated. In the vicinity of the wetland area east of the Sears building, the top of rock forms a subtle depression. Across Sears, the top of rock is relatively flat and contains occasional depressions.

The core logs showed a pattern of fining upward cycles of reddish-gray sandstone, siltstone, and mudstone. The thickness of the individual beds was found to range from less than 1 foot to over 20 feet (core log BRMW17). The predominant bedrock

Table 3-1
LABORATORY SOIL TESTING RESULTS

Boring No.	Property	Depth (ft)	Soil Horizon	Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Liquid Limit	Plasticity Index	Moisture (%)	USGS [a]
C24	Sears	4-6	Recent and Stratified Glacial Deposits	0	29	63.3	7.7	20	1	15.4	ML
C26	Federal Express	0-6	Recent and Stratified Glacial Deposits	6.7	64.4	21.1	7.8	17	2	13.7	SM
C31	DeSaussure	8-10	Till and/or Residual Soil	13.3	48.5	26.8	11.4	17	2	11.5	SM

[a] USCS = Unified Soil Classification System

Notes:
ML = Silt with low liquid limit
SM = Silty sand

found in most of the borings consisted of fine to very fine sandstone, which grades upward into muddy siltstone and, in some cases, into mudstone. These cycles are usually 3 to 7 feet thick and are marked by erosional contacts on the top and bottom. Erosional contacts are marked by clay-chip conglomerates, thin zones of disrupted and convoluted bedding, and scour surfaces.

The sandstones are composed of quartz, sodium feldspar, orthoclase, mica, and trace amounts of metallic and nonmetallic opaque minerals. Along most of the sandstone beddings, red staining was observed in the cores. This indicated the presence of hematite, which also composes a large percentage of the opaque minerals. Finer sandstone beds often contain large amounts of interstitial matrix material, which has been identified as illite and kaolinite (Schlische and Olsen). Many of the sandstone beds appeared to be cemented with calcite or silica. None of the cored sandstone units exhibited significant evidence of primary porosity. Overall bedrock quality was good to excellent, with RQD values ranging from 60 to 100 percent. Siltstone and mudstone beds were usually hard and massive but exhibited general fissility, with relatively more fracturing than the sandstones and a high degree of weathering.

At four boring locations (BRMW2, BRMW13, BRMW8, and BRMW17), the bedrock was cored to provide a better description of the bedrock lithology. The geophysical logs were compared to the core logs at each of the four coreholes to constrain log signatures to specific lithologies. Figures 3-8 and 3-9 depict a schematic comparison of log signatures and core lithology. The probable core lithology presented in the figures is not precise but is intended to demonstrate the thickness and variability of bedding. The geophysical logs are provided in Appendix K. Generally, log signature correlation to specific lithologies and bed thickness was good. The natural gamma log exhibited the greatest sensitivity to changes in lithology and appeared to be capable of detecting individual beds less than a ½-foot thick. Some distortion can be observed at specific contacts and is probably attributable to edge effects in the borehole and subtle rather than abrupt changes in lithology. Edge effects are separated into two categories: extraneous effects from changes in the borehole diameter and effects from composition of the borehole fluid. Additionally, in arkosic sandstones, natural gamma signatures can be affected by orthoclase content, which can contain gamma emitting radioisotopes such as potassium-40. Effects from either category could cause the slight displacement of the contacts observed in Figures 3-8 and 3-9.

Correlation of core logs with natural gamma signatures indicated that a hypothetical shale or siltstone line occurs around 100 API units. Signatures with values below 100 API units are usually sandstones, and those above are siltstones or mudstones. This correlation was used to produce general lithologic profiles at bedrock borings where coring was not conducted. The 16-inch normal resistivity log was useful in identifying thicker beds and abrupt changes in lithology. Comparison of the natural gamma and 16-inch normal resistivity signatures was useful for inferring quartz content (highly resistive), orthoclase content (higher gamma values than usual for arksoic sandstones)

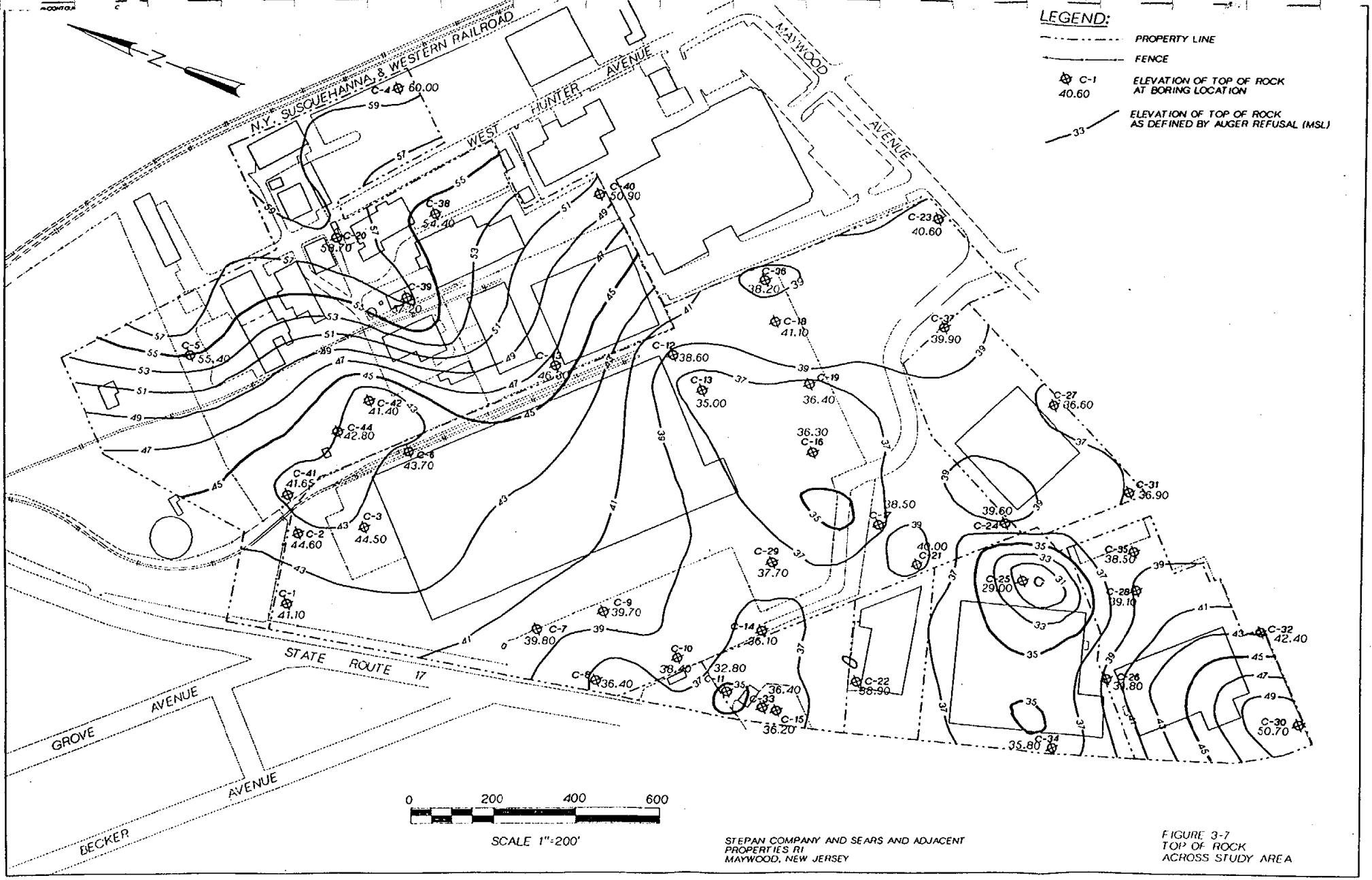

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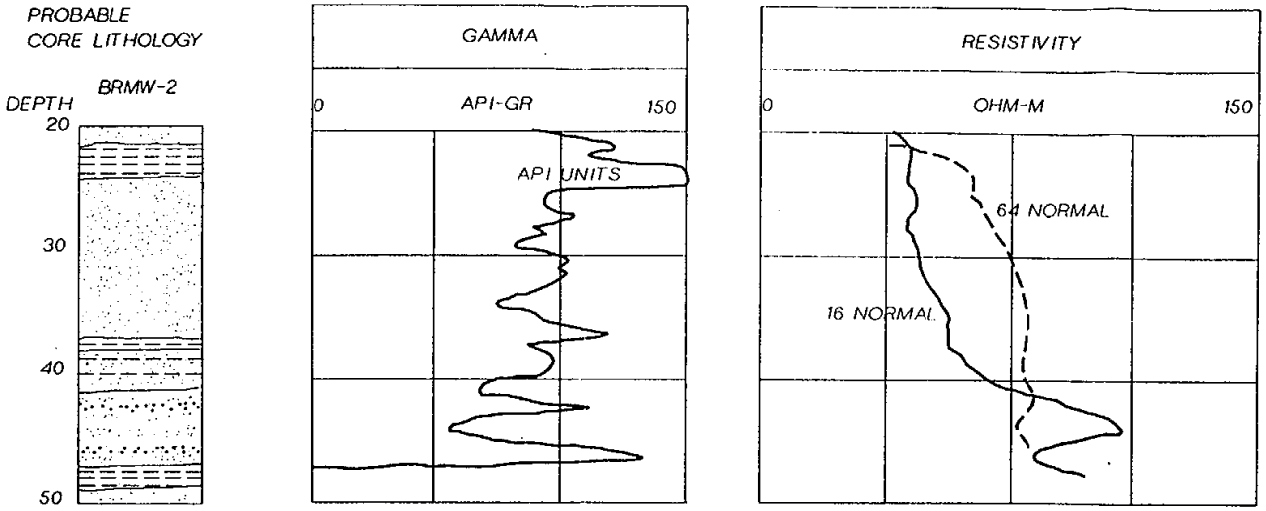
FIGURE 3-7
TOP OF ROCK
ACROSS STUDY AREA



NOTE: THE PROBABLE CORE LITHOLOGY PRESENTED IN THIS FIGURE IS NOT PRECISE BUT IS INTENDED TO DEMONSTRATE THE THICKNESS AND VARIABILITY OF BEDDING.

LEGEND:

- MUDSTONE
- SILTSTONE
- FINE SANDSTONE
- MEDIUM SANDSTONE
- COARSE & PEBBLY SANDSTONE

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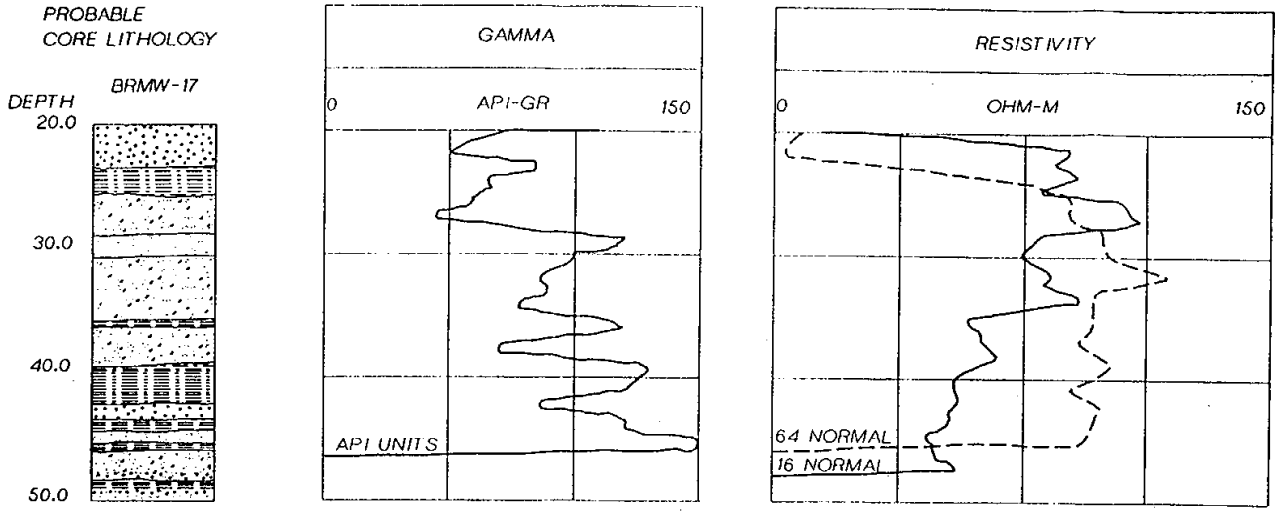
MAYWOOD, NEW JERSEY

FIGURE 3-8
CORRELATION OF CORE LITHOLOGY AND GEOPHYSICAL SIGNATURES FOR BRMW-2



NOTE: THE PROBABLE CORE LITHOLOGY PRESENTED IN THIS FIGURE IS NOT PRECISE BUT IS INTENDED TO DEMONSTRATE THE THICKNESS AND VARIABILITY OF BEDDING.

LEGEND:

- MUDSTONE
- SILTSTONE
- FINE SANDSTONE
- MEDIUM SANDSTONE
- COARSE & PEBBLY SANDSTONE

STEPAN COMPANY AND SEARS AND ADJACENT PROPERTIES RI
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FIGURE 3-9
SCHEMATIC CORRELATION OF CORE LITHOLOGY AND GEOPHYSICAL SIGNATURES FOR BRMW-17

and textural maturity in thicker sandstone beds. Assuming that borehole fluid resistivity was relatively uniform across the study area, a shale or siltstone line for the 16-inch normal resistivity log was established between 100 and 150 ohm-meters.

Because the core-holes across Stepan were relatively shallow, it was not possible to trace the down-dip of individual beds to allow correlation between bedrock boreholes. An exact orientation for the bedrock beneath the study area could not be calculated using geometric (three point) or stereographic methods. Recent mapping by the NJGS (Parker and Houghton), within the vicinity of Stepan, however, has revealed that the average orientation of bedding within the Passaic Formation is 26 degrees east of north, dipping to the northwest at about 9 degrees. Using this orientation and the geophysical logs as described above, generalized cross sections C-C' and D-D' were constructed to demonstrate the structure of bedrock in the study area. The section lines are presented in Figure 3-10, and the sections are presented in Figures 3-11 and 3-12. Section lines E-E' and F-F' are also presented in Figure 3-10 and will be discussed in 3.6.3. The location of Section C- C' was selected to be oriented sub-parallel to the strike of the bedrock . Section D-D' was selected for its sub-parallel orientation down-dip. Because of vertical exaggeration in Figure 3-12, the illustrated bedrock dip is exaggerated.

Cross section C-C' depicts the interbedded relationships of various lithologies sub-parallel to the strike. As is suggested by section C-C', with lateral movement, lithology also can vary significantly within individual beds. Medium sandstone beds appear to be thicker and more numerous on the north side of the site. The lithologic assignments in this section should be considered tentative because of the limitations of correlating geophysical logs with actual geologic conditions.

Mesoscopic fracture planes encountered within the core samples consisted of three distinct types: open fractures or joints, mineral-filled fractures or veins, and thin shear fractures marked by slickensides or breccia. Joints were the most common features encountered within the core. Joints were more abundant near the bedrock-overburden interface and less frequent as the rock became more competent and less weathered with depth. Most joints were shallow dipping and appeared to be bed partings. A second, less abundant set of joints appeared to be subvertical and normal to bedding, while a third set was moderately dipping (30 to 60 degrees). Joints oriented subparallel to bedding often exhibited extensive weathering and were often stained with limonite (red) or pyrolucite (black), or coated with mud. These features are diagnostic of alteration by mineral-laden groundwater, which suggests that joints parallel to bedding are the primary pathways for groundwater flow in the bedrock.

Mineral-filled veins were the second most common feature. These veins were fairly thin (less than 1 mm), and usually unweathered, suggesting they are not an important pathway for groundwater flow. Vein orientation was similar to the joint sets with three distinct orientations. The most common vein orientation was parallel to bedding. Most veins were filled with calcite or silica. Some of the veins subparallel to bedding appeared to be filled with gypsum.

The least abundant feature was shear fractures, which were identified by the presence of slickensides or thin breccia zones. Slickensided fractures were marked by calcite fiber slickenlines or tool and groove features. The small number of shear fractures identified in the cores were oriented subvertically. Shear fractures were relatively unweathered and because of their scarcity are probably not an important conduit for groundwater flow.

3.4.5 Geologic Conditions Encountered During Focused Investigation

Three primary types of overburden deposits were recognized during the Focused Investigation: miscellaneous fill, reworked Recent Age deposits and stratified drift (fill), and till and residual soil. These types are described below:

- The miscellaneous fill was encountered in the Aromatic and Essential Oils Manufacturing Area and in the Central Tank Farm Area, typically at the 1- to 4-foot soil horizon. Miscellaneous fill is similar to the fill described in Section 3.4.1.

- The recent deposits and stratified drift consisted of discrete units of organic silt, silty sand, sandy silt, and silty gravel deposits.

- The till and residual soil was encountered at the bottom of many borings. As described in Section 3.4, this horizon was characterized by an increase in blow counts and contained reddish-brown silt mixed with silty sandstone fragments.

Moist-to-wet conditions were observed at approximately 4 to 7 feet BGS. This depth correlates with water levels observed in nearby overburden monitoring wells.

3.5 Regional Hydrogeology

3.5.1 Topography, Drainage, and Hydrologic Basin

The study area is located within the Piedmont Physiographic Province, which is characterized by low topography and smooth relief. It attains its highest elevation along the border fault at its western margin and generally slopes southeastward (Assistant Secretary of the Army). The rolling and undulating plains are covered by glacial and post-glacial deposits and dissected by rivers of the Passaic Watershed and by the more resistant, flat-topped basaltic Watchung and Hook Mountains that contribute to the topography of the province. Many ridge and valley features are found in the region that are in part the result of preglacial stream and drainage channels. The orientation of these features is generally in a northeasterly direction, similar to the orientation of the strike of the rock. These channels were developed preferentially along the less resistant shales and mudstone sequences; the more

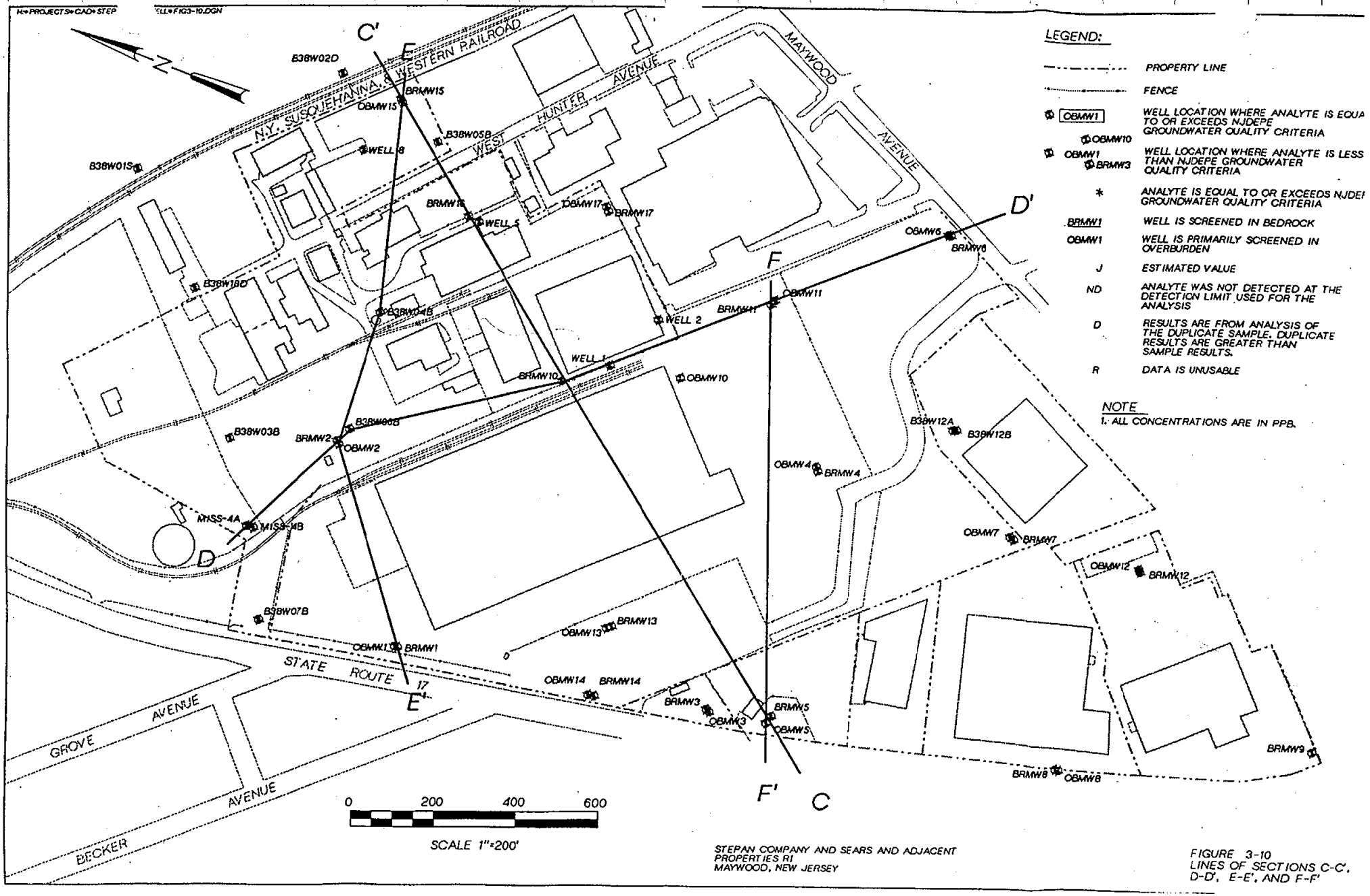

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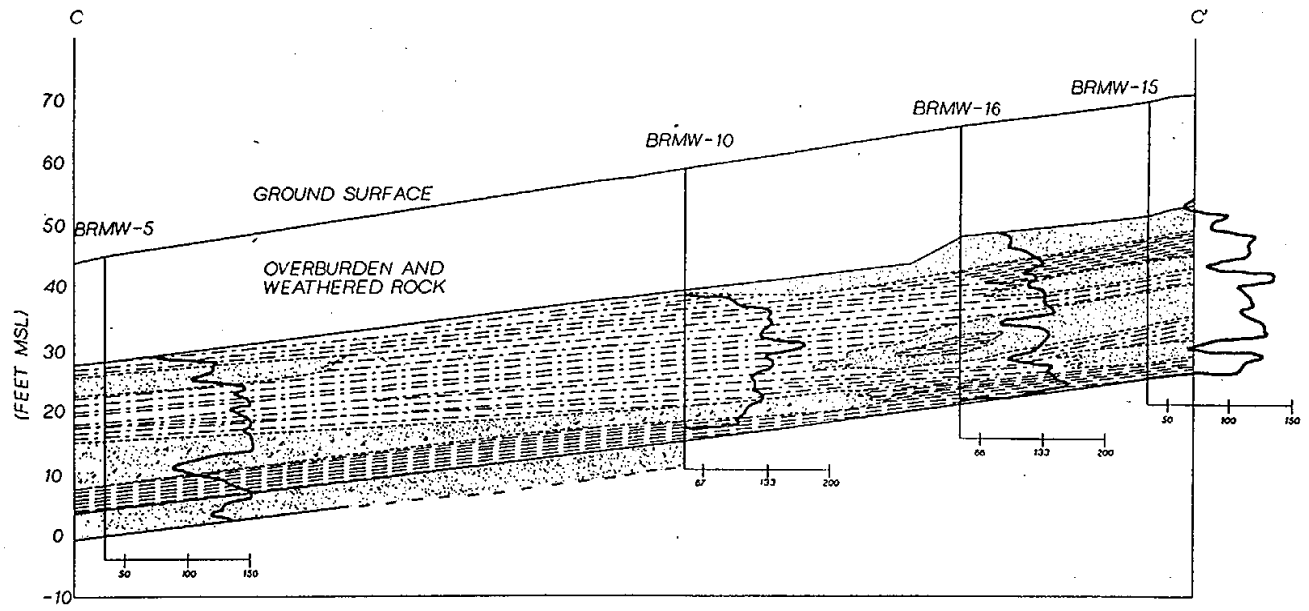
FIGURE 3-10
LINES OF SECTIONS C-C', D-D', E-E', AND F-F'

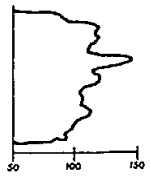
H:*PROJECTS*CAD*STE "CTC-C'.DGN



LEGEND:

- MUDSTONE
- SILTSTONE
- FINE SANDSTONE
- MEDIUM SANDSTONE
- COARSE & PEBBLY SANDSTONE
- BRMW-5 MONITOR WELL LOCATION

NATURAL GAMMA LOG



IN API UNITS

SCALE IN FEET

VERTICAL EXAG.=10X

NOTE: THE LITHOLOGIC ASSIGNMENTS MADE IN THIS SECTION SHOULD BE CONSIDERED TENTATIVE BASED ON THE LIMITATIONS OF CORRELATING GEOPHSYICAL LOGS WITH ACTUAL GEOLOGIC CONDITIONS.

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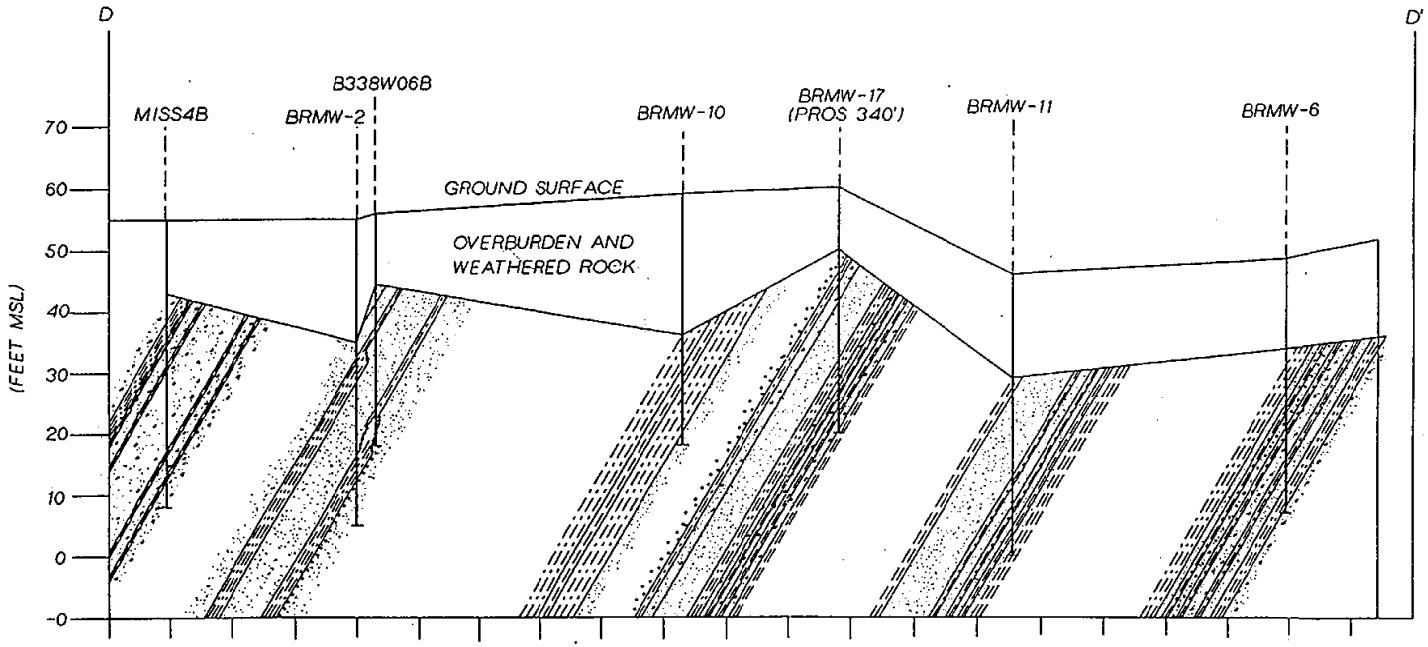
FIGURE 3-11
GENERALIZED CROSS SECTION C-C'
EXHIBITING STRUCTURE OF ROCK
PARALLEL TO STRIKE

D:*STEPAN*SEC .DGN



LEGEND:

- MUDSTONE
- SILTSTONE
- FINE SANDSTONE
- MEDIUM SANDSTONE
- COARSE & PEBBLY SANDSTONE
- MISS-4B BORING LOCATION

SCALE IN FEET
10
0 100
VERTICAL EXAG.=10X

STEPAN COMPANY AND SEARS AND ADJACENT
PROPERTIES RI
MAYWOOD, NEW JERSEY

FIGURE 3-12
GENERALIZED CROSS SECTION D-D'
EXHIBITING STRUCTURE OF ROCK
PARALLEL TO DIP

resistant sandstone complexes form the ridges. Many of the present-day valleys and river basins, including the present-day Hackensack River Basin east of the site and the Saddle River Basin in which the study area is located, probably were deepened during the Wisconsin glaciation and later filled largely with glacial deposits.

A portion of the Hackensack Quadrangle showing the location of the study area and surrounding topography is presented in Figure 3-13. The study area lies in the Saddle River Basin and is located halfway between the upland divide between the Saddle and Hackensack River Basins. The Saddle River Basin drains 61 square miles and runs 23 miles from its headwaters in Rockland County, New York, through Bergen County to its confluence with the Passaic River at Garfield and Wallington, New Jersey (Assistant Secretary of the Army). The Saddle River is the main tributary to the Passaic River in what is referred to as the Lower Valley of the Passaic River. The lower Passaic River is influenced by tidal flows from Newark Bay as far upstream as Dundee Dam in Garfield.

The Brunswick Formation provides a major source of groundwater in the Newark Basin. The fractures and joints at a depth of 200 to 600 feet bear significantly more water than those above 200 feet (Carswell). The aquifer underlying the study area is considered to be bounded by the divides of the Saddle River Basin that run vertically. These divides do not extend infinitely downward but become near-horizontal where they form divides with deeper and more regional flow systems.

3.5.2 Groundwater Occurrence and Flow

Groundwater in the Newark Basin occurs both as the water table in the intergranular openings of the unconsolidated deposits, and in joints, fractures, and partings of bedding in the consolidated rocks. Depending on the location, groundwater in bedrock occurs under confined, semi-confined, and water table conditions.

Overburden Deposits. In certain areas, stratified deposits are an important source of groundwater for public supply and industrial use in the Newark Basin (Perlmutter). These water-laid deposits are generally well sorted and uniform and exhibit greater porosity and permeability than the upland tills. Depending on the composition of the stratified deposits, the quantity of water available varies in the basin; the reported yield is found to vary from about one gallon to several hundred gallons per minute. Till deposits on top of the rock are generally unsorted because they were deposited directly from the underside of the glacier. Till characteristically has low permeability because it is poorly sorted; therefore, it stores only small quantities of water. The permeability of till is relatively higher in areas where till contains higher percentages of sands and gravels (Perlmutter). Lacustrine deposits of silts and clays that overlie bedrock and till have poor permeability and, in fact, impede the movement, discharge, and recharge of water in areas where they are present.

Groundwater flow in the overburden deposits generally is controlled by the interbedding and layering of deposits with different geologic properties. Water in the

stratified deposits generally occurs under water table conditions but may be underconfined conditions if overlain by silts and clays of significantly less permeability (Perlmutter). Compacted till composed largely of fines tends to act as a confining deposit. The stratified deposits generally are recharged by direct precipitation and upward leakage from the bedrock in the areas of discharge. Surface water may infiltrate when adjacent streams have higher water levels, such as during a flood event. Flow in the overburden is toward localized discharge points such as local streams and rivers.

Bedrock. Within the Newark Basin, the Brunswick Formation provides a major aquifer. Because of limited areal extent, hydrogeologic characteristics, and thickness, the Stockton and Lockatong Formations that stratigraphically overlie the Brunswick Formation are not considered significant producers. Groundwater in the Brunswick Formation is found mostly in the openings along bedding planes, joints, and fractures in what is known as secondary porosity. Groundwater found in the intergranular interstices within the matrix of the rock (primary porosity) is not considered an important source. In some horizons within the Brunswick Formation, however, the rock is poorly cemented, and primary porosity may greatly enhance the storage properties of the rock. Laboratory determinations of primary porosity in the Newark group, as a whole, have ranged from 1 to 21 percent (Perlmutter).

Other than bedding planes, contrast in bed fracturing within the vertical profile of a stratum is the other major factor that produces discrete aquifer zones within the Brunswick Formation (Michalski). Because frequency of the systematic fractures and joints within individual units of a heterogeneous sequence is a function of the lithology, the more resistant and thicker mudstones have fewer fractures than shale and generally act as aquitards. The cyclic character of the deposition of the Brunswick Formation has resulted in multiple repetitions of similar sequences at consistent intervals to create the aquifer/aquitard sequences.

A conceptual model of the Brunswick Formation presented by Michalski embodies a leaky, multi-unit aquifer system consisting of thin water-bearing units and much thicker intervening aquitards.

Carswell and Rooney state that discrete zones in the Passaic Member of the Brunswick Formation consist of a series of alternating tabular aquifers and aquitards that extend down-dip for hundreds of feet and are continuous along strike for thousands of feet. Carswell and Rooney also submit that hydraulic connection between aquifers is generally poor and that the tabular aquifers range up to tens of feet thick and dip to the west at about 10 degrees. Field evidence presented by Michalski confirms that the Brunswick Formation hosts a gently dipping multi-unit leaky aquifer system that consists of thin water-bearing units and thick intervening aquitards.

Groundwater in the upper Passaic Member of the Brunswick Formation may occur under both confined and unconfined conditions. Where the rock is mantled by

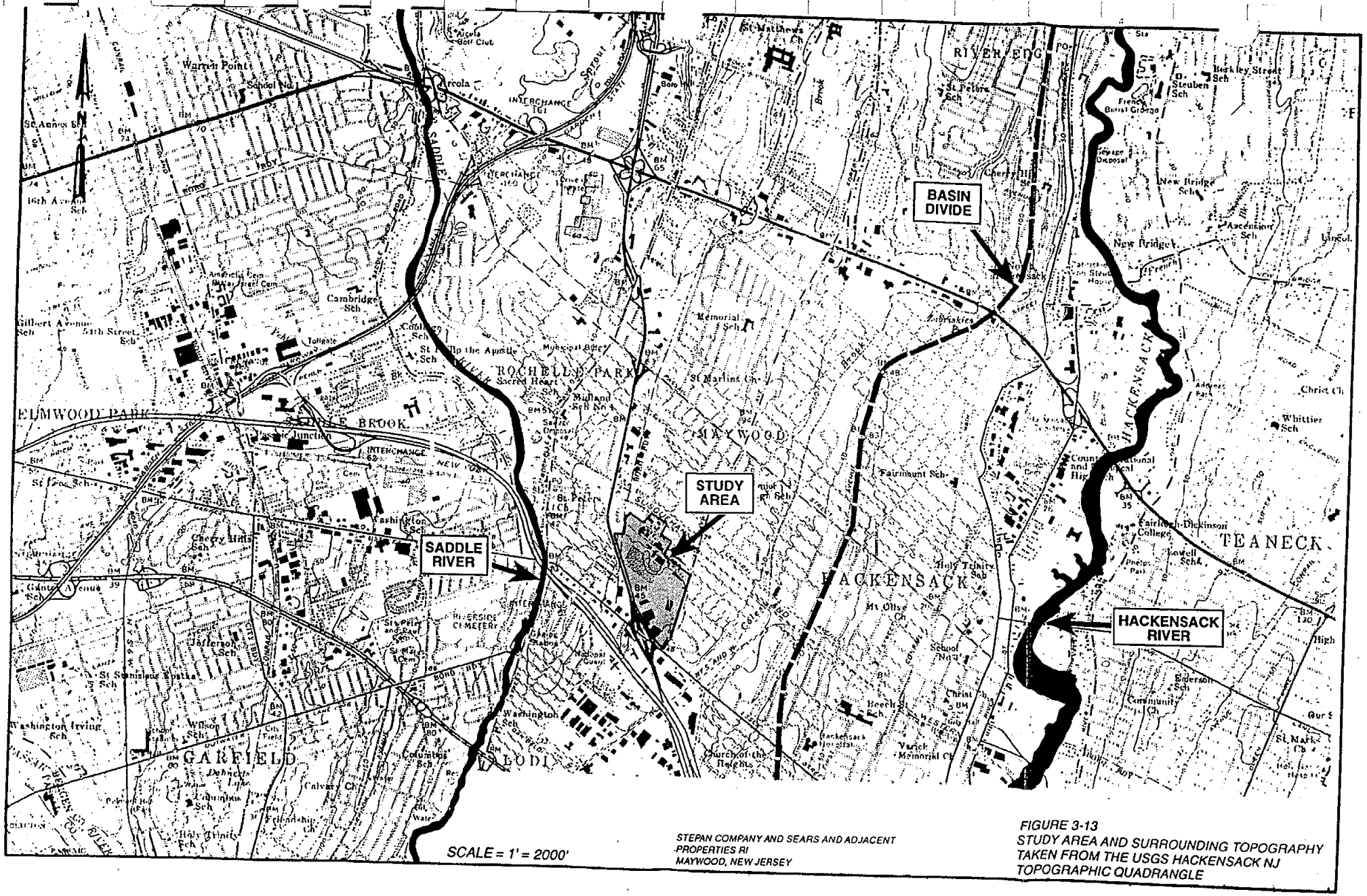


FIGURE 3-13
STUDY AREA AND SURROUNDING TOPOGRAPHY
TAKEN FROM THE USGS HACKENSACK NJ
TOPOGRAPHIC QUADRANGLE

permeable materials and in upland areas, the groundwater generally occurs under water table conditions. Where the rock is mantled by generally nonpermeable till or stratified deposits, groundwater may occur under artesian conditions.

Groundwater in the lower Passaic Member of the Brunswick Formation may be found in water-bearing units separated by relatively impermeable zones. This sequence beneath a recharge, upland area would result in successively deeper hydraulic heads in each water-bearing zone with depth. The net direction of flow would therefore be downward. The same multi-unit leaky aquifer sequence in a low-lying discharge area would result in successively higher heads with depth, resulting in artesian conditions and a net upward direction of groundwater flow.

Groundwater flow in the Brunswick Formation appears to be primarily influenced by partings along bedding and by the contrast in degree of fracturing. Layered, inherent heterogeneity of a dipping multi-unit aquifer system produces an anisotropic flow pattern. Along-strike flow direction is favored within the saturated reaches of individual water-bearing units, and vertical, flow across intervening aquitards is produced by head differences in the water-bearing units.

Systematic fractures, near-vertical joints, and partings along the bedding are generally believed to provide principal passage for groundwater flow through the Brunswick Formation. Considerable debate exists about whether groundwater flow in the Brunswick is controlled by the orientation of near-vertical principal joint sets or sub-horizontal bedding planes. According to Vecchioli et al., the dominant joint set is near-vertical with an orientation nearly parallel to the strike of the formation. Secondary near-vertical joints sets are roughly perpendicular to the primary joint set.

Groundwater occurring in horizontal fractures largely results in isotropic horizontal conditions. However, this condition probably decreases with depth because the weight of the overlying materials tends to close the near-horizontal bedding fractures at increasing depths (Herpers and Barksdale). Vertical fractures, not affected to the same degree by depth, control groundwater flow and cause aquifer anisotropy.

Considerable evidence exists, however, suggesting that the groundwater flow is also significantly influenced by bedding planes, which are near-horizontal in the study area (Carswell and Rooney; CH2M HILL; Vecchioli et al; Michalski). Perlmutter suggested that "water bearing openings" are probably largely along bedding planes, which in some places are not freely interconnected through joints and other vertical openings. Greenman documented vertical changes in permeability and related the changes to variations in the lithology of the rock type within the formation.

Variations in the porosity and permeability of the rock within the zone of freshwater flow is partly a function of where the formation is encountered with respect to the groundwater flow system. The natural chemistry of the water greatly affects the degree of weathering of the rock and therefore its intrinsic water-bearing properties. Upland recharge areas are subject to rainwater that is high in dissolved oxygen,

carbon dioxide, and humic acid, all characteristics that promote weathering of rock. Discharge areas are subject to issue groundwater that is at the end of its evolutionary cycle, high in pH, and generally less able to significantly weather rock. Furthermore, the discharging flow prevents rainwater from entering the groundwater system, thus inhibiting certain forms of weathering. Discharge areas, however, generally receive much greater amounts of groundwater flow than do hilltops and upland areas. The groundwater encountered in the study area, at depths well below the water table, appears to be midway along its path from recharge to discharge.

A comparison of the water levels in wells tapping the Newark group has shown levels in upland-hill wells to have higher elevations than levels in lowland-valley wells. Under natural conditions, the groundwater surface is thus highest beneath the hills and lowest in the valleys, resulting in a groundwater flow cycle from the hills to the valleys.

Although the general pattern of groundwater flow described above applies to groundwater beneath the study area, local complexities in the pattern of groundwater movement may be caused by random fracturing, discontinuous bedding, and overall bedrock heterogeneity. According to Perlmutter, the general direction of groundwater flow from intake to discharge generally should be driven by the relative heads, but actual paths are influenced significantly by the patterns of interconnected openings in the rock, and therefore may be quite irregular.

3.6 Hydrogeology of the Study Area

3.6.1 Topography and Drainage

The topography of the study area varies from more than 70 feet above mean sea level (MSL) at the northernmost portion of the Stepan property to less than 45 feet on the Sears property. The surface elevations at Stepan between the two railroad tracks vary from 70 feet at C-4 to about 55 feet above MSL near C-44. South of the Stepan property line with Sears, the surface elevations drop by about 11 feet. This is probably an artifact of backfilling that occurred on what is now known as the Stepan property. From east to west, the surface elevations on the Sears property ,vary from about 48 feet near C-6 to about 44 feet at C-19 in the wetland area. Surface elevation rises steadily toward the southern corner of the study area, on the Federal Express property to 52.7 feet MSL at C-30.

Natural site drainage is generally to the south. Stormwater runoff at Stepan is largely directed to a network of stormwater collection drains installed throughout the paved surface areas. The southwestern portion of the Stepan property is covered with crushed stone, and the surface water runoffs are directed to the catch basins along the southwestern property boundary. Some of the runoff drains into the natural ground or flows toward areas of lower topography.

Most surface water runoff from the Sears property and adjacent properties is directed to a network of stormwater collection drains. Some of the runoff drains into the wetlands area east of the Sears building. The wetlands area is drained by a single culvert which runs underneath the Sears access road, between Sunoco, Federal Express, and AMP, and toward Route 17 (Figure 3-1). This culvert is joined on the Sears property by another culvert which runs from Maywood Avenue between Federal Express and DeSaussure. West of the Sears building, a culvert perpendicular to Route 17 and running approximately 300 feet into the Sears property intersects another culvert that runs along Route 17 all the way to the northern extent of the Gulf property. These culverts are depicted as narrow wetlands in Figure 3-1.

3.6.2 Groundwater Investigation

Monitoring wells in the overburden were installed in general accordance with the work plan. The overburden wells were screened across the first water encountered during well drilling. The screened zones in the bedrock wells were selected on the basis of data from the pressure injection testing using double pneumatic packers. These screens were set in the zones that indicated the highest permeability.

Groundwater measurements in both the overburden and bedrock monitoring wells are summarized in Table 3-2. The measurements were taken on six dates between June 1, 1992, and November 5, 1992, and represent the stabilized water table.

Overburden. Groundwater in the overburden was generally higher on the Stepan property than on the properties located downgradient of the Stepan property. Such variations in the groundwater depths are attributed to the topographic variations across the study area. On the basis of a complete set of measurements for all wells at the wells at Stepan varied from 48.88 MSL at monitoring well OBMW2 to 56.83 MSL in monitoring well OBMW15. The lowest elevation of 47.97 MSL for groundwater was found at monitoring well MISS4A, located downgradient of OBMW2 on the Stepan amended property.

The elevations of the groundwater on the other properties in the study area located downgradient of Stepan varied from 48.04 MSL at OBMW10 to 40.06 MSL at OBMW12. Although the water level for OBMW10 seemed to coincide with area water levels, there is some question about the credibility of this measurement. OBMW10 is located close to the eastern wall of the Sears building and the northern boundaries of the presently defined wetlands. During drilling, it was observed that this well was located in relatively loose backfill used during the installation of an adjacent underground fuel-oil storage tank. Therefore, the water levels in this well are questionable.

Table 3-2
Summary of Water Level Measurments

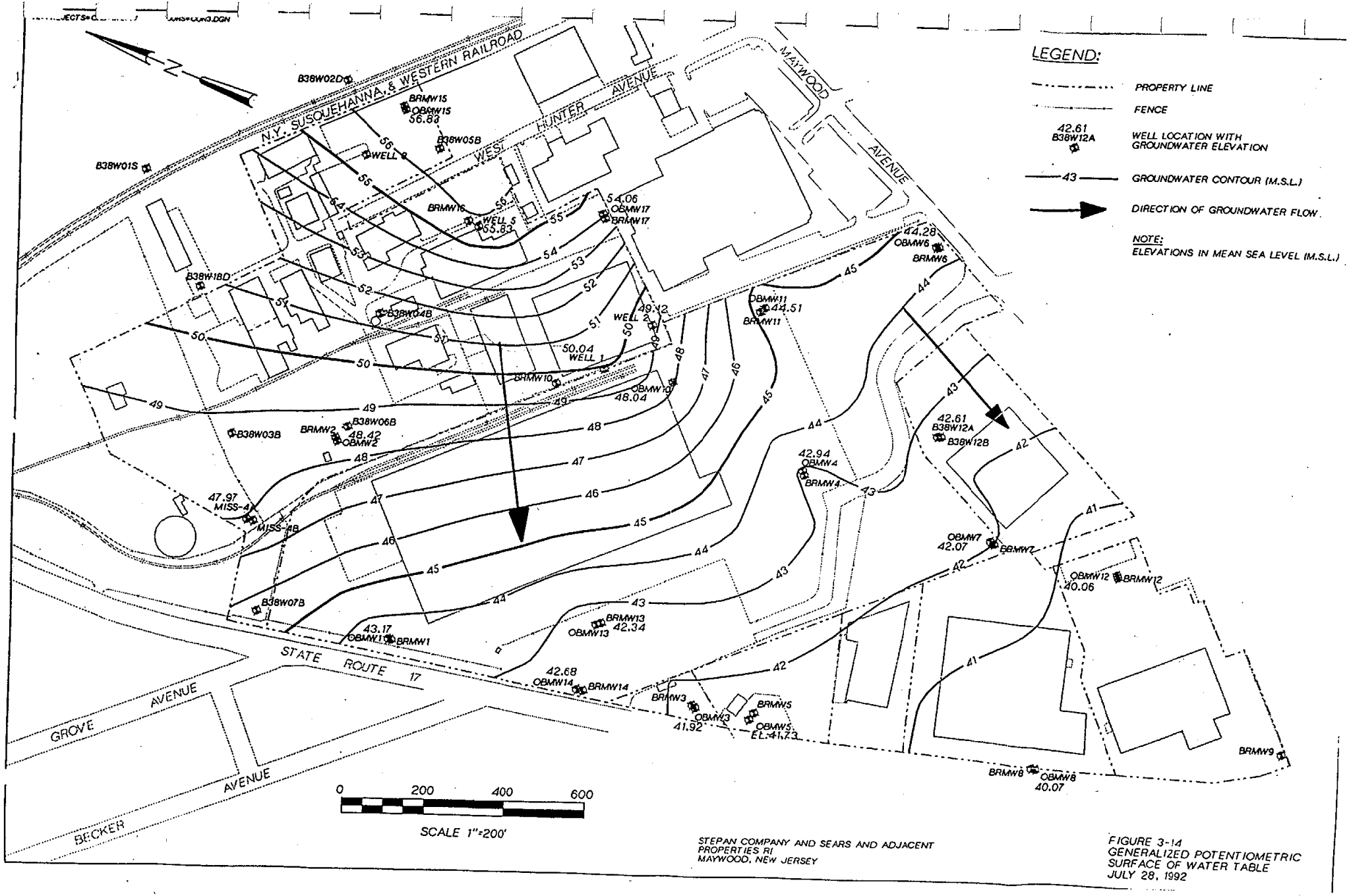
WELL LOCATION	Ground Elevation (ft. MSL)	Top of Protective Casing Elevation (ft. MSL)	Top of Riser Elevation (ft. MSL)	Top of Concrete Elevation (ft. MSL)	6/1/92		6/22/92		7/28/92		9/9/92		10/2/92		11/5/92	
					Depth To Water (ft.)	Water Elevation (ft. MSL)	Depth To Water (ft.)	Water Elevation (ft. MSL)	Depth To Water (ft.)	Water Elevation (ft. MSL)	Depth To Water (ft.)	Water Elevation (ft. MSL)	Depth To Water (ft.)	Water Elevation (ft. MSL)	Depth To Water (ft.)	Water Elevation (ft. MSL)
OBMW1	49.4	49.42	46.82	NM	4.51	44.31	5.00	43.82	5.65	43.17	5.26	43.56	5.80	43.02	5.78	43.04
BRMW1	49.5	49.49	49.08	NM	5.43	44.06	5.60	43.48	5.57	43.51	6.16	42.92	6.12	42.96	6.04	43.04
OBMW2	54.9	54.86	54.40	NM	4.77	49.63	5.11	49.29	5.98	48.42	5.52	48.88	6.16	48.24	6.18	48.22
BRMW2	54.9	54.92	54.61	NM	8.23	46.38	8.52	46.09	9.28	45.33	8.85	45.76	9.37	45.24	9.28	45.33
OBMW3	47.2	47.13	46.80	NM	4.25	42.55	4.47	42.33	4.88	41.92	4.80	42.00	5.06	41.74	5.08	41.72
BRMW3	46.9	46.93	46.67	NM	3.65	43.28	3.85	42.82	4.34	42.33	3.98	42.69	4.40	42.27	4.16	42.51
OBMW4	46.2	46.24	45.96	46.2	1.31	44.65	2.49	43.47	3.02	42.94	2.51	43.45	3.04	42.92	1.82	44.14
BRMW4	46.6	46.68	46.33	46.6	3.31	43.37	3.44	42.89	3.36	42.97	4.02	42.31	3.66	42.67	2.46	43.87
OBMW5	46.4	46.45	46.13	NM	4.00	42.13	3.95	42.18	4.40	41.73	4.03	42.10	4.50	41.63	4.31	41.82
BRMW5	46.4	46.41	45.97	NM	3.95	42.02	3.92	42.05	4.35	41.62	4.03	41.94	4.46	41.51	4.23	41.74
OBMW6	48.8	49.22	48.94	49.2	2.94	46.00	3.00	45.94	4.66	44.28	4.14	44.80	4.35	44.59	4.78	44.16
BRMW6	49.3	49.48	49.06	49.5	2.72	46.34	3.12	45.94	4.90	44.16	4.44	44.62	4.59	44.47	5.39	43.67
OBMW7	45.6	45.66	44.95	45.7	1.78	43.17	1.94	43.01	2.88	42.07	3.40	41.55	3.81	41.14	3.16	41.79
BRMW7	45.6	45.67	45.11	45.7	2.27	43.40	2.18	42.93	2.32	42.79	2.72	42.39	3.03	42.08	2.74	42.37
OBMW8	45.7	45.81	45.55	NM	4.32	41.23	4.71	40.84	5.48	40.07	5.34	40.21	5.74	39.81	6.02	39.53
BRMW8	45.7	45.68	45.17	NM	4.39	40.78	4.50	40.67	5.32	39.85	5.16	40.01	5.46	39.71	6.64	38.53
BRMW9 [a]	53.3	54.65	54.34	53.6	15.75	38.90	15.57	38.77	16.46	37.88	16.28	38.06	16.60	37.74	16.78	37.56
OBMW10	48.5	48.50	48.09	NM	0.00	48.09	0.11	47.98	0.05	48.04	0.10	47.99	0.20	47.89	0.10	47.99
BRMW10	59.4	59.39	58.95	NM	8.19	51.20	7.57	51.38	8.12	50.83	8.22	50.73	8.34	50.61	8.50	50.45
OBMW11 [a]	45.6	46.54	46.23	45.8	2.26	45.97	2.57	45.66	3.72	44.51	2.99	45.24	3.34	44.89	3.11	45.12
BRMW11 [a]	45.7	46.41	47.79	46.1	2.95	45.46	2.91	44.88	3.20	44.59	3.48	44.31	3.86	43.93	3.78	44.01
OBMW12	47.5	47.54	47.27	NM	6.05	41.49	6.10	41.17	7.21	40.06	6.04	41.23	6.08	41.19	7.58	39.69
BRMW12	47.6	47.61	47.23	NM	4.44	43.17	4.58	42.65	5.90	41.33	5.60	41.63	7.36	39.85	6.24	40.99
OBMW13	47.7	47.68	47.26	NM	3.69	43.57	3.93	43.33	4.92	42.34	4.20	43.06	4.48	42.78	4.81	42.45
BRMW13	47.6	47.66	47.21	NM	3.80	43.86	3.81	43.40	4.30	42.91	4.00	43.21	4.36	42.85	4.26	42.95
OBMW14	46.5	46.51	46.02	NM	2.17	43.85	2.93	43.09	3.34	42.68	2.97	43.05	3.37	42.65	3.32	42.70
BRMW14	46.6	46.58	46.22	NM	2.93	43.65	4.05	42.17	3.43	42.79	8.64	37.58	3.66	42.56	3.59	42.63

Table 3-2
Summary of Water Level Measurments

WELL LOCATION	Ground Elevation (ft. MSL)	Top of Protective Casing Elevation (ft. MSL)	Top of Riser Elevation (ft. MSL)	Top of Concrete Elevation (ft. MSL)	6/1/92		6/22/92		7/28/92		9/9/92		10/2/92		11/5/92	
					Depth To Water (ft.)	Water Elevation (ft. MSL)	Depth To Water (ft.)	Water Elevation (ft. MSL)	Depth To Water (ft.)	Water Elevation (ft. MSL)	Depth To Water (ft.)	Water Elevation (ft. MSL)	Depth To Water (ft.)	Water Elevation (ft. MSL)	Depth To Water (ft.)	Water Elevation (ft. MSL)
OBMW15 *	70.1	72.55	72.27	70.5	13.11	59.16	12.60	59.67	15.44	56.83	14.77	57.50	16.02	56.25	16.54	55.73
BRMW15 *	70.2	71.85	71.63	70.7	12.00	59.63	11.89	59.74	14.75	56.88	14.02	57.61	15.32	56.31	15.83	55.80
BRMW16*	66.9	68.52	67.96	67.3	10.00	57.96	9.96	58.00	12.05	55.91	11.92	56.04	12.82	55.14	13.60	54.36
OBMW17 *	60.5	63.02	62.70	60.9	7.70	55.00	7.50	55.20	8.64	54.06	8.66	54.04	9.00	53.70	9.60	53.10
BRMW17 *	60.3	62.37	62.04	60.7	6.75	55.29	6.17	55.87	7.90	54.14	7.78	54.26	NM	NA	9.18	52.86
WELL 1 *	56.3	59.04	58.82	NM	NM	NM	NM	NM	8.78	50.04	8.80	50.02	9.09	49.73	9.45	49.37
WELL 2 *	58.7	59.43	59.26	NM	NM	NM	NM	NM	10.16	49.12	10.16	49.12	10.50	48.78	10.31	48.97
WELL 5 *	62.1	62.60	62.17	NM	NM	NM	NM	NM	6.34	55.83	6.26	55.91	7.14	55.03	7.89	54.28
WELL 8 *	73.3	75.17	75.08	NM	NM	NM	NM	NM	14.78	60.39	15.22	59.86	16.05	59.03	16.48	58.60
B38W03B *	56.7	58.72	57.96	NM	NM	NM	NM	NM	10.47	47.49	9.66	48.28	10.54	47.42	10.52	47.44
B38W04B *	62.8	66.30	65.64	NM	NM	NM	NM	NM	11.65	53.99	11.55	54.09	12.24	53.40	12.21	53.43
B38W05B *	68.2	71.45	70.99	NM	NM	NM	NM	NM	14.47	56.52	14.10	56.89	15.16	55.83	16.08	54.91
B38W06B *	55.6	58.48	58.04	NM	NM	NM	NM	NM	10.54	47.50	10.15	47.89	10.68	47.36	10.62	47.42
B38W07B *	52.0	54.76	54.55	NM	NM	NM	NM	NM	10.08	44.47	NM	NA	NM	NA	NM	NA
B38W12A *	47.3	50.31	50.03	NM	NM	NM	NM	NM	7.42	42.61	6.98	43.05	7.52	42.51	7.32	42.71
B38W12B *	47.4	50.17	49.63	NM	NM	NM	NM	NM	6.86	42.77	6.50	43.13	7.00	42.63	7.06	42.57
B38W16D *	58.2	60.45	60.24	NM	NM	NM	NM	NM	6.73	53.51	6.00	54.24	6.54	53.70	6.73	53.51
MISS 4A *	55.2	57.29	57.23	NM	NM	NM	NM	NM	9.26	47.97	NM	NA	NM	NA	NM	NA
MISS 4B *	55.3	56.81	56.44	NM	NM	NM	NM	NM	10.98	45.46	NM	NA	NM	NA	NM	NA
ST-1	NA	NA	NA	46.68	3.15	43.53	NM	NM	3.46	43.22	3.74	42.94	3.80	42.88	3.66	43.02
ST-2	NA	NA	NA	46.35	3.51	42.84	NM	NM	3.81	42.54	**	NA	**	NA	**	NA

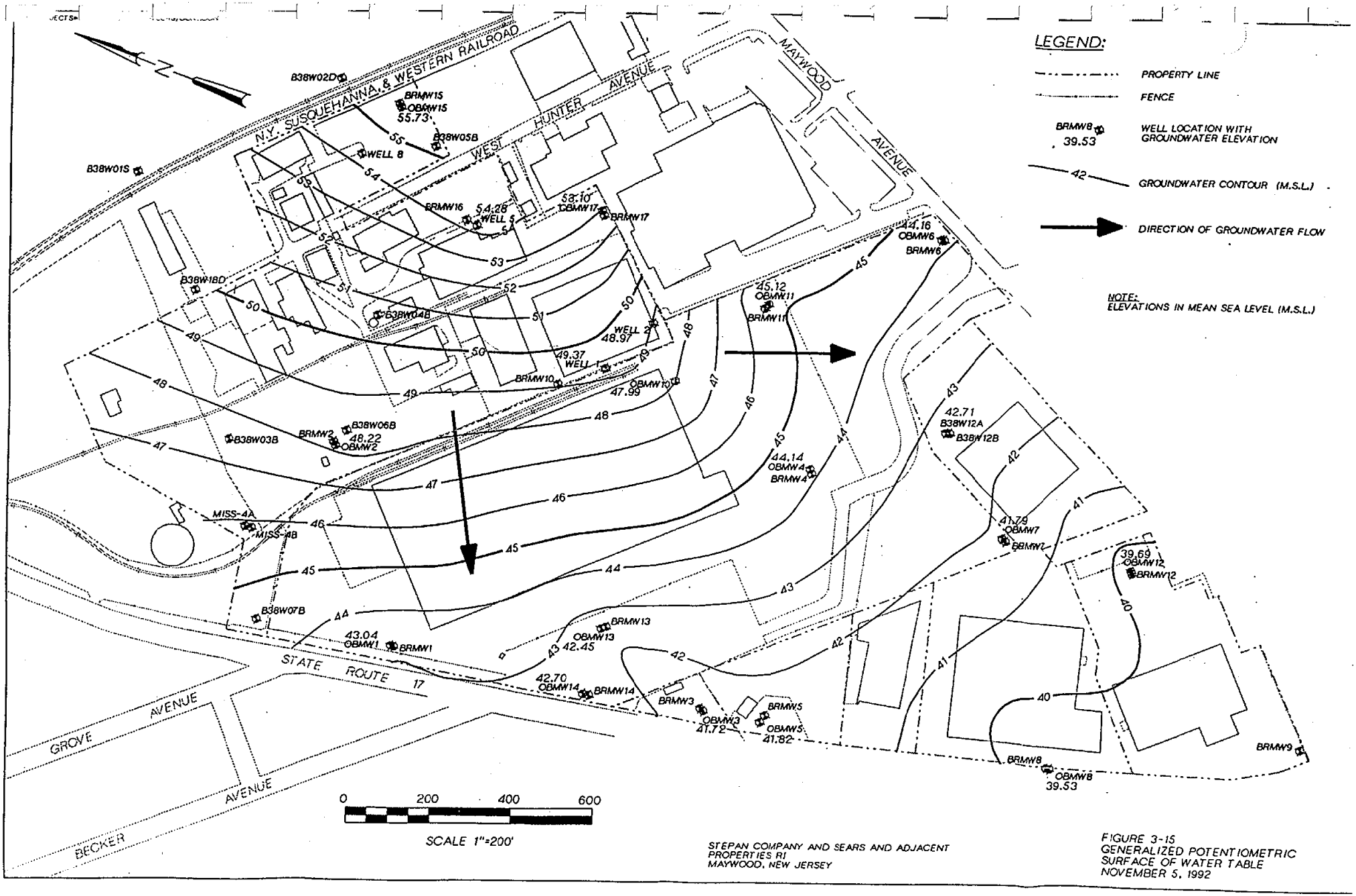
* Well is stickup construction.

Notes:
NM = Not Measured
NA = Not Applicable
* = Water Level Not Being Used For Contouring Purposes
** = Bench Mark Not Accessible Due To Excessive Plant Overgrowth



STEPAN COMPANY AND SEARS AND ADJACENT PROPERTIES RI
MAYWOOD, NEW JERSEY

FIGURE 3-14
GENERALIZED POTENTIOMETRIC SURFACE OF WATER TABLE
JULY 28, 1992



STEPAN COMPANY AND SEARS AND ADJACENT PROPERTIES RI
MAYWOOD, NEW JERSEY

FIGURE 3-15
GENERALIZED POTENTIOMETRIC SURFACE OF WATER TABLE
NOVEMBER 5, 1992

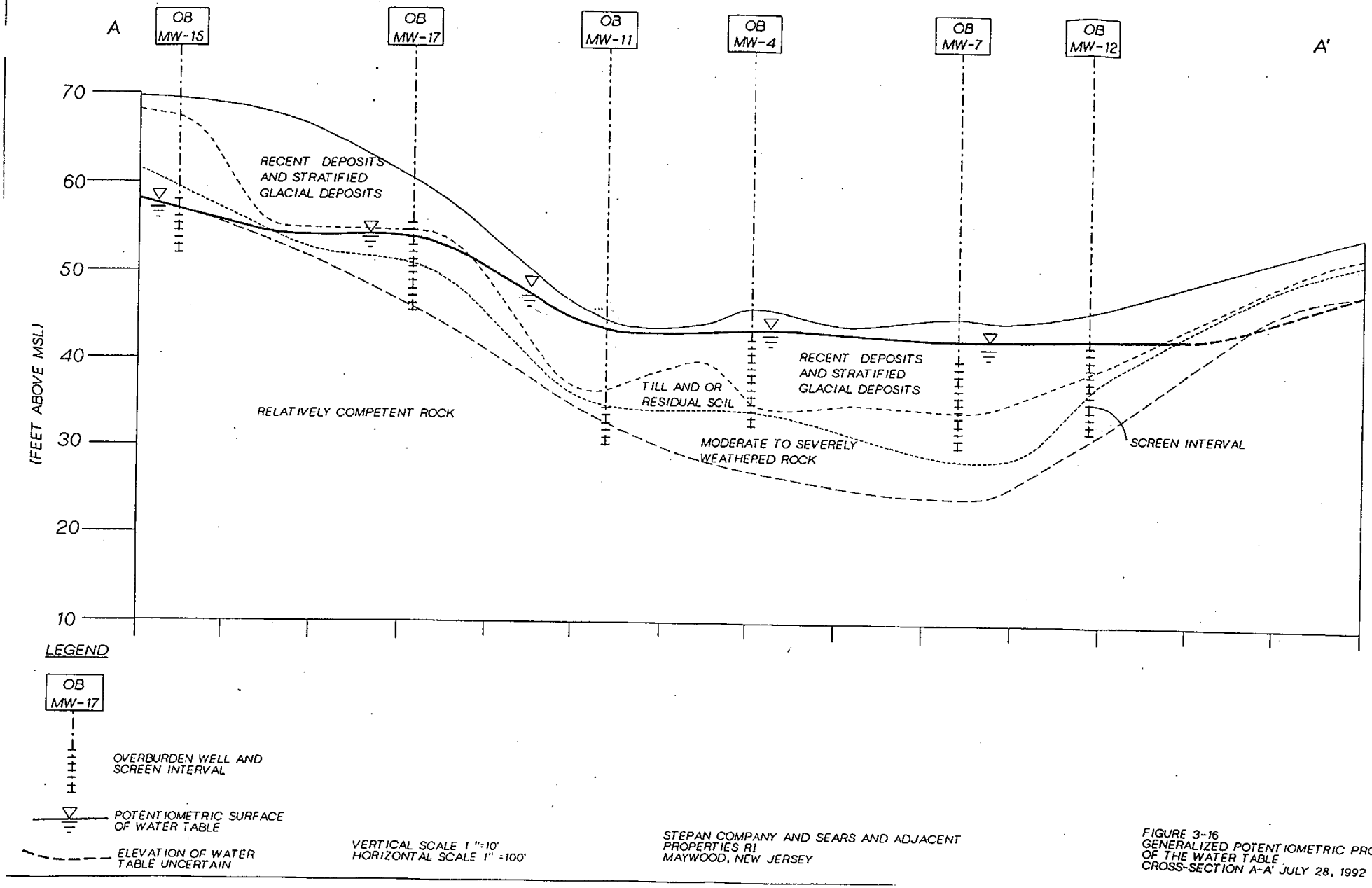
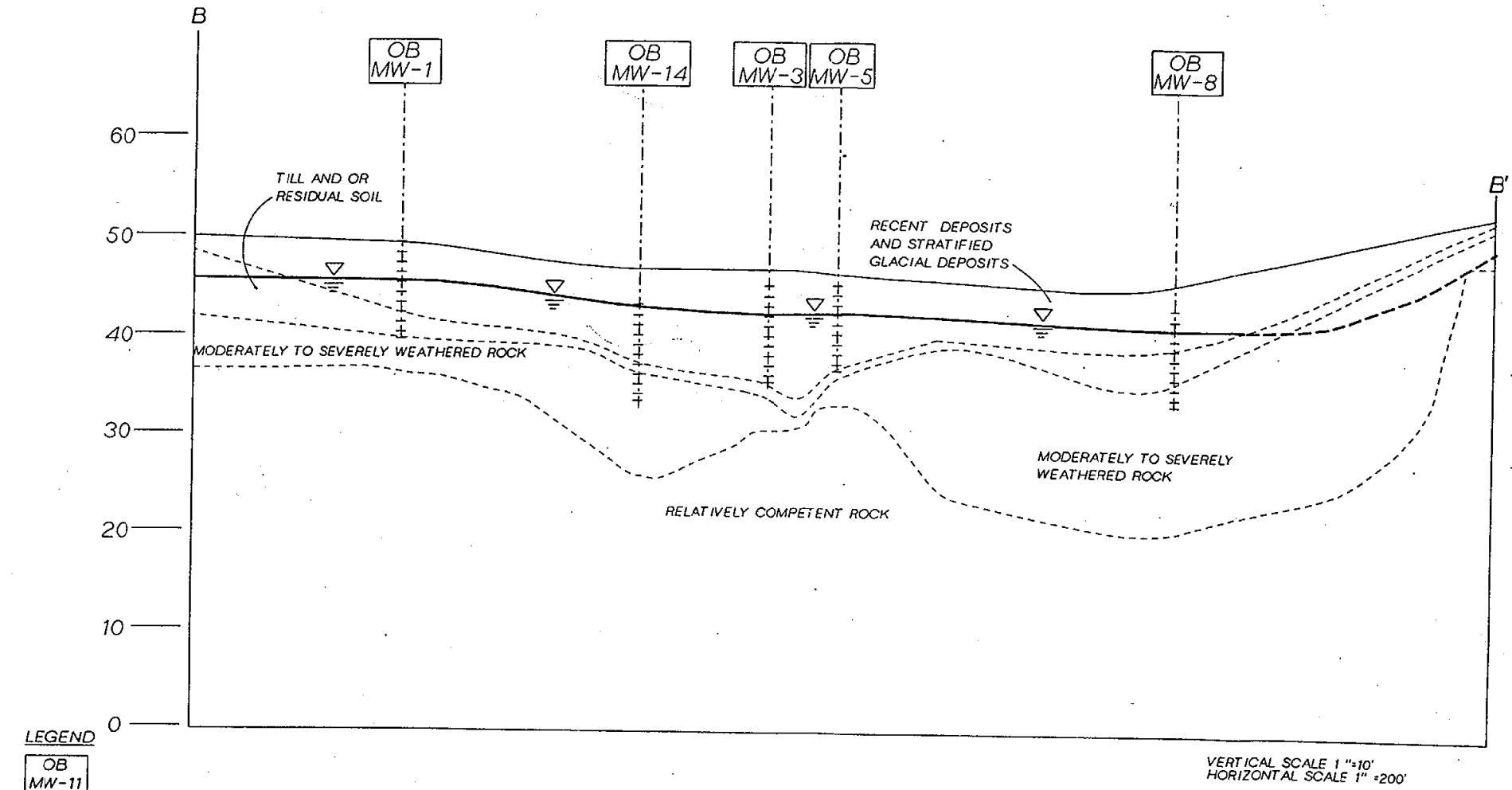


FIGURE 3-16
GENERALIZED POTENTIOMETRIC PROFILE OF THE WATER TABLE
CROSS-SECTION A-A' JULY 28, 1992

D:*STEPAN*SECTB-B 2



LEGEND

OB MW-11

OVERBURDEN WELL AND SCREEN INTERVAL

POTENTIOMETRIC SURFACE OF WATER TABLE

ELEVATION OF WATER TABLE UNCERTAIN

STEPAN COMPANY AND SEARS AND ADJACENT PROPERTIES RI
MAYWOOD, NEW JERSEY

FIGURE 3-17
GENERALIZED POTENTIOMETRIC PROFILE OF THE WATER TABLE
CROSS-SECTION B-B' JULY 28,1992

Generalized potentiometric maps of the water level measurements taken on July 28 and November 5, 1992, are presented in Figures 3-14 and 3-15. The measurements for these dates were selected because they provide the most elapsed time between the measurements and reflect seasonal changes in the configuration of water levels. The maps provide a basis for assessing the general direction of groundwater flow and hydraulic gradient across the study area.

Five surface water measurements were included in the water table map for July 28, 1992. These measurements included one point (SW1SD1) inside the wetland area east of the Sears building, and four points (SW3D3, SW4SD4, SW6SD5, and ST-1) along the drainage channels and wetland. The wetland is considered an expression of the water table throughout the year. Surface water in the drainage channels and culverts may represent base flow contributions from the water table during the wet season, when the water table is high. Generally, water elevations of the surface water points on July 28 were consistent with elevations of the water table measured in the overburden wells. During the dry season, however, there usually was no water in the drainage channels except during periods of stormwater runoff.

Both maps suggest that groundwater flows generally away from Stepan to the south and west. The maps also suggest that there is a flow component from the east side of Stepan toward the wetland area identified on Sears property. At the west side of the Stepan property, the flow of groundwater is indicated to be in a westerly direction, toward the Stepan amended property. The general directions of flow are also shown on the two maps referenced above. On the basis of water level measurements taken on July 28,1992 the hydraulic gradient between OBMW15 and OBMW2 was estimated to be .013 at the Stepan property. Between OBMW2 at Stepan and OBMW1 at Sears, the gradient was slightly steeper, estimated at .009. At the Sears and adjacent properties it was generally flatter and varied from .004 between OBMW11 and OBMW12 to 0.007 between OBMW10 and OBMW5. The generalized potentiometric profile of the water table was also plotted on the two subsurface cross sections A-A' and B-B' (Figures 3-16 and 3-17) to evaluate its relationship with the topography and the configuration of the bedrock surface. The locations of these cross sections are shown in Figure 3-4. The potentiometric surface of the water table is generally a reflection of the surface of the top of rock and surface topography.

Figures 3-16 and 3-17 also suggest that along A-A' at Stepan, the potentiometric surface of the water table generally occurs below the fill and extends into the residual soil zone and in some cases, as in OBMW15, up to the top of the bedrock. At the properties downgradient of Stepan, the potentiometric surfaces are indicated to be within the fill and the stratified deposits. Because the elevation of these deposits increases south of OBMW12, the water level is expected to increase also. This increase, however, cannot be confirmed because there are no shallow wells south of OBMW12.

Bedrock. Water level measurements in the bedrock wells are summarized in Table 3-2. The bedrock aquifer was found to be at higher elevations on Stepan than on the other properties in the study area (as was the water table). On the basis of measurements taken on July 28, 1992, the elevations of the potentiometric heads in the bedrock wells on Stepan property varied from 45.33 MSL in BRMW2 to 55.8 MSL in BRMW15. In most bedrock wells on the Sears and adjacent properties, water was measured at less than 5 feet below grade. For the same date, the potentiometric heads in bedrock wells on Stepan and Sears and adjacent properties varied from an elevation of 37.56 MSL in BRMW9 on the Federal Express property to 44.01 MSL in BRMW11. Two maps were prepared using water level measurements taken July 28 and November 5, 1992, to represent the potentiometric surfaces in the bedrock wells (Figures 3-18 and 3-19).

On the basis of the two maps (Figures 3-18 and 3-19), the general direction of flow in the bedrock aquifer in the study area appears to be similar to that within the water table. However, as discussed in the regional hydrogeology section, the groundwater regime in the Passaic Member of the Brunswick Formation is characterized as a system of multi-unit leaky aquifers separated by intervening thicknesses of impermeable bedding. This sequence dips to the west, which complicates the identification of the significant water-bearing zones and the movement of the groundwater. As shown in geologic cross section D-D', the bedrock wells in the study area are commonly screened in entirely separate zones, depending on which zone indicated the highest measured permeability in a boring. These zones are separated from each other (confined) by intervening nonpermeable strata and thus form discrete water-bearing zones. Each of these discrete zones has its own potentiometric surface influenced by (1) its location with respect to other permeable zones located above and below it, and (2) the degree to which the zone is hydraulically connected to other water-bearing zones. This results in a multi-unit aquifer sequence with multiple potentiometric surfaces. The location of the resulting potentiometric surface in a well is, therefore, also dependent upon the confining pressures in the water-bearing zones. Consequently, it is not appropriate to assume that contouring the bedrock wells provides a true representation of the groundwater flow in bedrock across the entire study area. However, considering that, with few exceptions (e.g., BRMW2, BRMW12 and BRMW17) most of the wells were relatively shallow and were screened close to the bedrock surface, the generalized flow directions suggested in Figures 3-18 and 3-19 represent the flow conditions in the upper portions of the bedrock groundwater.

Despite the potential for considerable variation and noncontinuity of water levels in the upper bedrock zone, the potentiometric surface maps for bedrock wells closely match the water table maps. This matching suggests that at least at the depths of the bedrock wells, bedrock structure does not necessarily influence the direction of groundwater flow as much as the factors that control the water table aquifer, such as topography.

The principal difference in flow patterns shown in Figures 3-18 and 3-19 is driven by the fact that the water elevation in BRMW2 is substantially lower than in OBMW2. The difference of nearly 3 feet compresses the contours for the upper bedrock map in the vicinity of BRMW2.

Seasonal Variation in Water Levels. The hydrographs of water levels in each well couplet for each date are presented in Appendix R. The overburden wells are plotted on the same graphs as the bedrock wells to illustrate the relationship between the two. In general, the water levels were found to decrease from June 1, 1992, to November 5, 1992, in both the overburden and bedrock wells. In well couplets OBMW2-BRMW2, OBMW5-BRMW5, OBMW6-BRMW6, and OBMW15-BRMW15, the overburden and bedrock wells acted in concert with each other. In other couplets the decline is evident in both, but the patterns are different. Groundwater fluctuations in the overburden and bedrock couplets are also indicated by the hydrographs. At these locations, the fluctuations in water levels in the overburden wells varied from 0.2 feet to 3.94 feet. The fluctuations in the water levels in the bedrock at the same locations varied from 0.54 feet to 6.07 feet.

Variations Observed During Continuous Water Level Monitoring. Water levels were measured continuously in the well couplets from September 9 through 16, 1992, to understand the relationship of water level fluctuations in the overburden and bedrock wells. The continuous water level data for each of the couplets, both with and without barometric data, are presented in Appendix S. The data for the overburden and bedrock wells in each couplet are presented in the same graph for ease of presentation and interpretation.

The data plots without barometric data are presented as absolute water levels. The plots with barometric data use a conversion to equivalent feet of head; these plots present the series as deviations from the mean value.

All of the wells, with the exception of BRMW14, showed a systematic increase in water level from September 9, 1992, when monitoring started to September 10, 1992, then a systematic decrease until the completion of monitoring on September 16, 1992. Just prior to and during setup of the monitoring equipment, the region in which the study area lies received considerable rainfall. From September 11 to September 16, there was no rainfall. The systematic increase in the beginning and decline in water levels throughout most of the duration of the testing period is attributed to the heavy rainfall at the beginning of the test and the lack of rainfall thereafter. Except for BRMW14, the deep wells responded in much the same fashion as the respective shallow offset wells. Unlike the other wells, BRMW1, BRMW7, and BRMW14 showed a recovery pattern, which is probably associated with the build-up of pressure in the headspace above the water level. When the caps were removed, the pressure was released and the water levels recovered.

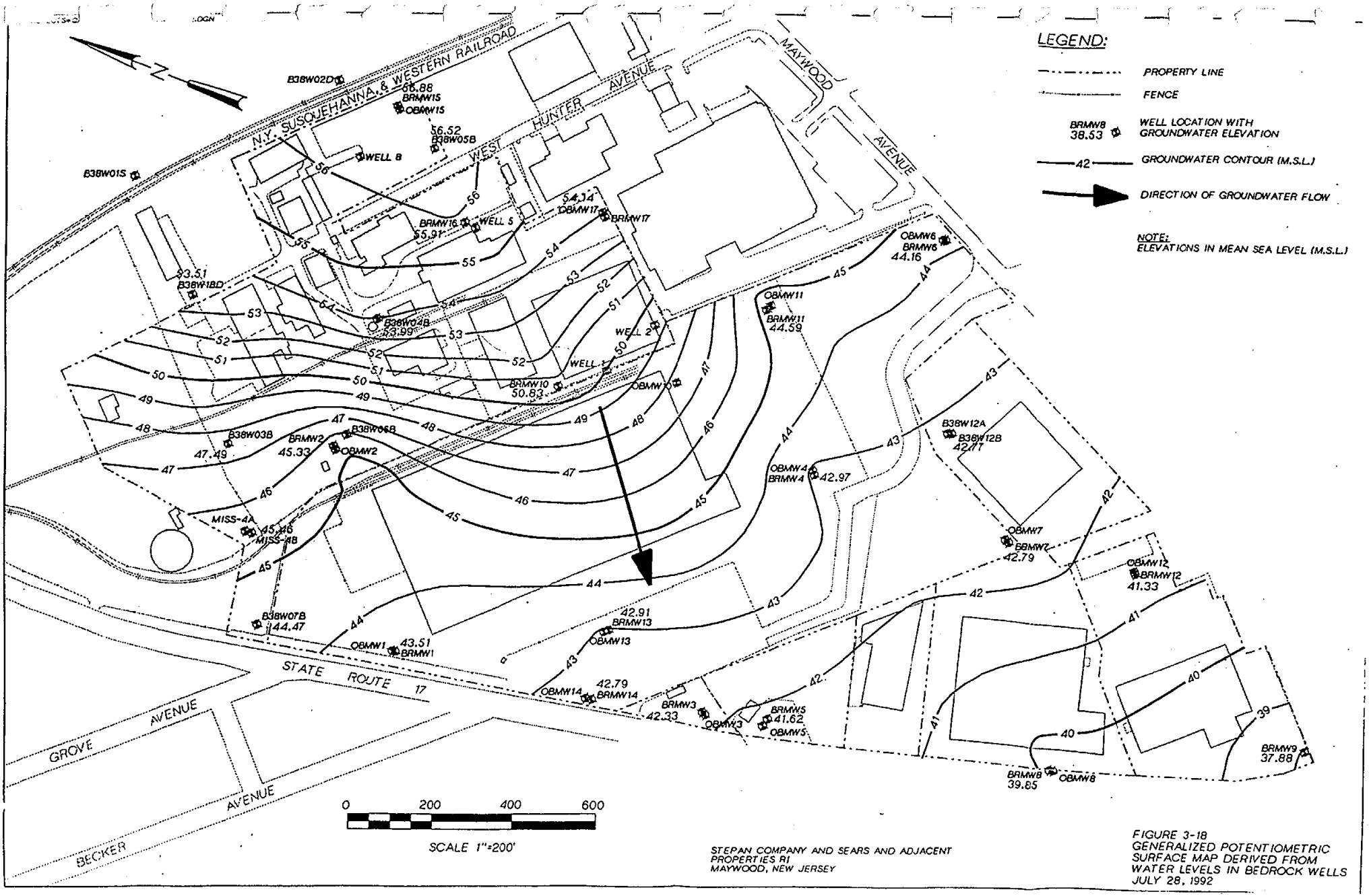


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FIGURE 3-18
GENERALIZED POTENTIOMETRIC SURFACE MAP DERIVED FROM WATER LEVELS IN BEDROCK WELLS
JULY 28, 1992

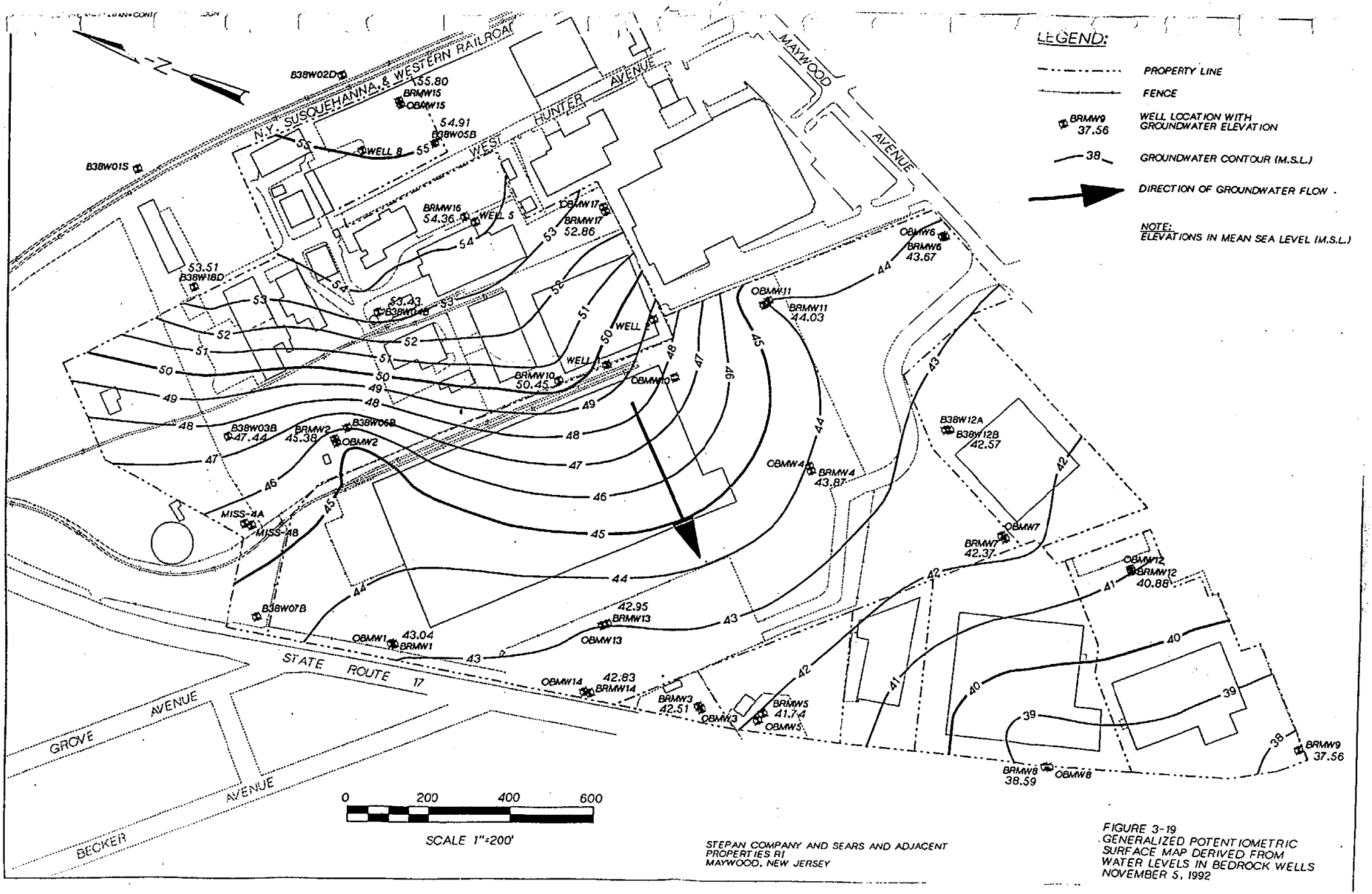

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FIGURE 3-19
GENERALIZED POTENTIOMETRIC SURFACE MAP DERIVED FROM WATER LEVELS IN BEDROCK WELLS
NOVEMBER 5, 1992

In three of the couplets, the levels fell off at similar rates. In couplets OBMW12-BRMW12 and OBMW13-BRMW13, the bedrock wells, which had higher water levels than the shallow wells, decreased at a faster rate than did the shallow wells.

Diurnal Barometric Influence. Low to moderate responses to barometric pressure were observed in the monitoring wells. The barometric pressure was relatively low at the beginning of the monitoring period when the region received considerable rainfall. During the remaining 6 days, the barometric pressure increased and then began to decrease again at the end of the test period. It is not apparent that the general increase in barometric pressure throughout most of the monitoring period and the slight decrease at the end influenced water levels sitewide. Barometric changes associated with changes in weather systems normally influence confined wells more than unconfined wells. Diurnal barometric changes have a definite impact, however, on water levels in some overburden and bedrock wells. The following discussion explains how variations in barometric pressure are related to temperature, and how both can cause fluctuations in the water table.

According to Turk, diurnal fluctuations of the phreatic surface can occur for the following two reasons: (1) Increases in temperature lower the surface tension in the capillary pores, decreasing the capacity for this zone to hold soil moisture. This moisture is released and reaches the water table, causing it to rise. (2) Both an increase in temperature and a decline in barometric pressure (which normally happen concurrently) cause expansion of trapped air in the soil pores within the capillary zone. This expansion drives soil moisture out of the capillary zone and into the water table.

This relationship is also documented by Van Hylckama, who states that the pressure fluctuations are highly correlated with changes in air temperature. Furthermore, Gardner determined that within the soil zone, moisture tension decreases at approximately .008 atm per degree rise in temperature.

At approximately 11 a.m. on the third day of testing, barometric pressure was observed to peak. After its nadir at 4 p.m. the same day, it was observed to peak again at 10 a.m. the next day. The same cycle occurred again, with the pressure reaching a minimum at nearly 5 p. m. and peaking again the next morning at 9 a.m. Other peaks during the monitoring period always were observed some time in the late morning, and lows always were observed in the late afternoon. This pattern suggests that barometric pressure was driven by daily fluctuations in temperature.

The relationship between changing diurnal barometric pressure and water levels was most evident in couplet OBMW12-BRMW12. The water levels in both the shallow and deep wells were found to decrease to a daily minimum at the same time that the barometric pressure reached its daily peak. Conversely, the water levels reached a daily maximum at the same time that the barometric pressure reached its daily minimum. This pattern was readily apparent for at least 3 consecutive days. The relationship between levels and barometric pressure was moderate in OBMW2-

BMRW2 and OBMW13-BRMW13. In OBMW11-BRMW11, the relationship was very weak, and there was little or no correlation in OBMW14-BRMW14 and OBMW15-BRMW15.

Site Pumping Influence. The water level series for OBMW15 and BRMW15 presents strong evidence of pumping in the northeastern section of Stepan. Two observations support this theory. The first is the periodic disruption in the continuous plots for both the shallow and the deep well. These disruptions, which appear to be the result of intermittent pumping, characteristically occur a day apart from each other but at irregular times. The second observation is that the deep well dropped in elevation at a much greater rate than the shallow well half way through the entire test period. This could indicate that pumping of a deep well is causing the fluctuations. It is possible that well number 2 on Figure 1-9 identified during the expanded well search may influence the water levels at the OBMW15/BRMW15 couplet. Well number 2 is located on West Magnolia Street which is north of the OBMW15/BRMW15 couplet.

Pressure Injection Testing. Table 3-3 provides data on the wells selected for the test, the test zones in each well, and all the variables used to compute hydraulic conductivity of the test sections. Hydraulic conductivity was computed using the following expression:

$$k = Q / (2\,LH) \times \ln (L/r)$$

where:

k = hydraulic conductivity
Q = constant rate of flow into the borehole
L = length of the portion of the hole tested
H = differential head of water
r = radius of hole tested

This method is adapted from the *Earth Manual*, authored by the U.S. Department of the Interior Bureau of Reclamation. The method is similar to another procedure for computing the hydraulic conductivity found in Geology Report G-97, published by the same, and other procedures described by Woodward Clyde Consultants in a report prepared for the U.S. Department of the Interior. The reliability of the results depends on the homogeneity of the stratum being tested. Resulting values represent the hydraulic conductivity of the entire test interval, which is variably fractured. This aspect of the test procedure must therefore be considered when evaluating the absolute values of the results. The best use of this testing procedure is to provide a database for relative comparison of test intervals both within individual boreholes and between boreholes.

The results of the pressure injection packer testing are summarized in Table 3-3. The permeability values ranged from less than 10^{-7} to 5.56×10^{-2} cm/sec. The values are also presented in Figure 3-20 as individual bar charts for each test well. The x-axis of

Table 3-3
PACKER TEST DATA AND RESULTS

WELL	TEST ZONE (FT)	TEST #	FLOW RATE (gpm)	FLOW RATE (ft^3/sec)	STATIC WATER LEVEL (ft BGS)	CENTER OF TEST INTERVAL (ft)	TEST ZONE PRESSURE (ft)	LENGTH OF TEST ZONE (ft)	RADIUS OF HOLE (ft)	COND. (cm/sec)	SELECTED SCREENING INTERVAL (FT)	RATIONALE FOR SELECTION OF SCREENING INTERVAL
BRMW1	(17-27)	1	0	0			90			1.0E-07		Permeability, flow comparisons
	(24-37)	1	0	0			57			1.0E-07		
	(30-40)	1	0.4	8.9E-04	6	35	114.7	10	0.25	1.86E-05		
	(30-47)	1	0.6	1.8E-03	6	37.5	113.6	17	0.25	2.61E-05	(30-47)	
BRMW2	(15-25)	1	0	0			99			1.0E-07		Permeability, flow comparisons
	(25-35)	1	0	0			110.6			1.0E-07		
	(32.5-42.5)	1	28.5	6.3E-02	9	37.5	56.5	10	0.25	4.06E-03	(32.5-42.5)	
	(32.5-49.5)	2	27	6.0E-02	9	40	52.14	17	0.25	3.43E-03		
BRMW4	(24-34)	1	0.6	1.3E-03	3.45	29	75	10	0.25	4.84E-05	(24-34)	Permeability, adjacent well conditions
	(30-40)	1	0	0.0E+00			83.2			1.0E-07		
		2	0	0.0E+00			149.6			1.0E-07		
	(36-53)	1	1.1	2.4E-03	3.45	43.5	108.1	17	0.25	4.34E-05		
		2	1.5	3.3E-03	3.45	43.5	151.2	17	0.25	3.62E-05		
BRMW5	(17-27)	1	35	7.8E-02	4.63	22	14.9	10	0.25	>1.0E-03[a]	(17-27)	Permeability
	(23-33)	1	0	0			111			1.0E-07		
	(29-46)	1	0	0			106			1.0E-07		
BRMW6	(15-25)	1	39.6	8.8E-02	7.58	20	16.62	10	0.25	3.76E-02	(15-25)	Permeability
	(21-31)	1	0.8	1.8E-03	7.58	26	89.49	10	0.25	4.49E-05		
		2	1.3	2.9E-03	7.58	26	134.29	10	0.25	4.47E-05		
	(27-44)	1	0	0			94.06	17	0.25	1.0E-07		
		2	0.9	2.0E-03	7.58	34.5	139.99	17	0.25	2.14E-05		
BRMW7[b]	(26-38)	1	10.8	2.4E-02	3	31	62.8	10	0.25	1.24E-03	(27-37)	Permeability
	(32-42)	1	0	0			93.7			1.0E-07		
		2	0	0			147			1.0E-07		
	(38-55)	1	0	0			72					
		2	0.8	1.8E-03	3	45.5	147	17	0.25	2.05E-05		
BRMW8	(30-40)	1	16.8	3.7E-02	5.6	35	67	10	0.25	1.78E-03	(32-42)	Permeability
	(36-46)	1	8.6	1.9E-02	5.6	41	90	10	0.25	6.28E-04		
		2	16.5	3.7E-02	5.6	41	117	10	0.25	8.06E-04		
	(42-52)	1	1.2	2.7E-03	5.6	47	115	10	0.25	6.50E-05		
	(42-59)	1	13	2.9E-02	5.6	50.5	83	17	0.25	9.15E-04		
		2	20	4.5E-02	5.6	50.5	128	17	0.25	6.46E-04		
BRMW10	(20-30)	1	1	2.2E-03	8.14	25	67.41	10	0.25	7.89E-05		Permeability
	(30-40)	1	1.3	2.9E-03	8.14	35	77.4	10	0.25	1.03E-04	(30-40)	
		2	2	4.5E-03	8.14	35	114.7	10	0.25	9.08E-05		
	(34.5-51.5)	1	0				125.9			1.0E-07		
BRMW11	(17-27)	1	3.5	7.8E-03	3.1	22	65.2	10	0.25	3.01E-04		Permeability, decision to screen shallowest zone.
	(23-33)	1	11	2.4E-02	3.1	28	64.7	10	0.25	1.10E-03	(23-33)	
		2	14.8	3.3E-02	3.1	28	103.2	10	0.25	7.54E-04		
	(29-39)	1	9.7	2.2E-02	3.1	34	65.8	10	0.25	1.11E-03		
		2	24	5.3E-02	3.1	34	105.2	10	0.25	1.29E-03		
	(29-46)	1	8.8	2.0E-02	3.1	37.5	69	17	0.25	6.82E-04		
		2	19.3	4.3E-02	3.1	37.5	102	17	0.25	7.66E-04		
BRMW12	(20-30)	1	2.7	6.0E-03	5.5	25	67	10	0.25	2.27E-04		Permeability, flow comparisons
	(25-35)	1	4	8.9E-03	5.5	30	64.45	10	0.25	3.99E-04		
		2	15.5	3.5E-02	5.5	30	128.37	10	0.25	5.95E-04		
	(31.5-41.5)	1	1.6	3.6E-03	5.5	36.5	81.7	10	0.25	1.26E-04		
	(31.5-48.5)	1	28.5	6.3E-02	5.5	39	48.7	17	0.25	5.03E-03	(38-48)	
BRMW13	(21-31)	1	18.2	4.1E-02	4.4	26	50.8	10	0.25	2.49E-03	(21-31)	Permeability
	(27-37)	1	7.8	1.7E-02	4.4	32	69.9	10	0.25	7.35E-04		
		2	12.1	2.7E-02	4.4	32	117	10	0.25	5.40E-04		
	(33-43)	1	1	2.2E-03	4.4	38	101.5	10	0.25	5.87E-05		
		2	1.3	2.9E-03	4.4	38	148.8	10	0.25	4.50E-05		
	(33-50)	1	0.9	2.0E-03	4.4	40.5	105.3	17	0.25	3.49E-05		
		2	1.9	4.2E-03	4.4	40.5	148.6	17	0.25	4.53E-05		
BRMW14	(25-35)	1	0				110.5			1.0E-07	(25-35)	Permeability
	(31-41)	1	0				108.3			1.0E-07		
	(37-54)	1	0				104			1.0E-07		
BRMW15	(15-25)	1	13.5	3.0E-02	11.67	20	59.08	10	0.25	1.06E-03	(15-25)	Permeability
		2	20	4.5E-02	11.67	20	99.31	10	0.25	8.77E-04		
	(25-35)	1	3.7	8.2E-03	11.67	30	78.2	10	0.25	2.46E-04		
		2	4.3	9.6E-03	11.67	30	117.4	10	0.25	1.73E-04		
	(30.5-47.5)	1	1.7	3.8E-03	11.67	38	101.4	17	0.25	6.06E-05		
		2	3.2	7.1E-03	11.67	38	147.2	17	0.25	7.10E-05		
BRMW16	(14.5-24.5)	1	4.7	1.0E-02	11.67	19.5	46.19	10	0.25	4.89E-04		Permeability
	(25-35)	1	0							1.0E-07		
	(30-47)	1	0							1.0E-07		
BRMW17	(17-27)	1	0				95			1.0E-07		
	(25-35)	1	2.3	5.1E-03	5.58	30	72.2	10	0.25	1.92E-04	(25-35)	Permeability
		2	10.5	2.3E-02	5.58	30	91.3	10	0.25	6.26E-04		
		3	18	3.6E-02	5.58	30	106.1	10	0.25	7.81E-04		
	(32.5-49.5)	1	0.7	1.6E-03	5.58	41	96.6	17	0.25	3.07E-05		
		2	1.4	3.1E-03	5.58	41	171.7	17	0.25	2.76E-05		

[a] Maximum pump rate too low for valid calculation.
[b] Flow rate invalid, water observed coming up through casing during test.

Note: BGS = Below Ground Surface

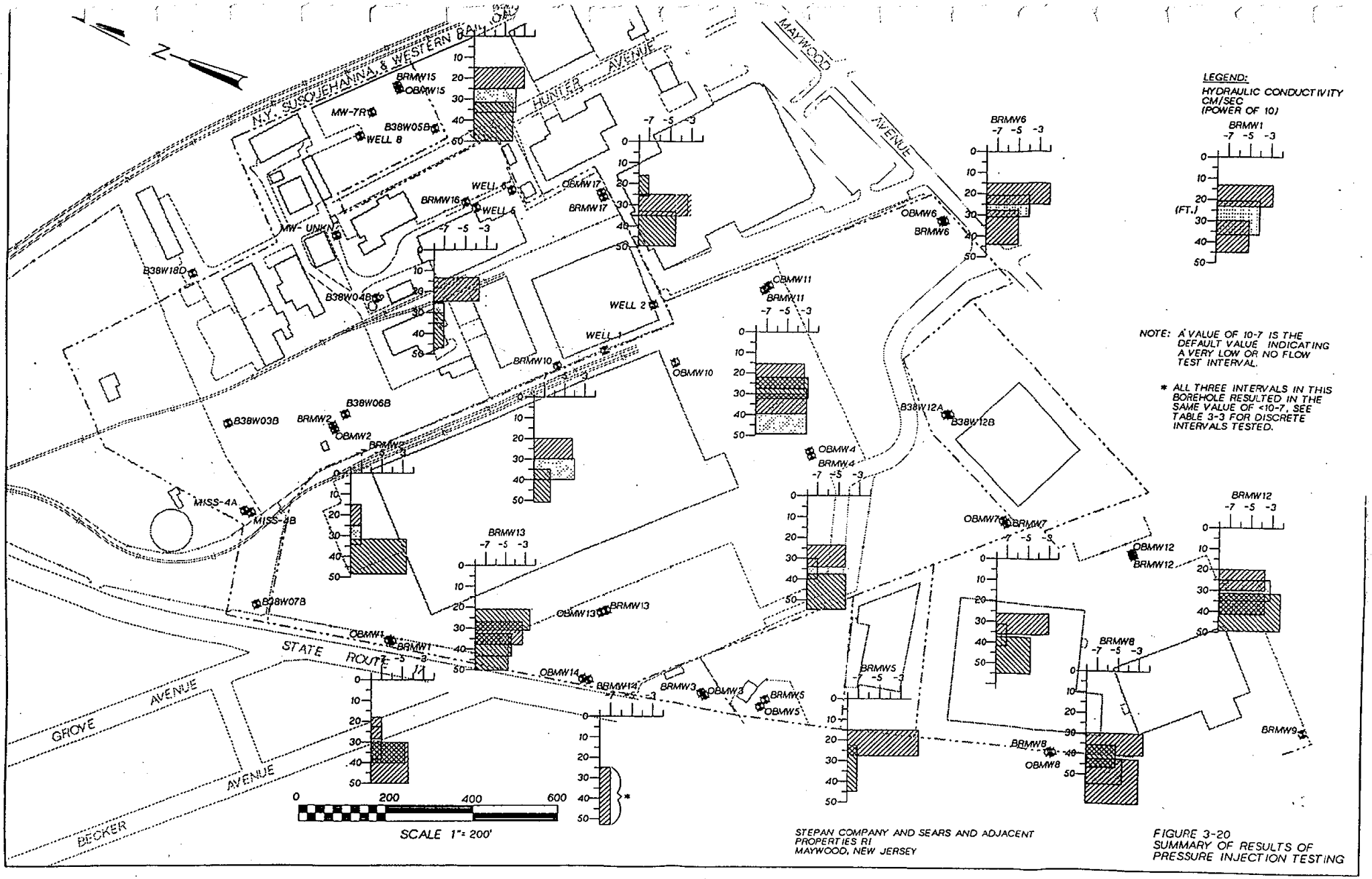

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FIGURE 3-20
SUMMARY OF RESULTS OF PRESSURE INJECTION TESTING

the chart is the resulting hydraulic conductivity expressed in cm/sec as a power of 10. The y-axis is the depth below grade with the bar width representing the test-zone interval and the length indicating k-value. The longer the bar, the higher the permeability. The most significant observation made from these profiles is that in 7 of the 15 tested profiles, the interval with the maximum permeability was the immediate test interval below the surface casing. This pattern may have two explanations. The first is that there is leakage around the bottom of the casing grout seal. This is unlikely because of the pressure testing that was performed following installation of the surface casings. The second and more probable explanation is that the influence of the weathered bedrock zone on permeability extends well below it, the bottom the surface casing.

The resulting k-values for test sections in the holes that were cored were evaluated with respect to stratigraphy to assess if there were any patterns associating bedding lithology with permeability. The results of this exercise were inconclusive because complex bedding patterns and the limited resolution of the test interval (10 feet) made the exercise extremely difficult. Many test zones included varying lithology and rock structure, thus preventing differentiation of permeable bedding types.

In only four of the tested profiles, the hydraulic conductivity was found to increase with depth. Of these four, BRMW2 and BRMW12 had considerable increase in conductivity with depth. In each of these profiles, relatively deep, high conductivity zones were overlain by a low permeability zone variable thickness. The first two tested intervals of the borehole immediately below the surface casing in BRMW2 (a total of 20 feet) did not accept water flow at as high a pressure as 99 psi. The third tested interval--32.5 to 42.5 feet below grade--resulted in a k-value of 4×10^{-3} cm/sec. In BRMW12, the most prolific zone was determined to be from 41.5 to 48.5 feet below grade, with a k-value of 5×10^{-3} cm/sec. The highest k-value of zones tested above this zone was 6×10^{-4} cm/sec. Wells BRMW11 and BRMW17 showed a moderate increase in permeability with depth.

The packer test results in BRMW2 and BRMW12 are consistent with the significantly different static water levels between the overburden and bedrock wells of each couplet (see water level data for both wells on each date in Table 3-2). The difference in water levels between the overburden and bedrock wells is explained by the occurrence of the low permeability bedding identified during packer testing.

Slug Test Results. Rising head tests were conducted on 14 wells screened in the overburden and on 17 wells in bedrock zones to determine the hydraulic conductivity and transmissivity of the zones tested. The data from each slug test was plotted according to the Bouwer and Rice method. In wells that showed some evidence of semi-confined or confined conditions (on the basis of packer and slug tests), data were also analyzed using the Hvorslev method to compare the results of both methods.

The plots of the data points showing the best-fit line for each data set are presented in the graphs in Appendix L. Tables 3-4 and 3-5 summarize the results of the analyses and the calculated values of hydraulic conductivity for each overburden and bedrock well. Table 3-6 presents the calculated transmissivities for the portion of the aquifer tested in the overburden wells.

Rising head tests were conducted on 14 wells screened within the overburden unit (OBMW1 through OBMW8, OBMW11 through OBMW15, and OBMW17). At least two tests were conducted on each of these wells except for OBMW15, which took a particularly long time to re-equilibrate after the slug was placed in the well. The range of geometric means of hydraulic conductivity in these wells was 1.41×10^{-4} cm/sec to 1.04×10^{-2} cm/sec. Estimates of transmissivity ranged from 22 to 1,874 gpd per foot.

Rising head tests were conducted on 17 wells screened within the bedrock unit (BRMW1 through BRMW17). At least two tests were conducted in each of the wells except BRMW1 and BRMW14, which took a long time to re-equilibrate and recover. The range of the geometric means of hydraulic conductivity, as calculated by the Bouwer and Rice analytical method, was 1.47×10^{-6} cm/sec to 2.96×10^{-2} cm/sec.

Nine of the bedrock wells that exhibited confined or semi-confined characteristics during the pressure-injection testing were analyzed with the Hvorslev method (BRMW2, BRMW5, BRMW6, BRMW8, BRMW11, BRMW12, BRMW13, BRMW15, BRMW16). The range of the geometric means of hydraulic conductivity in these wells using the Hvorslev method was 2.19×10^{-3} cm/sec to 1.17×10^{-2} cm/sec.

Comparison of Slug Test Results with Pressure Injection Testing. Hydraulic conductivities obtained from the slug test results were compared to results of the pressure injection testing to see how well the two test methods could be correlated. Results of this comparison are summarized in Table 3-7.

In general, similar intervals tested with both methods showed consistent k values (within the same order of magnitude) except in wells BRMW5, BRMW7, and BRMW16. The packer testing indicated higher k values in BRMW5 and BRMW7 and a lower value in BRMW16. Hydraulic conductivities obtained by both the Bouwer and Rice method and Hvorslev method are presented in Table 3-7, where applicable, to see which method value rendered more similar to the packer test results. In most wells where the results of both methods could be correlated, hydraulic conductivity values estimated from the packer testing were most similar to k values generated by the Bouwer and Rice Method (unconfined aquifer conditions).

Table 3-4
Summary of Hydraulic Conductivities (k) For Overburden Wells

Appendix A Figure No.	Well No., Test No.	k(cm/sec)	Data Analysis Method	Percent Recovery of Test	Total Displacement (ft)	Geometric Mean of Tests within Well K(cm/sec)
A-1	OBMW1, Test 1	6.64×10^{-3}	Bouwer	87	1.35	
A-2	OBMW1, Test 2	8.19×10^{-3}	Bouwer	83	1.32	7.37×10^{-3}
A-4	OBMW2, Test 1	1.16×10^{-3}	Bouwer	90	3.73	
A-5	OBMW2, Test 2	1.23×10^{-3}	Bouwer	90	3.48	1.19×10^{-3}
A-10	OBMW3, Test 1	9.80×10^{-4}	Bouwer	88	5.57	
A-11	OBMW3, Test 2	8.17×10^{-4}	Bouwer	90	3.26	8.95×10^{-4}
A-14	OBMW4, Test 1	6.99×10^{-4}	Bouwer	90	4.24	
A-15	OBMW4, Test 2	7.41×10^{-4}	Bouwer	90	4.38	
A-16	OBMW4, Test 3	7.45×10^{-4}	Bouwer	94	6.24	7.29×10^{-4}
A-19	OBMW5, Test 1	6.87×10^{-4}	Bouwer	90	1.89	
A-20	OBMW5, Test 2	1.18×10^{-3}	Bouwer	90	1.99	
A-21	OBMW5, Test 3	5.29×10^{-3}	Bouwer	90	1.77	1.42×10^{-3}
A-26	OBMW6, Test 1	2.59×10^{-3}	Bouwer	83	1.42	
A-27	OBMW6, Test 2	1.24×10^{-3}	Bouwer	80	1.42	1.79×10^{-3}
A-32	OBMW7, Test 1	2.46×10^{-4}	Bouwer	98	3.53	
A-33	OBMW7, Test 2	2.41×10^{-4}	Bouwer	100	4.24	2.43×10^{-4}
A-36	OBMW8, Test 1	9.79×10^{-4}	Bouwer	87	2.31	
A-37	OBMW8, Test 2	1.02×10^{-3}	Bouwer	87	2.36	9.99×10^{-4}
A-47	OBMW11, Test 1	2.85×10^{-4}	Bouwer	90	2.56	
A-48	OBMW11, Test 2	2.74×10^{-4}	Bouwer	90	2.52	2.79×10^{-4}

Table 3-4
Summary of Hydraulic Conductivities (k) For Overburden Wells

Appendix A Figure No.	Well No., Test No.	k(cm/sec)	Data Analysis Method	Percent Recovery of Test	Total Displacement (ft)	Geometric Mean of Tests within Well K(cm/sec)
A-53	OBMW12, Test 1	1.87×10^{-3}	Bouwer	90	2.2	
A-54	OBMW12, Test 2	1.14×10^{-2}	Bouwer	90	5.0	
A-55	OBMW12, Test 3	1.27×10^{-2}	Bouwer	90	3.0	6.50×10^{-3}
A-60	OBMW13, Test 1	3.85×10^{-3}	Bouwer	93	3.68	
A-61	OBMW13, Test 2	3.70×10^{-3}	Bouwer	100	5.48	3.77×10^{-3}
A-66	OBMW14, Test 1	4.00×10^{-4}	Bouwer	90	1.65	
A-67	OBMW14, Test 2	4.99×10^{-4}	Bouwer	90	2.12	
A-68	OBMW14, Test 3	3.67×10^{-4}	Bouwer	90	1.95	4.47×10^{-4}
A-71	OBMW15, Test 1	3.92×10^{-4}	Bouwer	90	1.41	3.92×10^{-4}
A-80	OBMW17, Test 1	1.04×10^{-2}	Bouwer	90	2.32	
A-81	OBMW17, Test 2	1.05×10^{-2}	Bouwer	90	1.67	1.04×10^{-2}

Table 3-5
Summary of Hydraulic Conductivities (k) For Bedrock Wells

Appendix A Figure No.	Well No., Test No.	k(cm/sec)	Data Analysis Method	Percent Recovery of Test	Total Displacement (ft)	Geometric Mean of Tests within Well K(cm/sec)
A-3	BRMW1, Test 1	1.99×10^{-5}	Bouwer	90	6.39	1.99×10^{-5}
A-6	BRMW2, Test 1	4.04×10^{-3}	Bouwer	90	10.01	
A-7	BRMW2, Test 2	4.19×10^{-3}	Bouwer	90	10.15	4.11×10^{-3}
A-8	BRMW2, Test 1	7.14×10^{-3}	Hvorslev	90	10.01	
A-9	BRMW2, Test 2	7.40×10^{-3}	Hvorslev	90	10.15	7.27×10^{-3}
A-12	BRMW3, Test 1	2.86×10^{-2}	Bouwer	96	10.07	
A-13	BRMW3, Test 2	3.07×10^{-2}	Bouwer	90	10.22	2.96×10^{-2}
A-17	BRMW4, Test 1	2.23×10^{-5}	Bouwer	85	5.13	
A-18	BRMW4, Test 2	2.08×10^{-5}	Bouwer	83	5.18	2.15×10^{-5}
A-22	BRMW5, Test 1	4.18×10^{-3}	Bouwer	90	10.01	
A-23	BRMW5, Test 2	4.65×10^{-3}	Bouwer	90	9.99	4.41×10^{-3}
A-24	BRMW5, Test 1	7.81×10^{-3}	Hvorslev	90	10.01	
A-25	BRMW5, Test 2	8.70×10^{-3}	Hvorslev	90	9.99	8.24×10^{-3}
A-28	BRMW6, Test 1	9.15×10^{-3}	Bouwer	100	10.01	
A-29	BRMW6, Test 2	8.95×10^{-3}	Bouwer	100	9.97	9.05×10^{-3}
A-30	BRMW6, Test 1	1.73×10^{-2}	Hvorslev	100	10.01	
A-31	BRMW6, Test 2	1.69×10^{-2}	Hvorslev	100	9.97	1.71×10^{-2}
A-34	BRMW7, Test 1	2.87×10^{-5}	Bouwer	90	7.23	
A-35	BRMW7, Test 2	5.21×10^{-5}	Bouwer	90	7.49	3.87×10^{-5}
A-38	BRMW8, Test 1	1.58×10^{-3}	Bouwer	96	9.99	

Table 3-5
Summary of Hydraulic Conductivities (k) For Bedrock Wells

Appendix A Figure No.	Well No., Test No.	k(cm/sec)	Data Analysis Method	Percent Recovery of Test	Total Displacement (ft)	Geometric Mean of Tests within Well K(cm/sec)
A-39	BRMW8, Test 2	1.54×10^{-3}	Bouwer	96	10.00	1.56×10^{-3}
A-40	BRMW8, Test 1	2.87×10^{-3}	Hvorslev	96	9.99	
A-41	BRMW8, Test 2	2.80×10^{-3}	Hvorslev	96	10.00	2.83×10^{-3}
A-42	BRMW9, Test 1	1.34×10^{-2}	Bouwer	90	3.86	
A-43	BRMW9, Test 2	3.99×10^{-2}	Bouwer	90	2.96	
A-44	BRMW9, Test 3	1.85×10^{-2}	Bouwer	95	5.5	2.15×10^{-2}
A-45	BRMW10, Test 1	3.91×10^{-4}	Bouwer	90	8.06	
A-46	BRMW10, Test 2	3.92×10^{-4}	Bouwer	90	8.02	3.92×10^{-4}
A-49	BRMW11, Test 1	1.58×10^{-3}	Bouwer	90	10.04	
A-50	BRMW11, Test 2	1.61×10^{-3}	Bouwer	90	10.03	1.59×10^{-3}
A-51	BRMW11, Test 1	2.82×10^{-3}	Hvorslev	90	10.04	
A-52	BRMW11, Test 2	2.88×10^{-3}	Hvorslev	90	10.03	2.85×10^{-3}
A-56	BRMW12, Test 1	9.97×10^{-3}	Bouwer	90	10.00	
A-57	BRMW12, Test 2	9.23×10^{-3}	Bouwer	90	9.99	9.59×10^{-3}
A-58	BRMW12, Test 1	1.65×10^{-2}	Hvorslev	90	10.00	
A-59	BRMW12, Test 2	1.53×10^{-2}	Hvorslev	90	9.99	1.59×10^{-2}
A-62	BRMW13, Test 1	1.93×10^{-3}	Bouwer	90	10.05	
A-63	BRMW13, Test 2	2.24×10^{-3}	Bouwer	90	10.04	2.07×10^{-3}
A-64	BRMW13, Test 1	3.40×10^{-3}	Hvorslev	90	10.05	
A-65	BRMW13, Test 2	3.96×10^{-3}	Hvorslev	90	10.04	3.67×10^{-3}

Table 3-5
Summary of Hydraulic Conductivities (k) For Bedrock Wells

Appendix A Figure No.	Well No., Test No.	k(cm/sec)	Data Analysis Method	Percent Recovery of Test	Total Displacement (ft)	Geometric Mean of Tests within Well K(cm/sec)
A-69 A-70	BRMW14, Test 1	1.47×10^{-6} 1.25×10^{-5}	Bouwer Bouwer	71 71 - 97	3.72 3.72	1.47×10^{-6} to 1.25×10^{-5}
A-72	BRMW15, Test 1	2.90×10^{-3}	Bouwer	90	4.06	
A-73	BRMW15, Test 2	3.03×10^{-3}	Bouwer	90	4.07	2.96×10^{-3}
A-74	BRMW15, Test 1	5.86×10^{-3}	Hvorslev	90	4.06	
A-75	BRMW15, Test 2	6.11×10^{-3}	Hvorslev	90	4.07	5.98×10^{-3}
A-76	BRMW16, Test 1	1.12×10^{-3}	Bouwer	90	5.02	
A-77	BRMW16, Test 2	1.11×10^{-3}	Bouwer	90	5.05	1.12×10^{-3}
A-78	BRMW16, Test 1	2.19×10^{-3}	Hvorslev	90	5.02	
A-79	BRMW16, Test 2	2.19×10^{-3}	Hvorslev	90	5.05	2.19×10^{-3}
A-82	BRMW17, Test 1	7.79×10^{-4}	Bouwer	90	10.04	
A-83	BRMW17, Test 2	7.67×10^{-4}	Bouwer	90	10.00	7.72×10^{-4}

Table 3-6
Estimated Transmissivities of Overburden Wells

Well #	Property	k (cm/sec)	k (gal/day/ft^2)	Thickness of Overburden (ft)	T (gal/day/ft)
OBMW1	Sears	7.37×10^{-3}	156.14	5	781
OBMW2	Stepan	1.19×10^{-3}	25.23	7	177
OBMW3	Gulf	8.95×10^{-4}	18.97	7	133
OBMW4	Sears	7.29×10^{-4}	15.45	12	185
OBMW5	Sunoco	1.42×10^{-3}	30.08	5.7	171
OBMW6	Sears	1.79×10^{-3}	37.92	3.8	144
OBMW7	Sears	2.43×10^{-4}	5.15	11.8	61
OBMW8	SWS Realty	9.99×10^{-4}	21.17	6.9	146
OBMW11	Sears	2.79×10^{-4}	5.91	9.5	56
OBMW12	Federal Express	6.50×10^{-3}	137.71	8	1,102
OBMW13	Sears	3.77×10^{-3}	79.87	9.8	783
OBMW14	Sears	4.47×10^{-4}	9.47	11	104
OBMW15	Stepan	3.92×10^{-4}	8.31	4	33
OBMW17	Stepan	1.04×10^{-2}	220.34	8.5	1,873

NOTES: k = hydraulic conductivity
T = transmissivity

Table 3-7
Comparison of Hydraulic Conductivities Estimated From Slug Testing and from Packer Testing

Well #	Well Screen Interval (ft)	Packer Test Interval (ft)	Hydraulic Conductivity (cm/sec)	
			Slug Test	Packer Test
BRMW1	37-47	30-47	1.99×10^{-5} (B)	2.61×10^{-5}
BRMW2	32-42	32.5-42.5	4.11×10^{-3} (B) 7.27×10^{-3} (H)	4.06×10^{-3}
BRMW3	20-30	No test	2.96×10^{-2} (B)	No test
BRMW4	26-36	24-34	2.15×10^{-5} (B)	4.84×10^{-5}
BRMW5	19-29	17-27	4.41×10^{-3} (B) 8.24×10^{-3} (H)	5.65×10^{-2}
BRMW6	17-27	15-25	9.05×10^{-3} (B) 1.71×10^{-2} (H)	3.76×10^{-2}
BRMW7	28-38	27-37	3.87×10^{-5} (B)	1.24×10^{-3}
BRMW8	32-42	32-42	1.56×10^{-3} (B) 2.83×10^{-3} (H)	2.09×10^{-3}
BRMW9	13.5-23.5	No test	2.15×10^{-2} (B)	No test
BRMW10	30-40	30-40	3.92×10^{-4} (B)	1.03×10^{-4}
BRMW11	23-33	23-33	1.59×10^{-3} (B) 2.85×10^{-3} (H)	1.10×10^{-3}
BRMW12	38-48	38-48	9.59×10^{-3} (B) 1.59×10^{-2} (H)	5.03×10^{-3}
BRMW13	23-33	21-31	2.07×10^{-3} (B) 3.67×10^{-3} (H)	2.49×10^{-3}

Table 3-7
Comparison of Hydraulic Conductivities Estimated From Slug Testing and from Packer Testing

Well #	Well Screen Interval (ft)	Packer Test Interval (ft)	Hydraulic Conductivity (cm/sec)	
			Slug Test	Packer Test
BRMW14	27-37	25-35	1.47×10^{-6} (B)	No test
BRMW15	20-30	15-25	2.96×10^{-3} (B) 5.98×10^{-3} (H)	1.06×10^{-3}
BRMW16	20-30	14.5-24.5	1.12×10^{-3} (B) 2.19×10^{-3} (H)	4.89×10^{-4}
BRMW17	25-35	25-35	7.72×10^{-4} (B)	1.92×10^{-4}

Notes: (B) = Bouwer and Rice Analysis Method
(H) = Hvorslev Analysis Method

3.6.3 Conceptual Hydrogeological Model of the Study Area

The hydrogeological model of the study area is similar to that discussed in Section 3.5. Site-specific data suggests that the study area is composed of two distinct water-bearing systems, the water table aquifer and the multi-unit leaky bedrock aquifer. The complex hydraulic relationship between the two regimes is discussed below.

Water Table Aquifer. The water table aquifer is the only continuous aquifer present across the study area whose geometry and hydrogeologic characteristics can be defined. The surface of the water table aquifer intersects the land surface at some places within the study area (wetland area east of Sears) and may be as deep as 14.75 feet below grade (BRMW15). In areas of higher topography, such as near BRMW15, the surface of the water table is within the weathered bedrock zone. This is also true in areas where the top of rock is extremely shallow, such as near the southern most extent of the Federal Express property. Generally, across the study area, the surface of the water table aquifer occurs in the overburden soil.

The data from the field investigations did not suggest the presence of a significant confining or semi-confining unit above the top of rock. The stratified glacial deposits and fill were not laterally extensive, nor did they contain enough fine sediments to represent an effective confining layer. The unstratified till and residual soil found on top of the rock in every boring was largely composed of coarse-grained material and rock fragments and does not provide an effective confining unit. The bottom of the water table aquifer is therefore a function of the location of the competent bedrock underlying the unconsolidated deposits. The thickness of the water table is also dependent upon the type of bedrock, the degree of its weathering, and its orientation. The water table aquifer generally extends to the top of the competent bedrock through the moderately to severely weathered zone above the bedrock. In areas where the bedrock underlying the unconsolidated deposits is a competent and relatively impermeable rock type, the thickness of the weathered zone is relatively small, and the lower limits of the water table are more defined. In areas where the underlying bedrock is less competent, more fractured, and relatively more permeable, the lower limits of water table are difficult to define and may constitute hydraulic connection with one or more of the discrete aquifers in the bedrock. The bottom of the water table aquifer in this case can be considered a transitional zone between the water table and bedrock aquifer systems.

The extension of the lower limits of the water table into the bedrock aquifer at some locations is supported by the data from both packer testing and slug testing. The data from the packer testing indicated that in 7 of the 15 test holes, the 10-foot zone immediately below the surface casing was the most permeable test section. This could have resulted from the influence of the weathered bedrock horizon. The average conductivity of the seven test zones was 1.64×10^{-3} cm/sec, and the average conductivity of the overburden was 8.72×10^{-4} cm/sec, indicating that the water table

can be considered contiguous with the bedrock aquifer immediately underlying the unconsolidated deposits at these locations. The significance of these observations is that the water table aquifer may actually be thicker than the overburden deposits.

Bedrock Aquifer. Similar to the regional hydrogeologic model, the groundwater regime below the top of bedrock in the study area appears to be controlled by a sequence of thin, fractured, water-bearing units bounded by thicker intervening units of low permeability. These units are defined by bedrock lithology resulting in a series of alternating tabular aquifers that may extend down-dip for a few hundred feet and be continuous along strike for considerable distances. Rock core evaluations revealed bedding thicknesses ranging from 1 to 20 feet, although the fractured zones were generally much less than 20 feet.

The presence of permeable zones bounded by impermeable zones was supported by the data from the packer testing (Section 3.6.2), which indicated the presence of significant thicknesses of relatively impermeable, intervening beds below the unconsolidated deposits. In some cases, the impermeable zones were found directly below the surface casing and in others (BRMW11 and BRMW12), the impermeable zones were found to alternate with relatively thin, discrete permeable zones.

Groundwater Occurrence and Flow. Systematic fractures such as partings along bedding and, to a lesser extent, near-vertical joint sets aligned with the strike of the bedding provide the principle pathways of groundwater flow. This assertion is based on a regional understanding of the groundwater flow in the Passaic Member of the Brunswick Formation and on the evaluations of the rock cores during the exploration program. Predominantly sub-horizontal fracture orientations and a lower percentage of sub-vertical fractures were observed in the rock cores. Complicating groundwater flow in this system is a random network of interconnected openings formed from joints, fractures, and solution cavities with no particular orientation. These water-bearing openings are not as dominant as the systematic fractures but do act to "short circuit" aquifers and increase hydraulic communication between aquifers. The investigation data suggest that groundwater flows preferentially along discrete fractures or a network of fractures.

By strict definition, the section of rock in which the bedrock monitoring wells are screened should be considered confined, for three reasons. The first is that the fractures screened are bounded above and below by bedding of low permeability and relatively little production. This condition is demonstrated by the pressure injection testing data, which verified the presence of alternately permeable and nonpermeable intervals down the borehole. This fulfills the classic definition of confined. The second reasons is that the potentiometric surfaces in the wells were found to be significantly above the elevation of the permeable test zones. Third, many of the bedrock monitoring wells were observed to have heads that consistently are slightly higher than those of their shallow counterparts, thus suggesting the presence of hydraulic pressures.

Despite this, the 7-day continuous water level plots of the overburden wells showed a response to diurnal barometric pressures similar to the responses in their deep counterparts, which indicates that in most of the bedrock well locations, a water table condition exists. Considering that most of the bedrock wells are relatively shallow and that the impermeable zones in most cases were in the lower portions of the bedrock investigated, it can be inferred that at these locations, the water table is in hydraulic communication with the water in the bedrock or that the bedrock aquifer is not in a fully confined condition.

The degree of confinement at the site is a function of both the depth and location of the water. The deeper the well, the greater the likelihood of encountering confined conditions. This is exhibited at couplets OBMW2-BRMW2 at Stepan and OBMW12-BRMW12 at Sears and other properties, which include two of the deepest wells and the largest static head differentials. Equally as important when considering degree of confinement is the well's position within the lithologic profile. In these wells, the presence of intervening low permeability rock above a permeable zone appears to have created semi-confined conditions.

It appears that the degree of confinement for wells in the study area lies on a continuum between confined and unconfined. Most of the bedrock wells behaved like water table wells, except for their slightly higher static head. BRMW2 and BRMW12 are more confined than the other wells, according to their static water levels. Regional hydrogeologic conditions suggest that, at depths greater than that of the wells in the study area, the multi-unit bedrock leaky aquifer system will invariably result in confined conditions.

The field data do not suggest a consistent vertical gradient upward or downward across the study area for any given date. On July 28, 1992, 11 of the 15 well couplets exhibited a vertical gradient upward. On this date, bedrock wells among these couplets had water elevations ranging from 0.03 to 1.27 feet higher than the shallow well counterpart. On September 9, 1992, seven couplets exhibited a vertical gradient upward. On October 2, 1992, only three couplets exhibited vertical gradients upward and, on November 5, 1993, five couplets had vertical gradients upward. One reason for this trend could be the build-up of water pressure as a result of spring recharge, which causes higher groundwater levels in the summer. By fall, the impacts of summer evapotranspiration reduce water levels and pressures in wells.

Certain well couplets showed consistent gradients. Well couplets BRMW3, BRMW7, BRMW10, BRMW12, BRMW15, and BRMW17 generally showed an upward gradient. Well couplets BRMW1, BRMW2, BRMW4, BRMW5, BRMW8, BRMW11, and BRMW14 show a downward gradient. As discussed, the gradients in these locations are a function of the type of bedrock and hence the degree of weathering that exists in the area of the overburden well. There is no discernable pattern or explanation for the distribution of wells exhibiting vertical gradients as opposed to downward gradients. Considering that groundwater flow in the Passaic Member of the Brunswick Formation is along the bedding partings and that water-bearing zones

alternate with intervening low permeability bedding, as defined by stratigraphy, it is plausible that some of the fracture zones screened are recharged hydraulically upgradient. Assuming a dip of 9 degrees and a hypothetical screen interval centered at 35 feet below grade, the fracture zone screened may outcrop as far as 220 feet up-dip. If the area where the fractured bedding outcrops is upgradient, hydraulically, the bedrock well may be artesian. At the very least, this hydrogeological scenario would account for the moderate vertical upward gradient observed in many of the couplets.

The above discussions explain the occasional, moderately confined conditions and the close behavioral relationship between the shallow and deep wells in the study area. On the basis of the data, a deep well may have a significantly different water elevation and contaminant profile than its shallow counterpart, yet behave similarly in a hydrogeological sense.

A schematic representation of geologic and hydrogeologic conditions are presented in Figures 3-21 and 3-22. The purpose of these figures is to present conceptual flow conditions between the overburden and bedrock aquifer systems at Sections E-E' and F-F'. Although vertical gradients near the top of rock may vary as discussed from month to month, the overall groundwater flux is from the overburden aquifer to the multiunit bedrock system. The overburden aquifer generally acts as storage for the underlying permeable bedrock aquifer system where head drops with depth in the multiunit aquifer system, resulting in considerable gradients across the overburden. In areas, however, the overburden sediment may be impermeable and significantly limit contaminant transport to the bedrock aquifer.

3.7 Results of Supplemental Hydrogeological Investigation

3.7.1 Results of Pressure Injection Testing and Selection of Screen Intervals for Bedrock Wells

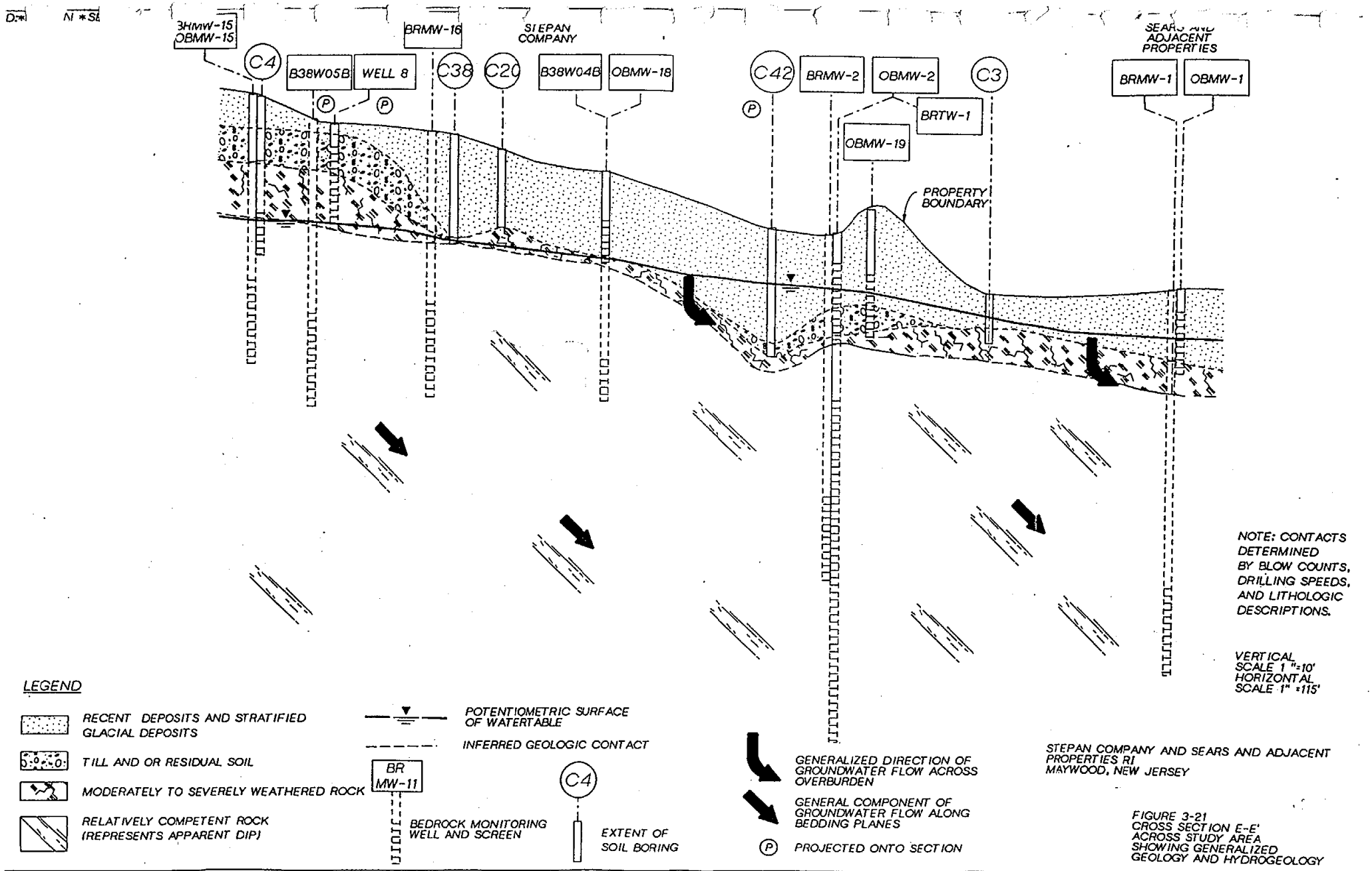
Pressure injection tests were performed at four locations: pumping wells BRTW1 and BRTW2 and bedrock couplets PT2 and PT3. Results of the tests are presented in Table 3-8. Injection test results and the intervals selected for screening are discussed below. The results should be considered apparent values because of the uncertainty of groundwater flow in fractured rock and the limitations of the analytical method. The limitations of the method are that the resulting hydraulic conductivity value is applied to the entire test interval when the water flow generally originates from only a discrete fracture.

In some cases, as for the 29- to 62-foot interval in BRTW1, the hydraulic conductivity values are approximate values. During the injection tests in this interval, the flow valves built into the system were fully open, and there was little back-pressure in the system. The low back-pressure is reflected in the small differences between the initial pressure and the final test zone pressure. This condition suggests that the formation

Table 3-8
Pressure Injection Test Data and Results

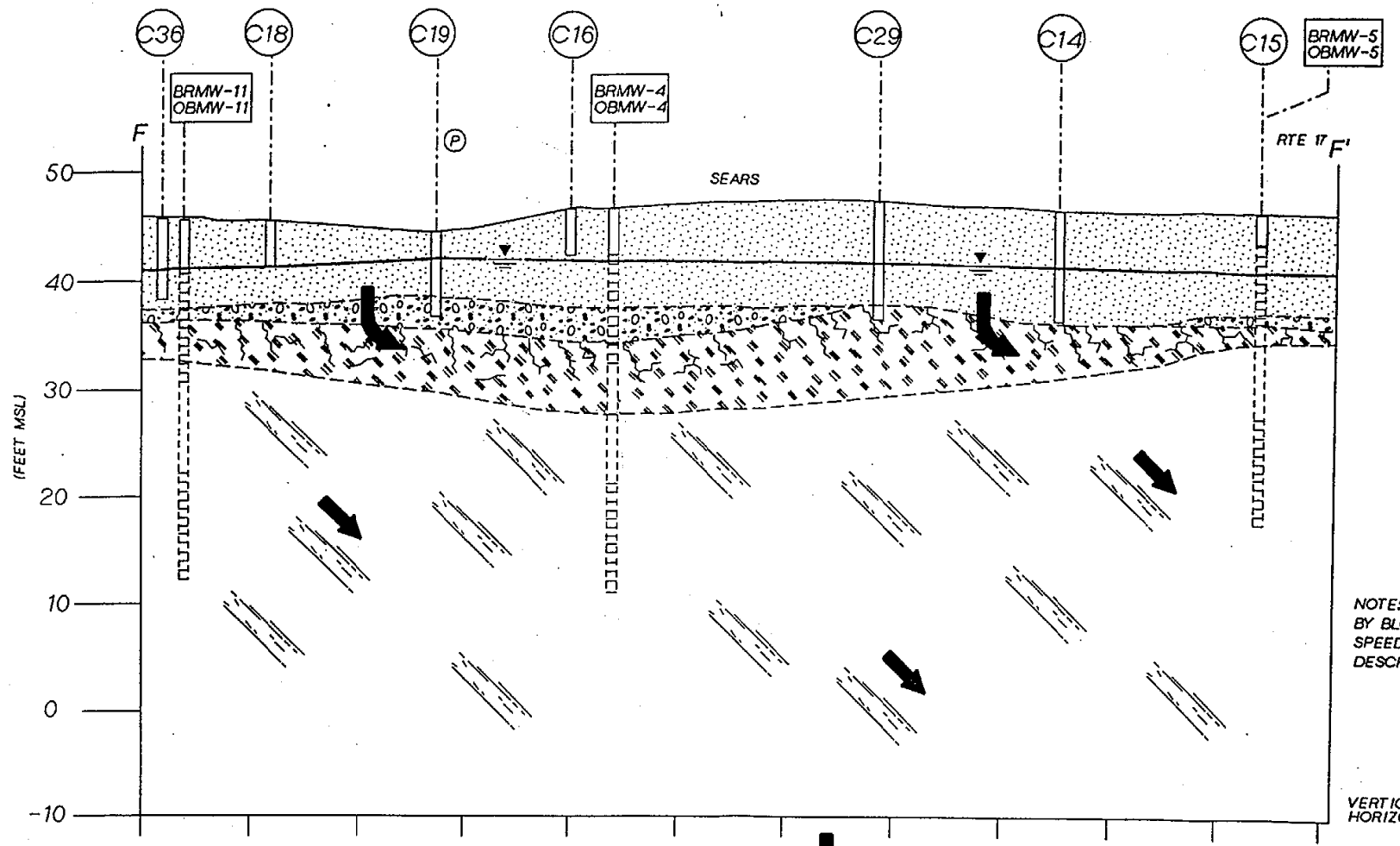
Well	Test Zone (ft)	Test Number	Flow Rate (gpm)	Flow Rate (ft³/sec)	**Initial Pressure (ft)	Test Zone Pressure (ft)	Length of Test Zone (ft)	Radius of Hole (ft)	Apparent Cond. (cm/sec)	Selected Screened Interval (ft)	Comments
BRTW1	(20-29.5)	1	3.7	8.24E-03	9.71	114.72	9.5	0.33	1.34E-04	Open Borehole	Left as open borehole to act as pumping well; significant waterbearing zone observed drilling at 37-42 feet.
	(29-40.5)	*1	33	7.35E-02	27.25	30.8	11.5	0.33	3.10E-02		
	(40.5-52)	*1	32	7.13E-02	44.12	47.29	11.5	0.33	3.36E-02		
	(40.5-62)	*1	29	6.46E-02	39.87	44.95	21.5	0.33	1.20E-02		
		*2	31.5	7.02E-02	39.87	47.18	21.5	0.33	9.03E-03		
PT2	(20.5-32)	1	2.5	5.57E-03	19.76	54.82	11.5	0.33	2.38E-04	PT-2D-A - (25-32)	Significant water bearing zone observed during drilling at 45-46 feet.
	(32-43.5)	1	2.1	4.68E-03	31.76	76.05	11.5	0.33	1.58E-04		
	(43.5-55)	*1	30	6.68E-02	42.93	50.66	11.5	0.33	1.29E-02	PT-2D-B - (40-50)	
	(50-62)	1	0.3	6.68E-04	48.25	85.08	12	0.33	2.63E-05		
BRTW2	(18 - 29.5)	1	16.75	3.73E-02	20.92	74.15	11.5	0.33	1.05E-03	Open Borehole	Significant water bearing zone observed during drilling at 20-22 feet.
		2	25	5.57E-02	20.92	99.69	11.5	0.33	1.06E-03		
		3	15.5	3.45E-02	20.92	64.64	11.5	0.33	1.18E-03		
	(29 - 62)	1	19.5	4.34E-02	32.51	73.55	33	0.33	7.16E-04		
		2	27	6.02E-02	32.51	97.09	33	0.33	6.30E-04		
	(41 - 62)	1	26.5	5.90E-02	44.09	118.24	21	0.33	7.63E-04		
	(52 - 61)	1	0.2	4.46E-04	55.09	112.17	9	0.33	1.39E-05		
PT3	(18 - 29.5)	*1	31	6.91E-02	20.34	30.25	11.5	0.33	1.04E-02	PT-3D-A - (18-29)	Significant water bearing zone observed during drilling at 20-22 feet.
	(29.5-41)	1	1.2	2.67E-03	31.91	77.38	11.5	0.33	8.79E-05		
		2	1.4	3.12E-03	31.91	87.71	11.5	0.33	8.36E-05		
	(41-52.5)	1	15	3.34E-02	43.3	101.41	11.5	0.33	8.60E-04	PT-3D-B - (41-51)	
		2	21.5	4.79E-02	43.3	156.42	11.5	0.33	6.33E-04		
		3	16	3.57E-02	43.3	110.7	11.5	0.33	7.91E-04		
		4	13.5	3.01E-02	43.3	97.09	11.5	0.33	8.36E-04		
		5	11.5	2.56E-02	43.3	87.69	11.5	0.33	8.63E-04		
	(41-59)	1	18	4.01E-02	43.3	117.74	18	0.33	5.80E-04		
		2	14	3.12E-02	43.3	97.3	18	0.33	6.21E-04		

Notes:
* Maximum pumping rate was too low for valid calculation; Conductivity value listed represents a minimum value.
** Height of water above transducer prior to start of pressure injection test.



STEPAN COMPANY AND SEARS AND ADJACENT PROPERTIES RI
MAYWOOD, NEW JERSEY

FIGURE 3-21
CROSS SECTION E-E'
ACROSS STUDY AREA
SHOWING GENERALIZED
GEOLOGY AND HYDROGEOLOGY



NOTE: CONTACTS DETERMINED BY BLOW COUNTS, DRILLING SPEEDS, AND LITHOLOGIC DESCRIPTIONS.

VERTICAL SCALE 1 "=10'
HORIZONTAL SCALE 1" =100'

LEGEND

- RECENT DEPOSITS AND STRATIFIED GLACIAL DEPOSITS
- TILL AND OR RESIDUAL SOIL
- MODERATELY TO SEVERELY WEATHERED ROCK
- RELATIVELY COMPETENT ROCK (REPRESENTS APPARENT DIP)
- POTENTIOMETRIC SURFACE OF WATERTABLE
- INFERRED GEOLOGIC CONTACT
- BR MW-11 — BEDROCK MONITORING WELL AND SCREEN
- C4 — EXTENT OF SOIL BORING
- GENERALIZED DIRECTION OF GROUNDWATER FLOW ACROSS OVERBURDEN
- GENERAL COMPONENT OF GROUNDWATER FLOW ALONG BEDDING PLANES
- (P) PROJECTED ONTO SECTION

STEPAN COMPANY AND SEARS AND ADJACENT PROPERTIES RI
MAYWOOD, NEW JERSEY

FIGURE 3-22
CROSS SECTION F-F'
ACROSS STUDY AREA
SHOWING GENERALIZED
GEOLOGY AND HYDROGEOLOGY

could have accepted greater flow rates. If a higher-capacity pump had been used during the test, higher conductivity values would have resulted. Therefore, the values presented probably reflect a low estimate of the actual hydraulic conductivity.

BRTW1. Pressure injection testing in BRTW1 indicated that the most permeable zone occurs between 29 and 52 feet below grade. The conductivity value for the 29- to 40.5-foot test zone was nearly equal to the value for the 40.5- to 52-foot test zone. These test results are similar because both zones straddle the zone between 37 and 42 feet. Observations during drilling indicated that the fracture zone most likely responsible for the high conductivity reported in the 29- to 52-foot interval actually occurs between 37 and 42 feet. As discussed earlier, open-borehole construction was used for pumping, so no well screens have been installed in BRTW1.

According to the formula used to calculate conductivity presented in 3.6.2, the conductivity value derived is a function of (L), the length of the test interval. The resulting conductivity is the average conductivity across the entire test interval. If it is assumed that all flow occurs through the entire interval for a given test interval where most flow originates from a discrete fracture, the resulting hydraulic conductivity would be falsely low. The test intervals across the permeable zone discussed above were 11.5 feet and 21.5 feet. If the actual flow zone is between 37 and 42 feet, the length of the zone tested should actually be considered to be only 5 feet. The reduced value of L would result in a hydraulic conductivity that is higher than the values reported in Table 3-8.

The intention of the pressure injection testing, however, was not to obtain absolute and accurate values of hydraulic conductivity from each of the test zones. The objective was to isolate the intervals where significant groundwater flow is occurring.

BRTW2. Because of obstructions in the borehole approximately 35 feet below grade, a single packer assembly was used for tests below 29 feet, and longer intervals were tested (Table 3-8). The zone yielding the highest conductivity was 18 to 29.5 feet below grade. Observations made during drilling located the fracture zone at approximately 20 to 22 feet. As discussed earlier, an open borehole construction was utilized for pumping during the pump test and therefore no well screens have been installed at BRTW2.

PT2. Four separate depth intervals were tested at PT2. The 43.5 - to 55-foot test zone yielded the highest hydraulic conductivity value and may straddle the same permeable fracture zone identified at BRTW1 at 37 to 42 feet below grade. During drilling, the actual location of the high-yield zone was observed to occur between 45 and 46 feet, which falls within the interval selected for the PT2D-B well screen (40 to 50 feet). The testing data and observations during drilling did not suggest that there are any other significant zones that should have been screened. It was decided, however, that a screen should be placed above the 40 to 50 foot zone to provide data

on the dynamics of groundwater flow in secondary fractures between the overburden zone and the zone screened by PT2D-B. PT2D-A therefore was screened from 26 to 32 feet.

PT3. As shown in Table 3-8, the 18- to 29.5-foot interval yielded the highest conductivity. During drilling, water-producing fractures were encountered at 20 to 22 feet. PT3D-A was screened across this zone, from 16 to 29 feet. PT3D-B was screened across the zone yielding the next highest quantity of water (41 to 51 feet) as indicated by the packer test results and drilling observations.

In the first test performed in this borehole, the capacity of the injection pump was reached before the test zone was adequately stressed. As such, the calculated conductivity is lower than the actual conductivity.

PT1. Pressure injection testing of PT1 was not possible because of obstructions within the borehole. Observations made during drilling indicated that fracture zones occur at 34 to 35 feet and at 61 to 62 feet below grade. On the basis of these observations, PT1D-A and PT1D-B were screened at 29 to 39 and 52 to 62 feet below grade.

3.7.2 Background Water-Level Monitoring Plots

The background water-level monitoring data plots were reviewed with two objectives. The first was to identify patterns or behavior that would provide insight into the overall evaluation of the responses of bedrock and overburden groundwater systems. All well responses were compared with barometric data. By factoring out the barometric effects, which was done qualitatively, extraneous influences such as leaky sewers or influences from nearby pumping wells were identified. The second objective was to identify any extraneous influences that may lesson the effectiveness of long-term pumping, should remediation be required.

The water level plots in Appendix S, generated during the RI for overburden well OBMW-2 and bedrock well BRMW-2 were similar to each other and exhibited an inverse relationship with barometric pressure. This relationship also was seen in other couplets (i.e., OBMW12 and BRMW12) and is explained in Section 3.6.2. This relationship was not as apparent to the same degree in the wells of the Stepan pumping test wellfield where, as illustrated in Figures 3-23 and 3-24, only a slight inverse relationship existed between the wells and barometric pressure. In these figures, barometric pressure is expressed in terms of equivalent feet of head instead of inches of mercury to allow for comparison of the barometric pressure series with the water level series.

The apparent independence of the shallow wells (PT1S and PT2S) from effects of barometric changes may be explained by the network of sewers that exist in the area of these wells. Leakage from these sewers may have obscured the anticipated barometric influences. Evidence of such leakage was provided by the high water-level elevation observed in PT2S. Even though this well is located downgradient of shallow

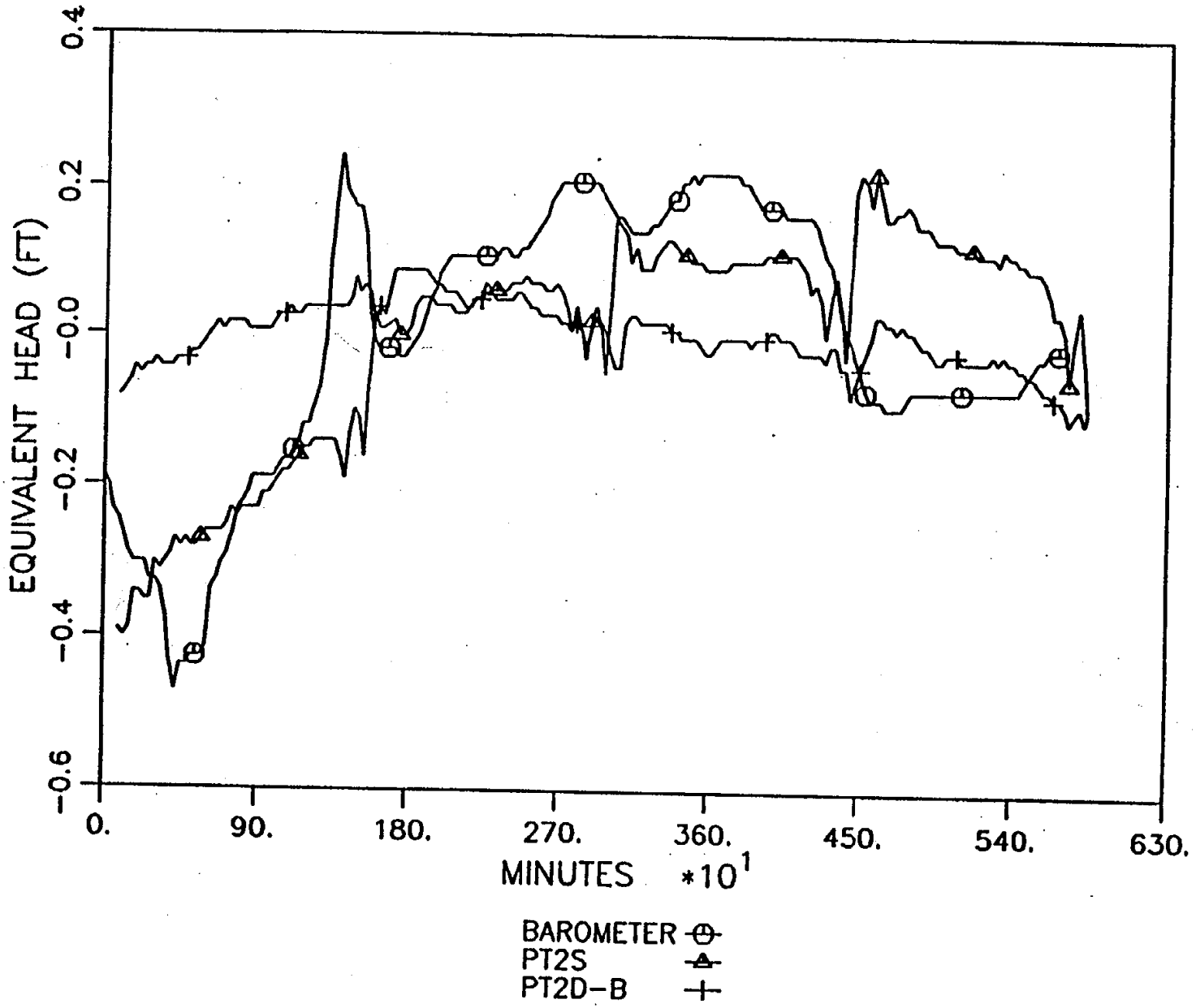


Figure 3-23
VARIATIONS IN BAROMETRIC PRESSURE AND MEASURED HEAD vs TIME AT PT-2

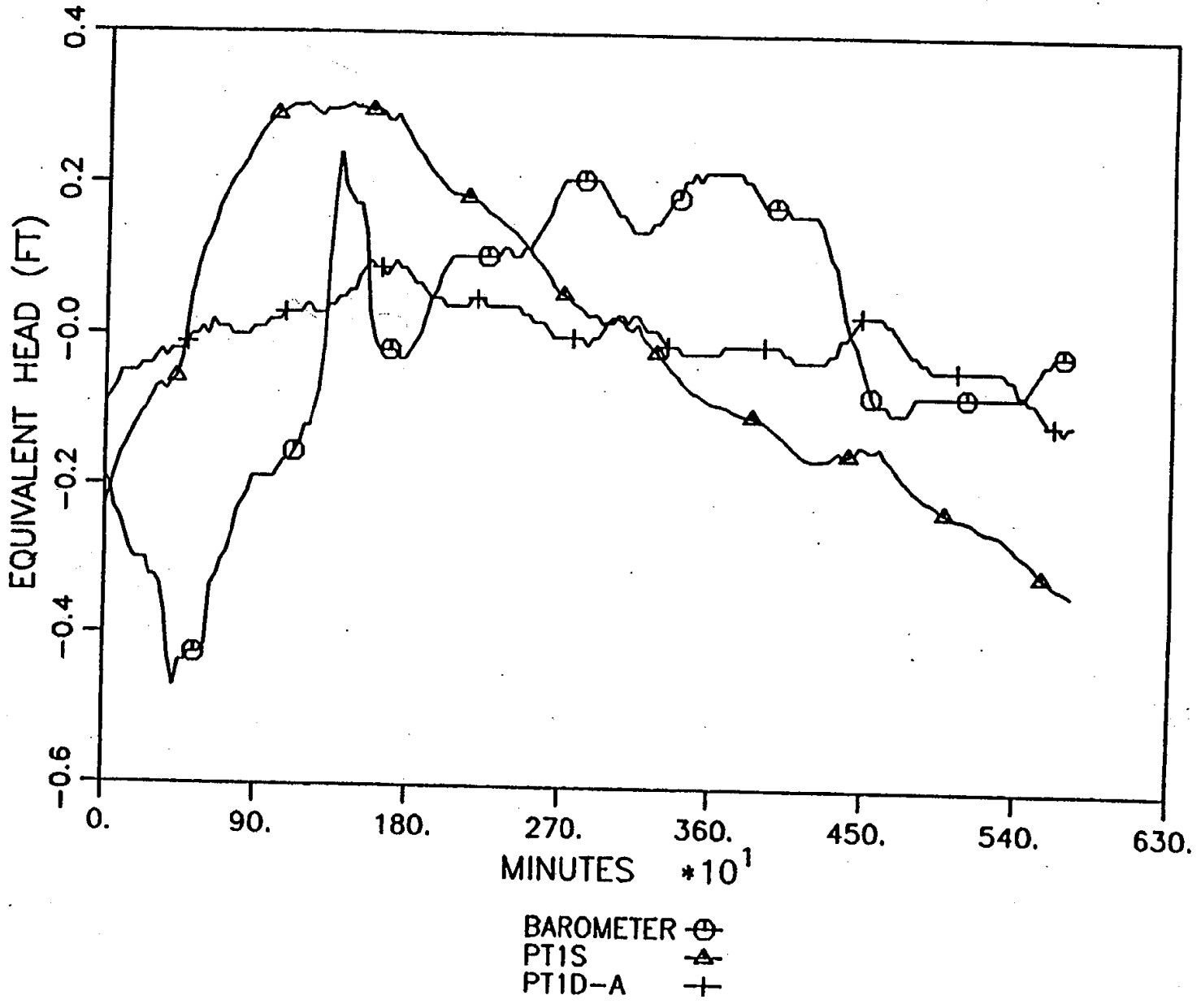


Figure 3-24
VARIATIONS IN BAROMETRIC PRESSURE AND MEASURED HEAD vs TIME AT PT-1

wells PT1S and OBMW2, its water-level elevation is higher than that of upgradient wells. Water-level elevations for wells in the Stepan pumping test area are presented in Table 3-9.

Significant diurnal fluctuations are clearly seen in the plots for PT2S and PT2D-B. At approximately 1,500, 3,000, and 4,500 minutes into the monitoring period, there were considerable and limited-duration fluctuations in the baseline record. These fluctuations also occurred to a limited extent in PT1S. It is not clear whether these fluctuations indicate influence from storm sewers or pumping. There are no wells reported to be operating within the study area that would account for the fluctuations, however, as stated in Section 3.6.2, well 2 on Figure 1-9 was identified during the expanded well search in addition to several other offsite pumping wells discussed in Section 1.7.2. Although the location of this well is more than 1,000 feet away, there are many examples in the literature which document the capability of wells screened in the Passaic Formation of influencing wells considerable distances away along the strike of the formation.

The wells monitored prior to the Sears pumping test were relatively stable. The water levels varied over a range of only 0.2 feet. Although the barometric series ranged nearly 1.1 inches of mercury (the equivalent of 1.2 feet of head), there was no strong relationship or effect on the water level series. Neither barometric fluctuations nor extraneous pumping or storm sewers seem to have affected the water levels near the Sears pumping test wellfield prior to the pumping test.

3.7.3 Stepan Bedrock Pumping Test

Discrete Flow Conditions. Review of drawdown and recovery data in all observation wells monitored and in the pumping well was approached both qualitatively and quantitatively. The qualitative evaluation of responses observed during pumping is presented first because it provides a basis for selecting drawdown curves appropriate for quantitative evaluation. Figure 3-25 is a fence diagram comparing the responses of bedrock piezometers monitored during the Stepan pumping test. This figure suggests there are two sets of plots. The first set consists of wells BRTW1, PT1D-A, and PT2D-B. It is uncommon in porous media to see observation wells positioned approximately 50 feet away from the pumping source to exhibit drawdown on the same order of magnitude as the pumping well itself, as is shown in Figure 3-25. This similarity in drawdown is a function of the hydraulic diffusivity and is discussed in Section 3.7.5. The curves suggest that aquifer conditions are controlled more by fractures than by matrix porosity. This suggestion is consistent with earlier ones documenting the lack of formation porosity and the likelihood that groundwater flow is dominated by fractures.

The second set of curves is for of B38W6B, PT1D-B, and PT2D-A. The response depicted by these curves is at least an order of magnitude less than the response of the pumping well.

Table 3-9
Water-Level Elevations Under Static Conditions (January 10, 1994)

Well	Inner Casing Elevation (MSL)	Depth to Water (ft)	Elevation of Water Surface (MSL)
Overburden Wells			
OBMW2	54.40	6.60	47.80
OBTW1	54.55	6.73	47.82
PT1S	55.02	6.30	48.72
PT2S	54.37	4.27	50.10
OBMW-19	58.93	10.88	48.05
Bedrock Wells			
Principal Water-bearing Zone:			
BRMW2	54.61	8.55	46.06
BRTW1	54.44	8.37	46.07
PT1D-A	54.82	8.72	46.10
PT2D-B	54.11	8.08	46.03
Secondary Water-bearing Zones:			
PT1D-B	54.74	8.93	45.81
PT2D-A	54.30	6.13	48.17
B38W06B	57.48	10.57	46.91

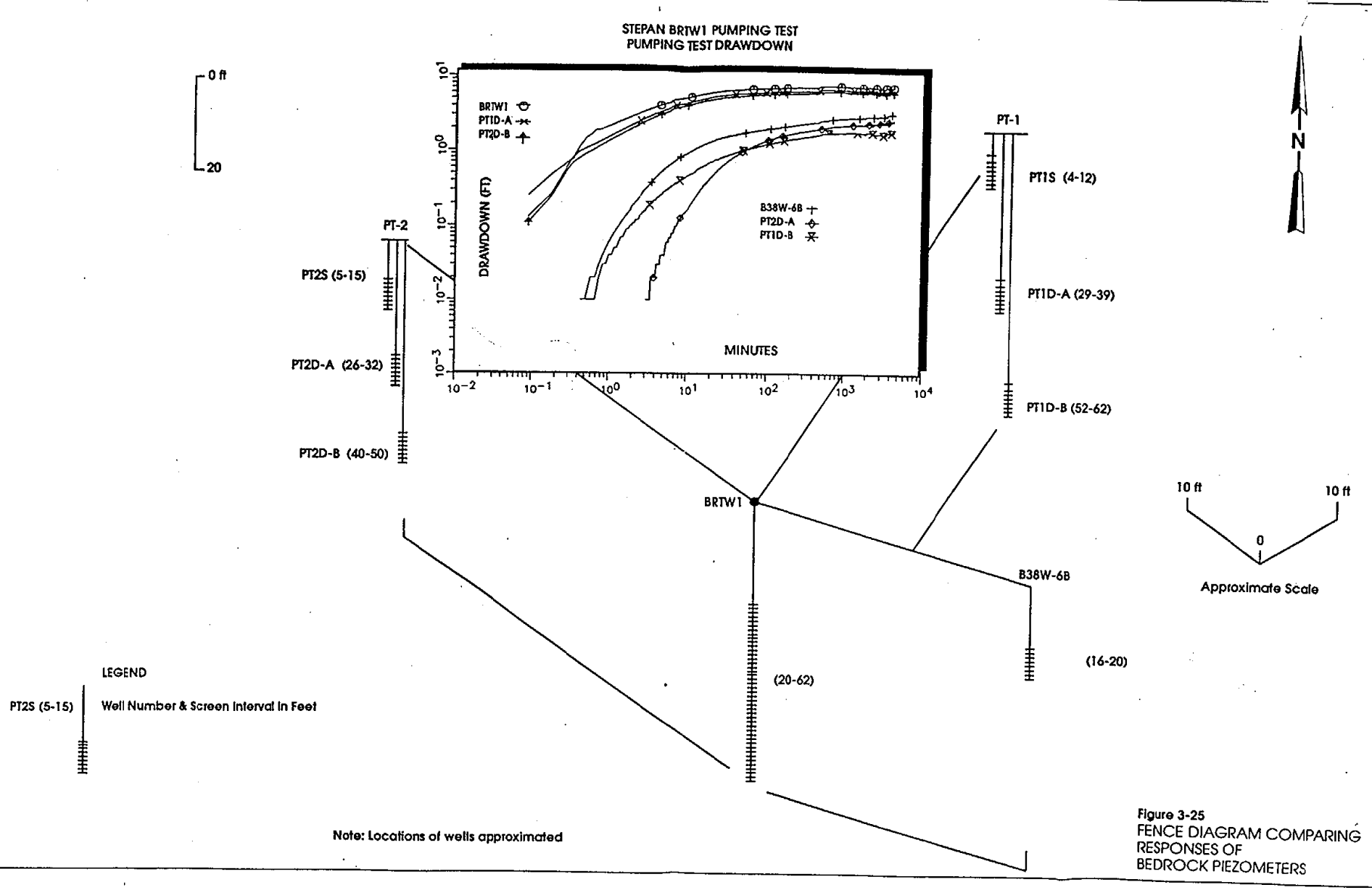


Figure 3-25
FENCE DIAGRAM COMPARING
RESPONSES OF
BEDROCK PIEZOMETERS

The reaction of the wells in Figure 3-25 appeared to be affected by the stratigraphy and structure of the Passaic Formation. As discussed in Section 3.6, groundwater flow is preferential along bedding planes and strike-oriented vertical faults and fractures. The line that joins the PT1 cluster and BRTW1 approximates the strike of the formation. The line joining the PT2 cluster and BRTW1 approximates the direction of the dip of the formation. Although BRTW1 is an open borehole, observations during pressure injection testing and drilling suggested that the most prolific water-bearing zone is 37 to 41 feet below grade. The screened interval at PT1D-A is 29 to 39 feet. Presuming that the rock strikes in the direction of PT1 with respect to BRTW1, the prolific zone at BRTW1 should be partly intercepted by PT1D-A. Likewise, if the zone dips in the direction of PT2, this zone should be encountered at a slightly greater depth. PT2D-B is screened at 40 to 50 feet. Connecting these screening intervals results in a plane that has an orientation similar to that of the bedding planes. These zones as discussed are thought to be either bedding planes or lithologic units that are relatively more fractured than the beds above or below, resulting in discrete flow conditions. The zone represented by the first set of bedrock wells is considered to be one of the first principal water-bearing zones encountered in the top of rock in the pumping test area.

The water level data corroborate the discussion above regarding the principal water-bearing zone. As seen in Table 3-9, the elevations of water levels in the principal water-bearing zone range from 46.03 to 46.10 feet MSL, a total difference of .07 feet. The direction of the gradient is also parallel with the site-wide gradient shown in the groundwater potentiometric maps for both bedrock and the overburden zone. Wells screened in other water-bearing zones range from 45.81 to 48.17 feet MSL, a total difference of 2.36 feet. The close measurements among the wells in the principal water-bearing zone verify that they are screened in a common zone.

Discrete flow conditions suggest that, unless an isolated well screen within a cluster is opened to the discrete fracture, it will not be as responsive as wells that are within that same cluster. This could explain why the second family of bedrock wells shows only marginal responses to pumping.

Relationship with Overburden Water-Bearing Zone. Figure 3-26 is a fence diagram comparing the first set of bedrock piezometers with the overburden piezometers. As was true for the second set of bedrock wells, the overburden wells on the average responded an order of magnitude less than the first family of bedrock wells. There are two explanations for these observations. The first is that there is some degree of confinement between the overburden water zone and the first principal water-bearing zone identified. This confinement can be the result of impermeable silts and clays that overlies the top of the rock and or the relatively competent and generally nonporous bedrock that overlies the first principal water-bearing zone. Second, because the overburden has a substantially greater storage capacity than the bedrock aquifers, and its transmissivity is much less, drawdown is not propagated as quickly and the overburden is not affected as much as the bedrock aquifers are.

Anisotropy. As introduced in Section 3.5, there are numerous discussions regarding the anisotropic tendencies for groundwater flow in the Passaic Formation. According to Papadopolous, at least three monitoring wells, all screened in the same groundwater zone and placed at three different angles from the pumping center, are needed for determination of anisotropy. The results of the pumping test program indicated that pumping well BRTW1 and observation wells PT1D-A and PT2D-B were screened across a common water-bearing zone. Because only two observation wells are screened in this zone, anisotropic conditions cannot be confirmed mathematically. However, Papadopolous's edict is based on the premise that little is known about the orientation of principal transmissivity axies. In the study area, it is known that strike approximates 26 degrees NE and that dip of the rock has an orientation of 64 degrees NW. With this knowledge, the PT1 and PT2 observation-well clusters were aligned parallel to and perpendicular to strike. These are the two prominent directions of transmissivity, according to the literature. If groundwater flow is preferential along either of these directions, response during the pumping test program should illustrate this preference.

The remarkably similar responses of PT1D-A and PT2D-B suggest that there is no condition of anisotropy in the immediate vicinity of BRTW1. The responses, presented in Figure 3-23, correspond very closely to each other and the pumping well. This observation should not be construed as suggesting that anisotropic conditions do not exist at all in the study area. Our knowledge of geologic conditions indicates that such conditions probably do exist. The observation applies only to the immediate vicinity of BRTW1. As suggested by Barksdale, preferential flow along the bedding planes tends to extend far less distance than flow along strike. The general tendency for groundwater flow, therefore, is along strike.

Determination of Aquifer Coefficients. Many discussions of groundwater flow in fractured rock assume equivalent porous media continuum (Streltsova, Long et al., Endo). The porous media continuum is based on the premise that if fractures and joints are dense and interconnected, the media may assume porous media characteristics where groundwater flow is based on the concept of radial flow. Endo concluded that valid continuum assumptions are a function of the size of the flow region relative to the degree of tortuosity of the travel paths. As the paths become larger and irregular, large flow regions are needed before continuum assumptions can apply.

In several cases, for both the Stepan site and Sears bedrock pumping tests, drawdown curves were either Theis-like in shape or similar to the leaky-type family of curves generated by Cooper for leaky beds with negligible storage. This indicates that equivalent porous media conditions assumptions can be used with discretion. This is discussed below.

Only the family of curves that represents screens in the first principal water-bearing zone were used for generation of formation coefficients. Any wells not screened across the principal water-bearing zone were matched for qualitative purposes only.

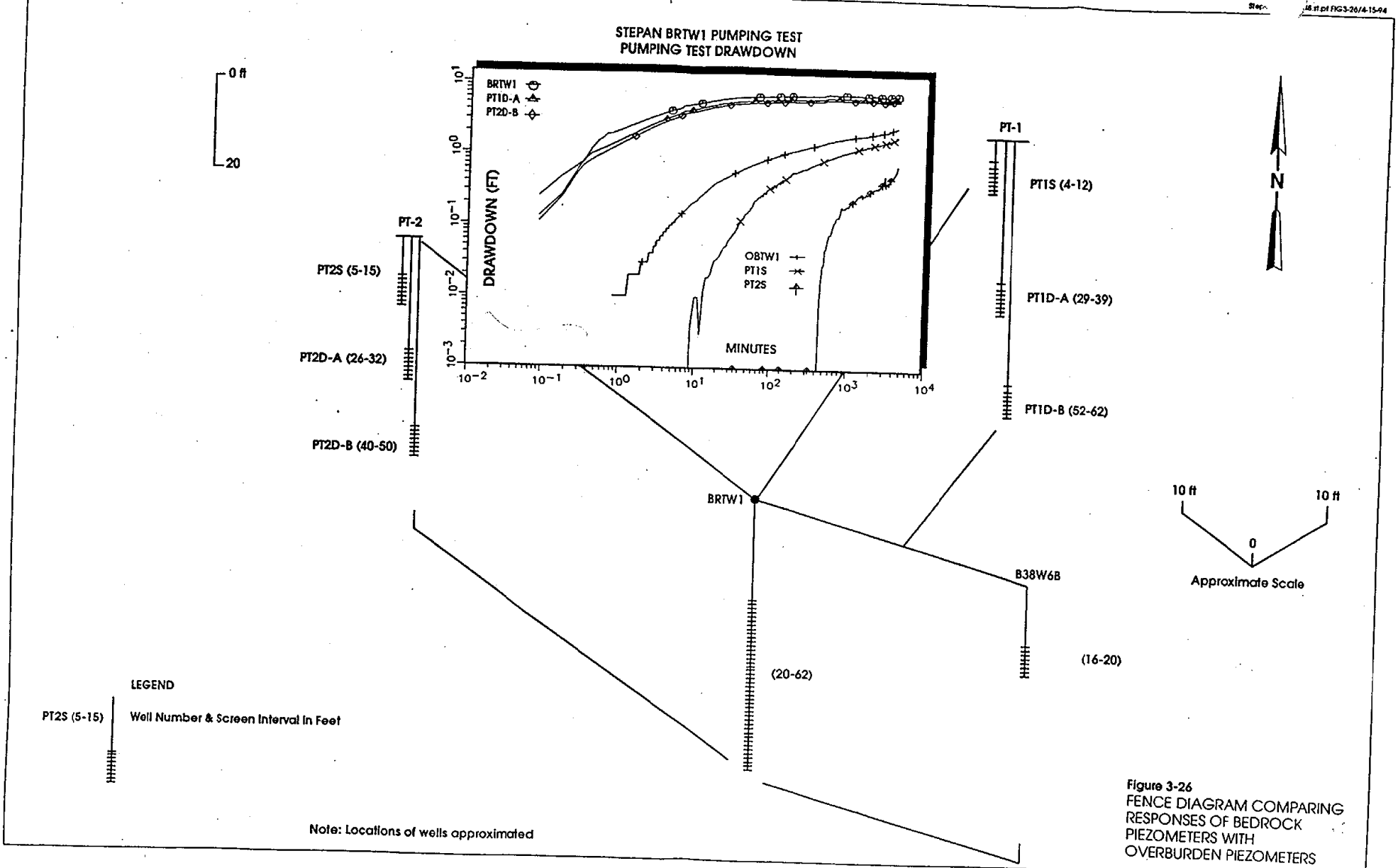


Figure 3-26
FENCE DIAGRAM COMPARING RESPONSES OF BEDROCK PIEZOMETERS WITH OVERBURDEN PIEZOMETERS

The drawdown and recovery curves were analyzed using the log-log leaky-type curves generated by Cooper for leaky beds with negligible storage.

In addition to the assumptions implied when matching to the Theis curve, the following assumptions also are necessary when matching to the leaky-type curves:

- The head in the confining layer that supplies leakage is constant throughout the test.
- Hydraulic conductivity of the confining bed is small compared to that of the aquifer; consequently, flow in the aquifer is horizontal, and flow in the confining bed is vertical.
- Storage in the confining bed is neglible.

A summary of the match points and resulting aquifer coefficients for the Stepan test is presented in Table 3-10. The transmissivity for the principal water-bearing zone identified ranges from 136 to 204 ft^2/day. The storativities, excluding that of the pumping test well, ranged from 4.07×10^{-5} to 4.54×10^{-5}.

The storativity for BRTW1 during both the drawdown and recovery periods is considerably higher than the values for the observation wells. The values for BRTW1 are not considered valid because they most probably result from the impact of the extra casing storage. Ordinarily, only matches of nonpumping wells are considered valid because they average the conditions over the whole aquifer. Despite this, the transmissivity match is consistent with the observation wells and is considered representative.

As indicated, the second set of curves is not representative of screens in the principal water-bearing zone identified and would therefore provide a falsely high value for transmissivity and storativity because they are insulated from the real propagation of influence that occurs in the principal water-bearing zone. The shape of the curve for B38W6B was qualitatively matched and suggested more of a Theis-like match, than a leaky curve match as was exhibited by the principal water-bearing zone wells. This difference in behavior provides additional evidence that there exists different zones and discrete layers across the multi-unit bedrock system.

3.7.4 Stepan Overburden Pumping Test

Despite the low pumping rate of 1.1 gpm for 48 hours from OBTW1, reasonable influence was observed in OBMW2 and PT1S. It is not clearly understood why the same amount of influence was not observed in PT2S as in PT1S. Normally, differential responses at different angles from the pumping center are not anticipated in porous media. The fact that PT2S did not respond as did PT1S suggests soil or bedrock residuum heterogeneities that probably result in elliptical cones of depression.

Table 3-10
Bedrock Pump Test Results

Location	Analysis & Well	Well Function	Well Function Value	1/u	Drawdown (ft)	Time (min)	Leaky-Type Curve	Radius (ft)	Transmissivity (gpd/ft)	Transmissivity (ft2/d)	Storage Coefficient	Leakance k'/b' (gpd/ft3)
STEPAN- BRTW1												
PUMPING RATE =		16 GPM										
	DRAWDOWN											
	BRTW1	L(u,v)	1	1	1.8	0.15	0.05	0.33	1,019	136	5.21E-01	93.541
	PT1D-A	L(u,v)	1	1	1.4	0.23	0.05	52	1,310	175	4.14E-05	0.005
	PT2D-B	L(u,v)	1	1	1.3	0.21	0.05	50	1,410	189	4.40E-05	0.006
	RECOVERY											
	BRTW-1	L(u,v)	1	1	1.5	0.15	0.05	0.33	1,222	163	6.25E-01	112.250
	PT1D-A	L(u,v)	1	1	1.3	0.21	0.05	52	1,410	189	4.07E-05	0.005
	PT2D-B	L(u,v)	1	1	1.2	0.2	0.05	50	1,528	204	4.54E-05	0.006
SEARS - BRTW2												
PUMPING RATE =		10.5 GPM										
	DRAWDOWN											
	BRTW2	L(u,v)	1	1	8.4	0.68	0.50	0.33	218	29	5.06E-01	2004.460
	PT3D-A	L(u,v)	1	1	0.77	0.85	0.30	50	2,381	318	3.01E-04	0.343
	BRMW1	L(u,v)	1	1	0.45	4.5	0.30	50	4,075	545	2.72E-03	0.587
	RECOVERY											
	BRTW2	L(u,v)	1	1	22.5	1.7	0.80	0.33	81	11	4.72E-01	1915.729
	PT3D-A	L(u,v)	1	1	1.9	2.45	0.60	50	965	129	3.51E-04	0.556
	BRMW1	L(u,v)	1	1	1.4	9.5	0.55	50	1,310	175	1.85E-03	0.634

Note: The values presented here are valid only to the extent that the fractured rock aquifer behaves as an equivalent porous media.

The overburden wells were matched to Boulton's delayed-gravity-drainage-type curves. These curves allow determination of the two storage properties of unconfined aquifers. When a water-table aquifer is stressed, the shape of the drawdown initially is dictated by the elastic storage properties of the sediments that release water as a result of a decrease in pressure and compaction of the aquifer as for confined aquifers. The later time of drawdown curves in unconfined aquifers is the result of delayed yield from storage as a result of gravity drainage. This is the mechanism that contributes to much greater storage properties of unconfined aquifers over confined and is the result of the free surface of the unconfined aquifer exposed to the atmosphere.

The heterogeneities suggested may be associated with the fact that OBTW-1, the test well, is screened a couple of feet into the top of the rock. Groundwater flow resulting during the test may partly be controlled by groundwater flow conditions in fractures, and not entirely characterized by porous media conditions. As discussed in 3.7.3, groundwater flow in fractured rock is often equivalent to that of porous media conditions. To the extent that porous media conditions do not apply, there are inherent limitations associated with applying the Boulton family of type curves.

Wells OBTW1 and OBMW2 were curve-matched to the Boulton-type curves. Both curves exhibited a later time gravity drainage stage that was matched to Boulton's type B curves. The early time data were matched to Boulton's type A curves. A summary of the match points and resulting aquifer coefficients for the overburden test is presented in Table 3-11. The match point for the early time data is designated as Match Point A and the match point for the late time data is designated as Match Point B. The transmissivity of the overburden ranges from 42 to 67 ft^2/day. The specific yield obtained from the late time match of OBMW2 is 0.05.

As discussed for the previous test, the storage values obtained from the pumping well were not considered valid. Also, no late time matching was performed on the recovery data because of the uncertainty associated with gravity drainage effects on recovery.

3.7.5 Sears Bedrock Pumping Test

Unlike the Stepan bedrock pumping test, a key water-bearing zone was not identified during the Sears pumping test. None of the bedrock wells monitored responded on or close to the same order of magnitude as that exhibited during the Stepan pumping test. The well that exhibited the greatest response was PT3D-A, which is screened at 16 to 29 feet. The response from this zone is consistent with observations made during the pressure injection testing that indicated that the most prolific zone in BRTW2 was between 19 to 29 feet. Assuming both PT3 and BRTW2 form a line parallel to strike, fractures should be encountered at the same intervals in both wells.

Table 3-11
Overburden Pump Test Results

Location	Analysis & Well	Well Function	W(Ua,b, r/D)	1/Ua,b	Early Time Match Points		Late Time Match Points			Radius (ft)	Early Time		Late Time	
					Drawdown (ft)	Time (min)	Drawdown (ft)	Time (min)	Curve Match (r/D)		Transmissivity ft2/day	Storage Coefficent	Transmissivity ft2/day	Specified Yield
STEPAN - OBTW1														
PUMPING RATE =		1.1 GPM												
	DRAWDOWN													
	OBTW1	W(Ua,Ub,r)	1	1	0.3	0.35	0.52	34	0.40	0.5	56	2.19E-01	32	1.22E+01
	OBMW2	W(Ua,Ub,r)	1	1	0.4	0.43	0.55	60	0.40	10	42	5.03E-04	31	5.11E-02
	RECOVERY													
	OBTW1	W(Ua,Ub,r)	1	1	0.25	0.3				0.5	67	0.00E+00		
	OBMW2	W(Ua,Ub,r)	1	1	0.31	22				10	54	3.32E-02		

Note: Boulton method used to analyze unconfined aquifer with delayed yield response to pumping. To the extent that fracture flow in the top of rock influenced the data; the results may be of limited value.

Fluctuations and Anisotropy. Several fluctuations are seen in the plots for PT3D-A and PT3D-B during the first 60 minutes of the test. The same patterns are not observed in either the pumping test well or BRMW1. When superimposing the flow rate series on top of the drawdown data, it is apparent that the noise observed in the two wells is associated with unstable flow rates during this period. The almost instantaneous response to flow rate changes in these observation wells is probably a result of the very low storage properties of the fractured rock aquifer. Small changes in flow rate are quickly transmitted to distal observation points. This relationship is a result of the high hydraulic diffusivity of the formation, which is represented by the following expression:

$$\text{alpha} = T/S$$

where T = the formation transmissivity
S = Storage coefficient

The significance of alpha is that the time of response of the formation to an imposed stress is inversely proportional to this value. Because the aquifer storage coefficient is so low, alpha, in this case, is relatively high, and explains the near real-time relationship between the pumping well and response in the observation wells. This relationship is generally not seen in a porous media system. The result of unstable flow is not observed in the pumping well because fluctuations are small relative to the total drawdown of this well.

Comparison of both wells from the PT3 cluster with BRMW1 suggests anisotropy may be more important in this vicinity than was identified in the Stepan bedrock pumping test. Although the magnitude of BRMW1 drawdown averages that of the PT3 cluster wells, its overall behavior is much less erratic than that of the PT3 wells. The more erratic behavior in the PT3 wells may be attributed to a greater hydraulic communication along strike than there is down-dip or anisotropic conditions.

Another possible explanation for the difference in behavior between the PT3 cluster wells and BRMW1 is that BRMW1 may be screened in a different fracture zone and thus may not respond to subtle changes in flow as the PT3 wells do. This explanation does not, however, account for the fact that PT3D-A and PT3D-B also are screened in two separate intervals separated by 11 feet. Therefore, it is more likely that vertical fracturing that is aligned subparallel to strike and joins PT3 with BRTW1 provides a pathway for rapid transmission of fluctuations in flow to the observation wells.

Quantitative Determination. As for the Stepan bedrock wells, the Theis and Hantush leaky-aquifer-type curves were used for matching to the field curves. Unlike the Stepan bedrock test, the curves generated from the Sears bedrock pumping test were less definitive and resulted in somewhat ambiguous curve-matches. Only PT3D-B, BRMW1, and the pumping well were matched. The response of PT3D-B was much too erratic and noncharacteristic of radial flow conditions to be curve-matched. The

results of the matches are presented in Table 3-10. The transmissivities ranged from 11 to 545 ft^2/day. The storativities ranged from 3.01×10^{-4} to 2.72×10^{-3}; the values for the pumping well were excluded for the same reasons discussed for the other tests. It should be noted that these estimates should not be applied beyond the limits of the observation wells used as data collection points during the test.

The transmissivity range generated from the curve matches is considerable. On the basis of a simple comparison of the results of the Stepan bedrock pumping test and the relationship of transmissivity with specific capacity, it can be assumed that the best indication of transmissivity is provided by the test well (BRTW2). Specific capacity varies directly with transmissivity, as derived by the following equation:

$$Q/s = T/264 \log (.3Tt/r2S)$$

where Q = flow rate
s = drawdown

After 72 hours of pumping, the specific capacity of BRTW1 at Stepan is 2 gpm/ft of drawdown (16 gpm/8 feet). The specific capacity of BRTW2 at Sears is approximately 1.22 gpm/ft of drawdown (11 gpm/9 feet). Accordingly, the transmissivity in the Sears pumping test area probably will not be greater than that obtained in the Stepan pumping test area.

The greater values of transmissivity of wells BRMW1 and PT3D-A are probably a result of the fact that they are not screened in the same zone that is supplying BRTW2 with most of its water. Unlike BRTW1, BRTW2 probably obtains its water from a number of discrete bedding planes and not from a single, principal zone. In this way, BRTW2 is different than BRTW1, in which most of the water appeared to be coming from zones that were monitored by observation wells in the principal water-bearing zone.

Alternatively, the reduced specific capacity in BRTW2 may be the result of head losses in the borehole caused by the turbulent flow from contributing fractures. If this is the case, the transmissivity values obtained from the monitoring wells would be more representative of the formation.

The curve-matches for the Sears wells suggest that the leakance into the entire open interval that is being pumped is considerably greater than the leakance that was observed in the Stepan bedrock wells. The greatest leakance was into the pumping well, as is expected because the gradient at this point is the greatest. This leakance may be coming either from the overburden zone or from deeper zones that are under pressure in the layered aquifer system below the open interval being pumped. This observation coincides with the above conclusion that the Sears pumping test area exhibits low transmissivity. As a result of the imposed stress in BRTW2 during pumping, leakance from adjacent water-bearing zones is required to replace the water lost in the low transmissivity aquifer being pumped.

It is also possible that the leakance effect on the pumping wells limits the effective matching of this curve because much of the formation curve is obscured by the leakance itself. Because of the general uncertainty associated with the matching of the wells, transmissivity should be presented as a range.

3.7.6 Water Quality Data

Results of analysis of the groundwater samples collected during the two bedrock pumping tests for TCL VOCs are presented in Table 3-12. Three samples were collected from BRTW1; 7 hour, 30 hours and 72 hours after the start of the Stepan pumping test. Four of the five VOCs detected exceeded the NJDEPE groundwater quality criteria: benzene, methylene chloride, vinyl chloride, and cis-1,2-dichloroethene. Benzene exceeded the NJDEPE groundwater quality criterion of 0.2 ppb in all three samples. The concentration of benzene ranged from 260 ppb 72 hours into the test to 360 ppb collected in the duplicate sample 7 hours into the test.

Methylene chloride exceeded the NJDEPE groundwater quality criterion of 2 ppb in two samples. The concentrations were estimated and ranged from 19 ppb to 42 ppb detected in the 7-hour and 30-hour samples, respectively.

Vinyl chloride, for which the NJDEPE groundwater quality criterion is 0.08 ppb, and cis-1,2-dichloroethene, for which the NJDEPE groundwater quality criterion is 10 ppb, were detected at estimated values of 17 ppb and 11 ppb, respectively. These concentrations were detected in the 72-hour sample. Ethylbenzene was the fifth volatile organic detected, but at levels below NJDEPE groundwater quality criteria.

Four samples were collected before and during the Sears bedrock pumping test. The test was conducted on well BRTW2. The first sample was taken before the test started, at the zero-hour mark, using the same sampling methods and procedures employed during the groundwater sampling program. The final three samples were taken at 7 hours, 28 hours, and 72 hours after the start of pumping. Seventeen TCL VOCs were identified in the four samples. Of the 17 VOCs detected, five exceeded NJDEPE groundwater quality criteria. Although benzene, toluene, and xylene were detected, only benzene was identified above its NJDEPE groundwater quality criterion of 0.2 ppb. The maximum concentration of benzene was 170 ppb, detected in the zero-hour sample.

Vinyl chloride was detected in three of the four samples at concentrations of 300 ppb in the duplicate sample collected at zero-hours, 760 ppb in the 7-hour sample, and 570 ppb in the 28-hour sample. These concentrations exceed the NJDEPE groundwater quality criterion of 0.08 ppb. Vinyl chloride was not detected in the zero-hour nonduplicate sample or in the 72-hour sample.

Cis-1,2-dichloroethene (cis-1,2-DCE) exceeded the NJDEPE groundwater quality criterion of 10 ppb in the four samples (including the duplicate) in which it was detected. Cis-1,2-DCE was detected at a maximum of 240 ppb in the zero-hour sample. Cis-1,2-DCE was not detected in the 72-hour sample.

In all five samples (including the duplicate) 1,2-dichloroethane exceeded the NJDEPE groundwater quality criterion of 0.3 ppb. The maximum of 9 ppb was detected in the zero-hour sample. The minimum concentration of 1 ppb was detected in the 72-hour sample.

In the 72-hour sample, 1,2-dichloropropane was detected at 1 ppb. This concentration exceeds the NJDEPE groundwater quality criterion of 0.5 ppb. The 72-hour sample is the only sample in which 1,2-dichloropropane was detected.

Acetone was detected in all five samples (including the duplicate) at relatively low concentrations ranging from 21 ppb to 52 ppb. Acetone also was detected in trip blanks at lower concentrations than in the samples and was detected at 400 ppb in the field blank.

3.7.7 Summary of Pumping Test and Review of Site Hydrogeological Model

The pumping test confirms the initial conceptual model and allows a more detailed discussion of groundwater flow and behavior. The site hydrogeological model was predicated on the existence of two significantly different groundwater zones: the water-table aquifer (overburden) and the multi-unit bedrock aquifer. The pumping tests confirms that both zones respond differently to pumping stresses and that the bedrock zone itself is composed of discrete flow zones. The bedrock zone exhibits anisotropic and heterogeneous tendencies that make interpreting the data and pumping test programs a complex task.

Although there seems to be a lack of hydraulic communication between the bedrock and overburden systems, which suggests the presence of a third lithology that is acting as a confining unit, another explanation for the differential response when pumping the different aquifers may be more feasible. Specifically, these are the contrasting formation coefficients between the overburden and the bedrock systems, and the nonporous, nonfractured intervening confining beds in the bedrock. The lower permeability of the overburden aquifer causes the delayed drainage. Although the bedrock aquifer zones can be considered very narrow and discrete (from less than 1 foot to 10 feet), transmissivity of the formation is generally much higher and storage coefficients much lower than that of the overburden water-table aquifer. The bedrock systems are capable of providing greater amounts of water because of their higher transmissivity, and thus, larger distances can be affected much sooner than in the overlying porous media environments. This phenomenon, called hydraulic diffusivity, is explained in Section 3.7.5.

Table 3-12
Focused Investigation Groundwater TCL VOC Results from Pump Test

Well No:	NJDEPE	Stepan Property				Sears Property				
Date:	Ground Water	BRTW1-1	BRTW1D-1	BRTW1-2	BRTW1-3	BRTW2-1	BRTW2D-1	BRTW2-2	BRTW2-3	BRTW2-4
		10/25/93	10/25/93	10/26/93	10/28/93	11/15/93	11/15/93	11/15/93	11/16/93	11/18/93
Hour Collected (From Start of Test):	Quality	7 hrs.	7 hrs.	30 hrs.	72 hrs.	0 hrs.	0 hrs.	7 hrs.	28 hrs.	72 hrs.
	Criteria [a]		Duplicate				Duplicate			
Volatile Organics (ppb)										
Toluene	1000	--	--	--	--	3	1 J	2	2	--
Ethylbenzene	700	4 J	5 J	--	--	--	--	--	--	--
Xylene (total)	40	--	--	--	--	3	2 J	3	2	--
Benzene	0.2	320	360	320	260	170	93 J	150	130	--
Methylene Chloride	2	21 J	19 J	42 J		0.6 J	0.9 J	0.5 J	--	--
Vinyl Chloride	0.08	--	--	--	17 J	--	300 J	570	570	--
cis-1,2-Dichloroethene	10	--	--	--	11 J	240	81 J	170	170	--
Trans-1,2-Dichloroethene	100	--	--	--	--	0.9 J	--	0.7 J	0.5 J	--
1,2-Dichloroethane	0.3	--	--	--	--	9	5 J	8	7	1
4-Methyl-2-pentanone	400	--	--	--	--	3 J	--	--	--	--
1,1,2,2-Tetrachloroethane	2	--	--	--	--	1 J	--	--	--	--
Chlorobenzene	4	--	--	--	--	0.8 J	0.6 J	--	--	0.6 J
1,4-Dichlorobenzene	75	--	--	--	--	0.5 J	0.5 J	--	--	1
Acetone	700	--	--	--	--	52	--	21	--	--
Chloromethane	[b]	--	--	--	--	--	--	0.6 J	--	--
1,2-Dichloropropane	0.5	--	--	--	--	--	--	--	--	1
1,2-Dichlorobenzene	600	--	--	--	--	--	--	--	--	2
1,1,2-Trichloroethane	3	--	--	--	--	--	--	--	--	0.6 J

[a] New Jersey Groundwater Cleanup Criteria for Class II-A Groundwater, *New Jersey Register*, February 1, 1993.

[b] No criteria currently exists

Notes:

Analytical data for the pump test samples was not validated.

Only detected values have been presented in this table.

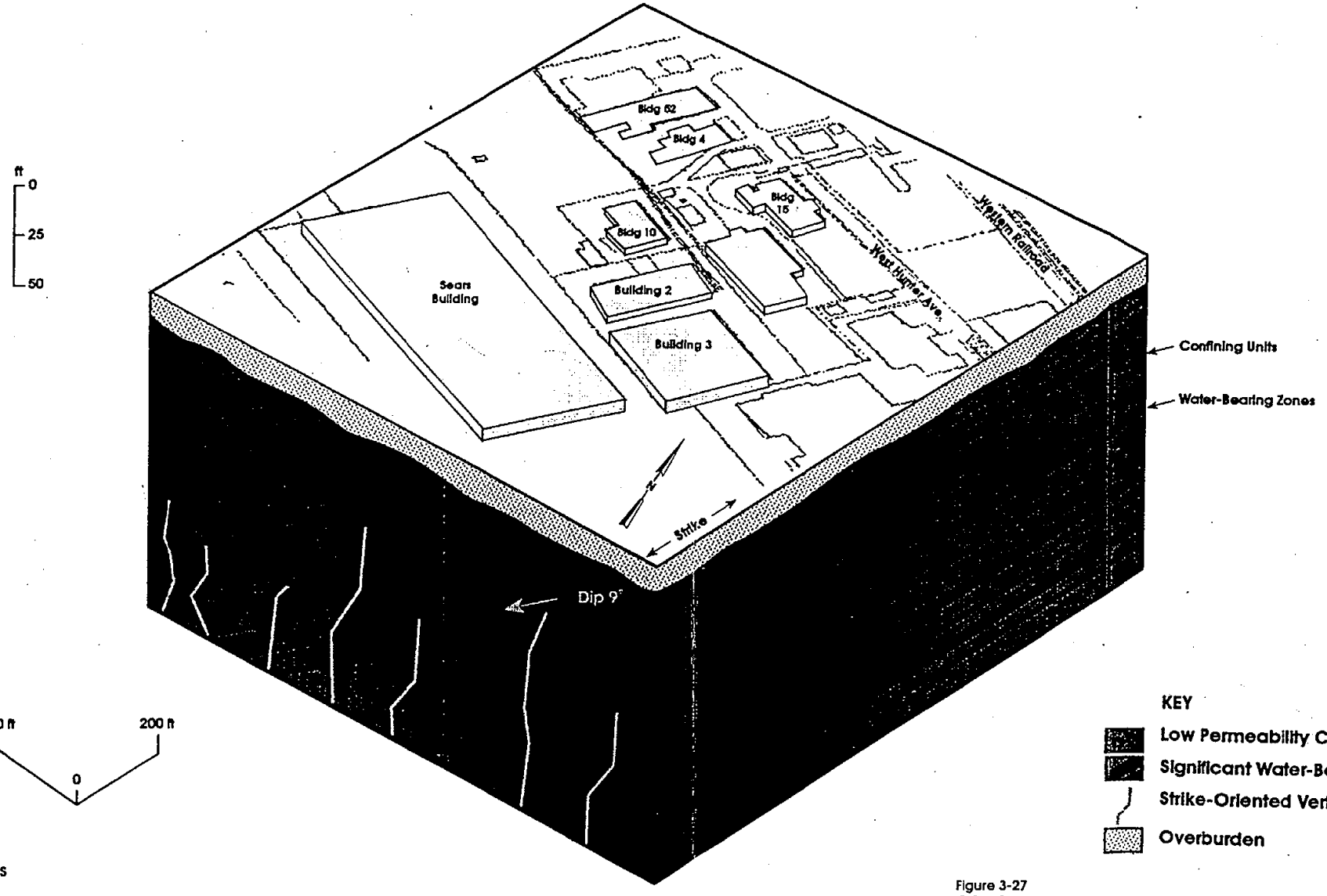
J- Estimated value

-- - Analyte was not detected at the detection limit used for the analysis.

In the bedrock, groundwater flows along the bedding planes, thus forming thin and discrete flow zones that are variably connected to zones above and below. The thickness of these flow zones could not be determined by the pressure injection pumping tests because the test zones were no shorter than 11 feet. The orientation of the discrete zone as defined by the Stepan pumping test suggests that the zones are formed by bedding partings or fractured beds. Core samples suggested that beds range in thickness from less than 1 foot to 20 feet. These discrete zones probably are connected via vertical jointing in some areas, as suggested by observations made during the Sears pumping test. At Sears, wells along strike were much more responsive to pumping fluctuations than the other bedrock wells located down-dip. Aside from this observation, there were no other strong indications of anisotropy.

Conditions observed at the Sears site were not entirely similar to those of the Stepan bedrock pumping test. This contrast in conditions in two pumping tests that were similar in terms of duration, observation-well positioning and orientation, and flowrate indicates there are heterogenic conditions across the study area. The implication of this conclusion is that formation constants and aquifer behavior ascertained from these tests cannot be necessarily projected to regions elsewhere in the study area. In addition, the reduced transmissivity and increased leakance at Sears both decrease the ability of pumping wells to induce influence across wide areas.

To better project the observations and conclusions derived from the literature search, from the initial work plan effort, and from the focused pumping test investigation, a conceptual model in the form of a block diagram is presented in Figure 3-27. In the figure, site buildings and surface features are projected above a schematic rendering of subsurface stratigraphy and structure to enable the reader to appreciate the orientation and juxtaposition of this framework. This presentation embodies all of the hydrogeologic features that dictate groundwater flow conditions in the study area. Shown are the two principal aquifer zones, the overburden zone, and the multi-unit bedrock aquifer. Significant groundwater zones consist of the overburden aquifer and the many discrete bedrock aquifer zones defined by the geologic bedding. Groundwater occurs under water-table conditions in the overburden and in places is hydraulically connected to the multi-unit bedrock zone, where the groundwater gradually comes under confined conditions. The discrete bedrock aquifers in the multi-unit bedrock system are vertically integrated by occasional vertical joints. Because of the tendency for the bedding planes to become discontinuous down-dip, the conceptual model shows these to be continuous along strike but limited in distance down-dip.



NOTES

Beds approximate apparent dip

Figure 3-27
CONCEPTUAL MODEL SHOWING ORIENTATION OF MULTIUNIT AQUIFER SYSTEM WITH RESPECT TO SITE FEATURES

Section 4

Nature and Extent of Contamination

4.1 Introduction

The results of the analysis of samples collected from soil, test pits, groundwater, surface water, and sediment during the RI and the Focused Investigation are evaluated in this section. Guidelines, criteria, and standards were used to evaluate the data. Some of these may become ARARs or TBCs during the Feasibility Study; however, for the RI, they were used solely as a frame of reference for evaluating the analytical results.

The March 1993 NJDEPE soil cleanup criteria were used to evaluate the soil boring analytical data. No federal cleanup standards currently exist for soil. The organics data for subsurface soils were compared to the NJDEPE impact-to-groundwater soil-cleanup criteria, with subsurface soil being defined as soil taken from a depth greater than 2 feet. The organics data for surface soil were compared either to the NJDEPE residential direct-contact soil-cleanup criteria or to the NJDEPE impact-to-groundwater soil-cleanup criteria, depending upon which was more conservative, with surface soil defined as soil taken from the 0- to 2-foot depth interval. Because there are no proposed NJDEPE impact-to-groundwater criteria for metals and cyanide, the metals and cyanide analytical data were compared to the residential direct contact criteria, regardless of the depth from which the samples were collected. An overview of chemical analytes detected in all matrices is presented in Table 4-1.

During the RI, samples from soil borings, sediment, test pits, surface water, and groundwater were collected for radiological analyses. In addition to radiological analyses, soil borings were logged for gamma radiation every 6 inches. Radiological data from soil media were compared to criteria established by DOE and the NRC. Radiological data from aqueous media were compared to proposed EPA MCLs.

Some of the criteria apply to concentrations of radionuclides above background, while other criteria include background concentrations in the limit. Because samples were not collected for background radiological analyses during the RI and because no relevant literature is available, detected concentrations were not reduced to allow for background concentrations when comparing data to respective criteria.

All organic data were validated in accordance with EPA's 1988 functional guidelines and 1990 draft functional guidelines; all inorganic data were validated in accordance with EPA's 1988 draft functional guidelines. The following EPA Region II SOPs also were used:

- SOP No. HW-13: *Superfund Analytical Methods for Low Concentration Water for Organics,* June 1991

Table 4-1
Number of Phase I Samples in Which Chemical Analytes Were Detected in All Matrices Sampled

Analyte	Soil Boring	Ground-water	Surface Water	Sediment	Test Pits
VOLATILE ORGANICS					
1,1,1-Trichloroethane	9	2	--	--	2
1,1,2-Trichloroethane	1	--	--	--	1
1,1-Dichloroethane	--	3	--	--	1
1,1-Dichloroethene	--	1	--	1	2
1,2-Dichlorobenzene	--	1	--	--	1*
1,2-Dichloroethane	--	3	--	--	1
1,2-Dichloroethene (Total)	2	--	--	--	2
1,2-Dichloropropane	--	1	--	--	1
1,3-Dichlorobenzene	--	1	--	--	--
1,4-Dichlorobenzene	--	1	--	--	--
2-Butanone	25	--	--	--	2
4-Methyl-2-Pentanone	1	--	--	--	2
Acetone	49	2	--	3	14
Benzene	8	18	--	1	12
Bromodichloromethane	--	--	--	--	1
Bromoform	1	--	--	--	1
Bromomethane	--	--	--	--	1
Carbon Disulfide	10	--	--	--	3
Carbon Tetrachloride	--	--	--	--	2
Chlorobenzene	--	--	--	1	1
Chloroethane	--	--	--	1	--
Chloroform	4	14	1	--	4
cis-1,2-Dichloroethene	--	19	1	--	--
cis-1,3-Dichloropropene	--	1	--	--	1
Dibromochloromethane	--	1	1	--	1
Ethylbenzene	7	5	--	2	7
Methylene Chloride	10	1	--	2	3
Styrene	--	1	--	--	3
Tetrachloroethene	--	11	--	1	2
Toluene	16	9	2	6	13
trans-1,2-Dichloroethene	--	1	--	--	--
trans-1,3-Dichloropropene	--	--	--	--	1
Trichloroethene	1	13	--	--	1
Vinyl Chloride	--	5	--	--	--
Xylene (Total)	17	11	--	2	11
SEMIVOLATILE ORGANICS (PAHs)					
2-Methlynaphthalene	18	2	--	2	2
Acenaphthene	11	2	--	2	1
Acenaphthylene	12	--	--	4	1
Anthracene	13	--	--	4	3
Benzo(b&k)fluoranthene	11	--	--	--	3
Benzo(a)anthracene	30	--	--	7	7
Benzo(a)pyrene	32	--	--	6	7
Benzo(b)fluoranthene	34	--	--	9	5
Benzo(ghi)perylene	20	--	--	6	4

Table 4–1
Number of Phase I Samples in Which Chemical Analytes Were Detected in All Matrices Sampled

Analyte	Soil Boring	Ground–water	Surface Water	Sediment	Test Pits
SEMIVOLATILE ORGANICS (PAHs) Continued					
Benzo(k)fluoranthene	3	--	--	--	--
Chrysene	38	--	--	7	8
Dibenzo(a,h)anthracene	14	--	--	5	1
Fluoranthene	46	--	1	9	8
Fluorene	12	--	--	2	2
Indeno(1,2,3–cd)pyrene	25	--	--	6	5
Naphthalene	16	3	--	2	4
Phenanthrene	36	--	--	9	8
Pyrene	48	2	--	9	7
SEMIVOLATILE ORGANICS (NON–PAHs)					
1,2–Diphenylhydrazine	1	--	--	--	--
2,4–Dimethylphenol	2	1	--	--	--
2–Methylphenol	2	1	--	--	--
3,3'–Dichlorobenzidine	1	--	--	--	--
4,6–Dinitro–2–Methylphenol	--	--	--	--	1
4–Chloro–3–Methylphenol	1	--	--	--	--
4–Methylphenol	4	1	--	4	5
4–Nitrophenol	1	1	--	--	--
Benzoic Acid	--	--	--	1	1
Benzyl butyl phthalate	10	2	1	3	--
Bis(2–ethylhexyl)phthalate	29	10	2	9	5
Di–n–butyl phthalate	30	10	1	5	2
Di–n–octyl phthalate	7	2	1	1	--
Dibenzofuran	8	--	--	1	1
Diethyl phthalate	7	--	--	1	--
Isophorone	--	--	--	--	1
n–Nitrosodiphenylamine	1	--	--	--	--
Nitrobenzene	2	--	--	--	1
Pentachlorophenol	1	2	--	--	3
Phenol	10	1	--	--	2
OTHER					
Caffeine	12	2	--	2	8
a–Pinene	--	--	--	1	1
d–Limonene	1	--	--	--	2
PESTICIDES/PCBs					
4,4'–DDD	1	--	--	--	1
4,4'–DDE	1	--	--	--	2
4,4'–DDT	2	--	--	--	--
BHC–Gamma (Lindane)	--	6	1	--	--
Dieldrin	--	3	--	--	--
Endosulfan I	1	--	--	--	--
Heptachlor epoxide	--	1	--	--	--

Table 4–1
Number of Phase I Samples in Which Chemical Analytes Were Detected in All Matrices Sampled

Analyte	Soil Boring	Ground–water	Surface Water	Sediment	Test Pits
INORGANICS (METALS/CYANIDE/LITHIUM)					
Aluminum	126	36	8	7	21
Antimony	48	8	1	--	8
Arsenic	126	30	5	7	21
Barium	126	51	8	7	20
Beryllium	107	21	--	--	4
Cadmium	11	13	--	1	13
Calcium	126	51	8	7	23
Chromium	117	44	--	7	19
Cobalt	58	16	--	1	11
Copper	108	26	4	7	21
Cyanide	8	8	5	4	9
Iron	122	50	8	7	23
Lead	121	44	8	7	20
Lithium	57	43	5	7	--
Magnesium	126	50	8	7	22
Manganese	122	50	8	7	22
Mercury	43	18	1	7	20
Nickel	115	36	--	1	20
Potassium	125	51	8	7	21
Selenium	35	4	--	6	6
Silver	27	1	--	--	6
Sodium	111	51	8	7	23
Thallium	29	--	--	--	12
Vanadium	105	30	1	7	16
Zinc	123	43	8	7	23

* Appears with semivolatile organics analytical results for test pits; Appears with volatile organics analytical results in other matrices.

Note: -- = Not detected in any of the samples analyzed for this matrix.

- SOP No. HW-6: *CLP Organics Review and Preliminary Review,* March 1990

- SOP No. HW-2: *Evaluation of Metals Data for the Contract Laboratory Program,* Revision X, February 1990

- SOP No. HW-7: *TCLP Data Validation,* Revision No. 1, March 1992

All radiological data were validated on the basis primarily of method-specific performance, laboratory SOPs, EPA's guidance on evaluating metals data (SOP No. HW-2), and SOPs developed by CH2M HILL (Appendix T).

Data resulting from the geotechnical testing of soil during the RI were not validated.

During the data validation process, laboratory QC data and the raw sample data were reviewed to verify that the analytical laboratory was operating within the required control limits. The objective of the data validation process was to identify any qualitative, unreliable, or invalid laboratory measurements. The process involved performing a technical review of instrument tuning, blanks, field duplicates, TCL and TAL analyte identification, compound quantitation, reported detection limits, and TICs. Validation of the RI and Focused Investigation data indicated that the analytical data from all three laboratories (TCT-St. Louis Laboratory; CH2M HILL's Montgomery, Alabama, laboratory; and Core Laboratory) met the data quality objectives of this investigation, so no resampling was required.

4.1.1 Soil and Sediment Radiological Comparison Criteria

Comparison criteria used in assessing the magnitude of radiological contamination in soil are from DOE Order 5400.5 and NRC's *Branch Technical Position on Disposal or Onsite Storage of Thorium or Uranium Wastes From Past Operations* (46 FR 352061). DOE's generic cleanup criteria apply to soil containing residual concentrations of thorium and radium and are based on radium criteria specified in 40 CFR 192. Of NRC's recommended criteria, only the criteria applying to natural uranium (U-234 plus U-238) were used. Although the DOE and NRC criteria are not necessarily applicable to sediments, they were used as comparison criteria in assessing the magnitude of contamination in sediment samples.

The DOE surface soil criterion for Ra-226, Ra-228, Th-230, and Th-232 is 5 pCi/g above background, averaged over the topmost 15 centimeters of soil. The criterion for these radionuclides also applies to subsurface soil (more than 15 centimeters below the surface) and is 15 pCi/g averaged over 15-centimeter-thick layers. The DOE criteria take into account the ingrowth of Ra-226 from Th-230 and Ra-228 from Th-232 and assume secular equilibrium. During the RI, if Th-230 and Ra-226 or Th-232 and Ra-228 were not in secular equilibrium, the guideline applied reflected the higher concentration. Residual contamination by these radionuclides is defined in DOE Order 5400.5 as contamination in excess of background concentrations,

averaged over a 100-square-meter area. When radiological data were scrutinized in light of these criteria, the areal extent of contamination was not considered, secular equilibrium was assumed to exist, and background concentrations were not subtracted from observed values because no background samples were collected.

The NRC-recommended criterion for U-234 and U-238 is 10 pCi/g total (U-234 plus U-238). This criterion assumes that natural uranium daughters are in equilibrium and includes background. Neither DOE nor EPA have developed site-specific cleanup levels for U-234 or U-238 for the study area. A typical, as opposed to site-specific, DOE surface soil cleanup guideline for U-238 would be 75 pCi/g (BNI, 1987b).

No comparison criteria for gross alpha and gross beta radiation exist; neither do comparison criteria for U-235 where it is present in naturally occurring percentages.

4.1.2 Groundwater and Surface Water Radiological Comparison Criteria

Proposed MCLs from the SDWA *Proposed Drinking Water Limits For Radionuclides* (56 FR 33050) were used as comparison criteria in assessing the magnitude of radiological contamination in aqueous media. The proposed federal MCLs are primary drinking water standards that apply to gross alpha, gross beta (and photon emitters), radium, thorium, and uranium.

The proposed MCL for gross alpha radiation is 15 pCi/L, excluding Ra-226, uranium, and Rn-222. The proposed MCL for Ra-226 and Ra-228 is 20 pCi/L each. For the purpose of comparing gross alpha levels to the MCL, Rn-222 levels were considered negligible because of the length of time between sample collection and analyses (the half-life of Ra-222 is less than 4 days). Detected values of Ra-226 and uranium were subtracted from detected gross alpha values before comparing the gross alpha levels to the 15 pCi/L MCL.

The proposed MCL for beta and photon emitters is 4 mrem ede/year. For ease of comparison to RI gross beta data expressed as pCi/L, the proposed presumptive level for compliance (50 pCi/L) was used. When the concentration of gross beta is below 50 pCi/L, it may be presumed that exposure from beta and photon emitters is below the 4 mrem ede/year MCL. Because beta- and photon-emitter doses were not calculated, samples containing gross beta levels greater than 50 pCi/L were not necessarily above the beta- and photon-emitter MCL of 4 mrem ede/year.

The proposed MCL for total uranium is 20 μg/L. For illustrative purposes, the MCL may be converted to pCi/L on the basis of the characteristics of the uranium present. In deriving the proposed uranium MCL in pCi/L, it was assumed that the uranium in the study area is natural uranium (U-234, U-235, and U-238 present in natural abundance), as opposed to depleted or enriched uranium. Assuming a U-234-to-U-238 activity ratio of 1, total uranium has a specific-activity-to-mass ratio of 0.68 pCi/μg. The derived MCL used for comparison would therefore be approximately 13.5 pCi/L (0.68 pCi/μg x 20 μg) for total uranium.

The proposed MCLs for Th-230 and Th-232 were obtained from Appendix C of 56 FR 33050 and are based on concentrations in water needed for a lifetime cancer mortality risk of 1×10^{-4}. The proposed MCLs for Th-230 and Th-232 are 82.7 and 91.8 pCi/L, respectively.

4.1.3 Gamma Radiation Comparison Values

Conversations with TMA/Eberline suggest that gamma logging of soil borings during the RI may have been conducted with a different type of probe than that used in DOE's radiological characterizations of the Sears and adjacent properties. The BHP-2 probe used during the RI is a lead-shielded probe. It is assumed that an unshielded SPA-3 probe was used during DOE's Sears and adjacent properties characterizations, which indicated a background level of 5,000 cpm. Typical count rates of background gamma radiation observed during the RI were as follows:

- SPA-3 probe on Maywood Ave, Maywood: 5,000 cpm
- BHP-2 probe at support zone on Stepan property: 6,500 cpm
- SPA-3 probe at support zone on Stepan property: 8,500 cpm

The gamma logging conducted during DOE's radiological characterizations confirmed a relationship of 40,000 cpm (using the unshielded SPA-3 probe) to 15 pCi/g Th-232. To be conservative, a SPA-3 probe measurement of 30,000 cpm was used by DOE as an indication that subsurface soil contained radiological contamination. Because of elevated radioactivity in soil boring samples selected for radiological analyses, the laboratory performed only total thorium analyses rather than individual Th-230 and Th-232 analyses. Therefore, a BHP-2-probe-cpm-to-Th-232-pCi/g ratio was not determined during the RI.

Because the BHP-2 probe is lead shielded, gamma log results using the BHP-2 probe are assumed to be lower than the results obtained with an unshielded SPA-3 probe for the same activity levels. The 30,000-cpm-to-15-pCi/g guideline was still used, however, as an approximate indication of potential subsurface radiological contamination. Because the BHP-2 probe gamma radiation results are assumed to be biased low with respect to DOE's previous site-specific gamma log results, soil borings showing gamma radiation levels below 30,000 cpm could not be accurately assessed solely on the basis of gamma log results.

Gamma radiation measurements were collected from test pits using an unshielded SPA-3 probe. The 30,000-cpm reference value was again used as an approximate indication of the potential for subsurface radiological contamination (Th-232 greater than 15 pCi/g) in test pits.

During DOE's characterization of the Sears property, a cpm-to-pCi/g ratio was also determined to establish a cpm-guideline for determining the presence of surface radiological contamination. The 11,000-cpm guideline (corresponding to 5 pCi/g Th-232) was established for use with a cone-shielded SPA-3 probe used for a surface

radiological walkover survey. Because the BHP-2 and the SPA-3 probe used during the RI differ from the cone-shielded probe used by DOE for surface surveys, the 11,000-cpm guideline could not be used in assessing the surface and 0.5-foot BGS gamma log measurements or the near-surface measurements collected with the unshielded SPA-3 probe during test pitting.

4.2 Soil

The objective of the RI soil boring sampling program was to identify and characterize existing sources of chemical, nonradiological contamination in the overburden soils. During this program, 44 soil borings were installed and 126 soil samples were collected and analyzed for the parameters listed in Table 2-2. In addition, four samples of the blue material located in the wooded area on the DeSaussure property and soil underlying this material were collected for characterization and to evaluate if additional investigation should be undertaken in this area. The locations of the 44 soil borings and the 4 blue-material areas sampled are shown on Figure 4-1.

The objectives of the Focused Investigation soil boring and hand-auger program were to identify potential sources of groundwater contamination and define the extent of soil contamination in the vicinity of well B38W04 (Stepan), well OBMW2 (Stepan), and soil boring C-41.

As stated in Section 4.1, the NJDEPE soil cleanup criteria were used as a basis for evaluating the RI soil-boring analytical results. A comparison of sample results with the cleanup criteria is presented in Tables 4-2 to 4-6. The original validated analytical data are included as Appendix U.

4.2.1 TCL VOCs

The total TCL VOCs detected at each soil boring-interval sampled during the RI are presented in Figure 4-2. Total VOC values were obtained by adding all detected VOC concentrations at each interval for each soil-boring location. Soil samples from boring C-25 (SWS) contained the highest total VOCs, with concentrations ranging from 7,960 ppb for the 0.5- to 2.5-foot interval, to 337,700 ppb for the 8.5- to 10.5-foot interval. Soil samples from borings C-44 (Stepan), C-42 (Stepan), and C-43 (Stepan) contained maximum total VOC concentrations of 4,700 ppb, 943 ppb, and 1,099 ppb, respectively.

The VOCs detected most frequently in soil-boring samples (i.e., detected in 10 or more samples) were acetone, 2-butanone, xylene, toluene, methylene chloride, and carbon disulfide. Table 4-2 shows the total number of soil samples analyzed for VOCs, the total number of samples in which each VOC was detected, and the concentration range for each VOC.

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N

N.Y. SUSQUEHANNA & WESTERN RAILROAD

WEST HUNTER AVENUE

MAYWOOD AVENUE

BURIAL SITE 1

BURIAL SITE 2

BURIAL SITE 3

C-1 C-2 C-3 C-4 C-5 C-6 C-7 C-8 C-9 C-10 C-11 C-12 C-13 C-14 C-15 C-16 C-17 C-18 C-19 C-20 C-21 C-22 C-23 C-24 C-25 C-26 C-27 C-28 C-29 C-30 C-31 C-32 C-33 C-34 C-35 C-36 C-37 C-38 C-39 C-40 C-41 C-42 C-43 C-44

BM-1 BM-2 BM-3 BM-4

STATE ROUTE 17

GROVE AVENUE

BECKER AVENUE

LEGEND:

- PROPERTY LINE
- FENCE
- C-1 SOIL BORING LOCATION AND NUMBER
- BM-1 BLUE MATERIAL LOCATION AND NUMBER
- RADIOACTIVE WASTE BURIAL AREAS
- EXISTING UNDERGROUND STORAGE TANK LOCATION
- FORMER UNDERGROUND STORAGE TANK LOCATION

0 200 400 600

SCALE 1"=200'

STEPAN COMPANY AND SEARS AND ADJACENT PROPERTIES RI
MAYWOOD, NEW JERSEY

FIGURE 4-1
RI SOIL BORINGS AND BLUE MATERIAL SAMPLE LOCATIONS

H:\PROJECTS\CAD\STEPAN\SOILBOR\SBC-5.DGN

N.Y. SUSQUEHANNA & WESTERN RAILROAD

WEST HUNTER AVENUE

MAYWOOD AVENUE

STATE ROUTE 17

GROVE AVENUE

BECKER AVENUE

C-4 ND (3-5) 1 (5-7) ND (7-9)

C-38 ND (8-10) ND (10-12) 2 (12-14)

C-40 ND (2-4) ND (4-6) ND (6-8)

C-20 ND (2.5-4.5) 9600 (4.5-6.5) 3860 (6.5-8.5)

C-39 ND 10-21 2 (4-6) ND (6-8)

C-5 1 (0-2) 21 (2-4)

C-43 1099 (3-5) 242 (7-9) 141 (11-13)

C-12 12 (0.5-2.5) 4 (2.5-4.5)

C-13 268 (1-3) 131 (3-5) 11 (5-7)

C-42 953 (4-6) 227 (6-8) 75 (10-12)

C-44 4700 (4-6) 383 (6-8) 1314 (8-10)

C-6 ND (0-2)

79 (0-2) 9 (4-6) 4 (6-8)

C-41

C-2 17 (0-2) 13 (3-4)

C-3 ND (0-2) 9 (2-4)

C-1 211 (1-3)D 69 (3-5) 38 (5-7)

C-36 ND (0-2) ND (2-4) 10 (4-6)

C-18 9 (0-2) ND (2-4)

C-23 ND (0-2) ND (4-6)

5 (0-2)D ND (2-4)

C-37

BM-2 ND (0-1)

BM-1 5 (0.5-1.0)

BM-3 3 (1-3) D 112 (3-4)

C-27 ND (2-4) 14 (4-6) ND (6-8)

C-19 390 (0-2) 20 (2-4) 16 (4-6)

C-16 ND (1.5-2.5) ND (2.5-4) ND (4-5.5)

C-17 ND (0-2) ND (2-3)

C-31 ND (2-4) ND (4-6) 7 (6-8)

C-24 240 (2-4) ND (4-6)

C-35 35 (3-5) 17 (5-7) 15 (7-9)

C-29 300 (1-3) 32 (5-7)D 7 (7-9)

C-21 ND (0-2) ND (2-4)

C-25 7960 (0.5-2.5) 32,660 (4.5-6.5) 337,700 (8.5-10.5)

C-28 47 (3-5) 31 (5-7) ND (7-9)

C-9 620 (0-2) 46 (4-6)

C-7 110 (2-4) ND (4-5) 72 (5-7)

310 (2-3) ND (4-6) ND (6-8)

C-10

C-14 ND (2-4) 10 (4-6)

C-32 6 (1-3) ND (3-5) ND (5-7)

C-8 107 (0-2) 67 (2-4)

C-11 10 (3-5) 17 (5-7)D 22 (7-9)

ND (1-3) ND (3-5) ND (7-9)

C-33

C-22 2 (1-3) ND (3-5) 3 (5-7)

C-26 4 (0-2) 11 (2-4) 13 (4-6)

C-15 ND (0-2) 849 (3-5) 8 (5-7)

C-34 264 (1-3) 4 (3-5) 2 (5-7)

C-30 ND (1-3)

0 200 400 600

SCALE 1"=200'

LEGEND:

----------	PROPERTY LINE
————	FENCE
C-1	SOIL BORING LOCATION
BM-1	BLUE MATERIAL SAMPLE LOCATION
(0-2)	DEPTH INTERVAL SAMPLED (FT.)
ND	ANALYTE WAS NOT DETECTED AT THE DETECTION LIMIT USED FOR THE ANALYSIS
D	RESULTS ARE FROM THE ANALYSIS OF THE DUPLICATE SAMPLE. DUPLICATE RESULTS ARE GREATER THAN SAMPLE RESULTS
J	ESTIMATED VALUE
R	DATA UNUSABLE

NOTES:

1. ALL CONCENTRATIONS PRESENTED ARE IN PPB.
2. TOTAL VOLATILE ORGANICS WERE DETERMINED BY SUMMING ALL THE DETECTED VALUES FOR VOLATILE ORGANIC COMPOUNDS FOR EACH SAMPLE

STEPAN COMPANY AND SEARS AND ADJACENT PROPERTIES RI
MAYWOOD, NEW JERSEY

FIGURE 4-2
TOTAL VOLATILE ORGANICS IN SOILS (PPB)
FEBRUARY - APRIL 1992

Table 4–2
Soil Boring VOC Results Compared to NJDEPE Soil Cleanup Criteria

Analyte	Residential Direct Contact Soil Cleanup Criteria (ppb) [a]	Impact to Groundwater Soil Cleanup Criteria (ppb) [a]	Total No. of Samples [b]	Detected Count [c]	Concentration Range (ppb) [d]	Location of Maximum Concentration		
						Property	Boring No.	Depth (ft)
1,1,1–Trichloroethane	210,000	50,000	128	9	1J – 480J	Stepan	C20	(6.5–8.5)
1,1,2–Trichloroethane	22,000	1,000	128	1	320J	Stepan	C20	(6.5–8.5)
1,2–Dichloroethene (Total)	•	•	128	2	9J – 22J	Stepan	C44	(8–10)
2–Butanone	1,000,000	50,000	57	25	3J – 130J	Stepan	C43	(3–5)
4–Methyl–2–pentanone	1,000,000	50,000	128	1	2,100J	Stepan	C20	(6.5–8.5)
Acetone	1,000,000	50,000	128	49	5J – 880J	Stepan	C42	(4–6)
Benzene	3,000	1,000	128	8	2J – 4,700J	Stepan	C44	(4–6)
Bromoform	86,000	1,000	128	1	480J	Stepan	C20	(6.5–8.5)
Carbon disulfide	--	--	125	10	2J – 48J	Stepan	C44	(8–10)
Chloroform	19,000	1,000	127	4	1J – 2J	Sears	C13	(1–3)
							C1	(3–5)
Ethylbenzene	1,000,000	100,000	127	8	12J – 39,000J	SWS	C25	(8.5–10.5)
Methylene chloride	49,000	10,000	127	12	1J – 78J	Sears	C13	(1–3)
Toluene	1,000,000	500,000	128	17	1J – 77,000J	SWS	C25	(8.5–10.5)
Trichloroethene	23,000	1,000	128	1	13.0J	Stepan	C41	(0–2)
Xylene (Total)	410,000	10,000	128	18	1J – 220,000J	SWS	C25	(8.5–10.5)
1,1–Dichloroethene	8	10	128	1	12J	DeSaussure	BM3	(3–4)
Chlorobenzene	37	1	128	1	14J	DeSaussure	BM3	(3–4)
Tetrachloroethene	4	1	128	1	14J	DeSaussure	BM3	(3–4)

[a] NJDEPE Residential Direct Contact Soil Cleanup Criteria and Impact to Groundwater Soil Cleanup Criteria, *New Jersey Register*, February 3, 1992, as revised March 8, 1993.

[b] Only validated data have been presented. If data was determined to be unusable during data validation, the values were not included.

[c] Represents the number of samples in which a particular analyte was detected.

[d] Lowest and highest concentrations detected in all samples for this matrix.

• The NJDEPE residential direct contact soil cleanup criteria is 79,000 ppb for cis–1,2–dichloroethene and 1,000,000 ppb for trans–1,2–dichloroethene. The NJDEPE impact to groundwater soil cleanup criteria is 50,000 ppb for cis–1,2–dichloroethene and 50,000 ppb for trans–1,2–dichloroethene.

Notes:
J = Estimated value.
-- = Cleanup criteria does not currently exist.

Table 4–3
Soil Boring Semivolatile Organics (PAH) Results Compared to NJDEPE Soil Cleanup Criteria

Analyte	Residential Direct Contact Soil Cleanup Criteria (ppb) [a]	Impact to Groundwater Soil Cleanup Criteria (ppb) [a]	Total No. of Samples [b]	Detected Count [c]	Concentration Range (ppb) [d]	Location of Maximum Concentration		
						Property	Boring No.	Depth (ft.)
Acenaphthene	3,400,000	100,000	130	11	49J – 2,800J	DeSaussure	C37	(2–4)
Acenaphthylene	--	--	130	12	53J – 1,040J	DeSaussure	C27	(2–4)
Anthracene	10,000,000	500,000	130	13	58J – 3,900J	DeSaussure	C37	(2–4)
Benzo(b&k)fluoranthene	900	500,000	11	11	58J – 18,000J	DeSaussure	C37	(2–4)
Benzo(a)anthracene	900	500,000	130	32	39J – 12,000J	DeSaussure	C37	(2–4)
Benzo(a)pyrene	660	100,000	130	32	46J – 12,000J	DeSaussure	C37	(2–4)
Benzo(b)fluoranthene	900	500,000	119	36	38J – 5,200J	DeSaussure	C27	(2–4)
Benzo(g,h,i)perylene	--	500,000	129	20	42J – 7,500J	DeSaussure	C37	(2–4)
Benzo(k)fluoranthene	900	500,000	118	3	49 – 4,100	Sears	C23	(0–2)
Chrysene	9,000	500,000	130	38	41J – 14,000J	DeSaussure	C37	(2–4)
Dibenzo(a,h)anthracene	660	500,000	129	14	38J – 2,600J	DeSaussure	C37	(2–4)
Fluoranthene	2,300,000	500,000	130	48	41J – 28,000J	DeSaussure	C37	(2–4)
Fluorene	2,300,000	100,000	130	12	41J – 4,000J	DeSaussure	C37	(2–4)
Indeno(1,2,3–c,d)pyrene	900	500,000	130	25	39J – 6,700J	DeSaussure	C37	(2–4)
2–Methylnaphthalene	--	--	130	18	50J – 13,000J	SWS	C25	(8.5–10.5)
Naphthalene	230,000	100,000	130	16	49J – 10,800J	SWS	C25	(8.5–10.5)
Phenanthrene	--	--	130	38	38J–25,000J	DeSaussure	C37	(2–4)
Pyrene	1,700,000	10,000,000	130	50	42J – 34,000J	DeSaussure	C37	(2–4)

[a] NJDEPE Residential Direct Contact Soil Cleanup Criteria and Impact to Groundwater Soil Cleanup Criteria, *New Jersey Register*, February 3, 1992, as revised March 8, 1993.
[b] Only validated data have been presented. If data was determined to be unusable during data validation, the values were not included.
[c] Represents the number of samples in which a particular analyte was detected.
[d] Lowest and highest concentration detected in all samples for this matrix.

Notes:
J = Estimated value.
-- = Cleanup criteria does not currently exist.

Table 4–4
Soil Boring Semivolatile Organic (Non–PAH) Results Compared to NJDEPE Soil Cleanup Criteria

Analyte	Residential Direct Contact Soil Cleanup Criteria (ppb) [a]	Impact to Groundwater Soil Cleanup Criteria (ppb) [a]	Total No. of Samples [b]	Detected Count [c]	Concentration Range (ppb) [d]	Location of Maximum Concentration		
						Property	Boring No.	Depth (ft.)
1,2–Diphenylhydrazine	--	--	15	1	63J	Stepan	C05	(0–2)
2,4–Dimethylphenol	1,100,000	10,000	130	2	69J – 77J	Sears	C17	(0–2)
2–Methylphenol	--	--	130	2	50J – 300J	Sears	C24	(2–4)
3,3'–Dichlorobenzidine	2,000	100,000	127	1	160J	Sears	C8	(0–2)
4–Chloro–3–methylphenol	10,000,000	100,000	130	1	87J	Sears	C17	(0–2)
4–Methylphenol	2,800,000	--	130	4	90J – 600J	Stepan	C41	(0–2)
4–Nitrophenol	--	--	130	1	70J	Sears	C07	(2–4)
Benzyl Butyl Phthalate	1,100,000	100,000	130	10	58J – 2,500J	Sears	C17	(3–4)
Bis (2–ethylhexyl) phthalate	49,000	100,000	130	31	37J – 2,600J	Sunoco	C15	(0–2)
Benzoic acid	--	--	130	1	730J	DeSaussure	BM–3	(3–4)
Di–n–butyl phthalate	5,700,000	100,000	130	34	38J – 520J	Sunoco	C15	(3–5)
Di–n–octyl phthalate	1,100,000	100,000	130	7	59J – 790J	Sears	C17	(3–4)
Dibenzofuran	--	--	130	8	80J – 1,300J	DeSaussure	C37	(2–4)
Diethyl Phthalate	10,000,000	50,000	130	7	37J – 110J	DeSaussure	C27	(2–4)
N–Nitrosodiphenylamine	140,000	100,000	130	1	610J	Sears	C17	(0–2)
Nitrobenzene	28,000	50,000	130	2	140J – 290J	Stepan	C20	(4.5–6.5)
Pentachlorophenol	6,000	100,000	130	1	220J	Stepan	C41	(0–2)
Phenol	10,000,000	50,000	130	10	98J – 2,200J	Sears	C24	(2–4)
						DeSaussure	C37	(0–2)
Caffeine	--	--	130	12	44J – 2100J	Sears	C9	(0–2)
d–Limonene	--	--	130	1	590J	Sears	C9	(0–2)

[a] NJDEPE Residential Direct Contact Soil Cleanup Criteria and Impact to Groundwater Soil Cleanup Criteria, *New Jersey Register*, February 3, 1992, as revised March 8, 1993.
[b] Only validated data have been presented. If data was determined to be unusable during data validation, the values were not included.
[c] Represents the number of samples in which a particular analyte was detected.
[d] Lowest and highest concentration detected in all samples for this matrix.

Notes:
J = Estimated value.
-- = Cleanup criteria does not currently exist.

Table 4–5
Soil Boring Pesticide Results Compared to NJDEPE Soil Cleanup Criteria

Analyte	Residential Direct Contact Soil Cleanup Criteria (ppb) [a]	Impact to Groundwater Soil Cleanup Criteria (ppb) [b]	Total No. of Samples [c]	Detected Count [d]	Concentration Range (ppb) [e]	Location of Maximum Concentration		
						Property	Boring No.	Depth (ft.)
4,4'–DDD	3,000	100,000	130	1	710J	DeSaussure	C37	(2–4)
4,4'–DDE	2,000	100,000	130	1	38	Sears	C23	(0–2)
4,4'–DDT	2,000	100,000	130	2	59–190	Sears	C23	(0–2)
Endosulfan I [e]	––	––	130	1	17J	Stepan	C41	(0–2)

[a] NJDEPE Residential Direct Contact Soil Cleanup Criteria and Impact to Groundwater Soil Cleanup Criteria, *New Jersey Register*, February 3, 1992, as revised March 8, 1993.
[b] Only validated data have been presented. If data was determined to be unusable during data validation, the values were not included.
[c] Represents the number of samples in which a particular analyte was detected.
[d] Lowest and highest concentration of contaminant in all samples for this matrix.
[e] The residential direct contact soil cleanup criteria for endosulfan is 3,000 ppb and the impact to ground water soil cleanup criteria is 50,000 ppb.

Notes:
It should be noted that PCBs were also analyzed for, but were not detected.
J = Estimated value.
–– = Cleanup criteria does not currently exist.

Table 4-6
Soil Boring Inorganic Results Compared to NJDEPE Soil Cleanup Criteria

Analyte	Residential Direct Contact Soil Cleanup Criteria (ppm) [a]	Total No. of Samples [b]	Detected Count [c]	Concentration Range (ppm) [d]	Location of Maximum Concentration		
					Property	Boring No.	Depth (ft)
Aluminum	--	130	130	156 - 24,100	Stepan	C38	(8-10)
Antimony	14	130	46	2.1J - 18.9J	Stepan	C38	(10-12)
Arsenic	20	130	130	0.65J - 105J	Sears	C29	(1-3)
Barium	700	130	130	13.9J - 1670J	DeSaussure	BM-3	(3-4)
Beryllium	1	130	108	0.07J - 1.8	Sears	C9	(0-2)
Cadmium	1	121	11	0.69J - 4	DeSaussure	C37	(2-4)
Calcium	--	130	130	341 - 286,000J	DeSaussure	BM-1	(0-1)
Chromium	500	122	119	3.1J - 2,440	Stepan	C41	(0-2)
Cobalt	--	130	58	1.8J - 15.9	Stepan	C5	(0-2)
Copper	600	116	112	2.1J - 358J	Sears	C9	(0-2)
Iron	--	126	126	415 - 30,200	Sears	C9	(0-2)
Lead	100	125	125	2.4J - 1,050J	DeSaussure	C27	(2-4)
Magnesium	--	130	130	54.6J - 10,800J	Stepan	C20	(4.5-6.5)
Manganese	--	126	126	3.7J - 750J	Sears	C13	(1-3)
Mercury	14	129	44	0.06J - 4.8	Sears	C17	(0-2)
Nickel	250	127	119	2.6J - 54.1	Sears	C9	(0-2)
Potassium	--	130	127	52.3J - 1,770	Stepan	C20	(4.5-6.5)
Selenium	63	125	35	0.24J - 3J	Stepan	C42	(4-6)
Silver	110	130	27	0.24J - 0.67J	Sears	C3	(2-4)
Sodium	--	116	115	22.2J - 3,050	Sears	C16	(1.5-2.5)
Thallium	2	130	29	0.23J - 0.74J	Stepan	C38	(10-12)
Vanadium	370	114	109	2J - 63.2	Sears	C24	(2-4)
Zinc	1500	127	127	5.4 - 735J	Sears	C9	(0-2)
Cyanide	1100	130	12	0.47J - 157	DeSaussure	BM-3	(3-4)
Lithium *	--	61	59	2J - 810J	Sears	C16	(1.5-2.5)

[a] NJDEPE Residential Direct Contact Soil Cleanup Criteria, *New Jersey Register*, February 3, 1992, as revised March 8, 1993.
[b] Only validated data have been presented. If data was determined to be unusable during data validation, the values were not included.
[c] Represents the number of samples in which a particular analyte was detected.
[d] The concentration range is lowest and highest concentration of an analyte detected in all samples for this matrix.
* Lithium was only analyzed for selected soil boring samples.

Notes:
J = Estimated Value
-- = Cleanup criteria does not currently exist.

Benzene and xylene were the only VOCs detected at concentrations exceeding NJDEPE soil-cleanup criteria. Benzene was detected at concentrations exceeding the NJDEPE impact-to-groundwater soil-cleanup criteria of 1,000 ppb in samples from borings C-25 (SWS) and C-44 (Stepan). The 4- to 6-foot interval from C-44 showed 4,700 ppb benzene, and the 8.5- to 10.5-foot interval from C-25 showed 1,700 ppb benzene. Xylene was detected at concentrations exceeding the 10,000-ppb impact-to-groundwater soil-cleanup criterion in samples from boring C-25. The 8.5- to 10.5-foot and 4.5- to 6.5-foot depth intervals from C-25 showed xylene at 22,000 ppb and 20,000 ppb, respectively.

Boring C-25 was near the former location of a gasoline UST on the SWS property (Figure 1-4). During the installation and sampling of this boring, field personnel noticed a gasoline odor coming from the borehole and from the soil removed for sampling. Elevated headspace readings also were measured with a PID during sampling.

Boring C-44 is located on Stepan, in an area where VOC contamination was detected during previous soil sampling investigations conducted by Ebasco and BNI. During the installation and sampling of boring C-44, field personnel noticed a chemical odor coming from the soil removed for sampling. Elevated headspace readings, measured with a PID, were noted during sampling at this location. The results of PID headspace screening are summarized in Table 2-8.

Based on the results of the soil gas survey conducted during the focused investigation, boring C-44 was installed in an area of elevated soil gas concentrations. This area has been referred to as the Aromatics and Essential Oils Manufacturing Area. There are no records of recent or historical spills within the area and there are no USTs near boring C-44. Historical aerial photos indicated that the area around boring C-44 was near an industrial production area (1940), and was used for open storage (1970 through 1974) and contained a debris pile (1970). It is possible that the area around boring C-44 was impacted by manufacturing/production operations that historically occurred in this portion of the site.

VOCs were detected also in samples from BM-1 and BM-3 from the DeSaussure property (Figure 4-2). No VOCs were found in the blue-material samples from the BM-2 0- to 1-foot interval and the BM-3 1- to 3-foot interval. In the 0.5- to 1.0-foot blue-material sample from BM-1, 1,1,1-TCA was found. Seven VOCs were found in the 3- to 4-foot soil sample from BM-3, collected just below the 1- to 3-foot blue-material sample from BM-3. The seven VOCs found were 1,1-DCA; chlorobenzene; ethylbenzene; methylene chloride; PCE; toluene; and xylene. All of these VOCs were below the NJDEPE direct contact and impact-to-groundwater soil-cleanup criteria. VOCs were not detected in any of the soil samples from the three soil borings installed on the DeSaussure property (C-37, C-27, C-31). VOCs were, however, detected in soil samples collected from C-20, C-42, and C-43. Boring C-20 was installed near the former gasoline tank area (Stepan) near the western edge of West Hunter Avenue. Borings C-42 and C-43 were installed near the western boundary of

the Stepan property. No VOCs were found in the 2.5- to 4.5-interval soil sample from C-20. In the 4.5- to 6.5-foot sample from C-20, xylene was detected. Six VOCs were detected in the 6.5- to 8.5-foot sample from C-20. These were 1,1,1-TCA; 1,1,2,2-PCA, 1,1,2-TCA; MIBK; bromoform; and ethylbenzene. In the 4- to 6-foot, 6- to 8-foot, and 10- to 12-foot interval samples from C-42, acetone was detected. MEK was detected in soils from C-42 from the 4- to 6-foot and 6- to 8-foot intervals. In the 3-to-5 foot sample from C-43, MEK, acetone, ethylbenzene, toluene, and xylene was found. In the 7- to 9-foot and 11- to 13-foot samples MEK and acetone were detected. All of the VOCs detected in soil samples from C-20, C-42, and C-43 were also below the NJDEPE direct contact and impact-to-groundwater soil-cleanup criteria.

4.2.2 TCL Semivolatile Organics

For the purposes of discussion, semivolatiles are classified as PAHs or non-PAHs. Table 4-7 presents a list of the PAH and non-PAH semivolatile organic compounds. PAH and non-PAH results are discussed separately below.

PAHs. The total PAHs detected in soil-boring samples during the RI are presented in Figure 4-3. Total PAH values were obtained by adding all detected PAH concentrations for each interval sampled. Samples from the following borings and depth intervals contained total PAHs at concentrations exceeding 10,000 ppb: C-27 (2 to 4 feet, DeSaussure); C-37 (0 to 2 feet, DeSaussure); C-37 (2 to 4 feet, DeSaussure); C-14 (2 to 4 feet, Sears); C-9 (0 to 2 feet, Sears); C-23 (0 to 2 feet, Sears); C-25 (8.5 to 10.5 feet, SWS); C-41 (0 to 2 feet, Stepan); and C-20 (4.5 to 6.5 feet, Stepan).

The PAHs most frequently detected in soil samples (i.e., detected in 20 or more samples) were benzo(b)fluoranthene; benzo(a)pyrene; benzo(a)anthracene; benzo(g,h,i)perylene; fluoranthene; indeno(1,2,3-cd)pyrene; phenanthrene; chrysene; and pyrene. Pyrene and fluoranthene were the most frequently detected PAHs, with detections in 38 percent and 37 percent of the samples, respectively. These compounds were not detected at concentrations exceeding the NJDEPE soil-cleanup criteria. Other PAHs were, however, detected at concentrations exceeding the NJDEPE soil-cleanup criteria.

Table 4-3 presents the total number of soil samples analyzed for PAHs, the total number of samples in which a particular PAH was detected, and the range of detected concentrations for each PAH.

Figure 4-4 presents the semivolatile PAHs detected above the NJDEPE soil-cleanup criteria. PAHs were detected at concentrations exceeding the NJDEPE soil-cleanup criteria only in those samples collected from the 0- to 2-foot depth interval at the following locations: C-37 (DeSaussure), C-23 (Sears), C-9 (Sears), C-17 (Sears), and C-41 (Stepan). The PAHs detected at concentrations exceeding the NJDEPE soil-

Table 4-7
Semivolatile Analytes (PAHs and Non-PAHs)

PAHs	NON-PAHs		
acenaphthene	1,2,4-trichlorobenzene	3-nitroaniline	di-n-octyl phthalate
acenaphthylene	1,2-dichlorobenzene	4,6-dinitro-2-methylphenol	dibenzofuran
anthracene	1,2-diphenylhydrazine	4-bromophenyl phenyl ether	diethyl phthalate
benzo(b&k)fluoranthene	1,3-dichlorobenzene	4-chloro-3-methylphenol	dimethyl phthalate
benzo(a)anthracene	1,4-dichlorobenzene	4-chloroaniline	hexachlorobenzene
benzo(a)pyrene	2,4,5-trichlorophenol	4-chlorophenyl phenyl ether	hexachlorobutadiene
benzo(b)fluoranthene	2,4,6-trichlorophenol	4-methylphenol	hexachlorocyclopentadiene
benzo(g,h,i)perylene	2,4-dichlorophenol	4-nitroaniline	hexachloroethane
benzo(k)fluoranthene	2,4-dimethylphenol	4-nitrophenol	isophorone
chrysene	2,4-dinitrophenol	benzoic acid	n-nitrosodinpropylamine
dibenzo(a,h)anthracene	2,4-dinitrotoluene	benzyl alcohol	n-nitrosodiphenylamine
fluoranthene	2,6-dinitrotoluene	benzyl butyl phthalate	nitrobenzene
fluorene	2-chloronaphthalene	bis(2-chloroethoxy)methane	pentachlorophenol
indeno(1,2,3-c,d)pyrene	2-chlorophenol	bis(2-chloroethyl)ether	phenol
2-methylnaphthalene	2-methylphenol	bis(2-chloroisopropyl)ether	a-pinene
naphthalene	2-nitroaniline	bis(2-ethylhexyl)phthalate	d-limonene
phenanthrene	2-nitrophenol	caffeine	
pyrene	3,3'-dichlorobenzidine	di-n-butyl phthalate	

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N

N.Y. SUSQUEHANNA & WESTERN RAILROAD

WEST HUNTER AVENUE

MAYWOOD AVENUE

STATE ROUTE 17

GROVE AVENUE

BECKER AVENUE

C-4
105 (3-5)
362 (5-7)
264 (7-9)

ND (8-10)
ND (10-12)
ND (12-14)

C-38

C-40
ND (2-4)
ND (4-6)
48 (6-8)

C-20
ND (2.5-4.5)
14886 (4.5-6.5)
4309 (6.5-8.5)

C-39
141 (0-2)
ND (4-6)
ND (6-8)

C-5
3243 (0-2)
82 (2-4)

847 (3-5)
ND (7-9)
134 (11-13)

C-43

C-42
92 (4-6)
ND (6-8)
57 (10-12)

C-44
ND (4-6)
ND (6-8)
ND (8-10)

C-6
365 (0-2)

14722 (0-2)
ND (4-6)
89 (6-8)

C-41

C-3
ND (0-2)
ND (2-4)

C-2
1386 (0-2)
ND (3-4)

C-1
2934 (1-3)D
110 (3-5)
ND (5-7)

C-9
13,389 (0-2)
529 (4-6)

C-7
1490 (2-4)
170 (4-5)
ND (5-7)
ND (7-8)

631 (2-3)
ND (4-6)
ND (6-8)

C-10

C-8
5444 (0-2)
ND (2-4)

501 (3-5)
ND (5-7)
ND (7-9)

C-11

C-12
ND (0.5-2.5)
ND (2.5-4.5)

C-13
ND (1-3)
ND (3-5)
ND (5-7)

C-36
1241 (0-2)
ND (2-4)
ND (4-6)

C-18
2409 (0-2)
860 (2-4)

C-19
2487 (0-2)
51 (2-4)
220 (4-6)

C-16
1398 (1.5-2.5)
2640 (2.5-4.0)
ND (4.0-5.5)

C-29
3977 (1-3)
ND (5-7)
ND (7-9)

C-14
12,189 (2-4)
ND (4-6)

1400 (1-3)
988 (3-5)
1449 (7-9)

C-33

C-15
3250 (0-2)
4278 (3-5)
ND (5-7)

C-23
46,518 (0-2)
245 (4-6)

17,558 (0-2)D
175,990 (2-4)

C-37

667 (0-1)
BM-2

BM-1
ND (0.5-1.0)

C-27

BM-3
87 (1-3)
2143 (3-4)

39,516 (2-4)
ND (4-6)
1114 (6-8)

C-17
8052 (0-2)
4788 (2-3)
6010 (3-4)

C-24
431 (2-4)
ND (4-6)

C-31
41 (2-4)
ND (4-6)
201 (6-8)

C-35
ND (3-5)
ND (5-7)
ND (7-9)

C-21
532 (0-2)
3188 (2-4)

C-25
6700 (0.5-2.5)
6136 (4.5-6.5)
24,512 (8.5-10.5)

C-28
ND (3-5)
ND (5-7)
43 (7-9)

C-32
117 (1-3)
ND (3-5)
ND (5-7)

C-22
ND (1-3)
310 (3-5)
38 (5-7)

C-26
335 (0-2)
ND (2-4)
ND (4-6)

263 (1-3)
ND (3-5)
ND (5-7)

C-34

C-30
ND (1-3)

LEGEND:

	PROPERTY LINE
	FENCE
C-1	SOIL BORING LOCATION
BM-1	BLUE MATERIAL SAMPLE LOCATION
(0-2)	DEPTH INTERVAL SAMPLED (FT.)
ND	ANALYTE WAS NOT DETECTED AT THE DETECTION LIMIT USED FOR THE ANALYSIS
D	RESULTS ARE FROM THE ANALYSIS OF THE DUPLICATE SAMPLE. DUPLICATE RESULTS ARE GREATER THAN SAMPLE RESULTS
J	ESTIMATED VALUE
R	DATA UNUSABLE

NOTES:

1. ALL CONCENTRATIONS PRESENTED ARE IN PPB.
2. TOTAL SEMIVOLATILE ORGANICS (PAHs) WERE DETERMINED BY SUMMING ALL THE DETECTED VALUES FOR SEMIVOLATILE ORGANIC (PAHs) COMPOUNDS FOR EACH SAMPLE.

0 200 400 600

SCALE 1"=200'

STEPAN COMPANY AND SEARS AND ADJACENT PROPERTIES RI
MAYWOOD, NEW JERSEY

FIGURE 4-3
TOTAL SEMIVOLATILE ORGANICS (PAHs) IN SOILS (PPB)
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N

N.Y. SUSQUEHANNA & WESTERN RAILROAD

WEST HUNTER AVENUE

MAYWOOD AVENUE

STATE ROUTE 17

GROVE AVENUE

RECKER AVENUE

C-4 C-38 C-40 C-20 C-39 C-5 C-42 C-43 C-44 C-6 C-41 C-2 C-3 C-1 C-29 C-9 C-7 C-8 C-10 C-11 C-33 C-15 C-14 C-12 C-13 C-18 C-36 C-23 C-37 C-19 C-16 C-17 C-27 C-31 C-24 C-21 C-35 C-25 C-28 C-32 C-22 C-26 C-30 C-34

BENZO (a) ANTHRACENE 3400*
BENZO (a) PYRENE 3100*
BENZO (b) FLUORANTHENE 3500*
BENZO (k) FLUORANTHENE 4100*
DIBENZO (a,h) ANTHRACENE 1200*
INDENO (1,2,3-CD) PYRENE 2900*

BENZO (a) ANTHRACENE 1300 JD*
BENZO (b & k) FLUORANTHENE 2400J*
BENZO (a) PYRENE 1400 JD*

BENZO (b) FLUORANTHENE 2400 J*
BENZO (a) PYRENE 1300 J*

BENZO (b) FLUORANTHENE 1300 J*

BENZO (b&k) FLUORANTHENE 1100 J*

BM-1 BM-2 BM-3

LEGEND:

- PROPERTY LINE
- FENCE
- C-1 — SOIL BORING LOCATION WHERE ANALYTE IS EQUAL TO OR EXCEEDS NJDEPE SOIL CLEANUP CRITERIA
- C-1 — SOIL BORING LOCATION WHERE ANALYTE IS LESS THAN NJDEPE SOIL CLEANUP CRITERIA
- BM-1 — BLUE MATERIAL SAMPLE LOCATION WHERE ANALYTE IS LESS THAN NJDEPE SOIL CLEANUP CRITERIA
- BM-1 — BLUE MATERIAL SAMPLE LOCATION WHERE ANALYTE IS EQUAL TO OR EXCEEDS NJDEPE SOIL CLEANUP CRITERIA
- * — ANALYTE IS EQUAL TO OR EXCEEDS NJDEPE SOIL CLEANUP CRITERIA
- (0-2) — DEPTH INTERVAL SAMPLED (FT.)
- ND — ANALYTE WAS NOT DETECTED AT THE DETECTION LIMIT USED FOR THE ANALYSIS
- D — RESULTS ARE FROM THE ANALYSIS OF THE DUPLICATE SAMPLE. DUPLICATE RESULTS ARE GREATER THAN SAMPLE RESULTS
- J — ESTIMATED VALUE
- R — DATA UNUSABLE

NOTES:

1. ALL CONCENTRATIONS PRESENTED ARE IN PPB.
2. ONLY VALUES THAT EXCEED NJDEPE CLEAN UP CRITERIA ARE PRESENTED. SAMPLES WERE COLLECTED FROM THE 0-TO-2 FOOT DEPTH INTERVAL.

0 200 400 600

SCALE 1"=200'

STEPAN COMPANY AND SEARS AND ADJACENT PROPERTIES RI
MAYWOOD, NEW JERSEY

FIGURE 4-4
SEMIVOLATILE ORGANICS (PAHs) IN SOILS (PPB) EXCEEDING NJDEPE SOIL CLEANUP CRITERIA
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cleanup criteria are as follows: benzo(a)anthracene; benzo(a)pyrene; benzo(b) fluoranthene; benzo(k)fluoranthene; dibenzo(a,h)anthracene; indeno(1,2,3-c,d)pyrene; and benzo(b&k)fluoranthene.

The sample from boring C-37, which contained three PAHs exceeding NJDEPE residential direct-contact soil-cleanup criteria, was taken on the DeSaussure property. The sample was not collected in the area of blue material found on the DeSaussure property.

The C-23 boring, located in a grassy area near Maywood Avenue, was installed to provide areal coverage of the Sears property. The 0- to 2-foot sample from C-23 contained the highest concentrations of PAHs (1,200 ppb to 4,100 ppb), as well as the greatest number of PAHs (six) detected above the NJDEPE residential direct-contact soil-cleanup criteria.

Boring C-9, which contained three PAHs exceeding NJDEPE residential direct-contact soil-cleanup criteria, was located in an area where buried drums were found and sampled during the test-pit program. Total PAH concentrations up to 5,044 ppb were detected in test-pit samples in the vicinity of boring C-9. Boring C-9 was located approximately 50 feet northeast of test pit 87.

The sample from boring C-17, which contained one PAH exceeding NJDEPE residential direct-contact soil-cleanup criteria, was collected near a surface drainage channel on the Sears property. Two test pits (TP-85 and TP-84) were installed in the vicinity of boring C-17. The materials encountered in these test pits were sampled, and no PAHs were detected.

The sample from boring C-41, which contained two PAHs exceeding NJDEPE direct-contact soil-cleanup criteria, was collected in an area on the Stepan property where aromatics manufacturing takes place. In general, PAHs were not detected below 5 feet; however, PAHs were detected below 5 feet in borings C-20, C-23, C-25, C-27, and C-31.

The following five semivolatile PAHs were detected in the blue-material samples: benzo(a)anthracene, benzo(b)fluoranthene, fluoranthene, phenanthrene, and pyrene. None of these was detected at a concentration exceeding the NJDEPE soil-cleanup criteria. No PAHs were detected in sample BM-1 (0.5 to 1 foot, DeSaussure). PAHs were detected in the 3- to 4-foot interval below the blue material at BM-3.

Non-PAHs. The total semivolatile non-PAHs detected in soil boring samples are presented in Figure 4-5. Samples from the following borings and depth intervals contained total non-PAHs at concentrations exceeding 1,000 ppb: C-37 (0 to 2 feet, and 2 to 4 feet, DeSaussure); C-33 (1 to 3 feet and 7 to 9 feet, Sunoco); C-15 (0 to 2 feet, Sunoco); C-1 (1 to 3 feet, Sears); C-16 (1 to 3 feet, Sears); C-17 (0 to 2 feet, 2 to 3 feet, and 3 to 4 feet, Sears); C-18 (0 to 2 feet, Sears); C-19 (0 to 2 feet, Sears); C-24 (2 to 4 feet, Sears); C-20 (0 to 2 feet, Sears); C-9 (0 to 2 feet, Sears); and C-29

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N.Y. SUSQUEHANNA & WESTERN RAILROAD

WEST HUNTER AVENUE

MAYWOOD AVENUE

STATE ROUTE 17

GROVE AVENUE

BECKER AVENUE

C-4 105 (3-5) 197 (5-7) 264 (7-9)

C-38 ND (8-10) ND (10-12) ND (12-14)

C-40 ND (2-4) ND (4-6) 48 (6-8)

C-20 ND (2.5-4.5) 290 (4.5-6.5) ND (6.5-8.5)

C-39 ND (0-2) 83 (4-6) 59 (6-8)D

C-5 423 (0-2) 44 (2-4)

C-43 ND (3-5) ND (7-9) 58 (11-13)

C-42 ND (4-6) ND (6-8) ND (10-12)

C-44 ND (4-6) ND (6-8) ND (8-10)

C-6 ND (0-2)

1490 (0-2) ND (4-8) 89 (6-8)

C-41

C-2 1209 (0-2) ND (3-4)

C-3 ND (0-2) ND (2-4)

C-1 1200 (1-3)D 110 (3-5) ND (5-7)

C-9 3010 (0-2) 110 (4-6)

C-7 398 (2-4) ND (4-5) ND (5-7) ND (7-8)

C-8 160 (0-2) ND (2-4)

ND (2-3) ND (4-6) ND (6-8)

C-10

C-11 65 (3-5) 50 (5-7)D ND (7-9)

C-12 ND (0.5-2.5) ND (2.5-4.5)

C-13 ND (1-3) ND (3-5) ND (5-7)

C-14 309 (2-4) ND (4-6)

1450 (1-3) 840 (3-5) 1449 (7-9)

C-33

C-15 2669 (0-2) 520 (3-5) ND (5-7)

C-29 1500 (1-3) ND (5-7) ND (7-9)

C-16 740 (1.5-2.5) 860 (2.5-4.0) ND (4.0-5.5)

C-17 1634 (0-2) 1430 (2-3) 6030 (3-4)

C-18 1723 (0-2) 780 (2-4)

C-19 1379 (0-2) 51 (2-4) 220 (4-6)

C-36 112 (0-2) ND (2-4) ND (4-6)

C-23 323 (0-2) ND (4-6)

3397 (0-2)D 3310 (2-4)

C-37

BM-2 109 (0-1)

BM-1 0 (0.5-1.0)

BM-3 156 (1-3) 833 (3-4)

C-27 310 (2-4) 99 (4-6) 100 (6-8)

C-31 41 (2-4) ND (4-6) 56 (6-8)

C-24 2688 (2-4) ND (4-6)

C-21 110 (0-2) 887 (2-4)

C-35 ND (3-5) ND (5-7) ND (7-9)

C-25 ND (0.5-2.5) 55 (4.5-8.5) 80 (8.5-10.5)

C-28 ND (3-5) ND (5-7) ND (7-9)

C-32 161 (1-3)D ND (3-5) ND (5-7)

C-22 ND (1-3) 54 (3-5) 138 (5-7)

C-26 ND (0-2) ND (2-4) ND (4-6)

C-30 ND (1-3)

C-34 ND (1-3) ND (3-5) ND (5-7)

LEGEND:

——·——·——	PROPERTY LINE
——+——+——	FENCE
⊗ C-1	SOIL BORING LOCATION
● BM-1	BLUE MATERIAL SAMPLE LOCATION
(0-2)	DEPTH INTERVAL SAMPLED (FT.)
ND	ANALYTE WAS NOT DETECTED AT THE DETECTION LIMIT USED FOR THE ANALYSIS
D	RESULTS ARE FROM THE ANALYSIS OF THE DUPLICATE SAMPLE. DUPLICATE RESULTS ARE GREATER THAN SAMPLE RESULTS
J	ESTIMATED VALUE
R	DATA UNUSABLE

NOTES:

1. ALL CONCENTRATIONS PRESENTED ARE IN PPB.
2. TOTAL SEMIVOLATILE ORGANICS (NON-PAHs) WERE DETERMINED BY SUMMING ALL THE DETECTED VALUES FOR SEMIVOLATILE ORGANICS (NON-PAHs) COMPOUNDS FOR EACH SAMPLE.

0 200 400 600

SCALE 1"=200'

STEPAN COMPANY AND SEARS AND ADJACENT PROPERTIES RI
MAYWOOD, NEW JERSEY

FIGURE 4-5
TOTAL SEMIVOLATILE ORGANICS (NON-PAHs) IN SOILS (PPB)
FEBRUARY - APRIL 1992

(1 to 3 feet, Sears). No non-PAHs were detected in soil boring samples at concentrations exceeding the NJDEPE soil-cleanup criteria. The semivolatile non-PAHs most frequently detected in soil boring samples were bis(2-ethylhexyl) phthalate and di-n-butyl phthalate, which were detected in 24 percent and 26 percent of the samples, respectively. The maximum concentrations of these compounds were 2,600 ppb for bis(2-ethylhexyl) phthalate and 520 ppb for di-n-butyl phthalate, detected in borings C-15 (0 to 2 feet, Sunoco) and C-15 (3 to 5 feet, Sunoco), respectively.

Table 4-4 presents the total number of soil samples analyzed for non-PAHs, the total number of samples in which a particular non-PAH was detected, and the concentration range for each non-PAH.

Three semivolatile non-PAHs were detected in the blue-material samples: benzoic acid (BM-3, 3- to 4-foot interval); bis(2-ethylhexyl) phthalate (BM-3, 1- to 3-foot interval, and BM-2, 0- to 1-foot interval); and di-n-butyl phthalate (detected in all blue-material samples except the BM-1 0.5- to 1-foot interval). However, none of the non-PAHs detected was present in concentrations exceeding the NJDEPE soil-cleanup criteria.

Caffeine, d-Limonene, and a-Pinene (indicators). As part of the semivolatile analysis, all soil-boring and blue-material samples were analyzed for the indicators caffeine, d-limonene, and a-pinene. These three compounds were analyzed at EPA's request because they were used in past manufacturing operations performed on the property now owned by Stepan. Figure 4-6 presents the locations where caffeine and d-limonene were detected, as well as the concentrations in which they were detected. Caffeine was detected in 12 of the 130 soil-boring samples. One of these 12 samples was located on the Stepan property (C-41), and 11 were located on the Sears property. The highest concentration of caffeine (2,100 ppb) was detected in the 0- to 2-foot sample from C-19. Caffeine was not detected in the blue-material samples taken during soil boring but was detected at 6,000 ppb in the blue-material sample collected during the test-pit program. D-limonene was detected in only one soil sample (C-9, 0- to 2-foot interval) and was not detected in any of the blue-material samples collected during the soil-boring program. A-pinene was not detected in any of the soil-boring or blue-material samples.

4.2.3 TCL Pesticides and PCBs

Figure 4-7 shows the concentrations of pesticides detected in soil-boring samples. TCL pesticide compounds were detected in three soil-boring samples: the 0- to 2-foot sample from C-23 (Sears) and the 2- to 4-foot samples from C-37 and C-27 (DeSaussure) at levels below the NJDEPE soil-cleanup criteria. The C-23 boring was located on a grassy area near Maywood Avenue; the pesticide compounds detected were 4,4'-DDE and 4,4'-DDT, which were detected at concentrations of 38 ppb and 190 ppb, respectively. The C-37 boring was located on a grassy area on the DeSaussure property; the insecticide 4,4'-DDD was detected at 710 ppb in the 2- to 4-foot interval. Boring C-27, also located on a grassy area of the DeSaussure

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N

N.Y. SUSQUEHANNA & WESTERN RAILROAD

WEST HUNTER AVENUE

MAYWOOD AVENUE

C-4 ND

ND C-38

C-40 ND

ND C-20

C-39 ND

ND C-5

C-36 44 J (0-2)

C-18 1600 J (0-2)

C-23 ND

C-37 ND

BM-2 ND

BM-1 ND

C-12 ND

C-13 ND

C-43 ND

ND C-42

C-19 1200 J (0-2)

C-27 ND

ND C-44

BM-3 ND

C-16 310 J (1.5-2.5) 860 J (2.5-4)

C-6 ND

400 J (0-2) C-41

ND C-3

C-2 ND

C-31 ND

ND C-17

C-24 ND

C-29 700 J (1-3)

86 J (2-4) C-21

C-35 ND

C-28 ND

C-25 ND

d-LIMONENE 590J (0-2) 2100 J (0-2) 110 J (4-6)

C-1 110 J (3-5)

230 J (2-4) C-7

C-9

C-14 ND

C-32 ND

C-10 ND

ND C-8

ND C-11

ND C-33

ND C-15

ND C-22

C-26 ND

C-30 ND

C-34 ND

STATE ROUTE 17

GROVE AVENUE

SECKER AVENUE

0 200 400 600

SCALE 1"=200'

LEGEND:

.....	PROPERTY LINE
—•—•—	FENCE
C-1	SOIL BORING LOCATION
BM-1	BLUE MATERIAL SAMPLE LOCATION
(0-2)	DEPTH INTERVAL SAMPLED (FT.)
ND	ANALYTE WAS NOT DETECTED AT THE DETECTION LIMIT USED FOR THE ANALYSIS
D	RESULTS ARE FROM THE ANALYSIS OF THE DUPLICATE SAMPLE. DUPLICATE RESULTS ARE GREATER THAN SAMPLE RESULTS
J	ESTIMATED VALUE
R	DATA UNUSABLE

NOTES:

1. ALL CONCENTRATIONS PRESENTED ARE IN PPB.
2. ALL CONCENTRATIONS PRESENTED ARE FOR CAFFEINE, EXCEPT WHERE NOTED.

STEPAN COMPANY AND SEARS AND ADJACENT PROPERTIES RI
MAYWOOD, NEW JERSEY

FIGURE 4-6
CAFFEINE AND d-LIMONENE IN SOILS (PPB)
FEBRUARY - APRIL 1992

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N

N.Y. SUSQUEHANNA, & WESTERN RAILROAD

WEST HUNTER AVENUE

MAYWOOD AVENUE

STATE ROUTE 17

GROVE AVENUE

BECKER AVENUE

C-1 C-2 C-3 C-4 C-5 C-6 C-7 C-8 C-9 C-10 C-11 C-12 C-13 C-14 C-15 C-16 C-17 C-18 C-19 C-20 C-21 C-22 C-23 C-24 C-25 C-26 C-27 C-28 C-29 C-30 C-31 C-32 C-33 C-34 C-35 C-36 C-37 C-38 C-39 C-40 C-41 C-42 C-43 C-44

C-23 4,4'-DDE 38 (0-2) 4,4'-DDT 190 (0-2)

C-37 BM-2 4,4'-DDD 710 J (2-4)

BM-1

BM-3 C-27 4,4'-DDT 59 J (2-4)

ENDOSULFAN I 17J (0-2)

0 200 400 600

SCALE 1"=200'

LEGEND:

PROPERTY LINE	
FENCE	
C-1	SOIL BORING LOCATION WHERE ANALYTE IS EQUAL TO OR EXCEEDS NJDEPE SOIL CLEANUP CRITERIA
C-1	SOIL BORING LOCATION WHERE ANALYTE IS LESS THAN NJDEPE SOIL CLEANUP CRITERIA
BM-1	BLUE MATERIAL SAMPLE LOCATION WHERE ANALYTE IS LESS THAN NJDEPE SOIL CLEANUP CRITERIA
BM-1	BLUE MATERIAL SAMPLE LOCATION WHERE ANALYTE IS EQUAL TO OR EXCEEDS NJDEPE SOIL CLEANUP CRITERIA
*	ANALYTE IS EQUAL TO OR EXCEEDS NJDEPE SOIL CLEANUP CRITERIA
(0-2)	DEPTH INTERVAL SAMPLED (FT.)
ND	ANALYTE WAS NOT DETECTED AT THE DETECTION LIMIT USED FOR THE ANALYSIS
D	RESULTS ARE FROM THE ANALYSIS OF THE DUPLICATE SAMPLE. DUPLICATE RESULTS ARE GREATER THAN SAMPLE RESULTS
J	ESTIMATED VALUE
R	DATA UNUSABLE

NOTES:

1. ALL CONCENTRATIONS PRESENTED ARE IN PPB.
2. ONLY DETECTED COMPOUNDS HAVE BEEN PRESENTED.

STEPAN COMPANY AND SEARS AND ADJACENT PROPERTIES RI
MAYWOOD, NEW JERSEY

FIGURE 4-7
PESTICIDES IN SOILS (PPB)
FEBRUARY - APRIL 1992

property, contained 4,4'-DDT at a concentration of 59 ppb. The material sampled from C-27 was described by field personnel as being soft, grayish-white and tan. The material sampled from C-23 and C-37, however, appeared to be native soil. Endosulfan was detected at an estimated concentration of 17 ppb in boring C-41 on the Stepan property.

TCL pesticides were not detected in any of the blue-material samples collected during the soil-boring program.

TCL PCBs were not detected in any of the soil-boring or blue-material samples.

4.2.4 TAL Metals and Cyanide

Because there are no NJDEPE impact-to-groundwater soil cleanup criteria for metals and cyanide, the soil-boring data were compared to the NJDEPE residential direct-contact soil-cleanup criteria.

Figures 4-8 through 4-13 present the concentrations of selected metals detected in the soil-boring and blue-material samples. The metals presented on these figures represent those parameters for which a significant number of samples exceeded the NJDEPE residential direct-contact soil-cleanup criteria.

The following metals were detected in all soil-boring and blue-material samples: aluminum, arsenic, barium, calcium, lead, magnesium, iron, manganese, and zinc. The metals detected at concentrations exceeding the NJDEPE residential direct-contact soil-cleanup criteria were arsenic, barium, beryllium, cadmium, lead, chromium, and antimony. The distribution of metals exceeding the standards is discussed in the following paragraphs.

Arsenic. Arsenic was detected in all soil-boring and blue-material samples. It was detected in 12 samples at concentrations exceeding the NJDEPE residential direct-contact soil-cleanup criteria of 20 ppm (Figure 4-8). Three of these samples were collected on the Stepan property; nine were collected on the Sears property. The maximum concentration of arsenic (105 ppm) was detected in boring C-29 (1 to 3 feet, Sears). The 0- to 2-foot sample from C-21 (Sears) also had an arsenic concentration above the proposed cleanup standard (90.1 ppm). The material from the 1 to 3-foot interval of boring C-29 was a hard black fill material. Test-pit samples collected in the areas of C-29 and C-21 did not have arsenic concentrations exceeding the NJDEPE residential direct-contact soil cleanup criteria. The material from the 0- to 2-foot interval of boring C-21 was described by field personnel as a white-gray material, similar to the material encountered in borings C-9, C-10, C-14, and C-16, also located on the Sears property. Of these four borings, only C-16 (1.5 to 2.5 feet) also had arsenic detected above the NJDEPE residential direct-contact soil-cleanup criteria.

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LEGEND:

- PROPERTY LINE
- FENCE
- C-1 — SOIL BORING LOCATION WHERE ANALYTE IS EQUAL TO OR EXCEEDS NJDEPE SOIL CLEANUP CRITERIA
- C-1 — SOIL BORING LOCATION WHERE ANALYTE IS LESS THAN NJDEPE SOIL CLEANUP CRITERIA
- BM-1 — BLUE MATERIAL SAMPLE LOCATION WHERE ANALYTE IS LESS THAN NJDEPE SOIL CLEANUP CRITERIA
- BM-1 — BLUE MATERIAL SAMPLE LOCATION WHERE ANALYTE IS EQUAL TO OR EXCEEDS NJDEPE SOIL CLEANUP CRITERIA
- * — ANALYTE IS EQUAL TO OR EXCEEDS NJDEPE SOIL CLEANUP CRITERIA
- (0-2) — DEPTH INTERVAL SAMPLED (FT.)
- ND — ANALYTE WAS NOT DETECTED AT THE DETECTION LIMIT USED FOR THE ANALYSIS
- D — RESULTS ARE FROM THE ANALYSIS OF THE DUPLICATE SAMPLE. DUPLICATE RESULTS ARE GREATER THAN SAMPLE RESULTS
- J — ESTIMATED VALUE
- R — DATA UNUSABLE

NOTE:

1. ALL CONCENTRATIONS PRESENTED ARE IN PPM.

C-4
0.92 J (3-5)
0.95 J (5-7)
0.76 J (7-9)

55.4 (8-10) *
56.3 (10-12) *
1.2 J (12-14)
C-38

C-40
4.6 (2-4)
1.2 J (4-6)
1.9 J (6-8)

C-20
1.3 J (2.5-4.5)
19.3 (4.5-6.5)
1.4 J (6.5-8.5)

C-23
6.8 (0-2)
4.5 (4-6)

C-39
2.5 J (0-2)
1.3 J (4-6)
1.6 J (6-8)D

C-36
26.8 J (0-2) *
2.3 J (2-4)
0.72 J (4-6)

7.8 J (0-2)D
6.3 J (2-4)
C-37

4.3 (3-5)
0.95 J (7-9)
1.2 J (11-13)

C-18
5.8 (0-2)
1.3 J (2-4)

C-5
2.3 (0-2)
1.3 J (2-4)

C-43

C-12
1.9 J (0.5-2.5)
2.1 J (2.5-4.5)

BM-2
1.7J (0-1)

BM-1
0.78 J (0.5-1.0)

C-42
1.4 J (4-6)
2.7 (6-8)
3.9 (10-12)

C-13
3.2 (1-3)
1.1 J (3-5)
1.1 J (5-7)

C-19
8.8 J (0-2)
1.7 J (2-4)
3 (4-6)

C-27
4.2 (2-4)
2.1 J (4-6)
7.6 (6-8)

1.8 J (4-6)
0.87 J (6-8)
1.2 J (8-10)
C-44

BM-3
1.2J (1-3) D
5.5J (3-4)

C-16
36.5 (1.5-2.5) *
15.3 (2.5-4)
1.3 J (4-5.5)

41.4 (0-2) *
4 (4-6)
3.9 (6-8)
C-41

C-6
7.5 J (0-2)

C-31
8.3 (2-4)
1.3 J (4-6)
5.6 (6-8)

20.9 J (0-2) *
11.7 J (2-3)
1 J (3-4)
C-17

C-24
33.2 J (2-4) *
0.65 J (4-6)

C-2
1.6 J (0-2)
2 J (3-4)

C-3
2.4 (0-2)
1.3 J (2-4)

C-35
1.5 J (3-5)
2.3 J (5-7)
1.5 J (7-9)

90.1 J (0-2) *
20.8 J (2-4) *
C-21

3.1 (0.5-2.5)
1.5 J (4.5-6.5)
1.5 J (8.5-10.5)
C-25

C-29
105 J (1-3) *
2.9 (5-7)
5.9 (7-9)

C-28
2.6 J (3-5)
2.9 (5-7)
2.3 (7-9)

C-1
5.8 (1-3)
0.83 J (3-5)
1.5 J (5-7)

C-9
15 (0-2)
0.74 J (4-6)

C-7
53.3 J (2-4) *
11.7 (4-5)
4.3 (5-7)
2.1 J (7-8)

2.7 (2-3)
10.4 (4-6)
3.4 (6-8)

C-14
7.3 (2-4)
1.2 J (4-6)

C-32
0.97 J (1-3)
2 J (3-5)
2.4 (5-7)

C-10

1.8 J (1-3)
4.6 (3-5)
1.4 J (7-9)

C-26
5.3 (0-2)
3.9 (2-4)
2.9 (4-6)

C-8
22.6 (0-2) *
3.6 (2-4)

C-11
2.8 (3-5)
1 J (5-7)
2 J (7-9)

C-22
1.9 J (1-3)
4.2 (3-5)
1.9 J (5-7)

C-33

C-15
1.9 J (0-2)
13.9 (3-5)
1.3 J (5-7)

C-30
1.9 J (1-3)

C-34
5.7 (1-3)D
2.2 J (3-5)
2 J (5-7)

STATE ROUTE 17

CRANE AVENUE

ANGLE AVENUE

0 200 400 600

SCALE 1"=200'

STEPAN COMPANY AND SEARS AND ADJACENT PROPERTIES RI
MAYWOOD, NEW JERSEY

FIGURE 4-8
ARSENIC IN SOILS (PPM)
FEBRUARY - APRIL 1992

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N

N.Y. SUSQUEHANNA, & WESTERN RAILROAD

WEST HUNTER AVENUE

MAYWOOD AVENUE

STATE ROUTE 17

GROVE AVENUE

BECKER AVENUE

C-4 ND (3-5) ND (5-7) ND (7-9)

C-38 ND (8-10) ND (10-12) ND (12-14)

C-40 ND (2-4) ND (4-6) ND (6-8)

C-20 ND (2.5-4.5) ND (4.5-6.5) ND (6.5-8.5)

C-39 ND (0-2) ND (4-6) ND (6-8)

C-5 ND (0-2) ND (2-4)

C-43 ND (3-5) ND (7-9) ND (11-13)

C-42 ND (4-6) ND (6-8) ND (10-12)

C-44 ND (4-6) ND (6-8) 0.87 J (8-10)

C-6 1.6 (0-2) *

ND (0-2) ND (4-6) ND (6-8)

C-41

C-3 ND (0-2) ND (2-4)

C-2 ND (0-2) ND (3-4)

C-1 ND (1-3) ND (3-5) ND (5-7)

C-9 2.4 (0-2) * ND (4-6)

C-7 ND (2-4) ND (4-5) ND (5-7) ND (7-8)

ND (2-3) ND (4-6) ND (6-8)

C-8 ND (0-2) ND (2-4)

C-10

C-11 ND (3-5) ND (5-7) ND (7-9)

C-14 ND (2-4) ND (4-6)

C-33

C-15 ND (0-2) 2.6 (3-5) * ND (5-7)

C-29 ND (1-3) ND (5-7) ND (7-9)

C-36 R (0-2) R (2-4) ND (4-6)

C-18 R (0-2) ND (2-4)

C-12 ND (0.5-2.5) 0.69 J (2.5-4.5)

C-13 ND (1-3) ND (3-5) ND (5-7)

C-19 2.3 (0-2) * ND (2-4) ND (4-6)

C-16 ND (1.5-2.5) ND (2.5-4) ND (4-5.5)

C-23 0.95 J (0-2) ND (4-6)

C-37 ND (0-2) 4 (2-4) *

BM-2 ND (0-1)

BM-1 ND (0.5-1.0)

BM-3 ND (1-3) R (3-4)

C-27 ND (2-4) ND (4-6) ND (6-8)

C-17 R (0-2) R (2-3) ND (3-4)

C-24 R (2-4) ND (4-6)

C-31 ND (2-4) ND (4-6) ND (6-8)

C-21 R (0-2) R (2-4)

C-22 ND (1-3) 1.1 (3-5) * ND (5-7)

C-25 1.4 (0.5-2.5) * ND (4.5-6.5) ND (8.5-10.5)

C-35 ND (3-5) ND (5-7) ND (7-9)

C-28 ND (3-5) ND (5-7) ND (7-9)

C-32 ND (1-3) ND (3-5) ND (5-7)

C-26 ND (0-2) ND (2-4) ND (4-6)

C-30 ND (1-3)

C-34 ND (1-3) ND (3-5) ND (5-7)

LEGEND:

- PROPERTY LINE
- FENCE
- C-1 — SOIL BORING LOCATION WHERE ANALYTE IS EQUAL TO OR EXCEEDS NJDEPE SOIL CLEANUP CRITERIA
- C-1 — SOIL BORING LOCATION WHERE ANALYTE IS LESS THAN NJDEPE SOIL CLEANUP CRITERIA
- BM-1 — BLUE MATERIAL SAMPLE LOCATION WHERE ANALYTE IS LESS THAN NJDEPE SOIL CLEANUP CRITERIA
- BM-1 — BLUE MATERIAL SAMPLE LOCATION WHERE ANALYTE IS EQUAL TO OR EXCEEDS NJDEPE SOIL CLEANUP CRITERIA
- * — ANALYTE IS EQUAL TO OR EXCEEDS NJDEPE SOIL CLEANUP CRITERIA
- (0-2) — DEPTH INTERVAL SAMPLED (FT.)
- ND — ANALYTE WAS NOT DETECTED AT THE DETECTION LIMIT USED FOR THE ANALYSIS
- D — RESULTS ARE FROM THE ANALYSIS OF THE DUPLICATE SAMPLE. DUPLICATE RESULTS ARE GREATER THAN SAMPLE RESULTS
- J — ESTIMATED VALUE
- R — DATA UNUSABLE

NOTE:

1. ALL CONCENTRATIONS PRESENTED ARE IN PPM.

0 200 400 600

SCALE 1"=200'

STEPAN COMPANY AND SEARS AND ADJACENT PROPERTIES RI
MAYWOOD, NEW JERSEY

FIGURE 4-9
CADMIUM IN SOILS (PPM)
FEBRUARY - APRIL 1992

sbc-12.dgn 25-JUL-1994 NJO/JMS 2

N

N.Y. SUSQUEHANNA, & WESTERN RAILROAD

WEST HUNTER AVENUE

MAYWOOD AVENUE

STATE ROUTE 17

GROVE AVENUE

BECKER AVENUE

C-4
7.6J(3-5)
5.4J(5-7)
7.6J(7-9)

C-38
22.6(8-10)
180 (10-12)
7.8J (12-14)

C-40
11.6(2-4)
10.5(4-6)
10.2(6-8)

C-20
6J(2.5-4.5)
14.4(4.5-6.5)
10.2J(6.5-8.5)

C-39
6J(0-2)
4.5J(4-6)
10.2JD(6-8)

C-5
762(0-2) *
22.2(2-4)

C-42
6.6J(4-6)
8.4J(6-8)
7.9J(10-12)

C-43
15.3(3-5)
5.6J(7-9)
3.1J(11-13)

C-44
94.3(4-6)
128(6-8)
53.4(8-10)

2440(0-2) *
197(4-6)
20.7(6-8)
C-41

C-6
35.1(0-2)

C-2
25.5(0-2)
12.6(3-4)

C-3
11(0-2)
9.5(2-4)

C-1
45.9JD(1-3)
9.3(3-5)
7.4(5-7)

548J(2-4) *
61.6J(4-5)
R(5-7)
402(7-8)
C-7

C-9
219J(0-2)
13.9J(4-6)

46.1J(2-3)
9.9(4-6)
8.2(6-8)
C-10

C-8
140J(0-2)
22J(2-4)

C-36
22.7(0-2)
8.7(2-4)
5.2(4-6)

C-18
38.8(0-2)
4.7(2-4)

C-12
11.1J(0.5-2.5)
12.4J(2.5-4.5)

C-13
19.2(1-3)
8.5(3-5)
4.4(5-7)

C-19
62(0-2)
11.1(2-4)
5.3(4-6)

C-16
250J(1.5-2.5)
297J(2.5-4.0)
12.3J(4.0-5.5)

C-11
123J(3-5)
9.7J(5-7)
10.9J(7-9)

C-33

C-15
11.4(0-2)
223(3-5)
8.2(5-7)

C-14
477J(2-4)
14(4-6)

13.1(1-3)
122(3-5)
10.6(7-9)

C-29
265J(1-3)
8.2J(5-7) D
9.4(7-9)

C-17
354(0-2)
82.6(2-3)
9.4(3-4)

C-21
1360(0-2) *
656(2-4) *

C-22
4.6(1-3)
7.2(3-5)
9.8(5-7)

C-23
19J(0-2)
8.1JD(4-6)

100(0-2)
55.8(2-4)
C-37

BM-2
3.3 (0-1)

BM-1
ND (0.5-1.0)

BM-3
ND (1-3)
11.5J (3-4)

C-27
12(2-4)
10.2(4-6)
6.2(6-8)

C-24
153(2-4)
20(4-6)

C-31
10(2-4)
6.1(4-6)
9.7(6-8)

C-25
11.8(0.5-2.5)
5.3(4.5-6.5)
7.6(8.5-10.5)

C-35
R(3-5)
R(5-7)
R(7-9)

C-28
R(3-5)
R(5-7)
R(7-9)

C-32
11.2(1-3)
R (3-5)
5.5(5-7)

C-26
20.1(0-2)
22.5(2-4)
10.7(4-6)

C-30
8.8(1-3)

C-34
3.8(1-3)D
3.5(3-5)
6(5-7)

LEGEND:

———	PROPERTY LINE
- - - -	FENCE
C-1	SOIL BORING LOCATION WHERE ANALYTE IS EQUAL TO OR EXCEEDS NJDEPE SOIL CLEANUP CRITERIA
C-1	SOIL BORING LOCATION WHERE ANALYTE IS LESS THAN NJDEPE SOIL CLEANUP CRITERIA
BM-1	BLUE MATERIAL SAMPLE LOCATION WHERE ANALYTE IS LESS THAN NJDEPE SOIL CLEANUP CRITERIA
BM-1	BLUE MATERIAL SAMPLE LOCATION WHERE ANALYTE IS EQUAL TO OR EXCEEDS NJDEPE SOIL CLEANUP CRITERIA
*	ANALYTE IS EQUAL TO OR EXCEEDS NJDEPE SOIL CLEANUP CRITERIA
(0-2)	DEPTH INTERVAL SAMPLED (FT.)
ND	ANALYTE WAS NOT DETECTED AT THE DETECTION LIMIT USED FOR THE ANALYSIS
D	RESULTS ARE FROM THE ANALYSIS OF THE DUPLICATE SAMPLE. DUPLICATE RESULTS ARE GREATER THAN SAMPLE RESULTS
J	ESTIMATED VALUE
R	DATA UNUSABLE

NOTE:

1. ALL CONCENTRATIONS PRESENTED ARE IN PPM.

0 200 400 600

SCALE 1"=200'

STEPAN COMPANY AND SEARS AND ADJACENT PROPERTIES RI
MAYWOOD, NEW JERSEY

FIGURE 4-10
CHROMIUM IN SOILS (PPM)
FEBRUARY - APRIL 1992

sbc-10.dgn 25-JUL-1994 NJO/JMS 2

N.Y., SUSQUEHANNA & WESTERN RAILROAD

WEST HUNTER AVENUE

MAYWOOD AVENUE

STATE ROUTE 17

GROVE AVENUE

BECKER AVENUE

C-4 3.5 (3-5) 4.7 (5-7) 5.7 (7-9)

C-38 409 (8-10) * 801 (10-12) * 16.1 (12-14)

C-40 5.6 (2-4) 4.3 (4-6) 8 (6-8)

C-20 2.8 (2.5-4.5) 47.4 (4.5-6.5) 7.3 (6.5-8.5)

C-39 23.6 (0-2) 3.5 (4-6) 4.5 (6-8)D

C-23 168 (0-2) * 3.4 (4-6)D

C-36 242 (0-2) * 4.3 J (2-4) 6.5 J (4-6)

109 (0-2) D * 612 (2-4) *

C-37

C-18 66.5 (0-2) 2.8 J (2-4)

C-5 R (0-2) R (2-4)

18.4 J (3-5) 3.5 (7-9) 3.9 (11-13)

C-43

C-12 5.7 (0.5-2.5) 6.1 (2.5-4.5)

C-42 64.6 (4-6) 15.3(6-8) 4.1 (10-12)

C-13 20.9 J (1-3) 7.3 J (3-5) 5.5 J (5-7)

C-19 123 J (0-2) * 6.9 J (2-4) 5 J (4-6)

BM-2 307 (1-3) *

BM-1 263 J (0.5-1.0) *

BM-3 207 (1-3) D * 480 J (3-4) *

C-27 1050 J (2-4) * 5.1 (4-6) 3.7 (6-8)

C-44 17.9 (4-6) 12.6 (6-8) 7.9 (8-10)

328 J (0-2) * R(4-6) R (6-8)

C-6 23.6 J (0-2)

C-16 105 (1.5-2.5) * 202 (2.5-4) * 6.7 (4-5.5)

C-31 3.2 J (2-4) 2.7 J (4-6) 14 J (6-8)

C-41

C-2 R (0-2) 8 J (3-4)

C-3 5.1 J (0-2) 5.2 J (2-4)

C-17 127 (2- 5.6 J (3-4) *

C-24 277 (2-4) * 10.6 J (4-6)

260 (0-2) * 238 (2-4) *

C-29 275 (1-3) * 5 (5-7)D 6.2 J (7-9)

C-21

C-35 6.5 (3-5) 4.6 (5-7) 4 (7-9)

C-25 32.4 J (0.5-2.5) 3.4 J (4.5-5.5) 4.1 J (8.5-10.5)

C-28 5.6 (3-5) 4.8 (5-7) 2.8 (7-9)

C-1 53 (1-3) 6.7 J (3-5) 7 J (5-7)

C-9 337 (0-2) * 9.2 (4-6)

C-7 130 (2-4) * 41.6 (4-5) 4.7 (5-7) 2.4 J (7-8)

42.7 (2-3) 13.5 J (4-6) 4.2 J (6-8)

C-14 168 (2-4) * 6.9 J (4-6)

C-32 5 (1-3)D 3.8 (3-5) 3.3 (5-7)

C-10

20.9 J (1-3) 23.2 J (3-5) 5.6 J (7-9)

C-8 229 (0-2) * 16.4 (2-4)

C-11 30.1 (3-5) 8.4 (5-7)D 4.4 J (7-9)

C-22 10.8 J (1-3) 28.1 J (3-5) 10.1 J (5-7)

C-26 49.3 (0-2) 19.9 (2-4) 5.4 (4-6)

C-33

C-15 18.4 J (0-2) 15.4 J (3-5) * 3.9 J (5-7)

C-30 6.5 (1-3)

C-34 204 J (1-3) * 3.2 (3-5) 3.1 (5-7)

LEGEND:

- PROPERTY LINE
- FENCE
- C-1 — SOIL BORING LOCATION WHERE ANALYTE IS EQUAL TO OR EXCEEDS NJDEPE SOIL CLEANUP CRITERIA
- C-1 — SOIL BORING LOCATION WHERE ANALYTE IS LESS THAN NJDEPE SOIL CLEANUP CRITERIA
- BM-1 — BLUE MATERIAL SAMPLE LOCATION WHERE ANALYTE IS LESS THAN NJDEPE SOIL CLEANUP CRITERIA
- BM-1 — BLUE MATERIAL SAMPLE LOCATION WHERE ANALYTE IS EQUAL TO OR EXCEEDS NJDEPE SOIL CLEANUP CRITERIA
- * — ANALYTE IS EQUAL TO OR EXCEEDS NJDEPE SOIL CLEANUP CRITERIA
- (0-2) — DEPTH INTERVAL SAMPLED (FT.)
- ND — ANALYTE WAS NOT DETECTED AT THE DETECTION LIMIT USED FOR THE ANALYSIS
- D — RESULTS ARE FROM THE ANALYSIS OF THE DUPLICATE SAMPLE. DUPLICATE RESULTS ARE GREATER THAN SAMPLE RESULTS
- J — ESTIMATED VALUE
- R — DATA UNUSABLE

NOTE:

1. ALL CONCENTRATIONS PRESENTED ARE IN PPM.

0 200 400 600

SCALE 1"=200'

STEPAN COMPANY AND SEARS AND ADJACENT PROPERTIES RI
MAYWOOD, NEW JERSEY

FIGURE 4-11
LEAD IN SOILS (PPM)
FEBRUARY - APRIL 1992

fig4-12.dgn 25-JUL-1994 NJO/JMS 2

N

N.Y. SUSQUEHANNA & WESTERN RAILROAD

WEST HUNTER AVENUE

MAYWOOD AVENUE

STATE ROUTE 17

GROVE AVENUE

BECKER AVENUE

C-4
0.31J (3-5)
0.35J (5-7)
0.57J (7-9)

C-38
1.8 (8-10)*
0.96J (10-12)
0.69J (12-14)

C-40
0.25J (2-4)
0.19J (4-6)
0.29J (6-8)

C-20
0.66J (2.5-4.5)
1.1J (4.5-6.5)*
1.3J (6.5-8.5)*

C-23
0.53J (0-2)
0.27J (4-6) D

C-36
ND (0-2)
ND (2-4)
ND (4-6)

C-39
0.67J (0-2)
0.67J (4-6)
0.7J (6-8)

C-18
0.53J (0-2)
0.89 (2-4)

C-37
ND (0-2)
1.1J (2-4)*

BM-2

C-5
0.34J (0-2)
0.39J (2-4)

1.1 (3.5)*
0.22J (7-9)
0.45J (11-13)

C-43

C-12
0.29J (0.5-2.5)
0.29J (2.5-4.5)

1.4J (4-6)*
0.47J (6-8)
0.92J (10-12)

C-42

BM-1

BM-4

BM-3

C-13
0.4J (1-3)
0.43J (3-5)
0.39J (5-7)

C-19
1.2 (0-2)*
0.69J (2-4)
0.46J (4-6)

C-27
0.43J (2-4)
0.71J (4-6)
0.69J (6-8)

C-44
0.09J (4-6)
0.09J (6-8)
0.07J (8-10)

C-16
0.91J (1.5-2.5)
1.5J (2.5-4)*
0.72J (4-5.5)

C-6
0.94 (0-2)

1.2 (0-2)*
0.52J (4-6)
0.35J (6-8)

C-41

C-31
0.89J (2-4)
0.45J (4-6)
0.69J (6-8)

0.5J (0-2)
0.48J (2-4)
C-3

C-17
1.1 (0-2)*
1.2 (2-3)*
0.94 (3-4)

C-24
1.3 (2-4)*
0.93 (4-6)

C-2
0.92 (0-2)
0.93J (3-4)

C-29
1.7 (1-3)*
0.68 (5-7) D
0.23J (7-9)

C-21
1.2 (0-2)*
1.2 (2-4)*

C-35
0.66J (3-5)
0.65J (5-7)
0.67J (7-9)

C-25
0.71J (0.5-2.5)
0.46J (4.5-6.5)
0.46J (8.5-10.5)

C-1
1.2 (1-3)*
0.42J (3-5)
0.37J (5-7)

C-9
1.8 (0-2)*
0.46 (4-6)

1.6J (2-4)*
0.44J (4-6)
C-14

C-28
0.65J (3-5)
0.67J (5-7)
0.44J (7-4)

C-7
1.5 (2-4)*
1.1J (4-5)*
0.68J (5-7)
0.15J (7-8)

C-32
0.4J (1-3)
0.65J (3-5)
0.86J (5-7)

C-10

C-8
1.2J (0-2)*
0.98J (2-4)

0.54 (2-3)
0.3J (4-6)
0.33J (6-8)

C-11

0.44J (1-3)
0.7J (3-5)
0.68J (7-9)

C-33

C-22
0.86J (1-3)
0.67J (3-5)
0.44J (5-7)

C-26
0.71J (0-2)
0.89J (2-4)
0.44J (4-6)

0.5J (3-5)
0.7J (5-7) D
1.2J (7-9)*

C-15
0.88J (0-2)
1.5 (3-5)*
0.46J (5-7)

C-30
0.88J (1-3)

C-34
0.54J (1-3)
0.22 (3-5)
0.46J (5-7)

0 200 400 600

SCALE 1"=200'

LEGEND:

——·——·——	PROPERTY LINE
——•——•——	FENCE
C-1	SOIL BORING LOCATION WHERE ANALYTE IS EQUAL TO OR EXCEEDS NJDEPE SOIL CLEANUP CRITERIA
C-1	SOIL BORING LOCATION WHERE ANALYTE IS LESS THAN NJDEPE SOIL CLEANUP CRITERIA
BM-1	BLUE MATERIAL SAMPLE LOCATION WHERE ANALYTE IS LESS THAN NJDEPE SOIL CLEANUP CRITERIA
BM-1	BLUE MATERIAL SAMPLE LOCATION WHERE ANALYTE IS EQUAL TO OR EXCEEDS NJDEPE SOIL CLEANUP CRITERIA
*	ANALYTE IS EQUAL TO OR EXCEEDS NJDEPE SOIL CLEANUP CRITERIA
(0-2)	DEPTH INTERVAL SAMPLED (FT.)
ND	ANALYTE WAS NOT DETECTED AT THE DETECTION LIMIT USED FOR THE ANALYSIS
D	RESULTS ARE FROM THE ANALYSIS OF THE DUPLICATE SAMPLE. DUPLICATE RESULTS ARE GREATER THAN SAMPLE RESULTS
J	ESTIMATED VALUE
R	DATA UNUSABLE

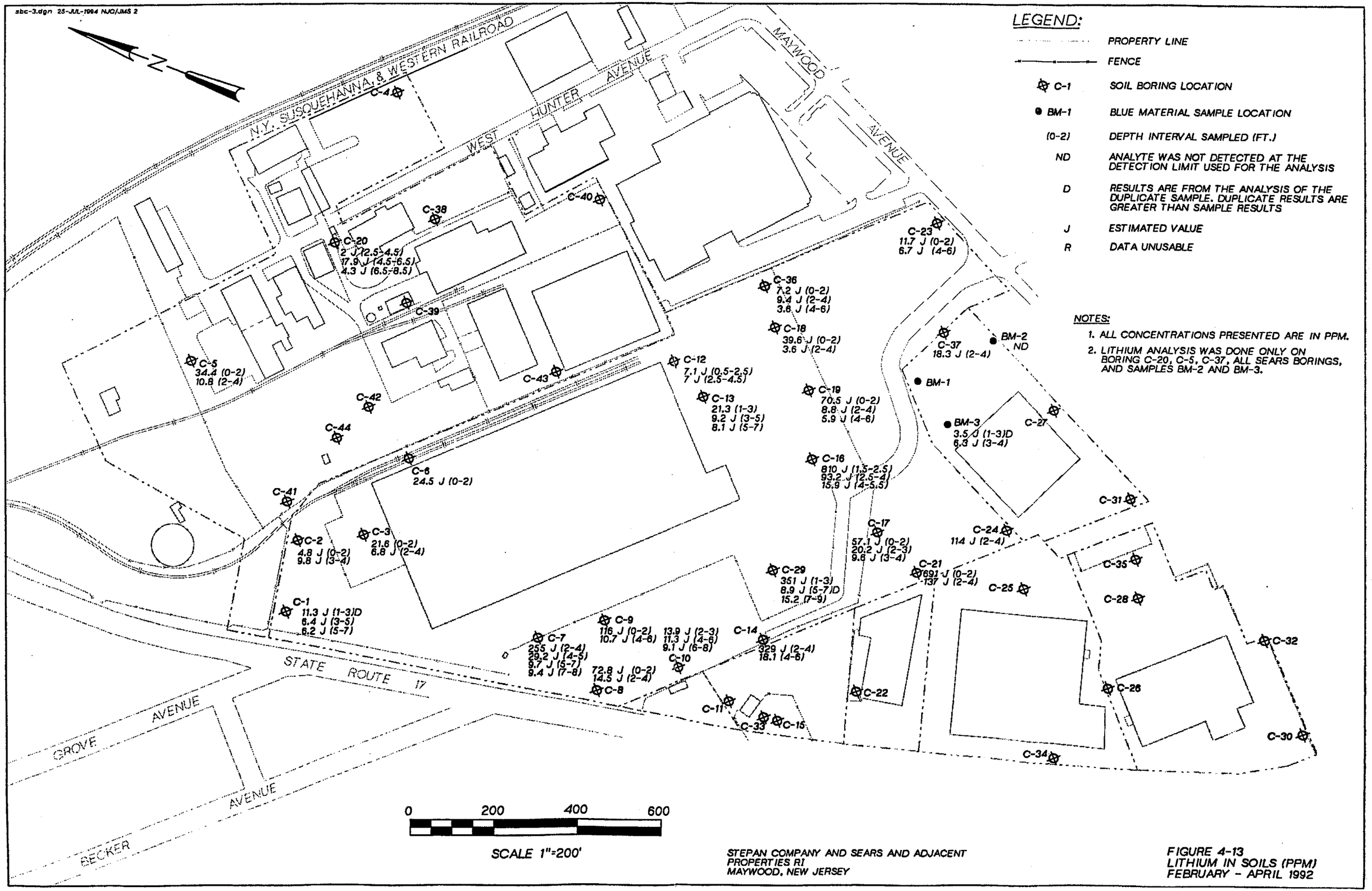
NOTE

1. ALL CONCENTRATIONS PRESENTED ARE IN PPM.

STEPAN COMPANY AND SEARS AND ADJACENT PROPERTIES RI
MAYWOOD, NEW JERSEY

FIGURE 4-12
BERYLLIUM IN SOILS (PPM)
FEBRUARY - APRIL 1992

sbc-3.dgn 25-JUL-1994 NJO/JMS 2



SCALE 1"=200'

LEGEND:

	PROPERTY LINE
	FENCE
C-1	SOIL BORING LOCATION
BM-1	BLUE MATERIAL SAMPLE LOCATION
(0-2)	DEPTH INTERVAL SAMPLED (FT.)
ND	ANALYTE WAS NOT DETECTED AT THE DETECTION LIMIT USED FOR THE ANALYSIS
D	RESULTS ARE FROM THE ANALYSIS OF THE DUPLICATE SAMPLE. DUPLICATE RESULTS ARE GREATER THAN SAMPLE RESULTS
J	ESTIMATED VALUE
R	DATA UNUSABLE

NOTES:

1. ALL CONCENTRATIONS PRESENTED ARE IN PPM.
2. LITHIUM ANALYSIS WAS DONE ONLY ON BORING C-20, C-5, C-37, ALL SEARS BORINGS, AND SAMPLES BM-2 AND BM-3.

STEPAN COMPANY AND SEARS AND ADJACENT PROPERTIES RI
MAYWOOD, NEW JERSEY

FIGURE 4-13
LITHIUM IN SOILS (PPM)
FEBRUARY - APRIL 1992

Barium. Barium was detected in all soil-boring and blue-material samples. Barium was present in only one sample at a concentration exceeding the NJDEPE residential direct-contact soil-cleanup criteria of 700 ppm. The 3- to 4-foot sample from BM-3 (DeSaussure) had a barium concentration of 1,670 ppm. The sample from BM-3 was collected from the soil below the blue material.

Cadmium. Cadmium was detected in eight samples at concentrations exceeding the NJDEPE soil-cleanup standard of 1 ppm. Three of these samples were located on Sears property, one on DeSaussure, two on Sunoco, one on SWS, and one on AMP (Figure 4-9). The maximum concentration detected (4 ppm) was detected in the 2- to 4-foot sample from C-37 (DeSaussure). Several of the samples that exceeded the standard for cadmium were less than 2 ppm above the NJDEPE cleanup criterion of 1 ppm.

Chromium. Total chromium was detected in 119 samples, 5 of which contained concentrations exceeding the NJDEPE residential direct-contact soil cleanup criteria. Two of these samples were on Sears property, and 3 were on Stepan (Figure 4-10). The maximum concentration of chromium (2,440 ppm) was detected in the 0- to 2-foot sample from C-41 (Stepan). Soil boring C-21 (Sears) contained chromium concentrations of 1,360 ppm in the 0- to 2-foot sample and 656 ppm in the 2- to 4-foot sample. Chromium concentrations appeared to decrease with depth at most locations. Generally, the higher concentrations were detected in what was commonly identified as fill on the Stepan property, and not in native soil.

Lead. Lead was detected in all the soil-boring and blue-material samples (Figure 4-11). Twenty-seven of the total of 126 samples collected contained lead concentrations exceeding the NJDEPE soil-cleanup criterion of 100 ppm. Of these 27 samples, 3 were on Stepan, 15 were on Sears, 1 was on Sunoco, 1 was on SWS, and 7 were on DeSaussure (three soil and four blue material). The maximum concentration of lead detected was 1,050 ppm, in the 2- to 4-foot sample from C-27 (DeSaussure). This sample was described by field personnel as soft, gray-white, and tan.

The EPA's target cleanup range for lead in soil is 500 to 1,000 ppm. Four soil borings had sample intervals which contained concentrations of lead within or exceeding this range. Borings C-17 (Sears), C-37 (Sears), and C-38 (Stepan) contained lead concentrations of 883 ppm (0-2 feet); 617 ppm (2-4 feet); and 801 ppm (10-12 feet) respectively. Boring C-27 (DeSaussure) contained lead at an estimated concentration of 1,050 ppm (2-4 feet) which exceeds the EPA range.

Lead concentrations vary randomly throughout the study area and with depth. Within the southern and southwestern sections of Sears and northern end of DeSaussure the lead concentrations are generally higher than those found in the rest of the study area.

Samples from C-17 (0 to 2 feet, Sears) and C-38 (10 to 12 feet, Stepan) also contained elevated lead concentrations of 883 ppm and 801 ppm, respectively. The

material sampled from the 10- to 12-foot interval at C-38 was black sludge with a hydrogen sulfide ("rotten egg") odor. The C-38 boring was located within burial site No. 1, shown on Figure 4-1. Boring C-17 was located near test pits TP-85 and TP-84, where buried drums were located and sampled. Lead concentrations of up to 3,660 ppm were detected in samples from these test pits.

The highest concentration of lead (480 ppm) detected in the soil below the blue material was in the 3- to 4-foot sample from BM-3 (DeSaussure). The lead concentrations in the other blue-material samples ranged from 207 ppm to 307 ppm.

Antimony. Antimony was detected in 48 soil-boring samples, 2 of which exceeded the proposed NJDEPE residential direct-contact soil-cleanup criterion of 14 ppm. Two samples were taken, one from the 8- to 10-foot interval and one from the 10- to 12-foot interval from boring C-38 (Stepan). The concentrations were 15.6 ppm in the 8- to 10-foot interval and 18.9 ppm in the 10- to 12-foot interval.

Beryllium. Beryllium was detected in 108 of the 130 soil boring samples analyzed (Figure 4-12). Nineteen of these samples had concentrations exceeding the NJDEPE residential soil-cleanup criteria of 1 ppm. Concentrations of beryllium detected ranged from 0.07 to 1.8 ppm.

Lithium. At EPA's request, lithium analysis was performed on all the soil boring samples from the Sears property and on samples from borings C-5 and C-20, located on the Stepan property. Inadvertently, the samples from boring C-37 (DeSaussure) also were analyzed by the laboratory. Blue-material samples from BM-2 and BM-3 were also analyzed for lithium. Lithium concentrations detected in soil boring samples are shown in Figure 4-13. Lithium was detected in all the soil samples analyzed. The maximum concentrations were 810 ppm in sample C-16 (1.5 to 2.5 feet, Sears) and 691 ppm in C-21 (0 to 2 feet, Sears). Lithium was detected in both the 1- to 3-foot and 3- to 4-foot intervals at BM-3 but was not detected in the BM-2 sample.

Cyanide. Cyanide was detected in 12 samples, 4 of which were blue-material samples. The maximum detected concentration of cyanide was 157 ppm in the 3- to 4-foot sample of BM-3, which is below the blue material. Cyanide was not detected at concentrations exceeding the NJDEPE residential direct-contact soil-cleanup criterion of 1,100 ppm.

4.2.5 Radiological Parameters

The 40,000-cpm site-specific DOE reference criterion was considered an approximate indication that subsurface soils may contain Th-232 above the DOE generic cleanup criterion of 15 pCi/g. Because of variations in equipment used for the RI (as compared to that used by DOE) and less-than-ideal field conditions, 30,000 cpm was used in lieu of 40,000 cpm as an approximation of subsurface radiological contamination. The correlation of 11,000 cpm to 5 pCi/g Th-232 (for surface soils

[BNI, 1987b]) cannot be directly applied to compare surface and 0.5 foot BGS gamma log measurements obtained during the RI. Typical background count rates on the Stepan property, measured with the BHP-2 probe, were approximately 6,500 cpm.

Ra-226 and Ra-228 levels in soil-boring samples were compared to DOE Order 5400.5 generic cleanup criteria. U-234 and U-238 results were compared to NRC's Branch Technical Position criteria. Total thorium results from soil-boring samples were not compared to the DOE cleanup criteria because the latter apply to Th-230 and Th-232 individually. No comparison criteria for gross alpha and gross beta radiation exist; neither does comparison criteria for U-235 where it is present in naturally occurring percentages. Table 4-8 summarizes soil boring sample results and comparison criteria, where applicable. Figure 4-14 shows radiological sample results at each soil-boring location.

Soils Excluding Blue Material. Fifteen of the 44 soil borings logged for gamma radiation exhibited gamma radiation measurements above the reference criterion of 40,000 cpm; 10 were on the Sears property, 2 were on Sunoco, 1 was on DeSaussure, and 2 were on Stepan. The maximum gamma log measurement was 867,544 cpm, from soil boring C-38 (Stepan). Table 4-9 summarizes the downhole gamma radiation logging results. Complete gamma logs for each boring are contained in soil-boring logs included in this report as Appendix D.

Analytical results from each boring interval are compared also to the gamma log results from the entire boring and the interval from which the boring was sampled for radiological analyses (Table 4-10). It should be noted that gamma log measurements were collected at 6-inch intervals, whereas the soil-boring samples collected for radiological analyses typically were collected over 2-foot intervals.

Although a site-specific gamma log cpm- to pCi/g ratio was not established, all but one of the soil samples containing radiological analytes above applicable comparison criteria were collected from an interval showing gamma radiation measurements greater than the site-specific DOE guideline of 40,000 cpm. The one sample that did not was C-20 (Stepan). Because the uranium data for the 6.5- to 8.5-foot sample from C-20 is estimated, and other radiological analytes are relatively low, it is possible that uranium levels from the 6.5- to 8.5-foot interval are actually below comparison criteria.

Soil borings C-10 (Sears), C-17 (Sears), C-33 (Sunoco), and C-42 (Stepan) showed gamma radiation measurements slightly greater than 40,000 cpm and were not among the 10 percent of the soil boring samples analyzed for radiological parameters. On the basis of the 40,000-cpm guideline, these boring locations may contain radioactive constituents in elevated concentrations.

Table 4-8
Summary of Radiological Sample Results for Soil Boring Samples

Analyte	Subsurface Soil Criteria (pCi/g)	Detected Minimum (pCi/g)	Detected Minimum Location	Detected Maximum 0	Detected Maximum Location	Detected Frequency (detects/total)	Detected > Comparison Criteria (> criteria/total)
Gross α	NE	22.8	C20(6.5-8.5)	8,310	C38(10-12)	13/13	NA
Gross β	NE	19.5	C20(6.5-8.5)	2,970	C38(10-12)	13/13	NA
Ra-226	15	1.4	C24(2-4)	266JH	C38(10-12)	13/13	5/13
Ra-228	15	[2.8]	C8(2-4)	283JH	C38(10-12)	13/13	6/13
Total-Th	15 [a]	29.2JC	C20(6.5-8.5)	3,920JC	C38(10-12)	13/13	NA
U-234	10 [b]	[7.4]JS	C37D(0-2)	31.8JH	C38(10-12)	10/13	10/13
U-235	NE	5.9JH	C38(10-12)	5.9JH	C38(10-12)	1/13	NA
U-238	10 [b]	10.3JS	C15(3-5)	61.9JH	C38(10-12)	9/13	10/13

[a] The 15 pCi/g criteria applies to Th-230 and Th-232 individually, it does not apply to total-Thorium.

[b] The 10pCi/g limit applies to natural uranium (total of u-234 and u-238) and is presented individually for illustrative purposes. No site-specific U-234 or U-238 cleanup guidelines have been established by DOE. The U-234 and U-238 criteria listed are recommended criteria from NRC's Branch Technical Position (46 FR 52061; October 23,1981). The criteria assumes natural uranium with all daughters in equilibrium and applies to the sum of U-234 plus U-238. A typical (as opposed to site specific) calculated DOE surface soil guideline for U-238 would be 75 pCi/g (BNI, 1987 c).

Notes: NE = None established
NA = Not applicable
D = duplicate sample
> = Greater than
J = Estimated value
C = Calibration criteria not met
S = Matrix spike recovery criteria not met
H = Holding time exceeded
[ ] = Values for which the counting error is equal to or greater than 50% of the detected value (i.e., gross alpha was detected at a low concentration of 20.0 +/- 11.6 pCi/g).
( ) = Depth interval sample was collected.
DOE generic, subsurface soil residual contaminant cleanup guidelines are for concentrations averaged over a 15-cm layer, greater than 15 cm below the surface. The DOE Order 5400.5 guidelines apply only to radium and thorium, and are based on radium criteria specified in 40 CFR 192.
Frequencies do not include duplicate sample detects if analyte was detected in both original and duplicate sample.
Number of samples greater than comparison criteria does not include duplicate sample if analyte was detected in both original and duplicate samples.

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N.Y. SUSQUEHANNA & WESTERN RAILROAD

WEST HUNTER AVENUE

MAYWOOD AVENUE

STATE ROUTE 17

GROVE AVENUE

BECKER AVENUE

C-1 C-2 C-3 C-4 C-5 C-6 C-7 C-8 C-9 C-10 C-11 C-12 C-13 C-14 C-15 C-16 C-17 C-18 C-19 C-20 C-21 C-22 C-23 C-24 C-25 C-26 C-27 C-28 C-29 C-30 C-31 C-32 C-33 C-34 C-35 C-36 C-37 C-38 C-39 C-40 C-41 C-42 C-43 C-44

C-20 (6.5-8.5)
GROSS ALPHA-22.6
GROSS BETA-19.5
Ra-226 -1.9 JH
Ra-228 -3.3 JH
TOTAL Th -29.2 JC
U-234 -23.8 JHS *
U-238 -20.8 JHS *

C-38 (10-12)
GROSS ALPHA-8310
GROSS BETA-2970
Ra-226 -226 JH *
Ra-228 -283 JH *
TOTAL Th -3920 JC
U-234 -31.6 JH *
U-235 -5.9 JH
U-238 -61.9 JH *

GROSS ALPHA-123
GROSS BETA-52.5
Ra-226 -6.8
Ra-228 -10.9
TOTAL Th (D) -102 JC
U-234 (D) -[7.4] JS *
U-238 (D)-12.7 JS *

C-37 (0-2)

BM-2 (0-1)
Ra-226 -0.5
Th-230 -[0.7]

BM-1

BM-3 (3-4)
(1-3)
Th-230 -[0.5]
U-234 -[1.6]
GROSS ALPHA-[20]
GROSS BETA-14.4
Ra-228 -0.7
Th-230 -1.4
U-234 -12.2 *
U-235 -1.8 JC
U-238 -9.9 *

C-24 (2-4)
GROSS ALPHA-307
GROSS BETA-124
Ra-226 -1.4
Ra-228 -40.5 *
TOTAL Th-241 JC
U-234 -[19.8] JS *
U-238 -28.2 JS *

C-21 (2-4)

GROSS ALPHA-172
GROSS BETA-68.6
Ra-226 -7.9
Ra-228 -14.4
TOTAL Th-139 JC
U-234 -9.1 JS *
U-238 -11.4JS *

GROSS ALPHA-248
GROSS BETA-107
Ra-226 -14.8
Ra-228 -21.3 *
TOTAL Th-216 JC
U-234 -12.5 JS *
U-238 -13.9 JS *

C-16 (2.5-4)

GROSS ALPHA-109
GROSS BETA-57.5
Ra-226 -4.6
Ra-228 -5.4
TOTAL Th -91.6 JC

GROSS ALPHA-46.0
GROSS BETA-29.7
Ra-226 -17.6 *
Ra-228 -4.2
TOTAL Th -46.6 JC

C-29 (5-7)

GROSS ALPHA-55.5
GROSS BETA-32.5
Ra-226 -2.6
Ra-228 -[4.8]
TOTAL Th -63.0 JC
U-234-10.6 JS *

C-7 (4-6)

C-9 (0-2)

GROSS ALPHA-670
GROSS BETA-252
Ra-226 -27.1 *
Ra-228 -90.4 *
TOTAL Th-595 JC
U-234 -15.7 *
U-238 -15.5 *

C-14 (2-4)

C-8 (2-4)
GROSS ALPHA-37.3
GROSS BETA-24.9
Ra-226 -2.7
Ra-228 -[2.8]
TOTAL Th -33.9 JC

C-15 (3-5)
GROSS ALPHA-553
GROSS BETA-194
Ra-226 -28.0 *
Ra-228 -52.2 *
TOTAL Th -439 JC
U-234 -8.5 JS *
U-238 -10.3 JS *

LEGEND:

- PROPERTY LINE
- FENCE
- C-1 — SOIL BORING LOCATION
- C-1 — SOIL BORING LOCATION CONTAINING ANALYTE THAT EXCEEDS COMPARISON CRITERIA
- (0-2) — DEPTH INTERVAL SAMPLED (FT)
- [ ] — VALUES FOR WHICH THE COUNTING ERROR IS EQUAL TO OR GREATER THAN 50% OF THE DETECTED VALUE
- * — ANALYTE EXCEEDS COMPARISON CRITERIA
- (D) — RESULTS ARE FROM THE ANALYSIS OF DUPLICATE SAMPLE
- C — CALIBRATION CRITERIA NOT MET
- H — HOLDING TIME EXCEEDED
- J — ESTIMATED VALUE
- S — MATRIX SPIKE RECOVERY CRITERIA NOT MET

NOTES:

1. CONCENTRATIONS PRESENTED ARE IN UNITS OF pC i/g.
2. COMPARISON CRITERIA ARE BASED ON DOE ORDER 5400.5-GENERIC, SURFACE SOIL RESIDUAL CONTAMINANT CLEANUP GUIDELINES FOR Ra-226, Ra-228, Th-230, AND Th-232. COMPARISON CRITERIA FOR THE TOTAL OF U-234 PLUS U-238 ACTIVITY (10 pCi/g), ARE RECOMMENDED CRITERIA FROM NRC's BRANCH TECHNICAL POSITION (46FR 352081, OCTOBER 23, 1981). DOE OR EPA HAVE NOT ESTABLISHED SITE-SPECIFIC CLEANUP GUIDELINES FOR URANIUM.
3. TOTAL -Th DATA WAS NOT COMPARED TO DOE'S SUBSURFACE CRITERIA OF 15p Ci/g BECAUSE THE CRITERIA APPLIES TO Th-230 AND Th-232 INDIVIDUALLY.

0 200 400 600

SCALE 1"=200'

STEPAN COMPANY AND SEARS AND ADJACENT PROPERTIES RI
MAYWOOD, NEW JERSEY

FIGURE 4-14
RADIOLOGICAL RESULTS IN SOIL BORING

Table 4-9
Summary of Downhole Gamma Radiation Logging

Soil Boring ID	Property	Surface Reading (cpm)	Gamma-Log Reading @ 0.5 ft (BGS) (cpm)	Maximum Gamma-Log Reading Below 0.5 ft: Reading (cpm)	Depth ft (BGS)	>30,000 ≈ 15 pCi/g Th-232	Comments
C1	Sears	8,110	9,769	15,934	2		
C2	Sears	3,599	4,240	5,249	1.5		
C3	Sears	19,481	12,286	21,000	1.5		
C4	Stepan	8,357	9,274	15,453	9.5		
C5	Stepan	12,435	8,357	12,261	3		
C6	Sears	10,340	NT	3,987	2		Bore hole collapsed--not able to complete log
C7	Sears	11,534	7,360	247,236	4	✓	> 30,000 cpm from 1.5-5.5 ft. below grade
C8	Sears	88,218	92,470	142,962	1.5	✓	> 30,000 cpm from 0-3.5 ft. below grade
C9	Sears	40,170	20,040	87,146	2	✓	> 30,000 cpm from 0-3.0 ft. below grade
C10	Sears	128,130	74,902	291,304	2.5	✓	> 30,000 cpm from 0-4.5 ft. below grade
C11	Sunoco	7,654	13,246	26,543	4		
C12	Sears	8,621	6,868	10,385	8.5		
C13	Sears	9,536	3,864	18,386	3		
C14	Sears	27,692	39,820	247,650	2.5	✓	> 30,000 cpm from 0.5-4.5 ft. below grade
C15	Sunoco	11,402	37,297	99,468	4	✓	> 30,000 cpm from 0.5 to 1 ft. and from 3.5-4.5 ft. below grade
C16	Sears	43,059	57,994	72,462	1	✓	> 30,000 cpm from 0-3 ft. below grade
C17	Sears	22,040	88,939	65,198	1	✓	> 30,000 cpm from 0.5-1.5 ft. below grade
C18	Sears	5,494	10,448	6,700	1		
C19	Sears	12,213	13,721	23,367	1		
C20	Stepan	15,058	16,200	15,767	1		
C21	Sears	42,158	102,768	335,944	1.5	✓	> 30,000 cpm from 0-3 ft. below grade
C22	AMP	5,058	7,008	11,251	6.5		
C23	Sears	1,804	3,148	4,960	4		
C24	Sears	30,263	42,081	142,599	2	✓	> 30,000 cpm from 0-2.5 ft. below grade -- no log below 2.5 ft.
C25	SWS	5,620	5,865	14,826	5		
C26	Federal Express	6,418	7,673	9,662	4.5		
C27	DeSaussure	5,882	6,073	9,662	8.5		
C28	Federal Express	9,379	12,203	13,303	1		
C29	Sears	24,983	96,207	277,799	1.5	✓	> 30,000 cpm from 0.5-5.5 ft. below grade
C30	Federal Express	5,186	7,169	10,792	1.5		

Table 4-9
Summary of Downhole Gamma Radiation Logging

Soil Boring ID	Property	Surface Reading (cpm)	Gamma-Log Reading @ 0.5 ft (BGS) (cpm)	Maximum Gamma-Log Reading Below 0.5 ft: Reading (cpm)	Depth ft (BGS)	>30,000 ≈ 15 pCi/g Th-232	Comments
C31	DeSaussure	5,546	6,719	9,678	9		
C32	Federal Express	7,312	7,809	11,238	7		
C33	Sunoco	4,768	5,738	45,216	4	✓	> 30,000 cpm from 3.5-4.5 below grade
C34	SWS	8,863	6,818	9,718	9.5		
C35	Federal Express	9,288	9,678	10,292	1		
C36	Sears	2,314	3,530	5,385	1		
C37	DeSaussure	24,979	36,955	48,943	1.5	✓	> 30,000 cpm from 0.5-2.0 ft. below grade
C38	Stepan	17,970	25,778	867,544	11	✓	> 30,000 cpm from 1-12.5 ft. below grade
C39	Stepan	7,428	11,868	13,696	3.5		
C40	Stepan	9,434	11,007	11,661	2.5		
C41	Stepan	15,073	23,066	32,753	1.5	✓	>30,000 cpm @ 1.5 ft. below grade
C42	Stepan	6,059	18,474	47,483	1.5	✓	> 30,000 cpm from 1.0-2.0 below grade
C43	Stepan	5,682	7,885	20,980	2.5		
C44	Stepan	10,468	22,292	27,063	1.5		
Total number of borings with readings above 40,000 cpm, below 0.5 ft (BGS) =						16	

Notes: cpm = Counts per minute
ft. = Feet
> = Greater than
BGS = Below ground surface
≈ = Approximately
NT = Not taken

An Eberline Model PRS-1 or PRS-2 count rate meter was used with an Eberline Model BHP-2 probe to collect downhole gamma radiation logs. The BHP-2 probe contained a 2 in. x 2 in. NaI scintillation crystal encased in a lead shield, and had a conversion efficiency of 1,115 cpm per 1 uR/hour (Ra-226).

The 30,000 cpm comparison criteria is conservatively based on site-specific correlation determined by DOE's previous investigation (BNI, 1987 c). DOE's 40,000 cpm criteria correlates to 15 pCi/g Th-232 -- assuming a SPA-3 probe is used for the gamma logging. Because the BHP-2 probe contains a lead shield, the BHP-2 probe results obtained during the RI are assumed to be lower than DOE's unshielded SPA-3 results, for the same activity levels and therefore 30,000 cpm is used.

The DOE 11,000-cpm(cone-shielded SPA-3)-to-5 pCi/g-Th-232 ratio cannot be directly applied to compare BHP-2 data from the surface and @ 0.5 ft. (BGS) measurements.

Complete downhole gamma radiation logging results for each boring are contained on soil boring logs.

Table 4-10
Radiological Sample Results and Corresponding Gamma Log Results for Soil Boring Samples

Soil Boring Sample ID (Interval)	Property	Analyte	Detected Concentration (pCi/g)	Counting Error (+/- pCi/g)	Downhole Gamma logging ft (BGS)	CPM	ft (BGS)	CPM	ft (BGS)	CPM
C7	Sears	Gross α	55.5	10.9	0	11,534	3	143,857	6	27,536
(4-6)		Gross β	32.6	5.1	0.5	7,360	3.5	215,948	6.5	13,075
		Ra-226	2.6	0.6	1	14,775	4	247,236	7	10,307
		Ra-228	4.8	2.5	1.5	31,112	4.5	194,181	7.5	9,483
		Total Thorium	63.0JC	7.6	2	62,239	5	95,199	8	11,928
		U-234	10.6JS	4.2	2.5	101,183	5.5	55,484		
C8	Sears	Gross α	37.3	9.3	0	88,218	3.5	32,664	7	7,468
(2-4)		Gross β	24.9	4.8	0.5	92,470	4	27,699	7.5	7,323
		Ra-226	2.7	0.6	1	97,381	4.5	19,590	8	6,137
		Ra-228	2.8	1.6	1.5	142,962	5	14,778	8.5	6,135
		Total Thorium	33.9JC	3.7	2	108,550	5.5	11,683	9	7,236
					2.5	75,475	6	9,358		
					3	38,518	6.5	8,232		
C9	Sears	Gross α	109	14.5	0	40,170	3	38,270	6	6,966
(0-2)		Gross β	57.5	6.0	0.5	20,040	3.5	23,464	6.5	6,996
		Ra-226	4.6	0.8	1	42,000	4	16,550	7	6,824
		Ra-228	5.4	1.4	1.5	75,500	4.5	13,628	7.5	6,522
		Total Thorium	91.6JC	5.3	2	87,146	5	10,682	8	8,340
					2.5	71,492	5.5	7,562		
C14	Sears	Gross α	670	34.5	0	27,692	3.5	135,166	7	5,042
(2-4)		Gross β	252	10.8	0.5	39,820	4	96,652	7.5	4,494
		Ra-226	27.1	2.0	1	109,608	4.5	41,820	8	5,630
		Ra-228	90.4	5.3	1.5	158,850	5	19,896	8.5	4,481
		Total Thorium	595JC	12.5	2	214,944	5.5	9,924	9	5,335
		U-234	15.7	3.5	2.5	247,650	6	7,522	9.5	7,660
		U-238	15.5	3.4	3	192,718	6.5	6,064	10	6,402
C15	Sunoco	Gross α	553	31.4	0	11,402	3.5	56,875	7	18,530
(3-5)		Gross β	194	9.6	0.5	37,297	4	99,468	7.5	14,519
		Ra-226	28.0	2.0	1	45,330	4.5	58,022	8	12,984
		Ra-228	52.2	4.6	1.5	27,109	5	26,899	8.5	12,357
		Total Thorium	439JC	18.6	2	18,768	5.5	22,241	9	12,759
		U-234	8.5JS	2.1	2.5	19,643	6	20,098	9.5	12,626
		U-238	10.3JS	2.3	3	27,426	6.5	19,740		
C16	Sears	Gross α	248	21.3	0	43,059	3.5	26,957	7	9,665
(2.5-4)		Gross β	107	7.6	0.5	57,994	4	16,863	7.5	9,016
		Ra-226	14.8	1.5	1	72,462	4.5	14,450	8	8,879
		Ra-228	21.3	2.8	1.5	57,676	5	14,335	8.5	8,194
		Total Thorium	216JC	7.7	2	43,977	5.5	13,964	9	9,657
		U-234	12.5JS	3.6	2.5	48,835	6	14,162		
		U-238	13.8JS	3.7	3	41,228	6.5	11,730		
C20	Stepan	Gross α	22.8	7.8	0	15,058	3.5	11,497		
(6.5-8.5)		Gross β	19.5	4.6	0.5	16,200	4	11,506		
		Ra-226	1.9JH	0.5	1	15,767	4.5	12,034		
		Ra-228	3.3JH	1.6	1.5	14,523	5	12,000		
		Total Thorium	29.2JC	5.6	2	15,066	5.5	12,402		
		U-234	23.8JHS	7.6	2.5	12,113	6	13,788		
		U-238	20.8JHS	7.2	3	11,651				

Table 4-10
Radiological Sample Results and Corresponding Gamma Log Results For Soil Boring Samples

Soil Boring Sample ID	Property	Analyte	Detected Concentration (pCi/g)	Counting Error (+/- pCi/g)	Downhole Gamma logging ft (BGS)	CPM	ft (BGS)	CPM	ft (BGS)	CPM
C21	Sears	Gross α	172	17.9	0	42,158	3.5	28,370		
(2-4)		Gross β	68.6	6.4	0.5	102,768				
		Ra-226	7.9	1.1	1	208,788				
		Ra-228	14.4	2.7	1.5	335,944				
		Total Thorium	139JC	6.3	2	272,819				
		U-234	9.1JS	3.6	2.5	129,282				
		U-238	11.4JS	4.0	3	103,502				
C24	Sears	Gross α	307	23.6	0	30,263				
(2-4)		Gross β	124	8.0	0.5	42,081				
		Ra-226	1.4	0.5	1	70,349				
		Ra-228	40.5	3.3	1.5	115,893				
		Total Thorium	241JC	8.1	2	142,599				
		U-234	19.8JS	10.9	2.5	141,931				
		U-238	28.2JS	12.3						
C29	Sears	Gross α	46.0	10.1	0	24,983	3.5	106,179	7	17,973
(5-7)		Gross β	29.7	5.0	0.5	96,207	4	86,161	7.5	13,958
		Ra-226	17.6	1.6	1	247,454	4.5	64,001	8	13,858
		Ra-228	4.2	1.7	1.5	277,799	5	41,808	8.5	11,047
		Total Thorium	46.6JC	4.1	2	195,966	5.5	30,397	9	16,912
					2.5	137,003	6	27,140		
					3	117,092	6.5	22,155		
C37	DeSaussure	Gross α	123	15.4	0	24,979	2.5	25,267		
(0-2)		Gross β	52.5	5.9	0.5	36,955	3	15,216		
		Ra-226	6.8	1.0	1	37,201	3.5	10,933		
		Ra-228	10.9	2.7	1.5	48,943				
		Total Thorium	95.1JC	9.1	2	48,346				
C37D	DeSaussure	Gross α	100	14.0	0	24,979	3.5	10,933		
(0-2)		Gross β	43.7	5.6	0.5	36,955				
		Ra-226	6.2	1.0	1	37,201				
		Ra-228	9.1	2.7	1.5	48,943				
		Total Thorium	102JC	9.4	2	48,346				
		U-234	7.4JS	4.5	2.5	25,267				
		U-238	12.7JS	5.1	3	15,216				
C38	Stepan	Gross α	8310	121	0	17,970	4.5	467,389	9	712,899
(10-12)		Gross β	2970	35.2	0.5	25,778	5	455,484	9.5	740,007
		Ra-226	266JH	6.3	1	30,555	5.5	524,127	10	784,846
		Ra-228	283JH	6.8	1.5	36,808	6	591,631	10.5	820,900
		Total Thorium	3920JC	77.4	2	51,564	6.5	634,343	11	867,544
		U-234	31.8JH	3.4	2.5	86,938	7	599,712	11.5	815,200
		U-235	5.9JH	1.5	3	169,429	7.5	600,475	12	807,411
		U-238	61.9JH	4.8	3.5	319,922	8	631,803	12.5	396,356
					4	478,061	8.5	674,782		
C38	Stepan	Gross α	2300	63.5	0	17,970	4.5	467,389	9	712,899
(12-14)		Gross β	741	17.8	0.5	25,778	5	455,484	9.5	740,007
		Ra-226	122	4.3	1	30,555	5.5	524,127	10	784,846
		Ra-228	220	8.5	1.5	36,808	6	591,631	10.5	820,900
		Total Thorium	1300JC	31.6	2	51,564	6.5	634,343	11	867,544
		U-234	8.2	1.5	2.5	86,938	7	599,712	11.5	815,200
		U-238	23.8	2.5	3	169,429	7.5	600,475	12	807,411
					3.5	319,922	8	631,803	12.5	396,356
					4	478,061	8.5	674,782		

Table 4-10
Radiological Sample Results and Corresponding Gamma Log Results for Soil Boring Samples

Notes: cpm = Counts per minute
BGS = Below ground surface
D = Duplicate sample
J = Estimated value
C = Calibration criteria not met
S = Matrix spike recovery criteria not met
H = Holding time exceeded
Shading indicates interval sampled.
An Eberline Model PRS-1 or PRS-2 count rate meter was used with an Eberline Model BHP-2 probe to collect downhole gamma radiation measurements. The BHP-2 probe contained a 2 in. x 2 in. NaI scintillation crystal encased in a lead shield, and had a conversion efficiency of 1,115 cpm per 1 uR/hour (Ra-226).
The 30,000 cpm comparison criteria is conservatively based on site-specific correlation determined by DOE's previous investigation (BNI, 1987 c). DOE's 40,000 cpm criteria correlates to 15 pCi/g Th-232 -- assuming a SPA-3 probe is used for the gamma logging. Because the BHP-2 probe contains a lead shield, the BHP-2 results are assumed to be lower than DOE's unshielded SPA-3 results, for the same activity levels, and therefore 30,000 cpm is used.
The DOE 11,000-cpm(cone-shielded SPA-3)-to-5 pCi/g-Th-232 ratio cannot be used to compare BHP-2 data from the surface and @ 0.5 ft. (BGS) measurements.
Complete downhole gamma radiation logging results for other borings are contained on soil boring logs.

Gross alpha and gross beta radiation was detected in all 13 soil-boring samples analyzed for radiological parameters, at maximum concentrations of 8,310 ± 121 pCi/g for gross alpha and 2,970 ± 35.2 pCi/g for gross beta (C-38, 10 to 12 feet, Stepan).

Ra-226 and Ra-228 were detected in all 13 soil-boring samples, at maximum concentrations of approximately 266 ± 6.3 and 283 ± 8.8 pCi/g, respectively (C-38, 10 to 12 feet). Five of the 13 soil-boring samples contained Ra-226 at levels greater than the DOE comparison criterion of 5 pCi/g at two locations on the Sears property, and at one location each on Sunoco and Stepan (C38 contained two sampled intervals). Ra-228 was detected at concentrations above the 5 pCi/g comparison criteria in 6 of 13 soil samples taken from 3 locations on Sears and 1 location each on Stepan and Sunoco.

Total thorium (by alpha scintillation) was detected in all of the soil samples. The concentrations of total thorium detected ranged from approximately 29.2 ± 5.6 pCi/g (C-20; 6.5 to 8.5 feet, Stepan) to approximately 3,920 ± 77.4 pCi/g (C-38; 10 to 12 feet).

U-234 was detected in 10 of the 13 soil-boring samples, at a maximum concentration of approximately 31.8 ± 3.4 pCi/g (C-38, 10 to 12 feet). U-235 was detected in one soil sample at a concentration of approximately 5.9 ± 1.5 pCi/g (C-38, 10 to 12 feet). U-238 was detected in 9 of the 13 soil samples at a maximum concentration of approximately 61.9 ±4.8 pCi/g (C-38, 10 to 12 feet). Concentrations of U-234 plus U-238 were detected at estimated concentrations greater than the NRC comparison criterion (10 pCi/g for U-234 plus U-238) in 10 of 13 soil boring samples at 5 locations on the Sears property, 2 locations on Stepan, and 1 location each on DeSaussure and Sunoco.

All of the maximum concentrations of the radiological analytes were detected in soil samples collected from boring C-38—the approximate location of burial site No. 1. The soil-boring sample containing the overall greatest degree (total activity) of radiological contamination (excluding the C-38 boring) was the sample taken from the 2- to 4-foot interval at C-14 (Sears). This sample contained Ra-226, Ra-228, U-234, and U-238 at concentrations greater than the comparison criteria, and total thorium estimated at 595 ± 12.5 pCi/g.

Blue Material. The sample from BM-2 (0 to 1 foot, DeSaussure), collected from the blue material, contained Ra-228 and Th-230 at levels below the DOE cleanup criteria. The 1- to 3-foot sample from BM-3 (DeSaussure) contained Th-230 and U-234, also at levels below comparison criteria. Similar levels of Th-230 and U-234 were detected in the duplicate sample collected from the 1- to 3-foot interval at BM-3.

The 3- to 4-foot sample from BM-3 (DeSaussure) was collected from the interval immediately below the blue material. Gross alpha and gross beta radiation were detected at concentrations of 20 ± 11.6 pCi/g and 14.4 ± 6.9 pCi/g, respectively.

Both Ra-228 and Th-230 were detected in this sample at concentrations below DOE comparison criteria. U-234 and U-238 were detected at concentrations of 12.2 ± 0.9 and 9.9 ± 0.8 pCi/g, respectively. U-235 was estimated to be present in the sample at a concentration of 1.8 ± 0.4 pCi/g. U-234 and U-238 were detected in the sample at levels above the NRC comparison criterion of 10 pCi/g.

4.2.6 TOC

The following three soil-boring samples were analyzed for TOC: the sample taken from the 4- to 6-foot interval of C-24 (Sears), the sample from the 0- to 6-foot interval at C-26 (Federal Express), and the sample from the 8- to 10-foot interval at C-31 (DeSaussure). The TOC results are presented in Table 4-11. The TOC results were 2,220 ppm (C-24), 12,440 ppm (C-26), and 1,760 ppm (C-31).

4.2.7 X-Ray Diffraction Analysis of Blue-Material Sample

A sample of the blue material located on the DeSaussure property was sent for X-ray diffraction analysis to identify its composition. A potential source of the material is the former caffeine extraction operation conducted by Citro Chemical Company, which was acquired by Pfizer in 1947. At the time of acquisition, Citro's business consisted mainly of caffeine extraction from tea waste and citric acid manufacture. Gypsum, which was used as a filter aide in both processes, was reportedly disposed on-site. While there are discrepancies between the data submitted in Pfizer's Eckhardt survey response and the material submitted as part of the 104(e) response, as much as 600 tons of gypsum and lime may have been disposed of on the Maywood property. The sample was collected from the 0.5- to 2-foot interval and was designated BM-4 (see Figure 4-1 for sampling location). The results of the X-ray diffraction are presented in Appendix V. These results indicated that the material is composed of hydrous calcium sulfate ($CaSO_4 \cdot 2H_2O$) or, as it is commonly known, gypsum. Metals results from the other blue- material samples (from BM-1, BM-2, and BM-3) showed elevated concentrations of calcium (286,000 ppm).

When the blue material was evaporated on a hot plate, $CaSO_4 \cdot 0.5H_2O$ (bassinite) was formed, and the material turned white in color. The blue coloring of the gypsum could be caused by the presence of transitional elements present at the ppb or ppt level.

4.2.8 Source Delineation Under Focused Investigation

On the basis of overall RI results, the RI work plan was amended to include a Focused Investigation under which a soil gas investigation was conducted to determine if soils in the Central Tank Farm Area and in Aromatic and Essential Oils Manufacturing Area could be a source of groundwater contamination. A soil-boring program was conducted in summer 1993 to collect samples for TCL VOC and TCL

Table 4-11
TOC Analytical Results from Selected Soil Boring Samples

Boring No.	Depth (ft)	Property	TOC Concentration (ppm)
C24	(4-6)	Sears	2,220
C26	(0-6)	Federal Express	12,440
C31	(8-10)	DeSaussure	1,760

Note: TOC analysis was performed only on those soil boring locations where samples were also collected for geotechnical parameters.

semivolatile organics analysis in areas deemed contaminated on the basis of soil gas results. These samples were collected in order to confirm the soil gas results and to provide quantitative information on contaminant concentrations for use in the FS.

Soil Gas. Analytical results of the soil gas investigation are presented in detail in Appendix Z. The soil gas results are presented in tabular form. Figures in the appendix show the soil gas sampling locations and isoconcentration contours of the target compounds. Isoconcentration contours were not prepared for vinyl chloride, carbon dioxide, or oxygen because no concentrations above ambient air concentrations were detected.

An overview of the analytical results is provided in this section.

The highest concentrations of the target compounds (primarily BTEX compounds) in the Central Tank Farm Area were detected at sampling locations CT-18 and CT-21. The isoconcentration contours indicated that there elevated concentrations of VOCs in the subsurface between the Hot Oil Shed and the northern corner of Building No. 10. Isolated concentrations of methane and TVHC also were detected at location CT-6.

Elevated concentrations were detected between a building foundation to the north (the former aromatics building), an electric building to the south and the former location of toluene USTs to the west. A total targeted VOC isoconcentration map and associated landmarks is presented as Figure 12 in Appendix Z.

The presence of an unknown VOC was indicated in some borings but not positively identified or quantified. The VOC was tentatively identified as trichloroethane (TCE) and was detected at sampling locations AR-23, AR-24, AR-44, AR-45, AR-46, AR-47, CT-21, and CT-23 (Figure 1, Appendix Z).

A summary of the organic vapor readings collected during the soil gas investigation using a PID is presented in Table 4-12. Contours of total targeted VOCs in relation to RI and Focused Investigation sampling locations are shown on Figure 4-15.

Soil Borings

TCL VOCs. The results of the TCL VOC analyses of soil for the detected compounds are summarized in Table 4-13. The results show that the compounds detected were primarily the BTEX constituents benzene, toluene, ethylbenzene, and xylene. The results also show that only these compounds exceeded the NJDEPE soil cleanup criteria. The BTEX results and those exceeding the criteria for each soil boring are presented in Figure 4-16. Isoconcentration maps for benzene and xylene in unsaturated soils are presented as Figure 4-17 and Figure 4-18. Isoconcentration lines are estimated on the basis of available soil-analysis data and soil-gas results. The highest exceedance relative to the criteria occurred for total xylene at SG-5 in the

Table 4-12
Summary of Organic Vapor Readings During Soil Gas Investigation

Location No.	Date	Depth (Ft BGS)	OVM Results (ppm)	Remarks
Central Tank Farm Area				
CT-01	7/26/93	3	0.0	Boring located near trade water sewer line.
CT-01	7/26/93	6	27.0	Analyzed soil gas sample CT-01.
CT-02	7/26/93	3	0.0	Boring located near sanitary sewer line.
CT-02	7/26/93	6	4.1	Analyzed soil gas sample CT-02.
CT-03	7/26/93	3	0.0	Boring located near city water line.
CT-03	7/26/93	6	0.0	Analyzed soil gas sample CT-03 to assess impact of abandoned alcohol UST.
CT-04	7/27/93	3	OVM Down	
CT-04	7/27/93	6	OVM Down	Analyzed soil gas sample CT-04.
CT-05	7/27/93	3	0.2	Boring located near trade water sewer line.
CT-05	7/27/93	6	0.0	Inadvertently analyzed soil gas sample CT-05 at 6 feet BGS, although sample from 3-foot interval exhibited a higher organic vapor concentration.
CT-06	7/28/93	3	1.2	Boring located near trade water sewer line.
CT-06	7/28/93	6	10.7	Analyzed soil gas sample CT-06.
CT-07	7/27/93	3	4.9	Boring located near sanitary sewer line.
CT-07[a]	7/27/93	6	6.0	Analyzed soil gas sample CT-07.
CT-08	7/27/93	3	0.0	Boring located near city water line.
CT-08[a]	7/27/93	6	0.0	Analyzed soil gas sample CT-08 to assess impact of organic compounds detected in B38W04B.

Table 4-12
Summary of Organic Vapor Readings During Soil Gas Investigation

Location No.	Date	Depth (Ft BGS)	OVM Results (ppm)	Remarks
CT-09	7/27/93	3	0.0	
Central Tank Farm Area				
CT-09	7/27/93	6	0.0	Analyzed soil gas sample CT-09.
CT-10	7/29/93	3	0.0	Boring located near trade water sewer line.
CT-10	7/29/93	6	4.3	Analyzed soil gas sample CT-10.
CT-11	7/28/93	3	0.9	Boring located near alcohol UST.
CT-11	7/28/93	6	12.0	Analyzed soil gas sample CT-11.
CT-12[a]	7/27/93	3	2.0	Analyzed soil gas sample CT-12.
CT-12	7/27/93	6	2.2	Boring located near cooling tower.
CT-13	7/27/93	3	12.2	Boring located near Hot Oil Shed.
CT-13[a]	7/27/93	6	27.2	Analyzed soil gas sample CT-13.
CT-14	7/27/93	3	0.0	Boring located near former No. 2 fuel oil UST.
CT-14[a]	7/27/93	6	1.7	Analyzed soil gas sample CT-14.
CT-15	7/29/93	3	0.0	Boring located near trade water sewer.
CT-15	7/29/93	6	0.0	Analyzed soil gas sample CT-15.
CT-16	7/28/93	3	1.6	Boring located near railroad track.
CT-16	7/28/93	5	1.6	Refusal at 5 feet BGS. Analyzed soil gas sample CT-16.
CT-17	7/28/93	3	42.2	Boring located near sanitary sewer line and railroad tracks.
CT-17	7/28/93	5.5	8.1	Analyzed soil gas sample CT-17.

Table 4-12
Summary of Organic Vapor Readings During Soil Gas Investigation

Location No.	Date	Depth (Ft BGS)	OVM Results (ppm)	Remarks
CT-18	7/28/93	3	49.0	Boring located on railroad track near storm sewer.
CT-18	7/28/93	6	55.0	Analyzed soil gas sample CT-18.
CT-19	7/28/93	3	2.2	Boring located near railroad track. Analyzed soil gas sample CT-19.
CT-19	7/28/93	5	0.0	Refusal at 5 feet BGS.
CT-20	7/29/93	3	0.0	Boring located near railroad tracks.
CT-20	7/29/93	N/A	N/A	Encountered river water supply line. No soil gas sample analyzed from this boring location.
CT-21	8/5/93	3	199.9	Boring located near northeast corner of Building 10.
CT-21	8/5/93	5.5	235.8	Refusal at 5.5 foot BGS. Analyzed soil gas sample CT-21.
CT-22	8/5/93	3	77.4	Boring located near Building 10. Analyzed soil gas sample CT-22.
CT-22	8/5/93	5	45.0	Refusal at 5 feet BGS.
CT-23	8/6/93	3	0.0	Boring located near aboveground tank farm.
CT-23	8/6/93	4.5	4.8	Encountered water at 5 feet BGS. Analyzed soil gas sample CT-23.
Aromatics and Essential Oils Manufacturing Area				
AR-01	7/29/93	3	496.0	Boring located near OBMW2 and BRMW2.
AR-01	7/29/93	6	1,784.0	Analyzed soil gas sample AR-01.
AR-02	7/29/93	3	2.1	Boring located near foundation (former Aromatic Area). Analyzed soil gas sample AR-02.
AR-02	7/29/93	5.5	0.0	Refusal at 5.5 feet BGS.
AR-03	7/29/93	3	0.0	Boring located near foundation (former Aromatic Area)

Table 4-12
Summary of Organic Vapor Readings During Soil Gas Investigation

Location No.	Date	Depth (Ft BGS)	OVM Results (ppm)	Remarks
AR-03	7/29/93	5.5	1.0	Refusal at 5.5 feet BGS. Analyzed soil gas sample AR-3.
AR-04	7/29/93	3	0.0	Boring located near foundation (former Aromatic Area).
AR-04	7/29/93	6	14.2	Analyzed soil gas sample AR-04.
AR-05	7/29/93	3	1.0	Boring located near foundation (former Aromatic Area).
AR-05	7/29/93	5	1.0	Encountered water at 6 feet BGS. Analyzed soil gas sample AR-5.
AR-06	7/29/93	3	0.0	Boring located near foundation (former Aromatic Area).
AR-06	7/29/93	5	0.0	Analyzed soil gas sample AR-06.
AR-07	7/30/93	3	1.6	
AR-07	7/30/93	6	1.6	Analyzed soil gas sample AR-07.
AR-08	7/30/93	3	3.2	Boring located near foundation (former Aromatic Area).
AR-08	7/30/93	6	36.0	Analyzed soil gas sample AR-08.
AR-09	7/30/93	3	3.2	Boring located near foundation (former Aromatic Area).
AR-09	7/30/93	5.5	85.0	Refusal at 5.5 feet BGS. Analyzed soil gas sample AR-09.
AR-10	7/30/93	3	14.7	Boring located near foundation (former Aromatic Area).
AR-10	7/30/93	6	345.0	Analyzed soil gas sample AR-10.
AR-11	7/30/93	3	52.4	Boring located near foundation (former Aromatic Area) and sanitary sewer line.
AR-11	7/30/93	6	59.0	Analyzed soil gas sample AR-11.
AR-12	7/30/93	3	40.2	Boring located near foundation (former Aromatic Area).
AR-12	7/30/93	6	90.0	Analyzed soil gas sample AR-12.

Table 4-12
Summary of Organic Vapor Readings During Soil Gas Investigation

Location No.	Date	Depth (Ft BGS)	OVM Results (ppm)	Remarks
AR-13	7/30/93	3	8.1	
AR-13	7/30/93	6	13.4	Analyzed soil gas sample AR-13.
AR-14	7/30/93	3	4.9	
AR-14	7/30/93	6	4.9	Analyzed soil gas sample AR-14.
AR-15	7/30/93	3	0.0	
AR-15	7/30/93	6	0.0	Analyzed soil gas sample AR-15.
AR-16	7/30/93	3	3.2	
AR-16	7/30/93	6	3.2	Analyzed soil gas sample AR-16.
AR-17	7/30/93	3	1.2	
AR-17	7/30/93	6	4.9	Analyzed soil gas sample AR-17.
AR-18	7/30/93	3	3.2	
AR-18	7/30/93	6	6.5	Analyzed soil gas sample AR-18.
AR-19	7/30/93	3	1.2	Boring located near sanitary sewer line and trade water sewer line. Advanced boring to 3 feet BGS because of utilities. Analyzed soil gas sample AR-19.
AR-20	8/2/93	3	4.9	
AR-20	8/2/93	6	9.8	Analyzed soil gas sample AR-20.
AR-21	8/2/93	3	131.0	Boring located near trade water sewer line. Analyzed soil gas sample AR-21.
AR-21	8/2/93	6	113.0	
AR-22	8/2/93	3	24.5	Analyzed soil gas sample AR-22.

Table 4-12
Summary of Organic Vapor Readings During Soil Gas Investigation

Location No.	Date	Depth (Ft BGS)	OVM Results (ppm)	Remarks
AR-22	8/2/93	5.5	16.3	Refusal at 5.5 feet BGS.
AR-23	8/2/93	3	163.9	Boring located near sanitary sewer line. Analyzed soil gas sample AR-23.
AR-23	8/2/93	6	137.2	
AR-24	8/2/93	3	6.4	Analyzed soil gas sample AR-24.
AR-24	8/2/93	5	4.9	Water encountered at 6 feet BGS. Had to collect sample at 5 feet BGS.
AR-25	8/2/93	3	449.0	Boring located near sanitary sewer line. Soft material encountered at this location (possibly sludge). Analyzed soil gas sample AR-25.
AR-25	8/2/93	4	283.0	Soft material caused excessive vacuum. Had to collect sample from 4 feet BGS.
AR-26	8/2/93	3	252.3	Soft material encountered at this location (possibly sludge). Analyzed soil gas sample AR-26.
AR-26	8/2/93	4.5	57.0	Soft material caused excessive vacuum. Had to collect sample from 4.5 feet BGS.
AR-27	8/2/93	3	8.7	Boring located near trade water sewer line. Soft material encountered at this location (possibly sludge).
AR-27	8/2/93	5	83.0	Water encountered at 6 feet BGS. Had to collect sample at 5 feet BGS.
AR-28	8/2/93	3	4.5	Analyzed soil gas sample AR-28.
AR-28	8/2/93	6	3.3	
AR-29	8/3/93	3	0.0	Boring advanced through foundation (former Aromatic Area).
AR-29	8/3/93	6	6.4	Analyzed soil gas sample AR-29.

Table 4-12
Summary of Organic Vapor Readings During Soil Gas Investigation

Location No.	Date	Depth (Ft BGS)	OVM Results (ppm)	Remarks
AR-30	8/3/93	3	0.0	Boring advanced through foundation (former Aromatic Area).
AR-30	8/3/93	5.5	0.0	Refusal at 5.5 feet BGS. Analyzed soil gas sample AR-30.
AR-31	8/3/93	3	0.0	Boring advanced through foundation (former Aromatic Area).
AR-31	8/3/93	5.5	0.0	Refusal at 5.5 feet BGS. Analyzed soil gas sample AR-31.
AR-32	8/3/93	3	0.0	Boring advanced through foundation (former Aromatic Area).
AR-32	8/3/93	5	0.0	Refusal at 5.5 feet BGS. Analyzed soil gas sample AR-32.
AR-33	8/3/93	3	0.0	Boring located near foundation (former Aromatic Area).
AR-33	8/3/93	5.5	0.0	Refusal at 5.5 feet BGS. Analyzed soil gas sample AR-33.
AR-34	8/3/93	3	0.0	Boring located near trade water sewer line.
AR-34	8/3/93	6	0.0	Analyzed soil gas sample AR-34.
AR-35	8/3/93	3	0.0	Boring located near trade water sewer line.
AR-35	8/3/93	6	0.0	Analyzed soil gas sample AR-35.
AR-36	8/3/93	3	0.0	Boring located near sanitary sewer line.
AR-36	8/3/93	5	0.0	Refusal at 5 feet BGS. Analyzed soil gas sample AR-36.
AR-37	8/3/93	3	0.0	Boring located near sanitary sewer line.
AR-37	8/3/93	5	0.0	Refusal at 5.5 feet BGS. Analyzed soil gas sample AR-37.
AR-38	8/3/93	3	0.0	Boring located near sanitary sewer line.
AR-38	8/3/93	5	8.0	Water encountered at 6.0 feet BGS. Had to collect sample at 5 feet BGS. Analyzed soil gas sample AR-38.
AR-39	8/4/93	3	3.2	Boring located near sanitary sewer line.

Table 4-12
Summary of Organic Vapor Readings During Soil Gas Investigation

Location No.	Date	Depth (Ft BGS)	OVM Results (ppm)	Remarks
AR-39	8/4/93	6	16.1	Analyzed soil gas sample AR-39.
AR-40	8/4/93	3	0.0	Boring located near sanitary sewer line.
AR-40	8/4/93	5	24.0	Refusal at 5.5 feet BGS. Analyzed soil gas sample AR-40.
AR-41	8/4/93	3	0.0	Boring located near sanitary sewer line.
AR-41	8/4/93	5	0.0	Refusal at 5.5 feet BGS. Analyzed soil gas sample AR-41.
AR-42	8/5/93	3	4.8	Analyzed soil gas sample AR-42.
AR-42	8/5/93	5.5	0.0	Excessive vacuum at 6 feet BGS. Had to collect sample at 5.5 feet BGS.
AR-43	8/5/93	3	4.8	Analyzed soil gas sample AR-43.
AR-43	8/5/93	5	0.0	Refusal at 5 feet BGS.
AR-44	8/5/93	3	0.0	Boring located near sanitary sewer line.
AR-44	8/5/93	6	3.2	Analyzed soil gas sample AR-44.
AR-45	8/5/93	3	209.6	Analyzed soil gas sample AR-45.
AR-45	8/5/93	6	164.5	
AR-46	8/5/93	3	38.7	Boring located near storm sewer line.
AR-46	8/5/93	5.5	38.7	Refusal at 5.5 feet BGS. Analyzed soil gas sample AR-46.
AR-47	8/5/93	3	22.5	Analyzed soil gas sample AR-47.
AR-47	8/5/93	6	16.1	

Table 4-12
Summary of Organic Vapor Readings During Soil Gas Investigatio

Location No.	Date	Depth (Ft BGS)	OVM Results (ppm)	
AR-48	8/5/93	3	27.4	Analyzed soil gas sample A
AR-48	8/5/93	6	4.8	

*Soil gas sample was analyzed for naphthalene at these locations

NOTES:

Ft BGS: Feet Below Ground Surface
OVM: Organic Vapor Monitor, Model 580B, 10.0 ev. lamp

F:\PROJECTS\CAD\STEPAN\FIGURES\TRACER.DGN

BLDG No. 67

BLDG No. 4

BLDG No. 52

CONCRETE PAD

C-5

OBMW18

B38W04B

HOT OIL SHED

C-39

SG-13

SG-12A

SG-12B

SG-11

SG-10

SG-14

SG-17

10,000

1,000

100

10

TANK FARM

SG-18

SG-18A

SG-19

BLDG No. 10

BLDG No. 10H

B38W03B

SG-9

PT1DA/ PT1DB

PT1S

SG-4

SG-6

SG-8

SG-5

SG-7

SG-2

OBTW1

PT2DA/ PT2DB

PT2S

SG-15

BRMW2

BRTW1

C44

OBMW2

SG-1

SG-3

B38W06B

SG-16

C-42

ELECTRIC BLDG

OBMW19

HA-1

HA-2

HA-3

C-41

MISS-4A

MISS-4B

C-6

LEGEND

- PROPERTY LINE
- FENCE
- SOIL GAS ISOCONCENTRATION LINE (ug/L)
- SOIL BORING
- MONITORING WELL
- HAND AUGER SAMPLING LOCATION
- SOIL BORING (SG)
- PUMP TEST WELL AND PIEZOMETER

NOTES:

1. TOTAL TARGETED VOC'S INCLUDE TOTAL BTEX, VINYL CHLORIDE, AND DCE.

SCALE 1"=50'

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FIGURE 4-15
ISOCONCENTRATION MAP OF TOTAL TARGETED VOLATILE ORGANIC COMPOUNDS FROM SOIL GAS SURVEY

Table 4–13
Soil Boring VOC Results from Focused Investigation Compared to NJDEPE Soil Cleanup Criteria

Analyte	Residential Direct Contact Soil Cleanup Criteria (ppb) [a]	Impact to Groundwater Soil Cleanup Criteria (ppb) [a]	Total No. of Samples [b]	Detected Count [c]	Concentration Range (ppb) [d]	Location of Maximum Concentration	
						Boring No.	Depth (ft)
1,2–Dichloroethane	6,000	1,000	20	1	1J	SG–2	(3–5)
1,2–Dichloroethene (Total)	•	•	20	1	4J	SG–8	(3–5)
2–Butanone	1,000,000	50,000	17	1	150J	SG–19	(3–5)
2–Hexanone	––	––	20	1	87J	SG–12	(3–5)
4–Methyl–2–pentanone	1,000,000	50,000	20	1	24J	SG–7	(2–4)
Acetone	1,000,000	50,000	17	8	7J–24,000J	SG–15	(4–6)
Benzene	3,000	1,000	20	18	2J–280,000J	SG–15	(4–6)
Carbon disulfide	––	––	20	2	2J – 6J	SG–19	(3–5)
Ethylbenzene	1,000,000	100,000	20	7	2J–440,000	SG–5	(3–5)
Methylene chloride	49,000	10,000	20	2	1J – 15J	SG–6	(3–5)
Toluene	1,000,000	500,000	20	18	4J–790,000J	SG–5	(3–5)
Xylene (Total)	410,000	10,000	20	13	10J–5,100,000	SG–5	(3–5)

[a] NJDEPE Residential Direct Contact Soil Cleanup Criteria and Impact to Groundwater Soil Cleanup Criteria, *New Jersey Register*, February 3, 1992, as revised March 8, 1993.
[b] Only validated data have been presented. If data was determined to be unusable during data validation, the values were not included.
[c] Represents the number of samples in which a particular analyte was detected, including duplicates.
[d] Lowest and highest concentrations detected in all samples for this matrix.
• The residential direct contact soil cleanup criteria is 79,000 ppb for cis–1,2–dichloroethene and 1,000,000 ppb for trans–1,2–dichloroethene. The impact to ground water soil cleanup criteria for cis–1,2–dichloroethene and trans–1,2–dichloroethene is 50,000 ppb.

Notes:
J = Estimated value.
–– = Standard does not currently exist.

H:\PROJECTS\CAD\STEPAN\FIGURES\FIG4-16.DGN

SG-13

(5-7)
* BENZENE 12,000J
TOLUENE 130,000J
ETHYLBENZENE-ND
* XYLENE 130,000J

SG-12A
SG-12B

(3-5)
BENZENE 13J
TOLUENE 18J
ETHYLBENZENE-ND
XYLENE-ND

(3-5)
BENZENE 2J
TOLUENE 4J
ETHYLBENZENE 2J
XYLENE-ND

SG-10

SG-11

(4-6)
BENZENE-ND
TOLUENE-ND
ETHYLBENZENE-ND
XYLENE-ND

SG-14

BUILDING 10

(5-7)
BENZENE 21J
TOLUENE 110
ETHYLBENZENE 30J
XYLENE 70

SG-17

(3-5)
BENZENE 370J
TOLUENE 41J
ETHYLBENZENE-ND
XYLENE-ND

TANK FARM

SG-18
SG-18A
N/A

(3-5)
* BENZENE 20,000
TOLUENE 130J
ETHYLBENZENE-ND
XYLENE-ND

SG-19

(3-5)
BENZENE 2J
TOLUENE 1J
ETHYLBENZENE-ND
XYLENE-ND

SG-18

(2-4)
BENZENE 38
TOLUENE 4J
ETHYLBENZENE-ND
XYLENE-ND

SG-4

(4-6)
BENZENE 21
TOLUENE 4J
ETHYLBENZENE-ND
XYLENE 10J

SG-2

(3-5)
BENZENE 28
TOLUENE 11J
ETHYLBENZENE-ND
XYLENE 32

SG-9
(3.5-5.5)
BENZENE-ND
TOLUENE-ND
ETHYLBENZENE-ND
XYLENE 17

SG-6

(3-5)
BENZENE 160
TOLUENE 270
ETHYLBENZENE-ND
*XYLENE 31,000

SG-15

(4-6)
* BENZENE 280,000
TOLUENE 120,000
ETHYLBENZENE 4000
* XYLENE 48,000

SG-1

(6-8)
BENZENE 12J
TOLUENE 6J
ETHYLBENZENE 8J
XYLENE 12J

SG-8

(3-5)
BENZENE 150
TOLUENE 10J
ETHYLBENZENE-ND
* XYLENE 11,000

SG-5

SG-7

(2-4)
BENZENE 11J
TOLUENE 61J
ETHYLBENZENE 14
XYLENE 220

(3-5)
* BENZENE 100,000D
* TOLUENE 780,000D
* ETHYLBENZENE 440,000D
* XYLENE 5,100,000D

SG-3

(1.5-3)
BENZENE 40
TOLUENE 220
ETHYLBENZENE 45
XYLENE 510

HA-1
HA-2
HA-3

LEGEND:

- PROPERTY LINE
- FENCE
- HA-1 — HAND AUGER SAMPLING LOCATIONS
- SG-13 — SOIL BORING WHERE ANALYTE EXCEEDS NJDEPE SOIL CLEANUP CRITERIA
- SG-13 — SOIL BORING WHERE ANALYTE IS LESS THAN NJDEPE SOIL CLEANUP CRITERIA
- * — ANALYTE IS EQUAL TO OR EXCEEDS NJDEPE SOIL CLEANUP CRITERIA
- J — ESTIMATED VALUE
- ND — ANALYTE WAS NOT DETECTED AT THE DETECTION LIMIT USED FOR THE ANALYSIS
- D — RESULTS ARE FROM ANALYSIS OF THE DUPLICATE SAMPLE. DUPLICATE RESULTS ARE GREATER THAN SAMPLE RESULTS.
- R — DATA IS UNUSABLE
- (0-2) — DEPTH INTERVAL SAMPLED (FT.)
- N/A — NOT ANALYZED FOR VOC'S

NOTE

1. ALL CONCENTRATIONS ARE IN PPB.
2. SG REFERS TO SOIL BORINGS INSTALLED BASED ON THE SOIL GAS SURVEY.

0 50 100 150

SCALE 1"=50'

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FIGURE 4-16
BENZENE, TOLUENE, ETHYLBENZENE AND XYLENE IN SOILS (PPB)
SEPTEMBER 1993

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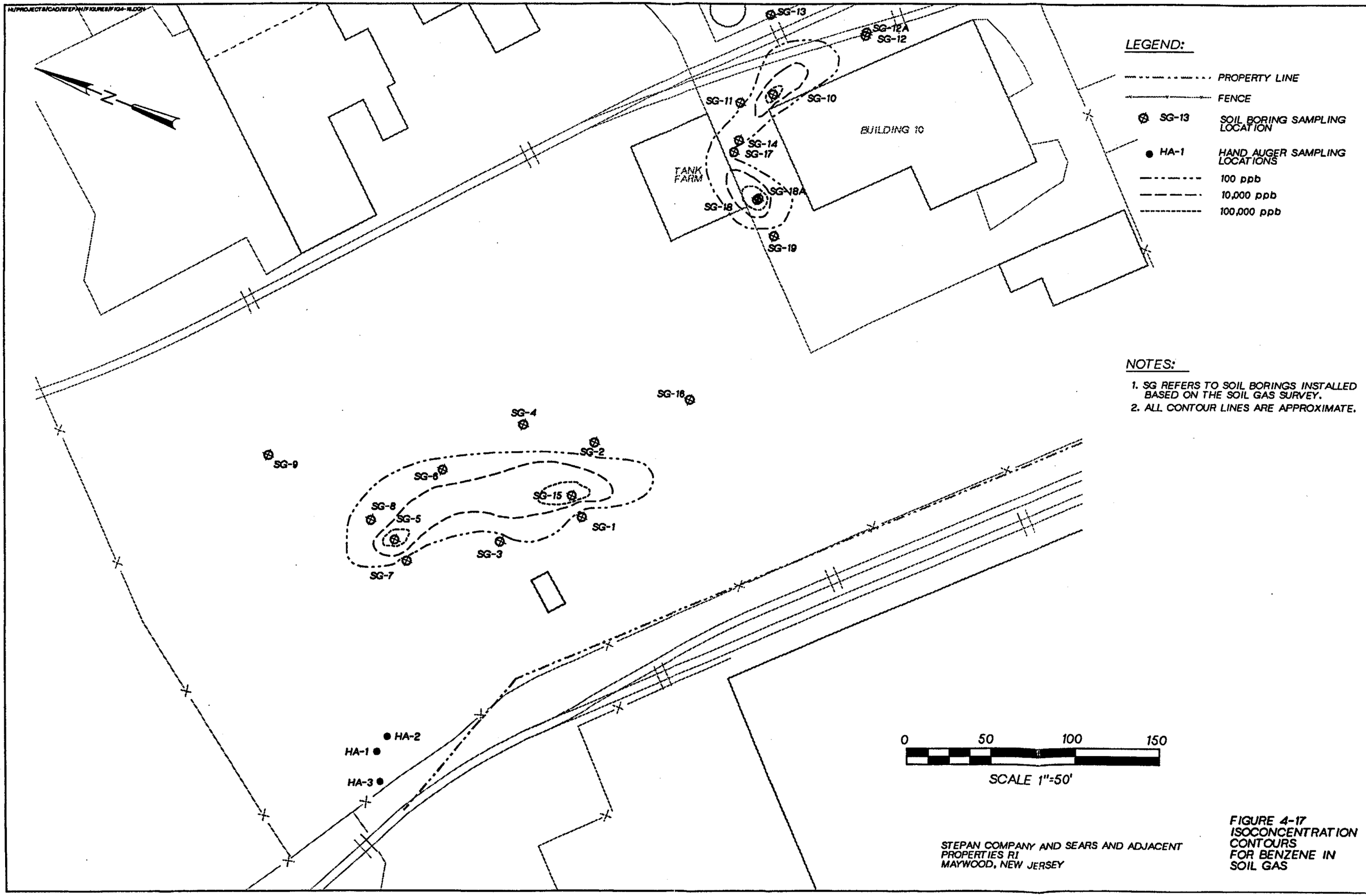

LEGEND:

- PROPERTY LINE
- FENCE
- SG-13 — SOIL BORING SAMPLING LOCATION
- HA-1 — HAND AUGER SAMPLING LOCATIONS
- 100 ppb
- 10,000 ppb
- 100,000 ppb

NOTES:

1. SG REFERS TO SOIL BORINGS INSTALLED BASED ON THE SOIL GAS SURVEY.
2. ALL CONTOUR LINES ARE APPROXIMATE.

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FIGURE 4-17
ISOCONCENTRATION CONTOURS FOR BENZENE IN SOIL GAS

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N

SG-13
SG-12A
SG-12
SG-11
SG-10
BUILDING 10
SG-14
SG-17
TANK FARM
SG-18A
SG-18
SG-19
SG-16
SG-4
SG-2
SG-9
SG-6
SG-15
SG-8
SG-5
SG-1
SG-3
SG-7
HA-2
HA-1
HA-3

LEGEND:

- PROPERTY LINE
- FENCE
- SG-13 SOIL BORING SAMPLING LOCATION
- HA-1 HAND AUGER SAMPLING LOCATIONS
- 100 ppb
- 10,000 ppb
- 100,000 ppb

NOTES:

1. SG REFERS TO SOIL BORINGS INSTALLED BASED ON THE SOIL GAS SURVEY.
2. ALL CONTOUR LINES ARE APPROXIMATE.

0 50 100 150

SCALE 1"=50'

STEPAN COMPANY AND SEARS AND ADJACENT PROPERTIES RI
MAYWOOD, NEW JERSEY

FIGURE 4-18
ISOCONCENTRATION CONTOURS FOR XYLENE IN SOIL GAS

Aromatic and Essential Oils Manufacturing Area. Other exceedances in this area occurred at SG-6, SG-8, and SG-15. Lower levels of BTEX compounds were detected at each of the seven other borings in the area. However, the levels are as much as four orders of magnitude lower than those in borings where exceedances occurred. This indicates that the contamination is delineated and confined to a limited area.

Field logs of borings indicated the presence of oily materials with petroleum-type odors. These samples may contain elevated levels of total petroleum hydrocarbons (TPH). Should this be the case, the inclusion of TPH as a target cleanup parameter will be considered at the time of remediation.

The location of the soil borings conducted during the Focused Investigation were based on the results of the soil gas survey. The soil gas survey detected trace amounts or did not detect compounds such as vinyl chloride. Soil samples collected from SG-5, SG-10, GS-15, and SG-18 contained very high concentrations of BTEX constituents. Because of the potentially high concentrations, these samples were diluted during analysis to the extent that the detection limits are extremely high. Highly volatile compounds such as vinyl chloride may be masked in this situation, however, given the soil gas data from points performed in the same area which indicated only trace amounts of vinyl chloride, it is unlikely that this is occurring.

In the Central Tank Farm Area, the two borings with exceedances of the cleanup criteria are SG-10 and SG-18. SG-19 did not have concentrations of BTEX compounds exceeding the criteria but, it did have relatively high PID readings and a "strong petroleum odor" was noted during the boring. Lower levels of BTEX compounds were detected in six of the seven other borings in this area. However, the levels of BTEX compounds in the other borings are four to five orders of magnitude lower. This indicates that the area of contamination in the Central Tank Farm Area is sharply delineated and confined to a limited area.

A summary of the PID measurements taken during the soil boring program is presented in Table 2-16.

TCL Semivolatile Organic Analyses. The detected results for the three borings selected for semivolatile organics analysis–SG-5 and SG-18A are summarized in Table 4-14. No results exceeded the NJDEPE soil-cleanup criteria. There was one exceedance of the criteria –at SG-18A–for residential direct contact. However, the result of 89,000 ppb is of the same order of magnitude as the standard. In addition, the standard is intended to be applied to the top 2 feet of soil; the sample at SG-18A was collected from the 3- to 5-foot interval. The limited nature of contamination indicates that there are no significant concentrations of semivolatile organics coincident with the BTEX contamination at SG-5, G-18A, and SG-19.

Table 4-14
Soil Boring Semivolatile Organic Results from Focused Investigation Compared to NJDEPE Soil Cleanup Criteria

Analyte	Residential Direct Contact Soil Cleanup Criteria (ppb) [a]	Impact to Groundwater Soil Cleanup Criteria (ppb) [a]	Total No. of Samples [b]	Detected Count [c]	Concentration (ppb)	Location of Detection	
						Boring No.	Depth (ft.)
Bis (2-ethylhexyl) phthalate	49,000	100,000	3	1	89,000	SG-18A	(3-5.5)
Di-n-butyl phthalate	5,700,000	100,000	3	1	5,300 J	SG-5	(3-5)
Diethyl Phthalate	10,000,000	50,000	3	1	5,500 J	SG-5	(3-5)
2-Methylnaphthalene	--	--	3	1	3,700 J	SG-18A	(3-5.5)
Isophorone	1,100,000	10,000	3	1	7,100 J	SG-18A	(3-5.5)
Phenanthrene	--	--	3	1	6,400 J	SG-5	(3-5)

[a] NJDEPE Residential Direct Contact Soil Cleanup Criteria and Impact to Groundwater Soil Cleanup Criteria, *New Jersey Register*, February 3, 1992, as revised March 8, 1993.
[b] Only validated data have been presented. If data was determined to be unusable during data validation, the values were not included.
[c] Represents the number of samples in which a particular analyte was detected, including duplicates.

Notes:
J = Estimated value.
-- = Standard does not currently exist.

The three hand-auger borings in the vicinity of C-41, HA-1, HA-2, and HA-3—showed no results exceeding the NJDEPE impact-to-groundwater soil-cleanup criteria or the residential direct-contact criteria. The contamination at C-41 appears to be confined to the shallow soil (0 to 2 feet) in that vicinity.

4.3 Test Pits

Of the 129 test pits excavated, 19 (1 on Stepan, 2 on Stepan amended, 2 on DeSaussure, and 14 on Sears) were found to contain crushed drums or drum remains with no contents. Figures showing all of the test-pit locations are in Appendix E. An additional 16 test pits on Sears were identified as containing drums with contents. The locations where drums were encountered are shown on Figure 4-19 and summarized in Table 4-15. Approximately 60 drums and possibly 1 tank were visually observed in the excavated test pits.

The test program was conducted primarily to determine the cause of the magnetic anomalies delineated during the surface geophysics program. A wide variety of materials, including scrap metal, reinforced concrete foundations or platforms, drums, and various types of organic materials, were observed during the program. The scrap metal included sections of poles and pipes.

The drums encountered during the test-pit program were in a number of different conditions. Many were crushed and/or rusted through in areas. Several drums were partially crushed and rusty, however, they also had some material inside them. Several drums were found to be upright and in good condition with some contents. The contents of some of the drums appeared to be groundwater or stormwater that had percolated through the soil and into a drum. Other drums contained organic material as described below.

The materials observed in drums or in soils associated with drums exhibited a variety of physical characteristics. To classify the materials encountered, test-pit locations containing three distinct types of materials were categorized into three groups: A, B, and C. Group A contained golden-brown, caramel-like, resin-like materials. Group B contained a black, oil-like viscous material. Group C contained black-green, peaty, soil-like material. In instances where multiple drums were encountered in a test pit, the test pit was assigned to a group according to the readily-observable drum contents or associated soils. Each drum in any given test pit was not individually investigated to determine its contents, nor was every drum containing physically similar material sampled. Table 4-16 summarizes the test pits categorized into Groups A, B, and C, and identifies the test pits where samples were collected.

In several instances, materials appeared in test pits with and without drums that had physical characteristics other than those observed in Groups A, B, and C. These materials included white, silty-cream material; hard, tan-colored, chalky material; and purple-black, soil-like material. White, silty-creamy material was identified in the test-pit walls in TP-32 (Stepan amended) and TP-91 (Sears). The hard, tan-colored,

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N

STEPAN

STEPAN AMENDED

SEARS

SEARS

DESAUSSUIZE

AMP

SUNOCO

GULF

SWS

FEDERAL EXPRESS

TP-25 (4)
TP-29 (1)
TP-21 (1)
TP-111 (1)
TP-112 (1)
TP-113 (1)
TP-76 (1)
TP-80 (1)
TP-33 (2)
TP-34 (3)
TP-78 (3)
TP-86 (3)
TP-84 (6)
TP-77 (1)
TP-85 (1 or 2)
TP-104 (4)
TP-101 (1)
TP-102 (1)
TP-79 (1)
TP-103 (1)
TP-83 (1)
TP-106 (2)
TP-107 (1)
TP-87 (3-4 DRUMS or 1 TANK)
TP-115 (1)
TP-99 (1)
TP-92 (3)
TP-88 (2)
TP-89 (2)
TP-96 (1)
TP-94 (1)
TP-119 (2)
TP-95 (1)
TP-91 (2)
TP-121 (3)

LEGEND

- PROPERTY LINE
- FENCE LINE
- TP-25 — TEST PIT LOCATIONS WHERE DRUMS WERE OBSERVED WITH NO CONTENTS
- TP-25 — TEST PIT LOCATIONS WHERE DRUMS WERE OBSERVED WITH CONTENTS
- TP-25 (4) — ESTIMATED NUMBER OF DRUMS OBSERVED IN TEST PITS
- S — SAMPLE COLLECTED

NOTES:

1. ESTIMATED NUMBER OF OBSERVED DRUMS MAY NOT BE REPRESENTATIVE OF TOTAL NUMBER OF DRUMS BASED ON AREAL EXTENT OF MAGNETIC ANOMALIES.
2. FOR TEST PITS TP-87 AND TP-88, TWO SAMPLES WERE COLLECTED FROM DIFFERENT LOCATIONS WITHIN EACH TEST PIT.

0 200 400 600

SCALE 1"=200'

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FIGURE 4-19
OBSERVED DRUM LOCATIONS

Table 4–15
Number of Test–Pit Locations with Drums

Property [a]	No. of Test Pits with Drums (No Contents)	No. of Test Pits with Drums (With Contents)	Estimated Number of Drums Observed [b]
Stepan	1	0	1
Stepan Amended	2	0	5
DeSaussure	2	0	5
Sunoco	0	0	0
AMP	0	0	0
Federal Express	0	0	0
SWS	0	0	0
Sears	14	16	50 [c]
TOTAL	19	16	61

[a] Test–pits were excavated on all properties within the study area except the Gulf property.
[b] The total number of drums is an estimate of what was observed in the test–pit excavations.
[c] This estimate includes approximately 49 drums and possibly 1 tank.

Table 4-16
GROUPING OF DRUM CONTENTS ON SEARS PROPERTY

Test Pit Number	Sample Collected [a]	Remarks
Group A: Golden brown, caramel-like, resin-like material		
TP-79	S	Hard, Caramel-colored resin from within folds of drum; some soil included in sample.
TP-83		Medium brown-black sandy silt, associated with remains of drum
TP-84	S	Very viscous, caramel-colored resin from within crushed drum
TP-101		Very viscous, caramel-colored resin from within crushed drum
TP-102		Hard, Caramel-colored resin associated with drum
TP-104 [b]		Very viscous, caramel-colored resin from within crushed drum
TP-106	S	Very viscous, caramel-colored resin from within crushed drum
TP-121		**Medium brown to dark grey and white lecked fine sand and silt.**
Group B: Black, oil-like viscous material		
TP-78		0.5 ft-3.5 ft Dark brown sandy silt. White clay-like material.
TP-87	S	Very viscous, black oil-like material from within drum or tank
TP-92		2-5 ft. Dark brown-black sandy silt. Beige colored layer at 3 ft.
TP-104 [b]		Very viscous, black oil-like material from within drum or tank
TP-119	S	Soils impacted by black, oil-like substance associated with crushed drum
TP-121		**Medium brown to dark grey and white lecked fine sand and silt.**
Group C: Green, peaty, soil-like material		
TP-76	S	Black-green colored soils from within folds of crushed drum
TP-85	S	Black-green colored soils associated with crushed drum
TP-101		**Very viscous, caramel-colored resin from within crushed drum (log says similar to TP-84)**

[a] An S indicates that a sample was collected. A blank indicates that a sample was not collected.
[b] Two sets of drums were found in this excavation. Group A drums were found at 1-2 ft. on east side of test pit. Group B drums were found at 2-3 ft. on the west and southwest side of test pit.

chalky material was observed in TP-23 (Stepan amended) and was similar to the material found in a drum in TP-107 (Sears). Samples TP-88-1 and TP-88-2, collected from two separate drums in the same test pit, both contained purple-black, soil-like material. Table 2 in Appendix E summarizes the information regarding the test pit samples collected, which includes the physical description and whether the samples were collected from within drums, from soils associated with drums, or from soils in test pits not associated with drums.

Twenty test-pit samples, plus 3 duplicate samples, were collected from 18 test pits and analyzed for the TCL and TCLP parameters listed in Table 2-2.

Test-pit sample locations are shown on Figure 4-20; complete analytical results are presented in Appendix W. Tables and figures summarizing and identifying key analytical results are presented in this section.

Analytical results were evaluated to characterize materials in the test pits sampled. Detected concentrations of compounds were compared to the NJDEPE residential direct-contact soil-cleanup criteria and NJDEPE impact-to-groundwater soil-cleanup criteria (depending upon sample depth, as described in Section 4.1). The TCLP analytical testing results were compared to EPA limits in 40 CFR 261.

The analytical results for the test-pit samples were also reviewed with respect to test-pit grouping to determine whether similar compounds were detected in materials exhibiting similar physical characteristics.

4.3.1 TCL Volatile Organics

TCL VOCs were detected in 21 of 23 test pit samples. Table 4-17 provides a summary of all TCL VOCs detected, the frequency and range of concentrations at which they were detected, and the location of the maximum concentration for each compound.

The TCL VOCs most frequently detected were acetone (14 samples), benzene (12 samples), toluene (13 samples), and xylene (11 samples). Most test-pit samples contained between one and five targeted VOCs. TP-106 (Sears) contained the greatest number of TCL VOCs, with a total of 26 detected. TP-106 (Sears) was also the location of the maximum concentration for every detected analyte, with the exceptions of 2-butanone, for which TP-22 (Stepan amended) had the maximum concentration, and acetone, for which the TP-79 duplicate (Sears) had the maximum concentration.

Figure 4-21 presents the total TCL VOC concentration detected in each test-pit sample. The test-pit sample containing the highest total VOC concentration (19,920,000 ppb) was TP-106 (Sears). Other test-pit samples containing high total VOC concentrations, which ranged from 27,670 ppb to 318,000 ppb, were also located

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N

BURIAL SITE 2

BURIAL SITE 1

BURIAL SITE 3

TP-22

TP-23

TP-25

TP-32

TP-76

TP-80

TP-42

TP-84

TP-85

TP-79

TP-106

TP-107

TP-57

TP-88-1

TP-87-1B

TP-88-2

TP-87-1

TP-119

TP-89

TP-91

LEGEND

PROPERTY LINE

FENCE LINE

TP-42 TEST PIT SAMPLE LOCATION AND NUMBER

RADIOACTIVE WASTE BURIAL AREAS

EXISTING UNDERGROUND STORAGE TANK LOCATION

FORMER UNDERGROUND STORAGE TANK LOCATION

0 200 400 600

SCALE 1"=200'

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FIGURE 4-20
RI TEST PIT LOCATIONS

Table 4-17
Summary of TCL VOC Analytical Results for Test Pit Samples

Analyte	Residential Direct Contact Soil Cleanup Criteria (ppb) [a]	Impact to Groundwater Soil Cleanup Criteria (ppb) [a]	Total No. of Samples [b]	Detected Count [c]	Concentration Range (ppb) [d]	Location of Maximum Concentration		
						Property	Test Pit No.	Depth (ft)
1,1,1-Trichloroethane	210,000	50,000	23	2	320J - 760,000	Sears	TP-106	2.0
1,1,2-Trichloroethane	22,000	1,000	23	1	530,000J	Sears	TP-106	2.0
1,1-Dichloroethane	570,000	1,000	23	1	550,000J	Sears	TP-106	2.0
1,1-Dichloroethene	8,000	10,000	23	2	330J - 740,000	Sears	TP-106	2.0
1,2-Dichloroethane	6,000	1,000	23	1	360,000J	Sears	TP-106	2.0
1,2-Dichloroethene (Total)	*	50,000	23	2	440J - 1,100,000	Sears	TP-106	2.0
1,2-Dichloropropane	10,000	---	23	1	540,000J	Sears	TP-106	2.0
2-Butanone	---	50,000	3	2	110 - 190J	Stepan	TP-22	2.0
4-Methyl-2-Pentanone	1,000,000	50,000	23	2	11J - 530,000J	Sears	TP-106	2.0
Acetone	1,000,000	50,000	23	14	71J - 30,000	Sears	TP-79D	1.0
Benzene	3,000	1,000	23	12	11J - 1,100,000	Sears	TP-106	2.0
Bromodichloromethane	5,000	1,000	23	1	400,000J	Sears	TP-106	2.0
Bromoform	86,000	1,000	23	1	390,000J	Sears	TP-106	2.0
Bromomethane	79,000	1,000	23	1	390,000J	Sears	TP-106	2.0
Carbon disulfide	---	---	23	3	19J - 560,000J	Sears	TP-106	2.0
Carbon tetrachloride	2,000	1,000	23	2	330J - 900,000	Sears	TP-106	2.0
Chlorobenzene	37,000	1,000	23	1	620,000J	Sears	TP-106	2.0
Chloroform	19,000	1,000	23	4	35J - 550,000J	Sears	TP-106	2.0
Cis-1,3-Dichloropropene	4,000	1,000	23	1	190,000J	Sears	TP-106	2.0
Dibromochloromethane	5,000	1,000	23	1	340,000J	Sears	TP-106	2.0
Ethylbenzene	1,000,000	100,000	23	7	58 - 960,000	Sears	TP-106	2.0
Methylene chloride	49,000	10,000	23	3	39 - 670,000	Sears	TP-106	2.0
Styrene	23,000	100,000	23	3	230J - 550,000J	Sears	TP-106	2.0
Tetrachloroethene	4,000	1,000	23	2	350J - 850,000	Sears	TP-106	2.0
Toluene	1,000,000	500,000	23	13	8J - 860,000	Sears	TP-106	2.0
Trans-1,3-Dichloropropene	4,000	1,000	23	1	710,000	Sears	TP-106	2.0
Trichloroethene	23,000	1,000	23	1	770,000	Sears	TP-106	2.0
Xylene (Total)	410,000	1,000	23	11	300J - 4,000,000	Sears	TP-106	2.0

[a] NJDEPE Residential Direct Contact Soil Cleanup Criteria and Impact to Groundwater Soil Cleanup Criteria, *New Jersey Register*, February 3, 1992, as revised March 8, 1993.

[b] Only validated data have been presented. If data were determined to be unusable during data validation, the values were not included.

[c] Represents the number of samples in which a particular analyte was detected.

[d] Lowest and highest concentrations detected in all samples for this matrix.

* The Residental Direct Contact Soil Cleanup Criteria for Cis-12-Dichloroethene is 79,000 ppb and for Trans-12,Dichloroethene is 1,000,000 ppb. The Impact to Groundwater Soil Cleanup Criteria is 50,000 ppb for each compound.

Notes:
J = Estimated value.
D = The maximum concentration was detected in a duplicate sample collected from the test pit. The concentration of acetone detected in the TP-79 sample was 9,200 ppb.

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N

LEGEND

PROPERTY LINE

FENCE LINE

TP-42 TEST PIT SAMPLE LOCATION

D RESULTS ARE FROM THE ANALYSIS OF THE DUPLICATE SAMPLE. DUPLICATE RESULTS ARE GREATER THAN SAMPLE RESULTS.

NOTE:
1. ALL CONCENTRATIONS PRESENTED ARE IN PPB.

TP-23 165

TP-22 4400 D

TP-25 ND

TP-32 71

TP-42 159

TP-76 4,550

TP-80 828

TP-84 318,000

TP-85 27,670

TP-79 37,880 D

TP-106 19,920,000

TP-107 71,590

TP-52 ND

TP-88-1 218

TP-88-2 16,390

TP-87-1B 12,650

TP-87-1 105,000

TP-119 1394

TP-89 338

TP-91 211

0 200 400 600

SCALE 1"=200'

STEPAN COMPANY AND SEARS AND ADJACENT PROPERTIES RI
MAYWOOD, NEW JERSEY

FIGURE 4-21
TOTAL VOLATILE ORGANICS IN TEST PITS (PPB)
MARCH - MAY 1992

on Sears (TP-87-1, TP-84, TP-107, TP-79, and TP-85). TP-84, TP-107, TP-79, TP-85, and TP-106 are located in the asphalt and grassy area on the southern portion of Sears.

The locations and concentrations of the TCL VOCs that were detected above the NJDEPE soil-cleanup criteria are shown in Figure 4-22. Benzene was detected at concentrations exceeding the NJDEPE residential direct-contact soil-cleanup criteria in four test pits on Sears (TP-106, TP-84, TP-85, and TP-87-1). TP-106, TP-84, and TP-87-1 were all sludge samples collected from within a drum. Sample TP-85 was a tar-like black soil associated with a crushed drum. The level of benzene detected in TP-106 was almost four orders of magnitude greater than the NJDEPE soil-cleanup criteria. The levels of benzene detected in the other three test pits were two orders of magnitude greater than the NJDEPE soil-cleanup criteria. Twenty TCL VOCs, including benzene, were detected in TP-106 at concentrations above the NJDEPE soil-cleanup criteria.

Field monitoring for volatile organic emissions during the test-pit program was done with an OVA and OVM. Continuous readings were taken in the test pit and the breathing zone. Of the four test-pits with TCL VOCs above the criteria, only TP-106 at 30 ppm had readings in the breathing zone. All four test pits had readings ranging from 200 ppm in TP-106 to greater than 1,088 ppm in TP-84.

4.3.2 TCL Semivolatile Organics

For purposes of discussion semivolatiles are classified into PAHs and non-PAHs. Semivolatile analyses included analyses for the indicators a-pinene, d-limonene, and caffeine. Table 4-18 provides a summary of PAHs detected, the frequency and range of concentrations at which they were detected, and the location of the maximum concentration for each compound. Table 4-19 provides the same information for non-PAHs, a-pinene, d-limonene, and caffeine.

PAHs. PAHs were detected in 10 samples in 9 test pits, including test pits on the Stepan amended property, Sears, AMP, and DeSaussure. Figure 4-23 shows the total PAH concentration detected in each test pit. A shallow soil sample (0.6 feet) associated with a crushed drum in TP-25 (Stepan amended) had the highest number of TCL semivolatile compounds detected (17), as well as the highest total concentration of PAHs (8,898 ppb). Other test pits contained total PAH concentrations ranging from 506 ppb to 5,044 ppb. The most frequently detected PAHs included phenanthrene, fluoranthene, chrysene, and benzo(b)fluoranthene (detected in seven samples each), and pyrene and benzo(a)anthracene (detected in six samples each).

Benzo(b)fluoranthene was the only PAH detected above NJDEPE soil-cleanup criteria. It was detected only in the sample from TP-25 (Stepan amended) at a concentration exceeding the NJDEPE soil-cleanup criteria.

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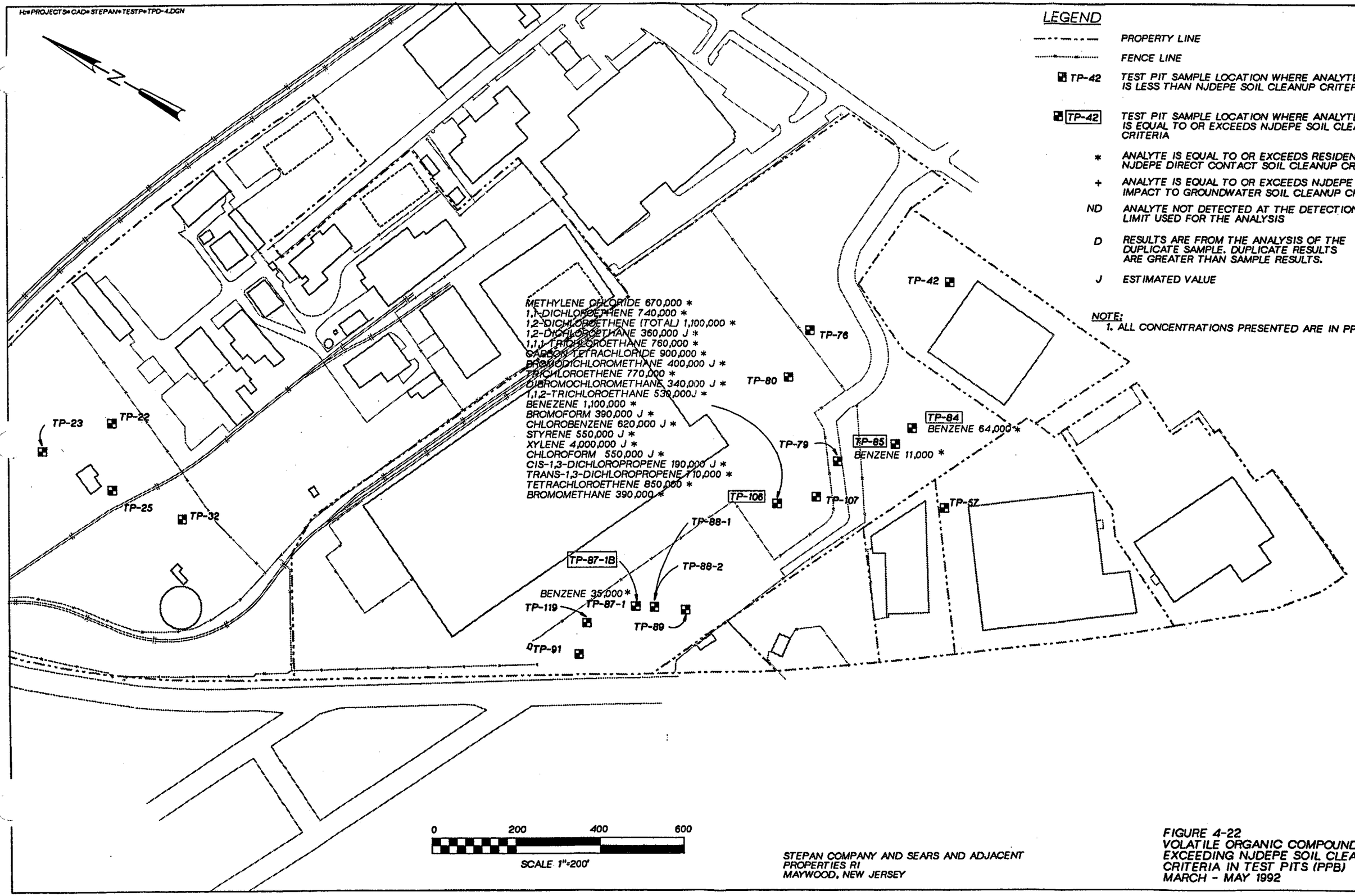

LEGEND

- PROPERTY LINE
- FENCE LINE
- TP-42 — TEST PIT SAMPLE LOCATION WHERE ANALYTE IS LESS THAN NJDEPE SOIL CLEANUP CRITERIA
- TP-42 — TEST PIT SAMPLE LOCATION WHERE ANALYTE IS EQUAL TO OR EXCEEDS NJDEPE SOIL CLEANUP CRITERIA
- * — ANALYTE IS EQUAL TO OR EXCEEDS RESIDENTIAL NJDEPE DIRECT CONTACT SOIL CLEANUP CRITERIA
- + — ANALYTE IS EQUAL TO OR EXCEEDS NJDEPE IMPACT TO GROUNDWATER SOIL CLEANUP CRITERIA
- ND — ANALYTE NOT DETECTED AT THE DETECTION LIMIT USED FOR THE ANALYSIS
- D — RESULTS ARE FROM THE ANALYSIS OF THE DUPLICATE SAMPLE. DUPLICATE RESULTS ARE GREATER THAN SAMPLE RESULTS.
- J — ESTIMATED VALUE

NOTE:
1. ALL CONCENTRATIONS PRESENTED ARE IN PPB.

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FIGURE 4-22
VOLATILE ORGANIC COMPOUNDS EXCEEDING NJDEPE SOIL CLEANUP CRITERIA IN TEST PITS (PPB)
MARCH - MAY 1992

Table 4–18
Summary of Semivolatile Organics (PAH) Analytical Results for Test–Pit Samples

Analyte	Residential Direct Contact Soil Cleanup Criteria (ppb) [a]	Impact to Groundwater Soil Cleanup Criteria (ppb) [a]	Total No. of Samples [b]	Detected Count [c]	Concentration Range (ppb) [d]	Location of Maximum Concentration		
						Property	Test Pit No.	Depth (ft)
Acenaphthene	3,400,000	100,000	23	1	59J	Stepan	TP–25	0.6
Acenaphthylene	--	--	23	1	78J	Stepan	TP–25	0.6
Anthracene	10,000,000	500,000	23	3	60J – 150J	Stepan	TP–25	0.6
Benzo(b&k)fluoranthene	--	--	3	3	360J –680	Sears	TP–91	3.0
Benzo(a)anthracene	900	500,000	23	7	68J – 630J	Stepan	TP–25	0.6
Benzo(a)pyrene	660	100,000	23	7	130J – 650J	Stepan	TP–25	0.6
Benzo(b)fluoranthene	900	500,000	20	5	70J – 1,300J	Stepan	TP–25	0.6
Benzo(g,h,i)perylene	--	500,000	23	4	89J – 330J	Stepan	TP–25	0.6
Chrysene	900	500,000	23	8	82J – 860J	Stepan	TP–25	0.6
Dibenzo(a,h)anthracene	660	500,000	23	1	120J	Stepan	TP–25	0.6
Fluoranthene	2,300,000	500,000	23	8	130J –1,700J	Stepan	TP–25	0.6
Fluorene	2,300,000	100,000	23	2	82J – 104J	Sears	TP–91	3.0
Indeno(1,2,3–c,d)pyrene	900	500,000	23	5	84J – 460J	Stepan	TP–25	0.6
2–Methylnaphthalene	--	--	23	1	830J – 1,300J	Sears	TP–88–1	1.0
Naphthalene	230,000	100,000	23	4	79J – 330	Sears	TP–88–1	1.0
Phenanthrene	--	--	23	8	78J – 1,100J	Stepan	TP–25	0.6
Pyrene	1,700,000	500,000	23	7	64J – 1,300J	Stepan	TP–25	0.6

[a] NJDEPE Residential Direct Contact Soil Cleanup Criteria and Impact to Groundwater Soil Cleanup Criteria, *New Jersey Register*, February 3, 1992, as revised March 8, 1993.
[b] Only validated data have been presented. If data were determined to be unusable during data validation, the values were not included.
[c] Represents the number of samples in which a particular analyte was detected.
[d] Lowest and highest concentrations detected in all samples for this matrix.

Notes: J = Estimated value.
--- = Cleanup criteria does not currently exist.

Table 4-19
Summary of Semivolatile Organics (Non-PAHs) Analytical Results for Test-Pit Samples

Analyte	Residential Direct Contact Soil Cleanup Criteria (ppb) [a]	Impact to Groundwater Soil Cleanup Criteria (ppb) [a]	Total No. of Samples [b]	Detected Count [c]	Concentration Range (ppb) [d]	Location of Maximum Concentration		
						Property	Test Pit No.	Depth (ft.)
1,2-Dichlorobenzene	5,100,000	50,000	23	1	140J	Sears	TP-88-1	1.0
2-Methylnaphthalene	--	--	23	2	830J-1,300J	Sears	TP-88-1	1.0
4,6-Dinitro-2-methylphenol	--	--	22	1	710J	Stepan	TP-22	2.0
4-Methylphenol	2,800,000	--	21	5	67J - 1,070J	Sears	TP-88-2	2.0
Benzoic Acid	--	--	23	1	960,000	Sears	TP-76	1.0
Bis(2-ethylhexyl)phthalate	49,000	100,000	23	5	80J - 900J	AMP	TP-57	2.0
Caffeine	--	--	23	8	79J - 6,000	Desaussure	TP-42	1.0
Di-n-butyl phthalate	5,700,000	100,000	23	2	77J - 83J	Sears	TP-80D	2.0
Dibenzofuran	--	--	23	1	83J	Stepan	TP-25	0.6
Isophorone	1,100,000	10,000	23	1	47J	AMP	TP-57	2.0
Nitrobenzene	28,000	50,000	23	1	95J	Stepan	TP-32	3.0
Pentachlorophenol	6,000	100,000	23	3	220J -52,000	Stepan	TP-22D	2.0
Phenol	10,000,000	50,000	22	2	60J - 4,900J	Stepan	TP-22	2.0
a-Pinene	--	--	23	1	160J	Sears	TP-107	3.0
d-Limonene	--	--	23	2	160J - 14,000J	Sears	TP-106	2.0

[a] NJDEPE Residential Direct Contact Soil Cleaup Criteria and Impact to Groundwater Soil Cleanup Criteria, *New Jersey Register*, February 3, 1992, as revised March 8, 1993.
[b] Only validated data have been presented. If data were determined to be unusable during data validation, the values were not included.
[c] Represents the number of samples in which a particular analyte was detected.
[d] Lowest and highest concentrations detected in all samples for this matrix.

Notes: J = Estimated value.
D = The maximum concentration was detected in a duplicate sample collected from the test pit.
--- = Cleanup criteria does not currently exist.

H:\PROJECTS\CAD\STEPAN\TESTP\FIG4-22.DGN

N

LEGEND

- PROPERTY LINE
- FENCE LINE
- TP-42 TEST PIT SAMPLE LOCATION
- D RESULTS ARE FROM THE ANALYSIS OF THE DUPLICATE SAMPLE. DUPLICATE RESULTS ARE GREATER THAN SAMPLE RESULTS.
- PAH POLYAROMATIC HYDROCARBON
- NON-PAH NON-POLYAROMATIC HYDROCARBON

NOTE:
1. ALL CONCENTRATIONS PRESENTED ARE IN PPB.

TP-23

TP-22
NON-PAH 52,610

TP-25
PAH 8898
NON-PAH 163

TP-32
PAH 1343
NON-PAH 95

TP-42
PAH 506
NON-PAH 6120
CAFFEINE 6000

TP-76
NON-PAH 960,000

TP-80
PAH 2656 D
NON-PAH 1549 D
CAFFEINE 1300 D

TP-84

TP-85

TP-79
NON-PAH 4800
CAFFEINE 4800 J

TP-106
NON-PAH 14,000
d-LIMONENE 14,000 J

TP-57
PAH 1299
NON-PAH 1007

TP-88-1
PAH 1630
NON-PAH 140

TP-87-1B

TP-88-2
PAH 1020
NON-PAH 6230
d-LIMONENE 160 J

TP-107
NON-PAH 3060
CAFFEINE 2900 J
a-PINENE 160 J

TP-119

TP-87-1

TP-89
PAH 1800
NON-PAH 419
CAFFEINE 79 J

TP-91
PAH 5044
NON-PAH 480
CAFFEINE 480 J

0 200 400 600

SCALE 1"=200'

STEPAN COMPANY AND SEARS AND ADJACENT PROPERTIES RI
MAYWOOD, NEW JERSEY

FIGURE 4-23
TOTAL SEMIVOLATILE ORGANICS (PAHs), (NON-PAHs), AND CAFFEINE, a-PINENE AND d-LIMONENE IN TEST PITS (PPB)
MARCH - MAY 1992

Samples in which PAHs were detected were either soils associated with drums or test-pit materials not associated with drums. PAHs were not detected in drum contents. PAHs were not detected in any of the six test pits on Sears containing the highest concentrations of VOCs.

Non-PAHs. Non-PAHs were detected in 17 of the 23 test-pit samples (Stepan amended, Sears, AMP, and DeSaussure). Figure 4-23 presents the total non-PAH concentrations detected in each test pit. The non-PAHs most frequently detected were 4-methylphenol (5 detections), and bis(2-ethylhexyl)phthalate (5 detections). TP-76 (Sears) contained the highest total concentration of non-PAHs, which was benzoic acid at a concentration of 960,000 ppb. TP-22 (Stepan amended) also contained a high total concentration of non-PAHs (52,610 ppb). Non-PAHs were not detected in any test pit at concentrations exceeding the NJDEPE soil-cleanup criteria.

Caffeine, d-Limonene, and a-Pinene. As part of the semivolatile analyses, test pit samples were analyzed for caffeine, d-limonene, and a-pinene. Figure 4-23 shows the locations and concentrations at which these were detected. A-pinene was detected in only one sample, from TP-107 (Sears), at 160 ppb. D-limonene was detected in two drum samples, from TP-106 (Sears) and TP-88-2 (Sears), with the maximum concentration of 14,000 detected in TP-106. Caffeine was detected in eight samples from six test pits (five test pits on Sears and one on DeSaussure). The highest concentrations of caffeine were detected in TP-42 (6,000 ppb; DeSaussure) and TP-107 (4,800 ppb; Sears).

4.3.3 TCL Pesticides and PCBs

TCL PCBs were not detected in any test-pit samples. TCL pesticides were detected in only 2 of the 20 test pits. 4,4'-DDE was detected at a concentration below the NJDEPE soil-cleanup criteria in a sludge sample collected from within the drum in TP-22 (Stepan amended) (Table 4-20). In TP-76, 4,4'-DDE and 4,4'-DDD were detected at concentrations exceeding the NJDEPE soil-cleanup criteria. The TP-76 sample was collected from the southeastern portion of Sears, in the marsh area.

4.3.4 TAL Metals and Cyanide

Inorganic compounds were detected in every test pit sample collected. Table 4-21 provides a summary of all inorganics detected, the frequency and range of concentrations at which they were detected, and the location of the maximum concentration for each compound. Over 75 percent of test-pit samples contained a minimum of 16 of the 24 targeted inorganic analytes. Barium, calcium, copper, iron, lead, sodium, and zinc were detected in all 23 test-pit samples.

Table 4–20
Summary of Pesticide and PCB Analytical Results for Test–Pit Samples

Analyte	Residential Direct Contact Soil Cleanup Criteria (ppb) [a]	Impact to Groundwater Soil Cleanup Criteria (ppb) [a]	Total No. of Samples [a]	Detected Count [b]	Concentration Range (ppb) [c]	Location of Maximum Concentration		
						Property	Test Pit No.	Depth (ft)
4,4'–DDD	3,000	~~100,000~~ 50,000	23	1	37,000J	Sears	TP–76	1.0
4,4'–DDE	2,000	100,000 50,000	23	2	216J – 4,300J	Sears	TP–76	1.0

[a] NJDEPE Residential Direct Contact Soil Cleanup Criteria and Impact to Groundwater Soil Cleanup Criteria, *New Jersey Register*, February 3, 1992, as revised March 8, 1993.
[b] Only validated data have been presented. If data were determined to be unusable during data validation, the values were not included.
[c] Represents the number of samples in which a particular analyte was detected.
[d] Lowest and highest concentrations detected in all samples for this matrix.

Note: J = Estimated value.

Table 4-21
Summary of Inorganic Analytical Results for Test-Pit Samples

Analyte	Residential Direct Contact Soil Cleanup Criteria (ppm) [a]	Impact to Groundwater Soil Cleanup Criteria (ppm) [a]	Total No. of Samples [b]	Detected Count [c]	Concentration Range (ppm) [d]	Location of Maximum Concentration		
						Property	Test Pit No.	Depth (ft)
Aluminum	--	--	23	21	79.4 - 47,000J	Stepan	TP-23	3.5
Antimony	14	--	23	8	2.8J - 16.6J	Sears	TP-119	3.0 - 4.0
Arsenic	20	--	23	21	0.98J - 306J	Sears	TP-88-2	2.0
Barium	700	--	20	20	0.61J - 198J	DeSaussure	TP-42	1.0
Beryllium	1	--	20	4	1.4 - 7.3	Stepan	TP-23	3.5
Cadmium	1	--	23	13	1.2J - 10J	Stepan	TP-32	3.0
Calcium	--	--	23	23	282J - 265,000	Stepan	TP-32	3.0
Chromium	500	--	23	19	3.2 - 53,800J	Stepan	TP-22D	2.0
Cobalt	--	--	23	11	3.5J - 7.3J	Sears	TP-88-2	2.0
Copper	600	--	21	21	20.3J - 3,800J	Sears	TP-88-1	1.0
Iron	--	--	23	23	146 - 69,100	Sears	TP-119	3.0 - 4.0
Lead	100 400	--	20	20	13.4J - 3,660	Sears	TP-84	2.0
Magnesium	--	--	23	22	28.7J - 4,250	AMP	TP-57	2.0
Manganese	--	--	23	22	2.1J - 697	Sears	TP-119	3.0 - 4.0
Mercury	14	--	23	20	0.07J - 28.7	Sears	TP-85	1.5
Nickel	230	--	23	20	5.2J - 88.4J	Sears	TP-119	3.0 - 4.0
Potassium	--	--	23	21	47.7J - 1,570J	Sears	TP-88-1	1.0
Selenium	63	--	23	6	0.52J - 2.9J	Sears	TP-107	3.0
Silver	110	--	23	6	0.31J - 1.2J	Sears	TP-89	1.0
Sodium	--	--	23	23	39.9J - 28,800J	Sears	TP-88-1	1.0
Thallium	2	--	23	12	0.29J - 1.2J	Sears	TP-80D	2.0
Vanadium	370	--	20	16	6.1J - 40.7J	Sears	TP-80D	2.0
Zinc	1,500	--	23	23	2.9J - 6,520J	Stepan	TP-32	3.0
Cyanide	1,100	--	23	9	3.4J - 452	Desaussure	TP-42	1.0

[a] NJDEPE Residential Direct Contact Soil Cleanup Criteria and Impact to Groundwater Soil Cleanup Criteria, *New Jersey Register*, February 3, 1992, as revised March 8, 1993.
[b] Only validated data have been presented. If data were determined to be unusable during data validation, the values were not included.
[c] Represents the number of samples in which a particular analyte was detected.
[d] Lowest and highest concentrations detected in all samples for this matrix.

Notes: J = Estimated value.
D = The maximum concentration was detected in a duplicate sample collected from the test pit.
--- = Cleanup criteria does not currently exist.

The following 9 TAL metals were detected at concentrations exceeding the NJDEPE residential direct-contact soil-cleanup criteria. The number in parentheses indicates the number of samples where the parameters exceeded the standards.

- Antimony (1)
- Arsenic (13)
- Beryllium (4)
- Cadmium (13)
- Chromium (5)
- Copper (4)
- Lead (11)
- Mercury (1)
- Zinc (2)

The distribution and concentrations of the four analytes detected the most frequently in excess of the NJDEPE residential direct-contact soil-cleanup criteria (arsenic, cadmium, chromium, and lead) are presented in Figure 4-24.

There are no NJDEPE impact-to-groundwater soil-cleanup criteria for metals; therefore, the NJDEPE direct-contact soil-cleanup criteria were used to evaluate the five subsurface test-pit samples (TP-23, TP-32, TP-91, TP-107, and TP-119).

4.3.5 TCLP Organics

Although several organic compounds were detected through TCLP testing, only two (nitrobenzene and benzene) were detected at concentrations exceeding the regulatory levels listed in 40 CFR 261.24. Nitrobenzene was detected in the purple-blue fibrous material found in TP-22 (Stepan amended) and its duplicate sample at concentrations of 2.6 ppm and 3.5 ppm, respectively, both exceeding the regulatory levels of 2.0 ppm. In the drum sample collected from TP-106 (Sears), benzene was detected at 5.9 ppm, exceeding the regulatory level of 0.5 ppm. The TCLP standards, range of detected concentrations, and the location of the maximum concentration of each contaminant detected by the TCLP analysis are shown in Table 4-22.

Nitrobenzene was detected above the TCLP limit; however, it was detected at an estimated value at the detection limit in the TCL analysis. Typically, one would expected to see actual concentrations in the TCL analysis if nitrobenzene was detected in the TCLP analysis. The difference in the results could be attributed to the heterogeneous composition of the soil.

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LEGEND

——·——·——	PROPERTY LINE
·····•·····	FENCE LINE
TP-42	TEST PIT SAMPLE LOCATION WHERE ANALYTE IS LESS THAN NJDEPE SOIL CLEANUP CRITERIA
TP-42	TEST PIT SAMPLE LOCATION WHERE ANALYTE IS EQUAL TO OR EXCEEDS NJDEPE SOIL CLEANUP CRITERIA
*	ANALYTE IS EQUAL TO OR EXCEEDS RESIDENTIAL NJDEPE DIRECT CONTACT SOIL CLEANUP CRITERIA
+	ANALYTE EXCEEDING NJDEPE IMPACT TO GROUNDWATER SOIL CLEANUP CRITERIA
ND	ANALYTE NOT DETECTED AT THE DETECTION LIMIT USED FOR THE ANALYSIS
D	RESULTS ARE FROM THE ANALYSIS OF THE DUPLICATE SAMPLE. DUPLICATE RESULTS ARE GREATER THAN SAMPLE RESULTS.
J	ESTIMATED VALUE
As	ARSENIC
Cd	CADMIUM
Cr	CHROMIUM
Pb	LEAD

NOTE:
1. ALL CONCENTRATIONS PRESENTED ARE IN PPB.
2. ONLY DETECTED, VALID DATA HAVE BEEN PRESENTED.

TP-23
As 20.1*
Cd 1.9 J*
Pb 293*

TP-22
Cr 53800 JD *
Pb 2300 JD

TP-25
Cd 1.2 J*
Cr 1220 *

TP-32
Cd 10 J*

TP-76

TP-80
As 20.7 JD*
Cd 1.6 J *
Cr 151 D

TP-79
As 21.4 *
Cd 1.5J *
Cr 125 D
Pb 290 D*

TP-85

TP-84
Cd 2.4 J*
Cr 524 *
Pb 3660*

TP-42
Pb 145*

TP-106
Pb 244*

TP-107
Pb 176

TP-88-1
As 171 J*
Cd 3.7 J*
Pb 247 J*

TP-88-2
As 306 J*
Cd 4.6 J*
Cr 249 J

TP-87-1B
Cd 3.4 J*
Cr 482 J
Pb 161 J*

TP-87-1

TP-119
As 54.5 *
Cd 4.9 J*
Cr 386 J

TP-89
Cd 4.3 J*
Cr 3760 *
Pb 399 *

TP-91
Cd 2.1 J*
Pb 150 *

TP-57
Cd 2.3 J*

0 200 400 600

SCALE 1"=200'

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FIGURE 4-24
ARSENIC, CADMIUM, CHROMIUM AND LEAD IN TEST PITS EXCEEDING NJDEPE SOIL CLEANUP CRITERIA (PPM)
MARCH - MAY 1992

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N

TP-22 (2)
GROSS ALPHA -14.1
GROSS BETA -18.2
RA-226 -4.2
Th-232 -[0.6]
U-234 -[1.0]

TP-23 (3.5)
RA-226 -1.7
Th-230 -[0.9]
Th-232 -[0.7]
U-234 -[0.6]
U-238 -1.1

TP-25 (0.6)
GROSS ALPHA -35.6
GROSS BETA -52.8
RA-226 -8.4
Th-228 -3.0
Th-230 -1.3
Th-232 -3.2
U-234 -2.3
U-235 -[0.3]
U-238 -1.3

TP-32 (3)
GROSS ALPHA -19.2
GROSS BETA -12.6
RA-226 -4.9
Th-228 -2.5
Th-230 -[0.5]
Th-232 -1.7
U-234 -[0.8]
U-235 -[0.3]
U-238 -1.8

GROSS ALPHA -88.3
GROSS BETA -47.9
RA-226 -15.6 *
Ra-228 -15.6 JDS *
Th-230 -0.9
Th-232 -5.0
U-234 -2.7 JD
U-235 -0.5 JD
U-238 -2.8 JD

TP-80 (2)
GROSS ALPHA -603
GROSS BETA -237
RA-226 -8.9
Ra-228 -12.2
Th-232 -23.3 *
U-234 -3.5 JC
U-235 -[1.2] JC
U-238 -5.5 JC
TOTAL-U -7.0

GROSS ALPHA -414
GROSS BETA -193
RA-226 -5.1
Ra-228 -11.1
Th-232 -18.7 *
TOTAL-U -2.3

TP-87-1B (1)
Th-232 -[0.3]

TP-87-1 (1)
GROSS ALPHA -15.9
GROSS BETA -20.2
RA-226 -5.5
Th-230 -0.7
Th-232 -2.2
U-234 -2.7 JD
U-235 -[0.3] JD
U-238 -1.1 JD

TP-119 (3-4)

TP-91 (3)
GROSS ALPHA -6240
GROSS BETA -2040
RA-226 -50.5 *
Th-228 -128JD *
Th-230 -159 *
Th-232 -213 *
U-234 -48.5 JC *
U-235 -[11.6] JCD
U-238 -40.5 JC *
TOTAL-U -96.7 *

GROSS ALPHA -[48.6]
GROSS BETA -[31.7]
RA-226 -[0.2]
Th-232 -0.5
U-235 -[1.1] JC

TP-76 (1)

Ra-226 -[0.3]
Th-230 -1.6

TP-106 (2)
RA-226 -0.8
U-235 -[0.7] JC

TP-88-1 (1)

TP-88-2 (2)

TP-89 (1)
GROSS ALPHA -[234]
GROSS BETA -170
RA-226 -4.2
Ra-228 -5.7
Th-232 -4.9
TOTAL-U -3.4

TP-42 (1)
GROSS ALPHA -44.6
GROSS BETA -13.8
Ra-226 -[0.4]
Th-232 -1.8
U-234 -[1.0]

GROSS ALPHA -134
GROSS BETA -76.1
RA-226 -0.9
Ra-228 -[1.2]
Th-232 -1.3

TP-84 (2)

TP-85 (1.5)

TP-79 (1)

TP-107 (3)
GROSS ALPHA -27.8
GROSS BETA -22.2
Ra-226 -9.0
Th-230 -0.8
Th-232 -2.8
U-234 -1.2
U-235 -[0.4]
U-238 -1.1

GROSS ALPHA -967
GROSS BETA -221
RA-226 -1.6
Ra-238 -2.6
Th-232 -1.3
TOTAL-U -1.0

GROSS ALPHA -356
GROSS BETA -166
RA-226 -4.4
Ra-228 -4.9
Th-232 -6.2
TOTAL-U-1.3

TP-57 (2)
GROSS ALPHA -13.9
GROSS BETA -23.4
Ra-226 -2.1
Th-232 -[0.7]
U-234 -[0.7]
U-238 -1.5

LEGEND

- PROPERTY LINE
- FENCE LINE
- TP-42 — TEST PIT SAMPLE LOCATION WHERE ANALYTES DID NOT EXCEED COMPARISON CRITERIA
- TP-42 — TEST PIT SAMPLE LOCATION WHERE ANALYTES EXCEEDS COMPARISON CRITERIA
- (2-4) — DEPTH INTERVAL SAMPLED (FT.)
- [ ] — VALUES FOR WHICH THE COUNTING ERROR IS EQUAL TO OR GREATER THAN 50 % OF THE DETECTED VALUE
- * — ANALYTE EXCEEDS COMPARISON CRITERIA
- C — CALIBRATION CRITERIA NOT MET
- D — DUPLICATE PRECISION NOT MET
- S — MATRIX SPIKE RECOVERY CRITERIA NOT MET

NOTES:

1. CONCENTRATIONS PRESENTED ARE IN UNITS OF pCi/g.
2. COMPARISON CRITERIA ARE BASED ON DOE ORDER 5400.5-GENERIC, SURFACE SOIL RESIDUAL CONTAMINANT CLEANUP GUIDELINES FOR Ra-226, Ra-228, Th-230, AND Th-232. COMPARISON CRITERIA FOR THE TOTAL OF U-234 PLUS U-238 ACTIVITY (10 pCi/g, ARE RECOMMENDED CRITERIA FROM NRC's BRANCH TECHNICAL POSITION (46FR 352061, OCTOBER 23,1981). DOE OR EPA HAVE NOT ESTABLISHED SITE-SPECIFIC CLEANUP GUIDELINES FOR URANIUM.

0 200 400 600

SCALE 1"=200'

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FIGURE 4-25
RADIOLOGICAL RESULTS IN TEST PITS

Table 4-22
Test Pit TCLP Data Compared to Federal and State Hazardous Waste Requirements

Analyte [a]	Federal/State Standard [b]	Concentration Range (ppb)	Location of Maximum Concentration	
			Property	Test Pit
1,2-Dichloroethane	500	130-22	Sears	TP-80D-01
2-Butanone (MEK)	200,000	50	Sears	TP-79-01
Benzene	500	10-5,900	Sears	TP-106-01
Tetrachloroethene	700	6-680	Stepan	TP-22-01
Trichloroethene	500	43-320	Sears	TP-84-01
Vinyl Chloride	200	130	Sears	TP-84-01
2,4,5-Trichlorophenol	400,000	110-130	Stepan	TP-22D-01
2,4,6-Trichlorophenol	2,000	24	Stepan	TP-22D-01
2-Methylphenol	NA	4-41	Sears	TP-76-01
4-Methylphenol	NA	2-9,100	Stepan	TP-22D-01
Nitrobenzene	2,000	2,600-3,500	Stepan	TP-22D-01
Pentachlorophenol	100,000	8-260	Stepan	TP-22-01
2,4-D	10,000	0.83-4.37	Stepan	TP-22-01
Silvex (2,4,5-TP)	1,000	0.84	Sears	TP-76-01
Arsenic	5,000	75-1,880	Sears	TP-88-01
Barium	100,000	9-5,120	Sears	TP-119-01
Cadmium	1,000	4-161	Stepan	TP-32-01
Chromium	5,000	8-12,000	Stepan	TP-22-01
Lead	5,000	234-752	DeSaussure	TP-42-01
Mercury	200	0.1-3.4	Stepan	TP-23-01
Selenium	1,000	128-1,470	Stepan	TP-22-01
Silver	5,000	7-64	Stepan	TP-22-01

[a] Only those analytes detected are listed.
[b] Standards shown are the maximum concentrations of contaminants, based on the toxicity characteristic, above which, the material is considered a hazardous substance.

Notes:
NA There is no available standard for this compound.

4.3.6 TCLP Inorganics

Although several inorganic compounds were detected through TCLP testing, only two compounds (chromium and selenium) were detected at concentrations exceeding the regulatory levels listed in 40 CFR 261.24. Both were detected at concentrations exceeding TCLP regulatory levels in the purple-blue fibrous material found in TP-22 (Stepan amended) and in its duplicate sample, which is also the location that failed TCLP for nitrobenzene. Chromium was detected at 12 ppm and 8.18 ppm, respectively, exceeding the regulatory level of 5 ppm. Selenium was detected at 1.47 ppm and 1.15 ppm, respectively, exceeding the regulatory level of 1 ppm.

4.3.7 Radiological Parameters

Test-pit sample results were compared to DOE generic cleanup guidelines and NRC branch technical position criteria for subsurface soils. Where appropriate, sample results that represent only drum contents (as opposed to drum contents with associated soils, or soils potentially impacted by drums) are noted. Comparison criteria for thorium and radium isotopes are 15 pCi/g (DOE generic cleanup guideline), and for total uranium (U-234 plus U-238) 10 pCi/g (NRC recommended guideline). No comparison criteria exist for gross alpha and gross beta radiation in soils; neither do comparison criteria exist for U-235 when present as natural (as opposed to enriched or depleted) uranium. Radiological results are summarized in Table 4-23 and Figure 4-25.

Gamma radiation was measured in test pits with an unshielded SPA-3 probe primarily for field monitoring purposes. A comparison criteria of 30,000 cpm used as an approximation of subsurface Th-232 contamination. Gamma radiation measurements from test pits were not compared to Th-232 analytical results because the samples often were not collected from soils and/or from the same depth interval from which the gamma measurements were obtained.

Although the gamma results were not intended for determining the extent of radiological contamination, the maximum observed readings may be used as an indication of the magnitude of radiological contamination present in each test pit. Maximum observed gamma radiation values from test pits are presented in the test pit technical memorandum and test pit logs (Appendix E).

The maximum SPA-3 readings observed in test pits on each property, without regard to depth, are as follows:

- Stepan–TP-9 — 350,000 cpm
- Stepan amended–TP-23 — 36,000 cpm
- DeSaussure–TP-33 — 300,000 cpm
- Sunoco–TP-50 — 740,000 cpm
- AMP–TP-54 — 13,000 cpm

Table 4-23
Summary of Radiological Sample Results for Test-Pit Samples

Analyte	Subsurface Soil Criteria (pCi/g)	Detected Minimum (pCi/g)	Detected Minimum Location	Detected Maximum (pCi/g)	Detected Maximum Location	Detected Frequency (detects/total)	Detected > Comparison Criteria (> criteria/total)
Gross α	NE	12.1	TP-22(D)	6,240	TP-91	16/20	NA
Gross β	NE	12.6	TP-32	2,040	TP-91	16/20	NA
Ra-226	15	[0.2]	TP-76	50.5	TP-91	19/20	2/20
Ra-228	15	[1.2]	TP-84	128JD	TP-91	10/20	2/20
Th-230	15	[0.5]	TP-32	159	TP-91	8/20	1/20
Th-232	15	[0.3]	TP-87	213	TP-91	18/20	3/20
U-234	10 [a]	[0.6]	TP-23	48.5JC	TP-91	11/20	1/20
U-235	NE	[0.3]	TP-25, 32, & 119	[11.6]JCD	TP-91	9/20	NA
U-238	10 [a]	1.1	TP-23, 107, & 119	40.5JC	TP-91	9/20	1/20
Total-U	NA	1.0	TP-88	96.7	TP-91	6/10 [b]	NA

[a] The 10 pCi/g limit applies to natural Uranium (total of U-234 and U-238), and is presented indiviually for illustrative purposes. No site-specific U-234 or U-238 cleanup guidelines have been established by DOE. The U-234 and U-238 criteria listed are recommended criteria from NRC's Branch Technical Position (46 FR 52061; October 23,1981).The of the criteria assumes natural uranium with all daughters in equilibrium and applies to the sum of U-234 and U-238. A typical (as opposed to site specific) calculated, DOE surface soil guideline for U-238 would be 75 pCi/g (BNI, 1987 c).

[b] Ten of the 20 samples were analyzed for total-U. Total-U data was used to back-calculate isotopic uranium results for those samples analyzed for total-U only -- assuming the presence of natural uranium (U-234, U-235, and U-238 in natural abundancies).

Notes: NE = None established
NA = Not applicable
(D) = duplicate sample
J = Estimated value
C = Calibration criteria no met
S = Matrix spike recovery criteria not met
D = Duplicate precision criteria not met
Values for which the counting error is equal to or greater than 50% of the detected value are noted in brackets (i.e., gross alpha was detected at a low concentration of 20.0 +/- 11.6 pCi/g).
DOE generic, subsurface soil residual contaminant cleanup guidelines are for concentrations averaged over a 15-cm layer, greater than 15 cm below the surface. The DOE Order 5400.5 guidelines apply only to radium and thorium, and are based on radium criteria specified in 40 CFR 192.
Frequencies do not include duplicate sample detects if analyte was detected in both original and duplicate sample.
Number of samples greater than comparison criteria does not include duplicate sample if analyte was detected in both original and duplicate samples.

N:\PROJECTS\CAD\STEPAN\MONWELL\MONLOC.DGN

N.Y. SUSQUEHANNA & WESTERN RAILROAD

WEST HUNTER AVENUE

MAYWOOD AVENUE

STATE ROUTE 17

GROVE AVENUE

BECKER AVENUE

B38W02D
BRMW15
OBMW15
BURIAL SITE 2
B38W05B
WELL 8
B38W01S
BURIAL SITE 1
WELL 6
OBMW17
BRMW17
BRMW16
WELL 5
OBMW6
BRMW6
B38W18D
OBMW16
B38W04B
BURIAL SITE 3
WELL 2
BRMW11
OBMW11
BRMW10
WELL 1
OBMW10
B38W12A
B38W12B
B38W06B
B38W03B
BRMW2
OBMW2
OBMW4
BRMW4
OBMW19
MISS-4A
MISS-4B
OBMW7
BRMW7
OBMW12
BRMW12
B38W07B
BRTW2
OBMW13
BRMW13
OBMW1
BRMW1
OBMW14
BRMW14
BRMW3
OBMW3
BRMW5
OBMW5
BRMW9
BRMW8
OBMW8

LEGEND:

- PROPERTY LINE
- FENCE
- MONITORING WELL
- EXISTING DRAINAGE CHANNEL
- FORMER DRAINAGE CHANNEL
- RADIOACTIVE WASTE BURIAL AREAS
- EXISTING UNDERGROUND STORAGE TANK LOCATION
- FORMER UNDERGROUND STORAGE TANK LOCATION

0 200 400 600

SCALE 1"=200'

STEPAN COMPANY AND SEARS AND ADJACENT PROPERTIES RI
MAYWOOD, NEW JERSEY

FIGURE 4-26
MONITORING WELL LOCATIONS
SAMPLED DURING RI

- Federal Express–TP-61 14,000 cpm
- SWS–TP-65 20,000 cpm
- Sears–TP-99 508,000 cpm

Gross alpha and gross beta were each detected in 16 of the 20 test-pit samples, at maximum concentrations of 6,240 ± 354 and 2,040 ± 105 pCi/g, respectively (TP-91; Sears). High gross alpha and gross beta activities could not be accounted for based on low radium, thorium, and uranium results in eight of the test-pit samples (TP-79, TP-79D, TP-84, TP-87B, TP-88 [2-foot interval], TP-89, and TP-91). A preliminary review did not indicate any problems with the radium, thorium, or uranium analyses of the eight samples. Gamma-spectroscopy will be conducted on the affected samples to determine the presence or absence of other gamma-emitting radionuclides, which may account for the high gross alpha and beta results. The results of these analyses will be forwarded to EPA when received from the laboratory.

Ra-226 was detected in 19 of the 20 test pit samples, at a maximum concentration of 50.5 ± 2.2 pCi/g (TP-91). Ra-228 was detected at a maximum concentration estimated at 128 ± 5 pCi/g (TP-91), and was also detected in nine other test pit samples. Ra-226 and Ra-228 were each detected above the DOE comparison criteria in two test-pit samples.

Th-230 was detected in 8 of the 20 test pit samples at a maximum concentration of 159 ± 46.6 pCi/g (TP-91). Th-232 was detected in 18 of the 20 test pit samples, at a maximum concentration of 213 ± 55.8 pCi/g (TP-91). Th-230 and Th-232 were each detected above the DOE comparison criteria in one and three test pit samples, respectively.

U-234 and U-238 were detected in 11 and 9 of the test pit samples, at maximum concentrations estimated to be 48.5 ± 12.1 and 40.5 ± 11.1 pCi/g, respectively (TP-91). U-234 plus U-238 were detected above the NRC comparison criteria of 10 pCi/g (U-234 plus U-238) in one of the test pit samples. U-235 was detected in 9 of the 20 test pit samples, at a maximum estimated concentration of 11.6 ± 5.9 (TP-91). Total-U was detected in six of the test pit samples, at a maximum concentration of 96.7 pCi/g (TP-91).

Test-pit samples TP-106, TP-84, TP-88(a), and TP-88(b) were drum contents only (samples collected from within drums not containing soils). The other test pit samples collected were either drum contents with associated soils, or potentially impacted soils. Radiological constituents were not detected above comparison criteria in the four test-pit samples consisting of only drum contents, while soil surrounding these drums exhibited elevated radiological readings.

4.3.8 Group Analysis

The analytical results for all samples within each group (A, B, and C) were compared with each other and with the results from the other two groups. The result of the

comparison was the conclusion that specific chemical constituents cannot be linked to specific physical characteristics, as described in Section 4.3.

Radiological results were not compared within or among the three groups, because the data were not considered to be representative of actual drum contents. They were not considered representative of actual contents because radiologically-contaminated soil may or may not have been included in the samples.

4.4 Groundwater

Two rounds of groundwater sampling (RI and Focused Investigation) were conducted at the Stepan Company and at Sears and adjacent properties, as discussed in Section 2.7. The objective of the RI groundwater sampling program was to quantify and characterize the vertical and horizontal extent of groundwater chemical contamination in the overburden and upper bedrock aquifers. The objectives of the Focused Investigation groundwater sampling program were to confirm the initial findings of the RI groundwater sampling, provide a comprehensive site-wide picture of groundwater contamination, and support the analysis of the fate and transport of contaminants in groundwater.

The locations of the 48 wells sampled during the RI are shown in Figure 4-26. The locations of the 51 wells sampled during the Focused Investigation (including wells OBMW18 and OBMW19 sampled October 1993, and well BRTW2 sampled November 1993, during pump test activities) are shown in Figure 4-27. Groundwater samples were analyzed for the parameters listed in Table 2-2. The results of the RI and Focused Investigation groundwater sample analyses were compared to the February 1, 1993, NJDEPE specific groundwater quality criteria--Class IIA--and to the April 1992 EPA drinking water regulations and health advisories. Figures 4-28 through 4-42 show concentrations of compounds compared with those specified in the NJDEPE groundwater quality criteria, which are the more stringent guidelines. Tables 4-24 to 4-29 present a comparison of maximum and minimum concentrations of analytes with both the NJDEPE and EPA standards.

The validated analytical data from the RI and Focused Investigation groundwater sampling programs are presented in Appendix X.

4.4.1 TCL VOCs

RI. Twenty-three TCL VOCs were detected in the groundwater samples collected during the RI. Of these VOCs, 12 were detected at concentrations exceeding the NJDEPE groundwater quality criteria: TCE; cis-1,2-DCE; trans-1,2-DCE; 1,2-DCA; vinyl chloride, benzene, toluene, ethyl benzene, methylene chloride, PCE, xylene (total), and 1,2-dichloropropane.

H:/PROJECTS/CAD/STEPAN/FIGURES/FIG4-28.DGN

N

LEGEND:

- PROPERTY LINE
- FENCE
- OBMW6 BRMW6 MONITORING WELL WHICH WERE SAMPLED
- EXISTING DRAINAGE CHANNEL
- FORMER DRAINAGE CHANNEL

N.Y. SUSQUEHANNA & WESTERN RAILROAD

WEST HUNTER AVENUE

MAYWOOD AVENUE

STATE ROUTE 17

GROVE AVENUE

BECKER AVENUE

B38W02D
BRMW15
OBMW15
B38W05B
WELL 8
B38W01S
BRMW16
WELL 5
OBMW17
BRMW17
MW1
B38W18D
OBMW18
B38W04B
WELL 2
OBMW6
BRMW6
BRMW11
OBMW11
BRMW10
WELL 1
OBMW10
B38W12A
B38W12B
B38W03B
BRMW2
B38W06B
OBMW2
OBMW19
OBMW4
BRMW4
MISS-4A
MISS-4B
OBMW7
BRMW7
OBMW12
BRMW12
B38W07B
BRTW2
BRMW13
OBMW13
OBMW1
BRMW1
OBMW14
BRMW14
BRMW3
OBMW3
BRMW5
OBMW5
BRMW9
BRMW8
OBMW8

0 200 400 600

SCALE 1"=200'

STEPAN COMPANY AND SEARS AND ADJACENT PROPERTIES RI
MAYWOOD, NEW JERSEY

FIGURE 4-27
MONITORING WELL LOCATIONS SAMPLED
DURING FOCUSED INVESTIGATION

H:\PROJECTS\CAD\STEPAN\MONWELL\MWD-10.DGN

N

N.Y. SUSQUEHANNA & WESTERN RAILROAD

HUNTER AVENUE

MAYWOOD AVENUE

STATE ROUTE 17

GROVE AVENUE

BECKER AVENUE

B38W02D ND

BRMW15 TT-DCA 0.2J PCE 0.3J

OBMW15 CHLOROFORM 0.6J

B38W05B CIS-1,2-DCE 0.2J CHLOROFORM 0.5J PCE 0.2J

WELL 8 ND

B38W01S ND

BRMW16 CHLOROFORM 0.2J

WELL 5 ND

OBMW17 CIS-1,2 - DCE 2 TCE 2* CHLOROFORM 0.2J PCE 0.4J*

BRMW17 PCE 1* CHLOROFORM 0.3J

OBMW6 ND

BRMW6 CHLOROFORM 0.6J

B38W18D ND

B38W04B CIS-1,2 - DCE 2900* VINYL CHLORIDE 2100*

WELL 2 ND

CIS-1,2 - DCE 11* TCE 1*

OBMW11

BRMW11 CIS-1,2 - DCE 8 1,1 -DCE 0.2 J TCE 3 * VINYL CHLORIDE 1 * PCE 0.8J *

WELL 1 ND

BRMW10 ND

OBMW10 CIS-1,2 - DCE 0.5 J

B38W03B METHYLENE CHLORIDE 15

BRMW2 CIS-1,2 - DCE 4 J

B38W06B ND

OBMW2 ND

CIS-1,2 - DCE 0.8 J TCE 0.8 J B38W12A

B38W12B CIS-1,2 - DCE 0.9 J TCE 4* PCE 0.3J

OBMW4 ND

BRMW4 CIS-1,2 - DCE 8 1,2 -DCA 0.4 J* TCE 3* PCE 0.3J

MISS-4A ND

MISS-4B CIS-1,2 - DCE 810 * VINYL CHLORIDE 520 *

OBMW7 ND

BRMW7 CIS-1,2 - DCE 1 TCE 1 * CHLOROFORM 0.7J PCE 0.8J

OBMW12 ND

BRMW12 CIS-1,2 - DCE 3 TRANS -1,2 -DCE 0.6 J TCE 2 *

B38W07B ND

OBMW13 ND

BRMW13 CIS-1,2 - DCE 0.7J 1,2 -DCA 0.2J TCE 0.4J PCE 2*

OBMW1 ND

BRMW1 VINYL CHLORIDE 1200*

OBMW14 ND

BRMW14 CIS-1,2 - DCE 21* 1,2 -DCA 1J* TCE 4* VINYL CHLORIDE 6* CHLOROFORM 0.6J PCE 0.9J*

BRMW3 CHLOROFORM 1 PCE 4*

OBMW3 ND

BRMW5 CIS-1,2 - DCE 0.4J CHLOROFORM 0.4J

OBMW5 ND

CHLOROFORM 0.3J CIS-1,2 - DCE 6 1,1 -DCA 0.3 J TCE 2*

CIS-1,2 - DCE 2 TCE 1 J *

BRMW9

BRMW8

OBMW8 CHLOROFORM 0.3J

0 200 400 600

SCALE 1"=200'

LEGEND:

- PROPERTY LINE
- FENCE
- OBMW1 — WELL LOCATION WHERE ANALYTE IS EQUAL TO OR EXCEEDS NJDEPE GROUNDWATER QUALITY CRITERIA
- OBMW1 — WELL LOCATION WHERE ANALYTE IS LESS THAN NJDEPE GROUNDWATER QUALITY CRITERIA
- * — ANALYTE IS EQUAL TO OR EXCEEDS NJDEPE GROUNDWATER QUALITY CRITERIA
- BRMW1 — WELL IS SCREENED IN BEDROCK
- OBMW1 — WELL IS PRIMARILY SCREENED IN OVERBURDEN
- J — ESTIMATED VALUE
- ND — ANALYTE WAS NOT DETECTED AT THE DETECTION LIMIT USED FOR THE ANALYSIS
- D — RESULTS ARE FROM ANALYSIS OF THE DUPLICATE SAMPLE. DUPLICATE RESULTS ARE GREATER THAN SAMPLE RESULTS.
- R — DATA IS UNUSABLE

NOTES:

1. ALL CONCENTRATIONS ARE IN PPB.
2. HIGHEST CONCENTRATION FROM DUPLICATE SAMPLES IS PRESENTED.

STEPAN COMPANY AND SEARS AND ADJACENT PROPERTIES RI
MAYWOOD, NEW JERSEY

FIGURE 4-28
TCE; 1,1-DCE; (CIS OR TRANS) 1,2-DCE; 1,1 - DCA; 1,2-DCA; VINYL CHLORIDE; PCE; CHLOROFORM AND METHYLENE CHLORIDE IN GROUNDWATER (PPB)
JULY - AUGUST 1992

H:*PROJECTS*CAD*STEPAN*MONWELL*MWD-9.DGN

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N.Y. SUSQUEHANNA, & WESTERN RAILROAD

HUNTER AVENUE

WEST

MAYWOOD AVENUE

STATE ROUTE 17

GROVE AVENUE

BECKER AVENUE

B38W02D ND

BRMW15 BENZENE 0.3J* ETHYLBENZENE 0.2J XYLENE (TOTAL) 0.9J

OBMW15 ND

B38W05B ND

BENZENE 2 * TOLUENE 0.2 J

B38W01S

WELL 8 ND

BRMW16 ND

WELL 5 ND

OBMW17 ND

BRMW17 ND

OBMW6 ND

BRMW6 ND

B38W10D ND

B38W04B BENZENE 560 J* ETHYLBENZENE 1100* TOLUENE 520 J XYLENE (TOTAL) 4900*

WELL 2 ND

BRMW11 ND

OBMW11 BENZENE 4*

BRMW10 ND

WELL 1 TOLUENE 0.05 J

OBMW10 ND

ND B38W12A

B38W12B BENZENE 0.2J*

B38W06B BENZENE 2 *

B38W03B ND

BRMW2 BENZENE 55*

OBMW2 BENZENE 33000*

OBMW4 XYLENE (TOTAL) 0.8 J

BRMW4 BENZENE 0.2J*

OBMW7 ND

BRMW7 ETHYLBENZENE 0.3J TOLUENE 0.3 J XYLENE (TOTAL) 2

OBMW12 ND

BRMW12 ND

MISS-4A ND

MISS-4B BENZENE 190 * TOLUENE 3 XYLENE (TOTAL) 1

B38W07B ND

OBMW13 ND

BRMW13 BENZENE 0.4J*

OBMW1 BENZENE 0.6J*

BRMW1 BENZENE 230

BRMW14

OBMW14 ND

BRMW3 ND

OBMW3

XYLENE (TOTAL) 3 BENZENE 0.2J*

BRMW5

OBMW5 BENZENE 2 * XYLENE (TOTAL) 2

BENZENE 610 * ETHYLBENZENE 740 * TOLUENE 1500 * XYLENE (TOTAL) 2800 *

BRMW8 BENZENE 1 * ETHYLBENZENE 3 TOLUENE 4 XYLENE (TOTAL) 16

OBMW8 TOLUENE 0.5 J XYLENE (TOTAL) 2

BRMW9 ND

0 200 400 600

SCALE 1"=200'

LEGEND:

- PROPERTY LINE
- FENCE
- OBMW1 — WELL LOCATION WHERE ANALYTE IS EQUAL TO OR EXCEEDS NJDEPE GROUNDWATER QUALITY CRITERIA
- OBMW1 — WELL LOCATION WHERE ANALYTE IS LESS THAN NJDEPE GROUNDWATER QUALITY CRITERIA
- * — ANALYTE IS EQUAL TO OR EXCEEDS NJDEPE GROUNDWATER QUALITY CRITERIA
- BRMW1 — WELL IS SCREENED IN BEDROCK
- OBMW1 — WELL IS PRIMARILY SCREENED IN OVERBURDEN
- J — ESTIMATED VALUE
- ND — ANALYTE WAS NOT DETECTED AT THE DETECTION LIMIT USED FOR THE ANALYSIS
- D — RESULTS ARE FROM ANALYSIS OF THE DUPLICATE SAMPLE. DUPLICATE RESULTS ARE GREATER THAN SAMPLE RESULTS.
- R — DATA IS UNUSABLE

NOTES:

1. ALL CONCENTRATIONS ARE IN PPB.
2. HIGHEST CONCENTRATION FROM DUPLICATE SAMPLES IS PRESENTED.

STEPAN COMPANY AND SEARS AND ADJACENT PROPERTIES RI
MAYWOOD, NEW JERSEY

FIGURE 4-29
BENZENE, TOLUENE, ETHYLBENZENE, AND XYLENE (TOTAL) IN GROUNDWATER (PPB)
JULY - AUGUST 1992

N:\PROJECT\STEPAN\CAD\STEPAN\FIGURES\F104-33.DGN

N.Y. SUSQUEHANNA & WESTERN RAILROAD

HUNTER AVENUE

WEST AVENUE

MAYWOOD AVENUE

STATE ROUTE 17

GROVE AVENUE

BECKER AVENUE

B38W02D ND

BRMW15 CHLOROFORM 3 PCE 0.2J

OBMW15 TCE 0.1J CHLOROFORM 0.5J PCE 0.1J

B38W01S ND

WELL 8 ND

B38W05B CHLOROFORM 0.4J PCE 0.2J

WELL 6 ND

OBMW17 *TCE 2 CIS-1,2-DCE 1 *PCE 0.4J

BRMW16 ND

WELL 5 ND

BRMW17 CHLOROFORM 0.2J *PCE 0.9J

MW-1 *METHYLENE CHLORIDE 130J

B38W18D ND

OBMW18 ND

B38W04B ND

WELL 2 ND

BRMW11 *TCE 2 CIS-1,2 DCE 7 *VINYL-CHLORIDE 0.9J *PCE 0.5J CHLOROFORM 0.2J

OBMW11 *TCE 1J *CIS-1,2 DCE 12 *VINYL-CHLORIDE 0.4J

WELL 1 ND

OBMW10 CIS-1,2 DCE 0.3J

BRMW10 ND

OBMW6 ND

BRMW6 CHLOROFORM 0.5J

B38W06B CIS-1,2-DCE 0.5J *VINYL CHLORIDE 0.2J

B38W03B ND

BRMW2 CIS-1,2-DCE 0.8J *VINYL CHLORIDE 1J

OBMW2 ND

OBMW16 ND

B38W12A TCE 0.5J CIS-1,2-DCE 0.5J

B38W12B *TCE 4 CIS-1,2-DCE 0.3J CHLOROFORM 1 PCE 0.4J

OBMW4 *TCE 520

BRMW4 *TCE 2 1,2-DCA 0.4J *VINYL-CHLORIDE 0.3J *PCE 0.3J

MISS-4A NA

MISS-4B *CIS-1,2-DCE 10 *VINYL CHLORIDE 20

OBMW7 ND

BRMW7 *TCE 3 CIS-1,2-DCE 3 *PCE 2 CHLOROFORM 0.2J

OBMW12 ND

BRMW12 CHLOROFORM 0.9J

METHYLENE CHLORIDE 0.6J *CIS-1,2 DCE 240 TRANS 1,2 DCE 0.9J 1,2 - DCA 9

B38W07B *TCE 3

BRTW2

OBMW1 ND

BRMW1 *CIS-1,2-DCE 1000 *VINYL CHLORIDE 1600

OBMW13 *VINYL-CHLORIDE 0.2J

BRMW13 TCE 0.4J CIS-1,2-DCE 0.5J *VINYL CHLORIDE 0.2J *PCE 3 CHLOROFORM 0.2J

*PCE 1 *TCE 4 *VINYL-CHLORIDE 4

OBMW14 ND

BRMW14

BRMW3

OBMW3 *TCE 460 *1,2-DCE 19J

TCE 0.2J CIS-1,2-DCE 0.1J *PCE 4 CHLOROFORM 0.2J

*PCE 0.9J TCE 0.4J CIS-1,2-DCE 0.3J

BRMW5

OBMW5 CIS-1,2-DCE 0.2J

BRMW9 CHLOROFORM 0.5J

BRMW8 *TCE 3 *VINYL CHLORIDE 0.4J 1,1-DCA 0.3J CIS-1,2-DCE 6

OBMW8 ND

0 200 400 600

SCALE 1"=200'

STEPAN COMPANY AND SEARS AND ADJACENT PROPERTIES RI
MAYWOOD, NEW JERSEY

LEGEND:

- PROPERTY LINE
- FENCE
- OBMW1 — WELL LOCATION WHERE ANALYTE IS EQUAL TO OR EXCEEDS NJDEPE GROUNDWATER CLEANUP STANDARD
- OBMW1 — WELL LOCATION WHERE ANALYTE IS LESS THAN NJDEPE GROUNDWATER CLEANUP STANDARD
- * — ANALYTE EXCEEDS PROPOSED NJDEPE GROUNDWATER CLEANUP STANDARDS
- BRMW1 — WELL IS SCREENED IN BEDROCK
- OBMW1 — WELL IS PRIMARILY SCREENED IN OVERBURDEN
- J — ESTIMATED VALUE
- ND — ANALYTE WAS NOT DETECTED AT THE DETECTION LIMIT USED FOR THE ANALYSIS
- D — RESULTS ARE FROM ANALYSIS OF THE DUPLICATE SAMPLE. DUPLICATE RESULTS ARE GREATER THAN SAMPLE RESULTS.
- R — DATA IS UNUSABLE
- NA — SAMPLE WAS NOT ANALYZED FOR THIS PARAMETER.

NOTE

1. ALL CONCENTRATIONS ARE IN PPB.

FIGURE 4-30
TCE; 1,1 - DCE; (CIS OR TRANS), 1,2 - DCE; 1,1 - DCA; 1,2 - DCA; VINYL CHLORIDE; PCE; CHLOROFORM; AND METHYLENE CHLORIDE IN GROUNDWATER (PPB)
JULY-AUGUST 1993

fig4-30c.dgn 25-JUL-1994 NJO/JMS 2

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N.Y. SUSQUEHANNA, & WESTERN RAILROAD

HUNTER AVENUE

WEST

MAYWOOD AVENUE

B38W02D ND

BRMW15 CHLOROFORM 3 PCE 0.2J

OBMW15 TCE 0.1J CHLOROFORM 0.5J PCE 0.1J

B38W01S ND

WELL 8 ND

B38W05B CHLOROFORM 0.4J PCE 0.2J

WELL 6 ND

OBMW17 *TCE 2 CIS-1,2-DCE 1 *PCE 0.4J

BRMW17 CHLOROFORM 0.2J *PCE 0.9J

BRMW16 ND

WELL 5 ND

MW-1 METHYLENE CHLORIDE 130J

B38W18D ND

OBMW18 ND

B38W04B XYLENE 5900 ETHYLBENZENE 1400 TOLUENE 320

WELL 2 ND

BRMW11 *TCE 2 *CIS-1,2 DCE 7 *VINYL-CHLORIDE .9 *PCE .5

OBMW11 *TCE 1J *CIS-1,2 DCE 12 *VINYL-CHLORIDE 0.4J

OBMW6 ND

BRMW6 CHLOROFORM 0.5J

WELL 1 ND

OBMW10 CIS-1,2 DCE 0.3J

BRMW10 ND

B38W06B CIS-1,2-DCE 0.5J *VINYL CHLORIDE 0.2J

B38W03B ND

BRMW2 CIS-1,2-DCE 0.8J *VINYL CHLORIDE 1J

OBMW2 ND

OBMW19 ND

MISS-4A NA

MISS-4B *CIS-1,2-DCE 10 *VINYL CHLORIDE 20

METHYLENE CHLORIDE 0.6J *CIS -1,2-DCE 240 TRANS - 1,2 DCE 0.9J 1,2 - DCA 9

BRTW2

B38W07B *TCE 3

OBMW1 ND

STATE ROUTE 17

BRMW1 *CIS-1,2-DCE 1000 *VINYL CHLORIDE 1800

OBMW14 ND

BRMW14

BRMW13 TCE 0.4J CIS-1,2-DCE 0.5J *VINYL CHLORIDE 0.2J *PCE 3 CHLOROFORM 0.2J

OBMW13 *VINYL-CHLORIDE 0.2J

*PCE 1 *TCE 4 *VINYL-CHLORIDE 4

BRMW3 TCE 0.2J CIS-1,2-DCE 0.1J *PCE 4 CHLOROFORM 0.2J

OBMW3 *TCE 460 *1,2-DCE 19J

*PCE 0.9J TCE 0.4J CIS-1,2-DCE 0.3J

BRMW5

OBMW5 CIS-1,2-DCE 0.2J

OBMW4 *TCE 520

BRMW4 *TCE 2 *1,2-DCA 0.4J *VINYL-CHLORIDE 0.3J *PCE 0.3J

B38W12A TCE 0.5J CIS-1,2-DCE 0.5J

B38W12B *TCE 4 CIS-1,2-DCE 0.3J CHLOROFORM 1 PCE 0.4J

OBMW7 ND

BRMW7 *TCE 3 CIS-1,2-DCE 3 *PCE 2 CHLOROFORM 0.2J

OBMW12 ND

BRMW12 CHLOROFORM 0.9J

BRMW9 CHLOROFORM 0.5J

BRMW8 *TCE 3 *VINYL CHLORIDE 0.4J 1,1-DCA 0.3J CIS-1,2-DCE 6

OBMW8 ND

AVENUE GROVE

AVENUE BECKER

0 200 400 600

SCALE 1"=200'

LEGEND:

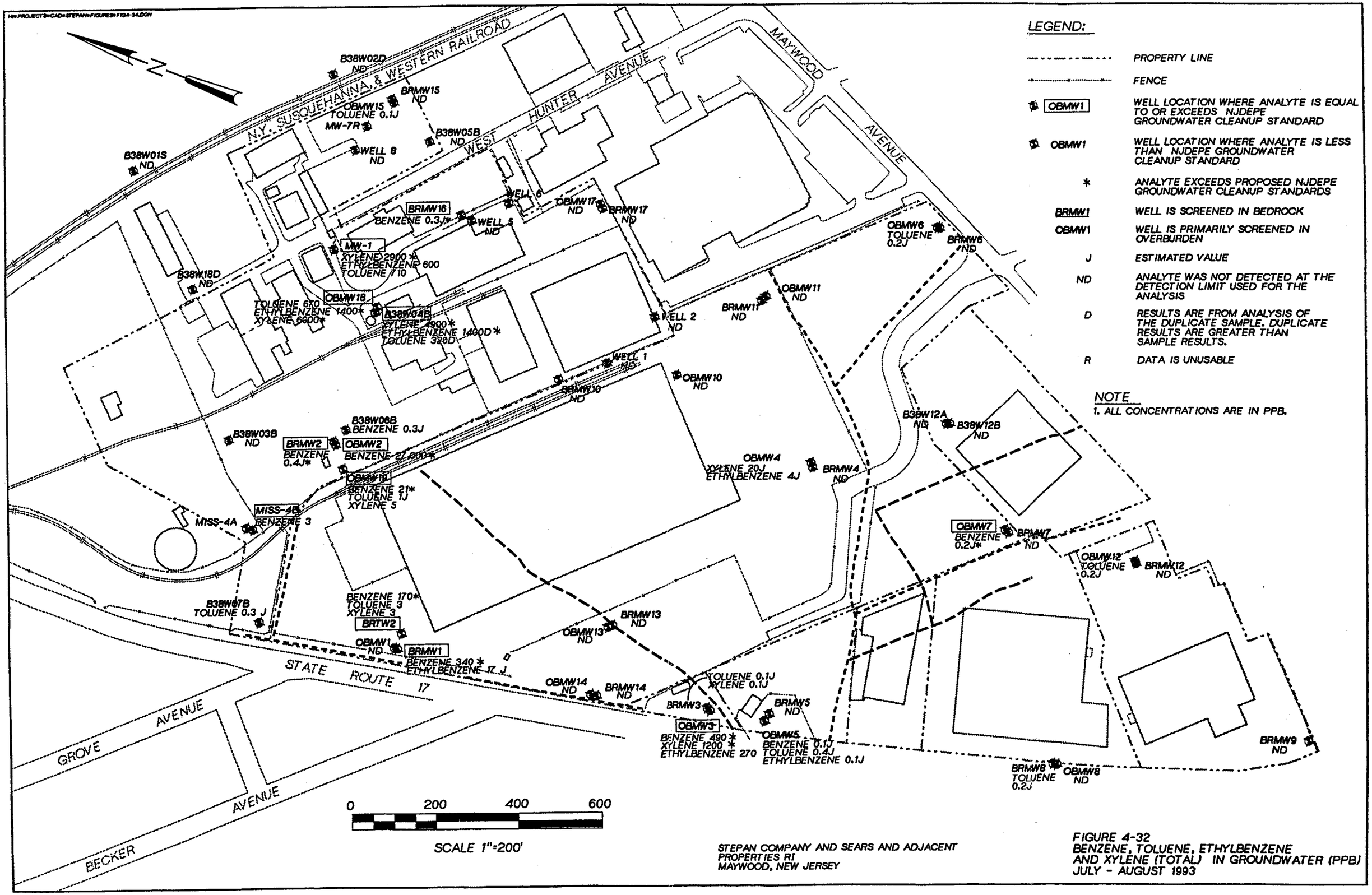
- PROPERTY LINE
- FENCE
- OBMW1 — WELL LOCATION WHERE ANALYTE IS EQUAL TO OR EXCEEDS NJDEPE GROUNDWATER QUALITY CRITERIA
- OBMW1 — WELL LOCATION WHERE ANALYTE IS LESS THAN NJDEPE GROUNDWATER QUALITY CRITERIA
- * — ANALYTE IS EQUAL TO OR EXCEEDS NJDEPE GROUNDWATER QUALITY CRITERIA
- BRMW1 — WELL IS SCREENED IN BEDROCK
- OBMW1 — WELL IS PRIMARILY SCREENED IN OVERBURDEN
- J — ESTIMATED VALUE
- ND — ANALYTE WAS NOT DETECTED AT THE DETECTION LIMIT USED FOR THE ANALYSIS
- D — RESULTS ARE FROM ANALYSIS OF THE DUPLICATE SAMPLE. DUPLICATE RESULTS ARE GREATER THAN SAMPLE RESULTS.
- R — DATA IS UNUSABLE
- CONCEPTUALIZED INTERPRETATION OF THE EXTENT OF CONTAMINATION ABOVE THE STANDARD IN THE BEDROCK ZONE
- CONCEPTUALIZED INTERPRETATION OF THE EXTENT OF CONTAMINATION ABOVE THE STANDARD IN THE OVERBURDEN ZONE
- NA — SAMPLE WAS NOT ANALYZED FOR THIS PARAMETER.

NOTE

1. ALL CONCENTRATIONS ARE IN PPB.
2. CIRCLES OF CONTAMINATION ARE CONJECTURAL. AREA MAY BE LARGER OR SMALLER THAN SHOWN.

STEPAN COMPANY AND SEARS AND ADJACENT PROPERTIES RI
MAYWOOD, NEW JERSEY

FIGURE 4-31
POTENTIAL HORIZONTAL EXTENT OF TCE; 1,1 - DCE; 1,2 - DCE; 1,1 - DCA; 1,2 - DCA; AND VINYL CHLORIDE IN GROUNDWATER JULY-AUGUST 1993



STEPAN COMPANY AND SEARS AND ADJACENT PROPERTIES RI
MAYWOOD, NEW JERSEY

FIGURE 4-32
BENZENE, TOLUENE, ETHYLBENZENE AND XYLENE (TOTAL) IN GROUNDWATER (PPB)
JULY - AUGUST 1993

H:\PROJECTS\CAD\STEPAN\FIGURES\FIG4-33C.DGN

N.Y. SUSQUEHANNA & WESTERN RAILROAD

WEST HUNTER AVENUE

MAYWOOD AVENUE

STATE ROUTE 17

GROVE AVENUE

BECKER AVENUE

B38W02D ND
BRMW15 ND
OBMW15 TOLUENE 0.1J
MW-7R
B38W05B ND
WELL 8 ND
B38W01S ND
WELL 6
OBMW17 ND
BRMW17 ND
BRMW16
BENZENE 0.3J*
WELL 5 ND
MW-1
XYLENE 2900
ETHYLBENZENE 600
TOLUENE 710*
B38W18D ND
OBMW18
TOLUENE 670
ETHYLBENZENE 1400*
XYLENE 6000*
B38W04B
XYLENE 2900*
ETHYLBENZENE 1400D*
TOLUENE 320D
WELL 2 ND
BRMW11 ND
OBMW11 ND
OBMW6 TOLUENE 0.2J
BRMW6 ND
WELL 1 ND
OBMW10 ND
BRMW10 ND
B38W06B BENZENE 0.3J
B38W03B ND
BRMW2 BENZENE 0.4J*
OBMW2 BENZENE 27,000*
OBMW19 BENZENE 21* TOLUENE 1J XYLENE 5
MISS-4B BENZENE 3
MISS-4A
OBMW4 XYLENE 20J ETHYLBENZENE 4J
BRMW4 ND
B38W12A ND
B38W12B ND
OBMW7 BENZENE 0.2J*
BRMW7 ND
OBMW12 TOLUENE 0.2J
BRMW12 ND
BENZENE 170*
TOLUENE 3
XYLENE 3
BRTW2
B38W07B TOLUENE 0.3 J
OBMW1 ND
BRMW1 BENZENE 940* ETHYLBENZENE 17 J
BRMW13 ND
OBMW13 ND
OBMW14 ND
BRMW14 ND
BRMW3 TOLUENE 0.1J XYLENE 0.1J
BRMW5 ND
OBMW3 BENZENE 490* XYLENE 1200* ETHYLBENZENE 270
OBMW5 BENZENE 0.1J TOLUENE 0.4J ETHYLBENZENE 0.1J
BRMW9 ND
BRMW8 TOLUENE 0.2J
OBMW8 ND

0 200 400 600

SCALE 1"=200'

LEGEND:

- PROPERTY LINE
- FENCE
- OBMW1 — WELL LOCATION WHERE ANALYTE IS EQUAL TO OR EXCEEDS NJDEPE GROUNDWATER QUALITY CRITERIA
- OBMW1 — WELL LOCATION WHERE ANALYTE IS LESS THAN NJDEPE GROUNDWATER QUALITY CRITERIA
- * — ANALYTE IS EQUAL TO OR EXCEEDS NJDEPE GROUNDWATER QUALITY CRITERIA
- BRMW1 — WELL IS SCREENED IN BEDROCK
- OBMW1 — WELL IS PRIMARILY SCREENED IN OVERBURDEN
- J — ESTIMATED VALUE
- ND — ANALYTE WAS NOT DETECTED AT THE DETECTION LIMIT USED FOR THE ANALYSIS
- D — RESULTS ARE FROM ANALYSIS OF THE DUPLICATE SAMPLE. DUPLICATE RESULTS ARE GREATER THAN SAMPLE RESULTS.
- R — DATA IS UNUSABLE
- POTENTIAL HORIZONTAL EXTENT OF CONTAMINATION ABOVE THE STANDARD IN THE BEDROCK ZONE
- POTENTIAL HORIZONTAL EXTENT OF CONTAMINATION ABOVE THE STANDARD IN THE OVERBURDEN ZONE
- POTENTIAL HORIZONTAL EXTENT OF CONTAMINATION ABOVE THE STANDARD IN BOTH THE BEDROCK AND OVERBURDEN ZONE

NOTE

1. ALL CONCENTRATIONS ARE IN PPB.

STEPAN COMPANY AND SEARS AND ADJACENT PROPERTIES RI
MAYWOOD, NEW JERSEY

FIGURE 4-33
POTENTIAL HORIZONTAL EXTENT OF BENZENE, TOLUENE, ETHYLBENZENE AND XYLENE CONTAMINATION
JULY-AUGUST 1993

H:*PROJECTS*CAD*STEPAN*MONWELL*MWD-11.DGN

N.Y. SUSQUEHANNA & WESTERN RAILROAD

MAYWOOD AVENUE

WEST HUNTER AVENUE

B38W02D
CAFFEINE 2J

BRMW15
OBMW15
ND
BIS (2-ETHYLHEXYL) PHTHALATE 61*
DI-N-OCTYLPHTHALATE 5J

B38W05B
ND

B38W01S
ND

WELL 8
ND

BIS (2-ETHYLHEXYL) PHTHALATE 3J*
DI-N-BUTYLPHTHALATE 1 J
CAFFEINE 2J

OBMW17
BRMW17
ND

BRMW16
ND

WELL 5

OBMW6
ND

BRMW6
ND

B38W18D
ND

OBMW11
ND

BRMW11

WELL 2
ND

BIS (2-ETHYLHEXYL) PHTHALATE 61 *
DI-N-OCTYLPHTHALATE 3 J

B38W04B

NAPHTHALENE 180
2-METHYL NAPHTHALENE 21
2,4-DIMETHYLPHENOL 13 J

ACENAPHTHENE 1J
PYRENE 3J
WELL 1

BRMW10
ND

OBMW10
ND

4-NITROPHENOL 63J
PENTACHLOROPHENOL 17J *

B38W03B

B38W06B
ND

BRMW2

OBMW2

BIS (2-ETHYLHEXYL) PHTHALATE 20J*
PENTACHLOROPHENOL 6J *

BIS (2-ETHYLHEXYL) PHTHALATE 4J *
NAPHTHALENE 3J

BIS (2-ETHYLHEXYL) PHTHALATE 2 J
DI-N-BUTYLPHTHALATE 4 J

OBMW4

BRMW4
ND

ND
B38W12A

B38W12B
ND

MISS-4A
BENZYL BUTYL PHTHALATE 12 J

MISS-4B
BENZYL BUTYL PHTHALATE 25

OBMW7
ND

BRMW7
ND

BIS (2-ETHYLHEXYL) PHTHALATE 940 *
DI-N-BUTYLPHTHALATE 3 J

OBMW12

BRMW12
ND

B38W07B
ND

BIS (2-ETHYLHEXYL) PHTHALATE 2 J

BRMW13

OBMW13
BIS (2-ETHYLHEXYL) PHTHALATE 2J
DI-N-BUTYLPHTHALATE 2J

ND
OBMW1

ND
BRMW1

STATE ROUTE 17

ND
OBMW14

ND
BRMW14

BRMW3

DI-N-BUTYLPHTHALATE 1 J

BRMW5 DI-N-BUTYLPHTHALATE 2 J

OBMW3

OBMW5 DI-N-BUTYLPHTHALATE 2 J

DI-N-BUTYLPHTHALATE 2 J
NAPHTHALENE 48
2-METHYLPHENOL 7J
4-METHYLPHENOL 4J
2-METHYLNAPHTHALENE 2J
PHENOL 13J

DI-N-BUTYLPHTHALATE 1 J

BRMW8

OBMW8
ND

BRMW9
ND

GROVE AVENUE

BECKER AVENUE

0 200 400 600

SCALE 1"=200'

LEGEND:

- PROPERTY LINE
- FENCE
- OBMW1 — WELL LOCATION WHERE ANALYTE IS EQUAL TO OR EXCEEDS NJDEPE GROUNDWATER QUALITY CRITERIA
- OBMW1 — WELL LOCATION WHERE ANALYTE IS LESS THAN NJDEPE GROUNDWATER QUALITY CRITERIA
- * — ANALYTE IS EQUAL TO OR EXCEEDS NJDEPE GROUNDWATER QUALITY CRITERIA
- BRMW1 — WELL IS SCREENED IN BEDROCK
- OBMW1 — WELL IS PRIMARILY SCREENED IN OVERBURDEN
- J — ESTIMATED VALUE
- ND — ANALYTE WAS NOT DETECTED AT THE DETECTION LIMIT USED FOR THE ANALYSIS
- D — RESULTS ARE FROM ANALYSIS OF THE DUPLICATE SAMPLE. DUPLICATE RESULTS ARE GREATER THAN SAMPLE RESULTS.
- R — DATA IS UNUSABLE

NOTE:

1. ALL CONCENTRATIONS ARE IN PPB.

STEPAN COMPANY AND SEARS AND ADJACENT PROPERTIES RI
MAYWOOD, NEW JERSEY

FIGURE 4-34
SEMIVOLATILE ORGANICS AND CAFFEINE IN GROUNDWATER (PPB)
JULY - AUGUST 1992

H:\PROJECTS\CAD\STEPAN\FIGURES\FIG4-35.DGN

N.Y. SUSQUEHANNA & WESTERN RAILROAD

WEST HUNTER AVENUE

MAYWOOD AVENUE

STATE ROUTE 17

GROVE AVENUE

BECKER AVENUE

B38W02D NA

BRMW15 *BIS(2-ETHYLHEXYL) PHTHALATE 6J

OBMW15 *BIS(2-ETHYLHEXYL) PHTHALATE 4J

B38W05B ND

B38W01S NA

WELL 8 1,4-DICHLOROBENZENE 4J *BIS(2-ETHYLHEXYL) PHTHALATE 8J

WELL 6

BRMW16 ND

WELL 5 ND

OBMW17 ND

BRMW17 ND

MW-1 *BIS(2-ETHYLHEXYL) PHTHALATE 100 NAPHTHALENE 160 2-METHYLNAPHTHALENE 43

B38W18D NA

OBMW18 DIETHYLPHTHALATE 2J DI-N-OCTYLPHTHALATE 10J NAPHTHALENE 210

B38W04B NAPHTHALENE 180D 2-METHYLNAPHTHALENE 170D

WELL 2 ND

BRMW11 ND

OBMW11 BIS(2-ETHYLHEXYL) PHTHALATE 2J

OBMW6 ND

BRMW6 ND

WELL 1 ND

OBMW10 *BIS(2-ETHYLHEXYL) PHTHALATE 11

BRMW10 ND

B38W12A ND

B38W12B ND

B38W06B ND

B38W03B ND

BRMW2 ND

OBMW2 ISOPHORONE 17

OBMW19 NA

OBMW4 ND

BRMW4 ND

MISS-4A

MISS-4B ND

OBMW7 ND

BRMW7 *BIS(2-ETHYLHEXYL) PHTHALATE 5J

OBMW12 ND

BRMW12 *BIS(2-ETHYLHEXYL) PHTHALATE 21D

B38W07B ND

BRTW2 NA

OBMW13 4-NITROPHENOL 12J

BRMW13 ND

OBMW1 ND

BRMW1 *BIS(2-ETHYLHEXYL) PHTHALATE 3J

OBMW14 ND

BRMW14 *BIS(2-ETHYLHEXYL) PHTHALATE 6J

BRMW3 ND

OBMW3 PHENOL 6J 4-METHYLPHENOL 3J 2,4-DIMETHYLPHENOL 4J BENZOIC ACID 5J NAPHTHALENE 27 2-METHYLNAPHTHALENE 3J

BRMW5 *BIS(2-ETHYLHEXYL) PHTHALATE 84

OBMW5 ND

BRMW8 *BIS(2-ETHYLHEXYL) PHTHALATE 9J

OBMW8 ND

BRMW9 *BIS(2-ETHYLHEXYL) PHTHALATE 3J

0 200 400 600

SCALE 1"=200'

LEGEND:

- PROPERTY LINE
- FENCE
- OBMW1 — WELL LOCATION WHERE ANALYTE IS EQUAL TO OR EXCEEDS NJDEPE GROUNDWATER CLEANUP STANDARD
- OBMW1 — WELL LOCATION WHERE ANALYTE IS LESS THAN NJDEPE GROUNDWATER CLEANUP STANDARD
- * — ANALYTE EXCEEDS PROPOSED NJDEPE GROUNDWATER CLEANUP STANDARDS
- BRMW1 — WELL IS SCREENED IN BEDROCK
- OBMW1 — WELL IS PRIMARILY SCREENED IN OVERBURDEN
- J — ESTIMATED VALUE
- ND — ANALYTE WAS NOT DETECTED AT THE DETECTION LIMIT USED FOR THE ANALYSIS
- D — RESULTS ARE FROM ANALYSIS OF THE DUPLICATE SAMPLE. DUPLICATE RESULTS ARE GREATER THAN SAMPLE RESULTS.
- R — DATA IS UNUSABLE
- NA — SAMPLE WAS NOT ANALYZED FOR THIS PARAMETER

NOTE

1. ALL CONCENTRATIONS ARE IN PPB.

STEPAN COMPANY AND SEARS AND ADJACENT PROPERTIES RI
MAYWOOD, NEW JERSEY

FIGURE 4-35
SEMIVOLATILE ORGANIC COMPOUNDS IN GROUNDWATER (PPB)
JULY - AUGUST 1993

H:*PROJECTS*CAD*STEPAN*MONWELL*MWD-14.DGN

N

N.Y. SUSQUEHANNA & WESTERN RAILROAD

HUNTER AVENUE

WEST

MAYWOOD AVENUE

B38W02D ND

BRMW15 DIELDRIN 0.49*
OBMW15 HEPTACHLOR EPOXIDE 0.1*
DIELDRIN 0.14*

B38W05B ND

WELL 8 ND

B38W01S ND

BRMW16 DIELDRIN 0.14*

WELL 5 ND

OBMW17 ND

BRMW17 BHC-GAMMA (LINDANE) 0.071

OBMW6 ND

BRMW6 ND

B38W18D BHC-GAMMA (LINDANE) 0.29*

OBMW11 BHC-GAMMA (LINDANE) 0.21*

BRMW11 ND

B38W04B ND

WELL 2 ND

BRMW10 ND

WELL 1 ND

OBMW10 ND

B38W12A ND

B38W12B ND

B38W03B ND

BRMW2 ND

B38W06B ND

OBMW2 ND

OBMW4 ND

BRMW4 BHC-GAMMA (LINDANE) 0.14

MISS-4A ND

MISS-4B ND

OBMW7 ND

BRMW7 ND

OBMW12 ND

BRMW12 ND

B38W07B ND

BRMW13 BHC-GAMMA (LINDANE) 0.089

OBMW13 BHC-GAMMA (LINDANE) 0.07

OBMW1 ND

BRMW1 ND

STATE ROUTE 17

OBMW14 ND

BRMW14 ND

BRMW3 ND

OBMW3 ND

BRMW5 ND

OBMW5 ND

BRMW9 ND

BRMW8 ND

OBMW8 ND

GROVE AVENUE

BECKER AVENUE

0 200 400 600

SCALE 1"=200'

LEGEND:

- PROPERTY LINE
- FENCE
- OBMW1 — WELL LOCATION WHERE ANALYTE IS EQUAL TO OR EXCEEDS NJDEPE GROUNDWATER QUALITY CRITERIA
- OBMW1 — WELL LOCATION WHERE ANALYTE IS LESS THAN NJDEPE GROUNDWATER QUALITY CRITERIA
- * — ANALYTE IS EQUAL TO OR EXCEEDS NJDEPE GROUNDWATER QUALITY CRITERIA
- BRMW1 — WELL IS SCREENED IN BEDROCK
- OBMW1 — WELL IS PRIMARILY SCREENED IN OVERBURDEN
- J — ESTIMATED VALUE
- ND — ANALYTE WAS NOT DETECTED AT THE DETECTION LIMIT USED FOR THE ANALYSIS
- D — RESULTS ARE FROM ANALYSIS OF THE DUPLICATE SAMPLE. DUPLICATE RESULTS ARE GREATER THAN SAMPLE RESULTS.
- R — DATA IS UNUSABLE

NOTE:
1. ALL CONCENTRATIONS ARE IN PPB.

STEPAN COMPANY AND SEARS AND ADJACENT PROPERTIES RI
MAYWOOD, NEW JERSEY

FIGURE 4-36
PESTICIDES IN GROUNDWATER (PPB)
JULY - AUGUST 1992

H:\PROJECTS\CAD\STEPAN\FIGURES\FIG4-38.DGN

N

B38W02D NA

BRMW15

OBMW15

*DIELDRIN 0.44
*TOTAL CHLORDANE 1.22
*HEPTACHLOR EPOXIDE 0.21

*DIELDRIN 0.57

B38W05B

*DIELDRIN 0.19

B38W01S NA

WELL 8 NA

WELL 6 NA

OBMW17 NA

BRMW17 NA

BRMW16 ND

WELL 5 NA

MW-1 NA

B38W18D ND

OBMW18 NS

B38W04B NA

WELL 2 NA

BRMW11 NA

OBMW11 ND

OBMW6 NA

BRMW6 NS

WELL 1 NA

OBMW10 NA

BRMW10 ND

B38W06B NA

B38W03B NA

BRMW2 NA

OBMW2 NA

OBMW19 NA

B38W12A NA

B38W12B NA

OBMW4 NA

BRMW4 NA

MISS-4A NA

MISS-4B NA

OBMW7 NA

BRMW7 NA

OBMW12 NA

BRMW12 NA

B38W07B NA

BRTW2 NA

OBMW1 NA

BRMW1 NA

OBMW13 NA

BRMW13 NA

STATE ROUTE 17

OBMW14 NA

BRMW14 NA

BRMW3 NA

OBMW3 NA

BRMW5 NA

OBMW5 NA

BRMW9 NA

BRMW8 NA

OBMW8 NA

GROVE AVENUE

BECKER AVENUE

HUNTER AVENUE

MAYWOOD AVENUE

SUSQUEHANNA & WESTERN RAILROAD

0 200 400 600

SCALE 1"=200'

LEGEND:

----	PROPERTY LINE
·····	FENCE
OBMW1	WELL LOCATION WHERE ANALYTE IS EQUAL TO OR EXCEEDS NJDEPE GROUNDWATER CLEANUP STANDARD
OBMW1	WELL LOCATION WHERE ANALYTE IS LESS THAN NJDEPE GROUNDWATER CLEANUP STANDARD
*	ANALYTE EXCEEDS PROPOSED NJDEPE GROUNDWATER CLEANUP STANDARDS
BRMW1	WELL IS SCREENED IN BEDROCK
OBMW1	WELL IS PRIMARILY SCREENED IN OVERBURDEN
J	ESTIMATED VALUE
ND	ANALYTE WAS NOT DETECTED AT THE DETECTION LIMIT USED FOR THE ANALYSIS
D	RESULTS ARE FROM ANALYSIS OF THE DUPLICATE SAMPLE. DUPLICATE RESULTS ARE GREATER THAN SAMPLE RESULTS.
R	DATA IS UNUSABLE
NA	SAMPLE WAS NOT ANALYZED FOR THIS PARAMETER.

NOTE
1. ALL CONCENTRATIONS ARE IN PPB.

STEPAN COMPANY AND SEARS AND ADJACENT PROPERTIES RI
MAYWOOD, NEW JERSEY

FIGURE 4-37
PESTICIDES IN GROUNDWATER (PPB)
JULY-AUGUST 1993

H:\PROJECTS\CAD\STEPAN\MONWELL\MWD-6.DGN

N.Y. SUSQUEHANNA & WESTERN RAILROAD

HUNTER AVENUE

WEST

MAYWOOD AVENUE

STATE ROUTE 17

GROVE AVENUE

BECKER AVENUE

B38W02D
As 2.5 J*
Pb 3.1 J

BRMW15
OBMW15
As 2.9 J*
Be 5*
Pb 24.5*
B38W05B
As 3.6 J*
Pb 20.4*

B38W01S
As 5.2 J*
Be 5*
Pb 4.6 J

WELL 8
Be 10*
Pb 6.3 J

BRMW16
Pb 4.7

WELL 5
As 21.4*
Be 8*
Pb 59.3*

OBMW17
As 14.7*
Pb 91.6*
BRMW17
As 2.4 J*
Pb 5.5*

OBMW6
As 12.3*
Be 2*
Pb 45.1*
BRMW6

B38W18D
Pb 5.8 J*

B38W04B
As 8.3 J*
Be 4 J*
Pb 50*

WELL 1
As 9.5 J D*
Be 10*
Pb 36.9 D*

WELL 2
As 51.2*
Be 13*
Pb 173*

BRMW11
OBMW11
As 10 J*
Be 2 J*
Pb 72..1*

BRMW10
As 4.5 J*
Pb 2.2

OBMW10
As 12.4*
Pb 41.5 J*

BRMW2
Pb 2.6 J
B38W06B
As 2.8 J*

B38W03B
As 3.4 J*
Pb 1.4 J

OBMW2
Be 3 J*
Pb 64.6*

B38W12A
As 8.6 J*
B38W12B

OBMW4
As 31.8*
Be 6*
Pb 114*
BRMW4
As 5.6 J*
Pb 2.4 J

MISS-4A
Pb 2.8J
MISS-4B
Pb 3.7

OBMW7
As 10.8*
Be 7*
Pb 38.8 J*
BRMW7
Pb 19.8J*

OBMW12
Be 4J*
Pb 12.2J*
BRMW12
Pb 32.6 J*

B38W07B
Pb 9*

OBMW1
As 20.2*
Be 12*
Pb 111*
BRMW1
Pb 6.2*

OBMW13
As 19.4 D*
Be 21*
Pb 73.3*
BRMW13
As 4.6 J*
Pb 3.8*

OBMW14
As 129*
Be 10*
Pb 64.2*
BRMW14
Pb 22.8*
BRMW3
As 5.3J*
Pb 17.5J*

BRMW5
As 20.3*
Pb 3 J
OBMW3
As 29.1*
Be 5*
Pb 39.1J*
OBMW5
As 131*
Be 18*
Pb 166J*

BRMW9
Pb 4.1 J

BRMW8
Pb 2.4 J D
OBMW8
Be 83*
Pb 127 J*

0 200 400 600

SCALE 1"=200'

LEGEND:

- PROPERTY LINE
- FENCE
- OBMW1 — WELL LOCATION WHERE ANALYTE IS EQUAL TO OR EXCEEDS NJDEPE GROUNDWATER QUALITY CRITERIA
- OBMW1 — WELL LOCATION WHERE ANALYTE IS LESS THAN NJDEPE GROUNDWATER QUALITY CRITERIA
- * — ANALYTE IS EQUAL TO OR EXCEEDS NJDEPE GROUNDWATER QUALITY CRITERIA
- BRMW1 — WELL IS SCREENED IN BEDROCK
- OBMW1 — WELL IS PRIMARILY SCREENED IN OVERBURDEN
- As — ARSENIC
- Be — BERYLLIUM
- Pb — LEAD
- J — ESTIMATED VALUE
- D — RESULTS ARE FROM ANALYSIS OF THE DUPLICATE SAMPLE. DUPLICATE RESULTS ARE GREATER THAN SAMPLE RESULTS.

NOTE

1. ALL CONCENTRATIONS ARE IN PPB.
2. ONLY DETECTED VALID DATA HAVE BEEN PRESENTED.
3. ONLY UNFILTERED METALS DATA HAVE BEEN PRESENTED.

STEPAN COMPANY AND SEARS AND ADJACENT PROPERTIES RI
MAYWOOD, NEW JERSEY

FIGURE 4-38
ARSENIC, BERYLLIUM AND LEAD IN GROUNDWATER (PPB)
JULY - AUGUST 1992

H:\PROJECTS\CAD\STEPAN\MONWELL\MWD-4.DGN

N

N.Y. SUSQUEHANNA & WESTERN RAILROAD

WEST HUNTER AVENUE

MAYWOOD AVENUE

STATE ROUTE 17

GROVE AVENUE

BECKER AVENUE

B38W02D
Ba 320 J
Cr 29
Ni 27 J

B38W01S
Ba 90 J
Cd 6*
Cr 18 J
Ni 54

BRMW15
Ba 162 J
Cr 47

OBMW15
Ba 838
Cd 23*
Cr 532*
Ni 564*

B38W05B
Ba 371
Cr 244*
Ni 141*

WELL 8
Ba 41 J
Cr 31 J

BRMW16
Ba 122 J
Cr 211*
Ni 30 J

WELL 5
Ba 329
Cd 28*
Cr 55
Ni 92

OBMW17
Ba 1210
Cd 42*
Cr 165*
Ni 241*

BRMW17
Ba 194 J
Cr 55
Ni 56

OBMW6
Ba 518 J
Cr 58
Ni 62

BRMW6
Ba 85 J
Cr 172*
Ni 85

B38W18D
Ba 24 J
Cr 39
Ni 34 J

B38W04B
Ba 351
Cr 31
Ni 50

WELL 2
Ba 1540 J
Cd 10*
Cr 171*
Ni 146*

BRMW11
Ba 100J

OBMW11
Ba 340
Cr 49

BRMW10
Ba 289
Cr 9 J

WELL 1
Ba 633 J D
Cd 6 D*
Cr 102 D*
Ni 98 D

OBMW10
Ba 317
Cr 39
Ni 96

B38W06B
Ba 176 J
Cr 6 J

B38W03B
Ba 13 J
Cd 29
Ni 24 J

BRMW2
Ba 108 J

OBMW2
Ba 200
Cr 380*

B38W12A
Ba 126 J
Cr 13 J
Ni 40

B38W12B
Ba 102 J
41 J

OBMW4
Ba 867
Cr 232*

BRMW4
Ba 138 J

MISS-4A
Ba 17 J
Ni 13

MISS-4B
Ba 98
Cr 15
Ni 17

OBMW7
Ba 734
Cd 7*
Cr 88
Ni 106*

BRMW7
Ba 37 J
Cr 17 J
Ni 40

OBMW12
Ba 696
Cr 32
Ni 56

BRMW12
Ba 195 J
Cr 228*
Ni 39 J

B38W07B
Ba 133 J
Cr 47
Ni 40

BRMW1
Ba 48 J
Cd 7*
Cr 19

OBMW13
Ba 2780 D*
Cd 42 D*
Cr 237 D*
Ni 241 D*

BRMW13
Ba 195 J

OBMW1
Ba 1030 J
Cd 10*
Cr 138*
Ni 114*

OBMW14
Ba 1450
Cd 10*
Cr 127*
Ni 107*

BRMW14
Ba 599 J
Cr 23
Ni 35

BRMW3
Ba 172 J
Cr 8 J

OBMW3
Ba 933
Cr 266*
Ni 89

BRMW5
Ba 162 J
Cr 6 J
Ni 34 J

OBMW5
Ba 2530
Cd 11*
Cr 231*
Ni 157*

BRMW9
Ba 183 J
Cr 17

BRMW8
Ba 106 J D
Ni 25 J D

OBMW8
Ba 2860*
Cd 25*
Cr 580*
Ni 584*

0 200 400 600

SCALE 1"=200'

LEGEND:

- PROPERTY LINE
- FENCE
- OBMW1 — WELL LOCATION WHERE ANALYTE IS EQUAL TO OR EXCEEDS NJDEPE GROUNDWATER QUALITY CRITERIA
- OBMW1 — WELL LOCATION WHERE ANALYTE IS LESS THAN NJDEPE GROUNDWATER QUALITY CRITERIA
- * — ANALYTE IS EQUAL TO OR EXCEEDS NJDEPE GROUNDWATER QUALITY CRITERIA
- BRMW1 — WELL IS SCREENED IN BEDROCK
- OBMW1 — WELL IS PRIMARILY SCREENED IN OVERBURDEN
- Ba — BARIUM
- Cd — CADMIUM
- Cr — CHROMIUM
- Ni — NICKEL
- J — ESTIMATED VALUE
- D — RESULTS ARE FROM ANALYSIS OF THE DUPLICATE SAMPLE. DUPLICATE RESULTS ARE GREATER THAN SAMPLE RESULTS.

NOTE

1. ALL CONCENTRATIONS ARE IN PPB.
2. ONLY DETECTED VALID DATA HAVE BEEN PRESENTED.
3. ONLY UNFILTERED METALS DATA HAVE BEEN PRESENTED..

STEPAN COMPANY AND SEARS AND ADJACENT PROPERTIES RI
MAYWOOD, NEW JERSEY

FIGURE 4-39
TOTAL BARIUM, CADMIUM, CHROMIUM AND NICKEL IN GROUNDWATER (PPB)
JULY - AUGUST 1992

fig4-41.dgn 25-JUL-1994 NJO/JMS 2

N.Y. SUSQUEHANNA & WESTERN RAILROAD

HUNTER AVENUE

WEST

MAYWOOD AVENUE

STATE ROUTE 17

GROVE AVENUE

BROKER AVENUE

B38W02D Mn 1630 *

BRMW15 Mn R

OBMW15 Mn 1830 J * Li 44

B38W05B Mn 795 J * Li 26

WELL 8 Mn 461 * Li 78300

Mn 2220 * Li 2540 B38W01S

BRMW16 Mn 188 * Li 80

WELL 5 Mn 2590 J * Li 142

OBMW17 Mn 4470 J * Li 84

BRMW17 Mn 727 J *

B38W18D Mn 4300 J * Li 3400

B38W04B Mn 8200 J * Li 1240

WELL 2 Mn 6370 * Li 161 Cn 56.3

BRMW11 Mn 421 * Li 15 J

OBMW11 Mn 5700 * Li 52 J Cn 20 J

BRMW10 Mn 928 *

WELL 1 Mn 3200 D Li 50 D Cn 6 D

OBMW10 Mn 1650 * Li 16 J

OBMW6 Mn 4860 * Li 11 J

BRMW6 Mn 347

B38W06B Mn 2820 * Li 565

B38W03B Mn 8880 J * Li 100

BRMW2 Mn 3170 * Li 2460

OBMW2 Mn 3630 * Li 360

B38W12A Mn 2940 * Li 71 Cn 87.80*

B38W12B Mn 46

OBMW4 Mn 3830 * Li 571

BRMW4 Mn 466 * Li 9 J

MISS-4A Mn 1570 J * Cn 18.8

MISS-4B Mn 4020 J * Li 42

OBMW7 Mn 9160 * Li 133

BRMW7 Mn 76 * Li 144 Cn 10.4

OBMW12 Mn 3180 * Li 19 J

BRMW12 Mn 59 J * Li 18 J

B38W07B Mn 4570 J * Li 65

OBMW1 Mn 17,100 * Li 661

BRMW1 Mn 1990 * Li 3910

OBMW13 Mn 8810 * Li 3570 D

BRMW13 Mn 444 * Li 477

OBMW14 Mn 5600 * Li 664

BRMW14 Mn 128 * Li 342

BRMW3 Mn 212 * Li 207

OBMW3 Mn 9460 * Li 676

BRMW5 Mn 4700 * Li 308

OBMW5 Mn 5870 * Li 902

BRMW8 Mn 837 * Li 34 Li 39 D Cn 15.5 D

OBMW8 Mn 7550 * Li 301 Cn 76.6

BRMW9 Mn 970 *

0 200 400 600

SCALE 1"=200'

LEGEND:

- PROPERTY LINE
- FENCE
- OBMW1 — MONITOR WELL CONTAINING ANALYTES WELL LOCATION WHERE ANALYTE IS EQUAL TO OR EXCEEDS NJDEPE GROUNDWATER QUALITY CRITERIA
- OBMW1 — WELL LOCATION WHERE ANALYTE IS LESS THAN NJDEPE GROUNDWATER QUALITY CRITERIA
- * — ANALYTE IS EQUAL TO OR EXCEEDS NJDEPE GROUNDWATER QUALITY CRITERIA
- BRMW1 — WELL IS SCREENED IN BEDROCK
- OBMW1 — WELL IS PRIMARILY SCREENED IN OVERBURDEN
- J — ESTIMATED VALUE
- D — RESULTS ARE FROM ANALYSIS OF THE DUPLICATE SAMPLE. DUPLICATE RESULTS ARE GREATER THAN SAMPLE RESULTS
- R — DATA UNUSABLE
- Mn — MANGANESE
- Li — LITHIUM
- Cn — CYANIDE

NOTE:

1. ALL CONCENTRATIONS ARE IN PPB.

STEPAN COMPANY AND SEARS AND ADJACENT PROPERTIES RI
MAYWOOD, NEW JERSEY

FIGURE 4-40
MANGANESE, LITHIUM AND CYANIDE IN GROUNDWATER (PPB)
JULY - AUGUST 1992

H:\PROJECTS\CAD\STEPAN\FIGURES\FIG4-44.DGN

N

B38W02D
Cr 7.9 B
Ni 14.8 B

N.Y. SUSQUEHANNA & WESTERN RAILROAD

BRMW15
Cr 250*

OBMW15
Cr 149*
Ni 226*

B38W05B
Cr 9.0J

B38W01S
Ni 14.8 B

WELL 8
Cd 10.9*
Cr 8.7

WEST HUNTER AVENUE

MAYWOOD AVENUE

WELL 6

OBMW17

BRMW17

BRMW16
Cr 24J

WELL 5
Ni 18

MW-1
Cd 7.7J*

OBMW6
Cd 9.3*
Cr 24.5

BRMW6
Cd 6.9*
Cr 5.42*
Ni 31.9

B38W10D
As 3.5 B*
Cr 29.9 D
Ni 37.6 B D

OBMW18
As 6.3 B*

B38W04B
As 3.8J*
Cd 5.4J*
Ni 13.9

OBMW11
As 5.6J*

BRMW11
12.7

WELL 2
As 29J*
Cd 7*

WELL 1
Cd 7*

OBMW10
As 61.4*
Cd 8J*
Ni 55.3

BRMW10
As 1.3
Ni 36

B38W12A

B38W12B
Cr 15.8J
Ni 147*

B38W06B
Cr 8J

B38W03B
As 1.3J

BRMW2
Cd 6.0*
Cr 7J
Ni 31 D

OBMW2
Cd 20*
Cr 19J
Ni 19

OBMW16
NA

OBMW4
As 5.1*
Cd 5.1J*

BRMW4
As 2.1J*
Cd 5.6J*
Ni 15.7

MISS-4A
NA

MISS-4B
Cd 8.7J*

OBMW7
As 3.4J
Cr 16.8J
Ni 37.1

BRMW7
Ni 11.8

OBMW12
Ni 12.7J

BRMW12
Cr 108*
Ni 416 D*

B38W07B
Cd 8.2*

BRTW2
NA

OBMW1

BRMW1
Ni 34.4

BRMW13
Cd 6.1*

OBMW13
As 21.6*
Cd 9.8*

STATE ROUTE 17

OBMW14
As 127*
Cd 10*

BRMW14
Cd 7.6J*

BRMW3
As 2.9J
Ni 11.3

OBMW3
As 4.4
Ni 13.0

BRMW5
As 20.9*
Ni 21.0

OBMW5
As 169J*

BRMW9
Ni 58.6J

BRMW8
Ni 16.2J

OBMW8
Ni 53.7

GROVE AVENUE

BECKER AVENUE

0 200 400 600

SCALE 1"=200'

LEGEND:

	PROPERTY LINE
	FENCE
OBMW1	WELL LOCATION WHERE ANALYTE IS EQUAL TO OR EXCEEDS NJDEPE GROUNDWATER QUALITY CRITERIA
OBMW1	WELL LOCATION WHERE ANALYTE IS LESS THAN NJDEPE GROUNDWATER QUALITY CRITERIA
*	ANALYTE IS EQUAL TO OR EXCEEDS NJDEPE GROUNDWATER QUALITY CRITERIA
BRMW1	WELL IS SCREENED IN BEDROCK
OBMW1	WELL IS PRIMARILY SCREENED IN OVERBURDEN
As	ARSENIC
Cd	CADMIUM
Cr	CHROMIUM
Ni	NICKEL
J	ESTIMATED VALUE
ND	ANALYTE WAS NOT DETECTED AT THE DETECTION LIMIT USED FOR THE ANALYSIS
D	RESULTS ARE FROM ANALYSIS OF THE DUPLICATE SAMPLE. DUPLICATE RESULTS ARE GREATER THAN SAMPLE RESULTS.
R	DATA IS UNUSABLE

NOTE

1. ALL CONCENTRATIONS ARE IN PPB.
2. ONLY DETECTED, VALID DATA HAVE BEEN PRESENTED.
3. ONLY UNFILTERED METALS DATA HAVE BEEN PRESENTED.

STEPAN COMPANY AND SEARS AND ADJACENT PROPERTIES RI
MAYWOOD, NEW JERSEY

FIGURE 4-41
ARSENIC, CADMIUM, CHROMIUM AND NICKEL IN GROUNDWATER (PPB)
JULY-AUGUST 1993

H:\PROJECTS\CAD\STEPAN\RAD\RAD-3.dgn

N

B38W02D
ND

BRMW15
Ra-226 -[1.1]
Th-230 -[1.2]

OBMW15
Ra-226 -[1.2]
Th-230 -[0.7]
Th-232 -[0.5]

WELL 8
NT

B38W01S
GROSS BETA-41

B38W05B
Ra-226 -2.4
Th-230 -[1.3]

GROSS BETA-[8.6]
Ra-226-[0.9]
Th-230 -[0.9]

OBMW17

BRMW17
Ra-226-[1.6]
Th-230 -1.2

BRMW16
GROSS BETA-11.6
U-234 -4.5
U-238 -[1.5]
U-238 -6.9

WELL 5
GROSS ALPHA-20.4
GROSS BETA-18.5
Ra-226 -2.6
Th-230 -2.0
Th-232 -[0.9]
U-234 -10.4 *
U-238 -10.1 *

B38W18D
GROSS ALPHA-[19]
GROSS BETA-[9]
Th-230 -[1.5]
Th-232 -[0.7]
U-234 -2.1
U-238 -2.3

B38W04B
ND

GROSS BETA-49.6
Ra-226-[1.4]
Ra-228 -4.6

WELL 2

GROSS ALPHA-[20.3] *
GROSS BETA-65.4 *
Ra-226 -[1.9]
Ra-228 -6.1

WELL 1

BRMW10
GROSS BETA-[9.4]
Ra-226-[1.2]
U-235 -[5.5]

OBMW10
GROSS ALPHA-[16.9] *
GROSS BETA-132 *
Ra-228 -[3.8]

BRMW11
Ra-226-1.3
Th-230 -[0.9]

OBMW11
Ra-226-1.6
Th-230 -[1.1]

OBMW6
GROSS ALPHA-8.4
GROSS BETA-12.5
Ra-226 -[1.4]
U-234 -[1.4]

BRMW6
GROSS BETA-4.6
Ra-226 -[1.2]

Th-230 -[0.9]
BRMW2

B38W06B
Ra-228 -[3.8]

OBMW2
ND

B38W03B
GROSS ALPHA-[37.9] *
GROSS BETA-53.6 *

OBMW4
Ra-226 -2.3
Th-230 -[0.9]
U-235 -[11.1] JS *
U-238 -[14.5]JS *

BRMW4
Th-230 -1.6
Th-232 -[0.8]

B38W12A
GROSS BETA-76.6 *
U-234 -5.8
U-235 -0.9
U-238 -4.3

B38W12B
Th-230 -[1.1]
U-234 -1.9
U-235 -[0.2]
U-238 -1.1

MISS-4A
GROSS ALPHA-13.6
GROSS BETA-33

MISS-4B
GROSS BETA-22.2

OBMW7
Ra-226 -[1.7]
U-234 -12.4 *
U-235 -[0.5] *
U-238 -7.2 *

BRMW7
Ra-226-[1.5]
Th-230 -[1.4]
U-234 -2.2
U-238 -1.8

OBMW12
Ra-228 -5.0

BRMW12
GROSS BETA-[4.2]
Ra-228 -[2.9]
U-234 -2.1
U-235 -[0.2]

GROSS ALPHA-[5.7]
GROSS BETA-20
Th-230 -2.5

B38W07B

Ra-226 -[1.8]
Th-230 -[0.9]

OBMW13
Ra-226 (D)-[1.4]
Th-230 -[1.4]
Th-232 (D)-[0.9]

BRMW13
Ra-226 -[0.9]
Th-230 -[1.4]
Th-232 -[0.5]
U-234 -[1.7]

OBMW1
BRMW1

STATE ROUTE 17

OBMW14

BRMW14

GROSS ALPHA-53.8 *
GROSS BETA-61.3 *
Ra-226 -5.8
Ra-228 -5.1
Th-230 -[0.8]
U-234 -[6.03]
U-235 -[4.7]

GROSS ALPHA-37.2 *
GROSS BETA-41.1
Ra-226 -[1.2]
Ra-234 -2.7
U-235 -0.6
U-238 -3.0

GROSS ALPHA-20
GROSS BETA-15.2
Th-230 -[0.7]
U-234 -10.3 *
U-235 -1.9 *
U-238 -8 *

GROSS ALPHA-[13.2]
GROSS BETA-10.9
Ra-226 -3.6
U-234 -5.1
U-238 -3.8

BRMW3

OBMW3

GROSS BETA-[12.2]
Ra-226 -[1.5]
Th-230 -[1.3]
U-234 -4.5
U-238 -2.8

BRMW5

OBMW5

Ra-226 -4.8
Ra-228 -6.4
Th-230 -[1.6]
U-234 -3.8
U-235 -[0.4]
U-238 -3.0

Ra-226 3.7
Ra-228 -5.5
Th-230 -[0.8]
Th-232 -0.7
U-234 -2.0

BRMW8
U-234 -3.8
U-235 -[0.3]
U-238 -2.6

OBMW8
GROSS ALPHA-40.7 *
GROSS BETA-[13.1]
Ra-226 -5.8
Ra-228 -[4.6]
Th-230 -[1.0]
U-234 -4.6
U-235 -[0.7]
U-238 -4.4

BRMW9
GROSS ALPHA-[11.2]
GROSS BETA-15.0
Ra-228 -5.5
U-234 -[0.5]

0 200 400 600

SCALE 1"=200'

N.Y. SUSQUEHANNA & WESTERN RAILROAD
HUNTER AVENUE
MAYWOOD AVENUE
GROVE AVENUE
BECKER AVENUE

LEGEND:

- PROPERTY LINE
- FENCE
- OBMW1 — WELL LOCATION WHERE ANALYTE DOES NOT EXCEED SDWA MCLs
- OBMW1 — WELL LOCATION WHERE ANALYTE EXCEEDS SDWA MCLs
- * — ANALYTE EXCEEDS SDWA MCL
- OBMW1 — WELL IS SCREENED IN BEDROCK
- OBMW1 — WELL IS PRIMARILY SCREENED IN OVERBURDEN
- (D) — RESULTS ARE FROM THE ANALYSIS OF DUPLICATE SAMPLE
- [ ] — VALUES FOR WHICH THE COUNTING ERROR IS EQUAL TO OR GREATER THAN 50% OF THE DETECTED VALUE
- J — ESTIMATED VALUE
- S — MATRIX SPIKE RECOVERY CRITERIA NOT MET
- ND — ANALYTES WERE NOT DETECTED AT THE DETECTION LIMITS USED FOR THE ANALYSES
- NT — SAMPLE NOT TAKEN FOR RADIOLOGICAL ANALYSES

NOTES:

1. CONCENTRATIONS ARE IN UNITS OF pC i/g.
2. DETECTED VALUES WERE COMPARED TO PROPOSED SDWA MCLs (56 FR 33050, JULY 18,1991). GROSS BETA VALUES WERE COMPARED TO PROPOSED PRESUMPTIVE COMPLIANCE LEVEL -THOSE EXCEEDING THAT LEVEL MAY NOT NECESSARILY BE ABOVE THE PROPOSED GROSS BETA MCL OF 4 mrem ede/yr. INDIVIDUAL U ISOTOPES BELOW 13.5 pCi/l MCL ARE MARKED WITH ASTERIKS BECAUSE MCL APPLIES TO TOTAL-U. AND SUM OF U ISOTOPES DETECTED IS GREATER THAN MCL. THE ACTUAL U MCL IS 20ug/L. AND APPLIES TO TOTAL-U, NOT EACH ISOTOPE. THE INDIVIDUAL U-ISOTOPE LIMIT (13.5 pCi/L) IS PRESENTED FOR ILLUSTRATIVE PURPOSES ONLY.
3. IF CONSTITUENT WAS NOT DETECTED IN SAMPLE, DUPLICATE SAMPLE RESULT IS PRESENTED.
4. DUPLICATE SAMPLE OBMW14D DETECTED ONLY GROSS BETA AT 19.4 ± 11 pCi/l.

STEPAN COMPANY AND SEARS AND ADJACENT PROPERTIES RI
MAYWOOD, NEW JERSEY

FIGURE 4-42
RADIOLOGICAL RESULTS IN GROUNDWATER
JULY-AUGUST 1992

Table 4-24
Comparison of Groundwater VOC Results to State and Federal Requirements

Analyte	NJDEPE Groundwater Quality Criteria (ppb) [a]	Federal Standard (ppb)	Remedial Investigation			Focused Investigation		
			Concentration Range (ppb) [b]	Location of Maximum Concentration		Concentration Range (ppb) [b]	Location of Maximum Concentration	
				Property	Well No.		Property	Well No.
cis-1,2 DCE	10	70 [c]	0.2J – 2,300	Stepan	B38W04B	0.1J – 1,000	Stepan	BRMW2
Benzene	0.2	5 [c]	0.2J – 33,000	Stepan	OBMW2	0.1J – 27,000	Stepan	OBMW2
Chloroform	6	100 [d]	0.2J – 1	Stepan Gulf	B38W18D BRMW3	0.2J – 3	Stepan	BRMW15
Xylene (Total)	40	10,000 [c]	0.8J – 4,000	Stepan	B38W04B	0.1J – 4,900	Stepan	B38W04B
TCE	1	5 [c]	0.4J – 4	DeSaussure Sears	B38W12B BRMW14	0.1J – 520	Sears	OBMW4
PCE	0.4	5 [c]	0.2J – 4	Gulf	BRMW3	0.1J – 4	Gulf	BRMW3
Toluene	1,000	1,000 [c]	0.05J – 1,500	Gulf	OBMW3	0.1J – 710	Stepan	MW1
Vinyl Chloride	0.08	2 [c]	1 – 2,100	Stepan	B38W04B	0.2J – 1,800	Sears	BRMW1
Ethylbenzene	700	700 [c]	0.2J – 1,100	Stepan	B38W04B	0.1J – 1,400	Stepan	B38W04B [d]
Methylene Chloride	2	--	15	Stepan	B38W03B	130J	Stepan	MW1
Acetone	700	--	16J – 21J	Sears	BRMW14	6J	Stepan	BRMW15
1,2 DCA	0.3	5 [c]	0.2J – 1J	Sears	BRMW14	0.4J – 1J	Sears	BRMW14
1,1,1 TCA	30	200 [c]	0.2J – 0.4J	DeSaussure	B38W12B	0.1J – 44	Gulf	OBMW3
1,1-DCE	1	7 [c]	0.2J	Sears	BRMW11	ND		
Trans-1,2-DCE	100	100 [c]	0.6J	Federal Express	BRMW12	ND		
1,2 Dichlorobenzene	600	600 [d]	0.4J	Sunoco	BRMW5	ND		
1,1 DCA	70	--	0.2 – 0.3J	SWS	BRMW8 BRMW8D	0.3J	SWS	BRMW8
1,2 Dichloropropane	--	5 [c]	0.4J	Stepan	BRMW15	ND		
1,3 Dichlorobenzene	600	--	0.2	Sears	OBMW4	0.1J – 0.5J	Sears	OBMW6
1,4 Dichlorobenzene	75	--	0.4	Stepan	WELL8	4J	Stepan	WELL8
cis-1,3-Dichloropropene	0.2	--	0.4	Stepan	BRMW15	0.2J	Stepan	B38W06B
Styrene	100	100 [c]	0.2	Sunoco	BRMW5	ND		
Dibromochloromethane	10	--	0.4	Stepan	BRMW15			
1,1,2,2 Tetrachloroethane	2	--	ND			0.3J – 2	Stepan	B38W06B
1,1,2 TCA	3	5 [c]	ND			0.5J	Stepan	B38W06B
1,2 Dibromomethane	--	--	ND			0.4J	Stepan	B38W06B
1,2 Dichloropropane	0.5	5 [c]	ND			0.3J	Stepan	B38W06B
2 Butanone	300	--	ND			2J	Stepan	BRMW2D
Bromoform	4	100 [d]	ND			0.3J	Stepan	B38W06B
Carbon Tetrachloride	0.4	5 [c]	ND			6J	Sears	OBMW4
Chloromethane	30	--	ND			0.2J – 0.7J	Stepan	OBMW17

[a] New Jersey Groundwater Cleanup Criteria, For Class II-A Groundwater, *New Jersey Register*, February 1, 1993.
[b] The concentration range is lowest and highest concentration of an analyte detected in all samples for this matrix.
[c] 40 CFR 141.60 – 40 CFR 141.62
[d] Drinking Water Regulations and Health Advisories from Office of Water U.S. Environmental Protection Agency, April, 1992.

Notes:
J = Estimated value.
ND = Undetected value.
-- = A standard for this analyte does not currently exist.

Table 4–25
Groundwater Analytical Results for Monitoring Wells OBMW18, OBMW19, and BRTW2

Analyte	NJDEPE Groundwater Quality Criteria [a]	Federal Standards	Well Number and Date Sampled				
			OBMW18 10/20/93	OBMW18D 10/20/93 Dup. of OB18	OBMW19 10/20/93	BRTW2 11/15/93	BRTW2D 11/15/93 Dup. of BRTW2
Volatile Organics (ppb)							
Acetone	700	--	--	--	--	52	--
Benzene	0.2	5 [b]	--	--	21	170	--
Chlorobenzene	4	--	--	--	--	0.8 J	0.6 J
1,3-Dichlorobenzene	600	--	--	280	--	--	--
1,4-Dichlorobenzene	75	--	--	--	--	0.5 J	0.5 J
1,2-Dichloroethane	0.3	5 [b]	--	--	--	9	5 J
Cis-1,2-Dichloroethene	10	70 [b]	--	--	--	240	81 J
Trans-1,2-Dichloroethene	100	100 [b]	--	--	--	0.9 J	--
Ethylbenzene	700	700 [c]	1,400	--	--	--	--
Methylene Chloride	2	--	--	--	--	0.6 J	--
4-Methyl-2-pentanone	400	--	--	--	--	3 J	--
1,1,2,2-Tetrachloroethane	2	--	--	--	--	1 J	--
Toluene	1,000	1,000 [b]	670	380	1 J	3	1 J
Xylene (total)	40	10,000 [b]	6,000	4,600	5	3	2 J
Vinyl Chloride	0.08	2 [b]	--	--	--	--	300 J
Semi-volatile Organics (ppb)							
bis(2-Ethylhexyl)phthalate	3	--	--	--	NA	NA	NA
Diethylphthalate	5,000	--	2 J		NA	NA	NA
Di-n-octylphthalate	100	--	10 J	--	NA	NA	NA
2-Methylnaphthalene	--	--	--	34 J	NA	NA	NA
Naphthalene	--	--	210	160 J	NA	NA	NA
Metals total (ppb)							
Aluminum	200	--	423	407	NA	NA	NA
Arsenic	0.02	50 [b]	6.3 B	5 B	NA	NA	NA
Barium	2,000	2,000 [b]	248	279	NA	NA	NA
Beryllium	0.008	4 [c]	5.7	9 J	NA	NA	NA
Calcium	--	--	229,000	230,000	NA	NA	NA
Cobalt	--	--	8.1 B	--	NA	NA	NA
Iron	300	--	12,000	6,240	NA	NA	NA
Lead	5	15 [b]	8 J	8 J	NA	NA	NA
Magnesium	--	--	38,800	40,000	NA	NA	NA
Manganese	50	--	16,800	15,100	NA	NA	NA
Mercury	2	2 [c]	0.11 B	--	NA	NA	NA
Potassium	--	--	35,400 B	36,400	NA	NA	NA
Sodium	50,000	--	274,000	274,000	NA	NA	NA
Vanadium	--	--	18.3 B	--	NA	NA	NA
Zinc	5,000	--	--	11.1 B	NA	NA	NA

[a] New Jersey Groundwater Cleanup Criteria, for Class II-A Groundwater, *New Jersey Register*, February 1, 1993.
[b] Drinking Water Regulations and Health Advisories from Office of Water U.S. Environmental Protection Agency, April, 1992.
[c] 40 CFR 141.60 – 40 CFR 141.62

Notes:
J = Estimated Value
B = Analyte was also detected in the laboratory blank
NA = Sample was not analyzed for this analyte

Table 4-26
Groundwater Semivolatile Organics Results Compared to State and Federal Requirements

Analyte	NJDEPE Groundwater Quality Criteria (ppb) [a]	Federal Standard (ppb)	Remedial Investigation			Focused Investigation		
			Concentration Range (ppb) [b]	Location of Maximum Concentration		Concentration Range (ppb) [b]	Location of Maximum Concentration	
				Property	Well No.		Property	Well No.
bis (2-ethylhexyl)phthalate	3	--	1J - 940	Federal Express	OBMW12	2J - 100	Stepan	MW1
Di-n-octylphthalate	--	--	3J - 5J	Stepan	BRMW15	ND		
Di-n-butylphthalate	900	--	1J - 4J	Sears	OBMW4	ND		
Butyl benzyl phthalate	100	100 [c]	12J - 25	Stepan	MISS4B	ND		
Naphthalene	--	--	3J - 160	Stepan	B38W04B	27 - 160	Stepan	MW1
2-Methylnaphthalene	--	--	2J - 21	Stepan	B38W04B	3J - 17	Stepan	B38W04B [d]
Pentachlorophenol	0.3	1 [e]	6J - 17J	Stepan	B38W03B	ND		
2,4-Dimethylphenol	100	--	13	Stepan	B38W04B	4J	Gulf	OBMW3
2-Methylphenol	--	--	7J	Gulf	OBMW3	ND		
4-Methylphenol	--	--	4J	Gulf	OBMW3	3J	Gulf	OBMW3
4-Nitrophenol	--	--	63J	Stepan	B38W03B	12J	Sears	OBMW13
Acenaphthene	400	--	1J - 1J	Stepan	WELL 1	ND		
Phenols	4000	--	13	Gulf	OBMW3	6J	Gulf	OBMW3
Pyrene	200	--	3	Stepan	WELL 1	ND		
Caffeine	--	--	2J	Stepan Stepan	B38W02D OBMW17	NA		
Benzoic Acid	--	--	ND			5J	Gulf	OBMW3
Isophorone	100	--	ND			17	Stepan	OBMW2

[a] New Jersey Groundwater Cleanup Criteria for Class II-A Groundwater, *New Jersey Register*, February 1, 1993.
[b] The concentration range is lowest and highest concentration of an analyte detected in all samples for this matrix.
[c] Drinking Water Regulations and Health Advisories form Office of Water U.S. Environmental Protection Agency, April 1992.
[d] Maximum concentration was detected in the duplicate sample from well B38W4B.
[e] 40 CFR 141.60-40 CFR 141.62

Notes:
J = Estimated value.
ND = Undetected value.
NA = Samples were not analyzed for this analyte during the second round of groundwater sampling.
-- = A standard for this analyte does not currently exist.

Table 4–27
Groundwater Pesticide Results Compared to State and Federal Requirements

Analyte	NJDEPE Groundwater Quality Criteria (ppb) [a]	Federal Standard (ppb)	Remedial Investigation			Focused Investigation		
			Concentration Range (ppb) [b]	Location of Maximum Concentration		Concentration Range (ppb) [b]	Location of Maximum Concentration	
				Property	Well No.		Property	Well No.
BHC–Gamma (Lindane)	0.2	0.2 [c]	0.071 – 0.29	Stepan	B38W18D	ND		
Dieldrin	0.002	--	0.14 – 0.49	Stepan	BRMW15	0.19 – 0.57	Stepan	BRMW15
Heptachlor Epoxide	0.008	0.2 [d]	0.10	Stepan	BRMW15	0.21	Stepan	BRMW15
Alpha–Chlordane	--	--	ND			0.64	Stepan	BRMW15
Gamma–Chlordane	--	--	ND			0.58	Stepan	BRMW15

[a] New Jersey Groundwater Cleanup Criteria. For Class II–A Groundwater, *New Jersey Register*, February 1, 1993.
[b] The concentration range is lowest and highest concentration of an analyte detected in all samples for this matrix.
[c] 40 CFR 141.60 to 40 CFR 141.62
[d] Drinking Water Regulations and Health Advisories from Office of Water U.S. Environmental Protection Agency, April 1992, unless noted.

Notes:
It should be noted that PCBs were also analyzed for, but were not detected.
J = Estimated value.
-- = A standard for this analyte does not currently exist.
ND = Undetected value

Table 4-28
Groundwater Inorganic Results Compared to State and Federal Requirements

Analyte	NJDEPE Groundwater Quality Criteria (ppb) [a]	Federal Standard (ppb)	Remedial Investigation			Focused Investigation		
			Concentration Range (ppb) [b]	Location of Maximum Concentration		Concentration Range (ppb) [b]	Location of Maximum Concentration	
				Property	Well No.		Property	Well No.
Aluminum	200	50 – 200 [c]	212 – 290,000	SWS	OBMW8	82.8 – 11,500	Sears	OBMW7
Antimony	2	6 [d]	6.1 – 11.6J	DeSaussure	B38W12A	47.9J	Stepan	B38W01S
Arsenic	0.02	50 [e]	2.4 – 131	Sunoco	OBMW5	1.3 – 235J [f]	Sunoco	OBMW5
Barium	2,000	2,000 [d]	13J – 2,860	SWS	OBMW8	10 – 1250	Sunoco	OBMW5
Beryllium	0.008	4 [d]	2 – 63	SWS	OBMW8	4J – 6.7	Stepan	WELL 8
Cadmium	4	5 [d]	6 – 42	Stepan/Sears	OBMW17/OBMW13	5.1J – 20	Stepan	OBMW2
Calcium	--	--	141 – 732,000	Sears	OBMW7	27,300 – 614,000	Stepan	OBMW2
Chromium	100	100 [d]	6J – 580	SWS	OBMW8	6J – 542	Sears	BRMW6
Cobalt	--	--	12J – 270	SWS	OBMW8	7.2 – 19.1	Sears	OBMW7
Copper	1,000	1,000 [d]	7J – 657	SWS	OBMW8	6 – 60.5	Stepan	MW1
Iron	300	300 [c]	456 – 645,000	SWS	OBMW8	26.7 – 45,700J	Sunoco	OBMW5
Lead	5	15 [e]	1.4J – 173	Stepan	WELL 2	1.6J – 8.4J	Sears	OBMW7
Magnesium	--	--	1,080J – 94,500J	SWS	OBMW8	1,120 – 83,700	Sears	BRMW1
Manganese	50	50 [d]	46 – 17,100	Sears	OBMW1	7.7J – 15,400 [f]	Sears	OBMW1
Mercury	2	2 [d]	0.11J – 0.74	Sears	OBMW4	0.12J – 0.25	SWS	BRMW8
Nickel	100	100 [d]	13 – 584	SWS	OBMW8	11.3 – 416	Federal Express	BRMW12 [g]
Potassium	--	--	1,000J – 137,000	Sears	OBMW10	900 – 115,000 [f]	Sears	OBMW10
Selenium	50	50 [d]	2.6 – 6.5J	Stepan	OBMW17	2J – 14.5J	Stepan/Sunoco	OBMW2/OBMW5
Silver	--	100 [c]	1.2J	Stepan	B38W02D	2J – 5.3	Stepan	BRMW2
Sodium	50,000	--	207J – 1,440,000	SWS	OBMW8	6,370 – 291,000 [f]	Sears	BRMW1
Thallium	0.5	2 [d]	ND			1 – 2J [f]	Sunoco	OBMW5
Vanadium	--	--	17J – 965	SWS	OBMW8	12.5 – 72.6	Sears	OBMW7
Zinc	5,000	5,000 [c]	8J – 1,400	SWS	OBMW8	6 – 239	Stepan	MW1
Cyanide	200	200 [d]	10.4 – 8,780	DeSaussure	B38W12A	14.4 – 476	DeSaussure	B38W12A
Lithium	--	--	9J – 78,300	Stepan	WELL 8	NA		

[a] New Jersey Groundwater Cleanup Criteria for Class II-A Groundwater, *New Jersey Register*, February 1, 1993.
[b] The concentration range is lowest and highest concentration of an analyte detected in all samples for the matrix.
[c] 40 CFR 143.3 (secondary maximum contaminant levels).
[d] 40 CFR 141.60 – 40 CFR 141.62 (MCL's).
[e] Drinking Water Regulations and Health Advisories from Office of Water, U.S. Environmental Protection Agency, April 1992.
[f] Maximum concentration was detected from a filtered sample.
[g] Maximum concentration was detected in the duplicate sample from well BRMW12.

Notes:
J = Estimated Value
-- = A standard for this analyte does not currently exist
NA = Samples were not analyzed for this analyte during the second round of groundwater sampling.
ND = Undetected value

Table 4-29
Summary of Radiological Constituents in Groundwater Samples

Analyte	Proposed SDWA MCLs (pCi/l)	Detected Minimum (pCi/l)	Detected Minimum Location	Detected Maximum (pCi/l)	Detected Maximum Location	Frequency (detects/total)	Number of Samples > Proposed SDWA MCL (>MCL/total)
Gross α	15.0	[5.7]	B38W7B	53.8	OBMW1	14/47	6/47
Gross β	50[a]	[4.2]	BRMW12	132	OBMW10	24/47	4/47[a]
Ra-226	20.0	[0.9]	BRMW13/ OBMW17	5.8	OBMW1	25/47	0/47
Ra-228	20.0	2.9	BRMW12	6.4	OBMW3	11/47	0/47
Th-230	82.7[b]	[0.7]	BRMW14/ OBMW15	2.5	B38W7B	24/47	0/47
Th-232	91.8[b]	[0.5]	BRMW13/ OBMW15	[0.9]	WELL 5	6/47	0/47
U-234	13.5[c]	[0.5]	BRMW9	12.4	OBMW7	20/47	4/47
U-235	13.5[c]	[0.2]	B38W12B/ BRMW12	[11.1]	OBMW4	14/47	
U-238	13.5[c]	1.1	B38W12B	[14.5]	OBMW4	15/47	

[a] Gross beta MCL is 4 mrem ede/year. 50 pCi/l criteria is the proposed presumptive screening level for compliance with the 4 mrem ede/year MCL.

[b] Th-230 and Th-232 MCLs are from Appendix C of 56 FR 33050 (July 18, 1991). Criteria is based on concentration in water for a lifetime cancer mortality risk of 1 E-4.

[c] Actual uranium MCL is 20 ug/l. The 13.5 pCi/l limit is based on a U-234/U-238 activity ratio of 1, and therefore assumes that uranium consists of natural uranium, which has a specific activity of 0.68 pCi/ug. The uranium MCL applies to total uranium, not each isotope, and is presented for each isotope for illustrative purposes only.

Notes: [] = Values for which the counting error is equal to or greater than 50% of the detected value (i.e., gross alpha was detected at a low concentration of 7.2 +/- 5.0 pCi/l)
Safe Drinking Water Act (SDWA) MCLs based on those proposed in 56 FR 33050 (July 18, 1991).
Frequencies do not include duplicate sample detects if analyte was detected in both original and duplicate samples.

Figure 4-28 presents the concentrations of the following ten compounds: TCE; 1,1-DCE; cis-1,2-DCE; trans-1,2-DCE; 1,1-DCA; 1,2-DCA; vinyl chloride; PCE; chloroform and methylene chloride. These compounds were grouped together because seven of the compounds are typically TCE degradation products. One or more of these ten compounds were detected in 28 wells. Of these 28 wells, 9 were located on the Stepan property, 1 was on Stepan amended, 9 were on Sears, 3 were on DeSaussure, 2 were on Federal Express, 2 were on SWS, 1 was on Gulf, and 1 was on Sunoco. TCE, cis-1,2-DCE, methylene chloride, PCE, and vinyl chloride were detected in groundwater samples at concentrations exceeding the NJDEPE groundwater quality criteria. Groundwater samples from 1 overburden well and 16 bedrock wells had concentrations of 1 or more of these compounds at levels above the NJDEPE groundwater quality criteria.

The following seven wells contained concentrations of TCE above the NJDEPE groundwater quality criterion of 1 ppb: BRMW12 (Federal Express), BRMW8 (SWS), BRMW4 (Sears), B38W12B (DeSaussure), OBMW17 (Stepan), BRMW11 (Stepan), and BRMW14 (Sears). The maximum concentration of TCE (4 ppb) was detected in wells B38W12B and BRMW14.

Cis-1,2-DCE was detected in the following four wells at concentrations exceeding the NJDEPE groundwater quality criterion of 10 ppb: B38W04B, OBMW11 (Sears), MISS4B, and BRMW14. The highest concentrations of cis-1,2-DCE were detected in wells B38W04B (2,300 ppb) and MISS4B (810 ppb).

Chloroform was detected in 14 groundwater samples. It was not detected in any of these samples at concentrations exceeding the NJDEPE groundwater quality criteria.

Methylene chloride was detected in only one well (B38W03B, Stepan). It was detected at a concentration of 15 ppb, which exceeds the NJDEPE groundwater quality criterion of 2 ppb.

PCE was detected in 11 of the 51 groundwater samples. It was detected at concentrations exceeding the NJDEPE groundwater quality criterion of 0.4 ppb in wells BRMW13 (Sears), BRMW3 (Gulf), BRMW7 (Sears), BRMW11 (Sears), BRMW14 (Sears), BRMW15 (Stepan), BRMW17 (Stepan), and OBMW17 (Stepan). The maximum concentration of PCE detected was 4 ppb, which was detected in BRMW3. PCE was detected in five wells on the Sears property, four wells on Stepan, one well on DeSaussure, and one well on Gulf.

Vinyl chloride was detected in the following five wells at concentrations exceeding the NJDEPE groundwater quality criterion of 0.08 ppb: B38W04B (Stepan), BRMW1 (Sears), BRMW11 (Sears), MISS4B (Stepan amended), and BRMW-14 (Sears). The highest concentrations of vinyl chloride were detected in wells B38W04B (2,100 ppb) and BRMW1 (1,200 ppb).

The boundaries represent an estimate of the horizontal extent of contamination because a more precise placement is not possible with the limited number of data points. Placement of the boundaries was done on the basis of an interpolation between well locations and where contaminants were detected at concentrations below the MCLs. These figures do not suggest that contamination in bedrock is uniform or occurs in discrete layers.

Figure 4-29 presents the concentrations of benzene, toluene, ethylbenzene, and xylene detected in the groundwater samples. These compounds were grouped together because they are often detected together in areas where gasoline contamination has occurred.

Benzene was detected in groundwater samples from a total of 18 wells (8 bedrock, 5 overburden, and 5 miscellaneous wells [NPC or DOE installed]). Six of these wells were located on Stepan, one was on Stepan amended, six were on Sears, one was on Gulf, two were on Sunoco, one was on SWS, and one was on DeSaussure. All eight of these groundwater samples had concentrations of benzene exceeding the NJDEPE groundwater quality criterion of 0.2 ppb. The highest concentration of benzene (33,000 ppb) was detected in the groundwater sample taken from well OBMW2 (Stepan). The groundwater sample from the bedrock component of the MW-2 couplet, BRMW2 (Stepan), had a benzene concentration of 55 ppb. Soil boring samples from boring C-44 (Stepan), located near the OBMW2/BRMW2 couplet, also contained elevated concentrations of benzene (4,700 ppb). The highest concentration of benzene detected in a bedrock well was 560 ppb; this was detected in the groundwater sample from well B38W04B. Groundwater samples from wells OBMW3 (Gulf), BRMW1 (Sears), MISS4B (Stepan amended), B38W04B, and OBMW2 all had concentrations of benzene greater than 100 ppb (greater than two orders of magnitude above the 0.2 ppb NJDEPE groundwater quality criteria). During purging and sampling of these five wells, chemical odors were noted.

Toluene was detected in a total of nine wells (two overburden, three bedrock, and four miscellaneous wells). Three of these wells were located on the Stepan property, one was on Stepan amended, one was on Sears, one was on Gulf, two were on SWS, and one was on DeSaussure. Toluene exceeded the NJDEPE groundwater quality criterion of 1,000 ppb in only one well (OBMW3), where it was detected at a concentration of 1,500 ppb.

Ethylbenzene was detected in groundwater samples from five wells (one overburden, three bedrock, and one miscellaneous well). Two of these wells were located on Stepan, one was on Gulf, one was on DeSaussure, and one was on SWS. Of these, groundwater samples from only two wells (B38W04B and OBMW3) contained concentrations of ethylbenzene exceeding the NJDEPE groundwater quality criterion of 700 ppb. Well B38W04B contained 1,100 ppb and well OBMW3 contained 740 ppb of ethylbenzene.

Xylene was detected in groundwater samples from 10 wells (4 overburden, 5 bedrock, and 1 miscellaneous well). Two of these wells were located on Stepan, one was on Stepan amended, one was on Sears, one was on Gulf, two were on Sunoco, two were on SWS, and one was on DeSaussure. Of these, groundwater samples from only two wells (B38W04B and OBMW3) contained concentrations of xylene exceeding the NJDEPE groundwater quality criterion of 40 ppb. Well B38W04B contained 4,000 ppb and well OBMW3 contained 2,800 ppb of xylene.

The boundaries represent an estimate of the horizontal extent of contamination because a more precise placement is not possible with the limited number of data points. Placement of the boundaries was done on the basis of an interpolation between well locations and where contaminants were detected at concentrations below the MCLs. These figures do not suggest that contamination in bedrock is uniform or occurs in discrete layers.

Focused Investigation. Twenty-four TCL VOCs were detected in the groundwater samples collected during the Focused Investigation July-August 1993 sampling event. Of these 24 TCL VOCs, 18 were also detected during the RI groundwater sampling and 6 were compounds which were not detected during the RI. However, these six TCL VOCs were detected in five or fewer groundwater samples from Focused Investigation sampling. Of the 24 TCL VOCs detected, 11 were detected at concentrations exceeding the NJDEPE groundwater quality criteria: cis-1,2-DCE, benzene, xylene (total), TCE, PCE, vinyl chloride, ethylbenzene, methylene chloride, 1,2-DCA, 1,1,1-TCA, and carbon tetrachloride. Table 4-25 compares RI and Focused Investigation groundwater results with state and federal regulatory levels.

One goal to the Focused Investigation was to located potential sources of BTEX contamination.

Four TCL VOCs were detected in the two new overburden wells OBMW18 and OBMW19 installed during Focused Investigation activities and sampled October 1993. Benzene, ethylbenzene, and xylene were the only TCL VOCs detected above the NJDEPE groundwater quality criteria. Table 4-25 provides the analytical results from sampling of wells OBMW18, OBMW19, and BRTW2 during the Focused Investigation. An expanded discussion of potential source areas for BTEX contamination is presented in Section 4.6.

Fourteen TCL VOCs were detected in the groundwater samples collected from pumping well BRTW2 in November 1993. Of these 14 compounds, only benzene, vinyl chloride, cis 1,2-DCE, and 1,2-DCA were detected above NJDEPE groundwater quality criteria. Vinyl chloride was detected at 300 ppb in the duplicate sample but was not detected at all in the sample from this well. Subsequent samples collected from BRTW2 did contain concentrations of vinyl chloride at approximately 550 ppb.

Samples from six of the seven wells that exceeded the NJDEPE groundwater quality criterion of 1 ppb for TCE during RI sampling also exceeded the criteria during

Focused Investigation sampling. Concentrations of TCE detected in these six wells during the Focused Investigation were similar to those concentrations detected during the RI. However, groundwater samples from wells B38W7B (Stepan amended), OBMW3 (Gulf), and OBMW4 (Sears), which did not contain TCE during the RI contained TCE concentrations of 3 ppb, 460 ppb, and 520 ppb respectively, during the Focused Investigation.

Figure 4-30 presents the concentrations of TCE and its degradation products detected in Focused Investigation groundwater samples. Figure 4-31 shows the potential horizontal extent of TCE; 1,1-DCE; cis-1,2-DCE; trans-1,2-DCE; 1,2-DCA; and vinyl chloride in concentrations exceeding the federal drinking water MCLs.

Cis-1,2-DCE was detected in two groundwater samples at concentrations exceeding the NJDEPE groundwater quality criterion of 10 ppb. These two samples were collected from wells OBMW11 (Sears) and BRMW1 (Sears). Cis-1,2-DCE, which was not detected in the groundwater sample from well BRMW1 during the RI, was detected at a concentration of 1,000 ppb during the Focused Investigation. The groundwater sample from well OBMW11 contained 12 ppb of cis-1,2-DCE. Groundwater samples from well B38W04B, which contained 2,300 ppb of cis-1,2-DCE during RI sampling, did not contain detectable concentrations of this compound during the Focused Investigation. It should be noted, however, that the detection limit for cis-1,2-DCE was 1,000 ppb, potentially masking lower concentrations of this contaminant. The concentration of cis-1,2-DCE in groundwater from well MISS4B decreased from 810 ppb, detected during the RI, to 10 ppb detected during the Focused Investigation.

In three groundwater samples, 1,2-DCA was detected in concentrations exceeding the NJDEPE groundwater quality criterion of 0.3 ppb. Samples from wells BRMW4 (Sears), BRMW14 (Sears), and OBMW3 (Gulf) contained 1,2-DCA in concentrations of 0.4 ppb, 1 ppb, and 19 ppb, respectively.

In groundwater samples from wells OBMW3 (Gulf) and OBMW4 (Sears), 1,1,1-TCA was detected at concentrations of 44 ppb and 41 ppb, respectively, both exceeding the NJDEPE groundwater quality criterion of 30 ppb.

Chloroform was detected in 13 of the groundwater samples collected during the Focused Investigation. It was not detected in any of these samples at concentrations exceeding NJDEPE groundwater quality criteria.

Methylene chloride was only detected in the sample from well MW-1 (Stepan). It was detected at a concentration of 130 ppb, exceeding the NJDEPE groundwater quality criteria. It was not, however, detected in the sample from well B38W03B, which exceeded the groundwater quality criteria during the RI.

PCE was detected in 13 groundwater samples during the Focused Investigation. It was detected at concentrations exceeding the NJDEPE groundwater quality criteria in samples from wells BRMW3 (Gulf), BRMW5 (Sunoco), BRMW7 (Sears), BRMW11 (Sears), BRMW13 (Sears), and BRMW17 (Stepan). Concentrations of PCE detected ranged from 0.5 ppb to 4 ppb.

All detected values for vinyl chloride in Focused Investigation groundwater samples exceeded the NJDEPE groundwater quality criterion of 0.08 ppb. However, the detection limit used in the analysis for vinyl chloride was 1 ppb. Notable differences between RI and Focused Investigation analytical results for vinyl chloride were that samples from well B38W4B, which contained 2,100 ppb of vinyl chloride during the RI, did not contain detectable concentrations during the Focused Investigation. It should be noted that the sample from B38W04B was diluted to the extent that the detection limits for vinyl chloride, benzene, xylene, and 1-2-dichloroethene were 1,000 ppb. In addition, the high volatility of vinyl chloride may also account for the variability in sampling results. Groundwater samples from well MISS4B also showed a decrease in the concentration of vinyl chloride, from 520 ppb, detected during the RI, to 20 ppb, detected during Focused Investigation sampling.

Figure 4-32 presents concentrations of benzene, toluene, ethylbenzene, and xylene detected in Focused Investigation groundwater samples. Figure 4-33 shows the potential horizontal extent of benzene, toluene, ethylbenzene, and xylene in concentrations exceeding the federal drinking water MCLs.

Benzene was detected above the NJDEPE groundwater quality criterion of 0.2 ppb in seven wells sampled during the July-to-August 1993 Focused Investigation sampling. The highest concentration of benzene (27,000 ppb) was detected in the sample from well OBMW2. The groundwater sample from this well also had the highest concentration of benzene during RI sampling. The benzene concentrations in three wells were significantly lower during the Focused Investigation than they were during the RI. The benzene concentration in well BRMW2 (Stepan) decreased from 55 ppb to 0.4 ppb; in well B38W04B (Stepan), the benzene concentration decreased from 560 ppb to no detection; in well MISS4B (Stepan), benzene concentration decreased from 190 ppb to 3 ppb. Benzene was also detected in the new well, OBMW19, at 21 ppb during the October 1993 sampling. It was not, however, detected in new well OBMW18. The sample from well BRTW2 (Sears), sampled November 1993, contained 170 ppb of benzene.

Toluene was not detected above NJDEPE groundwater quality criteria during Focused Investigation groundwater sampling. Toluene, which was detected in the groundwater sample taken from well OBMW3 (Gulf) at 1,500 ppb during the RI, was not detected in the Focused Investigation samples taken from this well. MW1 (Stepan), which was not sampled during the RI, contained 710 ppb of toluene. Toluene was detected in new wells OBMW18 (Stepan) and OBMW19 (Stepan) at concentrations of 670 ppb and 1 ppb, respectively. It was also detected in the sample from well BRTW2 (Sears) at a concentration of 3 ppb.

Xylene was detected in four groundwater samples at concentrations exceeding the NJDEPE groundwater quality criterion of 40 ppb. The sample from well OBMW3 (Gulf) contained 1,200 ppb of xylene. This well contained 2,800 ppb of xylene during the earlier RI groundwater sampling. Focused Investigation samples from well B38W04B (Stepan) contained 4,800 ppb of xylene; xylene was detected at a concentration of 4,000 ppb in the RI samples taken from this well. The groundwater samples from well MW1 (Stepan) contained 2,900 ppb of xylene. Field personnel noted a strong chemical odor coming from this well during purging and sampling.

Xylene was detected in samples from new wells OBMW18 and OBMW19 at concentrations of 6,000 ppb and 5 ppb, respectively. It was also detected in the sample from well BRTW2 (Sears) at a concentration of 3 ppb.

4.4.2 TCL Semivolatile Organics

RI. The TCL semivolatile organic compounds (PAHs and non-PAHs) and caffeine detected in the RI groundwater samples are presented in Figure 4-34. Four semivolatile PAHs and 10 semivolatile non-PAHs were detected in the groundwater samples. No PAHs were detected in groundwater samples at concentrations exceeding the NJDEPE groundwater quality criteria. Bis(2-ethylhexyl) phthalate and pentachlorophenol were the only non-PAHs detected in groundwater samples at concentrations exceeding NJDEPE groundwater quality criteria. It should be noted that during the purging and sampling of well B38W04B, which contained the highest concentrations of naphthalene, field personnel noticed a chemical odor. The groundwater from B38W04B was also described as being turbid and black-gray in color.

Bis(2-ethylhexyl)phthalate was detected in the groundwater samples taken from wells OBMW12 (Federal Express), BRMW15 (Stepan), and BRMW11 (Sears) at concentrations of 940 ppb, 81 ppb, and 61 ppb, respectively, all of which exceed the NJDEPE groundwater cleanup criterion of 3 ppb. The soil boring at well location BRMW11 showed a maximum concentration of 68 ppb for bis(2-ethylhexyl)phthalate. The boring at BRMW15 had a concentration of 63 ppb and the boring at OBMW12 had no bis(2-ethyhexyl)phthalate detected. Bis(2-ethylhexyl)phthalate was also detected at levels exceeding NJDEPE groundwater quality criteria in samples from wells OBMW17 (Stepan) and OBMW2 (Stepan) at concentrations of 3 and 4 ppb, respectively.

Pentachlorophenol was detected in the groundwater samples from wells B38W03B (Stepan) and BRMW2 (Stepan) at concentrations of 17 ppb and 6 ppb, respectively, exceeding the NJDEPE groundwater quality criterion of 0.3 ppb.

Caffeine was detected in only two groundwater samples. These samples were taken from wells B38W02D (Railroad) and OBMW17 (Stepan).

Focused Investigation. The TCL semivolatile organic compounds (PAHs and non-PAHs) detected in the Focused Investigation groundwater samples are presented in Figure 4-35. Table 4-25 compares the results of analysis of RI and Focused Investigation groundwater semivolatile organics against state and federal requirements. Four semivolatile organic PAHs and six non-PAHs were detected in the groundwater samples. No PAHs were detected in the groundwater samples at concentrations exceeding the NJDEPE groundwater quality criteria. Bis(2-ethylhexyl)phthalate was the only non-PAH detected above the NJDEPE groundwater quality criteria. Groundwater samples from eight wells contained concentrations of bis(2-ethylhexyl)phthalate above NJDEPE groundwater quality criteria of 3 ppb.

None of the three wells sampled during the RI that had exceedances for bis(2-ethylhexyl)phthalate had exceedances during Focused Investigation sampling. The highest concentration of bis(2-ethylhexyl)phthalate detected during the Focused Investigation was 100 ppb detected in the sample taken from well MW1 (Stepan).

Of the three new wells--OBMW18, OBMW19, and BRTW2--only OBMW18 was analyzed for semivolatile organics. Naphthalene, diethylphthalate, di-n-octylphthalate, and 2-methylnaphthalene were the only semivolatile organics detected in the groundwater samples taken from this well. Although naphthalene was detected at elevated levels, none of these compounds was detected at concentrations exceeding the NJDEPE groundwater quality criteria.

4.4.3 TCL Pesticides and PCBs

RI. The TCL pesticide analytical data for the RI groundwater samples are presented in Figure 4-36. The pesticides detected in groundwater samples were BHC-gamma (lindane), dieldrin, and heptachlor epoxide. These three pesticides were not detected in any of the soil boring, blue material, or test-pit samples analyzed. BHC-gamma (lindane) was detected in six of the groundwater samples analyzed, at concentrations ranging from 0.070 ppb to 0.29 ppb (the NJDEPE groundwater quality criterion is 0.20 ppb). These samples were taken from the following wells: B38W18D (Stepan), BRMW17 (Stepan), BRMW13 (Sears), OBMW11 (Sears), OBMW13 (Sears), and BRMW4 (Sears). The two that exceeded the cleanup standard were from wells OBMW11 and B38W18D, at 0.21 ppb and 0.29 ppb, respectively.

The NJDEPE groundwater quality criterion for dieldrin is 0.002 ppb. However, the detection limit for dieldrin used in the analysis of groundwater samples was 0.10 ppb. Dieldrin was detected in three groundwater samples taken from the following wells: BRMW16 (Stepan), OBMW15 (Stepan), and BRMW15 (Stepan) at concentrations ranging from 0.14 ppb to 0.49 ppb.

Heptachlor epoxide was detected only in the groundwater sample taken from well BRMW15 (Stepan). The concentration of heptachlor epoxide detected in this

groundwater sample (0.10 ppb) was below the NJDEPE groundwater quality criterion of 0.004 ppb. However, the detection limit for heptachlor epoxide used in the analysis of groundwater samples was 0.05 ppb.

TCL PCBs were not detected in any of the groundwater samples during the RI.

The TCL pesticide analytical data for Focused Investigation groundwater samples are presented in Figure 4-37. Table 4-27 compares the results of analysis of groundwater pesticide under the RI and Focused Investigation against state and federal requirements. Only five wells were analyzed for pesticides during the Focused Investigation. The five wells were B38W05B (Stepan), B38W18D (Stepan), BRMW15 (Stepan), BRMW16 (Stepan), and OBMW15 (Stepan). Dieldrin, heptachlor epoxide, and total chlordane were the only pesticides detected in the groundwater samples at concentrations exceeding the NJDEPE groundwater quality criteria. Dieldrin was detected in groundwater samples taken from wells BRMW15, B38W05B, and OBMW15 at concentrations of 0.57 ppb, 0.19 ppb, and 0.44 ppb, all exceeding the NJDEPE groundwater quality criterion of 0.002 ppb. Heptachlor epoxide and total chlordane were both detected in the sample taken from OBMW15 at concentrations of 0.21 ppb and 1.22 ppb respectively. It should be noted that the detection limit used in the analysis of the dieldrin and heptachlor epoxide was greater than the NJDEPE groundwater quality criteria for these compounds.

The differences in analytical results between the RI and Focused Investigation are shown on Figures 4-36 and 4-37. Complete data sets are provided in Appendix X. The majority of pesticides detected were in OBMW15 and BRMW15, located southeast of one of the Stepan burial areas reportedly used for thorium waste. The pesticides may be attributable to some hydraulically upgradient, offsite source.

TCL PCB analysis was not performed on any of the Focused Investigation groundwater samples.

4.4.4 TAL Metals and Cyanide

TAL metals and cyanide analyses were performed on unfiltered groundwater samples. Therefore, the analytical results are for total metals and cyanide.

Figures 4-38 and 4-39 show concentrations of selected metals detected in groundwater samples. The selection of metals presented in these figures was based on the frequency of detections and the number of samples exceeding the NJDEPE groundwater quality criterion.

The following metals were detected at concentrations exceeding the NJDEPE groundwater quality criteria: aluminum, antimony, arsenic, barium, beryllium, cadmium, chromium, lead, iron, manganese, nickel, and sodium.

Aluminum. Aluminum was detected in 36 groundwater samples. Of these 36 samples, all contained concentrations of aluminum above the NJDEPE groundwater quality criterion of 50 to 200 ppb. The highest concentration of aluminum was 290,000 ppb, which was detected in the sample taken from well OBMW8 (SWS).

Antimony. Antimony was detected in eight groundwater samples. Of these eight samples, all contained concentrations of antimony above the NJDEPE groundwater quality criterion of 2 ppb. Concentrations of antimony detected in the groundwater samples ranged from 6.1 ppb to 11.6 ppb. However, the detection limit for antimony used in the analysis of groundwater samples ranged from 5 ppb to 7 ppb.

Arsenic. Arsenic was detected in 30 groundwater samples. Of these 30 samples, all had concentrations of arsenic above the NJDEPE groundwater quality criterion of 0.02 ppb. However, the detection limit for arsenic used in the analysis of the groundwater samples was 2 ppb.

The highest concentrations of arsenic were in groundwater samples taken from wells OBMW5 (Sunoco) and OBMW14 (Sears), which had concentrations of 131 ppb and 129 ppb, respectively (Figure 4-38).

Barium. Barium was detected in all groundwater samples. The concentrations of barium ranged from 13 ppb to 2,860 ppb. Only four (three samples plus one duplicate) had concentrations of barium exceeding the NJDEPE groundwater quality criterion of 2,000 ppb (Figure 4-39). These four samples were taken from wells OBMW8 (SWS), OBMW5 (Sunoco), and OBMW13 (duplicate was taken from OBMW13), which had concentrations of 2,860 ppb, 2,530 ppb, and 2,170 ppb (2,780 ppb duplicate sample), respectively. During the purging and sampling of wells OBMW5 and OBMW8, the groundwater from these wells was described as brown and very turbid. Soil boring samples from borings C-15 and C-33, which were located in the vicinity of well OBMW5, had barium concentrations ranging from 36.5 ppm to 584 ppm. Soil boring samples from boring C-34, which was located in the vicinity of well OBMW8, had barium concentrations ranging from 31.5 ppm to 52.6 ppm.

Beryllium. Beryllium was detected in 21 groundwater samples. Of these 21 samples, all had concentrations of beryllium exceeding the NJDEPE groundwater quality criteria of 0.008 ppb (see Figure 4-38). However, the detection limit used in the analysis of groundwater samples was 2 ppb. Concentrations of beryllium detected in the groundwater samples ranged from 2 to 63 ppm, with the maximum concentration being detected in the sample from well B38W12A (DeSaussure).

Cadmium. On the basis of validated data, cadmium was detected in 13 of the 33 groundwater samples analyzed. The cadmium data for 18 groundwater samples were determined to be unusable during data validation. All of the 13 samples that contained cadmium showed concentrations exceeding the NJDEPE groundwater quality criterion of 4 ppb. Five of the 13 groundwater samples were collected from wells located on the Stepan property, 5 of the samples were from wells on Sears, 1

was from a well on Sunoco, 1 was from the railroad property, and 1 was from SWS (Figure 4-39). The highest concentrations of cadmium detected were in groundwater samples taken from wells OBMW17 (Stepan) and OBMW13 (Sears), both of which had 42 ppb of cadmium. The maximum cadmium concentrations detected in soil samples from borings in the vicinity of these wells was 2.4 ppm (C-9).

Chromium. Chromium was detected in 44 groundwater samples, 17 of which contained concentrations exceeding the NJDEPE groundwater quality criteria of 100 ppb. Thirteen of these samples were from overburden wells and four were from bedrock wells. Of these 17 groundwater samples, 7 were from wells located on the Stepan property, 6 were from wells on Sears, 1 was from Gulf, 1 was from Sunoco, 1 was from SWS, and 1 was from Federal Express (Figure 4-39). The highest concentrations of chromium detected were in groundwater samples taken from wells OBMW8 (580 ppb) and OBMW15 (532 ppb). The groundwater from well OBMW8 was described by field personnel as very turbid. However, the groundwater from well OBMW15 was described as clear and colorless.

Iron. Iron was detected in 50 of the 51 groundwater samples analyzed. The concentrations of iron detected in these samples exceeded the NJDEPE groundwater quality criterion of 300 ppb for all of these wells.

Lead. Lead was detected in 44 groundwater samples. Thirty of these samples contained concentrations of lead exceeding the NJDEPE groundwater quality criteria of 5 ppb. Of these 30 samples, 11 were from wells located on the Sears property, 12 were from Stepan, 2 were from Federal Express, 2 were from Gulf, 1 was from SWS, and 1 was from Sunoco (Figure 4-38). Groundwater samples from the following wells contained concentrations of lead greater than one order of magnitude above the NJDEPE groundwater quality criteria: Well 2 (Stepan), Well 5 (Stepan), OBMW1 (Sears), OBMW2 (Stepan), OBMW4 (Sears), OBMW5 (Sunoco), OBMW1 (Sears), OBMW4 (Sears), OBMW8 (SWS), OBMW11 (Sears), OBMW13 (Sears), OBMW14 (Sears), OBMW17 (Stepan), and B38W4B (Stepan). The highest concentration of lead was 173 ppb, which was detected in groundwater from Well 2. The groundwater from Well 2 was described by field personnel as cloudy with black particulates and as having a hydrogen sulfide ("rotten egg") odor.

Nickel. Nickel was detected in 36 of the groundwater samples analyzed. Of these 36 samples, 11 contained concentrations of nickel exceeding the NJDEPE groundwater quality criterion of 100 ppb (Figure 4-39). Nine of the 11 groundwater samples were from overburden wells and 2 were from miscellaneous wells. Of the 11 samples exceeding the NJDEPE groundwater quality criteria, 5 were taken from wells located on Sears (4 samples plus 1 duplicate), 4 were taken from wells located on Stepan, 1 was taken from Sunoco, and 1 was taken from SWS. The highest concentration detected was 584 ppb in the sample taken from well OBMW8 (SWS).

Manganese. Manganese was detected in all of the 50 groundwater samples analyzed. Of these 50 samples, 49 samples contained concentrations of manganese exceeding

the NJDEPE groundwater quality criteria of 50 ppb (Figure 4-40). Overburden wells tended to have concentrations of manganese one to two orders of magnitude greater than the bedrock wells. The highest concentration of manganese detected was 17,100 ppb, which was in the groundwater sample taken from OBMW1.

Sodium. Sodium was detected in all 52 groundwater samples analyzed at concentrations ranging from 207 ppb to 1,440,000 ppb. Sodium was detected in 16 of the 52 samples at concentrations exceeding the NJDEPE groundwater quality criterion of 50,000 ppb.

Lithium. Lithium, detected in 43 of the 51 groundwater samples analyzed, was found in the wells located on Stepan, Sears, Sunoco, DeSaussure, Federal Express, Gulf, and SWS properties (Figure 4-40). The highest concentration of lithium was detected in the groundwater sample from Well 8 (Stepan), at a concentration of 78,300 ppb.

Cyanide. Cyanide was detected in the groundwater samples taken from seven wells. Only one groundwater sample contained concentrations of cyanide exceeding the NJDEPE groundwater quality criterion of 200 ppb (Figure 4-40). This groundwater sample was from well B38W12A (DeSaussure), which had a cyanide concentration of 8,780 ppb.

Cyanide was detected at 157 ppm in the 3- to 4-foot interval of soil boring BM-3 (DeSaussure).

Focused Investigation. All 52 groundwater samples collected during the Focused Investigation were analyzed for total TAL metals. Analytical results are in Appendix X. Twenty-eight groundwater samples were also selected for filtered TAL metals analysis on the basis of the selection criteria discussed in Section 2.7.2. Total cyanide analysis was performed on only 13 wells during the Focused Investigation. These wells were selected by EPA.

Figure 4-41 shows concentrations of selected metals detected in groundwater samples. Table 4-27 comprises analytical results of groundwater metals and cyanide during the RI and Focused Investigation against state and federal requirements.

Well OBMW18 (Stepan) was installed as part of the Focused Investigation and sampled in October 1993. As discussed in Section 2.10, this well was installed and sampled as part of the source delineation study. The sample from this well was also analyzed for total TAL metals. Table 4-25 shows concentrations of metals detected in this well.

Aluminum. Aluminum was detected in 47 groundwater samples (including the sample taken from OBMW18). Of these 47 samples, all contained concentrations of aluminum above the NJDEPE groundwater quality criteria. The highest concentration detected was 11,500 ppb, which was detected in the sample taken from well OBMW7 (Sears). Concentrations of aluminum detected in samples collected

during the Focused Investigation using the low-flow purge/sample method were orders of magnitude less than the concentrations in samples collected during the initial RI. Seventeen of the 28 filtered metals samples exceeded the NJDEPE groundwater quality criteria. The highest concentration of aluminum in filtered metals samples was 687 ppb.

Antimony. Antimony was not detected in any of the groundwater samples analyzed for the total or filtered metals.

Arsenic. Arsenic was detected in 17 groundwater samples (including the sample taken from OBMW18). All 17 of these groundwater samples contained concentrations of arsenic exceeding the NJDEPE groundwater quality criteria. Concentrations of arsenic detected during the Focused Investigation were usually less than those detected during the initial RI, with the exception of samples taken from wells OBMW5 (Sunoco), OBMW10 (Sears), and OBMW13 (Sears). The highest concentration of arsenic was 235 ppb, detected in the sample taken from well OBMW5 (Sunoco). Nine of the 28 filtered groundwater samples also exceeded the NJDEPE groundwater quality criteria.

Barium. Barium was detected in 52 of the groundwater samples (including the sample taken from OBMW18) that were analyzed for total metals and in 28 of the samples analyzed for filtered metals. However, barium was not detected in any of the samples at concentrations exceeding the NJDEPE groundwater quality criteria.

In general, similar concentrations of barium were detected during the RI and Focused Investigation. Concentrations in the Focused Investigation differ by about $\pm$ 10 to 20% of the RI concentration. In the three wells that exceeded the barium criteria during the RI, the concentrations have greatly decreased. The concentrations have decreased from 2,530 to 1,250 ppb in OBMW5; 2,860 to 557 ppb in OBMW8; and 2,780 to 378 ppb in OBMW13.

Beryllium. Beryllium was detected in only seven groundwater samples. The samples were taken from the following wells: BRMW9 (SWS), OBMW7 (Sears), OBMW12 (Federal Express), B38W12A (DeSaussure), B38W1S (Railroad), Well 8 (Stepan), and OBMW18 (Stepan). Samples from these wells exceeded the NJDEPE groundwater quality criteria of 0.008 ppb. The filtered metals samples from wells OBMW7 and OBMW12 also contained concentrations of beryllium above the criterion. However, it should be noted the detection limit for beryllium used in the total and filtered metals analysis ranged from 1 to 5 ppb.

Cadmium. Cadmium was detected in 18 of the groundwater samples. All of these samples exceeded the NJDEPE groundwater quality criteria. The highest concentration of cadmium detected was 20 ppb, which was detected in the sample taken from well OBMW2 (Stepan). Cadmium was detected in only four of the filtered metals samples. These four wells included OBMW1 (Sears), OBMW2 (Stepan), OBMW13 (Sears), and Well 2 (Stepan). All four of these samples

contained concentrations of cadmium above the NJDEPE groundwater quality criterion. The highest concentration of cadmium detected in the filtered metals samples was 16 ppb, which was detected in the sample taken from well OBMW2.

Chromium. Chromium was detected in 18 groundwater samples, or less than half the number of samples in which chromium was detected during the initial RI. Of these 18 samples, only the samples from wells BRMW6 (Sears), BRMW12 (Federal Express), BRMW15 (Stepan), and OBMW15 (Stepan) exceeded the NJDEPE groundwater quality criteria. The highest concentration of chromium detected was 542 ppb. Chromium was only detected in the filtered metals samples from wells OBMW2 (Stepan) and B38W18D (Stepan). Chromium was not detected in either sample at concentrations exceeding the NJDEPE groundwater quality criteria.

Iron. Iron was detected in 50 of the groundwater samples (including the sample from OBMW18). In general, the concentrations of iron detected during the Focused Investigation were less than half as high as the concentrations detected during the initial RI. Of the 50 samples containing iron, 34 contained concentrations exceeding the NJDEPE groundwater quality criteria. Iron was also detected in 16 of the filtered metals samples, at levels exceeding the criteria.

Lead. Lead was detected in 12 of the groundwater samples (including the sample from OBMW18). Only six of these samples contained concentrations of lead exceeding the NJDEPE groundwater quality criteria. These samples were collected from wells BRMW5 (Sunoco), OBMW5 (Sunoco), BRMW6 (Sears), BRMW12 (Federal Express), BRMW15 (Stepan), and OBMW18 (Stepan). The highest concentration of lead detected was 8.4 ppb, which was detected in the sample taken from well OBMW7 (Sears). In the filtered metals samples, lead was detected in only one sample, taken from well OBMW12. The concentration of lead did not exceed the criteria.

Manganese. Manganese was detected in all 53 groundwater samples analyzed (including the sample from OBMW18). Thirty-nine of these samples contained concentrations of manganese exceeding the NJDEPE groundwater cleanup criteria. Manganese was also detected in all of the filtered metals samples. Twenty-five of these samples contained manganese at concentrations exceeding the criteria. The concentrations of manganese detected in the total and filtered samples collected during the Focused Investigation were similar to the total metals samples collected during the initial RI.

Nickel. Nickel was detected in 28 of the groundwater samples. Only four (three samples and one duplicate sample) of these samples contained concentrations exceeding the NJDEPE groundwater quality criteria. These four samples were collected from wells BRMW12 (Federal Express) and B38W12B (DeSaussure). The highest concentration detected was 416 ppb, which was detected in the duplicate

sample from well BRMW12. The filtered metals sample in from well B38W12B also exceeded the NJDEPE groundwater cleanup criteria for nickel. This was the only filtered metals sample in which nickel was detected above the criteria.

Sodium. Sodium was detected in all of the total and filtered groundwater samples. Sixteen of the total metals and 12 filtered metals samples contained concentrations exceeding the NJDEPE groundwater quality criteria. The highest concentration of sodium was 291,000 ppb, which was detected in the filtered metals sample taken from well BRMW1 (Sears).

Cyanide. Of the 13 groundwater samples analyzed for cyanide, it was detected only in 5 (2 were duplicates). In only one sample did concentrations exceed NJDEPE groundwater quality criteria. This duplicate sample, which was collected from well B38W12A (DeSaussure), had 476 ppb of cyanide detected. During the initial RI groundwater sampling of the well, 8,780 ppb of cyanide was detected.

Cyanide was also detected in monitoring wells BRMW7 (Sears) and BRMW8 (SWS) during the Focused Investigation at concentrations an order of magnitude lower than B38W12A. The concentrations were 28.6 and 14.4 ppb in BRMW7 and BRMW8, respectively. During the RI, cyanide was detected at 10.4 and 15.5 ppb in BRMW7 and BRMW8, respectively.

4.4.5 Radiological Parameters

Remedial Investigation. Forty-four of the 47 groundwater samples collected contained detectable quantities of radiological constituents. Well 8 (Stepan) was not sampled for radiological parameters. Detected values were compared to the proposed SDWA MCLs (56 FR 33050). Table 4-29 summarizes detected radiological parameters in groundwater and MCL comparison criteria. Concentrations of detected radiological parameters at each well location are presented in Figure 4-42.

Gross alpha was detected in 14 of the 47 groundwater samples, at a maximum concentration of 53.8 ± 16.6 pCi/L (OBMW1; Sears). Gross alpha values were adjusted by subtracting detected Ra-226 and uranium values; the adjusted value was compared to the proposed MCL. Six well samples showed gross alpha above the proposed MCL of 15 pCi/L. Gross beta was detected in 24 of the 47 wells sampled, at a maximum concentration of 132 ± 10.4 pCi/L (OBMW10, Sears). Gross beta was detected above the proposed presumed compliance level of 50 pCi/L in four of the groundwater samples. Beta-emitter dose equivalents were not calculated to determine if samples were actually above the proposed beta/photon-emitter MCL of 4 mrem ede/yr.

Well samples containing gross alpha above the proposed MCL and/or gross beta above the presumed compliance level were collected from wells located on the Stepan property (two wells), Sears (three wells), SWS (one well), and DeSaussure (one well).

Ra-226 was detected at a maximum concentration of 5.8 ± 1.6 pCi/L in well OBMW1 (Sears) and at lower concentrations in 24 other wells. Ra-228 was detected in 11 of the 47 well samples, at a maximum concentration of 6.4 ± 2.5 pCi/L (OBMW3; Gulf). Ra-228 and Ra-226 were not detected above the proposed radium MCLs (20 pCi/L).

Th-230 was detected in 24 of the 47 groundwater samples, at a maximum concentration of 2.5 ± 0.6 pCi/L (B38W7B; Stepan amended). Th-232 was detected in six wells, at a maximum concentration of 0.9 ± 0.7 pCi/L (Well 5, Stepan). Th-230 and Th-232 were not detected above the proposed MCLs of 82.7 and 91.8 pCi/L, respectively.

U-234 was detected in 20 of the 47 monitoring wells, at a maximum concentration of 12.4 ± 1.1 pCi/L (OBMW7; Sears). U-235 and U-238 were detected in 14 and 15 of the 47 well samples, respectively. U-235 and U-238 were detected at maximum concentrations estimated at 11.1 ± 5.8 and 14.5 ± 9.3 pCi/L, respectively (OBMW4, Sears). Total uranium was detected above the proposed MCL of 13.5 pCi/L in 4 of the 47 well samples.

Groundwater samples containing uranium above the proposed MCL were collected from wells located on the Stepan property (one well) and the Sears (three wells).

The number and levels of radiological analytes detected in samples from wells across the study area are generally greater than in wells B38W01S and B38W02D. The groundwater elevation contours suggest that these two wells are hydraulically upgradient of the study area and may serve as background well locations for radiological contaminants.

4.5 Surface Water and Sediment

The field measurements and validated analytical laboratory results for surface water and sediment samples are discussed below. Full data tables, including results for quality control samples, are included as Appendix Y. The NJDEPE impact-to-groundwater soil-cleanup criteria were used as a conservative basis of comparison for the surface water sample results because surface water may be hydraulically connected to shallow groundwater at the site. Surface water sample results were also compared with FAWQC and NJSWQC. Surface water and sediment sampling locations are shown on Figure 4-43. The NJDEPE residential direct-contact soil-cleanup criteria were used to evaluate the sediment sample results. Sediment criteria developed by NOAA were also used as a conservative basis of comparison for potential impact of sediments on aquatic life.

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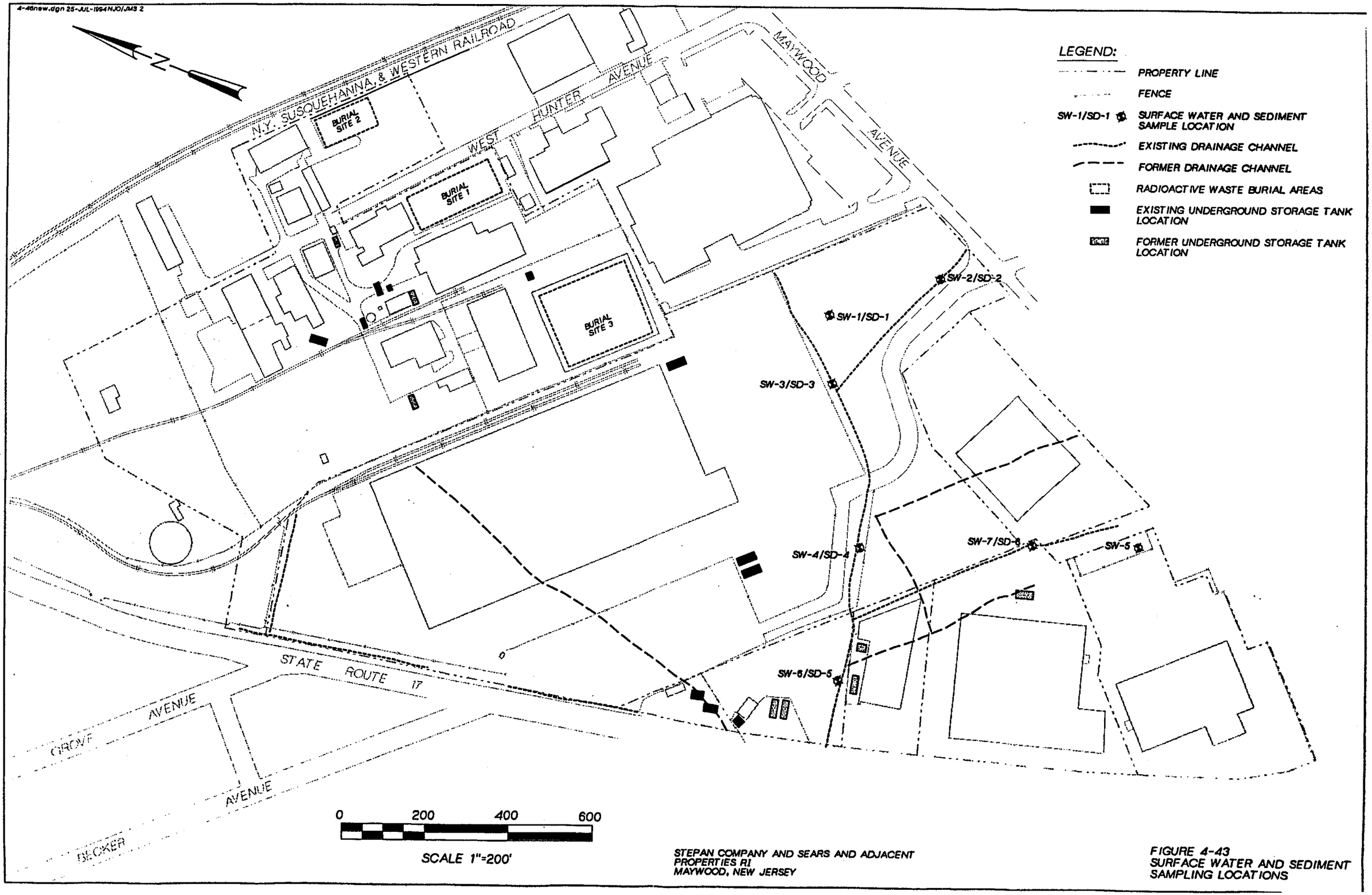

LEGEND:

- PROPERTY LINE
- FENCE
- SW-1/SD-1 — SURFACE WATER AND SEDIMENT SAMPLE LOCATION
- EXISTING DRAINAGE CHANNEL
- FORMER DRAINAGE CHANNEL
- RADIOACTIVE WASTE BURIAL AREAS
- EXISTING UNDERGROUND STORAGE TANK LOCATION
- FORMER UNDERGROUND STORAGE TANK LOCATION

STEPAN COMPANY AND SEARS AND ADJACENT PROPERTIES RI
MAYWOOD, NEW JERSEY

FIGURE 4-43
SURFACE WATER AND SEDIMENT SAMPLING LOCATIONS

4.5.1 Surface Water

Field monitoring results for surface water are shown in Table 4-30. Specific conductivities ranged from 60 to 690 umhos, and pH ranged from 6.09 to 6.67.

TCL VOCs. TCL VOCs were detected at low levels in surface water samples SW-1, SW-2, and SW-7. No VOCs were detected at levels above the NJDEPE groundwater quality criteria as shown in Table 4-31. The maximum concentrations of VOCs were 3 ppb for chloroform in SW-7; 3 ppb for cis-1,2-dichloroethylene in SW-2; 0.5 ppb (estimated) for dibromochloromethane in SW-7; and 2 ppb for toluene in SW-1.

Table 4-30
Surface Water Field Monitoring Results

Sample Location	Surface Water			Sediment
	pH (S.U.)	Temperature (°C)	Conductivity (umhos)	VOC Headspace (ppm)
SW-1/SD-1	6.67	22.9	610	0.6
SW-2/SD-2	6.54	20.7	60	0
SW-3/SD-3	6.77	25.4	690	0
SW-4/SD-4	6.59	23.8	610	0.3
SW-5	6.09	31.4	130	NA
SW-6/SD-5	6.13	23.7	510	0
SW-7/SD-6	6.5	23.7	390	3.7

TCL Semivolatile Organics. Five semivolatile organic compounds were detected in surface water samples, as listed in Table 4-31. Two of the five compounds were detected at levels above the NJDEPE groundwater quality soil-cleanup criteria: benzyl butyl phthalate and bis(2-ethylhexyl)phthalate. Butyl benzyl phthalate was detected only in sample SW-5, at a concentration of 120 ppb, which exceeds the groundwater cleanup criterion of 100 ppb. Bis(2-ethylhexyl)phthalate was detected in two samples: in SW-5 at 2 ppb (estimated), and in SW-6 at 120 ppb. The cleanup criteria is 30 ppb. Sediments at these sampling locations had detectable levels of bis(2-ethylhexyl)phthalate ranging from 310 ppb to 25,000 ppb.

TCL Pesticides and PCBs. Lindane was the only TCL pesticide detected in surface water samples. Lindane was detected in sample SW-4 at a concentration of 0.07 ppb, which is below the NJDEPE groundwater cleanup criterion of 0.2 ppb. No TCL PCBs were detected in surface water samples.

Table 4- 31
Surface Water Chemical Analysis Results Compared to State and Federal Requirements

Analyte	NJDEPE Groundwater Quality Criteria (ppb) [a]	FAWQC (ppb) [b]		Range of Concentrations (ppb)	Location of Max. Conc.
		Acute	Chronic		
Aluminum	200	750	87	263 - 8370	SW01
Antimony	20	na	na	7.3J	SW01
Arsenic	8	360 [c]	190 [c]	3.1J - 12.8J	SW01
Barium	2000	na	na	17J - 238	SW01
Copper [d]	1000	30	19	10J - 54	SW01
Lead [d]	10	169	6.6	4.2 - 184	SW01
Lithium	na	na	na	14J - 38	SW06
Mercury	2	2.4	0.012	0.23	SW01
Vanadium	na	na	na	16J	SW02
Zinc [d]	5000	190	172	6J - 470	SW01
Cyanide	200	22	5.2	7.2J - 17.8J	SW07
Chloroform	6	na	na	3	SW07
Dibromochloromethane	10	na	na	0.5J	SW07
Toluene	1000	na	na	0.8J - 2	SW01
cis-1,2-Dichloroethylene	10	na	na	3	SW02
Bis(2-Ethylhexyl)Phthalate	30	na	na	2J - 120	SW05
Butylbenzyl Phthalate	100	na	na	120	SW05
Di-n-Butyl Phthalate	900	na	na	1J	SW01
Di-n-Octyl Phthalate	100	na	na	18	SW05
Fluoranthene	300	na	na	2	SW01
gamma-BHC	0.2	2	0.08	0.07	SW04

[a] New Jersey Groundwater Cleanup Criteria. For Class II-A Groundwater, New Jersey Register, February 1, 1993.

[b] Federal Ambient Water Quality Criteria (FAWQC) are from Section 131.36(b)(1) of 40 CFR 60910 (December 22, 1992). The New Jersey Surface Water Quality Criteria (NJSWQC) were found to be identical to the FAWQC for these chemicals, and they can be found in Section 7:9B-1.14(c) of 25 NJR 5651 (December 6, 1993)

[c] Number assumes a water effect ratio (WER) of 1.0.

[d] Quality criterion determined on basis of water hardness.

Notes:

na - values not available.

TAL Metals and Cyanide. Seventeen TAL metals were detected in surface water samples. Lead and arsenic were detected at levels above the NJDEPE groundwater quality criteria. Lead was detected above the criterion of 5 ppb in samples SW-1 (184 ppb), SW-3 (10.4 ppb), SW-4 (32.6 ppb), SW-5 (11.9 ppb), SW-6 (5.5 ppb), and SW-7 (41.7 ppb). Arsenic was detected above the criterion of 0.02 ppb in sample SW-1 (12.8 ppb), SW-2 (3.1 ppb), SW-4 (6.2 ppb), and SW-6 (4.9 ppb).

Cyanide was detected in five surface water samples. Estimated concentrations ranged from 7.2 ppb in sample SW-6D to 17.8 ppb in sample SW-7. These concentrations are well below the cleanup criterion of 200 ppb.

Lithium was detected in four surface water samples. Concentrations ranged from 14 ppb (estimated) in sample SW-1 to 38 ppb in sample SW-6.

Comparison of Surface Water Criteria. Five of the metals--aluminum, copper, lead, mercury, and zinc--along with cyanide had concentrations that were detected above the freshwater chronic exposure concentrations of the FAWQC for these analytes. The FAWQCs, listed in Table 4-31, are identical to the NJSWQCs for the chemicals listed in the table. Because the drainage ditches convey surface water intermittently and are located within a commercial area, the FAWQCs and NJSWQCs serve as a conservative basis for comparison.

Radiological Parameters. Ra-228 , Th-232, U-234, and U-238 were not detected in surface water samples. Radiological constituents that were detected were compared to the proposed SDWA primary drinking water MCLs (56 FR 33050). Table 4-32 summarizes detected levels and lists the MCL comparison criteria. No results of radiological analysis of the surface water samples rendered results above comparison criteria levels.

Gross alpha was detected in one sample (SW-6, Sunoco) at a concentration of 9.3 ± 6.0 pCi/L. The duplicate sample (SW-6D) contained gross alpha at a concentration of 7.2 ± 5.0 pCi/L. Gross beta was detected in six samples; the maximum concentration was 22.3 ± 4.8 pCi/L in sample SW-7 (DeSaussure).

Ra-226 was detected in six samples; the maximum concentration was 2.6 ± 1.9 pCi/L in sample SW-1 (Sears). Th-230 was detected in five surface water samples; the maximum concentration was 2.1± 1.6 pCi/L in SW-1.

U-235 was detected in one sample (SW-5, Federal Express) at an estimated concentration of 1.8 ± 1.3 pCi/L.

Table 4-32
Summary of Radiological Constituents in Surface Water Samples

Analyte	Proposed SDWA MCLs (pCi/l)	Detected Minimum (pCi/l)	Detected Minimum Location	Detected Maximum (pCi/l)	Detected Maximum Location	Frequency (detects/total)
Gross α	15.0	[7.2]	SW-6D	[9.3]	SW-6	1/7
Gross β	50[a]	4.5	SW-2	22.3	SW-7	6/7
Ra-226	20.0	[0.8]	SW-7	[2.6]	SW-1	6/7
Ra-228	20.0	ND	NA	ND	NA	0/7
Th-230	82.7[b]	[0.6]	SW-3	[2.1]	SW-1	5/7
Th-232	91.8[b]	ND	NA	ND	NA	0/7
U-234	13.5[c]	ND	NA	ND	NA	0/7
U-235	13.5[c]	[1.8]JSD	SW-5	[1.8]JSD	SW-5	1/7
U-238	13.5[c]	ND	NA	ND	NA	0/7

[a] Gross beta MCL is 4 mrem ede/year. 50 pCi/l criteria is the proposed presumptive screening level for compliance with the 4 mrem ede/year MCL.

[b] Th-230 and Th-232 MCLs are from Appendix C of 56 FR 33050 (July 18, 1991). Criteria is based on concentration in water for a lifetime cancer mortality risk of 1 E-4.

[c] Actual uranium MCL is 20 ug/l. The 13.5 pCi/l limit is based on a U-234/U-238 activity ratio of 1, and therefore assumes that uranium consests of natural uranium, which has a specific activity of 0.68 pCi/ug. The uranium MCL applies to total uranium, not each isotope, and is presented for each isotope for each isotope for illustrative purposes only.

Notes: ND = Not-detected

NA = Not applicable

JSD = Estimated value; matrix spike recovery criteria not met; duplicate precision not met.

D = Duplicate sample

[ ] = Values for which the counting error is greater than or exceeds 50% of the detected value (i.e.,gross alpha was detected at a low concentration of 7.2 +/- 5.0 pCi/l)

Safe Drinking Water Act (SDWA) MCLs based on those proposed in 56 FR 33050 (July 18, 1991).

Frequencies do not include duplicate sample detects if analyte was detected in both original and duplicate samples.

4.5.2 Sediments

TCL VOCs. Six TCL VOCs were detected in sediment samples. No VOCs were detected at levels exceeding the NJDEPE residential direct-contact soil-cleanup criteria. The maximum concentrations of compounds detected were 170 ppb of acetone in sample SD-3, 790 ppb of chloroethane in sample SD-6, 8 ppb of ethylbenzene in sample SD-6, 310 ppb of toluene in sample SD-6, 23 ppb of benzene in sample SD-6, and 200 ppb of xylene in sample SD-6. Of the volatile compounds detected, only toluene was detected also in the sediment blank (0.2 ppb).

TCL Semivolatile Organics. Twenty-six TCL semivolatile organic compounds were detected in sediment samples. Five semivolatile organic compounds were detected at levels above the NJDEPE residential direct-contact soil-cleanup criteria: benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, dibenzo(a,h)anthracene, and indeno(1,2,3-c,d)pyrene. The NJDEPE cleanup criteria for each of these (all of which are PAHs) are provided in Table 4-33. The range detected, frequency of detection, and maximum concentration locations are presented in Table 4-27. Individual sample results for these compounds are provided in Figure 4-44. At every sediment sampling location except SD-5, the cleanup standard is exceeded for at least one of the compounds. Note that detection limits from sample SD-6 are high because of sample dilution.

Table 4-33
TCL Semivolatile Organics Detected In Sediments in Concentrations Above NJDEPE Residential Direct-Contact Soil-Cleanup Criteria

Compound	Criteria (ppb)	Range detected[a] (ppb)	Frequency Detected (detects/total)	Location of Maximum Detected Concentration
Benzo(a)anthracene	900	200 - 5,100	5 / 7	SD-2
Benzo(a)pyrene	660	110 - 5,400	6 / 7	SD-2
Benzo(b)fluoranthene	900	90 - 9,300	7 / 7	SD-6
Dibenzo(a,h)anthracene	660	63 - 930	5 / 7	SD-3
Indeno(1,2,3-cd)pyrene	900	130 - 4,200	6 / 7	SD-2

[a]All values are estimated concentrations

TCL Pesticides and PCBs. No TCL pesticides or PCBs were detected in sediment samples.

TAL Metals and Cyanide. Twenty-two TAL metals were detected in sediment samples. Two TAL metals, cadmium and lead, were detected at levels above the NJDEPE residential direct-contact soil-cleanup criteria (Table 4-34 and Figure 4-45). Cadmium was detected in sample SD-6 above the criterion of 1 ppm at a

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WEST HUNTER AVENUE

MAYWOOD AVENUE

STATE ROUTE 17

GROVE AVENUE

BECKER AVENUE

BENZO (a) ANTHRACENE 700J
BENZO (a) PYRENE 640J
BENZO (b) FLUORANTHENE 1,100 J *
BENZO (ghi) PERYLENE 680J
CHRYSENE 780J
DIBENZO (a,h) ANTHRACENE 230J
INDENO (1,2,3-cd) PYRENE 550J

SD-1

SD-2

BENZO (a) ANTHRACENE 5,100J *
BENZO (a) PYRENE 5,400J *
BENZO (b) FLUORANTHENE 9,200J *
BENZO (ghi) PERYLENE 3,800J
CHRYSENE 6,500J *
DIBENZO (a,h) ANTHRACENE 580J
INDENO (1,2,3-cd) PYRENE 4,200J *

SD-3

BENZO (a) ANTHRACENE 2,700J *
BENZO (a) PYRENE 2,500J *
BENZO (b) FLUORANTHENE 4,700J *
BENZO (ghi) PERYLENE 2,000J
CHRYSENE 3,300J
DIBENZO (a,h) ANTHRACENE 930J
INDENO (1,2,3-cd) PYRENE 2,300J *

SD-4

BENZO (a) ANTHRACENE 750J
BENZO (a) PYRENE 660J *
BENZO (b) FLUORANTHENE 1300J *
BENZO (ghi) PERYLENE 610J
CHRYSENE 820J
DIBENZO (a,h) ANTHRACENE 85J
INDENO (1,2,3-cd) PYRENE 690J

SD-5

BENZO (a) ANTHRACENE 200 JD
BENZO (a) PYRENE 170 JD
BENZO (b) FLUORANTHENE 370 JD
BENZO (ghi) PERYLENE 200JD
CHRYSENE 210JD
DIBENZO (a,h) ANTHRACENE 63JD
INDENO (1,2,3-cd) PYRENE 200JD

SD-6

BENZO (a) ANTHRACENE ND
BENZO (a) PYRENE ND
BENZO (b) FLUORANTHENE 9,300J
BENZO (ghi) PERYLENE ND
CHRYSENE 6100J
DIBENZO (a,h) ANTHRACENE ND
INDENO (1,2,3-cd) PYRENE ND

UNDERGROUND CULVERT TO LODI BROOK

LEGEND

- PROPERTY LINE
- FENCE
- SD-1 — SEDIMENT LOCATION WHERE ANALYTE IS LESS THAN NJDEPE SOIL CLEANUP CRITERIA
- SD-2 — SEDIMENT LOCATION WHERE ANALYTE EXCEEDS NJDEPE SOIL CLEANUP CRITERIA
- * — ANALYTE EXCEEDS NJDEPE SOIL CLEANUP CRITERIA
- ND — ANALYTE WAS NOT DETECTED AT THE DETECTION LIMIT USED FOR THE ANALYSIS
- J — ESTIMATED VALUE
- D — RESULTS ARE FROM THE ANALYSIS OF THE DUPLICATE SAMPLE
- EXISTING DRAINAGE CHANNEL AND FLOW DIRECTION

NOTE:
1. ALL CONCENTRATIONS ARE IN PPB

0 200 400 600

SCALE 1"=200'

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FIGURE 4-44
SEMIVOLATILE ORGANICS IN SEDIMENTS (PPB)

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WEST HUNTER AVENUE

MAYWOOD AVENUE

STATE ROUTE 17

GROVE AVENUE

BECKER AVENUE

SD-1
CADMIUM ND
CHROMIUM 14.5 J
LEAD 175 J *
SELENIUM 1.4 J

SD-2
CADMIUM ND
CHROMIUM 23.3
LEAD 198 J *
SELENIUM ND

SD-3
CADMIUM ND
CHROMIUM 71.5 J
LEAD 250 J *
SELENIUM 0.97 J

SD-4
CADMIUM ND
CHROMIUM 44.5 J
LEAD 183 J *
SELENIUM 1 J

SD-5
CADMIUM ND
CHROMIUM 25.9
LEAD 62 J
SELENIUM 0.62J

SD-6
CADMIUM 3.9J *
CHROMIUM 77.2 J
LEAD 645 J *
SELENIUM 0.89 J

UNDERGROUND CULVERT TO LODI BROOK

0 200 400 600

SCALE 1"=200'

LEGEND

- PROPERTY LINE
- FENCE
- SD-1 — SEDIMENT LOCATION WHERE ANALYTE IS LESS THAN NJDEPE SOIL CLEANUP CRITERIA
- SD-2 — SEDIMENT LOCATION WHERE ANALYTE EXCEEDS NJDEPE SOIL CLEANUP CRITERIA
- * — ANALYTE EXCEEDS NJDEPE SOIL CLEANUP CRITERIA
- ND — ANALYTE WAS NOT DETECTED AT THE DETECTION LIMIT USED FOR THE ANALYSIS
- J — ESTIMATED VALUE
- D — RESULTS ARE FROM THE ANALYSIS OF THE DUPLICATE SAMPLE
- EXISTING DRAINAGE CHANNEL AND FLOW DIRECTION

NOTE:
1. ALL CONCENTRATIONS ARE IN PPB.

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FIGURE 4-45
METALS IN SEDIMENT (PPM)
JULY-AUGUST 1992

concentration of 3.9 ppm. Although cadmium was not detected in other sediment samples, the detection limits (1.8 to 3.1 ppm) are above the criterion for cadmium. Lead was detected in all sediment samples above the criterion of 100 ppm except in sample SD-5, where it was detected at 62.1 ppm.

Table 4-34
TAL Metals Detected in Sediments in Concentrations Above NJDEPE Residential Direct-Contact Soil-Cleanup Criteria

Metal	NJDEPE Cleanup Criterion Proposed (ppm)	Range detected (ppm)
Cadmium	1	3.9 J
Lead	100	53.9 - 645 J
Note: J = estimated concentration		

Cyanide was detected in sediment samples at estimated concentrations ranging from 0.51 ppm (sample SD-2) to 10.7 ppm (sample SD-1). These levels are below the NJDEPE residential direct-contact soil-cleanup criterion of 1,100 ppm.

Lithium and TOC. Lithium was detected in all sediment samples. Results ranged from 5.5 ppm in sample SD-5D to 31.6 ppm in sample SD-3.

TOC results for sediment samples ranged from 7,990 ppm (sample SD-5) to 86,200 ppm (sample SD-6). TOC analysis includes soil organic matter and organic contamination.

Radiological Parameters. Radium and thorium levels were compared to DOE Order 5400.5 generic cleanup criteria. U-234 and U-238 results were compared to NRC's Branch Technical Position criteria (46 FR 52601). No comparison criteria for gross alpha and gross beta exist for sediments; neither do comparison criteria for U-235 when it is present in naturally occurring percentages. Table 4-35 summarizes sediment sample results and comparison criterion. Figure 4-46 shows radiological sample results for each sediment sample location.

Gross alpha radiation was detected in one-half of the samples, at a maximum concentration of 50 ± 15.4 pCi/g (SD-4; Sears). Gross beta radiation was detected in all of the sediment samples at a maximum concentration of 27.7 ± 7.2 pCi/g (SD-4).

Table 4-35
Summary of Radiological Constituents in Sediment Samples

Analyte	Surface Soil Criteria (pCi/g)	Detected Minimum (pCi/g)	Detected Minimum Location	Detected Maximum (pCi/g)	Detected Maximum Location	Frequency (detects/total)	Number of Samples > Comparison Criteria
Gross α	NE	[20][b]	SD-5D	50	SD-4	3/6	NA
Gross β	NE	[11.2]	SD-1	27.7	SD-4	6/6	NA
Ra-226	5	[1.3]	SD-2	10.1	SD-4	6/6	3
Ra-228	5	2.4	SD-5	5.3	SD-4	4/6	1
Th-230	5	1.6	SD-5	4.1	SD-3	6/6	None
Th-232	5	[1.0]	SD-5	5.9	SD-3	6/6	2
U-234	10[a]	[1.1]	SD-3/SD-5D	3.5	SD-1	4/6	None
U-235	NE	[0.2]	SD-3	[1.7]	SD-1	4/6	NA
U-238	10[a]	[1.0]	SD-5	[1.6]	SD-3/SD-4	3/6	None

[a] The 10 pCi/g limit applies to natural uranium (total of U-234 and U-238), and is presented indiviually for illustrative purposes. No site-specific U-234 or U-238 cleanup guidelines have been established by DOE or EPA. The U-234 and U-238 criteria listed are recommended from NRC's Branch Technical Position (46 FR 352061; October 23, 1981). The the criteria assumes natural uranium with all daughters in equilibrium and applies to the sum of U-234 and U-238. A typical (as opposed to site specific) calculated, DOE surface soil guideline for U-238 would be 75 pCi/g (BNI, 1987 c).

Notes: NE = None established
ND = Not detected
NA = Not applicable
D = Duplicate sample
[ ] = Values for which the counting error is equal to or greater than 50% of the detected value (i.e., gross alpha was detected at a minimum concentration of 20.0 +/- 11.6pCi/g).
DOE generic, surface soil residual contaminant cleanup guidelines do not necessarily apply to sediment. Criteria is for concentration averaged over the upper 15 cm of soil. The DOE Order 5400.5 guidelines apply only to radium and thorium, and are based on radium criteria specified in 40 CFR 192.
Frequencies do not include duplicate sample detects if analyte was detected in both the original and duplicate samples.
Number of samples greater than comparison criteria does not include duplicate sample if analyte was detected in both original and duplicate samples.

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WEST HUNTER AVENUE

MAYWOOD AVENUE

STATE ROUTE 17

GROVE AVENUE

BECKER AVENUE

GROSS BETA-[11.4]
Ra-226-4.0
Th-230- 2.3
Th-232-1.9
U -234- 3.5
U-235-[1.7]
SD-1

SD-2
GROSS BETA-17.6
Ra-226-[1.3]J
Th-230- 2.0JD
Th-232-1.9
TOTAL U -2 ug/g

SD-3
GROSS ALPHA-43.7
GROSS BETA-24.7
Ra-226-7.0 *
Ra-228-[2.5]
Th-230- 4.1
Th-232-5.9 *
U -234-[1.1]
U-238-[1.6]

GROSS ALPHA-50
GROSS BETA-27.7
SD-4
Ra-226-10.1 *
Ra-228-5.3 *
Th-230- 2.2
Th-232-5.2 *
U-234- [1.4]
U-235-[0.7]JS
U-238-[1.6]

SD-6
GROSS BETA-[17.2]
Ra-226-7.8 *
Th-228-3.4
Th-230-2.2
Th-232-3.8
U-235-[1.6]-JS

SD-5
GROSS ALPHA-[23.7]
GROSS BETA-[11.2]
Ra-226-3.7
Ra-228-2.4
Th-230-1.6
Th-232-[1.0]
U-234- [1.6]
U-235-[0.4]
U-238-[1.0]

UNDERGROUND CULVERT TO LODI BROOK

0 200 400 600

SCALE 1"=200'

LEGEND:

SD-1	SEDIMENT SAMPLE LOCATION WHERE ANALYTE DOES NOT EXCEED COMPARISON CRITERIA
SD-3	SEDIMENT SAMPLE LOCATION CONTAINING ANALYTE THAT EXCEEDS COMPARISON CRITERIA
*	ANALYTE EXCEEDS COMPARISON CRITERIA
J	ESTIMATED VALUE
S	MATRIX SPIKE RECOVERY CRITERIA NOT MET
D	DUPLICATE PRECISION NOT MET
[ ]	VALUES FOR WHICH THE COUNTING ERROR IS EQUAL TO OR GREATER THAN 50% OF THE DETECTED VALUE
→	EXISTING DRAINAGE CHANNEL AND FLOW DIRECTION

NOTES:

1. CONCENTRATIONS PRESENTED ARE IN UNITS OF pC i/g.
2. DUPLICATE SAMPLE RESULTS (SD-5) ARE NOT SHOWN.
3. COMPARISON CRITERIA ARE BASED ON DOE ORDER 5400.5-GENERIC, SURFACE SOIL RESIDUAL CONTAMINANT CLEANUP GUIDELINES FOR Ra-226, Ra-228, Th-230, AND Th-232. COMPARISON CRITERIA FOR THE TOTAL OF U-234 PLUS U-238 ACTIVITY (10 pCi/g), ARE RECOMMENDED CRITERIA FROM NRC's BRANCH TECHNICAL POSITION (46 FR 352061, OCTOBER 23,1981). DOE OR EPA HAVE NOT ESTABLISHED SITE-SPECIFIC CLEANUP GUIDELINES FOR URANIUM.
4. NO CORRESPONDING SURFACE WATER SAMPLE RESULTS WERE ABOVE PROPOSED SDWA MCL's (56 FR 33050, JULY 18,1991).

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FIGURE 4-46
RADIOLOGICAL RESULTS IN SEDIMENT
JULY-AUGUST 1992

Ra-226 was detected in all of the sediment samples at a maximum concentration of 10.1 ± 1.3 pCi/g (SD-4). Three sediment samples contained Ra-226 at concentrations above the 5 pCi/g comparison criteria. Ra-228 was detected in four sediment samples at a maximum concentration of 5.3 ± 1.7 pCi/g (SD-4). One sediment sample contained Ra-228 at a level above the 5 pCi/g comparison criterion.

Th-230 and Th-232 were detected in all of the sediment samples. Th-230 was detected at a maximum concentration of 4.1 ± 0.9 pCi/g (SD-3, Sears). Th-232 was detected at a maximum concentration of 5.9 ± 1.1 pCi/g (SD-3); it was detected above the 5 pCi/g comparison criterion in two samples.

U-234 was detected at a maximum concentration of 3.5 ± 1.7 pCi/g (SD-1, Sears); it was detected in four of the sediment samples. U-235 was detected in four of the sediment samples, with a maximum concentration of 1.7 ± 0.9 pCi/g (SD-1, Sears). U-238 was detected in five of the sediment samples, at a maximum concentration of 1.6 ± 0.9 pCi/g (SD-4).

Comparison to Sediment Quality Criteria. Sediment sample results were compared with guidelines developed for the NOAA by Long and Morgan (Long and Morgan). They assembled and evaluated seawater sediment data to provide an effects-based criterion for adverse biological effects caused by chemicals. For chemical concentrations observed or predicted to cause biological effects for seawater benthic communities, the lower 10 percentile was identified as the Effects Range Low (ER-L) and the median was identified as the Effects Range Median (ER-M). Forty-three compounds were detected in sediments taken from the site; the compounds are listed in Table 4-36. Of the 43 compounds, 21 exceed the Long and Morgan-derived ER-L value. Eleven chemicals, which are shaded in Table 4-36, had maximum concentrations that exceed the ER-M. Although the presence of a compound in concentration above the ER-M may indicate possible adverse effects on biological communities, some of the ER-L and ER-M values do not have a high level of confidence (see the "LOC" column in Table 4-36) and may not apply to freshwater communities associated with drainage channels that intermittently convey water. Further, Long and Morgan indicate that the ER-L and ER-M values should only be used as guidance, not as official standards.

4.6 Summary

The nature and extent of contamination within the study area is summarized in the following section. Potential source materials and representative contaminants are discussed. Given the relatively limited historical information related to past waste disposal activities, the historical aerial photography survey performed by EPA was used as a basis for discussion of potential source areas, where pertinent. These areas were summarized in Section 1.4 and Figure 1-5. Contaminants associated with potential source materials are presented and discussed with integrated soil, test pit,

Table 4-36
Sediment Chemical Analytical Results Compared to NOAA Criteria

COMPOUND	ER-L CONC. [a] (ppb)	LOC	ER-M CONC. [a] (ppb)	LOC	CONCENTRATION RANGE (ppb)	LOCATION OF MAX. CONC.
Arsenic	33000	L	85000	M	2300-11100	SD01
Barium	na	na	na	na	43700 - 277000	SD04
Cadmium	5000	H	9000	H	3900	SD06
Chromium (total)	80000	M	145000	M	14500 - 77200	SD06
Copper	7000	H	390000	H	12100 - 214000	SD06
Lead [b]	35000	M	110000	H	53900 - 645000	SD06
Lithium	na	na	na	na	5500 - 31600	SD03
Mercury	150	M	1300	H	90 - 950	SD03
Nickel	30000	M	50000	M	7700	SD05
Selenium	na	na	na	na	490 - 1400	SD01
Zinc [b]	120000	H	270000	H	145000 - 800000	SD06
Cyanide	na	na	na	na	510 - 10700	SD01
Acetone	na	na	na	na	23 - 170	SD03
Benzene	na	na	na	na	23	SD06
Ethylbenzene	na	na	na	na	8	SD06
Toluene	na	na	na	na	4 - 310	SD06
Xylene	na	na	na	na	200	SD06
Acenaphthene	150	L	650	L	350 - 430	SD02
Acenapthlyene	na	na	na	na	100 - 220	SD03
Anthracene [b]	85	L	960	M	110 - 1400	SD02
Benzo(a)Anthracene [b]	230	L	1600	M	200 - 5100	SD02
Benzo(a)Pyrene [b]	400	M	2500	M	110 - 5400	SD02
Benzo(b)Fluoranthene	na	na	na	na	190 - 9300	SD06
Benzo(ghi)Perylene	na	na	na	na	140 - 3600	SD02
Bis(2-Ethylhexyl)Phthalate	na	na	na	na	310 - 4000	SD02
Butylbenzyl Phthalate	na	na	na	na	98 - 500	SD02
Caffeine	na	na	na	na	81 - 510	SD03
Chrysene [b]	400	M	2800	M	140 - 6500	SD02
Dibenzo(a-h)Anthracene [b]	60	M	260	M	63 - 930	SD03
Dibenzofuran	na	na	na	na	290	SD02
Diethyl Phthalate	na	na	na	na	310	SD02
Di-n-Butyl Phthalate	na	na	na	na	120	SD03
Di-n-Octyl Phthalate	na	na	na	na	180	SD02
Fluoranthene [b]	600	H	3600	H	200 - 11000	SD02
Fluorene [b]	35	L	640	L	400 - 650	SD02
Indeno(1,2,3-cd)Pyrene	na	na	na	na	130 - 4200	SD02
2-Methylnaphthalene	65	L	670	L	63 - 95	SD03
4-Methylphenol	na	na	na	na	110 - 710	SD04
Naphthalene	340	M	2100	H	110	SD02,SD03
Phenanthrene	225	M	1380	M	120 - 7400	SD02
Pyrene [b]	350	M	2200	M	230 - 10000	SD06
Total PAH [b]	4000	L	35000	L	1570 - 72313	SD02
TOC	na	na	na	na	0.8% - 9.3%	SD01

[a] ER-L and ER-M from NOAA Technical Memorandum NOS OMA August 1992. Values were changed slightly by Macdonald (1992) for metals and PAHs.

[b] Compounds for which the maximum detected value is above the ER-M criteria are highlighted.

Notes:

LOC - Level of Confidence in ER-L and ER-M values, L-low, M-moderate, H-high.

na - values not available.

sediment, groundwater, and surface water sample results, where possible. These data summaries aid in the understanding of how potential source areas may be affecting various environmental media.

To assist in the interpretive analysis, graphic presentations were developed integrating results obtained during the RI for soil, test pit, sediment, groundwater, and surface water media, where possible. Figure 4-47 is provided as a reference figure showing relative sampling locations for soil, sediment, test pits, groundwater, and surface water. Some results are also presented for section line E-E' (Figure 4-47). The figures presented in the discussion below summarize data previously presented by media and contaminant. For the figures presented below, general areas with elevated concentrations in soil, test pits or sediments were identified based on data presented earlier in Section 4. General areas with elevated concentrations in groundwater or surface water are presented along with areas of elevated concentrations in soil media to develop an understanding of impacts that may be occurring from potential source areas to other environmental media.

4.6.1 Nature of Contamination

Historical industrial and commercial activities conducted within the study area and adjacent properties appear to have impacted environmental media. Potential source materials include:

- Petroleum-based fuels
- Organic residues from industrial production activities
- Solvents
- Leather solids filter cake from protein extraction
- Gypsum from an inorganic chemical manufacturing operation
- Tailings from ore processing and other inorganic residues
- Liquids in bermed areas and lagoons

Each of these potential source materials is discussed briefly below. Contaminant classes associated with these materials, and the general physical locations where each source material may be found within the study area, are also presented.

Petroleum-Based Fuels. Petroleum-based fuels were stored and handled for commercial, industrial, or retail marketing purposes within the study area. Residual concentrations of gasoline and fuel oil are sometimes present in areas where fuels were stored or handled. Because soil samples were not collected near all UST locations, it is not known whether residual concentrations of petroleum-based fuels are present at all UST locations.

Gasolines contain various petroleum hydrocarbons. TCL VOCs generally present in gasolines include aromatic hydrocarbons such as benzene, toluene, ethylbenzene,

H:\e PROJECTS\e CAD\e STEPAN\e FIGURES\e FIG-200.DGN

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N.Y. SUSQUEHANNA & WESTERN RAILROAD

WEST HUNTER AVENUE

MAYWOOD AVENUE

STATE ROUTE 17

GROVE AVENUE

BECKER AVENUE

B38W02D
B38W01S
B38W05B
B38W03B
B38W06B
B38W07B
B38W12A
B38W12B
B38W18D
BRMW15
OBMW15
WELL 8
BRMW16
WELL 5
OBMW17
BRMW17
OBMW6
BRMW6
OBMW18
B38W04B
WELL 2
WELL 1
BRMW11
OBMW11
BRMW10
OBMW10
BRMW2
OBMW2
OBMW16
HA-1
HA-2
HA-3
MISS-4A
MISS-4B
MW-1
BRTW2
BRMW1
OBMW1
BRMW13
OBMW13
BRMW14
OBMW14
BRMW3
OBMW3
BRMW5
OBMW15
BRMW4
OBMW4
BRMW7
OBMW7
BRMW12
OBMW12
BRMW8
OBMW8
BRMW9

C-1 C-2 C-3 C-4 C-5 C-6 C-7 C-8 C-9 C-10 C-11 C-12 C-13 C-14 C-15 C-16 C-17 C-18 C-19 C-20 C-21 C-22 C-23 C-24 C-25 C-26 C-27 C-28 C-29 C-30 C-31 C-32 C-33 C-34 C-35 C-36 C-37 C-38 C-39 C-40 C-41 C-42 C-43 C-44

TP-22 TP-23 TP-25 TP-32 TP-76 TP-79 TP-80 TP-84 TP-85 TP-87 TP-87-1B TP-88-1 TP-88-2 TP-89 TP-91 TP-106 TP-107 TP-119

SG-1 SG-2 SG-3 SG-4 SG-5 SG-6 SG-7 SG-8 SG-9 SG-10 SG-11 SG-12A SG-12B SG-13 SG-14 SG-15 SG-16 SG-17 SG-18 SG-18A SG-19

SW-1/SD-1 SW-2/SD-2 SW-3/SD-3 SW-4/SD-4 SW-5 SW-6/SD-5 SW-7/SD-6

BM-1 BM-2 BM-3 BM-4

LEGEND:

- PROPERTY LINE
- FENCE
- EXISTING DRAINAGE CHANNEL
- FORMER DRAINAGE CHANNEL
- SECTION LINE E-E'
- SURFACE WATER AND SEDIMENT SAMPLE LOCATION
- SOIL BORING
- TEST PIT
- MONITORING WELL
- HAND AUGER SAMPLING LOCATION
- FOCUSED INVESTIGATION SOIL BORING (SG)
- BLUE MATERIAL SOIL BORING

0 200 400 600

SCALE 1"=200'

STEPAN COMPANY AND SEARS AND ADJACENT PROPERTIES RI
MAYWOOD, NEW JERSEY

FIGURE 4-47
SAMPLING LOCATION OVERVIEW

toluene, and naphthalene. Some gasolines may also have contained tetraethyl lead. Fuel oils contain various PAHs. Former fuel USTs areas were located on the Stepan, Gulf, Sunoco, AMP, SWS, and Sears properties (Figure 4-48).

Organic Residues from Industrial Production Activities. Organic residues from industrial production activities include resins and oily residues. These materials were placed in drums. Solvents and degreasers, both halogenated and non-halogenated organic compounds, were occasionally detected in these residues. These drummed materials were placed on the ground on various areas of the Sears property and may have been covered with paving or buried during construction activities on the Sears property. Based on the RI test pit investigation, buried drums containing organic residues were limited to the Sears property. All test pits where drums were observed with organic or inorganic contents are presented on Figure 4-48.

An access road was identified by EPA in aerial photographs near the areas where buried drums were found. The road may have been the route for transportation of drummed materials from industrial production areas.

Solvents. Solvents and degreasers were likely used in commercial or industrial activities both within the study area and at adjacent properties. According to available information, some non-halogenated aromatic solvents and ketones were used within the study area. Areas within which these compounds have impacted soils include the aromatics and essential oils manufacturing area (Figure 4-48). No known historical use of halogenated solvents, such as TCE and vinyl chloride, were identified, although TCE is a common degreasing agent used in commercial and industrial facilities. Vinyl chloride is likely related to the biodegradation of TCE.

Leather Solids Filter Cake. A filter cake containing digested leather solids and lime was generated from a protein extraction process from the 1940's to the mid-1980's. Chromium from the tanned leather used for this process was found in the filter cake residues. Filter cake from this process was handled in two areas on the Stepan property (Figure 4-48). During the early years of operation, filter cake was likely stored in these areas on the ground surface prior to disposal. During the later years of operation, filter cake was placed into containers for offsite disposal.

Gypsum from Offsite Inorganic Chemical Operations. Based on site historical information, gypsum (calcium sulfate) was used as a filter aid during caffeine extraction and citric acid manufacturing operations adjacent to the present Stepan Company property. The gypsum residue from these processes, which also contained cyanide and metals, was reportedly disposed of within the boundaries of the study area. During the investigation, the gypsum was detected on the north and east portion of the Dessaussure property (Figure 4-48).

Inorganic Residues and Tailings from Ore Processing. Inorganic residues and tailings were generated from ore processing operations. Thorium, rare earth metals, and

lithium were extracted and purified from ores as described in Section 1.4. These inorganic residues contain metals from processed ores and inorganic compounds used in extraction and purification processes. Some of these materials were placed in the burial sites on the Stepan property (Figure 4-48). Based on information from DOE regarding radioactivity in surface and subsurface soils, it appears that these residues and tailings were also widely distributed in fill material and overburden soils on the Sears, Stepan, Sunoco, and Gulf properties. More localized areas of radioactivity were observed by DOE in soils on the DeSaussure, SWS, and AMP properties.

Mounded materials were identified within the study area by EPA during the historical aerial photography survey. These materials may have been tailings from ore processing operations. Areas where mounded materials were noted include the northern portion of the Sears property and areas along the property boundary between Stepan and Sears.

Liquids in bermed areas and lagoons. Bermed areas and lagoons identified by EPA during the aerial photography survey (Figure 1-5) could have contained liquid effluents or residues from industrial operations. No information was available regarding what types of contaminants may have been present in liquid materials stored within these areas. Three general locations where former bermed areas or lagoons were identified include:

- Northern corner of the Sears property and east of the Sears building. Available data for this area did not indicate concentrations of VOCs, semi-VOCs, or metals that would serve as a potential source material.

- Stepan property near the industrial production area. This area later became part of the aromatic and essential oils manufacturing area. The VOCs identified in subsurface soils that appear to be a source of groundwater contamination.

- Offsite lagoons located near the eastern study area boundary. Although these areas may be potential source areas, characterization samples were not obtained since these former lagoons were outside of the study area.

Other sources. Several other sources of contaminants identified within the study area may include imported fill material, unknown inorganic chemical operations, atmospheric deposition, and coal solids. Soil imported to the study area may have been used for fill material. Imported soils would likely contain concentrations of metals that are significantly different than levels in natural overburden soils in the study area. Fill material was widely distributed across the site. It is not known which areas contained imported fill and native soils for backfilling.

Other unknown inorganic chemical operations may have contributed to elevated metals concentrations in overburden soils. It is believed that a metals plating operation had occurred on the SWS property that may have produced wastes containing metals such as zinc, lead, and chromium.

Atmospheric particulate deposition from combustion sources is typical for highly developed commercial and industrial locations such as the study area. Particulates containing PAHs and metals were likely deposited on overburden soils as a result of stationary combustion sources, such as boilers and furnaces, or mobile sources such as vehicular traffic. Atmospheric deposition, in general, would be expected to widely impact surface soils across the study area. However, low-lying areas collecting rainwater runoff, such as the wetlands areas on the Sears property, would have a greater tendency to accumulate particulates from atmospheric deposition.

Residual coal solids may be present in portions of the study area where coal was stored and handled. Coal solids generally contain metals and higher molecular weight PAHs. Based on the aerial photography survey by EPA, coal was stored near a railroad spur on the Stepan property in the 1940's. Soil samples were not obtained in the areas of coal storage during the RI, but residual coal solids are likely present along railroad spurs or in low-lying areas that collect solids carried by rainwater runoff.

4.6.2 Extent of Contamination

This summary discussion is, to the extent possible, an integrated presentation of sample results for soil, test pit, sediment, groundwater and surface water collected during the RI and Focused Investigation. The purpose of the integrated presentation is to provide a basis for interpretive analysis and discussion regarding the horizontal and vertical extent of contamination among media. In addition, this discussion provides an understanding of how some source areas have affected different environmental media.

The classes of contaminants that have affected environmental media within the study area include inorganics, non-halogenated VOCs, halogenated VOCs, semivolatile organic compounds, and ketones. Representative compounds or constituents were selected for each class of contaminants using the following general criteria, in decreasing order of importance:

- Primary contaminants identified in the risk assessment (TRC, 1993)
- Constituents known to be associated with potential source materials
- Constituents detected at concentrations above chemical-specific cleanup criteria
- Constituents frequently detected in at least one media

Based on the above criteria, the following contaminants were selected for the discussion:

- Non-halogenated VOCs: benzene, total BTEX, naphthalene, acetone, 2-butanone (MEK), and 4-methyl-2-pentanone (MIBK)
- Halogenated VOCs: cis-1,2-DCE, TCE and vinyl chloride
- Semi-volatile organic compounds: bis-(2-ethylhexyl)phthalate and fluoranthene
- Inorganics: arsenic, lead, chromium, beryllium, manganese, and cyanide

The representative compounds are discussed below by contaminant class and the types of potential sources materials within the study area.

Non-halogenated VOCs

Non-halogenated VOCs discussed below include benzene, total BTEX, naphthalene, acetone, MEK, and MIBK. Potential source materials for non-halogenated VOCs are the following:

- Fuels (benzene, total BTEX, naphthalene)
- Organic residues from industrial activities (benzene, total BTEX, acetone, MEK, MIBK)
- Solvents (benzene, total BTEX, acetone, MEK, MIBK)

General areas where non-halogenated VOCs were found in the study area are summarized in Figure 4-49 and 4-50. Approximate areas of where these compounds were detected at elevated concentrations in soils, groundwater, or test pits are shown. Localized areas with elevated concentrations of these compounds were found on the Stepan, Sears, Gulf, and SWS properties. Estimated vertical zones of benzene and total BTEX compounds are presented on Section E-E' in Figure 4-51.

Four localized areas of BTEX compounds appear to be associated with USTs that historically contained fuel oil or gasoline. Spills or releases may have occurred during the handling of fuels in these areas. The four areas shown on Figure 4-49 are in the vicinity of well MW-1 (Stepan), well B38W04B (Stepan), well OBMW3 (Gulf), and boring C-25 (SWS). Former or existing USTs in these areas are shown in Figure 4-48. The presence of naphthalene and lead in these areas also points to residual petroleum fuels as a likely source for these contaminants.

H:\PROJECTS\CAD\STEPAN\FIGURES\FIG4-NEW.DGN

N

N.Y. SUSQUEHANNA & WESTERN RAILROAD

WEST HUNTER AVENUE

MAYWOOD AVENUE

BURIAL SITE #2

BURIAL SITE #1

BURIAL SITE #3

STEPAN

INACTIVE CENTRAL TANK FARM AREA

FORMER FILTER CAKE HANDLING AREA NO. 1

STEPAN (AMENDED)

FORMER AROMATICS AND ESSENTIAL OILS MANUFACTURING AREA

FORMER FILTER CAKE HANDLING AREA NO. 2

MISS

SEARS

TP-75

TP-80

TP-104

TP-78

TP-84

TP-85

TP-79

TP-101

TP-102

TP-106

TP-107

TP-92

TP-87-1B

TP-88-1

TP-88-2

TP-87-1

TP-119

TP-89

TP-121

TP-91

GULF

SUNOCO

AMP REALTY

SWS REALTY

FEDERAL EXPRESS

DESAUSSURE

STATE ROUTE 17

GROVE AVENUE

BECKER AVENUE

LEGEND

- PROPERTY LINE
- FENCE
- BLUE MATERIAL
- RADIOACTIVE BURIAL SITES
- FORMER LEATHER DIGESTION FILTER CAKE HANDLING AREAS
- FORMER INDUSTRIAL PROCESS AND STORAGE AREA
- EXISTING UNDERGROUND STORAGE TANK
- FORMER UNDERGROUND STORAGE TANK
- TEST PIT WHERE DRUMS WERE FOUND WITH CONTENTS
- TEST PIT WHERE DRUMS WERE OBSERVED WITH CONTENTS, NOT SAMPLED

NOTES:

1. ALL LOCATIONS AND SIZES ARE APPROXIMATE.
2. TANK AND TEST PIT SIZES ARE NOT TO SCALE.

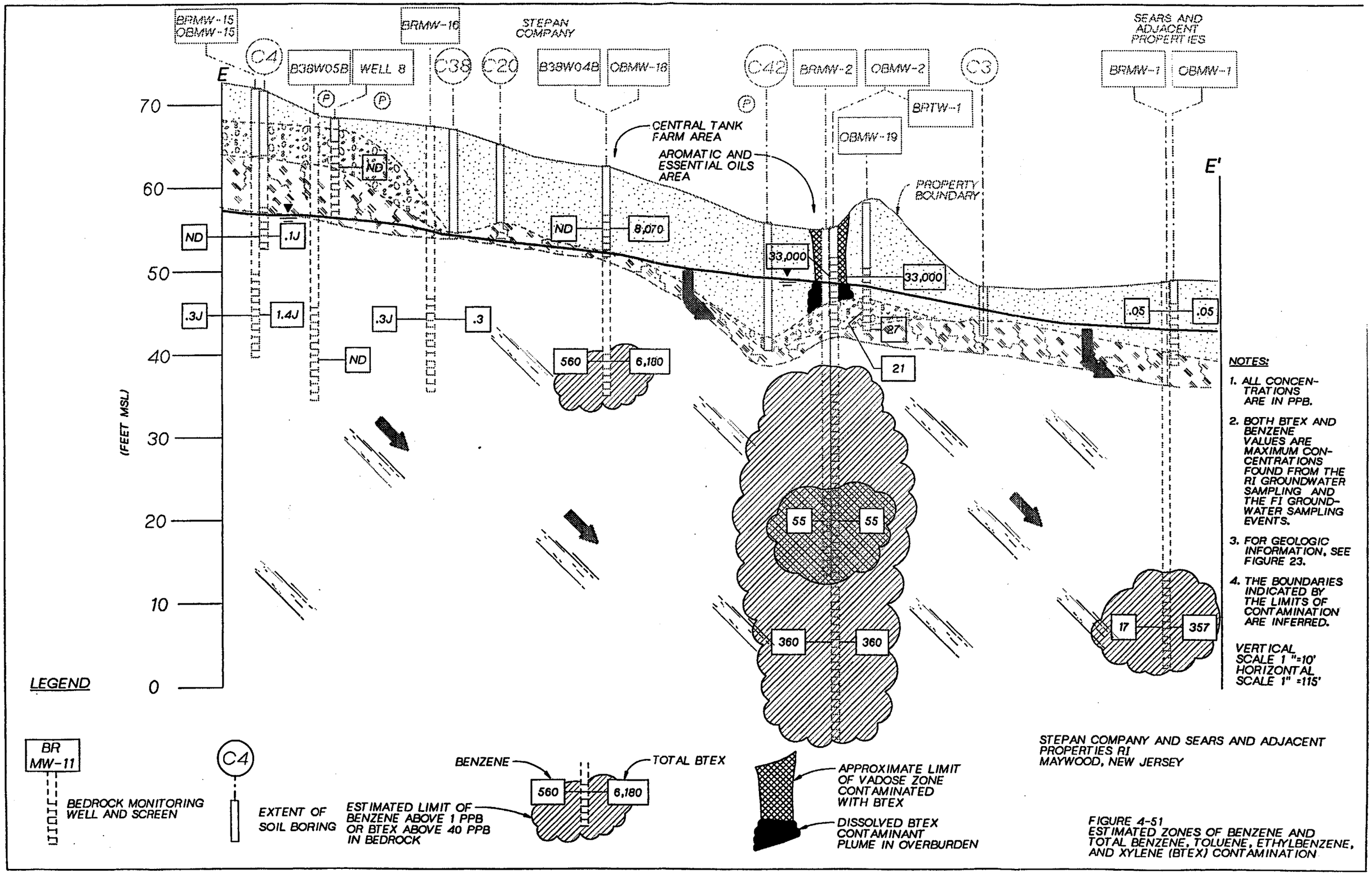
0 200 400 600

SCALE 1"=200'

STEPAN COMPANY AND SEARS AND ADJACENT PROPERTIES RI
MAYWOOD, NEW JERSEY

FIGURE 4-48
LOCATION OF POTENTIAL SOURCE MATERIAL AREAS

F:*PROJECTS*CAD*STEPAN*CONSECT1.DGN



NOTES:

1. ALL CONCENTRATIONS ARE IN PPB.
2. BOTH BTEX AND BENZENE VALUES ARE MAXIMUM CONCENTRATIONS FOUND FROM THE RI GROUNDWATER SAMPLING AND THE FI GROUNDWATER SAMPLING EVENTS.
3. FOR GEOLOGIC INFORMATION, SEE FIGURE 23.
4. THE BOUNDARIES INDICATED BY THE LIMITS OF CONTAMINATION ARE INFERRED.

VERTICAL SCALE 1 "=10'
HORIZONTAL SCALE 1" =115'

STEPAN COMPANY AND SEARS AND ADJACENT PROPERTIES RI
MAYWOOD, NEW JERSEY

FIGURE 4-51
ESTIMATED ZONES OF BENZENE AND TOTAL BENZENE, TOLUENE, ETHYLBENZENE, AND XYLENE (BTEX) CONTAMINATION

fig4-32b.dgn 25-JUL-1994 NJO/JMS 2

N

N.Y. SUSQUEHANNA & WESTERN RAILROAD

WEST HUNTER AVENUE

MAYWOOD AVENUE

STATE ROUTE 17

GROVE AVENUE

B38W02D ND
BRMW15 ND
OBMW15 BTEX 0.1J
MW-7R
B38W05B ND
WELL 8 ND
B38W01S ND
MW-1 BENZENE ND BTEX 4210 NAPPHTHALENE 160
C-20
BRMW16 BENZENE 0.3J* BTEX 0.3
WELL 6
WELL 5 ND
OBMW17 ND
BRMW17 ND
B38W18D ND
OBMW18 BENZENE ND BTEX 8070 NAPHTHALENE 210
B38W04B BENZENE ND* BTEX 6620 NAPHTHALENE 1300
WELL 2 ND
BRMW11 ND
OBMW11 ND
OBMW6 BENZENE ND BTEX 0.2
BRMW6 ND
WELL 1 ND
BRMW10 ND
OBMW10 ND
B38W06B BENZENE 0.3J BTEX 0.3
B38W03B ND
BRMW2 BENZENE 0.4J* BTEX 0.4
OBMW2 BENZENE 27,000* BTEX 27,000
OBMW19 BENZENE 21* BTEX 27
MISS-4B BENZENE 3 BTEX 3
MISS-4A
OBMW4 BENZENE ND BTEX 24
BRMW4 ND
B38W12A ND
B38W12B ND
TP-84
TP-85
OBMW7 BENZENE 0.2J* BTEX 0.2
BRMW7 ND
TP-106
OBMW12 BENZENE ND BTEX 0.2
BRMW12 ND
C-25
BENZENE 170* BTEX 176
BRTW2
B38W07B BENZENE ND BTEX 0.3
OBMW1 ND
BRMW1 BENZENE 340* BTEX 357
OBMW13 ND
BRMW13 ND
TP-87-1B
OBMW14 ND
BRMW14 ND
BRMW3 BENZENE ND BTEX 0.2
BRMW5 ND
OBMW3 BENZENE 490 * BTEX 1,980 NAPHTHALENE 27
OBMW5 BENZENE 0.1J BTEX 0.6
BRMW8 BENZENE ND BTEX 0.2J
OBMW8 ND
BRMW9 ND

0 200 400 600

SCALE 1"=200'

PROPERTY LINE

FENCE

* ANALYTE IS EQUAL TO OR EXCEEDS NJDEPE GROUNDWATER QUALITY CRITERA

BRMW1 WELL IS SCREENED IN BEDROCK

OBMW1 WELL IS PRIMARILY SCREENED IN OVERBURDEN

J ESTIMATED VALUE

ND ANALYTE WAS NOT DETECTED AT THE DETECTION LIMIT USED FOR THE ANALYSIS

CONCEPTUALIZED INTERPRETATION OF BEDROCK GROUNDWATER WITH BENZENE >1 PPB OR TOTAL BTEX >40 PPB

CONCEPTUALIZED INTERPRETATION OF GROUNDWATER WITH BENZENE >1 PPB OR TOTAL BTEX >40 PPB

CONCEPTUALIZED INTERPRETATION OF BOTH OVERBURDEN AND BEDROCK GROUNDWATER WITH BENZENE >1 PPB OR TOTAL BTEX >40 PPB

NAPHTHALENE CONCENTRATIONS IN SOIL >1,000 PPB. APPROXIMATE AREA

BENZENE >1,000 PPB OR BTEX >10,000 PPB IN SOIL SAMPLES APPROXIMATE AREA

TEST PITS WITH BENZENE >1,000 PPB OR BTEX >10,000 PPB IN SAMPLE. AREA REPRESENTATION NOT TO SCALE

NOTES:

1. ALL CONCENTRATION ARE IN PPB.
2. ALL TOTAL BTEX VALUES ARE TOTAL DETECTED CONCENTRATIONS.
3. NAPHTHALENE WAS DETECTED IN ONLY 4 WELLS: OBMW3, PBMW18, B38W04B AND MW-1
4. ALL LOCATIONS AND SIZES ARE APPROXIMATE

STEPAN COMPANY AND SEARS AND ADJACENT PROPERTIES RI
MAYWOOD, NEW JERSEY

FIGURE 4-49
BTEX AND NAPHTHALENE IN GROUNDWATER, SOIL AND TEST PITS

There is no evidence of a continuing UST source in the areas of former fuels activity. As presented in Figure 1-4, three existing and one former underground storage tank were located in this area. Tank 2 in Figure 1-4 is an existing 7,500 gallon alcohol tank that was abandoned in place in 1983. Tank 3 is an existing 250 gallon gasoline tank that is no longer used. Tank 4 is an existing 2,500 gallon alcohol tank that is no longer used. Tank 5 is a former 2,000 gallon No. 2 fuel oil tank removed in 1991. Based on the soil gas data as summarized in Figure 4-15, neither of the two fuel tank locations appear to represent sources of contamination. Additionally, soil boring SG-13, located south of tanks 2 and 3 and in between tanks 4 and 5, did not show any detects for BTEX compounds in the 4-6 foot sample. Low residual concentrations of VOCs in overburden soils, however, may be contributing to concentrations of these compounds in groundwater. Areas impacted by BTEX and naphthalene in groundwater appear to be limited in extent (Figure 4-49 and 4-51). Elevated concentrations of BTEX compounds in soils were present in samples from the SWS property, but groundwater sample results were not available for this area. BTEX and naphthalene concentrations in surface water and sediment were either not detected or detected at very low residual concentrations indicating that fuels sources are not impacting these media (Figure 4-52).

Two areas appear to be associated with historical spills or releases of non-halogenated aromatic solvents and ketones. These areas are located on the Stepan property in the former aromatics and essential oil manufacturing area, and the central tank farm area near Building 10 (Figure 4-49 and 4-50). BTEX compounds and acetone were detected in overburden soils and groundwater in the former aromatics area. BTEX compounds in groundwater appear to be limited in horizontal and vertical extent based on the low concentrations detected in underlying bedrock groundwater (BRMW2) and downgradient overburden groundwater (OBMW19). Estimated vertical zones of benzene and BTEX contamination for this area are presented in Figure 4-51. Impacts to groundwater near Building 10 could not be assessed due to the absence of a monitoring well in this area. The only ketone detected in this area was MEK at 2 ppb (BRMW2).

Four test pit areas on the Sears property contained buried drums with organic residues from industrial activities (Figure 4-49 and Figure 4-50). These residues contained non-halogenated aromatic solvents, such as benzene and ketones. Although these materials were generally contained in buried metal containers, they may serve as a potential future source of soil and groundwater contamination. Groundwater and surface water in the general area of these test pits did not appear to be impacted, although groundwater wells were not located in close proximity to the test pit areas, with the exception of TP-87.

With the exception of the test pit areas and the former aromatics and essential oils manufacturing area, low residual concentrations of ketones were detected in soil and sediments across the study area. Concentrations were less than 1,000 ppb, except for soil boring C-20 (2,100 ppb MIBK). These soil concentrations are well below the

NJDEPE impact to groundwater soil cleanup criteria of 50,000 ppb. Ketones were detected at low residual concentrations in groundwater from well BRMW2, BRMW14, BRMW15, and Well 8 (Figure 4-50).

Halogenated VOCs

Halogenated VOCs presented and discussed below include cis-1,2-DCE, TCE and vinyl chloride. A summary representation of test pit, and groundwater results is provided in Figure 4-53. The types of materials that could be sources for halogenated VOCs are the following:

- Organics residues found in drums (cis-1,2-DCE, TCE and vinyl chloride)
- Solvents (cis-1,2-DCE, TCE, and vinyl chloride)

Potential source areas for halogenated VOCs appear to be limited to one area where organic residues were found in a buried drum (TP-106; Sears). However, other buried container areas may be present on the Sears property which have not been identified or sampled and contain organic residues with halogenated VOCs. Halogenated solvents were not detected in soils, test pits, or sediments except at very low concentrations near the analytical detection limit. TCE was detected at one location (Stepan; boring C-41) at 13 ppb. DCE was detected at 2 locations at concentrations ranging from 9 ppb to 22 ppb. These concentrations of TCE and DCE are well below NJDEPE impact to groundwater soil cleanup criteria. Very low concentrations of DCE were detected in soil gas samples in the aromatics and essential oils manufacturing area. Vinyl chloride was not detected in any soil, test pit, or sediment samples.

Low or non-detectable sample concentrations indicate that surface water is not being significantly impacted by sources of halogenated VOCs. DCE was only detected in sample SW-2 (3 ppb). TCE and vinyl chloride were not detected.

Four areas where halogenated VOCs were detected in bedrock groundwater had no identifiable contaminant source. The four areas are in the vicinity of wells BRMW1 (Sears), BRMW14 (Sears), MISS-4B (Stepan), and B38W04B (Stepan). A continuing source of halogenated VOCs does not appear to be present at wells MISS-4B or B38W04B, since halogenated VOCs concentrations have decreased to non-detectable or low residual levels in the Focused Investigation and December 1993 sampling events. No overburden sources have been identified in the areas of wells BRMW1 and BRMW14, and samples of overburden groundwater in these areas did not contain detectable concentrations of halogenated VOCs. Estimated vertical zones of vinyl chloride and 1,2 DCA contamination are presented on section E-E' in Figure 4-54.

fig4-30b.dgn 25-JUL-1994 NJO/JMS 1

N.Y. SUSQUEHANNA & WESTERN RAILROAD

WEST HUNTER AVENUE

MAYWOOD AVENUE

STATE ROUTE 17

GROVE AVENUE

BROKER AVENUE

B38W02D ND
BRMW1S ND
OBMW1S TCE 0.1J
B38W01S ND
WELL 8 ND
B38W05B ND
BRMW16 ND
WELL 5 ND
WELL 6 ND
OBMW17 *TCE 2 CIS-1,2-DCE 1
BRMW17 ND
MW-1 ND
B38W16D ND
B38W04B
OBMW16 ND
WELL 2 ND
BRMW11 *TCE 2 CIS-1,2 DCE 7 *VINYL-CHLORIDE 0.9J
OBMW11 *TCE 1J *CIS-1,2 DCE 12 *VINYL-CHLORIDE 0.4J
OBMW6 ND
BRMW6 ND
WELL 1 ND
OBMW10 CIS-1,2 DCE 0.3J
BRMW10 ND
B38W03B ND
B38W06B CIS-1,2-DCE 0.5J *VINYL CHLORIDE 0.2J
BRMW2 CIS-1,2-DCE 0.8J *VINYL CHLORIDE 1J
OBMW2 ND
OBMW19 ND
MISS-4A NA
MISS-4B *CIS-1,2-DCE 10 *VINYL CHLORIDE 20
OBMW4 *TCE 520
BRMW4 *TCE 2 *VINYL-CHLORIDE 0.3J
B38W12A TCE 0.5J CIS-1,2-DCE 0.5J
B38W12B *TCE 4 CIS-1,2-DCE 0.3J
OBMW7 ND
BRMW7 TCE 3 CIS-1,2-DCE 3
OBMW12 ND
BRMW12 ND
TP-106
*CIS -1,2 DCE 240
BRTW2
B38W07B *TCE 3
OBMW1 ND
BRMW13 TCE 0.4J CIS-1,2-DCE 0.5J *VINYL CHLORIDE 0.2J
OBMW13 *VINYL-CHLORIDE 0.2J
*TCE 4 *VINYL-CHLORIDE 4
OBMW14 ND
BRMW14
BRMW1 *CIS-1,2-DCE 1000 *VINYL CHLORIDE 1800
BRMW3 TCE 0.2J CIS-1,2-DCE 0.1J
OBMW3 *TCE 460 *1,2-DCE 19J
TCE 0.4J CIS-1,2-DCE 0.3J
BRMW5
OBMW5 CIS-1,2-DCE 0.2J
BRMW8 *TCE 3 *VINYL CHLORIDE 0.4J CIS-1,2-DCE 6
OBMW8 ND
BRMW9 ND

0 200 400 600

SCALE 1"=200'

LEGEND:

- PROPERTY LINE
- FENCE
- * ANALYTE IS EQUAL TO OR EXCEEDS NJDEPE GROUNDWATER QUALITY CRITERIA
- BRMW1 WELL IS SCREENED IN BEDROCK
- OBMW1 WELL IS PRIMARILY SCREENED IN OVERBURDEN
- J ESTIMATED VALUE
- ND ANALYTE WAS NOT DETECTED AT THE DETECTION LIMIT USED FOR THE ANALYSIS
- R DATA IS UNUSABLE
- NA SAMPLE WAS NOT ANALYZED FOR THIS PARAMETER.
- TEST PIT
- CONCEPTUALIZED INTERPRETATION OF BEDROCK GROUNDWATER WITH TCE >5 PPB, CIS-1,2-DCE >10 PPB, OR VINYL CHLORIDE >2 PPB
- CONCEPTUALIZED INTERPRETATION OF OVERBURDEN GROUNDWATER WITH TCE >5 PPB, CIS-1,2-DCE >10 PPB, OR VINYL CHLORIDE >2 PPB
- VINYL CHLORIDE >1,000 PPB CIS-1,2-DCE >30,000 PPB, OR TCE >1,000 PPB IN TEST PIT OR SOIL SAMPLES. AREA REPRESENTATION NOT TO SCALE.

NOTE

1. ALL CONCENTRATIONS ARE IN PPB.
2. CIRCLES OF CONTAMINATION ARE CONJECTURAL. AREA MAY BE LARGER OR SMALLER THAN SHOWN.
2. VARIOUS CHLORIDE SALTS DETECTED IN RI SAMPLES FROM WELL B38W04B
3. ALL LOCATIONS AND SIZES ARE APPROXIMATE

STEPAN COMPANY AND SEARS AND ADJACENT PROPERTIES RI
MAYWOOD, NEW JERSEY

FIGURE 4-53
DCE, TCE AND VINYL CHLORIDE IN GROUNDWATER AND TEST PITS

H:\PROJECT\STEPAN\CAD\STEPAN\FIGURES\4-2-NEW2.DGN

N.Y. SUSQUEHANNA & WESTERN RAILROAD

WEST HUNTER AVENUE

MAYWOOD AVENUE

STATE ROUTE 17

GROVE AVENUE

BECKER AVENUE

LEGEND:

- PROPERTY LINE
- FENCE
- SW-2 ▽ SURFACE WATER SAMPLE LOCATION
- SD-2 ▽ SEDIMENT SAMPLE LOCATION
- EXISTING DRAINAGE CHANNEL
- FORMER DRAINAGE CHANNEL

NOTE:
1. ALL CONCENTRATIONS ARE IN PPB.

SW-1
BENZENE ND
TOTAL BTEX 2
NAPHTHALENE ND

SD-1
BENZENE ND
BTEX ND
NAPHTHALENE ND

SW-2
BENZENE ND
TOTAL BTEX 0.8
NAPHTHALENE ND

SD-2
BENZENE ND
BTEX 33
NAPHTHALENE 210

SW-3
BENZENE ND
TOTAL BTEX ND
NAPHTHALENE ND

SD-3
BENZENE ND
BTEX 13
NAPHTHALENE 110

SW-4
BENZENE ND
TOTAL BTEX ND
NAPHTHALENE ND

SD-4
BENZENE ND
BTEX 58
NAPHTHALENE ND

SD-6
BENZENE 23
BTEX 541
NAPHTHALENE ND

SW-7
BENZENE ND
TOTAL BTEX ND
NAPHTHALENE ND

SW-5
BENZENE ND
BTEX ND
NAPHTHALENE ND

SW-6
BENZENE ND
TOTAL BTEX ND
NAPHTHALENE ND

SD-5
BENZENE ND
BTEX 4
NAPHTHALENE ND

0 200 400 600

SCALE 1"=200'

STEPAN COMPANY AND SEARS AND ADJACENT PROPERTIES RI
MAYWOOD, NEW JERSEY

FIGURE 4-52
BTEX AND NAPHTHALENE IN SURFACE WATER AND SEDIMENT

Two areas where halogenated VOCs were detected in overburden groundwater had no identifiable source. The two areas are in the vicinity of wells OBMW4 (Sears) and OBMW3 (Gulf). Variable concentrations in these wells indicate that contaminants are present only in small, localized pockets within the overburden. It is possible that unidentified, or unsampled buried containers with organic residues may be the source for VOCs detected in the shallow groundwater.

Low residual concentrations of halogenated VOCs in bedrock groundwater across the southern and eastern portion of the study area could not be linked to any known historical operations. Unknown offsite chemical operations using these solvents may have been conducted upgradient from this portion of the site. Lagoons on the former Citrol property were identified in EPA's aerial photography survey, but no information was available regarding the liquid contents of these lagoons.

Semi-Volatile Organic Compounds

Semi-volatile organic compounds presented and discussed below include bis-(2-ethylhexyl)phthalate and fluoranthene. The types of materials that could be sources for halogenated VOCs are the following:

- Plasticizers (bis[2-ethylhexyl] phthalate)
- Fuel oil, combustion products, or coal residues (fluoranthene)

Fluoranthene was selected as a representative compound for medium and higher molecular weight PAHs. It was detected in several localized areas of surface soils, test pits, and sediments on the Sears and Stepan properties at concentrations up to 28 ppm (Figure 4-55). No source material was identified in areas of elevated concentrations. These concentrations may have been a result of atmospheric deposition from stationary and mobile combustion sources, and residual solids from coal handling and asphalt paving.

Fluoranthene and other PAHs in soils do not appear to be migrating into the other environmental media. Fluoranthene was not detected in any groundwater or surface water, with the exception of surface water sample SW-1 (2 ppb).

Phthalates were detected at very low concentration in soil (2.6 ppm or less), sediment (25 ppm or less), groundwater (0.94 ppm or less), and surface water (0.12 ppm or less). A summary of results are presented in Figure 4-55 and 4-56). No source of phthalates were indicated, however, this compound is a common plasticizer in plastics and rubber products. It is frequently encountered in the environment at low residual background concentrations where human activity occurs.

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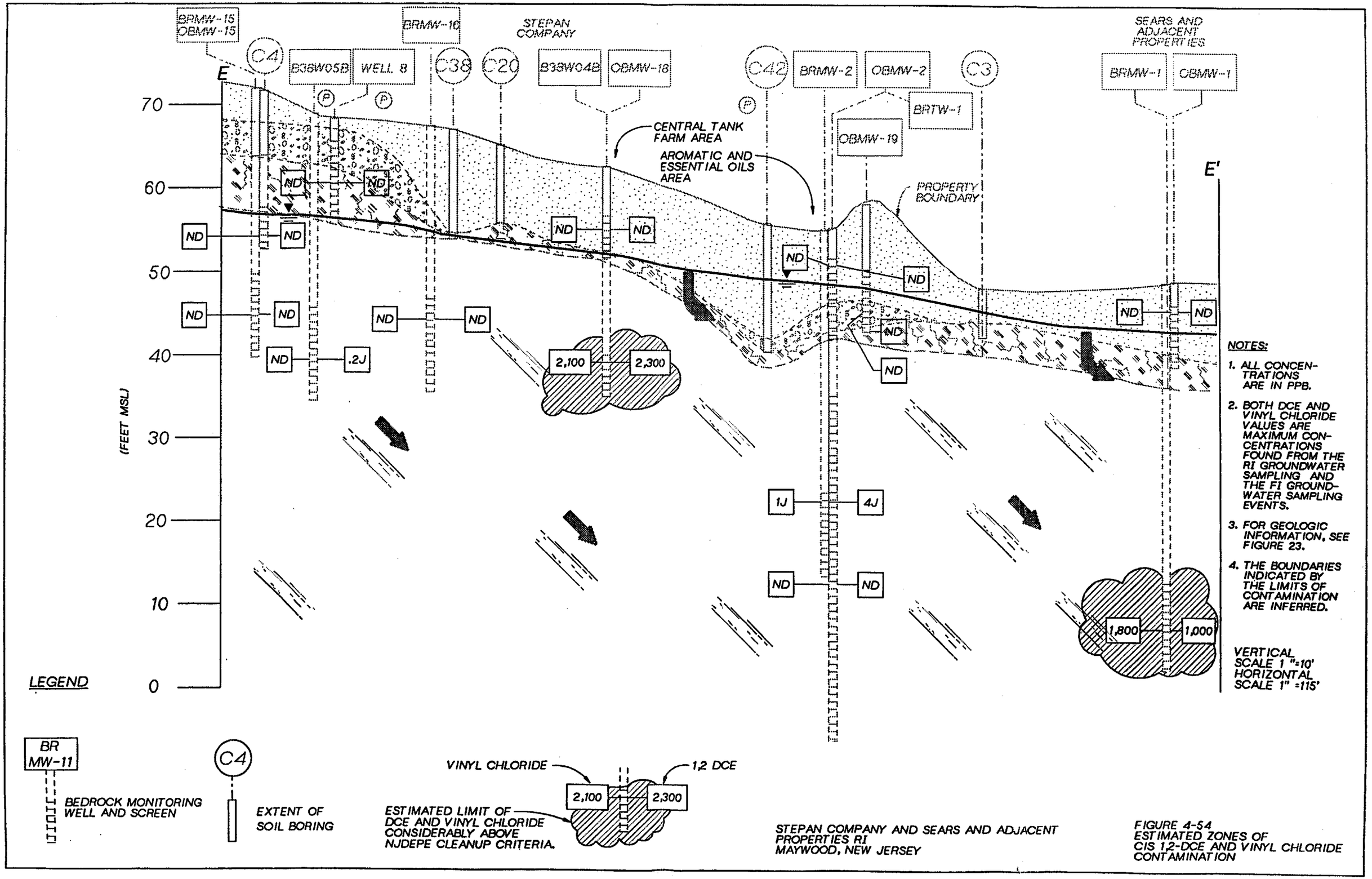

NOTES:

1. ALL CONCENTRATIONS ARE IN PPB.
2. BOTH DCE AND VINYL CHLORIDE VALUES ARE MAXIMUM CONCENTRATIONS FOUND FROM THE RI GROUNDWATER SAMPLING AND THE FI GROUNDWATER SAMPLING EVENTS.
3. FOR GEOLOGIC INFORMATION, SEE FIGURE 23.
4. THE BOUNDARIES INDICATED BY THE LIMITS OF CONTAMINATION ARE INFERRED.

VERTICAL SCALE 1 "=10'
HORIZONTAL SCALE 1" =115'

LEGEND

BR MW-11 — BEDROCK MONITORING WELL AND SCREEN

C4 — EXTENT OF SOIL BORING

STEPAN COMPANY AND SEARS AND ADJACENT PROPERTIES RI
MAYWOOD, NEW JERSEY

FIGURE 4-54
ESTIMATED ZONES OF CIS 1,2-DCE AND VINYL CHLORIDE CONTAMINATION

Inorganics

Inorganic compounds presented and discussed below include arsenic, lead, chromium, beryllium, manganese, and cyanide. The types of materials that could be sources for metals include the following:

- Leather solids filter cake from protein extraction (chromium)
- Gypsum from an offsite inorganic chemical manufacturing operation (cyanide, lead)
- Inorganic residues or ore tailings (various metals)
- Atmospheric deposition from stationary and mobile combustion sources (lead, beryllium)

Areas where elevated concentrations of metals occur in soils and groundwater is provided in Figure 4-57. General areas are indicated where soil or test pit concentrations exceeded one or more of the following criteria: arsenic (50 ppm), chromium (500 ppm), and lead (300 ppm). Groundwater areas are indicated where one or more of the following contaminant criteria are exceeded: arsenic (50 ppb), chromium (100 ppb), or lead (5 ppb). Detected and valid unfiltered groundwater concentration data from the Focused Investigation for arsenic, beryllium, chromium, lead, and manganese are shown on Figure 4-58. Focused investigation groundwater samples are considered to be more representative of groundwater conditions in the study area because of the low-flow sampling procedures used to minimize suspended sediments in samples.

Chromium is associated with filter cake that was produced during a former protein extraction process on the Stepan property. Areas where residues of filter cake may be found in shallow soils is limited to two areas of the Stepan property (Figure 4-48) based on samples from TP-22 and TP-25. Chromium in soils appears to be immobile, based on non-detectable concentrations in groundwater in this area (wells MISS-4B and B38W03B) presented in Figure 4-58.

Arsenic, chromium, or lead occur at elevated concentrations within a burial site on the Stepan property (boring C-38), and in overburden soils and test pits on the Sears property near the south and west sides of the Sears building (Figure 4-57). Sediment concentrations are also elevated near the SWS property. These concentrations may be associated with ore tailings and other inorganic residues since they are also known areas of radiological contamination.

Groundwater is impacted by metals on the Sears property in two nearby overburden areas (OBMW7 and OBMW14). Contaminants in groundwater do not appear to have migrated from specific, definable source areas in the overburden. It appears, however, that fill material used on the Sears property, mostly in the 0-to-4 foot depth

range, has generally higher concentrations of metals than other portions of the study area. Elevated metals concentrations in the fill material appear to be impacting shallow groundwater and downgradient areas of bedrock groundwater.

Surface water concentrations indicate some impact from lead, but no localized and identifiable sources in soils or sediments appear to exist (Figure 4-59). Elevated concentrations of lead in sediments appear to be characteristic of the fill material and overburden soils on the Sears property.

Beryllium and manganese appear to be at natural background concentrations throughout overburden soils in the study area. Beryllium concentrations in surface and subsurface soils across the study area ranged from 0.7 to 1.8 ppm (Figure 4-12), and manganese concentrations ranged from 3.7 to 750 ppm (Figure 4-60). In a study conducted for the NJDEPE, the average background concentration of beryllium was 2.94 ppm for urban areas of New Jersey (Fields et al, 1992). The average background concentration of manganese was 334 ppm for urban areas of New Jersey. The groundwater concentrations for beryllium and manganese are expected to have resulted from background concentrations in the overburden (Figure 4-58).

Cyanide was present in the gypsum material (blue material) generated by offsite inorganic chemical operations. Cyanide results for blue material, groundwater, surface water, and selected soil samples are presented in Figure 4-61. Based on field observations, blue material containing cyanide appears to be limited in areal extent to the DeSaussure property north and east of the building present on this site. Concentrations of cyanide in test pit or soil samples outside of the blue material were less than 15 ppm and would not be expected to be a source material for cyanide.

Impact to groundwater from cyanide in the blue material was limited to the area of one overburden well (B38W12A) in the area of the blue material, and low residual concentrations in one downgradient bedrock well (BRMW7). Low residual concentrations of cyanide which may or may not be associated with blue material were detected in surface water and sediment. Blue material does not appear to be a source material for other inorganics in groundwater.

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N.Y. SUSQUEHANNA & WESTERN RAILROAD

WEST HUNTER AVENUE

MAYWOOD AVENUE

STATE ROUTE 17

GROVE AVENUE

BECKER AVENUE

C-4
380 (3-5)
255 (5-7)
196 (7-9)

C-38
162 (8-10)
202 (10-12)
240 (12-14)

C-40
59 (2-4)
31.4 (4-6)
57.6 (6-8)

C-20
189 (2.5-4.5)
267 (4.5-6.5)
282 (6.5-8.5)

C-39
298 (0-2)
539 (4-6)
467 (6-8)

C-5
R (0-2)
R (2-4)

C-43
207 (3-5)
353 (7-9)
443 (11-13)

C-42
181 (4-6)
73.9 (6-8)
437 (10-12)

C-12
263 (0.5-2.5)
299 (2.5-4.5)

C-36
188 (0-2)
372 (2-4)
299 (4-6)

C-18
189 (0-2)
260 (2-4)

C-23
283 (0-2)
124 (4-6)

C-37
202 (0-2)
184 (2-4)

BM-2
38.6 (0-1)

BM-1
3.7 (0-1)

BM-4

BM-3
7.8 (0-1)
135 (3-4)

C-27
162 (2-4)
41.8 (4-6)
122 (6-8)

C-44
97 (4-6)
33.2 (6-8)
22.2 (8-10)

C-13
750 (1-3)
231 (3-5)
186 (5-7)

C-19
265 (0-2)
54.3 (2-4)
79.9 (4-6)

C-16
117 (1.5-2.5)
287 (2.5-4.0)
166 (4.0-5.5)

C-6
99.8 (0-2)

C-31
81.5 (2-4)
213 (4-6)
135 (6-8)

C-41
157 (0-2)

C-3
466 (0-2)
386 (2-4)

C-2
195 (0-2)
412 (3-4)

C-17
179 (0-2)
120 (2-3)
51 (3-4)

C-24
82.1 (2-4)
35.9 (4-6)

C-29
172 (1-3)
246 (5-7)
88.8 (7-9)

C-21
193 (0-2)
173 (2-4)

C-25
168 (0.5-2.5)
85.9 (4.5-8.5)
28.4 (8.5-10.5)

C-35
87.6 (3-5)
111 (5-7)
314 (7-9)

C-28
24.5 (3-5)
99.8 (5-7)
315 (7-9)

C-1
199 (0-1)
144 (3-5)
211 (5-7)

C-7
123 (2-4)
84.9 (4-5)
47.4 (5-7)
82.2 (7-8)

C-9
295 (0-2)
87.2 (4-6)

C-14
130 (2-4)
43.9 (4-6)

C-10
23.9 (2-3)
41.8 (4-6)
101 (6-8)

C-8
150 (0-2)
99.8 (2-4)

C-11
119 (3-5)
34.8 (5-7)
85.3 (7-9)

C-22
139 (1-3)
143 (3-5)
69.9 (5-7)

C-32
327 (1-3)
278 (3-5)
277 (5-7)

C-26
155 (0-2)
193 (2-4)
158 (4-6)

C-34
13.6 (1-3)
22.2 (3-5)
58.5 (5-7)

C-30
243 (1-3)

C-33
296 (1-3)
85.2 (3-5)
51.4 (7-9)

C-15
378 (0-2)
192 (3-5)
42.8 (5-7)

LEGEND:

- PROPERTY LINE
- FENCE
- C-1 — SOIL BORING LOCATION AND NUMBER
- BM-1 — BLUE MATERIAL LOCATION AND NUMBER
- (0-2) — DEPTH INTERVAL SAMPLED

NOTES:

1. ALL CONCENTRATIONS ARE IN PPM.

0 200 400 600

SCALE 1"=200'

STEPAN COMPANY AND SEARS AND ADJACENT PROPERTIES RI
MAYWOOD, NEW JERSEY

FIGURE 4-60
MANGANESE IN SOILS (PPM)
FEBRUARY - APRIL 1992

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N.Y. SUSQUEHANNA & WESTERN RAILROAD

WEST HUNTER AVENUE

MAYWOOD AVENUE

STATE ROUTE 17

GROVE AVENUE

BECKER AVENUE

	SW-1	SD-1
	As 12.8	As 11.1
	Pb 184	Cr 14.5
	Mn 915	Pb 175
		Mn 160

	SW-2	SD-2
	As 3.1	As 2.8
	Pb 9.6	Cr 23.3
	Mn 85	Pb 108
		Mn 137

	SW-3	SD-3
	Pb 10.4	As 7.3
	Mn 313	Cr 71.5
		Pb 250
		Mn 175

	SW-4	SD-4
	As 6.2	As 7.5
	Pb 32.6	Cr 44.5
	Mn 559	Pb 193
		Mn 186

	SW-7	SD-8
	Pb 41.7	As 3.7
	Mn 77	Cr 77.2
		Pb 645
		Mn 84.4

	SW-5
	Pb 11.9
	Mn 108

	SW-6	SD-5
	As 4.9	As 3.7
	Pb 5.5	Cr 25.9
	Mn 340	Pb 62.1
		Mn 88.2

LEGEND:

- PROPERTY LINE
- FENCE
- SW-1/SD-1 ▽ SURFACE WATER AND SEDIMENT SAMPLE LOCATION
- EXISTING DRAINAGE CHANNEL
- FORMER DRAINAGE CHANNEL
- SD-1 SEDIMENT SAMPLE LOCATION
- SW-1 SURFACE WATER SAMPLE LOCATION
- As ARSENIC
- Be BERYLLIUM
- Cr CHROMIUM
- Pb LEAD
- Mn MANGANESE

NOTES:

1. ALL WATER CONCENTRATIONS ARE IN PPB. ALL SEDIMENT CONCENTRATIONS ARE IN PPM.
2. ONLY DETECTED, VALID DATA HAVE BEEN PRESENTED.

0 200 400 600

SCALE 1"=200'

STEPAN COMPANY AND SEARS AND ADJACENT PROPERTIES RI
MAYWOOD, NEW JERSEY

FIGURE 4-59
ARSENIC, BERYLLIUM, CHROMIUM, LEAD, AND MANGANESE IN SURFACE WATER (PPB) AND SEDIMENT (PPM)

H:\PROJECTS\CAD\STEPAN\FIGURES\4-NEW7.DGN

N

N.Y. SUSQUEHANNA & WESTERN RAILROAD

HUNTER AVENUE

WEST

MAYWOOD AVENUE

B38W02D
Cr 7.9
Mn 2,220 J

BRMW15
Cr 250
Mn 34

OBMW15
Cr 149
Mn 75

B38W01S
Be 4
Mn 2,880 J

WELL 8
Cr 8.7
Be 8.7
Mn 387

B38W05B
Cr 9.0 J
Mn 30

WELL 6 OBMW17
Mn 1,890

BRMW16
Cr 24 J
Mn 9

WELL 5
Mn 128

BRMW17
Mn 27.8

MW-1
Mn 12,500

B38W18D
As 8.5
Cr 29.9
Mn 3,270 J

OBMW18
As 6.8 J
Be 6.0
Cr 8.0
Mn 16,800

B38W04B
As 3.3 J
Mn 9,290
Pb 7.8

OBMW6
Cr 24.5
Mn 766

BRMW6
Cr 542
Mn 63.8

OBMW11
As 5.6 J
Mn 3,590

BRMW11
Mn 988

WELL 2
As 29 J
Mn 5,410

WELL 1
Mn 2,270

OBMW10
As 61.4
Mn 1,940

BRMW10
As 1.3
Mn 838

B38W06B
Cr 8 J
Mn 2,860

B38W03B
As 1.3 J
Mn 5,580

BRMW2
Cr 7 J
Mn 3,490

OBMW2
Cr 19 J
Mn 3,410

OBMW19
NA

B38W12A
Be 4 J
Mn 2,180

B38W12B
Cr 15.8 J
Mn 52.9 J
Pb 1.9 J

OBMW4
As 5.1
Mn 1,840

BRMW4
As 2.1 J
Mn 378

MISS-4A
NA

MISS-4B
Mn 3,130

OBMW7
As 3.4 J
Cr 16.8 J
Be 6.9
Mn 3,110
Pb 8.4 J

OBMW12
Be 5 J
Mn 793
Pb 4 J

BRMW12
Cr 108
Mn 41.2 J
Pb 2.2 J

B38W07B
Mn 2,380

BRTW2
NA

OBMW1
Mn 14,100

BRMW1
Mn 2,930

OBMW13
As 21.6
Mn 3,560

BRMW13
Mn 17.7

BRMW7
Cr 15.8 J
Pb 4.5 J
Mn 7.7

STATE ROUTE 17

OBMW14
As 127
Mn 3,720

BRMW14
Mn 54.4

BRMW3
As 2.9 J
Mn 10 J

OBMW3
As 4.4
Mn 3,840
Pb 3.4 J

OBMW5
As 169 J
Mn 2,820
Pb 6.8 J

BRMW5
As 20.9
Mn 3,140
Pb 5.2 J

BRMW8
Mn 1,000 J
Pb 5.2 J

OBMW8
Mn 1,520 J

BRMW9
Be 5.8 J
Mn 75.6 J

GROVE AVENUE

BECKER AVENUE

0 200 400 600

SCALE 1"=200'

LEGEND:

----	PROPERTY LINE
----•----	FENCE
BRMW1	WELL IS SCREENED IN BEDROCK
OBMW1	WELL IS PRIMARILY SCREENED IN OVERBURDEN
As	ARSENIC
Be	BERYLLIUM
Cr	CHROMIUM
Pb	LEAD
Mn	MANGANESE
J	ESTIMATED VALUE

AREA OF OVERBURDEN GROUNDWATER WITH ONE OR MORE OF THE FOLLOWING:
ARSENIC >50 PPB
CHROMIUM >100 PPB
LEAD >5 PPB
BERYLLIUM >4 PPB

AREA OF BEDROCK GROUNDWATER WITH ONE OR MORE OF THE FOLLOWING:
ARSENIC >50 PPB
CHROMIUM >100 PPB
LEAD >5 PPB
BERYLLIUM >4 PPB

AREA OF OVERBURDEN AND BEDROCK GROUNDWATER AS DESCRIBED ABOVE

NOTES:

1. ALL CONCENTRATIONS ARE IN PPB.
2. ONLY DETECTED VALID DATA HAVE BEEN PRESENTED.
3. ONLY UNFILTERED METALS DATA HAVE BEEN PRESENTED.
4. ALL LOCATIONS AND SIZES ARE APPROXIMATE.

STEPAN COMPANY AND SEARS AND ADJACENT PROPERTIES RI
MAYWOOD, NEW JERSEY

FIGURE 4-58
ARSENIC, BERYLLIUM, CHROMIUM, LEAD AND MANGANESE IN GROUNDWATER (PPB)
JULY-AUGUST 1993

H:\PROJECTS\CAD\STEPAN\FIGURES\4-NEWMET.DGN

NOTES:

1. ALL LOCATIONS AND SIZES ARE APPROXIMATE.

LEGEND:

- PROPERTY LINE
- FENCE
- SURFACE WATER AND SEDIMENT SAMPLE LOCATION
- SOIL BORING
- TEST PIT
- MONITORING WELL
- HAND AUGER SAMPLING LOCATION
- SOIL BORING (SG)
- BLUE MATERIAL SOIL BORING
- SOIL, TEST PIT, OR SEDIMENT SAMPLE WITH ONE OR MORE OF THE FOLLOWING: ARSENIC >50 PPM, CHROMIUM >500 PPM, LEAD >300 PPM
- AREA OF BEDROCK GROUNDWATER WITH ONE OR MORE OF THE FOLLOWING: ARSENIC >50 PPB, CHROMIUM >100 PPB, LEAD >5 PPB, BERYLLIUM >5 PPB
- AREA OF OVERBURDEN GROUNDWATER WITH ONE OR MORE OF THE FOLLOWING: ARSENIC >50 PPB, CHROMIUM >100 PPB, LEAD >5 PPB, BERYLLIUM >5 PPB
- AREAS OF BOTH OVERBURDEN AND GROUNDWATER WITH ONE OR MORE OF THE FOLLOWING AS DESCRIBED ABOVE

N.Y. SUSQUEHANNA & WESTERN RAILROAD

HUNTER AVENUE

WEST AVENUE

MAYWOOD AVENUE

STATE ROUTE 17

GROVE AVENUE

BECKER AVENUE

0 200 400 600

SCALE 1"=200'

STEPAN COMPANY AND SEARS AND ADJACENT PROPERTIES RI
MAYWOOD, NEW JERSEY

FIGURE 4-57
AREAS OF METALS IN SOIL, TEST PITS, SEDIMENT, AND GROUNDWATER

H:\PROJECTS\CAD\STEPAN\FIGURES\F1G4-37.DGN

N

B38W02D NA

BRMW15 BPH 81 (RI) BPH 3 (FI)

OBMW15 BPH 4 (FI)

N.Y. SUSQUEHANNA & WESTERN RAILROAD

B38W05B ND

WEST HUNTER AVENUE

MAYWOOD AVENUE

B38W01S NA

WELL 8 BPH 8 (FI)

WELL 6

OBMW17 BPH 3 (RI)

BRMW16 ND

WELL 5 ND

BRMW17 ND

MW-1 BPH 109 (FI)

OBMW6 ND

BRMW6 ND

B38W18D NA

OBMW18

B38W04B

WELL 2 ND

BRMW11 BPH 61 (RI)

OBMW11 BPH 2 (FI)

SW-1 FLA 2

WELL 1 ND

OBMW10 BPH 11 (FI)

BRMW10 ND

B38W06B ND

B38W03B ND

BRMW2 BPH 201 (RI)

OBMW2 BPH 4 (RI)

OBMW19 NA

B38W12A ND

B38W12B ND

OBMW4 ND

BRMW4 ND

MISS-4A

MISS-4B ND

OBMW7 ND

BRMW7 BPH 5 (FI)

SW-5 BPH 120

SW-7/SD-6 BPH 2

OBMW12 BPH 940 (RI)

BRMW12 BPH 21 (FI)

B38W07B ND

BRTW2 NA

OBMW13 BPH 2 (RI)

BRMW13 BPH 2 (RI)

OBMW1 ND

BRMW1 BPH 3 (FI)

STATE ROUTE 17

OBMW14 ND

BRMW14 BPH 6 (FI)

BRMW3 ND

OBMW3

BRMW5 BPH 34 (FI)

OBMW5 ND

BRMW9 BPH 3 (FI)

BRMW8 BPH 9 (FI)

OBMW8 ND

GROVE AVENUE

BECKER AVENUE

0 200 400 600

SCALE 1"=200'

LEGEND:

	PROPERTY LINE
	FENCE
BRMW1	WELL IS SCREENED IN BEDROCK
OBMW1	WELL IS PRIMARILY SCREENED IN OVERBURDEN
SW-1/SD-1	SURFACE WATER AND SEDIMENT SAMPLE LOCATION
BPH	BIS (2-ETHYLHEXYL) PHTHALATE
FLA	FLUORANTHENE
RI	REMEDIAL INVESTIGATION RESULTS
FI	FOCUSED INVESTIGATION RESULTS

NOTES:

1. ALL CONCENTRATIONS ARE IN PPB.
2. ONLY DETECTED AND VALID CONCENTRATION DATA ARE PRESENTED.
3. FLUORANTHENE WAS NOT DETECTED IN RI AND FI GROUNDWATER SAMPLES.
4. ONLY SEDIMENT AND SURFACE WATER LOCATIONS WITH DETECTED CONCENTRATIONS ARE PRESENTED.

STEPAN COMPANY AND SEARS AND ADJACENT PROPERTIES RI
MAYWOOD, NEW JERSEY

FIGURE 4-56
BIS (2-ETHYLHEXYL) PHTHALATE AND FLUORANTHENE IN GROUNDWATER AND SURFACE WATER

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N

N.Y. SUSQUEHANNA & WESTERN RAILROAD

WEST HUNTER AVENUE

MAYWOOD AVENUE

STATE ROUTE 17

GROVE AVENUE

BECKER AVENUE

C-4 BPH 63 FLA 51
C-38
C-40 BPH 48
C-20 FLA 580
C-39 FLA 51
C-5 BPH 100 FLA 420
TP-22
TP-23
TP-25 BPH 80 FLA 1,700
TP-32 FLA 200
C-41 BPH 120 FLA 1,800
C-42
C-43
C-44
C-6 FLA 44
C-12
C-13
C-36 BPH 88 FLA 140
C-18 BPH 780 FLA 120
C-19 BPH 110 FLA 230
C-16 FLA 140
TP-80 BPH 99 FLA 430
SD-1 BPH 520 FLA 980
SD-2 BPH 4,000 FLA 11,000
SD-3 BPH 2,300 FLA 5,300
TP-76
C-23 BPH 93 FLA 6,400
C-37 BPH 990 FLA 28,000
BM-1
BM-2 BPH 64 FLA 190
BM-3 BPH 64 FLA 420
TP-42 BPH 120 FLA 190
C-27 BPH 64 FLA 6,900
C-31 FLA 49
C-17 BPH 2,500 FLA 630
TP-84
TP-85
C-24 BPH 130 FLA 97
C-21 BPH 310 FLA 300
TP-79
TP-106
TP-107
SD-4 BPH 770 FLA 1,100
SD-6 BPH 25,000 FLA 9,800
SW-5
C-35
C-28
C-29 FLA 550
C-2 BPH 320 FLA 54
C-3
C-1 FLA 350
TP-87-1
TP-87-1B
C-9 FLA 1,800
C-7 FLA 150
TP-119
TP-88-1
TP-88-2
TP-89 FLA 270
C-14 FLA 2,400
TP-91 FLA 970
C-8 FLA 890
C-10 FLA 110
C-11 FLA 84
C-33 BPH 1,400 FLA 47
C-15 BPH 2,600 FLA 590
SW-6/SD-8 BPH 470 FLA 290
C-22 FLA 55
C-25 FLA 120
TP-57 BPH 900 FLA 130
C-32
C-26 FLA 97
C-30
C-34 FLA 65

LEGEND:

----------	PROPERTY LINE
———	FENCE
C-1	SOIL BORING LOCATION
BM-1	BLUE MATERIAL SAMPLE LOCATION
*	ANALYTE IS EQUAL TO OR EXCEEDS NJDEPE SOIL CLEANUP CRITERIA
TP-23	TEST PIT SAMPLE LOCATION AND NUMBER
SW-1/SD-1	SURFACE WATER AND SEDIMENT SAMPLE LOCATION
BPH	BIS (2-ETHYLHEXYL) PHTHALATE
FLA	FLUORANTHENE
----------	EXISTING DRAINAGE CHANNEL

NOTES:

1. ALL CONCENTRATIONS PRESENTED ARE IN PPB.
2. ONLY DETECTED, VALID DATA ARE PRESENTED.

0 200 400 600

SCALE 1"=200'

STEPAN COMPANY AND SEARS AND ADJACENT PROPERTIES RI
MAYWOOD, NEW JERSEY

FIGURE 4-55
BIS (2-ETHYLHEXYL) PHTHALATE AND FLUORANTHENE CONCENTRATIONS IN SOIL, TEST PITS, AND SEDIMENTS

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N

N.Y. SUSQUEHANNA & WESTERN RAILROAD

HUNTER AVENUE

WEST

MAYWOOD AVENUE

STATE ROUTE 17

GROVE AVENUE

BECKER AVENUE

B38W02D ND
BRMW15 ND
OBMW15 ND
B38W05B ND
WELL 8 ND
B38W01S ND
BRMW16 ND
WELL 5 ND
OBMW17 ND
BRMW17 ND
B38W18D ND
B38W04B ND
WELL 2 56.3
BRMW11 ND
OBMW11 28J
SW-1 ND
OBMW6 ND
BRMW6 ND
SW-2 ND
C-37 0.82 (2-4)
BM-2 119 (0-1)
BM-1 3.6 (0-1)
SW-3 16
TP-42 TP-42 432 (1)
BM-3 157 (3-4)
B38W12A RI 8730 FI 438
B38W12B ND
C-27 ND
C-24 ND
C-31 ND
OBMW4 ND
BRMW4 ND
WELL 1 6D
BRMW10 ND
OBMW10 ND
B38W06B ND
B38W03B ND
BRMW2 ND
OBMW2 ND
MISS-4A 18.8
MISS-4B ND
B38W07B ND
OBMW1 ND
BRMW1 ND
OBMW13 ND
BRMW13 ND
OBMW14 ND
BRMW14 ND
BRMW3 ND
OBMW3 ND
BRMW5 ND
OBMW5 ND
SW-6 9
SW-4 15.8
OBMW7 ND
BRMW7 RI 10.4 FI 26.5
SW-7 17.8
SW-5 ND
OBMW12 ND
BRMW12 ND
BRMW9 ND
BRMW8 RI 15.5D FI 14.4
OBMW8 RI 76.6 FI ND

0 200 400 600

SCALE 1"=200'

LEGEND:

- PROPERTY LINE
- FENCE
- EXISTING DRAINAGE CHANNEL
- FORMER DRAINAGE CHANNEL
- * ANALYTE IS EQUAL TO OR EXCEEDS NJDEPE GROUNDWATER QUALITY CRITERIA
- BLUE MATERIAL AREA
- BM-1 BLUE MATERIAL SAMPLE LOCCATION
- C-24 SOIL BORING SAMPLE LOCATION
- TP-42 TEST PIT SAMPLE LOCATION
- SW-1 SURFACE WATER SAMPLE LOCATION
- BRMW1 WELL IS SCREENED IN BEDROCK
- OBMW1 WELL IS PRIMARILY SCREENED IN OVERBURDEN (IN BOTH RI AND FI)
- ND ANALYTE WAS NOT DETECTED AT THE DETECTION LIMIT USED FOR THE ANALYSIS (IN BOTH RI AND FI)
- APPROXIMATE AREA OF OVERBURDEN GROUNDWATER WITH CYANIDE >200 PPB

NOTE:

1. ALL GROUNDWATER AND SURFACE WATER CONCENTRATIONS ARE IN PPB.
2. ALL SOIL, BLUE MATERIAL, AND TEST PIT CONCENTRATIONS ARE IN PPB.
3. ONLY WELLS B38W12A, BRMW7,BRMW8, OBMW8 WERE SAMPLED DURING THE FOCUSED INVESTIGATION. "RI" SIGNIFIES RI DATA, "FI" SIGNIFIES FOCUSED INVESTIGATION DATA FOR THESE WELLS.
4. ALL LOCATIONS AND SIZES ARE APPROXIMATE

STEPAN COMPANY AND SEARS AND ADJACENT PROPERTIES RI
MAYWOOD, NEW JERSEY

FIGURE 4-61
CYANIDE IN GROUNDWATER, SURFACE WATER AND BLUE MATERIAL AREAS

Section 5
Contaminant Fate and Transport

5.1 Introduction

The release and migration of contaminants in the study area and the persistence of contaminants in the environment are affected by the physical and chemical properties of the contaminants and by the site characteristics, which include hydrogeology and hydrology, the composition of surface and subsurface material, and the extent of surface and subsurface improvements. The relevant physical and chemical properties and transformation processes determine the fates of specific contaminants as they encounter soil, water, and air. Characteristics of selected contaminants and several potential migration pathways from source areas to underlying groundwater zones are discussed in this section. The analytical data collected indicated that volatilization and soil particulate pathways to air are not significant migration pathways. Therefore, these pathways are not discussed in this report.

Contaminants were selected for the fate and transport discussion if (1) the contaminant was detected at a level at least two times the NJDEPE groundwater cleanup criteria, or (2) the contaminant was detected in soil borings, test pits, or sediments at a level at least two times the NJDEPE residential direct contact soil cleanup criteria. Exceptions were made for compounds that were detected in only one or two localized samples. These exceptions included the following: methylene chloride, pentachlorophenol, bis(2-ethylhexyl)phthalate, beryllium, selenium, cyanide, and chlorinated organics in test pit TP-106.

The contaminants selected for the fate and transport discussion in this section are:

- Benzene, toluene, ethylbenzene, and xylene (BTEX)
- PAHs in soils and sediments
- TCE and its microbial degradation products in groundwater
- Selected metals (arsenic, cadmium, chromium, lead, nickel)

5.2 Physical and Chemical Properties of Contaminants

Contaminants discussed in this section are representative of the major groups of contaminants encountered in the study area at levels above proposed NJDEPE cleanup criteria. Properties of both organic and inorganic parameters are discussed below as they relate to fate and transport processes.

5.2.1 Organic Compounds

Fate and transport of organic compounds is affected by solubility, adsorption, and biodegradation. The probable behavior of volatile and semivolatile organic compounds in the study area can be projected on the basis of their physical and chemical properties. These properties include molecular weight, aqueous solubility, octanol-water partition coefficient (K_{ow}), and soil-water partition coefficient normalized for soil organic carbon content (K_{oc}). Published values for these properties are provided in Table 5-1.

Molecular weight, or molecular size, affects the adsorption potential of a compound. Generally, the larger the molecule, the greater its tendency to exist in an adsorbed state. Molecular weight also has an effect on compound solubility and biodegradability.

Aqueous solubility is determined by the maximum concentration of the organic compound that can be dissolved in pure water. The higher the solubility, the more likely the contaminant will be dissolved in and transported by groundwater. Conversely, the lower the solubility, the more likely the compound will be associated with the soil matrix or organic material. Chlorinated ethenes and ethanes are compounds with relatively high solubility, while PAHs have relatively low solubility.

The octanol-water partition coefficient, K_{ow}, is the ratio of the amounts of a particular pure compound present in the water and organic phases under equilibrium conditions. Octanol is the standard solvent used to represent the organic phase. A high value for K_{ow} indicates that the compound is more likely to be found in the soil organic matter than in the aqueous phase. PAHs have relatively high values for K_{ow}, while chlorinated ethanes have relatively low values.

The soil water partition coefficient, K_{oc}, is the relative proportion of the chemical present in the soil matrix and the amount present in the water phase under equilibrium conditions. K_{oc} is normalized for soil organic content so that much of the variation due to soil type can be eliminated. Compounds with high K_{oc} values are more likely to be found in soil, sediment, or particulate matter than dissolved in water.

Mobility classes for organic compounds in soil are provided in Table 5-1. These categories of relative mobility are based on the ranges of values for K_{oc} (Fetter) and retardation factors for soil thin-layer chromatography (Dragun); these categories are presented in Table 5-2. The mobility of an organic chemical decreases as its affinity to the soil matrix (measured by K_{oc}) increases. Assigning compounds to mobility classes provides a qualitative understanding of the potential for contaminant transport in soil.

Table 5-1
Physical and Chemical Properties of Organic Compounds

Chemical	Molecular Weight	Aqueous Solubility (mg/L)	Log K_{ow}	Log K_{oc}	Mobility Class[a]
BTEX					
Benzene	78.11	1,750	2.12	1.94	Mobile
Ethylbenzene	106.17	152	3.13	2.20	Intermediate mobility
Toluene	92.14	515	2.65	2.18	Intermediate mobility
m-Xylene	106.17	158	3.20	3.20	Low mobility
o-Xylene	106.17	152	2.95	2.11	Intermediate mobility
p-Xylene	106.17	198	3.18	2.31	Intermediate mobility
Chlorinated Ethenes and Ethanes					
Chloroethane	64.52	5,700	1.43	0.54 E	Very mobile
1,1-Dichloroethane	98.96	5,500	1.79	1.48	Very mobile
1,2-Dichloroethane	98.96	8,690	1.48	1.15	Very mobile
1,1-Dichloroethene	96.94	2,250	1.84	1.81	Mobile
cis-1,2-Dichloroethene	96.94	–	–	–	–
trans-1,2-Dichloroethene	96.94	6,300	2.09	1.77	Mobile
Tetrachloroethene (PCE)	165.83	150	2.60	2.42	Intermediate mobility
TCE	131.39	1,100	2.53	2.03	Mobile
Vinyl chloride	62.50	1,100	0.60	0.39 E	Very mobile
PAHs					
Acenaphthene	154.21	3.47	4.13	3.41 [b]	Slight mobility
Acenaphthylene	152.20	3.93	4.07	3.68 E	Slight mobility
Anthracene	178.24	0.0450	4.45	4.27	Slight mobility
Benzo(a)anthracene	228.30	0.0120	5.90	6.14	Immobile
Benzo(b)fluoranthene	252.32	0.0140	6.57	5.74	Immobile
Benzo(k)fluoranthene	252.32	0.000550	6.85	6.64 E	Immobile
Benzo(g,h,i)perylene	276.34	0.000260	7.10	6.89 E	Immobile
Benzo(a)pyrene	252.32	0.00390	6.00	6.00 E	Immobile
Chrysene	228.30	0.00180	5.61	5.39 E	Immobile
Dibenzo(a,h)anthracene	278.36	0.00500	6.36	6.22	Immobile
Fluoranthene	202.26	0.240	5.22	4.62	Immobile
Fluorene	166.22	1.69	4.18	3.70	Slight mobility
Indeno(1,2,3-c,d)pyrene	276.34	0.0620	7.70	7.49 E	Immobile
2-Methylnaphthalene	142.20	24.6	4.11	3.93	Slight mobility
Naphthalene	128.18	30.0	3.36	3.11	Low mobility
Phenanthrene	178.24	1.00	4.52	4.36	Immobile
Pyrene	202.26	0.135	5.09	4.81	Immobile

[a] Table 5-2
[b] Value from Fetter, p.404

Note:
E= estimated value

Source of physical and chemical property data:
Knox et al, p.394-404, unless otherwise indicated.

Table 5-2 Mobility Classifications		
K_{oc}	Log K_{oc}	Mobility class
> 20,000	4.3	Immobile
2,000 to 20,000	3.3 - 4.3	Slight mobility
500 to 2,000	2.7 - 3.3	Low mobility
150 to 500	2.2 - 2.7	Intermediate mobility
50 to 150	1.7 - 2.2	Mobile
< 50	< 1.7	Very mobile
NOTE: Based on Dragun		

Many organic compounds are potentially biodegraded in the subsurface environment. Chemical properties influencing biodegradability include aqueous solubility, molecular weight, degree of branching and unsaturation in hydrocarbon structures, and degree of halogenation. BTEX and PAHs can biodegrade in aerobic and anoxic environments, and TCE can biodegrade in anoxic environments. Suitable pH and nutrient conditions also need to be present for biodegradation to occur.

5.2.2 Inorganic Compounds

The fate and transport of inorganic compounds are affected by solubility equilibria, oxidation-reduction (redox) reactions, complex ion formation, and ion-exchange and adsorption processes. Metal behavior is also influenced by a number of interrelated factors, including pH, redox potential, ionic strength, and concentrations of specific anions and cations. Site-specific information regarding most of these factors was not available to support further evaluation of fate and transport processes associated with inorganics.

Groundwater pH was available for both overburden and bedrock zones. Although pH ranged from 5.4 to 11.7, the pH for most overburden and bedrock monitoring wells was in the 6 to 7 range. Generally, the metal cation concentration increases with decreasing pH.

Two factors influencing ion exchange and adsorption processes are hydrated ionic radius and valence. Metal cations typically adsorb onto negatively charged soil surfaces by an ion exchange process that occurs when the soil charge deficiency is more effectively neutralized by ions in the water phase than ions that are already adsorbed. For water with low to moderate ionic concentrations, higher valency ions generally replace lower valency ions, and smaller ions generally replace larger ions of

the same valence (Dragun). Arsenic, cadmium, chromium, lead, and nickel are multivalent cations that would be expected to replace common ions such as sodium and potassium.

5.3 Soil Properties

Overburden soil properties that affect contaminant fate and transport are the soil organic fraction, clay content, and cation exchange capacity. TOC analysis of samples from three borings in the study area indicated little or no organic contamination; the soil organic carbon ranged from about 0.2 to 1 percent. Generally, the higher the organic carbon content, the higher the adsorption potential for organic compounds. The organic content of most of the overburden soil is relatively low. Although the organic content in the wetlands area east of the Sears building is expected to be moderate to high, this condition is very localized and does not represent general site conditions.

The soil surface area for adsorption of inorganics and organics increases with increasing silt and clay content. The most dominant surface area for metals adsorption in soil is generally the clay fraction. The clay content of soil was determined on the basis of grain-size analysis of samples from three borings in the study area. The clay content ranged from about 8 to 12 percent (Appendix U). This is a relatively low clay content, so adsorption potential for metal cations is relatively limited.

Both the silt and clay fractions also provide a medium for adsorption and physical incorporation of hydrocarbons in the soil matrix. VOC and semivolatile organic constituents in soil generally are associated with the fines fraction. Fines content (the sum of the silt and clay fractions) ranged from about 30 to 70 percent, although geologic logging during the study indicates the soil size is generally silty fine sands or more coarse grained material.

The cation exchange capacity of soil was not determined but can be estimated on the basis of clay content of the overburden material, which was classified overall on the basis of grain-size analysis and geological logging as a silty sand. Silty sand material is expected to have a relatively low cation exchange capacity of about 10 milliequivalents per 100 grams of soil. Metal cations typically have moderate to high mobility in silty sand soil because of the relatively low cation adsorption potential.

5.4 Transport Mechanisms in Groundwater

In addition to adsorption, hydrolysis, and degradation, the factors that control the transport of contaminants in groundwater are advection, dispersion, and diffusion. Advection is the dominant transport mechanism in groundwater; advection results

when the solutes are transported by the bulk motion of groundwater. Dispersion is the process by which solutes spread out from the path they would be expected to follow on the basis of advective hydraulics. Dispersion is caused by mechanical mixing, which results from differential groundwater flow velocities. Diffusion is a dispersion process that is caused by concentration gradients and is important only at low velocities.

5.4.1 Overburden Groundwater System

Aquifer heterogeneities resulting in variations of hydraulic conductivity both vertically and horizontally will substantially affect advection, dispersion, and diffusion of contaminants in the overburden groundwater system. Resulting plume shapes will be irregular and controlled, to a large degree, by preferential flow patterns that develop in the overburden. In general, soil lenses of low hydraulic conductivity dispersed throughout sediment can cause a plume to widen or shorten and sometimes to bifurcate. High contaminant concentrations tend to remain closer to source areas. Soil types exhibiting higher hydraulic conductivity will cause a plume to narrow and become longer. Zones of higher conductivity also become the preferential zones for contaminant flow.

The intrinsic soil properties that affect hydraulic conductivity in the overburden include grain size distribution, degree of cementation, packing arrangement, and grain shape. These properties were generally described and recorded during the soil boring program in accordance with accepted soil classification procedures. However, the soil boring information does not provide enough detail for quantitative evaluation of these properties. As presented in Section 3, two general facies are identified, each of which exhibits distinct hydrogeologic properties: 1) The upper deposit, consisting of Recent Age deposits and stratified glacial deposits; 2) The lower deposit, consisting of unstratified glacial till and residual soil. Although the lower deposit is not thought to act as a semi-confining layer, it is considerably more compact and less sorted than the overlying stratified deposits. Contaminant distribution within this zone is expected to exhibit patterns similar to those associated with deposits having lower conductivity than the zone above.

In addition to the differences between the two facies, vertical and horizontal heterogeneities in the soil also will affect contaminant migration.

5.4.2 Bedrock Groundwater System

Contaminant transport behavior within the fractured bedrock system is quite different than in the overburden groundwater system. The principal mechanisms that affect contaminant flow in the fractured rock are advection and dispersion. The following discussion assumes that most groundwater flow occurs through fractures because matrix porosity is not significant in the Passaic Formation beneath the study area.

The discussion also assumes that chemical reactions of contaminants with the fracture surface are negligible because of the general paucity of organic materials.

Continuum Approach. Conceptualization of transport in fractured rock generally employs the continuum approach. This approach assumes that the complex of fractures in which groundwater flows in a rock mass can be approximated as an equivalent porous medium. The medium is assigned averaged hydrogeologic properties, and the same assumptions that are applied to nonfractured porous media can be used. This approach has not adequately mapped actual contaminant distribution in fractured rock consistently. Studies have shown that equivalent porous media assumptions may not be appropriate for certain fractured rock environments (Endo *et al*, Krizek *et al*, Schwartz *et al*). In these cases, the investigation of contaminant transport requires detailed fracture geometry and simulation of transport in discrete fractures within the fracture network. Even if simulations of the study area had been performed, the resulting transport model would likely suggest complicated, irregular contaminant distribution plumes and pathways, as discussed below.

Non-Gaussian Distribution. Dispersion of contaminants in porous media is usually assumed to result in a Gaussian particle distribution, which in practice is generally adequate for predicting shapes of contaminant plumes. According to Schwartz, however, particle distribution in fractured rock in the direction of flow is non-Gaussian (not distributed normally). This pattern is attributed to the higher velocity along fractures and pathways in the direction of flow than the velocity in pathways oriented perpendicular to the direction of flow. Long *et al* stated that fracture sets may become nonconductive if the hydraulic gradient is perpendicular to the orientation of the fracture set. Likewise, Krizek *et al* concluded that the orientation of the joints in a fractured rock mass significantly influences the dispersion characteristics, with marked longitudinal dispersion (dispersion in the direction of bulk groundwater flow) occurring even a short distance from a source. These conclusions underscore the increased complexity and difficulty of characterizing contaminant transport in the multi-unit bedrock aquifer system that underlies the site.

Equipotential Contours. Krizek *et al* did conclude that the shapes of equiconcentration contours are intimately related to the shapes of the equipotential contours, and a first order approximation of the contaminant distribution can be performed with a knowledge of the hydraulic potential distribution. However, because multiple potentiometric surfaces are indicated to be present in the multi-unit leaky bedrock aquifer underlying the site, determining the distribution of hydraulic potential in the bedrock system at the study area was not possible during this investigation.

Mixing. Mixing within a fracture is a function of fracture aperture (spacing) and the degree of roughness of the fracture wall. When the aperture is small and the walls touch, mixing is increased. Greater fracture-face roughness causes vortices and turbulence, which increase mixing. In continuum models, mixing at fracture interfaces

is normally assumed to be complete. Recent studies indicate, however, that four-way fracture intersections where flow is equal and laminar in each fracture results in no mixing at all (Robinson and Gale). The same authors conclude that contaminants migrating through fractured media will not be dispersed and diluted to the extent suggested in continuum models. Consequently, in fractured media, contaminants travel more quickly and at higher concentrations than the continuum model would indicate. If a monitoring well penetrates a contaminant-laden fracture, the concentration of detected contaminants in groundwater will be high. The pattern of groundwater contamination surrounding this monitoring point, however, would not resemble plumes typical of porous-media environments.

5.5 Pathways of Contaminant Migration

The most probable pathways of contaminant migration from the study area are:

- Overburden soil to shallow groundwater
- Shallow groundwater to deeper groundwater zones
- Groundwater to surface water and surface water runoff

Each of these pathways is discussed below. The soil-to-air pathway is not discussed in detail because emissions of dust and organic vapor from soil are considered to be very limited. Most of the study area is covered with pavement or buildings that prevent emission of dust and organic vapor. Unpaved portions of the study area are either vegetated or covered with crushed stone, so a high level of soil moisture is maintained, which also serves to limit dust emissions in unpaved areas. The only unpaved portion of the study area with elevated levels of VOCs in soil is a small area on the Stepan property (formerly Aromatics and Essential Oils Manufacturing Area); high soil moisture would also limit organic vapor emissions from this area, so potential exposure would be limited for this industrial site.

5.5.1 Overburden Soil to Shallow Groundwater

Organic and inorganic contaminants can migrate from source soil into shallow groundwater within the overburden material. Contaminants may dissolve from the unsaturated-zone overburden soil into water traveling through the zone. Contaminants present in the saturated-zone overburden soil may dissolve into the water phase.

BTEX, TCE, and TCE Degradation Products. USTs that contain gasoline, benzene or toluene are a common source of BTEX compounds. USTs that contain other petroleum oils may be associated with PAHs. TCE could cause contamination either by the presence of TCE itself or its degradation products. High concentrations of BTEX or PAHs could result in the presence of free-phase hydrocarbons, whereas

TCE would be a dense non-aqueous phase liquid that would sink through the water column.

The only overburden wells that contained VOCs considerably higher (two orders of magnitude) than the NJDEPE groundwater quality criteria were wells OBMW2 (Stepan), OBMW3 (Gulf), and OBMW4 (Sears). Wells OBMW2 (Stepan) and OBMW3 (Gulf) contained BTEX compounds. Wells OBMW3 (Gulf) and OBMW4 (Sears) had elevated levels of TCE detected during the Focused Investigation sampling.

Although limited sampling was conducted in areas that contained USTs, it appears that no significant hydrocarbon-phase source areas are present in the study area. No free-phase hydrocarbons were observed in field sampling activities. Aqueous contaminant concentrations approaching the solubility limit would indicate the presence of hydrocarbon-phase source areas, but the maximum aqueous concentrations of BTEX, TCE, and TCE degradation products in groundwater samples were less than 3 percent of the aqueous solubility for each of those compounds.

Although BTEX compounds were not frequently encountered in overburden soil at concentrations exceeding NJDEPE impact to groundwater soil cleanup criteria, soil that did have elevated BTEX levels could affect the shallow overburden groundwater. The most mobile BTEX compound detected in soil samples was benzene. Benzene has a relatively high potential to migrate into shallow groundwater from the localized areas where it was detected. Benzene and other BTEX compounds would likely be attenuated to some degree by aerobic and anoxic biodegradation processes and sorption in the overburden material.

TCE where present in overburden soil could migrate into shallow groundwater. TCE has an intermediate degree of mobility in the subsurface. TCE can undergo anoxic biodegradation through a pathway that includes the seven chlorinated degradation products shown in Table 5-3. Three of these—chloroethane; 1,1-dichloroethane; and 1,2-dichloroethane—are more mobile than TCE. Soil adsorption is generally not expected to be high for these compounds.

Sampling data confirmed that shallow groundwater has been slightly affected by TCE and its degradation products. Although TCE and TCE degradation products were not found in overburden soil at levels above the NJDEPE residential direct contact soil cleanup criteria, these compounds were detected in overburden groundwater samples (OBMW17 and OBMW11) at levels exceeding NJDEPE groundwater cleanup criteria. However, a high concentration of TCE was detected in the drum content sample collected from TP-106.

Table 5-3 Chlorinated Degradation Products of TCE
1,1-dichloroethylene Cis-1,2-dichloroethylene Trans-1,2-dichloroethylene 1,1-dichloroethane 1,2-dichloroethane Vinyl chloride Chloroethane
Source: Dragun

Elevated concentrations of vinyl chloride and DCE were detected in monitoring well B38W04B, a partial bedrock well. During the Focused Investigation, vinyl chloride and DCE were not detected in samples from B38W04B, although high detection levels may have masked the presence of these contaminants. The source of the contamination in the deeper groundwater may be affecting shallow groundwater as well.

Specific areas of VOC-contaminated soil that may be sources of shallow groundwater contamination were identified during the RI and the Focused Investigation. The VOCs and affected areas include:

- BTEX–soils near well OBMW2 (Stepan) and boring C-44 (Stepan)
- BTEX–soil on the north side of Building 10 (Stepan)
- VOCs–wastes in buried containers in test pit TP-106 (Sears)
- BTEX–wastes in buried containers in test pits TP-84, TP-85, and TP-87 (all on Sears)
- BTEX–soil on east side of SWS property near boring C-25 (SWS) where a UST had been located

PAHs. PAHs were found primarily in shallow soils and sediments in the study area at a depth of 0 to 4 feet. PAHs can dissolve into water traveling through the unsaturated zone and affect the quality of shallow groundwater. The PAHs found in shallow soil on the site, however, are slightly mobile or relatively immobile except for naphthalene, which has low mobility (Table 5-2). These compounds have a relatively high molecular weight and are characterized by very low aqueous solubilities (0.26 to 240 ppb) with the exception of naphthalene (30,000 ppb) and 2-methylnaphthalene

(24,600 ppb). These compounds are not expected to have a significant impact on the shallow groundwater, especially in paved areas where water infiltration through the vadose zone is expected to be very low. Sample results confirm that this is a reasonable expectation: in areas where heavy PAHs were found in soil at elevated levels, these PAHs were not found at detectable concentrations in groundwater.

Naphthalene and 2-methylnaphthalene were detected in the RI and Focused Investigation at relatively low concentrations in localized areas of groundwater where BTEX compounds also were detected (Stepan wells B38W04B, MW1, and OBMW2). Soil samples were not obtained near these wells except for well MW1 (Stepan), where naphthalene and 2-methylnaphthalene were detected in soil at 2,500 ppb or less. These low levels of PAHs may be attributed to residual contamination from past handling of gasoline or fuel because the PAHs occur together with BTEX compounds. USTs were removed from the area near Stepan wells MW1 and B38W04B in October 1991 (Section 1.3.9 and Appendix C). Two gasoline USTs are located near well OBMW3 (Gulf). An area of BTEX-contaminated soil was delineated near well OBMW2 (Stepan) during the Focused Investigation.

Metals. Lead, chromium, arsenic, cadmium, and nickel found at elevated levels in overburden soil could affect the shallow groundwater. These metals are generally expected to have moderate mobility in silty sand soil because of their moderate degree of soil adsorption and potential for chemical transformation to less mobile forms. Samples in the overburden soil indicated the presence of metals at concentrations above the NJDEPE impact to groundwater soil cleanup criteria. Well locations with elevated concentrations of a particular metal did not, however, necessarily correspond exactly to soil boring or test-pit sampling locations with high levels of that particular metal. Therefore, specific source areas for metals contamination of groundwater have not been accurately determined.

5.5.2 Shallow Groundwater to Deeper Zones

Migration of dissolved contaminant shallow to deeper zones is controlled by site-specific groundwater flow and hydrogeology. As discussed in Section 3.4, the occurrence and movement of groundwater in the bedrock aquifer both regionally and locally is rather complex. The hydraulic communication of the overburden groundwater system with the bedrock aquifer system is localized, and where present, the vertical gradients are not consistently upward or downward.

Once contaminants reach the bedrock groundwater zone, the potential for horizontal migration and dispersion is relatively high. The bedrock zone is expected to have horizontal groundwater flow velocities of a higher magnitude than the overburden soil zone, especially along bedrock fractures.

In general, contaminants have a relatively high potential for migration from localized areas in the overburden groundwater system to the bedrock aquifer, where there is hydraulic connection with a downward gradient. Contaminant movement may be

retarded by adsorption within the overburden zone groundwater system as a result of fines and organic matter.

The site hydrogeologic framework determined during the RI and the distribution of contaminants observed in the overburden wells in comparison to that in the bedrock wells suggested that contaminant transport is much more effective in the multi-unit leaky aquifer system than in the saturated overburden.

The water table was found to be below the bottom of the overburden in select places (e.g., BRMW9, OBMW15) across the study area. The intermittent presence of the water table above the top of the rock slows the long-distance transport of contaminants within the overburden groundwater system.

BTEX. Dissolved BTEX compounds are not expected to be significantly adsorbed in the bedrock aquifer, but some degree of anoxic biodegradation may occur.

Attenuation of organic compounds is expected to be greater in the overburden than in the bedrock because of the organic carbon fraction present in the fine-grained soil. Little or no organic carbon is expected to be in the multi-unit bedrock system so adsorption is not a mechanism for retardation of organics migration.

Where the vertical gradient in the study area is downward, contaminants would be expected to flow from the overburden groundwater system into the multi-unit bedrock aquifer system. Bedrock aquifers underneath the site are considered to be continuous thousands of feet along the strike of the bedding, and hundreds of feet down-dip. Therefore, in areas where the vertical head is downward, contaminants may travel considerable distances in the bedrock aquifer system. However, considering that the direction of the vertical gradient is not consistently downward and that cross flows between discrete aquifers are not prevalent, the transport mechanism of contaminants is considered to be very complex.

In general, BTEX, TCE, and TCE degradation products are more prevalent in the bedrock wells than in the overburden wells. The only overburden wells that contained VOCs in considerably higher concentrations (two orders of magnitude) than the cleanup criteria were OBMW3 (Gulf), OBMW2 (Stepan), OBMW4 (Sears), OBMW18 (Stepan), and MW-1 (Stepan). BTEX compounds in well OBMW3 are likely associated with handling of gasoline near USTs at Gulf and are not thought to have traveled from a great distance in the overburden because of the limited permeability of the overburden soil. Benzene was detected at high levels in well OBMW2 but was present in much lower concentrations (four orders of magnitude) in the bedrock well at this location, BRMW2. This suggests the existence of a significant barrier to contaminant transport in the bedrock zone at this location.

Several bedrock wells in the area sampled during the RI had BTEX compounds two orders of magnitude higher than NJDEPE groundwater quality criteria. Well B38W04B had a benzene concentration of 560 ppb and a total toluene, ethylbenzene,

and xylene concentration of 5,620 ppb. In the bedrock wells located downgradient of B38W04B (Stepan), BRMW2 (Stepan) had benzene at 55 ppb; MISS4B (Stepan Amended) had benzene at 190 ppb; and BRMW1 (Sears) had benzene at 230 ppb. BRMW1 is located near the Sears property boundary and Route 17, so benzene contamination may have the potential to migrate off the site from this area.

BRMW8 had a total BTEX concentration of 24 ppb for the RI. The source area for the BTEX compounds detected in BRMW8 is suspected to be associated with the gasoline UST formerly located on the east side of the SWS property. The total BTEX concentration decreased to 0.2 ppb for this well during the Focused Investigation; therefore, a significant upgradient source area is not suggested.

TCE and TCE Degradation Products. Several bedrock wells contained elevated levels of cis-1,2-DCE and vinyl chloride during the RI, although these wells did not contain TCE. Of these bedrock wells, only wells BRMW1 and BRMW14 are at a downgradient edge of the site. In BRMW1, cis-1,2-DCE was not detected; BRMW14 had a concentration of 21 ppb. BRMW1 had a concentration of 1,200 ppb for vinyl chloride; BRMW14 had 6 ppb of vinyl chloride. MISS4B, located upgradient of wells BRMW1 and B38W07B, exhibited cis-1,2-DCE at 810 ppb and vinyl chloride at 520 ppb. B38W07B did not exhibit any of this family of compounds; however, as stated previously, BRMW14 did. Well B38WO4B exhibited high levels of cis-1,2-DCE (2,300 ppb) and vinyl chloride (2,100 ppb); however, only one of three wells immediately downgradient contained cis-1,2-DCE, at a much lower concentration (4 ppb). The other onsite bedrock wells exhibiting elevated levels of TCE and its degradation products are unlikely to significantly affect the quality of bedrock water offsite because contaminated levels are low.

Groundwater samples taken during the Focused Investigation had significantly lower concentrations of vinyl chloride and cis-1,2-DCE in wells B38W04B and MISS4B than did samples taken in the RI. Concentrations for these two compounds decreased to nondetectable levels in well B38W04B. Concentrations in well MISS4B decreased to 20 ppb or less for both compounds. It should be noted that the sample from B38W04B was diluted to the extent that the detection limits for vinyl chloride, benzene, xylene, and 1-2-dichloroethene were 1,000 ppb. In addition, the high volatility of vinyl chloride may also account for the variability in sampling results.

Groundwater samples from the Focused Investigation had higher concentrations of cis-1,2-DCE and vinyl chloride in well BRMW1 (Sears) than did samples taken in the RI. The concentration of cis-1,2-DCE increased from a nondetectable concentration to 1,000 ppb and the concentration of vinyl chloride increased from 1,200 ppb to 1,800 ppb. Maximum concentrations of these compounds in samples collected from pump test wells BRTW2 (Sears), which is approximately 50 feet upgradient of well BRMW1, were 570 ppb for vinyl chloride and 240 ppb for cis-1,2-DCE. These results suggested that there are elevated concentrations of vinyl chloride and cis-1,2-DCE in this portion of the Sears property, but no upgradient source areas were identified on the basis of available data.

Metals. In general, concentrations of total metals detected in the RI were found to be greater in the overburden wells than in the bedrock wells. This pattern may be explained by the fact that silt and sediment loads observed in overburden groundwater samples were generally greater than in bedrock samples. For some metals, however, concentrations in some of the bedrock wells were higher than the NJDEPE groundwater quality criteria, even though samples from these wells generally did not exhibit high suspended solids. The low-flow groundwater sampling method used during the Focused Investigation resulted in much lower total metals concentrations due to lower silt and sediments in groundwater samples. Because the low-flow sample results are considered to be more representative of metals concentrations in the study area than samples obtained during the RI, only results of the Focused Investigation will be used in the following discussion.

Concentrations of lead in the unfiltered groundwater were within two times the NJDEPE groundwater quality criteria. Lead was only detected in the unfiltered sample from one well (OBMW12) at a concentration below the groundwater quality criteria. Thus, lead is not considered to be at levels of concern for bedrock migration because filtered samples, or dissolved metals concentrations are below the groundwater criteria.

Cadmium results for unfiltered groundwater samples were within three times the NJDEPE groundwater quality criteria of 4 ppb, except in well OBMW2. Cadmium was detected in filtered groundwater samples taken from wells OBMW1, OBMW2, OBMW13, and Well 2 at a maximum concentration of 16 ppb. Each of these wells are overburden wells. Cadmium therefore, is not considered to be at a level of concern for migration into bedrock because filtered samples, or dissolved metals concentrations in overburden are very low and dissolved cadmium was not detected in bedrock wells.

Chromium exceeded two times the NJDEPE groundwater quality criteria of 100 ppb in only two wells: BRMW15 (Stepan) and BRMW6 (Sears). Both of these wells are located near hydraulically upgradient property boundaries of the study area, and soil samples collected near these wells during the RI did not indicate elevated concentrations of chromium. Chromium was detected in filtered groundwater samples from only wells OBMW2 (Stepan) and B38W18D (Stepan) at a maximum concentration of 27.2 ppb. Chromium is therefore not considered to be at levels of concern for migration into bedrock because filtered sample, or dissolved metals are generally at nondetectable concentrations.

5.5.3 Groundwater to Surface Water, and Surface Water Runoff

Shallow groundwater in the overburden material can discharge during certain times of the year to the wetlands area and to drainage ditches (both open swales and underground channels) east and south of the Sears building. These drainage features

are connected to an underground culvert that leads to Lodi Brook. Contamination discharging to surface water is expected to be diluted by contributions to streamflow from overland flow.

BTEX, TCE, and TCE Degradation Compounds. BTEX compounds, TCE, and TCE degradation products were found in sediments at low levels and are not expected to affect surface water. This is confirmed by surface water sampling results that showed that VOCs were detected in only one or two surface water samples at levels below NJDEPE groundwater quality criteria. No VOCs were detected at the surface water discharge points from the study area (SW-4 and SW-6).

BTEX, TCE, and TCE degradation products were found at low levels in localized areas of overburden groundwater near this area. Although no data are available to qualify the quality of discharged groundwater, the VOCs are expected to have volatilized or to have been diluted by surface water to concentrations below NJDEPE groundwater cleanup criteria upon discharging to wetlands and drainage ditches in the study area.

PAHs. Although PAHs were detected in sediments at levels above the NJDEPE soil cleanup criteria, the heavy PAHs detected are not expected to migrate into surface water to a significant degree. This is because they have a very low aqueous solubility and a strong tendency to partition to the soil phase. This expectation was confirmed by sampling results. No PAHs were detected in surface water samples at concentrations exceeding NJDEPE groundwater quality criteria.

Metals. Lead and arsenic, found at elevated levels in soils and/or sediments in unpaved areas east of the Sears building, may affect the quality of surface water in the wetlands area. The highest concentrations of lead and arsenic detected in surface water samples were taken from the center of the wetlands area (SW-1). Lead and arsenic concentrations were lower in the channels draining the wetlands area south of the Sears building and east of Sunoco.

Section 6

Summary and Conclusions

The RI provided some important findings regarding the geology and hydrogeology of the study area, presence of contaminants in the various media, and the fate and transport of those contaminants. These findings are summarized below.

6.1 Geology/Hydrogeology

- The study area is located within the Piedmont Physiographic Province, also known in New Jersey as the Newark Basin, a north-northeast trending half graben composed primarily of sedimentary rock sequence (Newark Group) consisting of sandstones, shales, mudstones and conglomerates dipping between 7 and 15 degrees west. The rocks are covered with unconsolidated materials consisting of fill, recent deposits, glacial stratified and unstratified deposits, and soil residual (derived from advanced weathering of the bedrock).

- Similarity in soil properties led to the convention of dividing overburden materials into two significant deposits:

  - The fill and recent deposits and stratified glacial deposits
  - Unstratified glacial deposits and residual soil

- Miscellaneous fill thickness varied from 2 feet in boring C30 (Federal Express) to 12 feet in boring C38 (Stepan). Combined thickness of the fill and recent deposits and stratified glacial deposits in borings varied from 0 to 14 feet. The thickness of the unstratified glacial deposits and residual soil varied from 1 to 11.5 feet.

- The bedrock sequence underlying the study area consists of sandstones, mudstones and siltstones representing the Passaic Member of the Brunswick Formation, the oldest of the Newark Group. The average orientation of bedrock is N26E with a dip at an average of 9 degrees to the northwest.

- Prominent fractures include open fractures or joints, mineral-filled veins, and thin shear fractures with breccia. Three prominent joint systems were observed in rock cores. Most joints were shallow dipping and appeared to be bed partings. A second less abundant set of joints appeared to be subvertical and normal to bedding while a third set of joints was moderately dipping (30 to 60 degrees). The shallow dipping beds were coated with minerals indicative of groundwater flow and silt

and clay, suggesting the joints oriented subparallel and parallel to bedding are the primary pathways for groundwater flow. Zones of open fractures and higher hydraulic conductivity were identified by in-situ packer testing.

- During drilling, it was observed that generally the upper portion of the bedrock ranging from 0.5 to 15 feet thick was moderate to moderately severely weathered. Competence of rock below this weathered zone is a function of bedrock lithology and stratigraphy.

- Groundwater occurs under water table conditions in the overburden soils, and in places, is hydraulically connected to the multi-unit bedrock zone, where the groundwater gradually comes under confined conditions. The discrete bedrock aquifers are vertically integrated by occasional vertical joints.

- The water table extends through the varying thicknesses of the weathered bedrock zone to the top of the competent bedrock zone. The depth and orientation of this zone is controlled by bedrock stratigraphy.

- The flow of groundwater in the overburden generally radiates from the Stepan property roughly between due south and due west. The hydraulic gradient at Stepan varies from 0.013 to 0.009. Downgradient of Stepan, the gradient varies from 0.004 to 0.007.

- Depending on the location, the bedrock aquifer at the site may or may not be hydraulically connected to the water table. The degree of confinement of the bedrock aquifer appears to be a function of location and depth; the deeper the well, the greater the likelihood of encountering confined conditions. At the relatively shallow depths monitored by the bedrock wells, with few exceptions, the bedrock aquifer is considered contiguous with the water table.

- The degree of confinement at the site lies on a continuum between confined and unconfined.

- Systematic fractures, such as partings along the bedding and near vertical joint sets aligned with the strike of the bedding provide the principal passage of groundwater flow.

- Vertical gradients in the bedrock aquifer are not consistently upward or downward. The bedrock zone exhibits anisotropic and heterogeneous tendencies that complicate the task of interpreting the pumping test programs.

- Pumping tests on the Stepan and Sears properties confirm that the overburden and bedrock aquifers respond differently to pumping stresses.

- Results of the Stepan pumping test indicate that the thin and discrete bedrock flow zones are formed by bedding partings or fractured beds.

- The difference in conditions observed in both pumping tests implies heterogenetic conditions in the study area. Formation constants and aquifer behavior confirmed by these tests cannot necessarily be projected to other areas of the site.

6.2 Nature and Extent of Contamination

6.2.1 Soils and Groundwater

TCL VOCs. Benzene and xylene were detected at levels above the NJDEPE soil cleanup criteria at several locations on the Stepan and SWS properties. Sampling locations with the highest total VOCs were also located on those properties. The Stepan boring locations are in an area that also exhibits BTEX groundwater contamination. Groundwater from well B38W04B (Stepan) had elevated concentrations of BTEX, cis-1,2-DCE and vinyl chloride.

There are eight underground storage tank areas on Stepan; two on Sears, Sunoco and AMP; and one on Gulf (Figure 1-4). In the areas where the USTs were removed (Stepan, AMP, and SWS) it is unlikely that the soils are a continuing or residual source of groundwater contamination. In areas where the actual UST location is unknown (Stepan) or the USTs are no longer in use (Sears), there is a possibility that soil in these areas maybe a continuing or residual source of groundwater contamination. Soil associated with the active UST areas (Stepan, Sears, Gulf, and Sunoco) may also be a continuing or residual source of groundwater contamination.

Vinyl chloride contamination is present in bedrock wells on Stepan and the Sears property adjacent to Route 17.

Trace concentrations of VOCs were detected in one upgradient well within the study area.

Although there were similar VOCs detected in samples taken during the Focused Investigation and RI, there were some significant differences in the concentrations of VOCs detected. The following summarizes some of the major differences:

- TCE was detected in wells OBMW3 (Gulf) and OBMW4 (Sears) at concentrations of 460 ppb and 520 ppb respectively during the Focused Investigation, but it was not detected in these wells during the RI sampling.

- Cis-1,2 DCE was detected in well BRMW1 (Sears) at a concentrations of 1,000 ppb during the Focused Investigation, but it was not detected during the RI sampling.

- Samples collected during the RI from well B38W04B (Stepan) contained concentrations of Cis-1,2 DCE, benzene, xylene, and vinyl chloride exceeding the NJDEPE groundwater quality criteria, but of these compounds, only xylene was detected at a concentration of 4,800 ppb during the Focused Investigation sampling. Ethylbenzene was not detected in this well during the RI. However, it was detected during the Focused Investigation sampling at 980 ppb.

- Benzene concentrations collected during the Focused Investigation from wells MISS4B (Stepan) and BRMW2 (Stepan) were significantly lower than concentrations detected during the RI.

TCL Semivolatile Organics. PAHs at levels exceeding the NJDEPE cleanup criteria were present at the 0-to-2-foot depth interval at several borings on the Sears and Stepan properties. Total PAHs at concentrations exceeding 10,000 ppb were found in samples from borings located on DeSaussure, Sears, and Stepan. PAHs do not appear to be impacting groundwater, and are present in samples from only three wells, one of which may be contaminated with gasoline constituents.

Other semivolatile organics (non-PAHs) were detected at total concentrations exceeding 1,000 ppb in samples from DeSaussure, Sunoco, and Sears. Individual compounds were not detected at levels above the proposed NJDEPE cleanup criteria at any locations. Pentachlorophenol was detected in samples from two wells on the Stepan property, and bis(2-ethylhexyl) phthalate was detected in samples from three wells located on the Federal Express, Stepan, and Sears properties.

Caffeine was detected at C41 (Stepan) and in 11 samples taken from borings at the Sears property. D-limonene was found in one sample from boring C9 (Sears), and a-pinene was not detected. Caffeine was detected in groundwater in one offsite well (B38W02D) that is hydraulically upgradient of the study area and at one location on Stepan.

Bis(2-ethylhexyl) phthalate was the only semivolatile organic compound that was detected above NJDEPE groundwater quality criteria during the Focused Investigation sampling. The highest concentration of this compound (100 ppb) was detected in the sample from well MW1 (Stepan).

TCL Pesticides and PCBs. Pesticide compounds (4,4-DDE, 4,4-DDD, and 4,4-DDT) were detected in soil samples taken from borings on Sears and DeSaussure. Pesticides found in groundwater at locations on Stepan (adjacent to the hydraulically upgradient property boundary) and Sears were BHC gamma (Lindane), dieldrin and heptachlor epoxide. Based on these findings, it appears that pesticides in soils are not affecting groundwater. However, pesticide compounds different from those that were detected in soils were detected in groundwater at levels exceeding the proposed groundwater quality criteria.

PCBs were not detected in any soil or groundwater samples.

Dieldrin, heptachlor epoxide, and total chlordane were the only pesticides detected in the five wells sampled during the Focused Investigation, at concentrations exceeding the NJDEPE groundwater quality criteria.

TAL Inorganics (Metals and Cyanide). Inorganics were widely distributed in soils. Arsenic, barium, cadmium, lead, selenium, and antimony were all found in soil samples at levels exceeding the NJDEPE soil cleanup criteria. Lithium was found in all samples for which it was analyzed, and cyanide was detected in 12 samples, 4 of which were of the blue material found on DeSaussure. Metals were also widely distributed in groundwater, primarily in the samples collected from overburden wells. Arsenic, barium, beryllium, cadmium, chromium, lead, nickel, and manganese were all detected in groundwater at levels exceeding groundwater quality criteria. Elevated levels of arsenic, cadmium, chromium, lead, nickel, and manganese, exceeding groundwater quality criteria, were detected in onsite wells located along the hydraulically upgradient property boundaries of the study area. Elevated levels of manganese and arsenic were detected in offsite well B38W02D. It should be noted that analyses were performed on unfiltered groundwater samples. Therefore, the analytical results are for total metals and cyanide. Most metals contamination above criteria occurred in samples from overburden wells, possibly due to high concentrations of suspended solids in groundwater. Borings near these wells often demonstrated elevated metals concentrations.

Metals concentrations in groundwater samples collected during the Focused Investigation were lower than the RI samples for a majority of the metals. This reduction in metals concentration is due to the low flow purge/sample method used during the Focused Investigation, which resulted in a reduction of sediments in the

samples. Samples from overburden monitoring wells collected during the Focused Investigation still contained the highest concentration of metals and the most exceedances of groundwater quality criteria.

6.2.2 Surface Water and Sediments

TCL VOCs. TCL VOCs were not found in surface water or sediments at levels above the NJDEPE cleanup criteria.

TCL Semivolatile Organics. PAHs were found in most sediments at concentrations above the NJDEPE soil cleanup criteria. No PAHs were detected in surface water samples except fluoranthene at an estimated concentration of 2 ppb. Phthalates were found in some surface water samples at concentrations less than 150 ppb.

TCL Pesticides and PCBs. No pesticides or PCBs were detected in surface water or sediment samples except for lindane at a concentration below the NJDEPE groundwater quality criteria.

TAL Inorganics (Metals and Cyanide). Lead, cadmium and selenium were found in sediments at concentrations above the proposed standards. Lead was detected in 5 of 8 surface water samples at concentrations above the NJDEPE groundwater quality criteria. Arsenic was detected in 1 sample at concentrations exceeding the criteria.

6.2.3 Test Pits

The test program was conducted primarily to determine the cause of the magnetic anomalies delineated during the surface geophysics program. A wide variety of materials, including scrap metal, reinforced concrete foundations or platforms, drums, and various types of organic materials, were observed during the program. The scrap metal included sections of poles and pipes.

The drums encountered during the test-pit program were in a number of different conditions. Many were crushed and/or rusted through in areas. Several drums were partially crushed and rusty, however, they also had some material inside them. Several drums were found to be upright and in good condition with some contents. The contents of some of the drums appeared to be groundwater or stormwater that had percolated through the soil and into a drum. Other drums contained organic material as described below.

TCL VOCs. A cluster of test pits, located in the asphalt/grassy area alongside culvert on the Sears property, contained very high total concentrations of VOCs (13,360 ppb to 19,920,000 ppb). This entire area, including test pits TP-106, TP-107, TP-79, TP-85, and TP-84, may be considered as a potential source area for VOCs. TP-87-1 (Sears) also had very high VOC concentrations (105,000 ppb).

Benzene was detected at levels above the NJDEPE cleanup criteria in four test pits on the Sears property (TP-106, TP-84, TP-85, and TP-87-1). The concentration of benzene was detected at four orders of magnitude greater than the NJDEPE cleanup criteria for TP-106, and two orders of magnitude greater than the criteria for the other three test pits.

Fourteen VOCs in addition to benzene, were detected above cleanup criteria in TP-106.

All samples for which high or exceeding concentrations of VOCs were detected were collected from sludges within drums, with the exception of TP-85, which was collected from soils associated with a crushed drum.

Acetone, benzene, toluene, and xylene were detected at low concentrations in several test pits on Stepan, Sears, and DeSaussure. No VOCs were detected on AMP.

TCL Semivolatile Organics. Semivolatile PAHs were detected in 43 percent of test pits. TP-25 (Stepan) had the maximum total semivolatile PAHs detected at 8,898,000 ppb, and contained 15 of the 18 PAHs for which the sample was analyzed. The sample was collected from soils associated with a crushed drum, at a depth of 0.6 foot. This test pit location may be a potential source of contamination.

PAH compounds exceeding the NJDEPE criteria include chrysene, benzo(b)flouranthene TP-25 (Stepan) (0.6-foot); benzo(b&k)flouranthene TP-91 (Sears) 3.0-foot subsurface); and benzo(b)flouranthene TP-57 (AMP) (2.0-foot).

Semivolatile non-PAHs were detected in 74 percent of test pits (all properties) at generally low concentrations. Concentrations of non-PAHs were below the NJDEPE cleanup criteria at all locations.

Caffeine, d-limonene, and a-pinene were not detected on the Stepan site. Caffeine was detected in six Sears test pits (eight samples, includes two duplicates) and one DeSaussure sample. D-limonene was detected in two Sears test pits. A-pinene was detected in one Sears test pit. The highest concentration of d-limonene was detected in TP-106, which is the test pit containing 15 VOCs exceeding the NJDEPE cleanup criteria.

TCL Pesticides and PCBs. No PCBs were detected in any test pit samples.

Pesticides were detected in TP-22 (Stepan) and TP-76 (Sears), and concentrations for 4,4'-DDE and 4,4'-DDD in TP-76 exceeded the NJDEPE cleanup criteria.

TAL Inorganics (Metals and Cyanide). A high frequency of inorganics was detected in all test pits.

The following metals and cyanide were detected above the proposed NJDEPE cleanup criteria; arsenic, beryllium, cadmium, chromium, copper, lead, mercury, selenium, zinc, cyanide, and antimony.

TCLP Organics. Benzene failed TCLP in TP-106 (Sears). Benzene was also detected at four orders of magnitude above the cleanup criteria at that location.

Nitrobenzene failed TCLP in TP-22 (Stepan). Total nitrobenzene data for TP-22 was unusable.

TCLP Inorganics. Chromium and selenium failed TCLP in TP-22 (Stepan). Total chromium data was detected in TP-22 above cleanup criteria. Total selenium data for TP-22 was unusable.

6.2.4 General Radiological Findings

The EPA-requested hand auger samples, collected from the blue material on DeSaussure, contained low levels of Ra-228, Th-230, and U-234. The sample collected from the interval below the blue material contained detectable levels of gross alpha and beta, Ra-228, Th-230, U-234, U-235, and U-238, with only U-234 and U-238 detected above the NRC comparison criteria.

Soil boring samples analyzed for radiological constituents identified subsurface radiological contamination on Sears, Stepan, Sunoco, and DeSaussure. Downhole gamma logging results also indicate potential subsurface radiological contamination at select soil boring locations on these properties. Downhole gamma logging results do not indicate the presence of radiological subsurface contamination in soil borings located on AMP, Federal Express, and SWS. Soils on the Gulf and Stepan amended properties could not be assessed because soil borings were not installed on these properties.

Surface contamination could not be determined because gamma log results could not be compared to DOE's 11,000-cpm site-specific surface soil guideline.

The thirteen soil boring samples analyzed for radiological parameters contained some radiological constituent(s) at concentrations or estimated concentrations greater than the DOE and/or NRC comparison criteria. Ra-226, Ra-228, U-234, and U-238 were detected in soils above comparison criteria. The maximum concentrations of the radiological analytes were all detected in soil samples collected from boring C38, which was drilled within Burial Site No. 1 (grassy area on Stepan west of West Hunter Avenue).

Total-Th was detected at elevated concentrations, but was not compared to the DOE generic cleanup criteria because the criteria apply to Th-230 and Th-232 individually.

Four of the 20 test pit samples contained at least one radioisotope at levels above the DOE and NRC comparison criteria. These four test pit samples were located on the Sears property. Test pit samples collected from within a drum, and not associated with soils, contained radioisotopes at concentrations below DOE and NRC comparison criteria.

Although gamma radiation results from test pits were not intended for use in assessing the extent of radiological contamination, gamma results from test pits located on AMP, Federal Express, and SWS are consistent with gamma log results from the soil borings installed on these properties. Test-pit results do not indicate the presence of subsurface radiological contamination at measured locations on these properties. Gamma radiation measurements collected from test pits on the Stepan amended property were below the DOE reference guideline of 40,000 cpm.

Radiological constituents in unfiltered groundwater samples were generally detected at elevated concentrations with respect to groundwater samples collected from monitoring wells that are hydraulically upgradient of the study area. In general, radiological constituents (gross alpha and beta, and uranium) were detected above proposed MCLs in overburden wells, as opposed to bedrock wells.

Although groundwater within the study area may appear to be impacted by radiological contamination, analytical data was based on unfiltered samples only. Gross alpha, gross beta, and total uranium were detected above the proposed federal primary drinking water standards in unfiltered groundwater samples collected from the Stepan, Sears, SWS, and DeSaussure. Targeted thorium and radium isotopes were not detected in groundwater samples above the proposed MCLs. Because groundwater samples were not collected on AMP the presence of radiological constituents in groundwater in this area is unknown.

Surface water samples contained detectable levels of gross alpha and beta, Ra-226, Th-230, and U-235. None of the detected radiological parameters were above proposed SDWA MCLs.

Sediment samples contained detectable levels of gross alpha and beta, Th-230, Th-232, U-234, U-235, and U-238. One sediment sample (SD-3; Sears) contained Ra-226 and Th-232 at levels above DOE's surface soil guidelines. One sediment sample (SD-6; drainage channel between Sears and SWS) contained Ra-226 above DOE's surface soil guideline. Radium-226, Ra-228, and Th-232 were detected at concentrations above DOE's surface soil guidelines in one sediment sample (SD-4; Sears). The other sediment samples (SD-1 and SD-2, Sears; SD-5, Sunoco) did not contain radiological constituents at concentrations above DOE soil guidelines.

6.2.5 Nature and Extent of Contamination

Potential source materials include:

- Petroleum-based fuels in areas of former USTs
- Organic residues in buried drums
- Solvents used near the former Aromatic and Essential Oils Manufacturing area
- Leather solids filter cake from protein extraction process
- Gypsum from an offsite inorganic chemical manufacturing operation
- Tailings from ore processing and other inorganic residues
- Liquids in bermed areas and lagoons identified in aerial photos

Conclusions regarding the nature and extent of contamination are as follows:

- Areas of BTEX and naphthalene contamination associated with fuel USTs appear to be residual concentrations in soil and shallow groundwater (2 areas on Stepan, 1 area on Gulf, and 1 area on SWS).
- Two localized areas of BTEX and acetone in subsurface soils were identified on the Stepan property. One of these areas has impacted overburden groundwater to a limited extent (former aromatics and essential oils manufacturing area).
- Buried containers containing organic residues with BTEX compounds, ketones, or chlorinated solvents are present on the Sears property. Extent of impact to soils is not defined, but impact to groundwater appears to be minimal.
- There is an unknown source contributing to vinyl chloride and DCE in bedrock groundwater on the northwest portion of the Sears property.
- An unknown source, possibly offsite, appears to be contributing to low residual TCE concentrations in bedrock groundwater across the south and east portion of the study area.

- Moderate to high molecular weight PAHs were found in localized areas of shallow soils, possibly originating from combustion products or residual coal solids. These PAHs are not migrating into groundwater or surface water.

- Chromium is present in leather solids filter cake residues on the north portion of the Stepan property. Chromium from this material does not appear to be impacting groundwater.

- Metals appear to be widely distributed in fill material across the study area. These metals may have originated from inorganic residues and tailings for ore processing operations. Localized areas of overburden and bedrock groundwater appear to have been impacted by the fill material, but no identifiable source areas appear to exist.

- Beryllium and manganese appear to be present at natural background concentrations in overburden soils. Resulting concentrations in groundwater also appear to be at background concentrations.

- Cyanide present in blue material on the DeSaussure property is impacting shallow groundwater underlying the blue material. Migration of cyanide appears to be limited, but low residual concentrations were detected in downgradient bedrock groundwater and nearby surface waters.

6.3 Contaminant Fate and Transport

6.3.1 Groundwater

Patterns of contaminant transport in the overburden zone are expected to be controlled by vertical and horizontal variability in soil, causing variations in hydraulic conductivity and aquifer heterogeneity.

Dissolved contaminant migration from the overburden to the bedrock zone is controlled by bedrock stratigraphy and occurs where the two zones are hydraulically connected.

Patterns of contaminant distribution in the multiunit bedrock aquifers are expected to be highly irregular, due to the complexity of flow in fractured rock. Complex flow in fractured rock partly results from the variable alignment of preferential flow channels with the prevailing direction of groundwater flow.

Contaminant transport in the overburden is inhibited by attenuation due to organic matter and the tendency for the water table to occur below the top of rock. Contaminant transport in bedrock is characterized by higher velocities and is not attenuated to the same degree as in the overburden due to the scarcity of organic matter.

Elevated levels of volatile organic compounds were found in overburden wells OBMW2, OBMW3, and OBMW4, but were generally more prevalent in bedrock wells.

Several areas of VOC-contaminated soils may be sources of shallow groundwater contamination. These include: soils near well OBMW2 and boring C-44; soils on the north side of Building 10 (Stepan); wastes from container samples from test pit locations TP-84; TP-85, and TP-87 (Sears); soils on the east side of the SWS property near boring C-25; and wastes in buried containers in test pit TP-106.

PAHs in soils do not appear to be impacting groundwater, particularly in paved portions of the study area. Sample results indicate that, even in areas with elevated concentrations of PAHs in soils, PAHs were not detected in groundwater samples from wells near soil boring locations. Low levels of napthalene and 2-methylnapthalene were detected in localized areas of groundwater where BTEX compounds also were detected.

BTEX, TCE, and TCE degradation products are generally more prevalent in bedrock wells than in overburden wells. The presence of benzene at a level four orders of magnitude higher in the overburden well OBMW2 than in bedrock well BRMW2 suggests a significant barrier to contaminant transport to the bedrock zone at this location.

Data collected during the Focused Investigation indicate that metals are not at levels of concern for migration into bedrock, since filtered sample or dissolved concentrations in overburden well samples indicate nondetectable or low concentrations of these parameters. Migration of dissolved metals may be potentially limited in the overburden zone by soil adsorption and chemical transformation to less mobile forms. Source areas for elevated metals concentrations in groundwater were not detected during the RI and Focused Investigation.

TCE is expected to have moderate mobility and undergo a biodegradation pathway to other compounds including dichloroethanes, dichloroethylenes, vinyl chloride and chloroethane. Samples taken during the Focused Investigation indicated significantly lower levels of vinyl chloride and cis-1,2-DCE in wells B38W04B and MISS4B than samples collected during the RI. This suggests that a source for these contaminants does not exist in these areas. Focused Investigation results for well BRMW1 indicated significantly higher concentrations of vinyl chloride and cis-1,2-DCE than

those found in the RI, suggesting elevated levels on this portion of the Sears property. However, no source areas were identified based on the available data. The potential exists for offsite migration of TCE or chlorinated degradation products near wells BRMW1 and BRMW14.

6.3.2 Surface Water and Sediments

BTEX, TCE, TCE degradation products and PAHs are not expected to impact surface water above the proposed NJDEPE standards.

There exists the potential for minor lead and arsenic impact to surface water in the wetlands area on the Sears property from elevated concentrations of those metals in nearby surface soils and sediments.

Section 7

Recommendations

Based on the results of the Remedial Investigation, the Draft Remedial Investigation Report detailed a number of recommendation for additional investigation at the Stepan and Sears and Adjacent properties. In their May 13, 1993 letter, EPA commented on those recommendations. EPA's comments were incorporated into the scope of work for the Focused Investigation. Implementation of the Focused Investigation has, to the extent possible, addressed the original set of recommendations

7.1 Soils

The two areas in which further investigation appears warranted are the location of the tanned leather wastes on the Stepan and Stepan Amended properties. These areas have not been fully delineated by the current soils analyses and should be further investigated prior to proposing a remedial alternative in the Feasibility Study.

It should be noted that prior analyses performed on filter cake from a process using the tanned leather scraps indicates very low levels of hexavalent chromium.

7.2 Groundwater

A confirmatory round of groundwater sampling was performed during the Focused Investigation, along with a more detailed hydrogeologic evaluation of the study area. No additional groundwater investigation is proposed.

7.3 Test Pits

Because buried containers were identified on Sears and only selected magnetic anomalies were investigated, it is likely that there are additional buried containers on Sears, which were not identified during the test pitting program. Magnetic anomalies that were identified on Sears prior to the test pitting program should be considered as areas where a buried container may exist and soil remediation in these areas should be conducted accordingly.

Section 8
Works Cited

American Society for Testing and Materials. ASTM D 1586-84. Standard Method for Penetration Test and Split-Barrel Sampling of Soils. *Annual Book of ASTM Standards.*

_____. ASTM D 2113-83. Standard Practice for Diamond Core Drilling for Site Investigation. *Annual Book of ASTM Standards.*

_____. ASTM D 2488-84. Standard Practice for Description and Identification of Soils (Visual-Manual Procedure). *Annual Book of ASTM Standards.*

_____. ASTM D 4630-86. Standard Test Method for Determining Transmissivity and Storativity of Low-Permeability Rocks by In-Situ Measurements Using the Constant Head Injection Test. *Annual Book of ASTM Standards.*

Assistant Secretary of the Army (Civil Works). Passaic River Mainstem Report and Environmental Impact Statement (New Jersey and New York). Washington, DC: U.S. Government Printing Office. 101st Congress, 2d Session. House Document 101-163. 1990.

Barksdale, Henry C. et al. *The Ground-Water Supplies of Middlesex County, New Jersey*. State Water Policy Commission. 1943.

Bergen County Department of Planning and Economic Development. *Planner's Data Book for Bergen County, Technical Report No. 1.* Bergen County, NJ. 1991.

_____. *Planner's Data Book for Bergen County, Technical Report No. 2.* Bergen County, NJ. 1991.

Bechtel National, Inc. 1984.

_____. *Maywood Interim Storage Site Annual Site Environmental Report, Calendar Year 1985; Maywood, New Jersey.* FUSRAP Contract No. DE-ACO5-810R20722. Oak Ridge, TN. 1986.

_____. *Characterization Report for the Maywood Interim Storage Site; Maywood, New Jersey.* FUSRAP Contract No. DE-ACO5-810R20722. Oak Ridge, TN. 1987a.

_____. *Characterization Report for the Sears Property; Maywood, New Jersey.* FUSRAP Contract No. DE-ACO5-810R20722. Oak Ridge, TN. 1987b.

_____. *Radiological and Limited Chemical Characterization Report for the Sunoco Station Property; Maywood, New Jersey.* FUSRAP contract NO. DE-ACO5-810R20722. Oak Ridge, TN. 1987c.

_____. *Radiological and Limited Chemical Characterization Report for the Hunter Douglas Property; Maywood, New Jersey.* FUSRAP Contract No. DE ACO5-810R20722. Oak Ridge, TN. 1987d.

_____. *Maywood Interim Storage Site Annual Site Environmental Report, Calendar Year 1986; Maywood, New Jersey.* FUSRAP Contract No. DE-ACO5-810R20722. Oak Ridge, TN. 1987e.

_____. *Radiological Characterization Report for the Federal Express Property; Maywood, New Jersey.* FUSRAP Contract No. DE-ACO5-810R20722. Oak Ridge, TN. 1987f.

_____. 1988.

_____. *Maywood Interim Storage Site Annual Site Environmental Report, Calendar Year 1988; Maywood, New Jersey.* FUSRAP Contract No. DE-ACO5-810R20722. Oak Ridge, TN. 1989a.

_____. *Radiological Characterization Report for the DeSaussure Property; Maywood, New Jersey.* FUSRAP Contract No. DE-ACO5-810R20722. Oak Ridge, TN. 1989b.

_____. *Radiological Characterization Report for the Gulf Station Property; Maywood, New Jersey.* FUSRAP Contract No. DE-ACO5-810R20722. Oak Ridge, TN. 1989c.

_____. 1990.

_____. *Maywood Interim Storage Site Annual Environmental Report for Calendar Year 1990; Maywood, New Jersey.* FUSRAP Contract No. DE-ACO5-910R21949. Oak Ridge, TN. 1991.

_____. 1992.

Bouwer, Herman, and R.C. Rice. "A Slug Test for Determining Hydraulic Conductivity of Unconfined Aquifers With Completely or Partially Penetrating Wells." *Water Resources Research.* Vol. 12, No. 3. June 1976.

Candeub, Fleissig, and Associates. *Comprehensive Master Plan.* Prepared for the Maywood Planning Board. 1989.

Carswell, L.D. "Appraisal of Water Resources in the Hackensack River Basin, New Jersey." U.S. Geological Survey Water Resources Investigation 76-74. 1976.

Carswell, L.D., and J.G. Rooney. *Summary of Geology and Ground-Water Resources of Passaic County, New Jersey.* Water Resources Investigations 76-75. Trenton, NJ: U.S. Geological Survey in cooperation with New Jersey Department of Environmental Protection, Division of Water Resources. 1976.

CH2M HILL. Draft Technical Memorandum for Groundwater Investigation; Raymark Site Remedial Investigation and Feasibility Study. Contract No. 68-W8-0090. Prepared for the U.S. Environmental Protection Agency, Region III. Parsippany, NJ. 1991a.

_____. *Remedial Investigation and Feasibility Study Site Health and Safety Plan, Quality Assurance Project Plan, and RI Project Schedule.* Parsippany, NJ. 1991b.

_____. Letter to United States Environmental Protection Agency, Region II. January 7, 1992.

_____. Letter to United States Environmental Protection Agency, Region II. January 17, 1992.

_____. Letter to United States Environmental Protection Agency, Region II. October 25, 1991.

Conner and Shaklette. 1985.

Dragun, James. *The Soil Chemistry of Hazardous Materials.* Greenbelt, MD: The Hazardous Materials Control Resources Institute. 1988.

Ebasco. 1988.

Endo, H.K. et al. "A Model for Investigating Mechanical Transport in Fracture Networks." *Water Resources Research.* Vol. 20, No. 10. October 1984.

Environmental Profile Laboratories. *Site Assessment Summary Report.* Toms River, NJ. 1992.

Federal Emergency Management Agency. Flood Insurance Rate Map and Street Index, Borough of Maywood, Bergen County, New Jersey. Community Panel Number 340050 0001 B. Revised January 17, 1990.

_____. Flood Insurance Rate Map and Street Index, Township of Rochelle Park, Bergen County, New Jersey. Community Panel Number 340070 0001 C. Revised December 18, 1981.

Federal Interagency Committee for Wetland Delineation. *Federal Manual for Identifying and Delineating Jurisdictional Wetlands.* Washington, D.C.: U.S. Army Corps of Engineers, U.S. Environmental Protection Agency, U.S. Fish and Wildlife Service, and U.S.D.A. Soil Conservation Service (cooperative publication). 1989.

Fetter, C.W. *Applied Hydrogeology.* 2nd ed. Columbus, OH: Merrill Publishing Company. 1988.

Fields, Tessie W. et al. *A Summary of Selected Soil Constituents and Contaminants at Background Concentrations in New Jersey.* Prepared for the NJDEPE and Rutgers University. March 1992.

Gardner, R. "Relation of Temperature to Moisture Tension of Soil." *Soil Science.* Vol. 79. 1955.

Greenman, D.W. *Groundwater Resources of Bucks County, Pennsylvania.* Pennsylvania Geological Survey Fourth Series Bulletin W11. 1955.

Herpers, Henry, and H.C. Barksdale. *Preliminary Report on the Geology and Ground-Water Supplies of the Newark, New Jersey Area.* New Jersey Department of Conservation and Economic Development, Division of Water Policy and Supply. Special Report 10. 1951.

Houghton, Hugh F. *Hydrogeology of the Triassic Rocks of the Newark Basin: Technical Notes and Guide to Field Trip in Central New Jersey.* New Jersey Geological Survey Open-File Report 86-__. Trenton, NJ: Department of Environmental Protection, Division of Water Resources, Bureau of Geology and Topography. 1986.

Hvorslev, M.J. *Time Lag and Soil Permeability in Ground-Water Observations.* Bulletin No. 36. Vicksburg, MS: U.S. Army Corps of Engineers Waterways Experiment Station. 1951.

Knox, Robert C., et al. *Subsurface Transport and Fate Processes.* Lewis Publishers. 1993.

Krizek, Raymond J., et al. Dispersion of a Contaminant in Fissured Rock. Presented at the International Society of Rock Mechanics Symposium on Perculation Through Fissured Rock. Stuttgart. 1972.

Long, Edward R., and Lee G. Morgan. *The Potential for Biological Effects of Sediment-Sorbed Contaminants Tested in the National Status and Trends Program.* NOAA Technical Memorandum NOS OMA 52. August 1991.

Michalski, Andrew. "Hydrogeology of the Brunswick (Passaic) Formation and Implications for Ground Water Monitoring Practice." *Ground Water Monitoring Review.* Dublin, OH: Water Well Journal Publishing Co. Vol. 1. Fall 1980.

New Jersey Department of Environmental Protection and Energy. Proposed Surface Soil Cleanup Standards for Residential Soil (NJAC 7:26D). 24 NJR 373. February 3, 1992.

_____. Proposed Soil Cleanup Standards for Subsurface Soil (NJAC 7:26D). 24 NJR 373. February 3, 1992.

_____. Groundwater Quality Standards. NJAC 7:9-6. 1982.

_____. Proposed Groundwater Cleanup Standards for Class II-A Groundwater (NJAC 7:26D). 24 NJR 373. February 3, 1992.

Nuclear Regulatory Commission. Branch Technical Position on Disposal or Onsite Storage of Thorium or Uranium Wastes from Past Operations. 46 FR 52061. October 23, 1981.

Olsen, Paul E. "Triassic and Jurassic Formations of Newark Basin." *Field Studies of New Jersey Geology and Guide to Field Trips.* Warren Manspeizer, ed. 52nd Annual Meeting of the New York State Geological Association. Newark, NJ: Rutgers University. 1980.

Papadopulos, S.I., *Nonsteady Flow to a Well in an Infinite Anisotropic Aquifer.* International Association of Scientific Hydrology. Proceedings, Dubrovnik Symposium on the Hydrology of Fractured Rocks, p. 21. 1965.

Parker, Ronald, and Hugh Houghton. Bedrock Geological Map of the Hackensack, New Jersey Quadrangle. Unpublished map. On file at the offices of the New Jersey Geological Survey, Trenton, NJ.

Perlmutter, Nathaniel M. *Geology and Ground-Water Resources of Rockland County, New York, With Special Emphasis on the Newark Group (Triassic).* Bulletin GW-42. Albany, NY: U.S. Geological Survey in cooperation with the New York Water Power and Control Commission. 1959.

Plumb, Russell H. Jr. *Procedures for Handling and Chemical Analysis of Sediment Water Samples.* Prepared for the U.S. Environmental Protection Agency/U.S. Corps of Engineers Technical Committee on Criteria for Dredged and Fill Material; Contract No. EPA-4805572010. Vicksburg, MS: Environmental Laboratory, U.S. Army Engineer Waterways Experiment Station. 1981.

Robinson, J.W., and Gale, J.E. "A Laboratory and Numerical Investigation of Solute Transport in Discontinuous Fracture Systems." *Ground Water.* Vol. 28, No. 1. January-February 1990.

Schlische, Roy W., and Paul E. Olsen. Structural Evolution of the Newark Basin. *Geology of the Central Newark Basin.* Field Guide and Proceedings of the Fifth Annual Meeting of the Geological Association of New Jersey. Jonathan M. Husch and Michael J. Hozik, eds. October 7-9, 1988.

Schwartz, Franklin W., et al. "A Stochastic Analysis of Macroscopic Dispersion in Fractured Media." *Water Resources Research.* Vol. 19, No. 5. October 1983.

Stanford, Scott D. Surficial Geological Map of the Hackensack, New Jersey Quadrangle. Unpublished map. On file at the offices of the New Jersey Geological Survey, Trenton, NJ.

Stepan Company. Remedial Investigation Workplan Amendment. Northfield, IL. June 1993.

Turk, L.J. "Diurnal Fluctuations of Water Tables Induced by Atmospheric Pressure Changes." *Journal of Hydrology.* Amsterdam, Netherlands: Elsevier Scientific Publishing Company. Vol. 26. 1975.

United States Department of Agriculture, in cooperation with the Bergen County Soil Conservation District. *Interim Soil Survey of Bergen County New Jersey.* Bergen County, NJ. 1990.

United States Department of Energy. Radiation Protection for Occupational Workers. Order 5480.11. December 21, 1988.

_____. Radiation Protection of the Public and the Environment. Order 5400.5. June 5, 1990.

United States Environmental Protection Agency. Proposed Drinking Water Limits for Radionuclides. 56 FR 33050. July 18, 1991.

_____. Environmental Monitoring Systems Laboratory. *Maywood Chemical Sites, Maywood and Rochelle Park, New Jersey.* TS-PIC-94023. May 1984.

_____. Health and Environmental Standards for Remedial Actions at Inactive Uranium Processing Sites. 40 CFR 192. January 5, 1983.

_____. *Superfund Analytical Methods for Low Concentration Water for Organic Analysis.* SAMLCO691. 1991.

_____. *CLP Statement of Work for Organics Analysis, Multi-Media, Multi-Concentration.* 1988.

_____ *CLP Statement of Work for Inorganics Analysis, Multi-Media, Multi-Concentration.* March 1990.

_____, Office of Solid Waste and Emergency Response. *Test Methods for Evaluating Solid Waste (SW846).* 3d ed. November 1986.

_____, Monitoring and Support Laboratory. *Methods for Chemical Analysis of Water and Wastes (Method 415.1).* Cincinnati, OH. March 1983.

_____, Hazardous Site Evaluation Division. *Laboratory Data Validation Functional Guidelines for Evaluating Organics Analyses.* February 1988.

_____, Hazardous Site Evaluation Division. *Draft Laboratory Data Validation Functional Guidelines for Evaluating Organics Analyses.* 1990.

_____, Hazardous Site Evaluation Division. *Draft Laboratory Data Validation Functional Guidelines for Evaluating Inorganics Analyses.* 1988.

_____, Region II Toxic and Hazardous Waste Section. *Superfund Analytical Methods for Low Concentration Water for Organics.* SOP No. HW-13. June 1991.

_____, Region II Toxic and Hazardous Waste Section. *CLP Organics Review and Preliminary Review.* SOP No. HW-6. March 1990.

_____, Region II Toxic and Hazardous Waste Section. *Evaluation of Metals Data for the Contract Laboratory Program.* SOP No. HW-2, Revision X. Based on February 1989 revision of SOW dated July 1988. February 1990.

_____. *TCLP Data Validation.* SOP No. HW-7, Revision No. 1. March 1992.

_____, Region II. *Standard Operating Procedure for Selecting Ground Water Well Construction Material.*

_____. Office of Water. Drinking Water Regulations and Health Advisories. April 1992.

United States Department of the Interior, Bureau of Reclamation. *Earth Manual: A Water Resources Technical Publication.* 2nd ed. Denver, CO: United States Government Printing Office. 1985.

United States Department of the Interior, Bureau of Reclamation. *Permeability Tests Using Drill Holes and Wells.* Geology Report No. G-97. Denver, CO: U.S. Department of the Interior, Bureau of Reclamation. 1951.

Unites States Department of the Interior, Fish and Wildlife Service. National Wetlands Inventory Map, Hackensack Quadrangle.

Van Houten, F. "Late Triassic Newark Group, North Central New Jersey and Adjacent Pennsylvania and New York." *Geology of Selected Areas in New Jersey and Eastern Pennsylvania.* S. Subitzky, ed. New Brunswick, NJ: Rutgers University Press. 1969.

Vecchioli, John D., et al. "Occurrence and Movement of Ground Water in the Brunswick Shale at a Site Near Trenton, New Jersey." U.S. Geological Survey Professional Paper 650-B.

Van Hylckama 1968.

Woodward-Clyde Consultants. *Field Permeability Test Methods With Applications to Solution Mining.* Prepared for Bureau of Mines, Washington, DC. San Francisco, CA. 1977.