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Schering Corporation
Union, New Jersey

Remedial Investigation Report
Schering Corporation
Union, New Jersey

June 1986

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Volume 1

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June 11, 1986

Mr. Peter T. Lynch, Chief
Metro Bureau of Regional Enforcement
NJDEP - Division of Water Resources
2 Babcock Place
West Orange, N.J. 07052

Dear Mr. Lynch:

RE: Submission of Remedial Investigation Report -
Schering Corporation, Union, New Jersey

Schering Corporation herewith submits a full documentation of the findings and conclusions of the remedial investigation conducted at its Union facility in accordance with the terms of the Administrative Consent Order. On March 5, 1986 the Division of Water Resources approved an extension to June 11, 1986 for submission of this report.

The report was prepared by Roy F. Weston, Inc. An executive summary provides an overview of the study and its findings. The report describes site history, previous studies and the site environmental setting; it details field methods and analytical approaches; it discusses findings of the investigation, the nature and extent of public health and environmental concerns, and provides conclusions and potential response actions. Appendices include procedures used during the investigation, data developed through the field and laboratory programs, and information synthesized from other sources.

Additional field and laboratory data from the continuing quarterly sampling program, have been submitted with previous quarterly reports.

Contact me at (201) 820-6985 for further information.

Sincerely,

Joseph A. Nusser

Joseph A. Nusser
Senior Environmental Engineer

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WESTON
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REMEDIAL INVESTIGATION REPORT

SCHERING CORPORATION
UNION, NEW JERSEY

VOLUME 1
FINAL REPORT

J. N. Dougherty
Principal Investigator

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Project Manager

A. J. Zupko, P.E.
Project Director

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JUN 11 1986
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11 June 1986

Prepared By:

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West Chester, Pennsylvania

W.O. 1120-21-03

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Executive Summary

EXECUTIVE SUMMARY

This section summarizes the study objectives, methods, findings, conclusions, and response actions for the Remedial Investigation (RI) of the Schering Corporation (Schering), Union, New Jersey facility. The RI was conducted by Roy F. Weston, Inc. (WESTON) on behalf of Schering in accordance with the project workplan approved by the New Jersey Department of Environmental Protection (NJDEP) and the Administrative Consent Order (dated 19 December 1985) between Schering and NJDEP.

Two previous studies were conducted by WESTON at this facility for Schering. These studies included the following:

- **A Phase I Hydrogeological Investigation concluded that environmental concerns, due to past material-handling practices, may exist at the site.** A total of seven areas of potential environmental concern on the plant property were identified, and a workplan for further investigation was prepared and presented to NJDEP for review and concurrence.
- **A Phase II Hydrogeological Study was subsequently conducted to define groundwater and soil quality in the plant and the potential for off-site migration of any contaminants. Only four of the seven zones of potential environmental concern yielded subsurface concentrations of contaminants.** During this study, the chemical characteristics of the seven areas identified in the Phase I effort were further defined. Soil samples were collected, 14 monitoring wells in the unconsolidated sediments were installed, and stream and groundwater sampling was conducted.

At the conclusion of these earlier studies, a comprehensive workplan was developed to thoroughly define the nature and extent of contamination at the site. The workplan recommended completion of a Remedial Investigation, followed by a Feasibility Study (FS) for possible remediation of the site. The RI workplan was approved by the NJDEP on 16 May 1985. The RI activity addressed the four zones of environmental concern on the plant site defined by the Phase II Study including the possibility of off-site migration of contaminants.

Major field activities in the RI included:

1. Installation of additional monitoring wells and piezometers to evaluate flow and quality of groundwater (both horizontally and vertically) in the unconsolidated sediment water-bearing zone, the shallow bedrock, the deep bedrock aquifer, and in the surficial water-bearing zone adjacent to, and east of, the Elizabeth River.

2. Geophysical surveys, site-screening techniques, review of time-sequence site photographs and maps to determine surface features and site developments.

3. Aquifer testing and simulation models to evaluate groundwater vectors and migration potentials for a 2-mile radius surrounding the plant site.

4. Comprehensive sampling of soil and water media have been routinely completed at least quarterly to analyze for a wide spectrum of priority and non-priority pollutant chemicals.

The RI has determined that there are two areas of environmental concern: the volatile organic chemicals in the soil and the groundwater in the northeast area of the plant and east of the Elizabeth River. The other two areas of potential environmental concern defined in the original workplan did not present situations requiring remediation.

The major findings of the RI included:

1. **The lateral groundwater flow in the unconsolidated deposits in the vicinity of Schering is towards the Elizabeth River, with flow velocities ranging from 120 to 470 feet per year (0.3 to 1.3 ft/day).** Normally, **groundwater discharges** to the Elizabeth River; however, **flow also occurs** beneath the river. In addition, near the river, there is lateral groundwater flow in the direction of river flow. The velocity range of this lateral groundwater flow has been estimated at 20 to 60 feet per year (0.06 to 0.17 feet per day).

2. **Groundwater flow in the vicinity of the Schering facility is away from any known public supply or domestic wells.** Modelling has shown a groundwater divide to the northwest of the facility site preventing flow toward public-water supply.

*3. There is a slight potential for contaminant migration from the unconsolidated deposits downward to the shallow bedrock.

4. Elevated levels of volatile organic priority pollutants occur primarily in the northeast sector of the plant and have migrated off-site to a relatively narrow area across the river to the east of the plant site.

5. A narrow horizontal band of the same volatile organic priority pollutants found in the unconsolidated deposits was in the shallow bedrock underlying the plant site.

6. The same volatile organic priority pollutants found in the groundwater, primarily in the northeast sector of the facility, were found in the unsaturated zone.

7. A number of unidentified non-priority pollutant compounds have been detected in groundwater samples.

8. No environmentally-significant concentrations of chromium were found in the areas of the former surface impoundments.

9. No significant levels of priority pollutants were found in the Elizabeth River upstream or downstream of the Schering facility.

10. No environmentally-significant concentrations of base/neutral compounds were found in the eastern area of the plant site.

11. Concentrations of total hydrocarbons in the air above background readings only occurred during drilling operations of selected boreholes and only in the immediate vicinity of the drilling rig.

The complete spectrum of response actions and technologies for remediation of soil and groundwater contamination was initially screened on the basis of potential applicability to the plant site for the required remediation. The **potentially feasible options** are as follows:

Groundwater Remediation	
Response Actions	Technologies
No Action	Periodic Monitoring and Analyses
Pumping	Groundwater Removal
Collection	Interceptor Trenches, French Drains
On-Site Treatment	Incineration, Air Stripping, Carbon Adsorption
Off-Site Treatment	Incineration, Biological
In Situ Treatment	Biological

Soil Remediation	
Response Actions	Technologies
No Action	Periodic Monitoring and Analyses
Containment	Capping, Barriers
On-Site Treatment	Incineration, Stripping
Off-Site Treatment	Incineration
In Situ Treatment	Soil Flushing, Air Stripping, Biological
Partial Removal	Excavating and Backfilling
Off-Site Disposal	Landfilling, Land Application

Detailed screening, selection, recommendation and conceptual engineering design of response actions and remediation technologies will be completed in the Feasibility Study, which will begin after review and approval of this RI report by NJDEP.

Section 1
Introduction

SECTION 1

INTRODUCTION

1.1 OVERVIEW

This report details the findings, conclusions, and recommendations of the Remedial Investigation (RI) conducted by Roy F. Weston, Inc. (WESTON) at the Schering Corporation's Union, New Jersey facility. This facility is located at 1011 Morris Avenue (State Rt. 82) which is approximately 1 mile east of Exit 140 on the Garden State Parkway. The regional location of the Schering facility is shown in Figure 1-1.

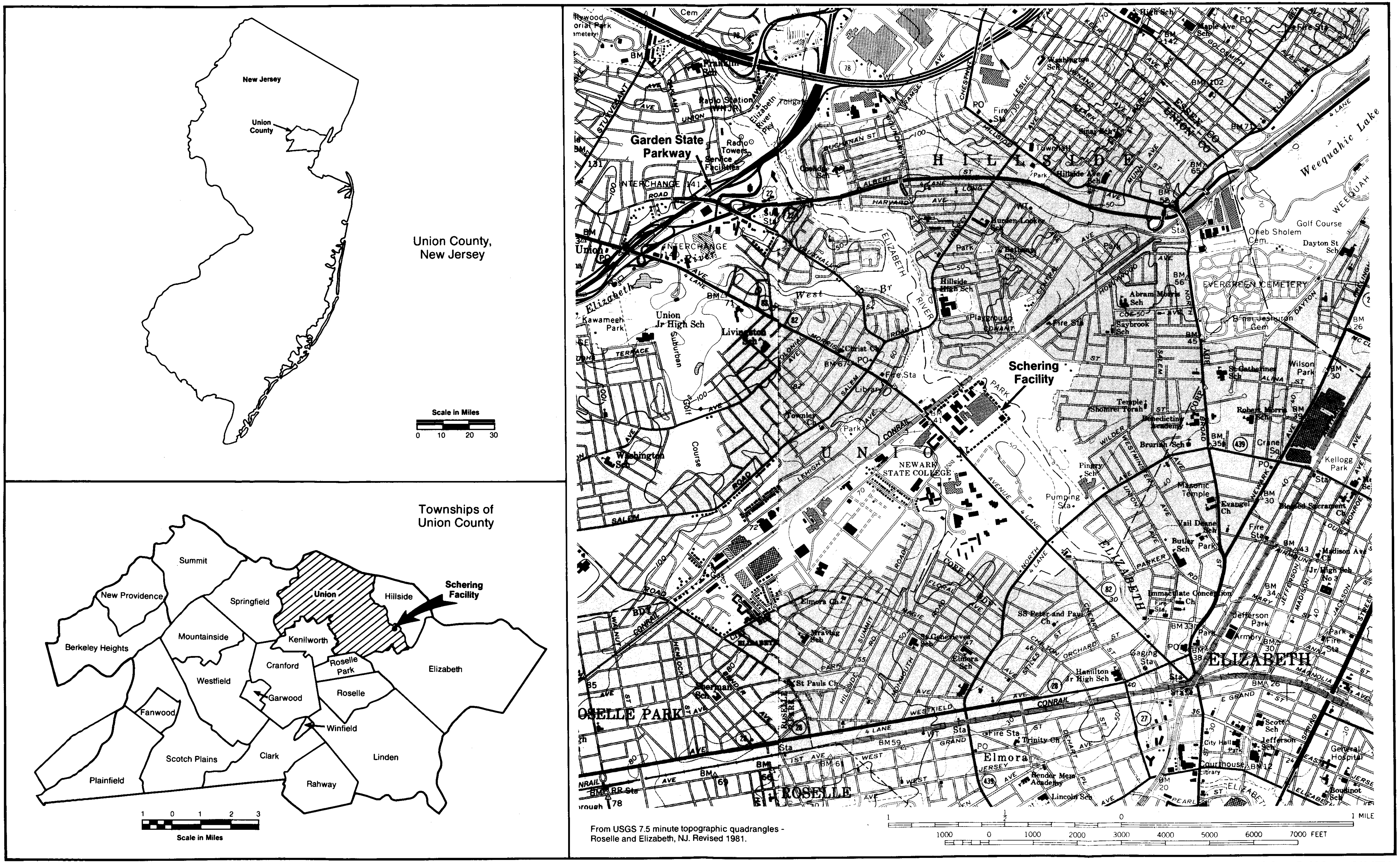
This RI is the first phase of a Remedial Investigation/ Feasibility Study (RI/FS) being conducted by WESTON at this site. The scope and methods for conducting the RI/FS were detailed in the "RI/FS Workplan for the Schering Corporation's Union, New Jersey Facility" (WESTON, 1985). This workplan was approved by the New Jersey Department of Environmental Protection (NJDEP) on 16 May 1985 and field work began on 26 May 1985. This RI/FS is being conducted under the terms of an Administrative Consent Order entered into by the Schering Corporation and the New Jersey Department of Environmental Protection on 19 December 1985. **The goal of the RI is to provide the data necessary to conduct a thorough Feasibility Study (FS) which will define and** address environmental concerns at the site. These data include understanding the geology, hydrogeology, and chemistry of the site and study area, which includes a radius of approximately 2 miles surrounding the Schering facility.

The potential environmental impact of the Schering facility on the study area was assessed in the RI. Identifying the remedial alternatives needed to mitigate environmental concerns at the site and the impact of the site on the study area are the goals of the FS. The Feasibility Study is currently underway and those remedial alternatives which will be pursued in the FS are discussed in Section 8 of this report.

Prev[illegible] 5 Section

1.2 GENERAL SITE HISTORY

Since 1938, the Schering Corporation has operated a pharmaceuticals manufacturing, packaging, and research and development facility at this site in Union, New Jersey. The Schering facility is shown in Figure 1-2. The area was originally fields and trees, and was cleared for Buildings 5, 6, 7, 8, 11 and a railroad spur in 1937. In the vicinity of the buildings, fill was added from the southwest corner of the site



From USGS 7.5 minute topographic quadrangles - Roselle and Elizabeth, NJ. Revised 1981.

FIGURE 1-1 SITE LOCATION, SCHERING FACILITY, UNION, NEW JERSEY

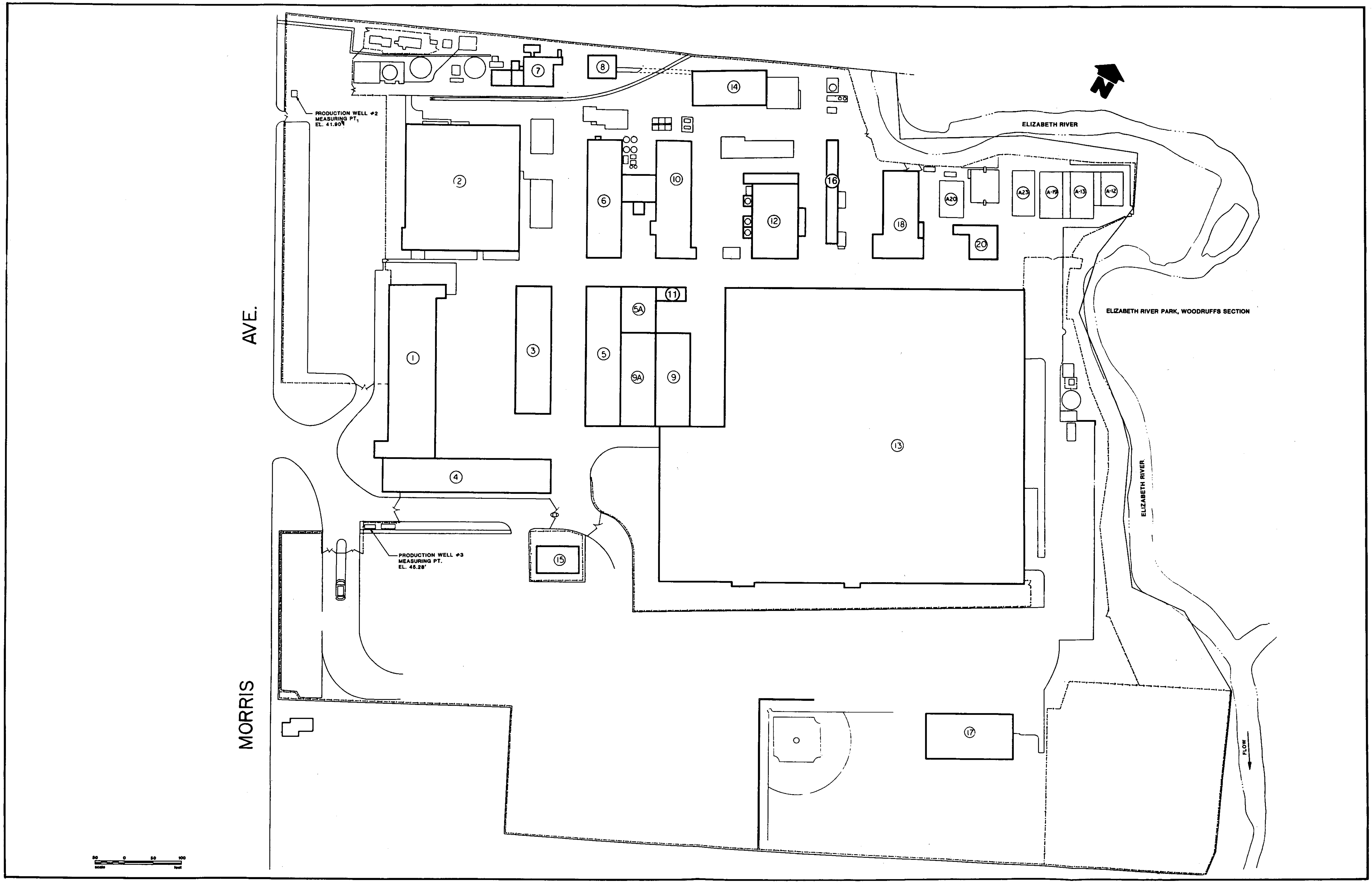


FIGURE 1-2 SITE MAP - SCHERING FACILITY, UNION, NEW JERSEY

to level the land prior to 1941. **Several surface impoundments,** which were **used for wastewater**, were constructed in the **1940's** and remained in service up **to the early** 1950's when they were demolished to accommodate new construction. By 1951, four more buildings (numbers 4, 9, 10, and 16) were constructed and, consequently, more land was cleared and leveled. Building 5A and an addition to Building 13 were in place by 1954.

Most of the industrial growth on the site occurred by 1961. By that time, a tract of land to the southeast of the site had been leased from the John Kean estate. This nearly doubled the size of the facility. Buildings 1, 2, 3, 14, and 18 were all built by 1961. In 1960-1961, Building 13 was expanded over a large amount of fill that was emplaced between the building and the Elizabeth River. A large extension was added to Building 13 in 1969, and a smaller extension added to Building 14. By 1977, Buildings 15, 17, 20, and additions to Buildings 1 and 2 were constructed, and Building 12 construction was started. **Since 1977, no new buildings** have been constructed, and **no additional areas have been cleared or filled**. Site history is discussed in more detail in Section 2 with the aid of aerial photography records and plant archive information.

1.3 SUMMARY OF PREVIOUS STUDIES

1.3.1 Phase I Hydrogeologic Investigation (February - May 1984)

On 14 February 1984, WESTON was retained by Schering Corporation to conduct a preliminary hydrogeological investigation of Schering's Union, New Jersey facility. As stated in the objectives of that investigation, "The purpose ... is to compile and analyze existing hydrogeologic and geologic data at the Schering plant and to provide a summary report of these analyses to serve as baseline site data." However, while the investigation of available hydrogeologic and geologic data was in progress, Schering informed WESTON that an internal review of past materials-handling practices at Schering's Union facility revealed that previous operations may have resulted in releases of chemicals to the soil and groundwater underlying the site.

As a result of these developments, Schering expanded WESTON's original scope of work to include an analysis of the plant's history and its activities with the goal of locating areas in the Union facility where past practices may have released chemicals into the environment. Data sources used to complete this preliminary investigation included the following:

- **Soil boring logs** completed at the Union facility **for previous construction projects**.

- Chemical analyses of water samples from: existing Production Wells 1, 2, and 3; Outfall 001 (a permitted discharge point for noncontact cooling water into the adjacent Elizabeth River); and the Elizabeth River.
- Facility drawings, historical data, and aerial photographs.
- New Jersey Department of Environmental Protection (NJDEP) well permits, diversion allocation permits, and well record data files.
- Published and unpublished literature, and reports of the surrounding area.
- Anecdotal information from long-term Schering personnel who recalled past operations at the Union facility.

Using the data sources cataloged above, WESTON **identified seven areas in the Union facility where past materials-handling practices may have released chemicals into the unconsolidated deposits on the plant site.** Descriptions of these seven areas of concern are presented in Figure 1-3 and are summarized as follows:

- Area 1 - The area surrounding Building 7, where Production Well 1 is located.
- Area 2 - The area under, and immediately adjacent to, Building 14, where four surface impoundments were used during the 1940's to early 1950's.
- Area 3 - The area where Building 12 now stands, which was formerly used for drum storage.
- Area 4 - The area east of Building 18, formerly used for drum storage.
- Area 5 - The area between Buildings 5A and 9, where "oily odors" were reported in one foundation study soil boring.
- Areas 6 and 7 - Storage areas used for fill material excavated during different phases of plant construction. These are located near the drum sheds in the northeast area and the ball field in the southeast area of the facility.

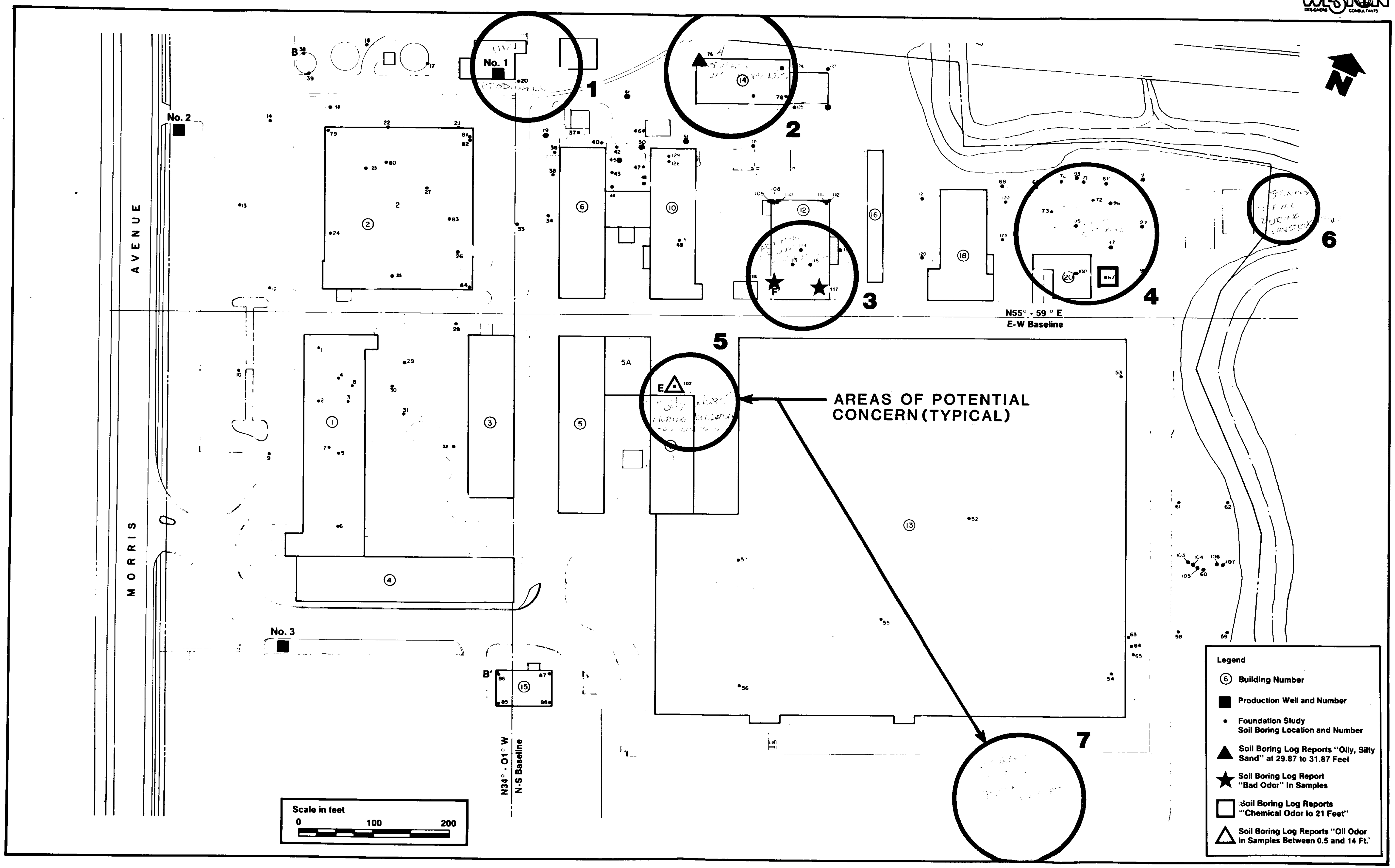


FIGURE 1-3 AREAS OF POTENTIAL CONCERN AS DEFINED IN PHASE I

Based on these findings, Schering directed WESTON to develop a Phase II Workplan for a field investigation to determine whether these areas were in fact contaminated as a result of past practices, and to assess the nature and extent of contamination.

This Phase II Workplan was presented to the NJDEP in April 1984 for its review and comment prior to proceeding with field activities. Concurrence on the Phase II Workplan was received from NJDEP in May 1984. The field investigation was initiated in June 1984, and the project report was completed in November 1984.

1.3.2 Phase II Hydrogeologic Study of the Schering Corporation's Union, New Jersey Facility (June 1984 - November 1984)

The Phase II field investigation had the following objectives:

- Define soil and groundwater quality in the unconsolidated deposits underlying the plant.
- Determine the potential for migration of substances in this shallow groundwater zone.
- Determine the relationship among the shallow groundwater zone, potential discharge areas (such as the Elizabeth River), and the deeper bedrock aquifer.

To accomplish these objectives, the field program included the following elements:

- A site-specific field safety program.
- Monitor wells and soil sampling sites located within the facility.
- Soil borings at 14 selected locations.
- Monitor wells constructed in 14 locations in the unconsolidated deposits.
- Soil samples and periodic groundwater samples from these borings and wells collected and analyzed.
- Stream sampling and flow measurements conducted on the Elizabeth River.
- Groundwater flow measurements and pump tests conducted to evaluate migration rates.

- A report summarizing the results of the Phase II investigation prepared and submitted to the NJDEP on 16 November 1984.

A separate and parallel activity, involving the cleaning and abandonment of Production Well 1, was also accomplished during the Phase II field investigation.

During the Phase II field investigation, four zones of the facility were identified where priority pollutant contamination, requiring further study and possible remediation, had occurred. These zones are shown in Figure 1-4.

The findings of the Phase II study included the following:

- Analyses of pump test and flow data in the unconsolidated deposits indicated that the predominant flow of groundwater is lateral and toward the Elizabeth River to the north and east of the facility. A low potential for downward groundwater flow was recognized, but could not be quantified at that time.

- Analyses of soil samples from the unconsolidated deposits yielded the following results:
    - Volatile organic priority pollutants were detected in Zone 1.
    - Insoluble metals, particularly chromium, were detected in Zone 2.
    - Base/neutral priority pollutants were detected in Zone 3.

- Analyses of groundwater samples from the unconsolidated deposits yielded the following results:
    - Volatile organic priority pollutants were detected at concentrations of >10 ppm in Zone 1.
    - No significant chromium or other heavy metals contamination was detected in Zone 2.
    - No significant base/neutral priority pollutants were detected in Zone 3.
    - The source of volatile organic priority pollutants in Production Well 1 (concentrations generally less than 1 ppm) in Zone 4 was not identifiable.

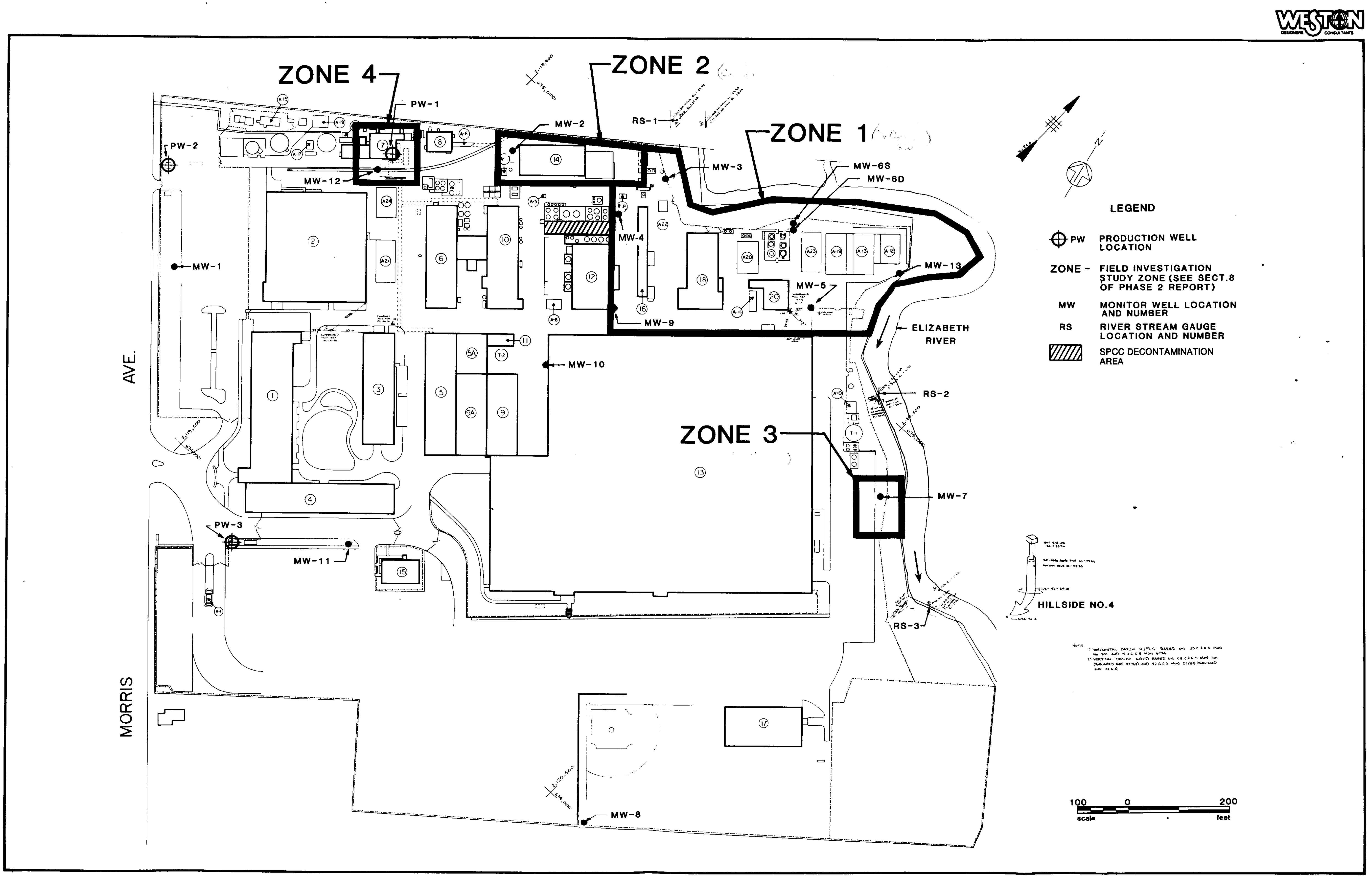


FIGURE 1-4 PHASE II FIELD INVESTIGATION SUMMARY MAP

- Priority pollutant volatile organics were consistently identified in groundwater samples from wells outside Zone 1 at average levels of less than 1 ppm.

- Available pump test data from the Hummocks Well Field, a major public water supply 1.5 miles northwest of the Union facility, indicated that pumping at the well field did not appreciably affect groundwater levels in the unconsolidated deposits at the Schering facility.

- Preliminary analyses of contaminant migration rates indicated that the pollutants were either contained in designated areas within the plant or were moving at a slow rate and, therefore, did not pose an immediate environmental concern outside of the Schering facility.

As a result of the Phase II investigation, WESTON recommended that a Remedial Investigation/Feasibility Study (RI/FS) be conducted to further quantify the magnitude and extent of contamination in the subsurface in the four zones identified.

1.4 REMEDIAL INVESTIGATION/FEASIBILITY STUDY (RI/FS - May 1985 - March 1987)

1.4.1 Background

In November 1984, Schering directed WESTON to produce a workplan and accompanying documents (e.g., contractor bid specifications) to conduct an RI/FS at the Union facility. This workplan was presented to the NJDEP on 8 April 1985. Conditional concurrence from the NJDEP was received on 16 May 1985. The main condition imposed by the NJDEP, and accepted by Schering, was that monitoring wells be installed outside of the eastern plant boundary to assess groundwater conditions adjacent to, and beneath, the Elizabeth River.

1.4.2 Remedial Investigation Objectives

The objective of the Remedial Investigation is to provide the data necessary to conduct a thorough Feasibility Study which will address environmental concerns at the site. The RI conducted at the Schering facility included the following elements:

- Quantification of the volume and extent of priority pollutants present in the soils in the unconsolidated deposits by conducting additional soil borings, samplings, and analyses.

- **Quantification of the extent of** priority **pollutants** present in **the groundwater** in the unconsolidated deposits by constructing additional monitor wells and by instituting a routine sampling and analytical program.

- **Estimation of the quantity of vertical groundwater migration** from the unconsolidated deposits to the bedrock aquifer by conducting flow analyses using data from bedrock monitor wells, piezometers, shallow monitor wells, and pump tests.

- **Assessment of the groundwater quality in the upper bedrock zone** (0 to 30 feet below the top of bedrock) underlying the facility by installing monitor wells and instituting a routine sampling and analytical program.

- **Assessment of the impact of groundwater discharges from beneath the Schering facility** on the surface water quality in the Elizabeth River by instituting a routine sampling and analytical program.

and ground water?

- Preliminary determinations of appropriate remedial actions required in the four study zones discussed in the workplan.

- Assessment of remedial action technologies applicable to the site and its environmental concerns.

Conceptual engineering designs for remedial actions found to be necessary are being developed based on the results of the RI. **A workplan will be prepared for detailed design and implementation of required technologies at the conclusion of the FS.** *

1.4 3 Summary of Specific RI Field Activities

The field activities conducted by WESTON at the Schering facility were designed to provide the physical and chemical data needed to complete the RI. The field program was discussed in detail in the RI/FS Workplan (WESTON, 1985). In general, the RI field activities included the following:

- Soil borings drilled and sampled to supply geologic and chemical data.

- Monitoring well and piezometer installations to assess groundwater flow and quality.

- Groundwater and surface water sampling to provide water quality data.

- Geophysical surveying conducted to identify areas of disturbed soils.

- Hydrogeologic data collected to estimate groundwater flow directions and rates.

Table 1-1 summarizes the chronology of these activities. Plate 1 shows the soil boring locations and Plate 2 shows the monitoring well, piezometer and production well locations. (Note that monitor wells MW-1 through MW-13 were installed in 1984 as part of the Phase II study.)

1.5 REMEDIAL INVESTIGATION REPORT SUMMARY

As shown in Figure 1-4, four zones of the Schering facility were identified during the Phase II study as having known, or potential, environmental contamination concerns. These zones did not have rigid boundaries and were originally proposed as an aid to conceptualizing and categorizing environmental concerns at the facility. As WESTON's and Schering's knowledge and understanding of the site increased during the RI, it became clear that the concept of clearly-defined "zones" was inappropriate. Rather, [illegible] report addresses four "areas of concern." These areas are:

- Groundwater contaminated with organic compounds.

- Soil contaminated with organic compounds.

- Former surface impoundment area under Building 14 (formerly Zone 2).

- Base/neutral compound occurrence in the soil (formerly Zone 3).

Section 2 of this report discusses site history in detail. Section 3 presents the site features investigation which includes: demography, land use, natural resources, climatology, topography, and surface water drainage and use. Section 4 describes the specific field methods used during the Remedial Investigation. Section 5 discusses the results of the Remedial Investigation, such as soil and groundwater quality. Section 6 presents the nature and extent of environmental contamination at the Schering facility and the potential for off-site contamination. Section 7 discusses the potential health risks of the Schering facility. Section 8 details WESTON's conclusions, recommendations, and preliminary evaluations of remedial alternatives.

Table 1-1

Chronology of Major RI Field Activities

Activity	Completion Schedule
Soil Boring and Sampling	May - July 1985
Ground Penetrating Radar Survey	July 1985
Shallow Bedrock Monitoring Well Installation (BW-1 to BW-7)	July 1985
Unconsolidated Deposit Monitoring Well and Piezometer Installation (MW-14 to MW-18, MW-20 to MW-27, P-1 to P-6, P-9, P-10, P-13, P-14)*	August - September 1985
Groundwater and Surface Water Sampling	March, August, and November 1985; February and March 1986
Pump Testing	October 1985
Installation of MW-19, P-7, and P-8	December 1985
Installation of Off-Site Piezometers (PE-1 to PE-8)	January 1986

*MW-1 to MW-13 were installed in 1984 as part of the Phase II hydrogeological investigation.

Section 2
Chronological Site History

SECTION 2

CHRONOLOGICAL SITE HISTORY

2.1 OVERVIEW

WESTON has developed this chronological site development and operational history for the Remedial Investigation of Schering's Union facility. This history has been used primarily to gain insights into past operating practices and processing procedures, with the objective of identifying potential source areas for the soil and groundwater contamination identified at the site. These potential source areas are shown in Plate 3. (Refer to this plate for information on the location of items in the following discussion.) Interpretation of aerial photography, plant information (drawings, production records, process technologies, etc.) and interviews with long-term plant personnel by WESTON and Schering were incorporated into this chronological history. A construction summary for the Union facility is presented in Table 2-1.

2.2 1930's

c. 1930 aerial photography (Photo No. 79, NJDEP Bureau of Tidelands Management) showed that the site area appeared to be grassland in the east and north. Two cleared areas, one in the middle and one on the east end of the site, may have been cultivated fields. A dirt road extended along the southern flank of the study area with crossroads leading to the two cleared areas. Several buildings, possibly houses, were visible on Morris Avenue. One of these buildings was on the site.

2.3 1940 - 1950

1941 aerial photography (Frames 2812 and 2811), Figure 2-1, showed Buildings 5 and 6 as well as Buildings 7 and 8. The area near the buildings was cleared, while areas adjacent to the river were wooded. A railroad spur into the facility was also visible.

From this photo, **at least three vertical tanks** were situated **on** a cleared, **unpaved area immediately north of Building 6**. The **concrete settling basin** was visible to the **north of Building 6** (near the present site of Building 10). A total of **six partitioned compartments** were evident. **A dark line** (possibly representing trenching) extended **along the northeast** side of Buildings 5 and 6 leading to the settling basin.

Table 2-1

Summary of Union Facility Construction History

Building No.*	Initial Construction	Additions or Renovations to Buildings
U-1	1959	1974-1975
U-2	1957	1974-1975
U-3	1958	
U-4	1944	Renovated 1957
U-5	1939	1953
U-6	1939	
U-7	pre-1940	1951, 1958
U-8	1940	
U-9	1944	
U-10	1944	Renovated 1970-1971
U-11	1939	Rebuilt 1979
U-12	1977	
U-13	1944	1948, 1950, 1952, 1960-1961, 1969
U-13 Truck Dock	1960	
U-14	1958	1967 - Media Preparation Addition
U-15	1972	
U-16	1949	
U-17	1972	
U-18	1956	
U-20	1974-1975	

*"U" refers to the Union, New Jersey plant. Building numbers represent the latest numbering sequence of structures according to the site plan.

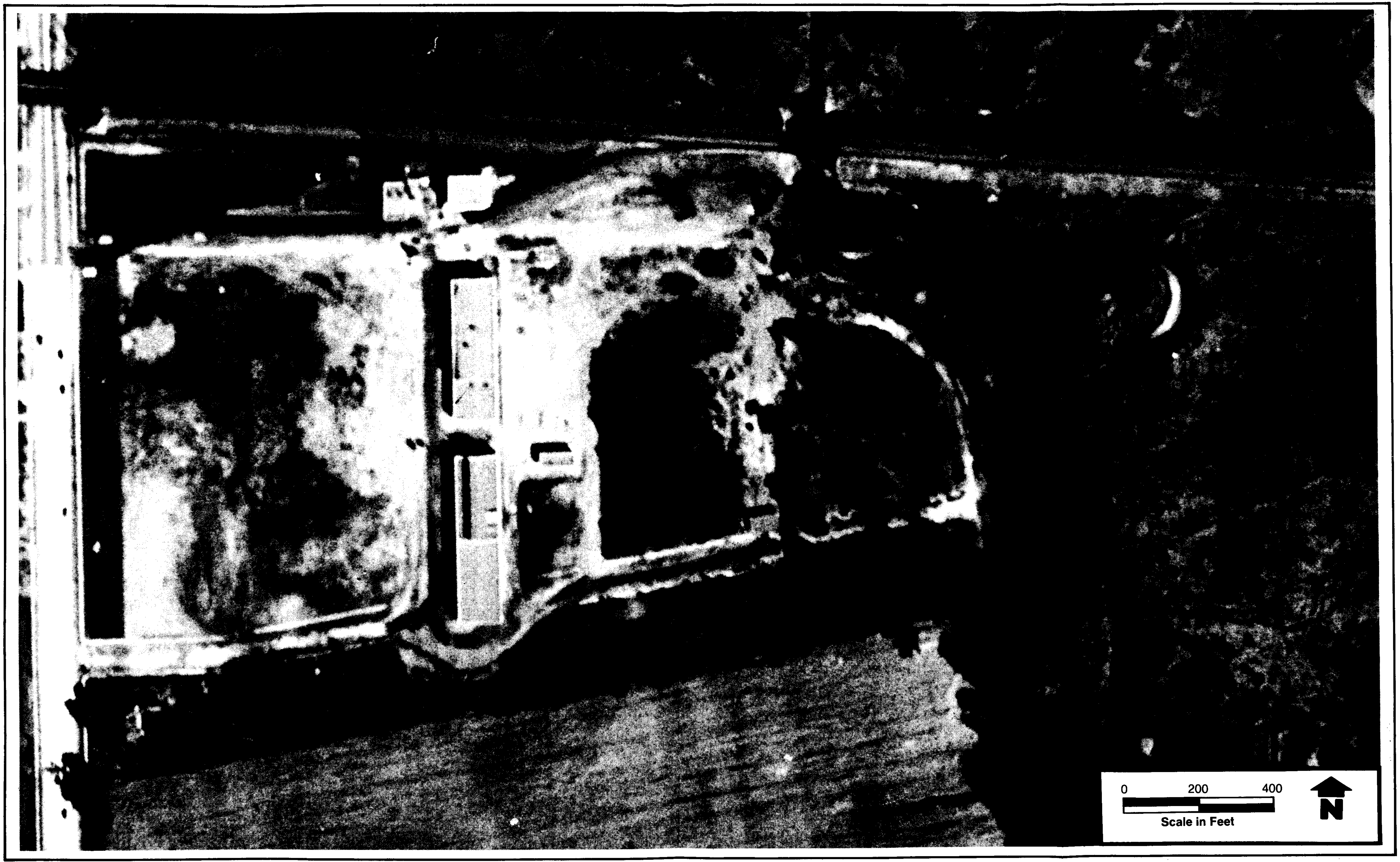


FIGURE 2-1 1940 AERIAL PHOTOGRAPH

According to interviews with Schering personnel, a significant amount of **railcar traffic** was accepted into the plant spur from 1945 to 1951. Railcar traffic diminished after 1952. **Fuel oil, methylene chloride, acids, and chloroform**, among other raw materials, **were received via rail. Numerous small spills** reportedly occurred over the years during the transfer of these liquids from tank cars to storage tanks. However, interviewees **could not recall any major incidents.**

Schering Drawing D-2258 (c. 1948) showed that, adjacent to the railroad spur in the tank farm north of Building 6, there were **four above-ground 12,000-gallon storage tanks for ethylene dichloride, butyl ether, methylene chloride, and chloroform.** In addition, a **12,000-gallon underground storage tank for methanol** was shown in the same vicinity. This drawing also showed the "new position" for **two 9-foot diameter above-ground tanks for "green liquor."** According to long-term plant personnel, green (mother) liquor was **the result of using lime to neutralize spent sulfuric and chromic acids**, which were utilized to oxidize cholesterol in the pharmaceutical plant. This also showed that **only the ethylene dichloride and butyl ether tanks were surrounded by a 5'9" high cinder block dike which extended about 1 foot underground. Three sumps** surrounded these tanks **and discharged into a pipe trench which was concrete lined.**

Schering Drawing D-1714 (8/19/48) showed the extent of site paving during this era. The area between Buildings 10 and 16 was largely unpaved. The **solvent dispensing shed**, Building 7, was visible at the southern **corner of the unpaved area.** Additionally, **the area between Building 16 and the waste solvents tank farm was also unpaved. Both open areas** were utilized for **drum storage.** A drum storage area in the vicinity of the current location of Building A-13 was shown. The locations of the **acid sump and neutralization tank** serving the sewers from Building 16 were shown. The **tank car solvent unloading station** was located between Buildings 7A and 7B on the southeastern side of the railroad spur. The drawing also showed an **underground** drain connection which originated in the vicinity of the solvent unloading station and ran **to an existing tile storm drain along the northern fenceline. An underground gasoline tank** near the pumphouse for Production Well 2 was also shown.

Schering Drawing D-2468 (1/16/49) showed the location of four "settling lagoons" northeast of Building 10. A sanitary sewer lateral leading from the concrete settling basin to the Hillside sewer on the east side of the Elizabeth River was shown. Industrial sewers from Buildings 5, 6, and 10 were shown leading to the settling basin. Long-term plant personnel reported that aqueous wastes from chemical processes in Building 10 were occasionally discharged to the concrete settling basin north of Building 6 for solids removal and solvent flotation. Wastewaters from the basin entered a sewer that flowed under the Elizabeth River and connected to the Hillside sewer system.

A 1949 artist's isometric conception of the facility illustrated the existence of at least three surface impoundments in the area presently occupied by Building 14. Tank cars on the railroad spur were shown in the vicinity of Building 7. At least one storage tank without a dike was shown north of Building 6. The concrete settling basin near Building 10 was also illustrated. Railroad traffic on the tracks outside the plant was shown.

2.4 1950 - 1954

Schering Drawing D-3161 (c. 1951) showed a 12,000-gallon acetone storage tank and a 20,000-gallon methanol storage tank immediately adjacent to Building 7 and the railroad spur, in the area presently occupied by Shed A-24.

1951 aerial photography (Frames 287-3311, 289-3310), Figure 2-2, showed a total of four surface impoundments (SI's). Two of the SI's are completely filled with a light-toned material. The third SI contained liquid in approximately two-thirds of the surface area, and the remaining area was filled with a light-toned material. The fourth SI appeared to have been filled and was evidenced only by remnants of the retaining dike. (The existence of the fourth SI was confirmed by Drawing D-2468, dated 1/16/49.) Interviews with long-term employees indicated that the lagoons were used until the early 50's and were filled in between 1952 and 1954. Most of the waste placed in the SI's originated from testosterone production. In this process, cholesterol was oxidized with chromic acid in one of the initial processing steps. Acidic waste liquids were drained into local wooden neutralization vats outside of the production buildings. The pH was raised with a caustic solution, and neutralized waste was then discharged into the SI's. The oxidation and neutralization steps reportedly converted the hexavalent chromium to the trivalent form. The processing included a zinc reduction step over a nickel-based catalyst. The cortisone process (conducted between 1950 and 1953) also utilized selenium; most of this material was recovered, but some was discharged to the SI's.

WESTON

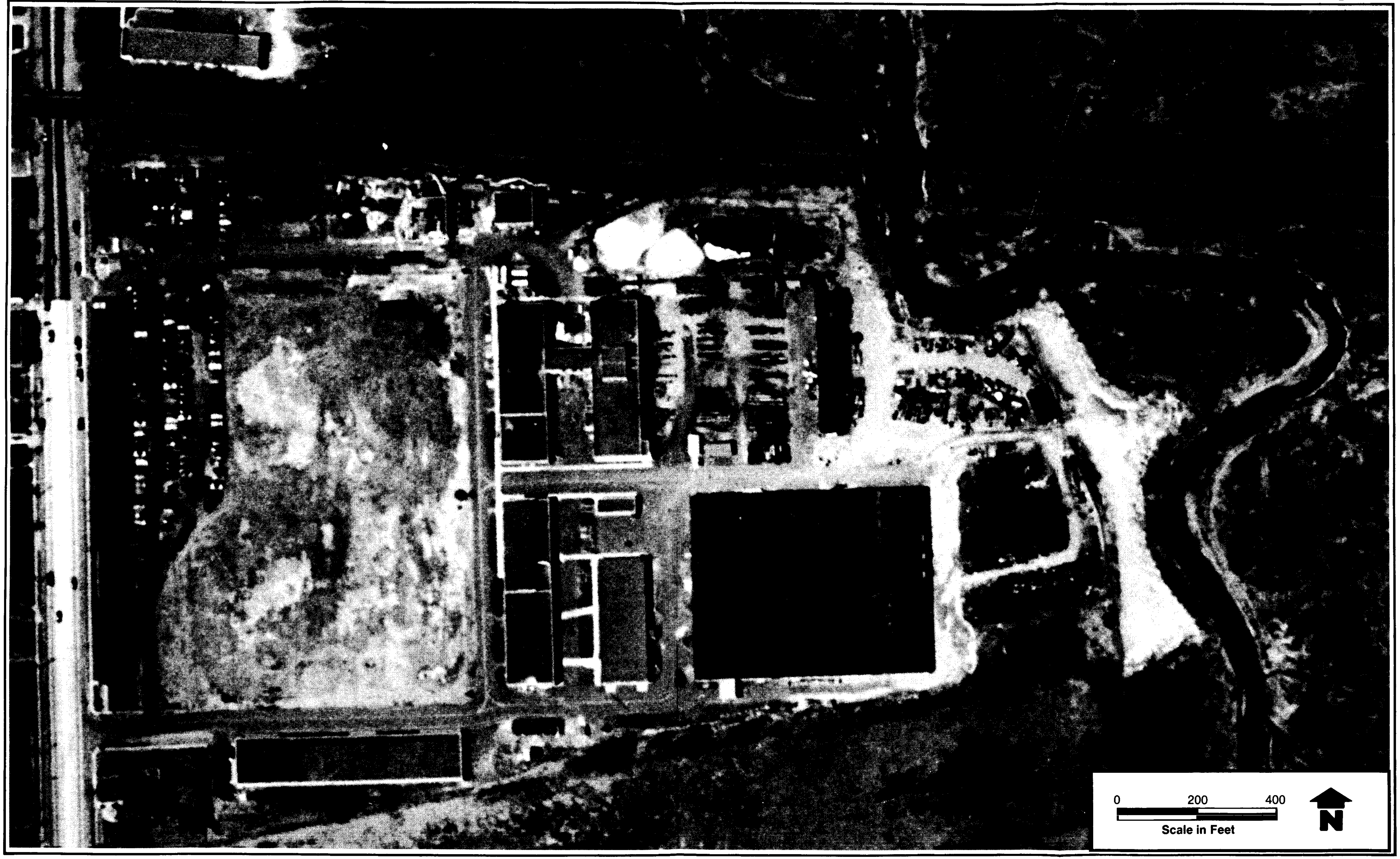


FIGURE 2-2 1951 AERIAL PHOTOGRAPH

The surface impoundments were constructed over a period of years, during the 1940's, as production capacity expanded in the plant. The SI's reportedly filled with solids after each 1 to 1 1/2 years of operation. At that time, a drag line was used to remove the accumulated solids which were then transported by various contractors to off-site disposal areas. After removing the solids, the SI's were again placed into service until they were finally cleaned and demolished in the early 1950's for new building construction. The SI's did not have designated outfalls; evaporation and infiltration regulated fluid levels.

Reportedly, between 1950 and 1952, drums of mixed solvents (e.g., toluene, ethers, alcohols, pyridines, carbon tetrachloride and others) were disposed of by dumping the contents into an unlined basin 15 feet in diameter by 8 to 9 feet deep. The basin was located east of Building 16 under the current site of Building 18. Aerial photography from 1951 did not clearly show this feature; however, at least three dark circular areas in the current location of Building 18, which may have been local neutralization vats, were shown. The practice of dumping waste solvents into the basin was discontinued in 1953. No records exist to quantify the amount of solvents discharged into this basin. Seepage on the north side of the peninsula along the river was observed during this period.

Aerial photography from 1951 also showed some fill activity along the northeast flank of the site bordering the river. Long-term plant personnel stated that the materials placed near the river were mostly spoils from construction of new buildings. An additional fill area was visible off-site in the industrial property immediately north of the railroad.

Schering Drawing D-1714 (c. 1954) showed that the areas between Buildings 10 and 16 and to the east of Building 16 were largely unpaved. The four surface impoundments had been filled by July 1954.

2.5 1960's

1961 aerial photography (Frames NJ 62, 12, 584, 585), Figure 2-3, showed that some fill activity may have been conducted in the area southeast of Building 13. Drum storage between Building A-12 and the tank farm east of Building 18 was located on an unpaved area. Also, the drum storage area between Buildings 10 and 16 appeared to be unpaved; however, fewer drums were in storage than in previous photographs. Dikes around the

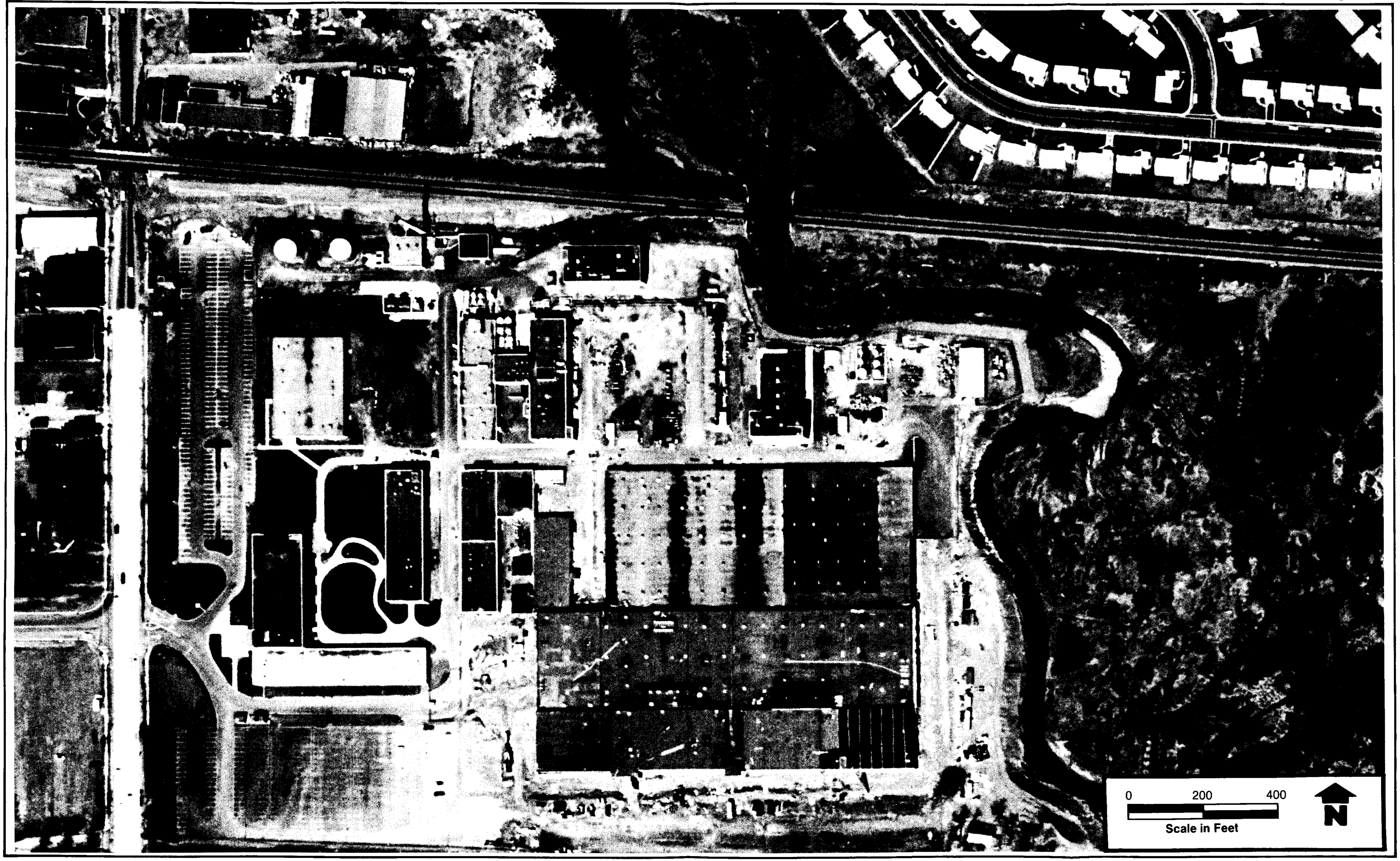


FIGURE 2-3 1961 AERIAL PHOTOGRAPH

storage tanks near Building 6 had been constructed. (These tanks are currently used for storing toluene.) Drum storage on unpaved surfaces adjacent to the main building was evident. There was extensive off-site fill activity near the industrial site on the north side of the railroad tracks.

1969 aerial photography (uncatalogued source), Figure 2-4, showed that Building 13 had been expanded significantly. Containment dikes were visible around many storage tanks. The drum storage area between Buildings 10 and 16 was being used extensively and appeared to be unpaved. The drum storage area between Building A-13 and the tank farm east of Building 18 appeared to have been paved.

Schering Drawing C-6921 (5/2/63) illustrated that the drum storage area between Buildings 10 and 16 was still largely unpaved. The drum storage area between Buildings 18 and A-13 had been partially occupied by Building 20. Protected drum storage had been provided in Building A-12.

2.6 EARLY 1970's

1974 aerial photography (Frames 40, 1620), Figure 2-5, showed that the drum storage area between Buildings 10 and 16 had been at least partially paved. The railroad spur was apparently used up to this time. Fill activity south of the parking lot near Building 17 was evidenced by numerous piles of fill material. Fill activity on the northeast peninsula was also evidenced by numerous piles.

2.7 MID TO LATE 1970's

According to long-term plant personnel, prior to 1977 - 1978, the plant's sewers were reportedly in poor condition with numerous leaks and cross-connections. Many sewer lines had no acid bricking; floor drains and trenches were eroded to earth. Many waste acid lines to the neutralization vats were located in trenches that had no structural bottoms since the concrete had been dissolved by acid leaks. Extensive sewer repairs and Spill Prevention Control and Countermeasure (SPCC) facilities were installed during 1977 and 1978.

FIGURE 2-4 1969 AERIAL PHOTOGRAPH

FIGURE 2-5 1974 AERIAL PHOTOGRAPH

1977 aerial photography (uncatalogued source), Figure 2-6, showed that foundation work for Building 12 had displaced drum storage onto the paved area between Buildings 10, 14, and A-8. Drum storage areas at the northeast corner of Building 13 and at the northwest corner of Building 18 appeared to be paved. Drum storage along the northern and eastern sides of Building A-12, between the fence and the building, was evident. Excavation for Building A-13 was visible. Some fill activity south of the parking lot near Building 17 continued.

2.8 1980's

Schering Drawing C-6921 (revised 2/20/80) showed that the drum storage area between Buildings 10 and 16 had been partially occupied by Building 12 and that the tanks adjacent to Building 12 were protected by secondary containment. The solvent dispensing shed, Building A-7, was no longer visible. The remainder of the drum storage area was shown as paved.

2.9 UNDERGROUND STORAGE TANK INVENTORY

A total of 10 underground storage tanks have been installed during development of the Schering facility. Table 2-2 summarizes the relevant data regarding these tanks and their current status. Tank locations are shown on Figure 2-7. All of the tanks have been evaluated as possible sources of subsurface contamination, and their significance will be discussed more fully in Section 6.

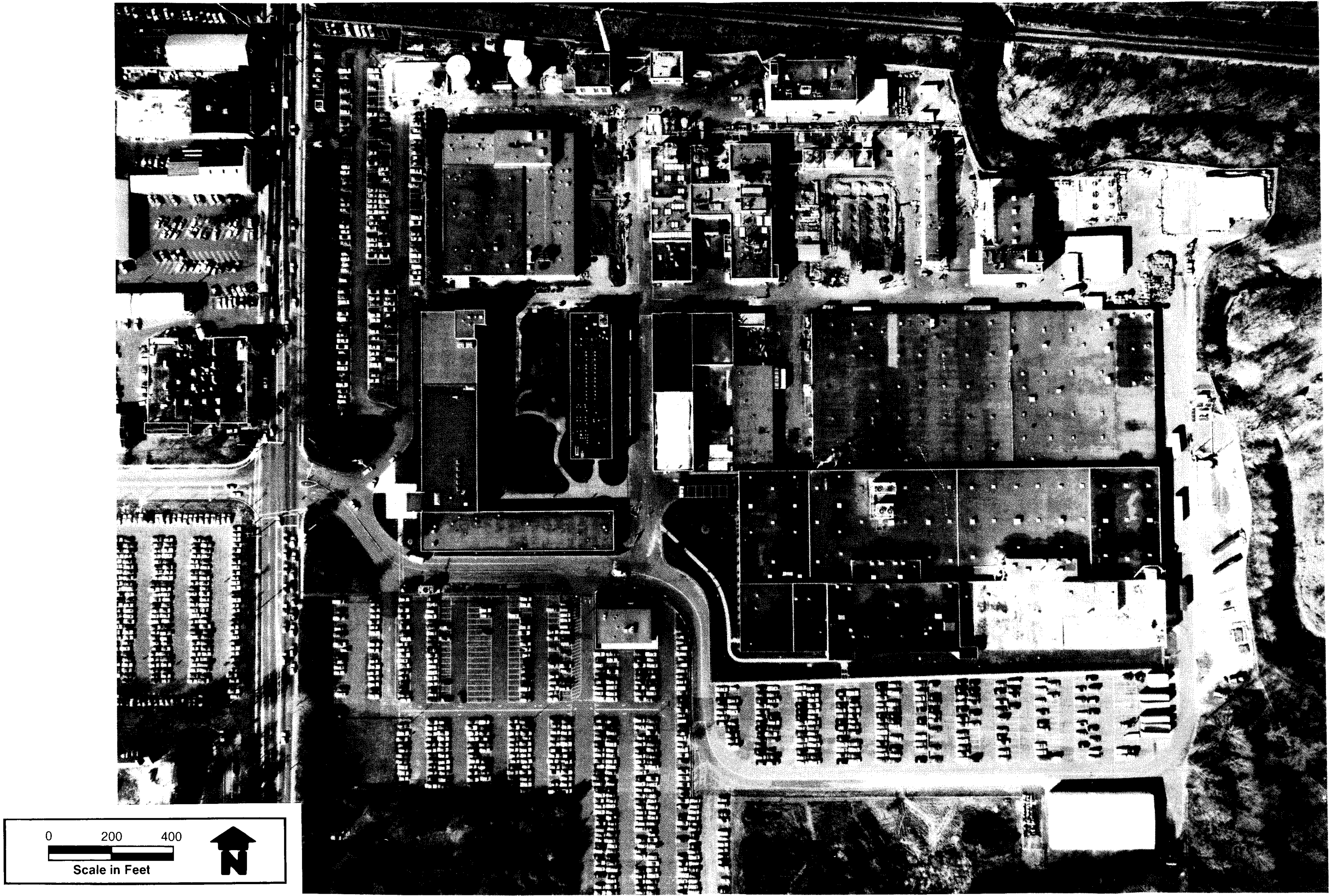


FIGURE 2-6 1977 AERIAL PHOTOGRAPH

Table 2-2

Underground Storage Tank Inventory

Tank No.	Contents	Current Status
1	Alcohol	Removed.
2	Gasoline	Abandoned; filled with sand.
3, 4	Fuel Oil	Removed.
5, 6	Fuel Oil	Removed.
7	Water	Abandoned; filled with sand.
8	Methanol	Abandoned; filled with sand.
9	Gasoline	In use; Monitoring Wells MW-19, P-9, and P-10 installed in vicinity.
10	Glycol-Water	Abandoned; filled with sand.

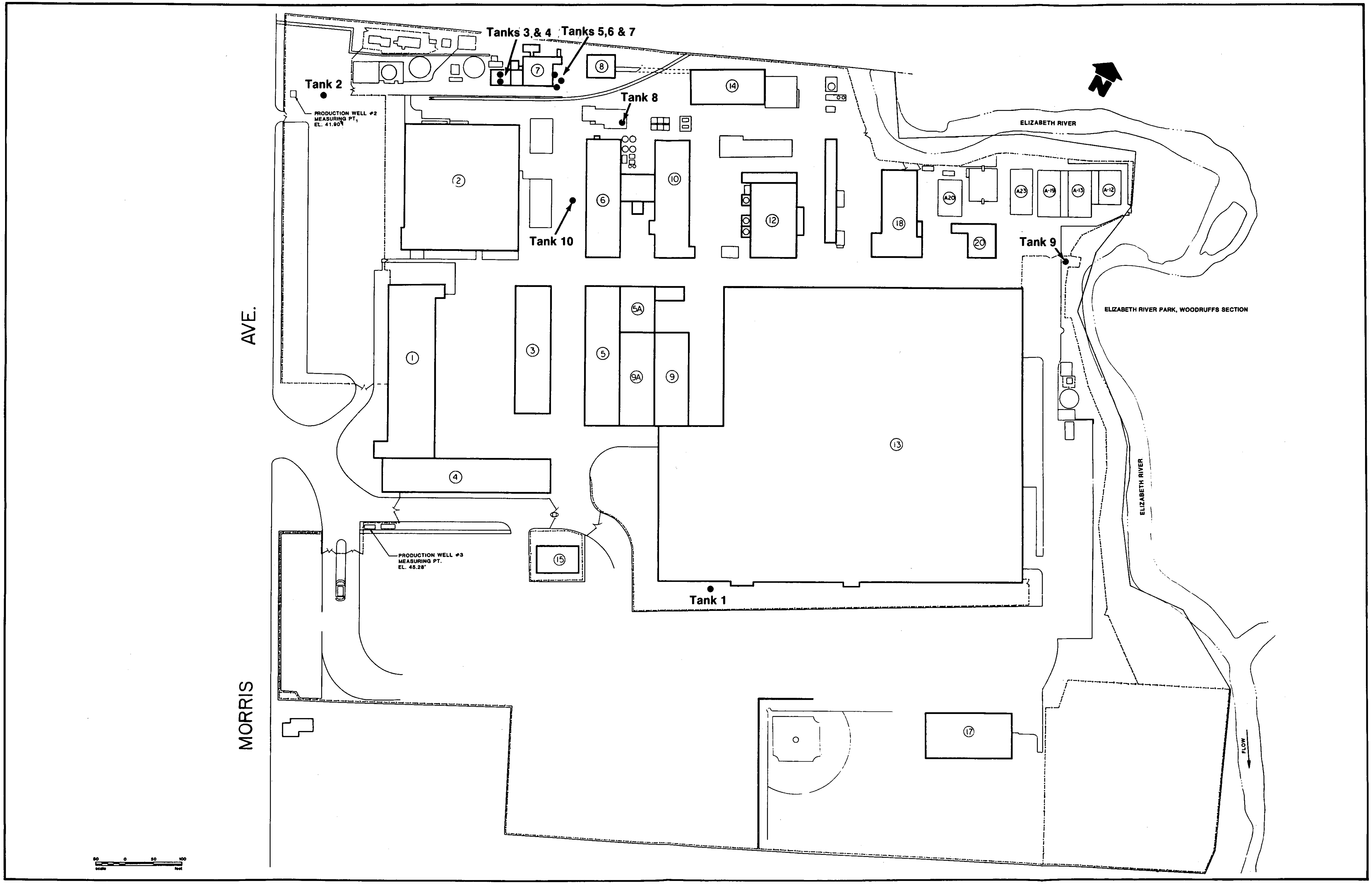


FIGURE 2-7 UNDERGROUND STORAGE TANK LOCATION MAP (SEE TABLE 2-2 FOR KEY)

Section 3
Site Features Investigation

SECTION 3

SITE FEATURES INVESTIGATION

3.1 OVERVIEW

To facilitate the planning and execution of the RI/FS for Schering's Union, New Jersey facility, a Site Features Investigation was conducted to provide a definition of the overall environmental and physical setting of the study area which includes a 2-mile radius surrounding the plant site.

Elements of the Site Features Investigation included: demography, land use, groundwater resources, climatology, topography, and drainage. The discussion in this section is based upon published and unpublished literature, NJDEP Division of Water Resources files, site reconnaissance, topographic mapping, aerial photographs, and other pertinent sources of information.

3.2 DEMOGRAPHY

Union County has one of the largest populations, but the second smallest land area in New Jersey (Nemickas, 1976). The high-population density (4,922 people per square mile) is a result of being situated between Philadelphia, Newark, and New York City. Within its approximately 105 square miles of land area, Union County had an estimated population of 505,500 in 1984 (Current Population Series, 1984). This is nearly 5 times the population of 99,353 that lived in the county in 1900 (Ten Years of Change, 1971).

The county population grew steadily between the years 1900 to 1970; however, between 1976 and 1980, the population declined about 8 percent to the 1960 level, as shown in Table 3-1. The greatest growth for the region occurred in the 1920's and 1950's when 105,052 and 106,117 people, respectively, were added to the census. Union Township and Hillside Township populations have followed similar trends with a current Union Township population of nearly 51,000 and a Hillside Township population of approximately 21,000 (Current Population Series, 1984).

Table 3-1

Summary of Population Data for Union County, Union Township, and Hillside Township, New Jersey

Year	Union County	Union Township	Hillside Township
1900[1]	99,353	ND[4]	ND
1910[1]	140,197	ND	ND
1920[1]	200,157	ND	ND
1930[1]	305,209	ND	ND
1940[1]	328,344	ND	ND
1950[1]	398,138	ND	ND
1960[1]	504,255	51,499	22,304
1970[1]	543,116	53,077	21,636
1980[2]	504,094	50,184	21,440
est. 7/1/84[3]	505,500	50,799	21,567

[1] Ten Years of Change 1971
[2] 1980 Census, 1981
[3] Current Population Series, 1984
[4] ND -- No Data

3.3 LAND USE PATTERNS

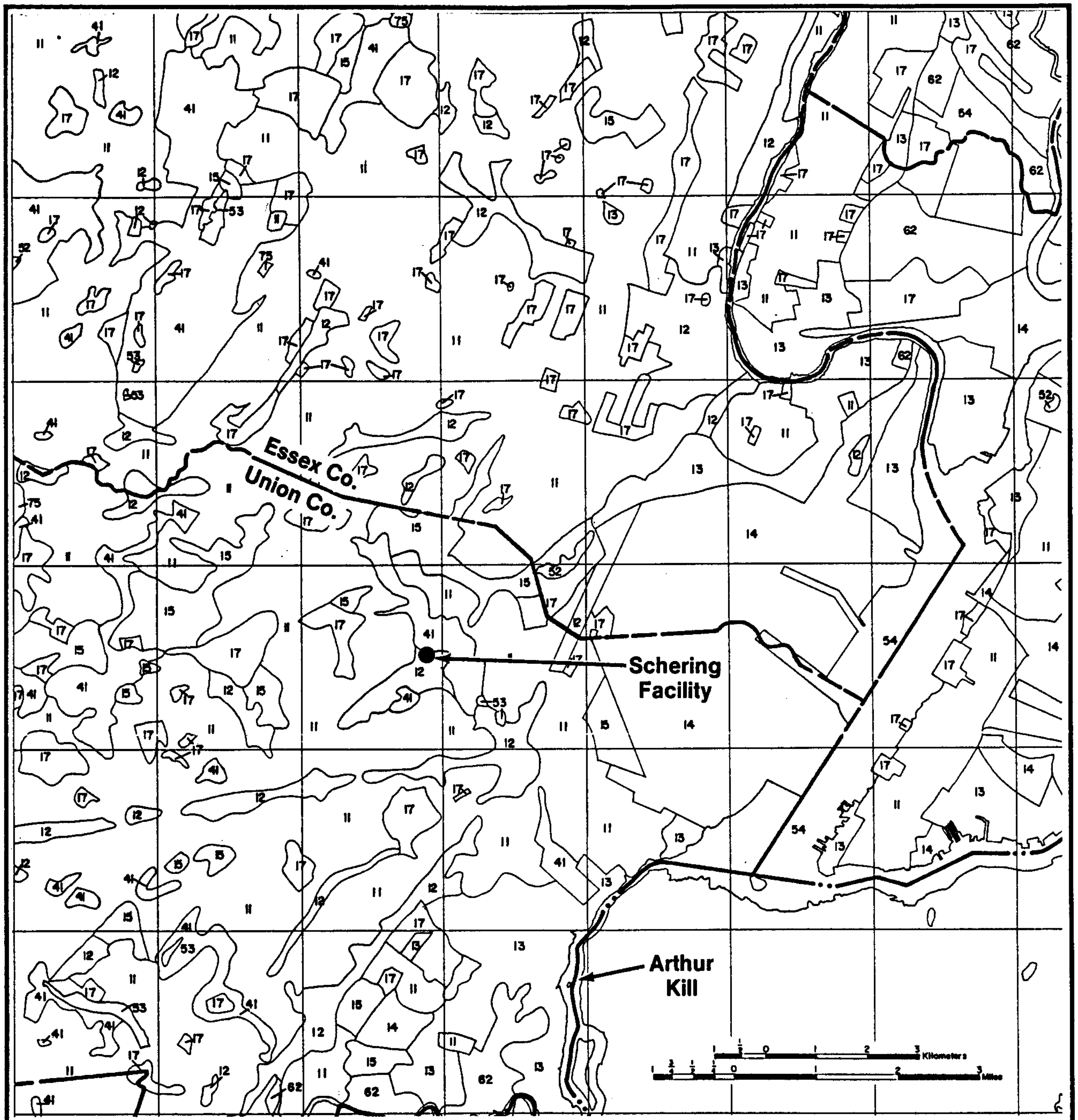
Of the 104.94 square miles in Union County, 1.55 square miles is water, and most of the remaining area is residential (Nemickas, 1976). The eastern two-thirds of the county has almost as many commercial and industrial sites as residential, with part of Newark Airport occupying the northeast corner of the county. The western third of the county has significantly more forest land, with very little industry, because of the Watchung Mountains at the western edge of the county (New Jersey Topographic Series, 1976). This county is one of the major industrial centers of the state with more than 1,000 manufacturing facilities within its borders (Know Your State, 1960).

As shown in Figure 3-1, the wooded areas near the Schering site are primarily along the Elizabeth River, within Elizabeth River Park. Next in abundance, the commercial sites are generally sited along the major highways. Residential property occupies the greatest land portion, about 50 percent, of the total area surrounding the Schering site.

3.4 GROUNDWATER USE

To determine the extent of groundwater use and to identify potential receptors in the study area, WESTON reviewed available data in the NJDEP, Division of Water Resources files (Well Permit, Well Record, and Diversion Permit) and in Nemickas (1976). Using these sources, WESTON has identified a total of 52 well owners, with a total of 134 wells, within approximately a 2-mile radius of the Schering facility. The locations of these wells are shown in Plate 4 and supporting data are contained in Appendix A.

Of these 134 wells, 13 are identified in NJDEP permit files and/or Nemickas (1976) as being used for "domestic" purposes. Twelve of these domestic wells are accurately located in Plate 4; however, the 13th well could only be tentatively located based on the grid coordinates given in the well permit files. This well should be located approximately 2 miles to the northwest of the Schering facility. The nearest recorded domestic well is 1.2 miles southwest of the Schering site. The owner, according to Nemickas (1976), is Mr. William Einhorn of Elizabeth, New Jersey. This well was installed in 1954 to a total depth of 110 feet; therefore, it was located within the Brunswick Formation. Nemickas (1976) gives the well yield as 15 gallons per minute; no data are currently available on the present status of this well.



LEGEND

Urban and Built-Up Land	**Water**
11 Residential	52 Lakes
12 Commercial and Services	53 Reservoirs
13 Industrial	54 Bays and Estuaries
14 Transportation, Communication and Utilities	**Wetland**
15 Industrial and Commercial Complexes	62 Nonforested Wetland
16 Mixed Urban and Built-Up Land	**Barren Land**
17 Other Urban or Built-Up Land	75 Strip Mines, Quarries, and Gravel Pits
Forest Land	
41 Deciduous	

Source: Sheet 26, New Jersey Topographic Series: Land Use Overlay, N.J. DEP 1976.

FIGURE 3-1 REGIONAL LAND USE IN THE VICINITY OF THE SCHERING FACILITY

Of the total of 134 wells, 35 are identified as "public water supply" wells according to NJDEP permit files and/or Nemickas (1976). The closest public supply wells are located in the Hummocks Well Field, approximately 1.5 miles northwest of Schering. According to permit files, this well field includes 27 pumping wells and 1 observation well. In 1985, an average of three million gallons per day were pumped from the Hummocks Well Field.

Table 3-2 contains the domestic and public-supply well owners, and Table 3-3 lists the total number of wells and their uses based upon examination of available records. Diversion permits are required by the NJDEP from groundwater users that pump in excess of 100,000 gallons per day. According to WESTON's review, there are 38 diversion permit holders for industrial and public use. Of this total, 13 are within the study area. In 1985, these 13 permit holders collectively pumped an average of approximately 7 million gallons of groundwater per day, primarily from the Brunswick Formation. These diversion permit holders are summarized in Table 3-4.

In Union County, there are also 16 holders of diversion permits for using groundwater in amounts less than 100,000 gallons per day. Two of these users are located within the study area (Union Township Board of Education and Accurate Bushing Co.) in Union Township. The other permit holders are outside of the study region.

There were some discrepancies among well data from NJDEP well permit files, Nemickas (1976), and WESTON's field observations. The main problem was that all the wells identified by Nemickas (1976) within a given NJPCS grid square did not have corresponding well permits. This could be due to well abandonment, or transfer of ownership, or errors in the permit files and/or the Nemickas report. In addition, the well location was not always stated explicitly in its respective permit. To resolve these discrepancies completely, each well owner would have to be contacted individually.

Locations given by Nemickas (1976) were used for all wells installed before 1974 within the study area. These locations were then verified by NJDEP permits, when available, for each well. For a given owner, wells installed after 1974 were plotted when their locations could be determined accurately from the NJDEP permit files. Only three wells listed in Nemickas (1976) and the NJDEP files could not be located in Plate 4. Data for these wells are listed at the end of Appendix A.

Table 3-2

Domestic and Public-Supply Well Owners Within Approximately a Two-Mile Radius of the Schering Facility

Well No.[1]	Domestic Wells	Well No.[1]	Public-Supply Wells
23	Leonard Lehnbauer	9	Elizabethtown Water Company Hummocks Well Field
25	G. H. M. Krouse	21	Elizabethtown Water Company Quinton and Richfield Avenues
34	Stephen Orlando		
47	E. A. Lavin	46	Elizabethtown Water Company 1st Avenue
48	William Einhorn	49	Elizabethtown Water Company St. Walaburga 1 through 4
56	Nick Giordano		
58	Mrs. J. Brink	54	Elizabethtown Water Company Chandler Avenue
59	Jewish Education Center		
60	Gino Abbate		
61	Gus DeFonseca		
63	Joseph Waldo		
64	J.E. Bryan		
---	Carl Walsh[2]		

[1] Refers to location on Plate 4.
[2] Tentative location only -- approximately 2 miles northwest of the Schering plant.

Table 3-3

Groundwater Uses Within Approximately a Two-Mile Radius of the Schering Facility

Use	Number of Wells[1]
Air Conditioning	10
Diffusion	1
Domestic	13
Industrial and Commercial	39
Irrigation	2
Observation	12
Public Water Supply	35
Unknown	15
Unused or Abandoned	7
Total	134

[1] Total Number of Owners = 52

Source: NJDEP Division of Water Resources, Bureau of Water Allocation Well Permit Files and Nemickas, 1976.

Table 3-4

Data Summary for Holders of Diversion Permits for Pumping Greater Than 100,000 gpd Within Approximately a Two-Mile Radius of the Schering Facility[1]

Diversion Permit No.	Owner	Number of Wells[2]	Production Average for 1985 (gpd)[3]
2020P	Schering Corp., Kenilworth	5	494,323
2051P	Bristol Meyers	4	127,354
2056P	Atlas Tool	2	64,181
2081P	Certified Processing	2 1 Diffusion[4]	102,658
2101P	Decorator Plastics	1	129,197
2107P	Tuscan Dairy	3	461,261
2140P	Rotary Pen	2	85,507
2168P	Emeloid (EMCO Graphics, Inc.)	2	56,118
2276P	Schering Corp., Union	2	350,439
2279P	Volco Brass	1	337,968
2306P	Hayward Manufacturing Products	2	106,445[5]
5029	Elizabethtown Water Company		
	Chandler Avenue	1	218,592
	First Avenue	1	188,640
	Quinton Avenue	1	257,328
	Richfield Avenue	1	218,016
	St. Walaburga	4	850,176
5050	Elizabethtown Water Company		
	Hummocks Well Field	27	2,939,184

---

[1] Source: NJDEP, Division of Water Resources, Bureau of Water Allocation Diversion Permit Files

[2] All wells listed are production wells (i.e., they are used to pump groundwater out of the aquifer).

[3] gpd = gallons per day

[4] A diffusion well is used to pump water into the aquifer.

[5] 1984 data.

In recent years, groundwater usage has been accelerating in Union County. In 1965, groundwater accounted for only 10 percent of the total fresh water use; however, it had increased 24 percent over the previous decade (Halasi-Kun, 1972). Specific groundwater users and the impacts of groundwater use are discussed in greater detail in Section 5 of this report.

3.5 CLIMATE

Generally, Union County experiences a continental climate consisting of humid, warm summers and moderately-cold winters, with an annual-average temperature of 53°F (Nemickas, 1976). The winds, predominantly from the west-northwest and north-northwest, flow over and down the Watchung Mountains causing some adiabatic temperature increase (NOAA, 1985). This drying effect of the downslope winds causes few convectional thunderstorms as compared to more western counties in New Jersey.

The northeastern storms off the Atlantic coast, which normally last two days in the fall or winter, typically produce an inch or two of rain in Union County. The average, annual precipitation for the period of 1955 to 1984 was 42.82 inches as recorded at Newark Airport, 3 miles east of Schering (NOAA, 1985).

Summers and periods of hot weather are related to the west-southwest prevailing winds, which have a long path overland on the left side of the Bermuda high-pressure system. Winters and cold periods are associated with outbreaks of frigid air traveling rapidly southeast from the Hudson Bay area. The ocean influence is particularly noticeable when the winds shift from southwest to southeast, causing a temperature drop of 5 to 15 degrees, depending on the season (NOAA, 1985).

3.6 TOPOGRAPHY, SURFACE WATER DRAINAGE, AND USE

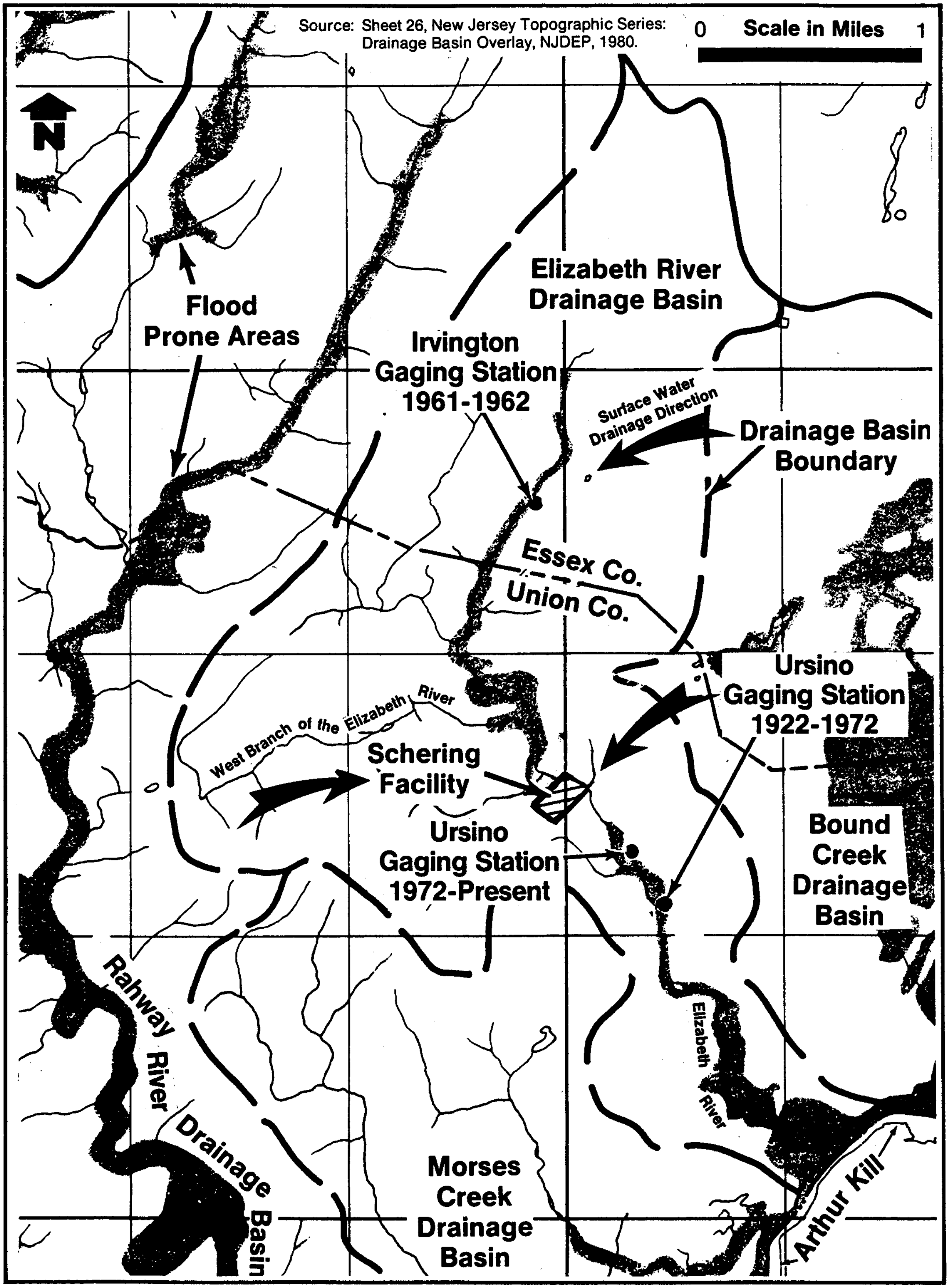
The study area lies within the Triassic Lowlands Region of the Piedmont Physiographic Province. Within the study area, topography consists of low hills, characteristic of the Pliestocene terminal and ground morraine deposits, which have been dissected by recent streams. The average land surface in the study areas rises from a low of about 30 feet above mean sea level to the southeast, near Elizabeth, to a high of about 100 feet above sea level, near Exit 140 on the Garden State Parkway.

The Elizabeth River drains an eastern part of Union County and a small section of Essex County near Irvington Township. The river originates in Irvington Township, Essex County, and flows generally in a south to southeast direction, draining into the Arthur Kill south of Elizabeth. The Elizabeth River, its tributaries and their topographic drainage divides are shown in Figure 3-2. The west branch of the Elizabeth River begins near Kenilworth Township, Union County, and flows in an easterly direction joining the Elizabeth River in the vicinity of the Hillside High School, as shown in Figure 3-2.

The meander pattern of the Elizabeth River may in part be controlled by the orientation of fractures in the underlying Brunswick Formation. In the Brunswick Formation, the primary joint set (or fracture) has a **strike of N45°E and a dip of approximately** 90° (Nemickas, 1976). These fractures are zones of weakness in the bedrock; hence, the river would tend to flow along these fractures since they are the path of least resistance. A bend in the river parallels the northeast border of the plant, as shown in Figure 3-2. The strike of this bend is N53°E. This strike is subparallel to the regional strike of the primary joint set (N45°E) in the Brunswick Formation. The unconsolidated deposits beneath the Elizabeth River are only about 10-feet thick adjacent to the Schering facility. This apparent fracture control of river flow is most noticeable along the Rahway River in Winfield, New Jersey in the southern section of the USGS Roselle Quadrangle (7.5 min. series).

On 6 August 1984, the average Elizabeth River flow computed from stream depth and velocity measurements at RS-1, a river-gaging point installed for the RI immediately upstream of Schering, was 6.8 million gpd or **10.5 cfs** (WESTON, 1984). This compares with a measurement on 6 August 1984 of 9.69 million gpd **(15.0 cfs)** at the Ursino gaging station, **about 1 mile downstream** of Schering. On 9 August 1984, the flow at Ursino had dropped to 7.75 million gpd (12.0 cfs). Due to higher evapotranspiration and lower rainfall (NOAA, 1985), August 1984 was a period of low flow in the Elizabeth River. The measurements in August compare with the annual average river flow at Ursino for 1984 of 16.9 million gpd or 26.1 cfs (Brauersfield et al, 1985). The drainage area for the Ursino gaging station is 16.9 square miles.

The drainage area upstream of the Schering facility has been estimated at 14.9 square miles by WESTON. For 6 August 1984, this yields a runoff (or drainage) rate of 0.46 million gpd per square mile upstream of Schering and 0.57 million gpd per square mile upstream of the Ursino gaging station.



Source: Sheet 26, New Jersey Topographic Series: Drainage Basin Overlay, NJDEP, 1980.

FIGURE 3-2 ELIZABETH RIVER DRAINAGE BASIN AND TOPOGRAPHIC DRAINAGE DIVIDES

Surface flow patterns in the study area are changing as a result of urbanization. The extreme values of peak and lowest stream flows are significantly influenced when land is converted from forest or agricultural use to a highly-developed metropolitan area because of the increase of impervious areas (e.g., roads and parking lots).

Land previously used for agriculture becomes 12 to 40 percent impervious with residential construction, and 40 to 100 percent impervious with industrial and commercial uses (Halasi-Kun, 1972). Urbanization also causes a thermal effect, which increases the potential for evaporation, thereby further reducing long-term surface flow. Consequently, development of the study area over the past 50 years has increased the quantity of stormwater runoff and decreased runoff duration, thereby intensifying flow extremes in the Elizabeth River.

The flood potential of the Schering site is shown in Figure 3-3. The stormwater drainage channel northeast of the site was constructed prior to 1940 as residential development in the area increased. As Figure 3-3 shows, the Schering facility is not normally subject to floods. The Elizabeth River, adjacent to and downstream of the Schering facility, is bordered on the east by the Elizabeth River Park. This land generally occupies the flood plain and is used for flood control and recreational activities (e.g., baseball and soccer fields). The NJDEP classifies the river as an FW2 (non-trout) water body. None of the surrounding municipalities (Union County, Union Township, Hillside Township, and the City of Elizabeth) sanction or organize any swimming or fishing activities along, or in, the river (personal communications, Sigmund, et al., 1985-86). There are no reported uses of the river for public water supply intakes (personal communications, Lynne Stout, 1985).

The Elizabethtown Water Company supplies Union and Hillside Townships with potable water, and the Elizabeth Joint Meeting Authority treats an average of 75 mgd of sewage for the same region (New Jersey Topographical Series, 1976).

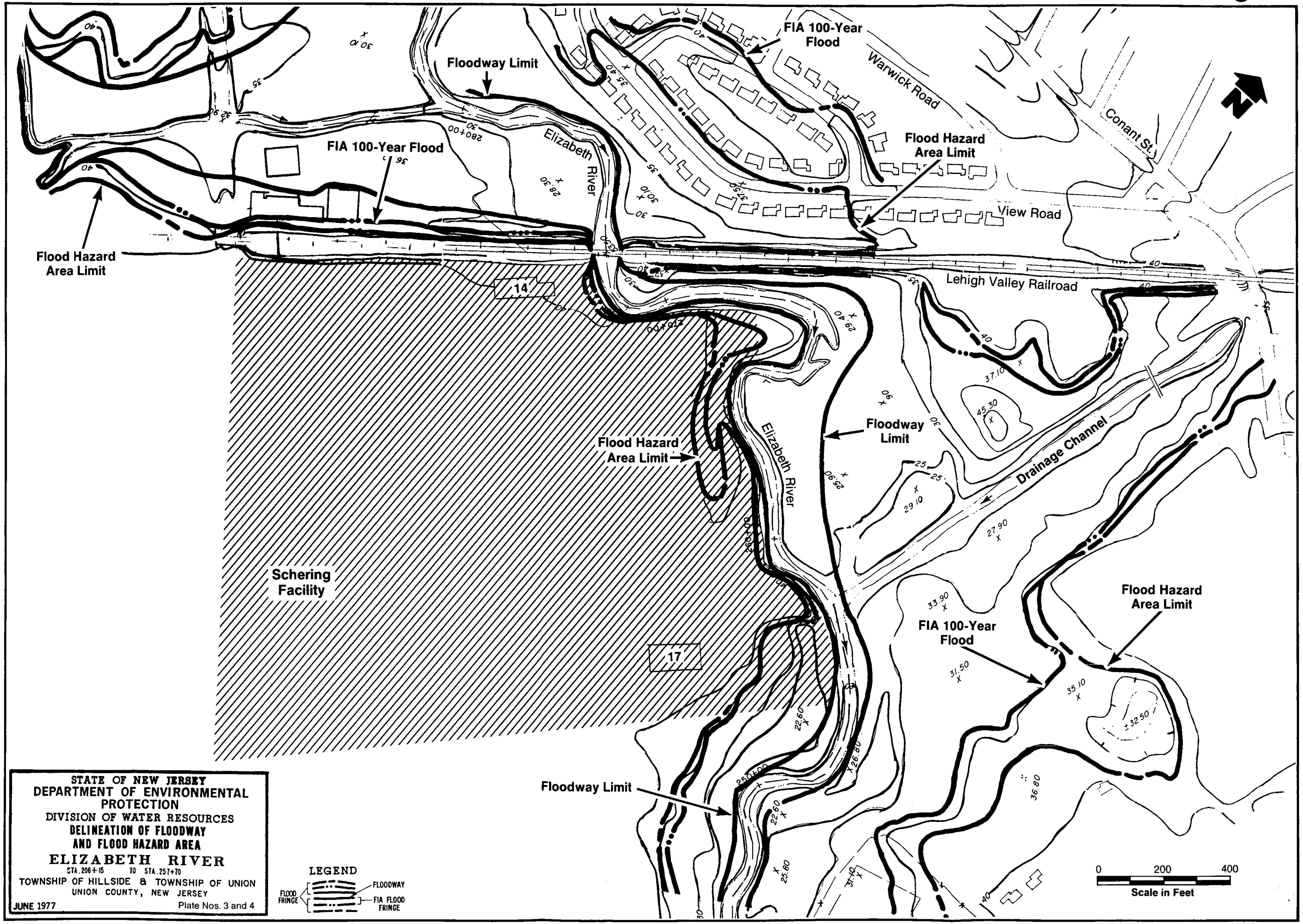


FIGURE 3-3 FLOOD POTENTIAL MAP

Warnico Park Lake, approximately one mile northeast of Schering, is occasionally used for fishing tournaments (Personal Communication, Bob Morgodonna, 1985). The NJDEP classifies the Elizabeth River as an FW2 water body. There are no reported uses of the river for public surface water intakes (Personal Communications, Lynne Stout, 1985).

The Elizabethtown Water Company supplies Union and Hillside Townships with potable water and the Elizabeth Joint Meeting treats an average of 75.0 mgd of sewage for the same region (New Jersey Topographical Series, 1976).

Section 4
Field Methods

SECTION 4

FIELD METHODS

4.1 OVERVIEW

This section details the various field techniques that were employed by WESTON to gather data regarding the geology, hydrogeology, and soil/groundwater chemistry of the Schering facility.

The geology of the site was defined by performing surface geophysical surveys and collecting geologic data during the installation of soil borings and monitoring wells. Monitoring wells and piezometers then provided data for both hydrogeology and groundwater quality. Soil samples were collected from borings and were used to provide data for the chemistry of soils in the unsaturated zone beneath the site. The results of these field efforts are discussed in Section 5 and the environmental conditions of the study area are presented in Section 6.

4.2 SURFACE GEOPHYSICAL SURVEYING

4.2.1 Objectives

WESTON conducted a surface geophysical investigation at the Schering facility in Union, New Jersey between 1 and 3 July 1985. Subsurface mapping using **Ground Penetrating Radar** (GPR) was completed in a grid fashion within the potentially-contaminated area shown in Figure 4-1. The instrumentation utilized by WESTON was a Geophysical Survey Systems, Inc. (GSSI) Model 4800 Ground Penetrating Radar System. GPR was employed to detect and define areas of **disturbed soils and/or buried materials**. The subsurface objects included pipes, drainlines, utility services, drum-like targets and other subsurface materials, which could be suspected sources of chemicals found in the soil and groundwater at the facility.

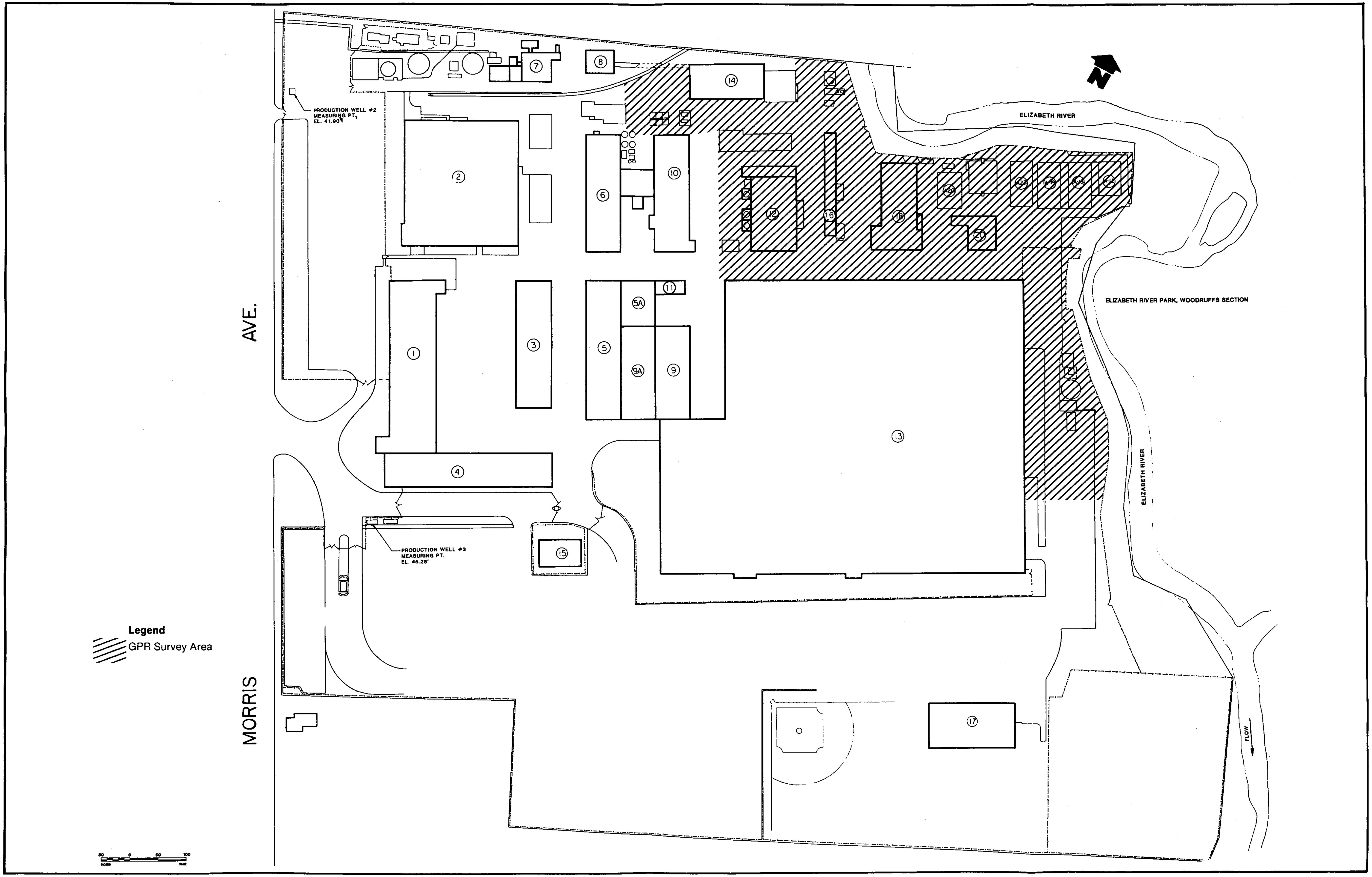


FIGURE 4-1 GROUND PENETRATING RADAR SURVEY AREA

4.2.2 Methodology

Prior to conducting the geophysical survey, a control grid was established over the study area at **25-foot intervals.** The function of the control grid was to serve as a ground surface reference for any subsurface anomalies detected by the GPR. After establishing the control grid, the GPR system was calibrated. To calibrate the system, either the dielectric constant (E_r) of the survey medium, or the depth to a potential object at the interface, must be known. Calibration of the system was accomplished at the site in two procedures incorporating both techniques. An initial theoretical time calibration was calculated, using a dielectric constant (E_r) of 1.8 nanoseconds per foot (ns/ft), based upon on-site soil and moisture characteristics (moist clay sands and silt). Two-way travel time versus depth was then calculated, using the following mathematical relationship:

$$TWT = E_r \times D$$

$$TWT = 1.8 \text{ ns/ft} \times 45 \text{ ft} = 81 \text{ ns}$$

where:

TWT = Two-way travel time in nanoseconds (ns)

E_r = Dielectric constant of the survey medium [1.8 nanoseconds per foot (ns/ft)]

D = Desired full-display depth of profile [45 feet (ft)]

The calibration profile shown on the left-hand side of Figure 4-2 was obtained by coupling a signal calibrator to the GPR unit. The signal calibrator enables the GPR operator to adjust the two-way travel time (TWT) of the radar signal to a calculated depth. Next, to verify the accuracy of the theoretical time calibration, a "real time" profile (right-hand side of Figure 4-2) was conducted by traversing an 18"-diameter cast iron pipe buried at a known depth of 7.2 feet. From the calibration procedure, a vertical depth scale of 1" to 7.0 ft was constructed.

After calibrating the GPR system, survey traverses were conducted over the site with the GPR antenna along each grid line, covering as much of the accessible area as possible. The product of the survey was a series of 105 real-time subsurface profiles. Samples of typical real-time radar profiles are included and discussed in Section 5. Profiles were standardized by "fixing" marks on the profile for a given traverse at 25-foot intervals and selected landmark references. The profiles were then analyzed and interpreted in WESTON's office.

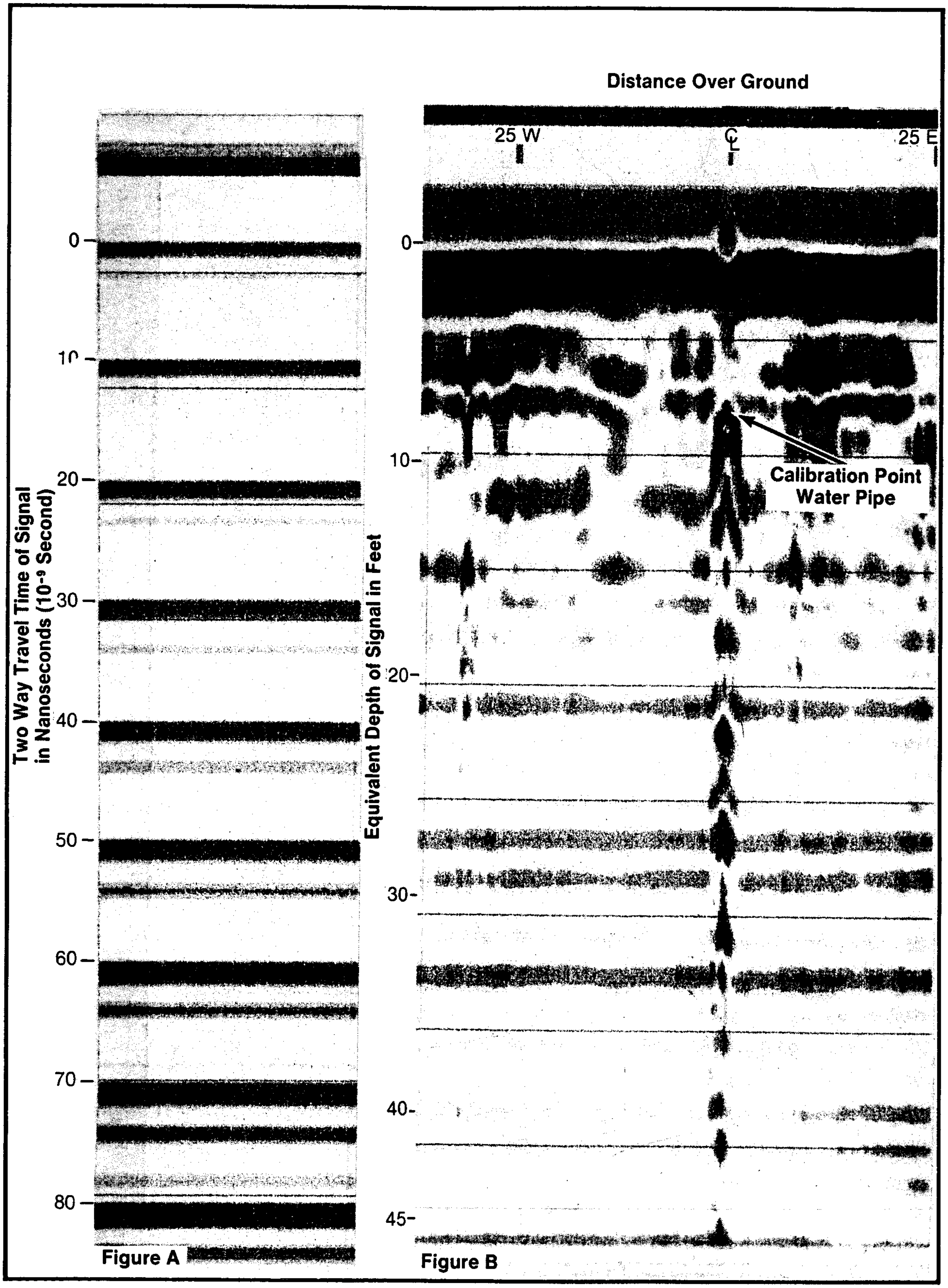


Figure A

Figure B

FIGURE 4-2 GPR CALIBRATION PROFILES

4.3 DRILLING PROGRAM

4.3.1 Introduction

The drilling program conducted during the RI at the Schering facility consisted of soil borings and the installation of monitoring wells and piezometers. A total of 65 soil borings were completed during May through August 1985. The soil borings were undertaken to evaluate areas of possible soil contamination and to provide data for locating future monitoring wells and piezometers. During the RI, a total of 14 monitoring wells were installed in the unconsolidated deposits from August through December 1985. (These were in addition to the 14 monitoring wells installed in 1984 during the Phase II work.) A total of 20 piezometers were also installed in the unconsolidated deposits. Together, these monitoring wells and piezometers provided hydrogeologic and groundwater-quality data. To provide similar data for the shallow-bedrock aquifer, seven monitoring wells were installed.

WESTON personnel involved with the field work were medically certified and fit tested for possible use of respiratory protection equipment. They were also trained in the use of personnel protective equipment and site safety procedures. Prior to all drilling activities, the borehole locations were cleared by Schering personnel for subsurface utilities and obstructions. Following this, a "work area" was secured to provide a defined area within which WESTON personnel could work and to ensure that unauthorized personnel would remain outside of the designated area. The complete health and safety plan is included in the "RI/FS Workplan" (WESTON, 1985).

4.3.2 Soil-Boring Program

The soil-boring and sampling program was conducted to define the nature and extent of possible soil contamination in four zones of the Schering facility. These zones were identified as Zones 1, 2, 3, and 4 in the "RI/FS Workplan" (WESTON, 1985). The locations of these zones are shown in Figure 1-4 of this report. In each of the zones, continuous soil samples were collected until the water table was reached. When the boring was continued to bedrock, after reaching the water table, soil samples were collected at 5-foot intervals. Soil samples were collected in accordance with ASTM Standard D1586-76. This standard specifies the use of a 27-inch split-spoon sampler with a hardened-steel drive shoe. The sampler was driven into the soil, with blows from a 130-pound hammer dropping 2 feet, until the spoon penetrated 24 inches into the soil or until 100 blows were applied. Geologic logs and blow counts were recorded by the WESTON field geologist. An OVA (Organic Vapor Analyzer) and an HNu (Photoionization Detector) were used to screen soil samples from the unsaturated zone. The screened samples provided qualitative indications of the concentrations of volatile organic compounds in the soil. The OVA/HNu and geologic logs from the soil borings are included in Appendix B.

Using data from soil samples collected in 1984 during Phase II, which established the general pattern of potential soil contamination, the initial borings for the RI were located far apart in relation to one another and the 1984 borings. The later RI borings were more closely spaced to better define the vertical and lateral extent of possible soil contamination.

The soil-boring programs in Zones 1 and 4 were conducted to determine the possible extent of organic priority pollutant contamination in the unsaturated soil. A total of 38 borings were completed in Zone 1 and their locations are shown in Plate 1. Thirty of these borings were completed to a total depth of approximately 12 feet, since sampling in these borings was limited to the unsaturated zone. These borings were completed between 30 May 1985 and 24 June 1985. The remaining 8 borings were completed to bedrock. Also shown in Plate 1 are the locations of 7 borings completed in Zone 4. These borings were completed between 30 May 1985 and 19 June 1985.

The focus of the soil-boring program in the former surface impoundment area, in the vicinity of Building 14, was to determine the extent and nature of possible soil contamination that may have resulted from waste disposal in the impoundments. To accomplish this, 17 borings were completed to bedrock. This area was designated as "Zone 2" in the "RI/FS Workplan" (WESTON, 1985); and, the locations of the borings are shown in Plate 1.

In the area designated as "Zone 3," a total of 3 borings were completed to establish the extent and nature of base/neutral compounds in the soil.

4.3.3 Monitoring-Well Installation

A total of 28 unconsolidated-deposit monitoring wells (MW's) were installed at the Schering facility. Fourteen of these monitoring wells (MW-1 through MW-13) were installed in 1984 as part of the Phase II Investigation (WESTON, 1984). For the RI, 14 additional monitoring wells (MW-14 through MW-27) were installed between August and December 1985. The locations of these monitoring wells are shown on Plate 2.

The monitoring wells installed during Phase II (1984) were located to provide both upgradient groundwater quality and potentially-contaminated area groundwater quality data. Using the groundwater quality data accumulated to date and the results of the soil-boring program for the RI, the following locations were selected for the additional monitoring wells installed to complete the RI:

- MW-14, MW-15, and MW-16 were situated near Building 7 to expand the investigation of the source of contaminants in the groundwater.
- MW-17 was located to provide upgradient water-quality data.
- MW-18, MW-19, and MW-25 were located near areas of soil contamination and on the facility perimeter to assess the potential for off-site migration of groundwater.
- MW-20, MW-21, MW-22, MW-26, and MW-27 were located in areas of soil contamination and suspected groundwater contamination to provide water-quality data.
- MW-23 and MW-24 were situated to provide additional data on groundwater quality in the vicinity of the former surface impoundments.

All monitoring wells and piezometers for the RI were installed by Empire Soil Investigations, Inc., a licensed New Jersey well driller. Following construction activity, well elevations were provided by B_2A Consultants, a licensed New Jersey surveyor. All wells and piezometers were constructed and surveyed according to NJDEP specifications, as discussed in the "RI/FS Workplan" (WESTON, 1985).

Each monitoring well was individually constructed, using hollow-stem augers, to screen the maximum interval possible in the saturated zone above the bedrock interface. The monitoring well was then constructed using 4-inch diameter Schedule 40 stainless steel casing and Johnson wire-wrapped, 0.010-inch slot well screen. The first four wells (MW-21, MW-22, MW-25 and MW-27) were constructed with the driller's-preferred Schedule 5 stainless steel casing. After a request from the NJDEP, a changeover was made to Schedule 40 stainless steel casing. Stainless steel was chosen as the casing and screen material because it is resistant to organic materials which may be present in groundwater. The screen extended from slightly above bedrock to at least 2 feet above the water table. Positioning the screen in this manner allowed for seasonal fluctuations in the height of the water table and ensured that the wells intercepted any floating fractions.

Construction details for a typical unconsolidated-deposit monitoring well are shown in Figure 4-3. The annular space around the screen was packed with No. 1 Morrie Gravel to 2 feet above the top of the screen. A 1-foot bentonite clay layer was emplaced atop the gravel to prevent vertical water infiltration and grout seepage during cementing. Cement grout, consisting of 3 to 5 pounds of bentonite per 100 pounds of Portland cement, was used to fill the remainder of the annulus at each well.

Ten wells required the use of flush-mounted security casings due to their locations in heavily-traveled areas of the facility. The flush-mounted wells were secured with water-tight locking caps. The areas around all of the flush-mounted wells were repaved with toed-in asphalt for durability and appearance, and graded to transport runoff away from the well. Five-foot lengths of 6-inch diameter steel casings with hinged, locking steel caps were installed over the remaining four wells. All protective casings for the monitoring wells were painted and marked with the appropriate well number and NJDEP permit number. Brightly-painted protective bumper guards, constructed of 5-foot sections of 4-inch diameter, concrete-filled steel pipe, were installed around wells MW-19, MW-20, and BW-1.

Plate 2 contains a summary of important construction elevation data for all 28 of the unconsolidated-deposit monitoring wells. Appendix C includes geologic and construction logs for unconsolidated-deposit monitoring wells installed during the RI.

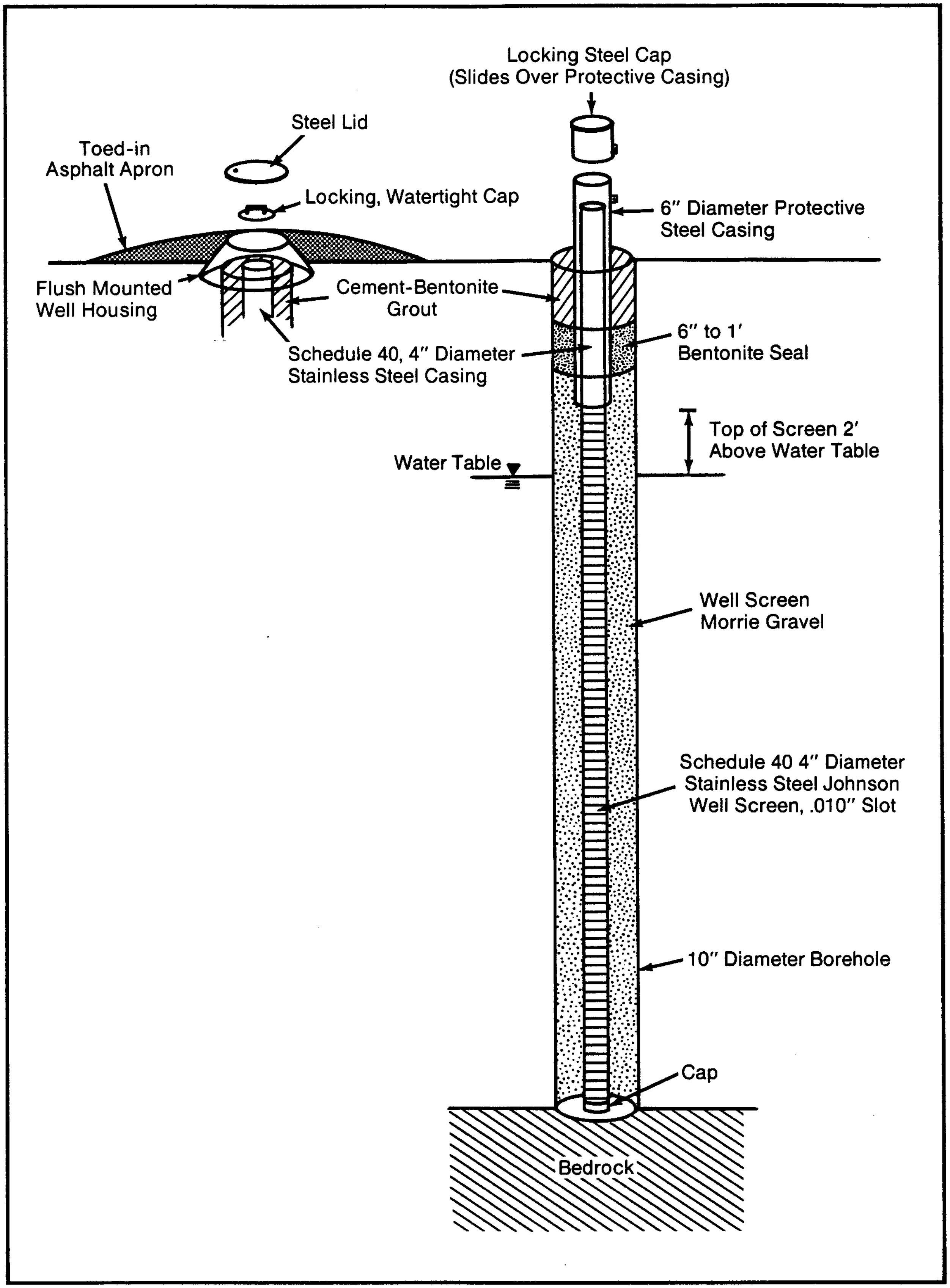


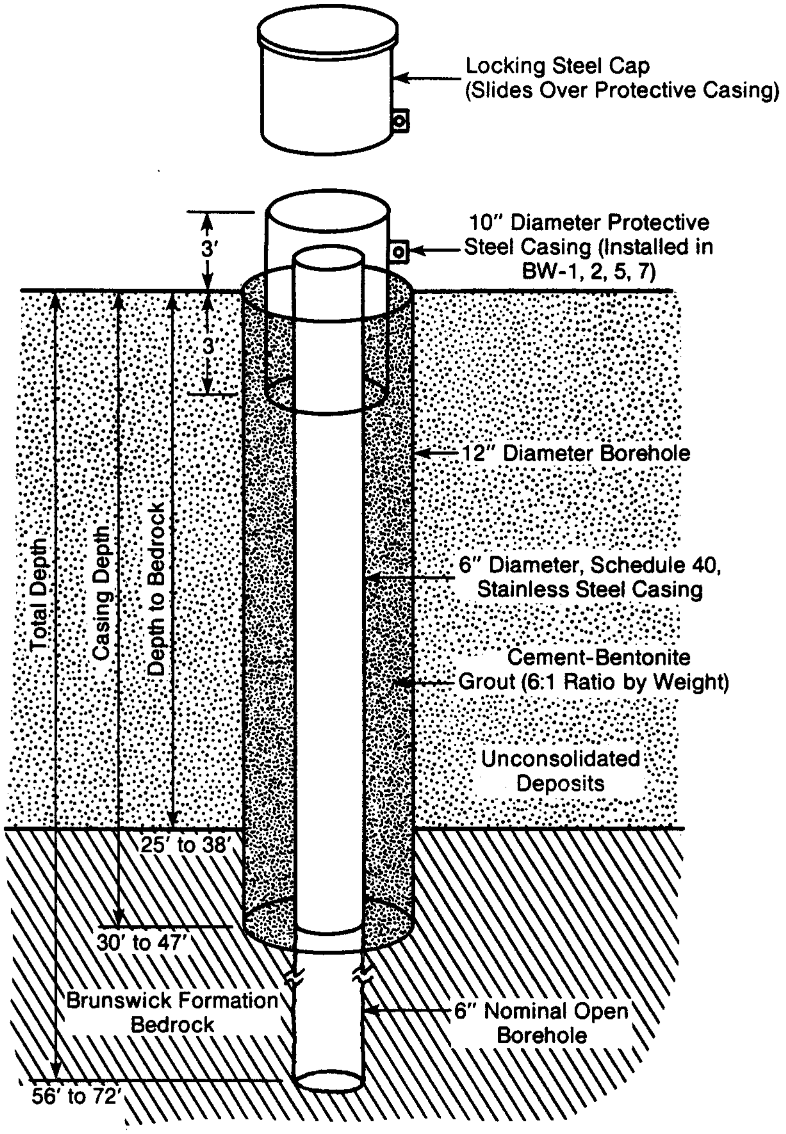
FIGURE 4-3 UNCONSOLIDATED-DEPOSIT MONITORING WELL CONSTRUCTION DETAILS (TYPICAL)

4.3.4 Shallow-Bedrock Monitoring Well Installation

The Brunswick Formation is the regional bedrock aquifer that underlies the Schering facility. The only water-quality and hydrogeologic data that were available for this formation in the vicinity of Schering were from analyses of water samples from Schering Production Wells 1, 2, and 3 (PW-1, PW-2, and PW-3, respectively), as shown in Plate 2. As part of the RI investigation, shallow-bedrock monitor wells were installed in August and September 1985 to determine the groundwater quality in the shallow-bedrock zone underlying the site. The shallow-bedrock monitoring wells installed during the RI were also used to evaluate the connective hydrogeologic relationships between the upper-bedrock zone and the overlying unconsolidated deposits, as well as the connective relationships between the Elizabeth River and the upper-bedrock zone. Plate 2 shows the locations of all seven shallow-bedrock monitoring wells installed during the RI. The rationale for locating these wells was:

- BW-1 was installed on the southwest corner of the facility to provide a nominal off-site well.
- BW-2 was located adjacent to abandoned Schering Production Well 1 to provide a sampling point of known integrity.
- BW-3 through BW-7 were installed in the areas of suspected groundwater contamination to assess the extent of the vertical movement of contaminants.
- Wells were arrayed in an approximate radial pattern to aid in collecting data during a pump test using Schering Production Well 3 (PW-3) as the pumping well.

The shallow-bedrock monitoring wells were installed using an air-rotary drilling rig. The wells were cased and pressure-grouted about 5 to 7 feet into competent bedrock to seal off the unconsolidated deposits and to prevent vertical migration of groundwater along the casing. An open borehole, approximately 25 feet deep, was then extended into the bedrock. The average total depth of these wells is approximately 65 feet below site grade level. Plate 2 contains a summary of construction data for these shallow-bedrock monitoring wells. Figure 4-4 shows the typical construction for shallow-bedrock monitoring wells. The geologic and construction logs for the shallow-bedrock monitoring wells are presented in Appendix D.



**Completion Detail For Flush Mounted
Bedrock Monitoring Wells BW-3, 4, 6**

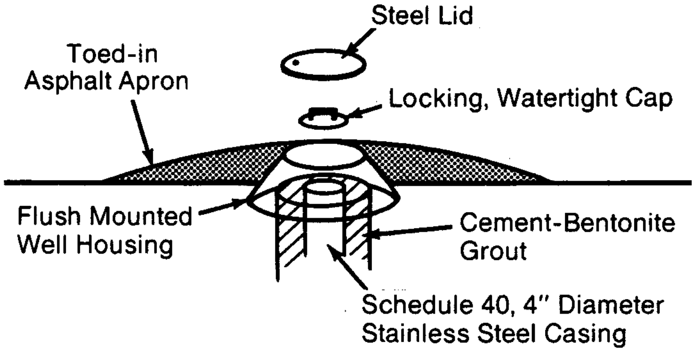


FIGURE 4-4 SHALLOW-BEDROCK MONITORING WELL CONSTRUCTION DETAILS (TYPICAL)

4.3.5 Piezometer Installation

Piezometers installed during the RI provided data to establish the hydraulic heads in specific regions of the unconsolidated deposits, thereby enabling analysis of the vertical groundwater flow. A total of 20 (10 pairs) piezometers were installed during the RI. Six pairs of piezometers were installed within the Schering facility during September to December 1985. Four pairs of piezometers were installed in January 1986 on the east bank of the Elizabeth River, adjacent to the Schering facility, in the Woodruffs Section of the Elizabeth River Park. The addition of these off-site piezometers assisted in determining the direction and rate of groundwater movement north and east, towards and beneath, the Elizabeth River from the plant site.

Piezometers were constructed in a manner similar to the monitoring wells. The essential difference was that the screened interval in the piezometer is short, typically 2 feet, as compared to an unconsolidated-deposit monitoring well in which the screen is on the order of 20 feet. Since the water level in the piezometer is a function of pressure in the aquifer, the short-screened interval ensures that the water level measured is representative of the pressure at a specific point in the aquifer.

Ten pairs of "upper" and "lower" 4-inch diameter piezometers, utilizing 2-foot screens, were installed. The same construction materials were used as those for monitoring well installations. The upper piezometer was screened just below the top of the seasonal low-water table elevation, most often 10 to 15 feet below the surface, based on historical data from nearby monitoring wells. The lower piezometer was screened 2 to 5 feet above the top of bedrock.

Figure 4-5 illustrates typical construction details used to install the piezometers. Figure 4-6 illustrates the methods used to prevent flooding of piezometers PE-1 through PE-8 installed in the flood plain region on the east bank of the Elizabeth River. Plate 2 contains a summary of the important construction elevation data and locations for the piezometers. Appendix E contains the geologic and construction logs for all piezometers installed during the RI.

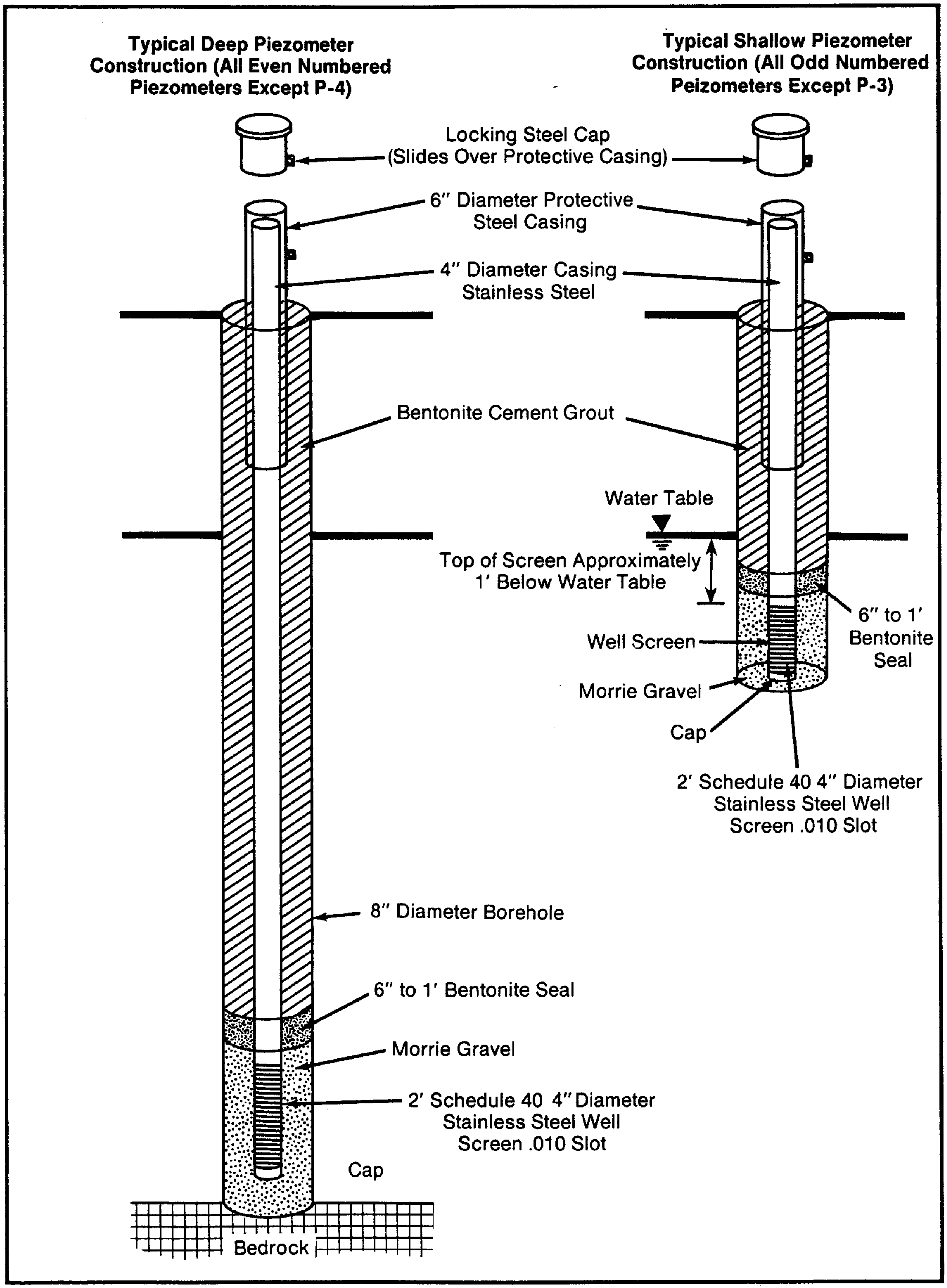
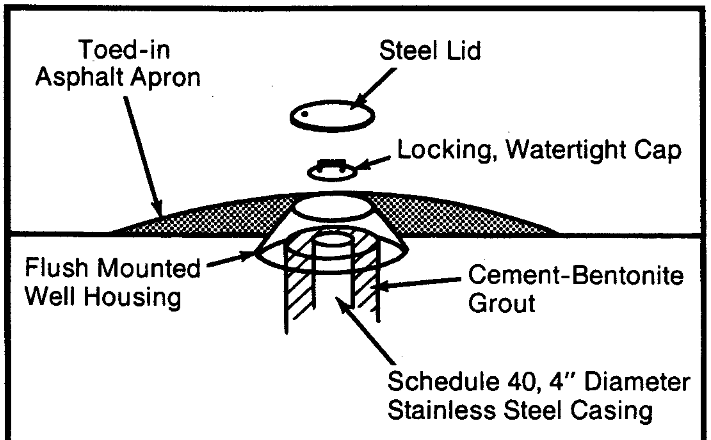
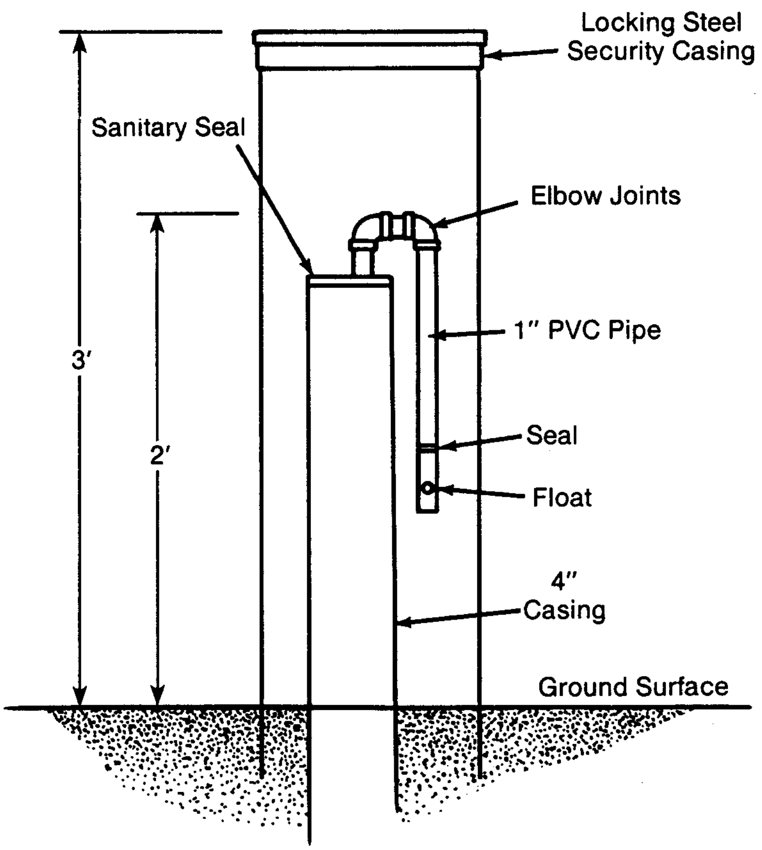


FIGURE 4-5 PIEZOMETER CONSTRUCTION DETAILS (TYPICAL)



Completion Detail for Flush Mounted Piezometers P-3 and P-4



Completion Detail for Flood-Proof, Above-Ground Piezometers PE-1 to PE-8

FIGURE 4-6 CONSTRUCTION DETAIL FOR SECURITY CASING USED ON PIEZOMETERS

4.3.6 Well Development

Each of the 41 monitoring wells and piezometers installed for the RI were developed after installation. Proper development ensured that any "filter cake" and fine-grained sediments were removed from the well, such that groundwater entered the well freely during sampling operations.

Wells were developed using a centrifugal pump and surge block to ensure optimal yield and sediment-free water. Each well was surged and then pumped to remove sediments drawn into the well. Water was added to the well and the process was repeated until the well produced water freely. For wells in which drilling muds were added, development was monitored using a specific conductivity meter. As the filter cake degraded, and as the well produced clearer water, the specific conductivity of the pumped water decreased over time until average aquifer conductivities were achieved. This was verified for all wells monitored, indicating that all developments were successful.

4.3.7 Rig and Equipment Decontamination

To minimize the opportunity for drilling-induced contamination or cross-contamination between wells, careful decontamination procedures were established and followed for all phases of drilling, sampling, and well construction. Rig decontamination was accomplished in one of Schering's designated spill-control areas (adjacent to Building 12). A decontamination procedure, using a spray gun with high-pressure steam and hot water, was applied. The resultant mixture of high-temperature, high-pressure water effectively removed all dirt, oils, and volatile compounds from equipment used for soil borings and well installations.

The drill rig, flatbed, tower and terminal equipment were thoroughly steam-cleaned by the driller prior to the initiation of drilling. All augers, drill rods, storage compartments, tools, and equipment that might have contained driller-borne contaminants were similarly cleaned. Once on-site, the rig was steam-cleaned in the spill-control area to remove any dirt or oil picked up on the highway. Following the drilling of each pilot hole or well, steam-cleaning was repeated for the drill rig and all equipment. This included rinsing the portable mud pan and mud pump with hot water.

Split-spoon equipment used in sample collection was subjected to the following decontamination protocol:

- All split-spoon components were disassembled at the end of use.
- The split-spoon components were rinsed in an Alconox solution.
- A deionized water rinse was applied.
- An acetone (nanograde) rinse was applied.
- A hexane rinse was applied.
- Deionized water rinse was applied.
- Split-spoon components were air dried.
- The split spoon was reassembled for next use.

Split spoons were decontaminated after each use and placed on a clean plastic surface after decontamination.

4.3.8 Disposal of Drilling Cuttings

The drilling cuttings produced at each unconsolidated-deposit monitoring well and each piezometer consisted of sediments. These cuttings were stored in DOT (17E/17H) 55-gallon steel drums labeled with the respective well number. The drums were stored on-site pending the results of the soil analyses from each borehole. Composite samples from these drums were collected and analyzed for petroleum hydrocarbons, ignitability, cyanide and sulfide reactivity, and EP toxicity. The results of these analyses (Appendix P) were presented to the NJDEP Division of Waste Management in a letter from Schering dated 21 January 1986. In the opinion of NJDEP, the wastes, as represented by the samples, were classified as industrial wastes (I.D. #27). A copy of the Department's letter is included in Appendix F. Accordingly, Schering disposed of these cuttings in a Class II solid-waste disposal facility.

During the installation of the shallow-bedrock monitoring wells, bentonite drilling mud was used sparingly and only during drilling in the unconsolidated deposits. During drilling in the bedrock, only air and water were used. All fluids were collected in a 900-gallon stainless-steel tank wagon and were disposed of in the Schering industrial sewer settling basin. The liquid was drained slowly from the tank to allow proper handling in the basin and sewer system.

Cuttings generated during installation of the piezometers on the east side of the Elizabeth River were spread in the area near the piezometer. A hollow-stem auger was used; therefore, no drilling mud was produced.

4.3.9 Elevation Surveying

Following installation and complete development of all wells and piezometers, the horizontal location and mean sea-level elevation of each well and piezometer was determined by a New Jersey-licensed professional surveyor, B_2A Consultants. Schering Production Wells 2 and 3, Hillside Monitor Well No. 4, and three river-stage gauging points were also surveyed. The well coordinates were located by field measurement with respect to 2 permanent U.S. Geodetic Survey Monuments located outside of the Schering facility. All surveyed positions and elevations were certified accurate to ±0.01 foot to comply with NJDEP regulations.

To facilitate the re-establishment of location or elevation data, or to locate new wells, 2 permanent copperweld survey monuments were installed in the Schering plant. The locations of these monuments and the surveyed elevations of all monitoring points installed during Phase II and the RI are shown in Plate 2.

4.4 SAMPLING AND CHEMICAL ANALYSIS PROGRAM

4.4.1 Introduction

The purpose of the sampling and chemical analysis program was to identify the nature and extent of any hazardous substances present in: the soils in the unconsolidated deposits, the adjacent Elizabeth River, the groundwater in the unconsolidated deposits, and the shallow-bedrock groundwater underlying the Schering facility. A sampling and analyses plan is fully described in the "RI/FS Workplan" (WESTON, 1985). The sampling program was accomplished by:

- Taking soil samples from the unsaturated zone to test for possible contamination in the unconsolidated deposits. (This was accomplished while drilling monitoring wells and conducting soil borings.)
- Taking water samples from the Elizabeth River to test for possible surface-water contamination.
- Taking water samples from unconsolidated-deposit monitoring wells and piezometers to test for possible contamination of groundwater.

- Taking water samples from the shallow-bedrock monitoring wells to test for possible contamination of the groundwater.
- Taking water samples from the production wells to test for possible contamination of the deep bedrock.

Pursuant to the Administrative Consent Order between Schering and NJDEP, water and soil samples were analyzed by IT Corporation (formerly Princeton Aqua Science, PAS), a New Jersey laboratory certified for gas chromatography in water pollution analyses. Soil samples were collected and analyzed according to methods described in U.S. EPA's "Test Methods for the Evaluation of Solid Waste, SW-846." Water samples were collected from each of the monitoring wells and piezometers in accordance with sampling procedures given in N.J.A.C. 7:14A-6.12 and were analyzed according to methods described in U.S. EPA's "Guidelines Establishing Test Procedures for the Analysis of Pollutants," 40 CFR Part 136.

4.4.2 Soil-Sampling Program

Soil sampling was conducted in each of the four zones of the Schering facility that were defined in the "RI/FS Workplan" (WESTON, 1985). The locations of these soil borings are shown in Plate 1. Soil samples were collected using a 27-inch split spoon.

The assembled split spoon was driven into the ground ahead of the auger to ensure an undisturbed sample. Upon removal, the spoon was placed on a clean work surface and opened. The cylinder of soil was quickly split open with a knife and was tested for the presence of volatile organic compounds using HNu and OVA meters. The HNu photoionization detector (PID) and OVA flame ionization detector (FID) are capable of detecting a wide spectrum of volatile organic compounds. Fluctuations on the meters, indicating the presence of volatile compounds in the soil, were recorded by the WESTON geologist. The HNu meter was also used periodically to sweep the work area and borehole for airborne volatiles. The HNu and OVA data assisted in determining which soil samples were to be analyzed. For each well, at least one sample was collected for analysis. The remainder of the samples were placed in standard half-pint sample jars, and were retained for future reference. Detailed sample-collection protocols are included in Appendix G.

As each soil sample was collected, a WESTON geologist inspected the sample and identified the Burmeister primary and secondary soil constituents, the field permeability, the approximate moisture content, and the recovery (length in inches) of the soil sample. The information was recorded in the drilling logs, and is presented in Appendix B. Also recorded in the logs were the sample color (Munsell soil index), the sample number, the blow-counts of the split spoon per each 6 inches of penetration, the depth to first and subsequent water encountered and the HNu and OVA detector readings.

Soil samples were analyzed for the parameters shown in Table 4-1. This table also shows the distributions of and types of samples from each of the four zones of potential environmental concern for the RI/FS.

Shelby tube samples were collected from soil borings for MW-22, MW-23, MW-27, P-2, P-6, P-10, and P-14 at the Schering facility. The Shelby tubes were used to obtain an undisturbed soil sample for physical analysis. The exact locations for these samples were chosen after the soil-sample field screening data were analyzed. The Shelby tube samples were subjected to U.S. Army Corps of Engineers Falling Head Permeability Testing Method (EM-1110-2-1906) to determine vertical permeability. The results of these analyses are discussed in Section 5 of this report.

4.4.3 Surface-Water Sampling

The only surface water body which could be impacted by the Schering facility is the Elizabeth River. The effect on water quality of the Elizabeth River, from groundwater discharges from beneath the facility, was monitored by collecting river water samples from upstream and downstream of the facility. The river sampling points, RS-1 and RS-3, are shown in Plate 2. The samples were analyzed for the parameters shown in Table 4-2.

The sampling procedure involved wading to the middle of the river and collecting the sample upstream of the collector. The sample container was held at a point halfway between the surface and the river bottom. The container was opened, filled, and then resealed before being brought to the surface. During Phase II, samples were collected in July and August 1984. During the RI, river water samples were collected in March, August, November 1985, and February 1986. These activities are summarized in Table 4-3 and results of the sampling program are discussed in Sections 5 and 6 of this report.

Table 4-1

Soil Sample Analytical Parameters
(EPA Method Number)

Parameters	Zone 1	Zone 2	Zone 3	Zone 4
Priority Pollutant Volatile Organic Compounds (Methods 8010/8020 and 8240) including xylenes	X	X		X
Priority Pollutant Base Neutral Compounds (Method 8270)	X	X	X	
Total Recoverable Petroleum Hydrocarbon (Method 418.1)	X	X	X	X
Total Organic Carbon	X	X	X	X
Priority Pollutant Metals (Method 6010 or 7000 series)	X	X		X
Cyanide (Method 9010)	X	X		
Sulfide (Method 9030)	X	X		
Carbon Exchange Capacity (Method 9080/9081)	X	X		

Source: RI/FS Workplan (WESTON, 1985).

Table 4-2

1985 RI/FS Water Analysis Plan
List 1 Parameters[1]
(EPA Method Number)

Priority Pollutant Volatile Organic Compounds (Method 624)

Priority Pollutant Acid Extractable/Base Neutral Compounds (Method 625)

Total Recoverable Petroleum Hydrocarbon (Method 418.1)

Priority Pollutant and Safe Drinking Water Act Metals (soluble, Method 200.7)

Total Organic Carbon (Method 415.2)

Total Dissolved Solids (Method 160.1)

Acidity and Alkalinity (Method 305.2 and 310.1)

Nitrate, Nitrite and Ammonia (Method 352,354, and 350)

Phenolics (Method 420.1)

Sulfide (Method 376)

Total Kjeldahl Nitrogen (Method 351)

pH (field measurement)[2]

Specific Conductance (field measurement)[2]

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[1] This list includes all parameters analyzed in groundwater and surface water samples. Not all samples were analyzed for all parameters ("RI/FS Workplan," WESTON, 1985).

[2] WESTON field personnel measured each sample three times within approximately 1 hour of sample collection.

Table 4-3

Completed and Tentatively-Planned Water Sampling Activities (as of June 1986)

Sampling Event	Sample Points*	Dates	Project Phase
1.	Schering Production Wells 1, 2, and 3 (PW-1, PW-2, PW-3)	February/March 1984	Phase I
2.	MW-1 to MW-13** (installed 1984) RS-1 and RS-3	July 1984	Phase II
3.	MW-1 to MW-13 RS-1 and RS-3	August 1984	Phase II
4.	MW-1 to MW-13 PW-2 and PW-3 RS-1 and RS-3	March/April 1985	Phase II
5.	MW-1 to MW-13 BW-1 to BW-7 (installed 1985, first time sampled) PW-2 and PW-3 Hillside No. 4 (first off-site well sampled) RS-1 and RS-3	August/September 1985	RI/FS
6.	MW-1 to MW-13 MW-14 to MW-27 BW-1 to BW-7 PW-2 and PW-3 Hillside No. 4 RS-1 and RS-3 P-1 to P-14*** (installed 1985, first time sampled)	November 1985	RI/FS
7.	MW-1 to MW-13 MW-14 to MW-27 BW-1 to BW-7 PW-2 and PW-3 Hillside No. 4 RS-1 and RS-3 P-1 to P-14, PE-1 to PE-8 (installed 1986, first time sampled)	February 1986	RI/FS

Table 4-3
(continued)

Sampling Event	Sample Points*	Dates	Project Phase
8	PE-1 to PE-8	March 1986	RI/FS
9.	Exact sampling locations and analytical parameters to be determined.	June 1986 (tentative)	RI/FS
10.	Same as 9.	August 1986 (tentative)	RI/FS
11.	Same as 9.	November 1986 (tentative)	RI/FS
12.	Same as 9.	February 1987 (tentative)	RI/FS

*Legend:

MW = Unconsolidated-deposit monitoring wells (total: 28)
BW = Shallow-bedrock monitoring wells (total: 7)
PW = Schering production wells (total: 2 active)
P = Piezometers installed on the Schering facility (total: 12)
PE = Piezometers installed on the east bank of the Elizabeth River to the east of Schering (total: 8)
RS = River sampling locations (total: 2)

** Fourteen monitoring wells were installed in 1984. Numbering sequence only goes up to 13 because there is an MW-6S (shallow) and MW-6D (deep).

***P-11 and P-12 are omitted from numbering sequence.

4.4.4 Groundwater Sampling

Groundwater samples were collected and analyzed to determine water quality in the unconsolidated deposits, shallow-bedrock aquifer and the underlying Brunswick Formation. The groundwater and surface water sampling points are shown in Plate 2. Table 4-3 summarizes the completed and planned groundwater sampling activities at the Schering facility. Samples have been analyzed for the parameters listed in Table 4-2. The results of groundwater sampling are discussed in Sections 5 and 6 of this report.

Groundwater sampling activities have been conducted on a quarterly basis since July 1984, beginning with the Phase II program, under the control of an approved Sampling and Analysis Plan. This plan ensured that the field efforts and laboratory programs were properly coordinated and executed. A copy of the Sampling and Analysis Plan for the February 1986 sampling activities is included in Appendix H. Also included in Appendix H is a description of the techniques used to collect groundwater samples from monitoring wells and piezometers.

Sampling procedures for Schering Production Wells 2 and 3 complied with the guidelines in the "Handbook for Sampling and Sample Preservation of Water and Wastewater," EPA-600/4-82-029.

4.4.5 Air Sampling

There are no currently-exposed waste sources at the Schering facility that contribute to contamination of the atmosphere. Consequently, WESTON's air-sampling program was conducted during all soil-boring and well-installation activities to monitor ambient air quality in the vicinity of the drilling rig. These drilling locations are shown in Plate 1 (soil borings) and Plate 2 (monitoring wells and piezometers).

Air was monitored for total hydrocarbons, using an HNu photoionization detector and a Century OVA-88 flame ionization detector. A background reading of 6 ppm of total hydrocarbons was routinely recorded adjacent to the WESTON trailer on-site and in Schering's parking lots. Similarly, background readings were taken at each drilling site before drilling operations began. In general, background concentrations at the borehole locations ranged from 6 to 8 ppm. During drilling operations, readings never rose more than 5 ppm above background in the "breathing" zone in the work area. Occasionally, whenever the levels approached 5 ppm above the background concentration, area personnel used respirators while working closely with drilling equipment, sample collection, decontamination, etc. The results of air monitoring are discussed in Section 5 of this report.

4.5 HYDROGEOLOGIC DATA COLLECTION AND ANALYSIS

4.5.1 Introduction

Three methods were used to collect hydrogeologic data for the unconsolidated deposits, the shallow bedrock, and the Brunswick Formation near the Schering facility. A pump test was conducted in October 1985 to evaluate the effects of pumping Schering Production Well 3 on groundwater flows in the unconsolidated deposits and shallow bedrock. Slug and bailer tests were performed on the unconsolidated-deposit monitoring wells and piezometers to evaluate the hydraulic conductivities in individual wells.

4.5.2 Pumping Test

A pump test was conducted at the Schering facility to assess the impacts of pumping from Schering Production Well 3 (PW-3) on groundwater flows in the unconsolidated deposits, in the shallow-bedrock zone, and in the deep bedrock zone (Brunswick Formation). Production Well 3 was chosen as the pumping well because it is capable of producing about 400 gpm, whereas PW-2 pumps about 250 gpm. Schering PW-2 is 676 feet deep and Hillside No. 4 is 400 feet deep, while PW-3 is 635 deep. All three wells are completed to depth with open boreholes in the bedrock of the Brunswick Formation.

The impacts of pumping PW-3 for the deep bedrock (Brunswick Formation) aquifer were observed in PW-2, PW-3, and Hillside No. 4 by monitoring water levels with time. To monitor the pumping effects in the shallow-bedrock zone, the seven shallow-bedrock monitoring wells were used. Observations were also made in unconsolidated-deposit monitoring wells and piezometers to assess the influence of PW-3 on water levels in the unconsolidated deposits. Table 4-4 summarizes the locations, dimensions, and use information for the pumping well and the observation wells used during the pump test. Figure 4-7 summarizes the relationships between PW-3 and the observation wells. Plate 2 shows the locations of PW-3 and the observation wells.

The pump test was divided into three phases: 1) background (pre-shutdown) monitoring; 2) recovery (shut-down) phase; and 3) draw-down phase. Background monitoring began on 30 September 1985 and concluded on 18 October 1985. During this phase, an In-Situ SE-200 Hydrologic Data System was used to monitor water levels in BW-3, MW-10, P-3, and P-4. The recovery phase began on 18 October 1985 at 8:30 p.m. At that time, PW-3 was shut down. (PW-2 had been shut down at noon on 18 October.) The

Table 4-4

Construction Data Summary for Pump Test Wells

Location	Depth to Bedrock (ft)	Casing Depth (ft)	Use	Well Depth (ft)	Well Diameter (in.)	Distance from PW-3 (ft)
PW-2	27	80	Observation	676	10	770
PW-3	23	50	Pumping	635	10	0
Hillside No. 4	21	21	Observation	400	12	1,520
BW-1	25	30	Observation	68	6	300
BW-2	25	31	Observation	56	6	780
BW-3	32	38	Observation	62	6	720
BW-4	30	35	Observation	60	6	1,065
BW-5	34	39	Observation	64	6	1,250
BW-6	38	47	Observation	72	6	1,380
BW-7	35	40	Observation	64	6	1,250
MW-10	30.5	5.5	Observation	30.5	4	700
P-3	NA[1]	12	Observation	14	4	710
P-4	28	25	Observation	27	4	695

[1] Not Applicable.

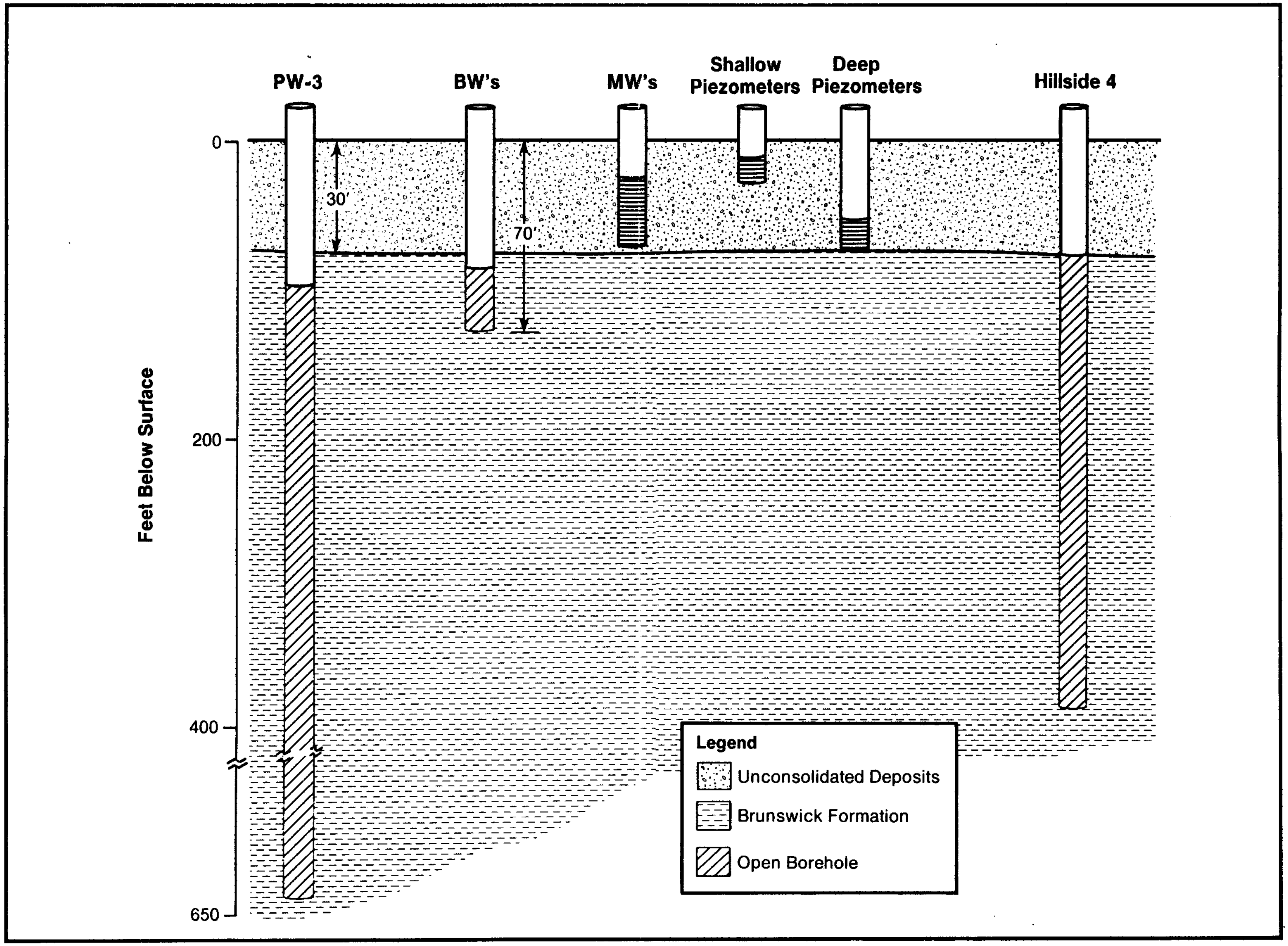


FIGURE 4-7 SCHEMATIC ILLUSTRATION OF PUMPING WELL AND OBSERVATION WELL RELATIONSHIPS

SE-200 began recording water levels on a logarithmic time scale. In addition, Leupold and Stevens Type F water level recorders were installed on Hillside No. 4, BW-2, BW-6, BW-1, and BW-4 to gather data during the recovery and the draw-down phases of the test. The recovery phase was 2,564 minutes and ended at 3:15 p.m. on 20 October 1985. Then, as PW-3 was switched on, the draw-down phase began. This phase was 6,975 minutes and ended on 25 October 1985 at 11:30 a.m.

Appendix J includes data for the pump test. The results are discussed in Sections 5 and 6 of this report.

4.5.3 Slug and Bailer Tests

In December 1985, slug and bail-down recovery tests were performed on monitor wells MW-5, -17, -21, -23, -25, -26, -27, and piezometer P-3. An In-Situ Corporation SE-1000 transducer network was used to record water levels versus time in a logarithmic manner. The slug was a capped section of weighted, 3-inch diameter pipe, which was lowered into the well to displace water. When the water in the well had recovered to the original level, the test was completed. To perform the bailer recovery test, the slug was removed, thus instantaneously lowering the water level in the well. The test was completed when water had recovered to the original level.

In February 1986, slug and bailer tests were performed on the piezometers on the east side of the river. However, a test was not performed on PE-5, since its recovery period of approximately 24 hours would have required equipment to be left unattended overnight in the Elizabeth River Park.

Test data are included in Appendix I. The results of the slug and bailer tests are discussed in Sections 5 and 6 of this report.

4.6 LABORATORY QUALITY ASSURANCE/QUALITY CONTROL PROGRAM

4.6.1 Introduction

The goal of the Laboratory Quality Assurance/Quality Control (QA/QC) Program was to ensure that the analytical laboratory generated reliable, high quality, defensible data. The key to achieving this goal was the Sampling and Analysis Plan (SAP). This plan enabled the field sampling personnel and laboratory analysts to coordinate activities, resolve problems, and complete their assigned work in an expeditious manner. A copy of the SAP for the water sampling program conducted during February 1986 is included in Appendix H. A similar plan was implemented during the soil sampling program based on the procedures discussed in the "RI/FS Workplan" (WESTON, 1985).

4.6.2 Field Groundwater Sampling Quality Assurance/Quality Control Program

The field QA/QC program conducted by the sampling crew was designed to ensure that physical characteristics of sampled locations were accurate, that samples were collected and recorded in accordance with approved procedures, and that laboratory analyses were properly requested for each specific sample.

In order to execute the field QA/QC program, two standard forms were used. The Field Sampling Sheet (FSS), shown in Appendix H, assured that relevant physical data regarding the sampling locations were collected. This information was then incorporated into a data base such that the specific sampling procedure used at each well could be repeated. Reproducing the approved sampling procedure assisted in minimizing potential sources of errors in analytical results.

The second standard form used by the field sampling crew was the Data Analysis Sheet (DAS), an example of which is included in Appendix H. This form accompanied each sample to the laboratory and listed the required parameters for analyses. The analytical data report received from the laboratory was then compared to the DAS to verify that all requested analyses were completed.

Strict adherence to chain-of-custody procedures was maintained by field and laboratory personnel during all phases of sample collection, transport, receipt, and analysis.

The overall sampling program was conducted under a strict schedule agreed to in advance between the field sampling crew and the laboratory. The February 1986 sampling/analytical schedule is included in Appendix H. This schedule specified when each location was sampled, when samples were delivered to the laboratory, and the list of analyses to be performed. Any changes in the schedule caused by field conditions and/or laboratory circumstances were discussed and resolved as soon as possible between the sampling and laboratory personnel. The schedule also grouped samples into lots to facilitate laboratory analyses and the QA/QC Program. The analytical results and QA/QC data for each sample lot were presented in separately-bound volumes in order to expedite review of the laboratory results and supporting documentation. Within 30 days after delivery of a sample lot to the laboratory, the volumes (analytical results and QA/QC data) were returned to WESTON for final review.

4.6.3 Results of the Laboratory QA/QC Program for Groundwater Sampling

During February and March 1986, a total of 11 lots of samples were analyzed. The eleven volumes, including analytical reports and QA/QC results for each lot, are included with this RI Report. The purpose of this subsection is to compare the actual February - March 1986 groundwater sampling and analysis program to the Sampling and Analysis Plan and contract for laboratory services. The analytical results from the field samples and quality control samples received from the laboratory, as specified in the SAP, are the basis of this evaluation.

The use of a detailed Sampling and Analysis Plan (SAP) facilitated communications among sampling program management, field crews, and the analytical laboratory. The result was the generation of reliable, acceptable, and defensible analytical data. All previously-established schedules were met by the sampling team and the laboratory with very few minor exceptions. The following conclusions resulted from these coordinated efforts:

- VOA results were excellent.
  - Few, if any, false-positive or false-negative identifications were made.
  - Accurate quantification was obtained.

  - 16 non-priority pollutant volatile organic compounds were also tentatively identified.
  - Accurate and precise quality control information was obtained.

- The base/neutral results were good.
  - A number of tentatively-identified, non-priority pollutant compounds and unknowns were observed.
  - There was a high level of confidence for the identification of the priority pollutants found.
  - There was a high level of confidence that the methodology yielded representative information for groundwater samples.

- The acid extractable results were good.
  - The results indicated that there were non-priority pollutants present in the groundwater.
  - The quality control information indicated that Method 625 may not have been the best methodology for this particular analyte-matrix combination.

- The inorganic results were excellent.
  - The concentrations of inorganic parameters found were reasonable for most sampling locations.
  - Quality control information obtained was acceptable.

- Field blanks showed a consistent, low concentration (<20 ppb) of chloroform which was believed to be the result of chlorination of city water prior to entering Schering's deionized water system. Water from the deionizer was used to clean sampling equipment and to prepare field blanks. Overall, field blanks and trip blanks have shown that decontamination and sample-handling procedures prevented cross-contamination of samples.

- Tetrahydrofuran, tentatively identified in samples from PE-3, PE-4, and PE-7, was probably the result of glue used in the construction of a special PVC fitting on the well cap which was designed to prevent flooding of the piezometers.

There were three meetings held at the IT Laboratory in Edison, New Jersey during the February - March 1986 sampling program attended by representatives from Schering, WESTON, and IT. Actual as well as potential concerns were identified, solutions were developed, and agreements were made expeditiously. These meetings proved to be extremely productive. As a result of this timely communication, selective corrective actions were made to the original SAP and implemented in a coordinated manner.

4.6.4 Results of the Laboratory QA/QC Program for Soil Sampling

The soil-sampling field program was conducted in accordance with the procedures and QA/QC program detailed in the "RI/FS Workplan" (WESTON, 1985). Analytical results produced assisted in defining occurrence of VOC's, base/neutral, and acid extractable priority pollutants in the unconsolidated sediments. The data generated were of excellent quality and were supported by thorough QA/QC documentation.

5. Geophysical and
Hydrogeologic Findings

Section 5
Geophysical and Hydrogeologic Findings

SECTION 5

GEOPHYSICAL AND HYDROGEOLOGIC FINDINGS

5.1 OVERVIEW

A variety of investigations were undertaken at the Schering facility in Union to determine the geologic and hydrogeologic conditions at the site. Findings of the various investigations are summarized below:

- A ground penetrating radar survey of the northern sector of the facility identified the area where the former surface impoundments had been prior to construction of Building 14.
- The geologic investigation determined that a large portion of the plant in the area east of Building 7 and Building 13 has been filled to a depth of as much as 10 feet during development of the site. This fill is underlain by glacial till which, in turn, is underlain by the bedrock Brunswick Formation.
- The hydrogeologic investigation has determined that groundwater flow in the unconsolidated deposits on both sides of the Elizabeth River is towards the Elizabeth River. Groundwater flow velocities are in the range of 120 to 470 feet per year.
- The groundwater modeling effort has shown that flow in the unconsolidated deposits and the Brunswick Formation in the vicinity of the Schering facility is away from any known public supply wells.

5.2 FINDINGS OF THE GEOPHYSICAL SURVEY

5.2.1 Data Analysis Methodology

Analyses of GPR survey data involved interpreting each profile individually, and then comparing the results collectively. The interpretation process had two objectives:

- Applying specific knowledge of known signature densities and configurations to identify pipes, drums, stratigraphy, soil structures, trenches, and discontinuities.
- Identifying trends and conditions by comparing standard profiles to one another. This process identified soil interfaces, buried utilities, and groundwater data.

The GPR profiles resulting from this survey exhibited high resolution, clearly defining changes in soil characteristics and highlighting individual targets beneath the site. As-built drawings for underground utilities (cooling water, industrial and storm sewer piping, electricity, and gas) were carefully reviewed in order to correlate the targets that the GPR detected with existing utilities.

5.2.2 GPR Survey Results

Figure 5-1 exemplifies a ground truth relationship between the physical geologic log for MW-5 and the real-time radar profile associated with the same stratigraphic unit adjacent to MW-5. Numerous natural and unnatural variations within the the profiles are observed both laterally and vertically. Variations occur between materials exhibiting contrasting dielectric constants. The stratigraphic transition vertically from a sand with clay in the upper unit to a predominantly silt with clay middle unit is portrayed in the profile by the black "banding" in the 4- to 15-foot interval, and white "clean" background between the groundwater interface and lower shale bedrock unit, respectively.

The groundwater and bedrock interfaces appear as dark "singular" bands across the profile at respective depths of 16 and 30 feet. Subsurface utilities reflecting characteristic hyperbolic signatures within the profile were confirmed by as-built drawings.

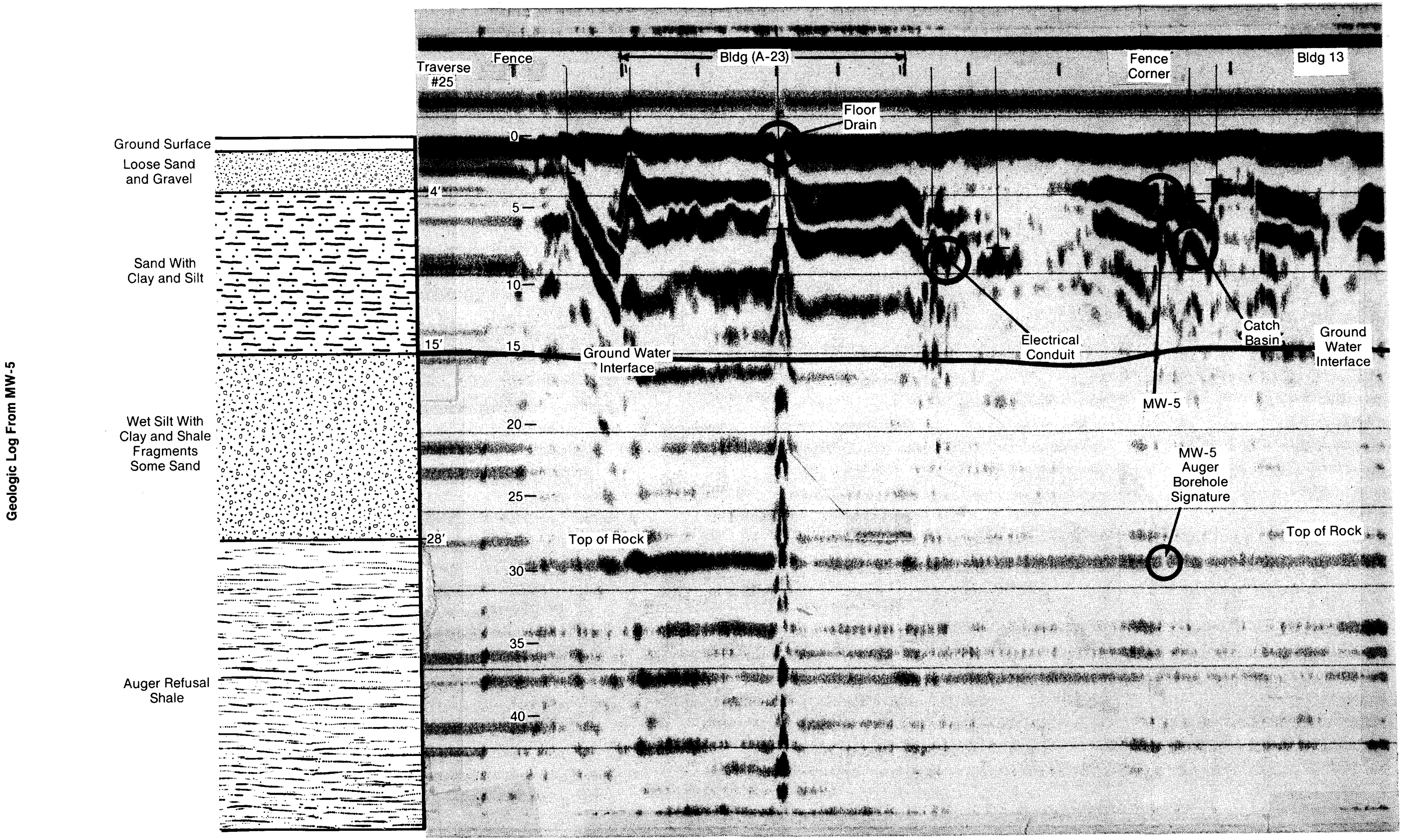


FIGURE 5-1 CORRELATION OF GEOLOGIC LOG AGAINST REAL TIME RADAR PROFILE

Figures 5-2, 5-3, and 5-4 show three areas of the facility where the GPR survey was conducted. Depicted are the location of suspected subsurface targets detected by the GPR that could not be correlated with the as-built utility plans. The approximate range of depth of these targets, as determined from the profiles, is 0 to 20 feet. These targets exhibited geometric radar signatures on profiles typical of discrete objects, while some of the targets appear to be small utilities. Although the GPR can locate and determine the depths of such objects, confirmation as to their nature can only be made through ground truth activities, such as soil borings and backhoe test pits.

Figure 5-2 shows the results of the survey in the area designated as Zone 3 in the RI/FS Work Plan. In this area soil borings completed both for the RI and for foundation studies showed extensive filling in the area during development of the site. The logs of these borings indicate the presence of bricks and wood. The targets shown in Figure 5-2 could be such materials. In addition, boulders in the glacial till could produce similar targets. A total of 15 borings in this area did not encounter any buried drums.

Figure 5-3 shows the results of the GPR survey in what was designated as Zone 1 in the RI/FS Work Plan. The survey showed some areas of disturbed soils, which is not surprising because extensive filling took place in this area during development of the site. Thus, the targets may be either cobbles and boulders in the glacial till, or bricks and wood in the overlying fill material.

The results of the GPR survey in the area formerly occupied by four surface impoundments are shown in Figure 5-4. The area outlined as disturbed soils corresponds well with the outline of the area that site drawings and personal testimony indicate was occupied by the surface impoundments during the 1940's to early 1950's. These GPR results provide independent confirmation that the borings conducted in this area were correctly placed so as to intercept any remnants of the former surface impoundments.

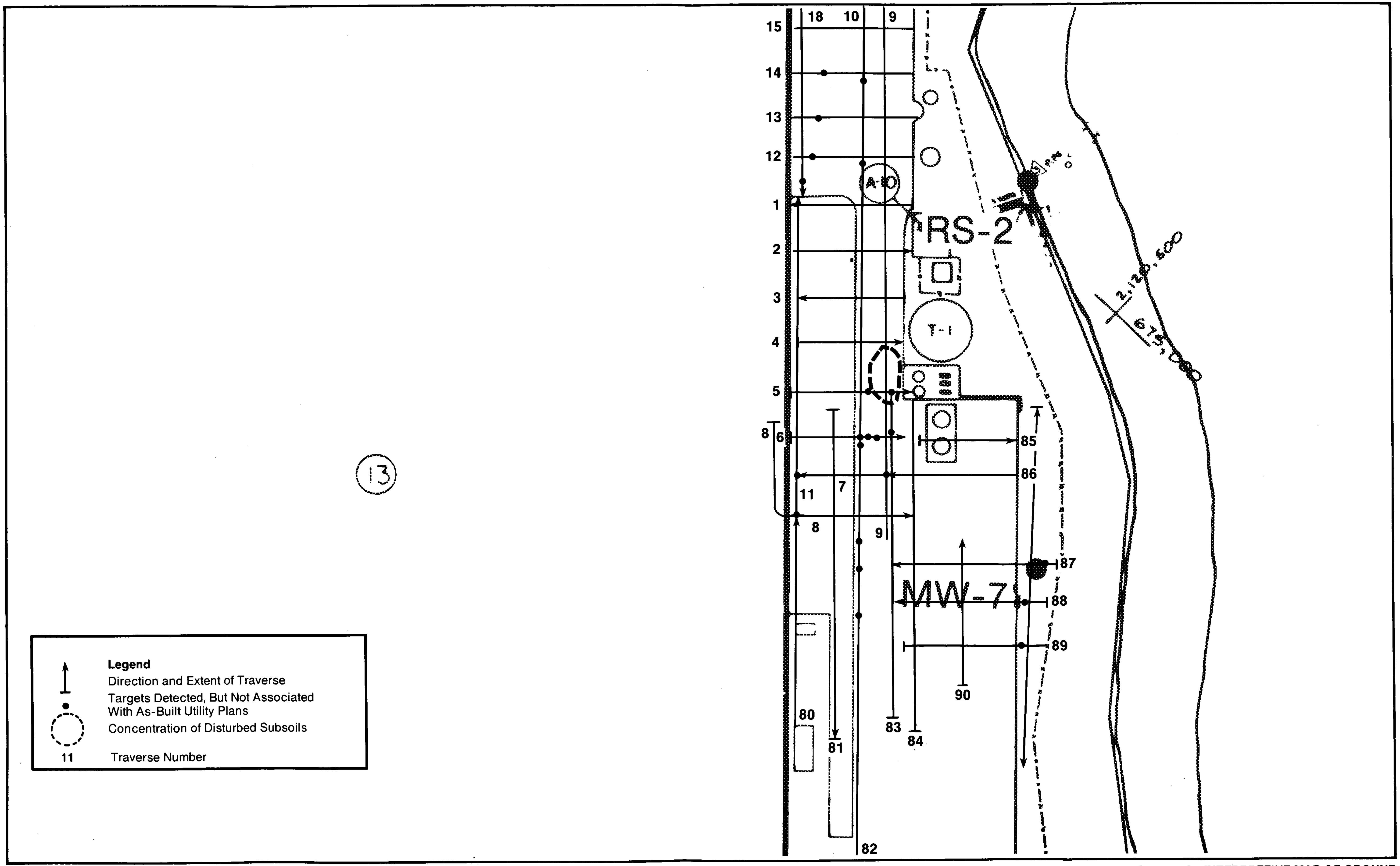


FIGURE 5-2 INTERPRETIVE MAP OF GROUND PENETRATING RADAR RESULTS FOR ZONE 3

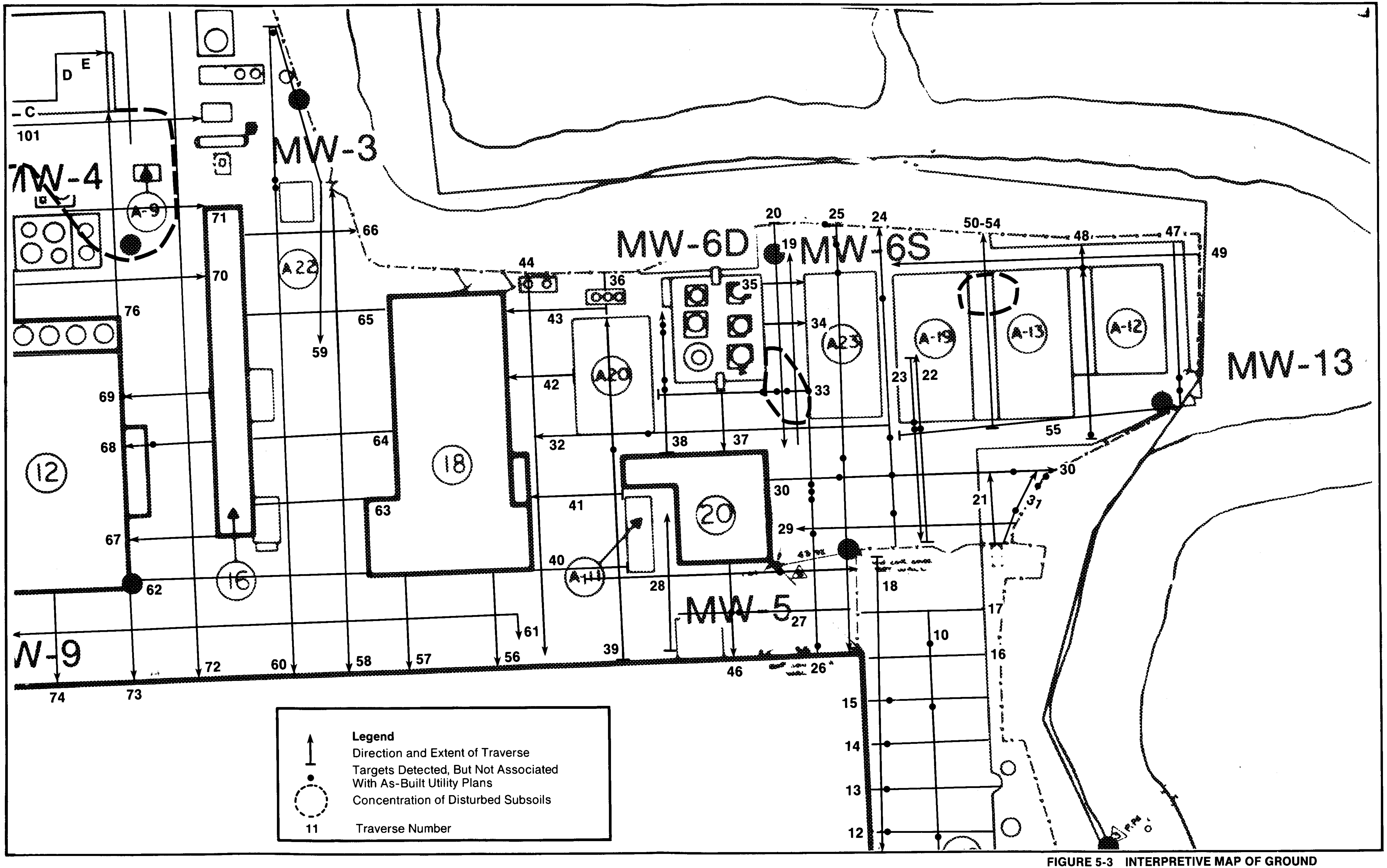


FIGURE 5-3 INTERPRETIVE MAP OF GROUND PENETRATING RADAR RESULTS FOR THE NORTHEAST AREA OF THE FACILITY (ZONE 1)

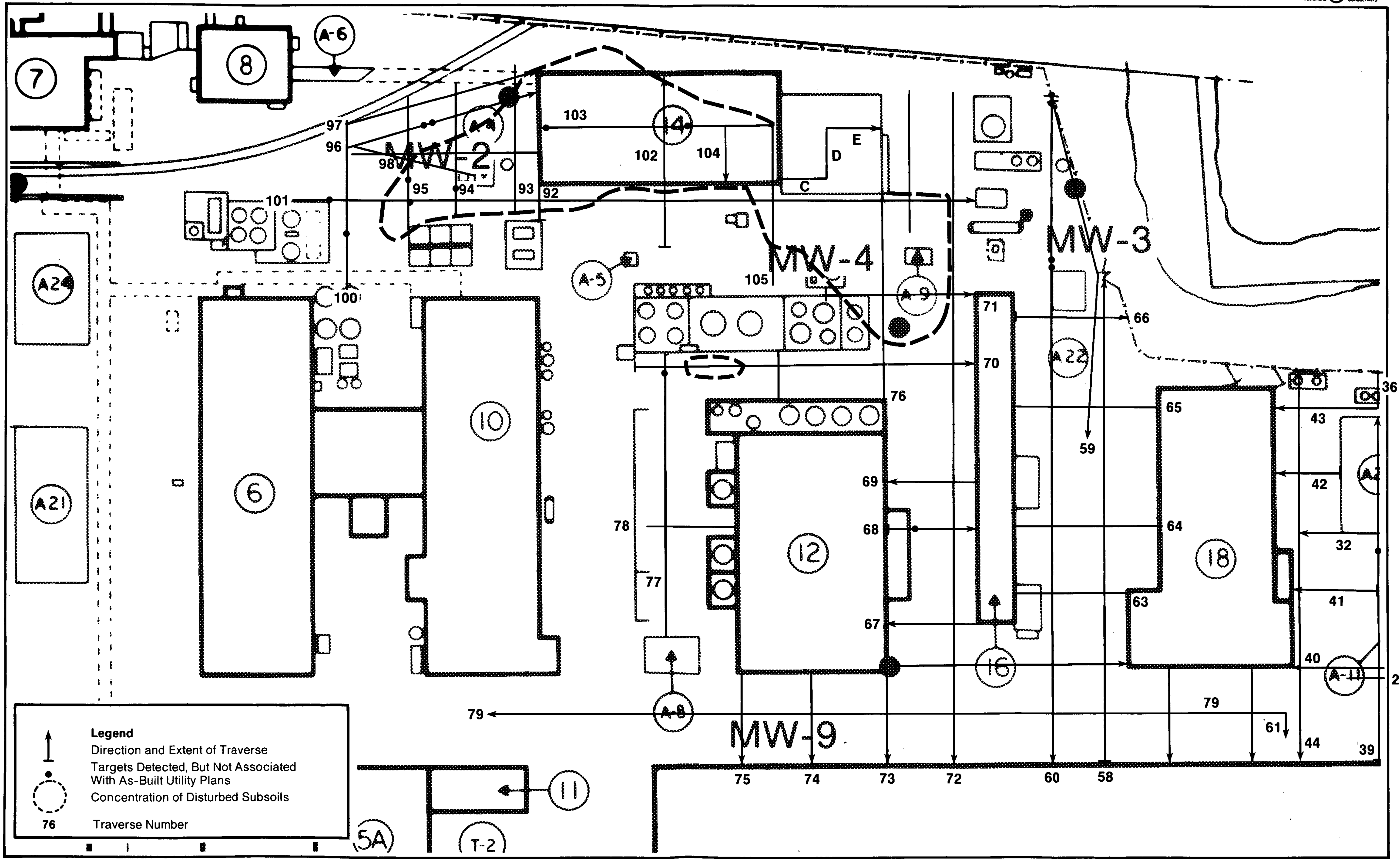


FIGURE 5-4 INTERPRETIVE MAP OF GROUND PENETRATING RADAR RESULTS FOR THE FORMER SURFACE IMPOUNDMENT AREA

5.3 GEOLOGIC AND HYDROGEOLOGIC INVESTIGATION FINDINGS

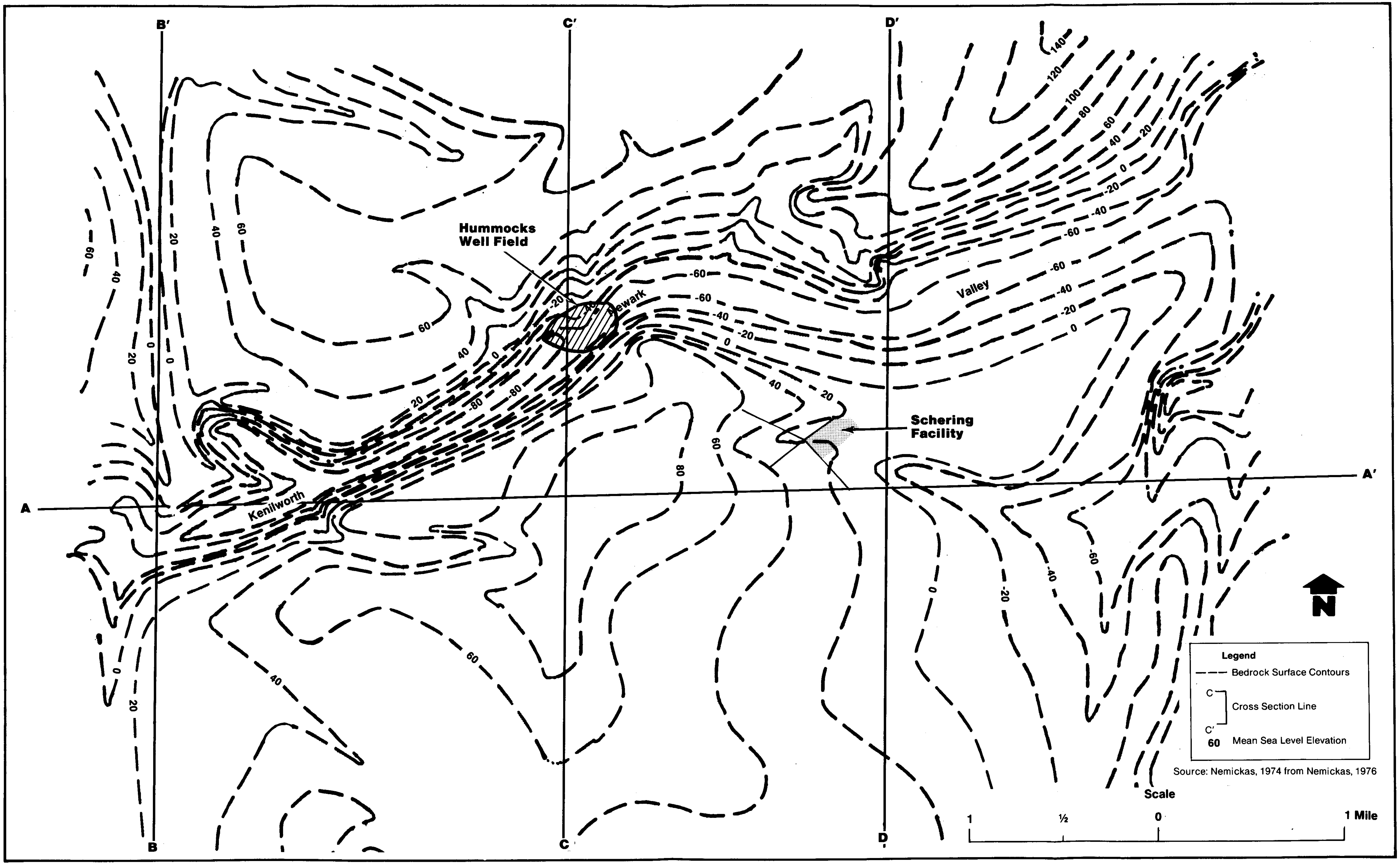
5.3.1 Regional Hydrogeology

The overburden in the study area consists of unconsolidated, unstratified, Pliestocene-aged glacial till, and glacio-fluvial deposits composed of silt with clay, fine grained sand with clay, occasional boulders, and cobbles. Recent alluvial deposits flank streams and rivers in the study area. Thickness of the unconsolidated material varies from about 20 to 30 feet at the Schering facility to over 150 feet in the Kenilworth-Newark bedrock valley to the northwest of Schering. The thicker stratified glacial drift deposits of the Kenilworth-Newark Valley constitute the only known significant aquifer in the unconsolidated deposits in the study area.

Underlying the unconsolidated deposits in the study area is the Brunswick Formation, part of the Newark Group, that is composed of thin bedded shales, mudstones and sandstones. Figure 5-5 shows the approximate configuration of the bedrock surface (Nemickas, 1976). The most prominent bedrock feature in the area is the Kenilworth-Newark Valley which trends northeast-southwest with bedrock surface elevations as low as 80 feet below sea level. In contrast, the altitude of the bedrock surface is about 10 to 20 feet above sea level beneath the Schering facility. This valley was cut into the bedrock by rivers draining the area prior to the last glaciation. Subsequently, as the glaciers retreated, glacial till and outwash sediments filled the valley.

Groundwater movement in the unconsolidated deposits usually occurs under unconfined conditions and is controlled by topography and bedrock configuration with flow generally toward streams and rivers. Groundwater may occur under confined conditions where the unconsolidated deposits have sufficient thickness and stratification such as in the Kenilworth-Newark Valley. Groundwater movement in the Brunswick Formation generally occurs under confined conditions due to stratification within the formation and to confinement by the overburden layer. Most evidence suggests that movement of groundwater in the Brunswick Formation occurs primarily along fractures in the bedrock (Nemickas, 1976; Vechiolli, 1969).

Spayd (1985) provides a good review of the literature on the occurrence of fractures in the Brunswick Formation. Nearly vertical fractures containing groundwater have been observed in tunnels drilled through the Brunswick. In these tunnels fractures along the bedding planes were nearly dry. This is due to the increasing weight of the overburden compressing these near horizontal fractures with depth.



Source: Nemickas, 1974 from Nemickas, 1976

FIGURE 5-5 BRUNSWICK FORMATION BEDROCK SURFACE TOPOGRAPHIC MAP

Evidence of the anisotropic (directionally-dependent) flow of groundwater along fractures in the Brunswick Formation has been provided by pumping tests conducted in this unit. Vecchioli (1969) observed that the beds in the Brunswick Formation are broken by a dominant near-vertical joint set whose strike is nearly parallel to the strike of the beds (N50°E in the Schering vicinity). He also noted that secondary near-vertical joints are roughly perpendicular to the primary set, and random joints of minor importance are common. These intersecting fractures and joints provide the principal means for storage and movement of groundwater in the Brunswick Formation.

During five aquifer-pumping tests, performed within the Brunswick Formation, Vecchioli (1967) reported that greater drawdowns occurred in monitoring wells aligned parallel to the regional strike, thus reflecting the preferential fracturing of the bedrock parallel to the strike. Similar observations during pumping tests at the Schering facility are described in this report. Pumping tests by Herpers and Barksdale (1951) and Longwill and Wood (1965) also confirm that groundwater movement in the Brunswick Formation occurs primarily in fractures.

Data reported in the 1984 Water Year (Brauersfeld et al, 1985) from four Brunswick Formation Observation Wells (Hillside No. 4, Hatfield No. 2, White Labs No. 3, and the Union County Park Well) indicate regional groundwater flow is toward the east, toward Newark Bay and the Arthur Kill. (See Plate 4.) Recharge to the Brunswick is primarily via infiltration of rainwater through the unconsolidated sediments (Nemickas, 1976). Rates of recharge are unknown, but are estimated in this study to be about 4 to 8 inches per year based on USGS data for the area (Sinnott and Cushing, 1983). These data were used in calibrating the groundwater flow model developed as an aid in understanding groundwater flow in the Brunswick Formation. This model and the results are discussed in Subsection 5.3.4.

5.3.2 Regional Groundwater Use

As discussed in Subsection 3.4, during 1985 approximately seven million gallons of water were pumped from wells within approximately a 2-mile radius of Schering's Union plant. The largest center of pumping, the Hummocks Well field, produced on average three million gallons per day during 1985. The Hummocks Well field draws water primarily from the Kenilworth-Newark Valley fill aquifer, but probably also produces water from the Brunswick Formation. The other major producers draw water from the Brunswick Formation. Plate 4 shows the locations of principal groundwater users and observation wells in the Brunswick Formation within approximately a 2-mile radius of Schering.

5.3.3 Site Geology

5.3.3.1 Unconsolidated Deposits

The unconsolidated deposits at the Schering facility are composed of an unconsolidated glacial till and glacial outwash deposits consisting of silt, fine grained sand with clay, occasional cobbles, and boulders. In the area east of Building 7 and Building 13, these deposits are overlain by a layer of fill material. This fill consists of till excavated from other areas of the site, sand and demolition debris. Emplacement of fill and development at the Schering site has significantly altered the original surface topography, surface water drainage, and infiltration patterns.

Figure 5-6 illustrates the original topography of the site in 1937, just prior to site development. This map shows that the land surface slopes toward the Elizabeth River and that two small hills were in the area presently occupied by Building 13. Land surface elevations (AMSL) at the site vary from a maximum of 54 feet at the top of one of the hills to 24 feet along the river. Surface water drainage is to the northwest and towards the Elizabeth River. Figure 5-7 shows the most current topographic map of the Schering facility, which was completed in 1977. All the major buildings are shown except Building 12 (which was under construction at the time) in the area between Building 10 and 16. Comparison of the two figures shows how the site has been leveled to a more uniform elevation of approximately 40 feet. This filling also increased the steepness of the drop off to the river. Surface water drainage is provided primarily by storm sewers constructed at the facility during development.

Filling at the site occurred in stages which were linked to expanding site use. Figure 5-8 illustrates the thickness of fill across the site and the history of emplacement. This figure clearly shows that most of the fill was in place by about 1961. Fill thickness increases across the site from west to east from less than 2 feet to about 15 feet. This map was compiled from comparison of the two topographic maps, examination of aerial photos, and analyses of boring logs.

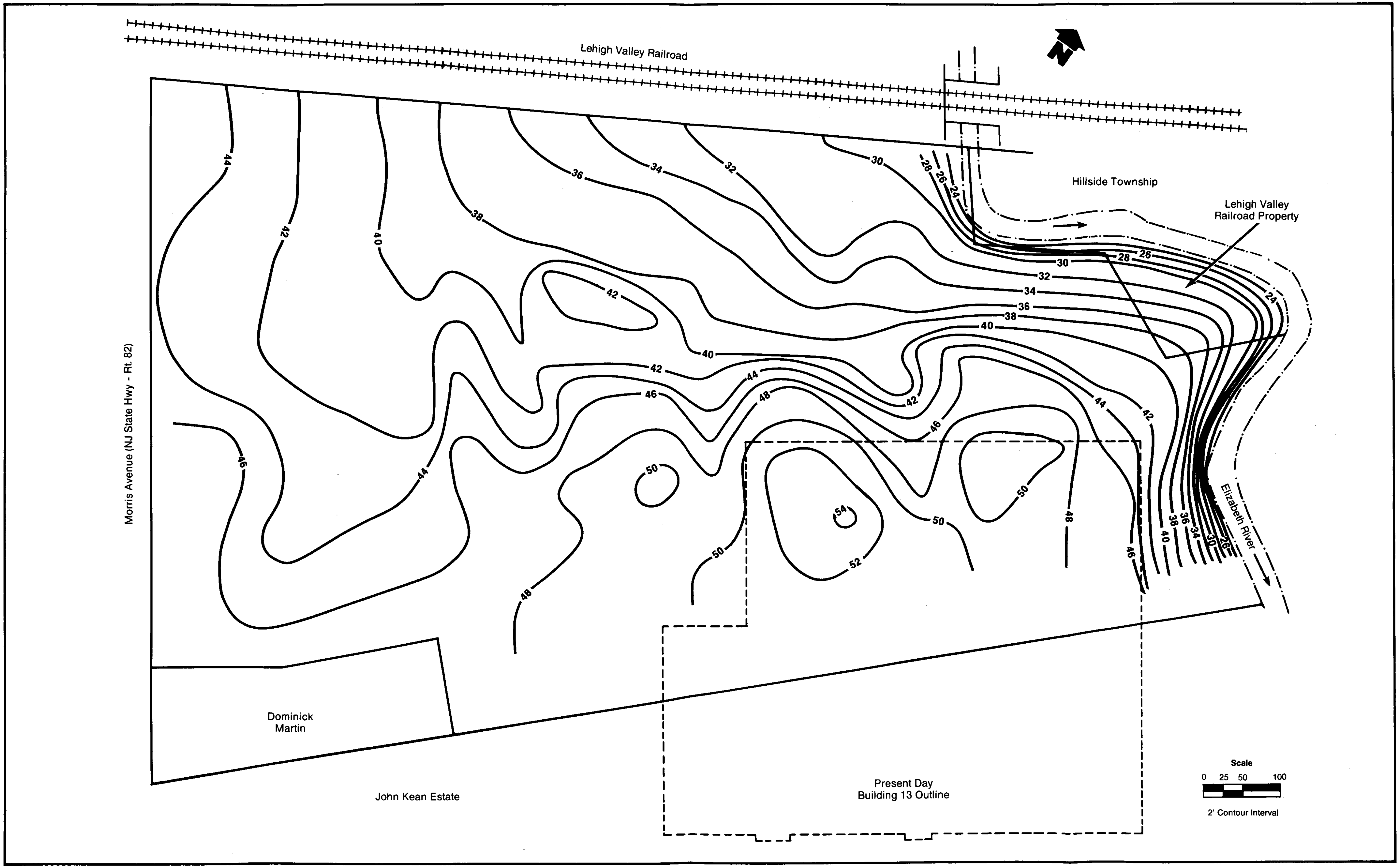


FIGURE 5-6 TOPOGRAPHIC MAP, SCHERING FACILITY
SEPTEMBER 16, 1937

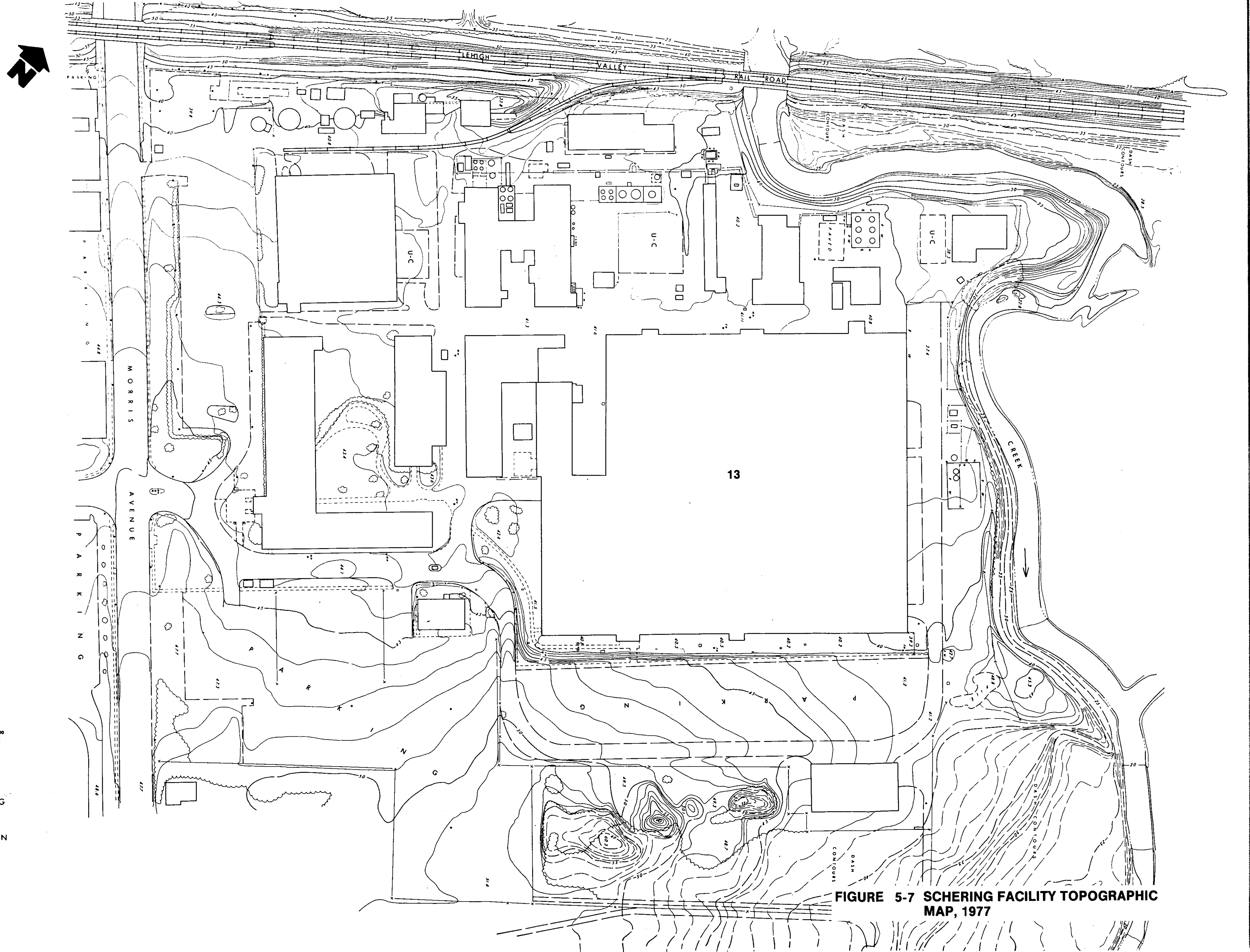


FIGURE 5-7 SCHERING FACILITY TOPOGRAPHIC MAP, 1977

TOPOGRAPHIC MAPPING
OF
SCHERING CORPORATION
UNION N.J FACILITY

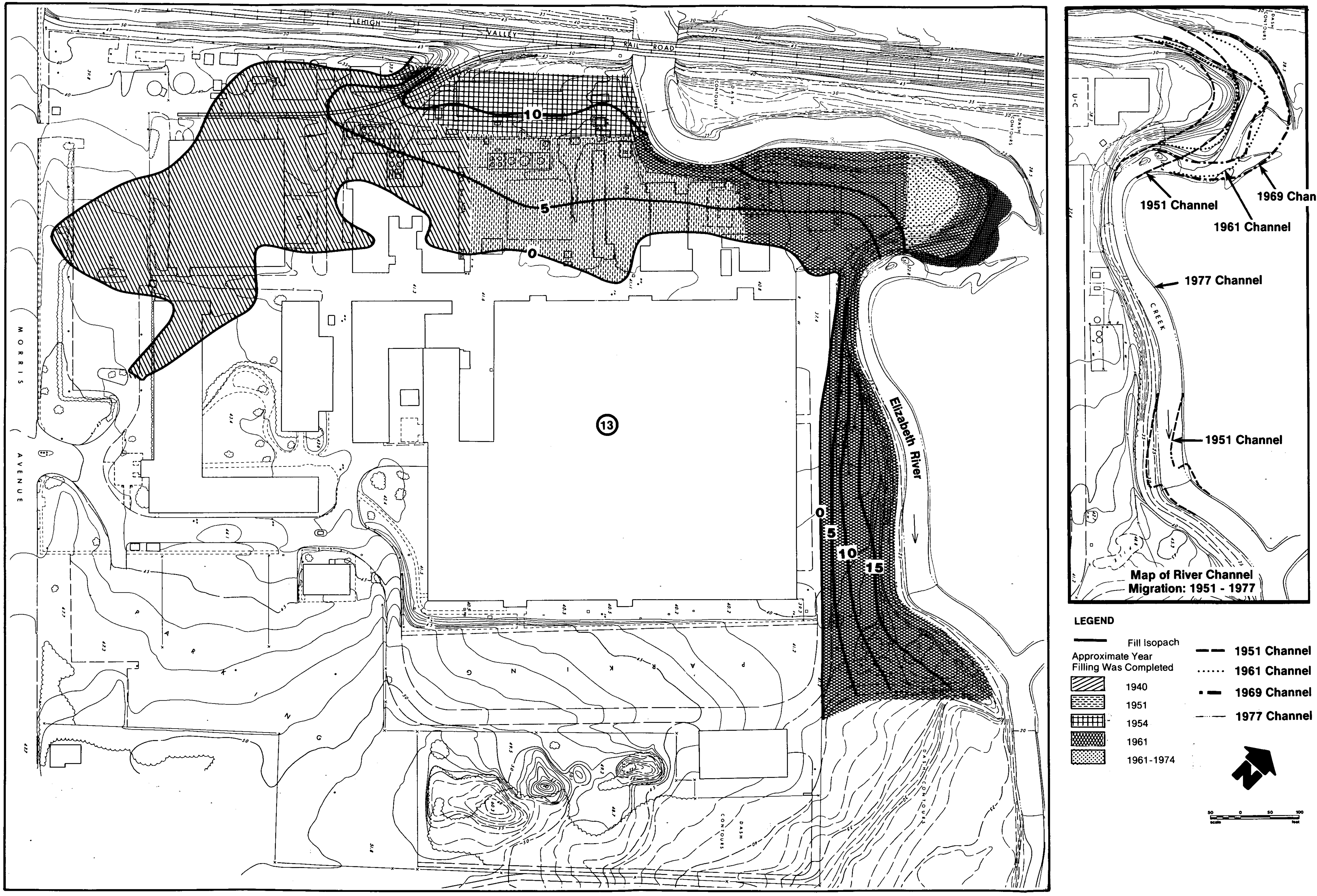


FIGURE 5-8 FILL ISOPACH AND HISTORY MAP

Soil borings were conducted at the locations shown in Plate 1 to determine the subsurface geologic conditions. Plate 5 shows cross section A-A' which illustrates the geology of the unconsolidated deposits in the northern area of the facility in an east-to-west direction. This cross section clearly illustrates the presence of the fill layer, the underlying relic soil horizon, and the underlying till. Cross section B-B' shows the same type of geology in a north-south direction on the eastern side of the facility.

In contrast, the east bank of the Elizabeth River, to the east of Schering, has never been developed. The flood plain along the west bank of the river slopes very gently to the river. Information from the 1977 flood hazard map (Figure 3-3) shows elevations are in the range of 24 feet near the river to 30 feet near the edge of the flood plain. A total of eight borings were completed in this area. Four of the borings (PE-2, PE-4, PE-6, and PE-8) were drilled to the top of bedrock and completed as piezometers (see Plate 2 for locations). Deposits in the vicinity of these piezometers consist of unconsolidated sediments typical of river flood plain areas: bar deposits consisting of layers of silty gravelly sand, and overbank deposits of clayey silt. These layers are about five to seven feet thick. Glacial till underlies these deposits.

Cross section C-C' illustrates the geology in the vicinity of P-5/P-6 and PE-1/PE-2. This area is at a bend in the river where a bar has formed. Consequently, the sandy bar deposit overlies the silty clay and clayey silt of the overbank deposit. At a depth of about 10 feet the silty clay grades into the glacial till which extends to bedrock at about 20 feet below the surface. Cross sections D-D' and E-E' (see Plate 5) also show the same general geology.

Cross section D-D' shows the geology in the vicinity of PE-4. Along this section, six feet of alternating clayey silts and silty clays are underlain by a six-foot layer of gravelly, coarse-grained sand. This sand and gravel layer appears to be connected to the river as shown in cross section D-D' because PE-3, which is screened in this layer, produces water readily.

Cross section E-E' shows that, in PE-8, the distinct sand layer is absent, having been replaced by silty clay and clayey silt. At PE-6, the geology is similar to that seen at PE-4. Logs for these piezometers are included in Appendix E.

To help illustrate in three dimensions the site geology at the facility and its relationship to the geology on the east bank of the Elizabeth River, two fence diagrams were constructed. Figure 5-9 illustrates the geologic data provided by soil borings conducted in Zone 1. (See Plate 1 of boring and zone locations.) This perspective shows the changing thickness of the fill material and the pattern of the relic soil horizon.

Figure 5-10 illustrates the fence diagram constructed using data from borings conducted in Zone 2, the area around and under Building 14. This fence diagram again shows the extent of the old soil horizon and the fill material. Also shown is the blue-green clayey material. This has been identified as waste material from surface impoundments which had been operated in the area from the mid 1940's to 1953 or 1954. As the diagram shows, this material is encountered only in three isolated pockets and there is no evidence of a continuous layer beneath Building 14 or the surrounding area.

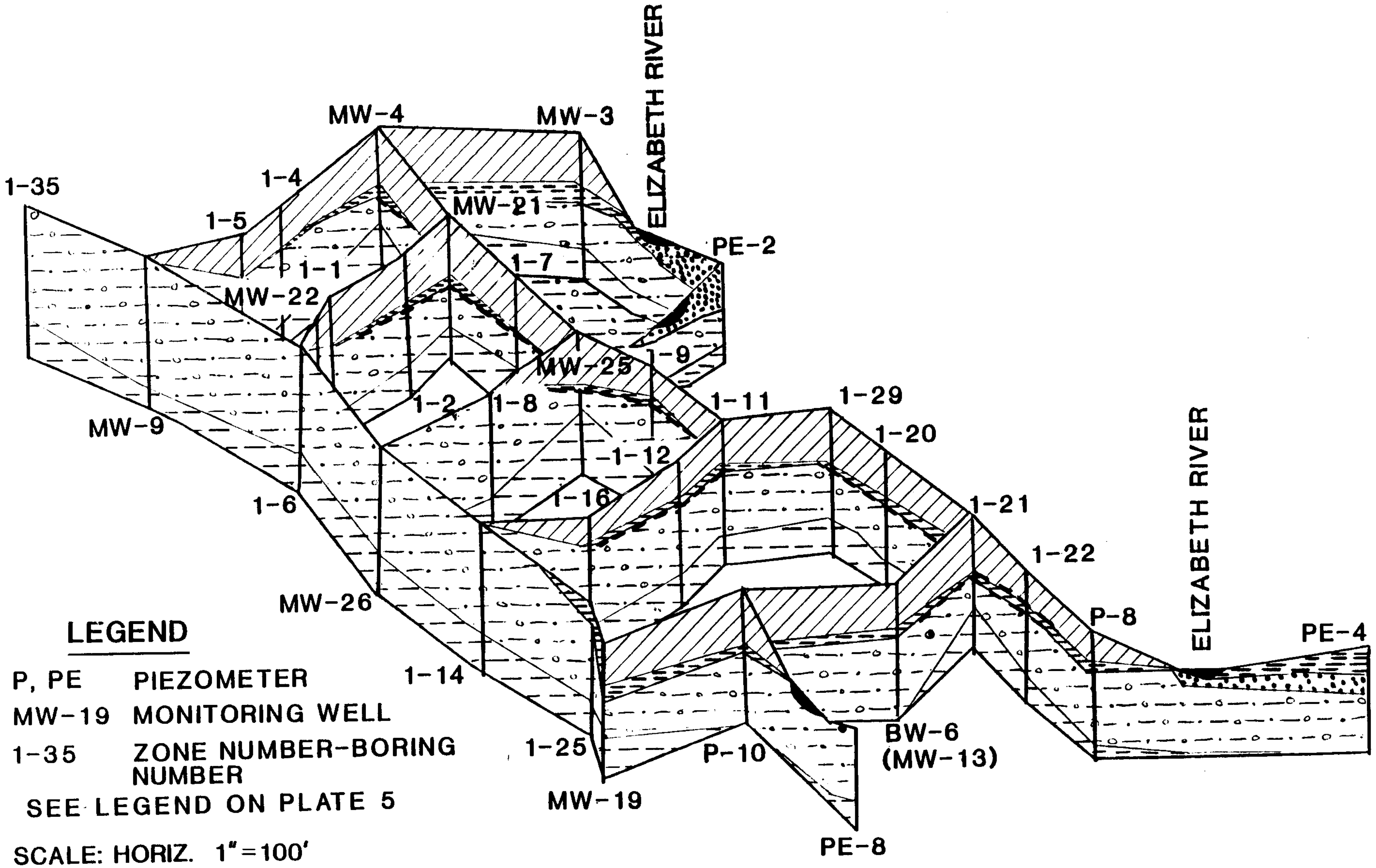
5.3.3.2 Bedrock Geology

The unconsolidated surficial sediments are underlain by the Brunswick Formation. Cuttings from seven wells installed at the site showed this bedrock unit to consist of dark reddish brown shale and siltstone. Figure 5-11 illustrates the topography of the bedrock surface underlying the facility as determined from drilling logs for borings completed on-site. This surface dips to the east as shown in Figure 5-5. It was not possible to measure the strike and dip of the beds at the site, but Nemickas (1976) reports the strike as N50°E and the dip of the beds as 9 to 13°NW.

5.3.4 Site Hydrogeology

5.3.4.1 Lateral Groundwater Movement in the Unconsolidated Deposits

Groundwater occurs under unconfined conditions in the unconsolidated deposits at the plant and the adjoining section of the Elizabeth River Park. Groundwater flows from west to east across the plant and toward the Elizabeth River during all times of the year. On the east side of the Elizabeth River, groundwater flows from east to west toward the river. This flow pattern fluctuates seasonally, thereby controlling underflow beneath the Elizabeth River. In addition, there is a lateral component of groundwater flow close to the river in the direction of Elizabeth River flow.



LEGEND

P, PE	PIEZOMETER
MW-19	MONITORING WELL
1-35	ZONE NUMBER-BORING NUMBER

SEE LEGEND ON PLATE 5

SCALE: HORIZ. 1" = 100'
VERT. 1" = 40'

NOTE: SEE PLATE 1, FOR BORING LOCATIONS

FENCE DIAGRAM
ZONE 1
VIEW TO THE NORTHWEST

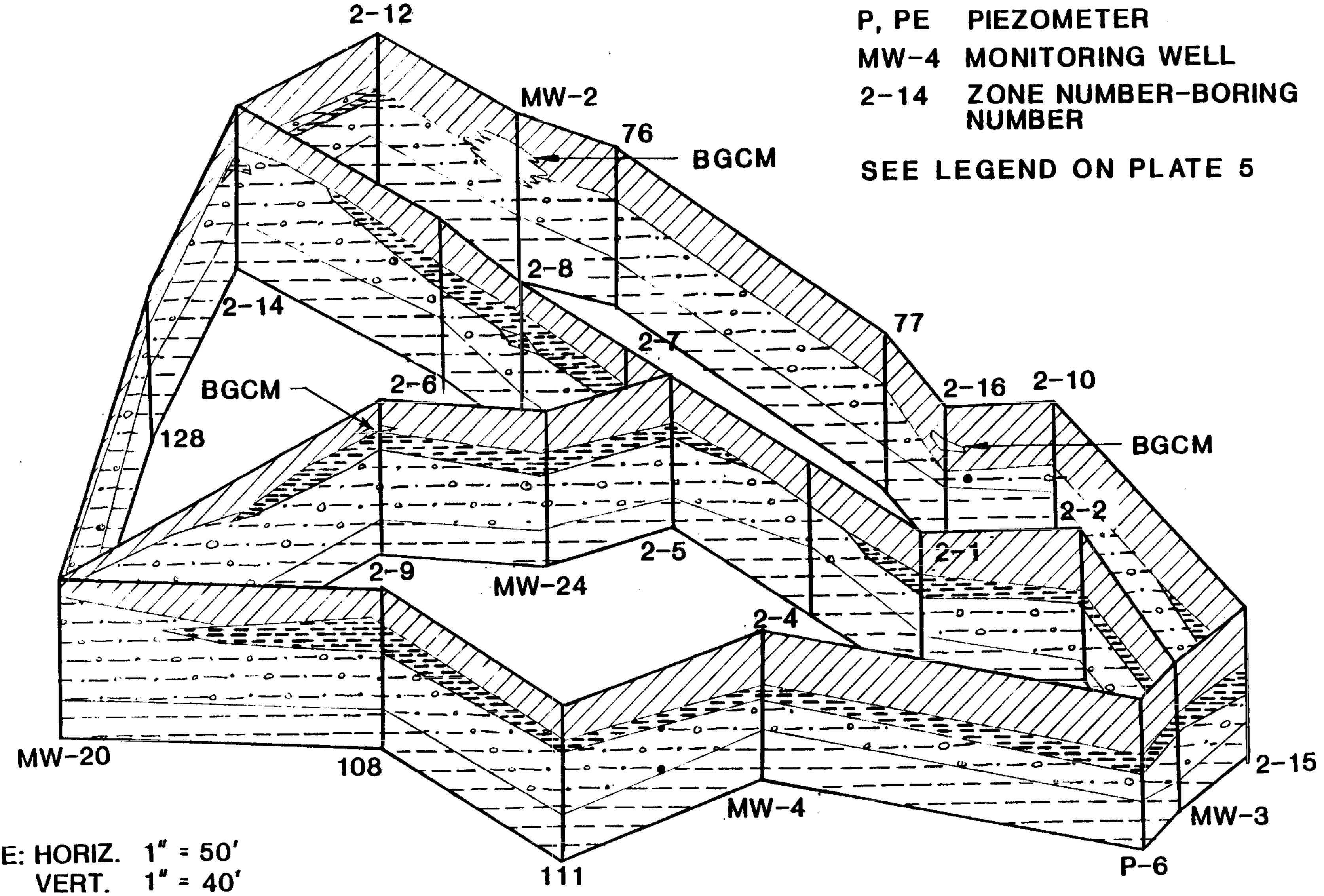
ROY F. WESTON, INC.
WESTON
ENVIRONMENTAL CONSULTANTS-DESIGNERS

DRAWN LRM	DATE 5/86	DES. ENG. JHF	DATE	W. O. NO. 1120-21-03
CHECKED		APPROVED	5/14/86	DWG. NO. FIG. 5-9

LEGEND

P, PE	PIEZOMETER
MW-4	MONITORING WELL
2-14	ZONE NUMBER-BORING NUMBER

SEE LEGEND ON PLATE 5



SCALE: HORIZ. 1" = 50'
VERT. 1" = 40'

NOTE: SEE PLATE 1, FOR BORING LOCATIONS

FENCE DIAGRAM

ZONE 2

VIEW LOOKING NORTHWEST

ROY F. WESTON, INC.
WESTON
ENVIRONMENTAL CONSULTANTS-DESIGNERS

DRAWN LRM	DATE 5/86	DES. ENG. JHF	DATE	W. O. NO. 1120-21-03
CHECKED		APPROVED	5/14/86	DWG. NO. FIG. 5-10

Plate 6 shows the potentiometric surface for the monitoring wells of the unconsolidated deposits installed at the Schering facility. Water levels in these wells are representative of water table conditions at the site. The lines on the drawings represent lines of equal water level elevation; groundwater generally flows at right angles to these lines in the direction of decreasing elevation or head. Clearly, the gradient is driving groundwater flow towards the river. The shape of the water table surface does not exhibit significant seasonal changes across most of the site. The elevation of the surface commonly shifts one foot or less over the period of a year.

This stable gradient is indicative of an area receiving steady recharge, or inflow of groundwater, from the west of the plant. The plant is almost entirely paved and built upon in the area where most of the monitoring wells are concentrated. There is probably little recharge to groundwater from infiltrating rainfall on the site. Most of the recharge to the groundwater in the unconsolidated deposits at Schering is believed to result from rainfall infiltration in the park area to the northwest of Schering and on the area to the west of Schering.

Significant seasonal fluctuations occur adjacent to the Elizabeth River, which are best illustrated by data from the piezometers. To provide data on the lateral and vertical groundwater movement in the unconsolidated deposits, a total of ten shallow and ten deep piezometers were installed as discussed in Subsection 4.3.5. Plate 7 shows shallow and deep potentiometric surfaces for January, February, March, and April 1986. Comparison of the January shallow piezometric surface with later months shows that during January flow in the unconsolidated deposits was from the plant, beneath the Elizabeth River and toward the vicinity of PE-5 and PE-6. However, in later months this trend was reversed and groundwater flow in the Elizabeth River Park was to the west, toward the Elizabeth River. This pattern may be caused by decreased infiltration. This decreased infiltration allows the steeper gradient under Schering to drive groundwater towards PE-5 and PE-6. As recharge and/or flow from the east increases, the potentiometric surfaces for the months of February, March, and April 1986 show a consistent pattern of groundwater flow toward the Elizabeth River and in the direction of Elizabeth River flow.

The lateral groundwater flow velocity is dependent on the hydraulic gradient and the hydraulic conductivity of the geologic materials. To compute hydraulic conductivity in the unconsolidated deposits, piezometer tests were conducted on monitoring wells and piezometers across the plant site. The data were analyzed using the method of Bouwer and Rice (1976). The methodology for these tests is discussed in Subsection 4.5.2.

Slug and/or bail tests were conducted on 17 of the 28 unconsolidated deposit monitoring wells and 6 of the 20 piezometers. The results of these analyses are summarized in Table 5-1. As can be seen, these values of hydraulic conductivity (K) fall in the range for published values for silty sand and silt which have been encountered throughout the site. However, the values also fall in the range for clean sand which may reflect lenses of more permeable sands and the influence of the well gravel pack. A sample velocity calculation using the range of computed K values in Table 5-1 is presented in Table 5-2.

Using the values of K given in Table 5-1, a range of lateral flow velocities was computed to bracket the likely velocity. In addition, these estimates are probably conservative, that is, these are probably high estimates of possible velocities. The most probable average groundwater velocity beneath the plant site is in the range of 160 to 470 feet per year.

Results from the groundwater flow model were used to compute the hydraulic gradient on the east side of the Elizabeth River. The model provided more complete head data over a larger area and thus provides a more reliable basis for computing the gradient. The computed value of 0.008 was used in the velocity calculations in Table 5-2 to give a range of values between 125 and 365 feet per year. The calculation of the flow velocity and water level elevation data for all monitoring wells and piezometers are included in Appendices J and K, respectively.

Data from the groundwater flow model were used to estimate the rate of lateral groundwater movement in the unconsolidated deposits in the direction of Elizabeth River flow. Using data for October 1985, a gradient of 0.0013 was calculated over a distance of 3,800 feet (see Appendix J). Using a K of 12.92 ft/day and an effective porosity of 0.1 and 0.3, a range of velocities from 0.17 ft/day to 0.06 ft/day, respectively, was calculated. These values translate to a range of velocities of 20 to 60 ft/yr.

5.3.4.2 Vertical Groundwater Movement and the Hydrogeology of the Elizabeth River

Vertical hydraulic gradient data indicate a general downward gradient in the unconsolidated deposits underlying the Schering facility in the vicinity of P-3 and P-4, P-5 and P-6, P-1 and P-2, and MW-6S and MW-6D. There is a slight downward gradient in the vicinity of P-13 and P-14. Data for these piezometer pairs and nearby unconsolidated deposit and bedrock monitoring

Table 5-1

Calculation of the Range of Lateral Velocity Values in the Unconsolidated Deposits

Monitoring Wells Adjacent to the Elizabeth River	Hydraulic Conductivity (K) (ft/day)
MW-3	1.42
MW-5	19.84
MW-7	3.63
MW-13	0.87
MW-21	5.99
MW-25	12.35
Range	0.87 to 19.84
Average	7.35

Other Selected Location On-Site and Off-Site	K (ft/day)
MW-4	3.11
MW-8	23.16
MW-17	23.01
MW-17[1]	17.31
PE-3	29.38
PE-7	17.99
PE-8	10.41
PE-8[1]	12.41
Range for All Values	0.87 to 29.38
Average for All Values	12.92
+1 Standard Deviation:	22.06
-1 Standard Deviation:	3.78

Published Values (Freeze and Cherry, 1979)

Glacial Till: Range = 2.6×10^{-8} to 2.6×10^{-2} ft/day

Silt = 2.63×10^{-5} to 0.26
Silty Sand = 2.64×10^{-3} to 26.4
Clean Sand = 0.26 to 263.5

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[1] Slug test analysis result, others for bail tests.

Table 5-2

Sample Velocity Calculations and Range of Computed Values for Lateral Groundwater Migration Velocity

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Lohman (1972) shows than an expression for the average seepage velocity can be derived from Darcy's flow equation, as follows:

$$V = \frac{Ki}{ø}$$

where:

V = Velocity of groundwater flow in the direction of the gradient, ft/day (L/T)

K = Average hydraulic conductivity of the deposits, ft/day (L/T)

i = Average groundwater gradient, or the change in water level elevation per unit distance measured in the direction of flow across the site.

ø = Effective porosity of the deposits, dimensionless

Velocities were calculated for a variety of K, ø and i values:

for ø = 0.3 and i = 0.01 and

K = 3.78 V(ft/day) = 0.13 V (ft/yr) = 47
= 12.92 = 0.43 = 160
= 22.06 = 0.74 = 270

for ø = 0.1 and the same K values the following velocities were calculated:

K = 3.78 V (ft/day) = 0.38 V (ft/yr) = 138
= 12.92 = 1.3 = 470
= 22.06 = 2.2 = 800

The most probable average groundwater velocity beneath the Schering facility is in the range of 160 to 470 feet per year.

Table 5-2
(continued)

On the east bank of the Elizabeth River a gradient of 0.008 was calculated using data from the potentiometric surface computed by the groundwater flow model; see Plate 9. The following velocities were calculated.

For ø = 0.3 and i = 0.008,

K = 3.78 V (ft/day) = 0.10 V (ft/yr) = 37
= 12.92 = 0.34 = 125
= 22.06 = 0.59 = 215

For ø = 0.1 and i = 0.008,

K = 3.78 V (ft/day) = 0.30 V (ft/yr) = 110
= 12.92 = 1.0 = 365
= 22.06 = 1.8 = 660

---

wells are presented in Appendix K. The downward gradient in areas of the Schering facility indicates downward groundwater flow resulting from recharge occurring on and near the site. The vertical gradients are also controlled by vertical differences in hydraulic conductivity caused by changes in geology. One such change may be due to fill emplaced in the area. If the fill was compacted during emplacment, it could have a much lower permeability than the underlying deposits.

In contrast, potentiometric data from piezometers adjacent to the Elizabeth River in the Woodruffs section of the Elizabeth River Park east of Schering show a consistently upward gradient. At PE-5 and PE-6, the measured heads are very close and the difference may not be significant. This upward gradient near the river is indicative of groundwater discharge to the Elizabeth River. These data are presented in Appendix K.

Gradient data indicate that groundwater flow in the unconsolidated deposits has both lateral and vertical components. The vertical component of seepage velocity is estimated at 10^{-2} to 10^{-1} feet per year towards the bedrock. This compares with a lateral component seepage velocity of 160 to 470 feet per year. This comparison indicates that the vertical component of velocity is 5,000 to 15,000 times less than the lateral velocity. This estimate of vertical seepage is based on measurement of vertical permeability of about 10^{-4} ft/day from analyses of Shelby tube samples collected from the unconsolidated deposits at both shallow and deeper depths. These values may not be representative of the unconsolidated sediments as a whole and are low estimates of permeability. (See Appendix I.) Head measurements were made at six clusters of shallow piezometer, deep piezometer, unconsolidated deposit moitoring well and bedrock monitoring wells (Plate 2). An effective porosity of 0.1, considered a conservative estimate, was assumed. A higher value of ϕ would give a lower velocity. These data showed a consistent downward gradient at each of the locations. At MW-13 and BW-6 the gradient is consistently upward. This gradient is on the order of 10^{-3} ft per year. Such a gradient is indicative of discharge from the bedrock towards the Elizabeth River. The gradients at other clusters are indicative of recharge to the bedrock. Data and calculations are included in Appendix J.

To quantify the volume of discharge toward the Elizabeth River, the average transmissivity, determined from monitor well pump tests, was input into Darcy's equation for flow, a form of which is:

$$Q = KbiL\ (7.48)$$

where:

Q = Flow, gal/day (L^3/T)

K = Average hydraulic conductivity of the on-site monitor wells, ft/day (L/T)

b = Average saturated thickness of the unconsolidated deposits adjacent to the Elizabeth River, ft (L)

i = Hydraulic gradient, dimensionless

L = Length of the discharge face, feet (L)

7.48 = Conversion factor for cubic feet to gallons, gal/cu ft (L^3/L^3)

The length of the cross sectional area representing the contact zone between the Schering property and the Elizabeth River was determined to be approximately 2,050 feet. Table 5-3 provides a summary of discharges toward the Elizabeth River from both the Schering side and the park side.

To assess how much groundwater may be discharging into the river, flow measurements were made at RS-1 and RS-3 upstream and downstream, respectively, of the Schering facility. The flow was computed from depth and velocity measurements collected in August 1984.

Stream cross-sections were measured and discharge volumes calculated (data and calculations in WESTON, 1984). Using the discharge equation:

$$Qgw = (Q_2 - Q_1)$$

where:

Qgw = Discharge of groundwater from the unconsolidated deposits on both banks to the Elizabeth River.

Q_2 = Discharge through a downstream cross-section measured at RS-3 (uncorrected for basin area)

Q_1 = Discharge through an upstream cross-section measured at RS-1 (uncorrected for basin area)

Table 5-3

Summary of Discharge Volumes Towards the Elizabeth River

Equation: $Q = KbiL\ (7.48)$

Calculations:

1. K (ft/day)	2. b (ft)	3. i	L (ft)	Q (gal/day)
For Discharge from the West Side of the River:				
3.78	14.4	0.01	2,050	8,350
12.92	14.4	0.01	2,050	28,530
22.06	14.4	0.01	2,050	48,700
For Discharge from the East Side of the River:				
3.78	18.75	0.008	2,050	8,700
12.92	18.75	0.008	2,050	29,700
22.06	18.75	0.008	2,050	50,740

1. Hydraulic Conductivity
2. Saturated Thickness in the Vicinity of the River
3. Hydraulic Gradient

Therefore:

$$Qgw = 6.79 \times 10^6 \text{ gal/day} - 6.74 \times 10^6 \text{ gal/day}$$
$$= 5.0 \times 10^4 \text{ gal/day}$$

The estimate of 50,000 gallons per day of groundwater discharge to the river compares well with the estimated discharge from east and west of the river which totals between 17,000 gallons and 99,400 gallons per day depending on the conductivity value chosen. This information combined with the data showing groundwater flow toward the Elizabeth River indicates that groundwater is discharging to the Elizabeth River and flowing to the east-southeast in the direction of the river flow. During some times of the year when groundwater levels are low and river stage is high, the river probably loses or discharges water to the unconsolidated deposits. This case was illustrated in January 1986 when the potentiometric surface extended from the Schering facility beneath the river.

5.3.4.3 Groundwater Movement in the Shallow Bedrock Zone

Groundwater movement in the shallow bedrock zone beneath the Schering facility is controlled by fractures. Available data indicate at least one set of fractures or joints is well developed in the shallow zone. This fracture zone apparently trends along a line striking in the range of N50°E to N70°E. The occurrence of this fracture zone was indicated by observation of the shallow bedrock potentiometric surface and the pattern of volatile organic priority pollutants.

To assess the hydrogeology and groundwater quality of the shallow bedrock zone beneath the Schering facility, a total of seven bedrock monitoring wells have been installed (see Plate 2 for locations). These wells penetrate to a total depth of about 65 feet below ground surface and 30 feet into bedrock. In addition, Hillside No. 4, a 400-foot deep well in the Brunswick Formation, is also used for observing water level fluctuations.

The potentiometric surface in the shallow bedrock zone is illustrated in Figures 5-12, 5-13, and 5-14 for the months of August and November 1985 and April 1986. These figures illustrate a consistent gradient to the east. This gradient varies only in that the overall elevation increased about two feet between August 1985 and February 1986. This general rise in water levels is consistent with seasonal change in water levels observed in Hillside No. 4.

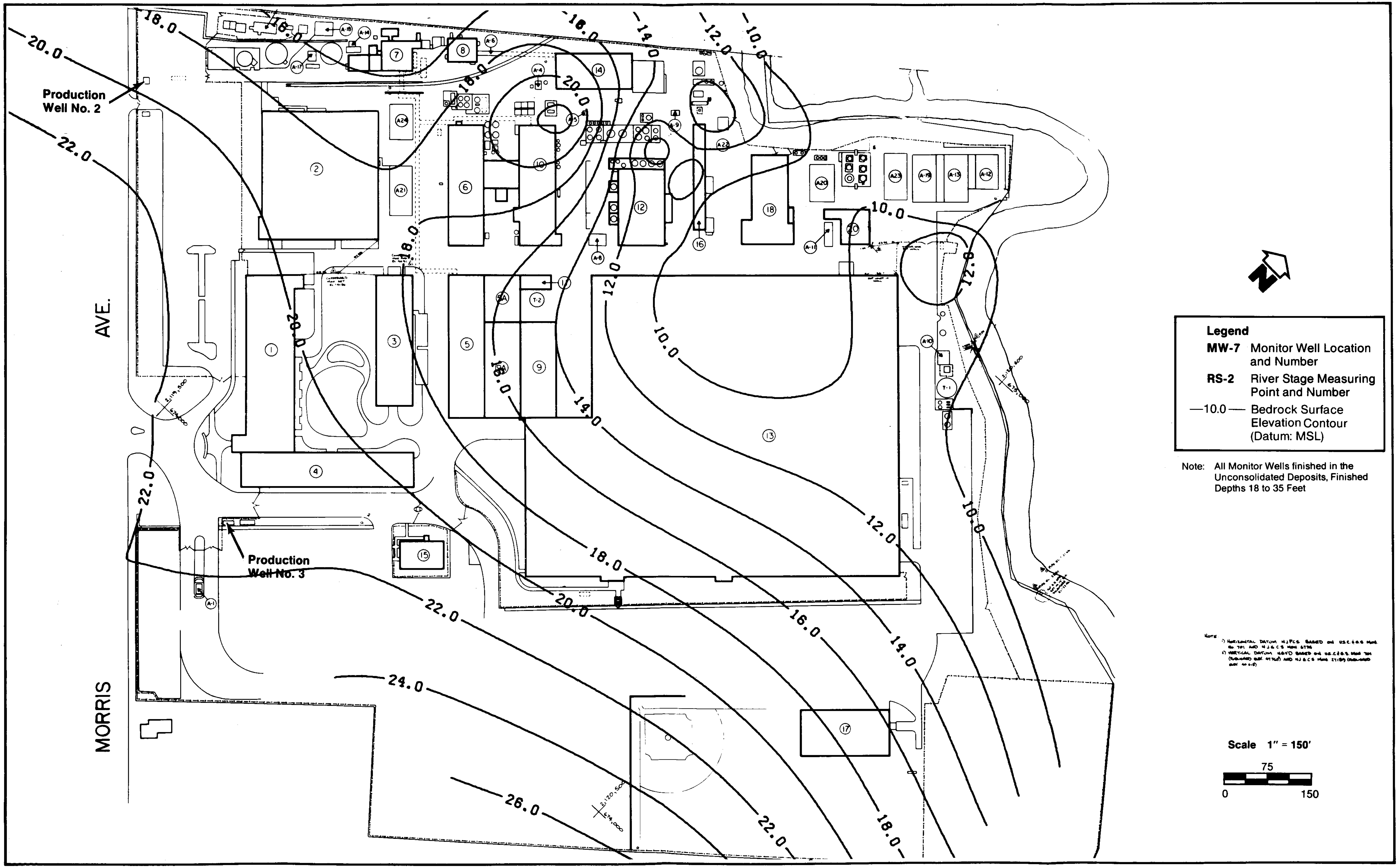


FIGURE 5-11 BEDROCK SURFACE CONTOUR MAP BENEATH THE SCHERING FACILITY

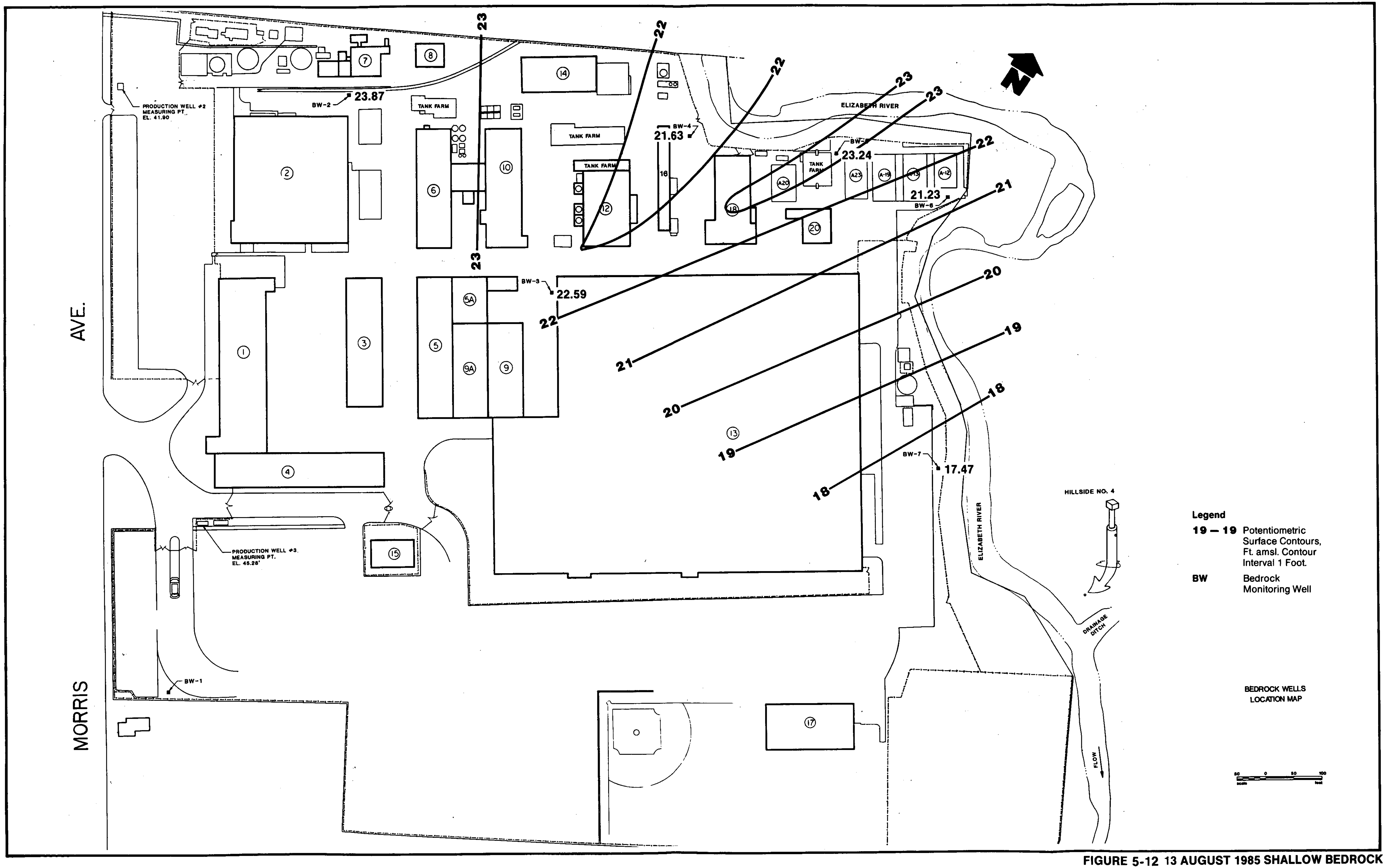


FIGURE 5-12 13 AUGUST 1985 SHALLOW BEDROCK (BW) MONITORING WELL POTENTIOMETRIC SURFACE

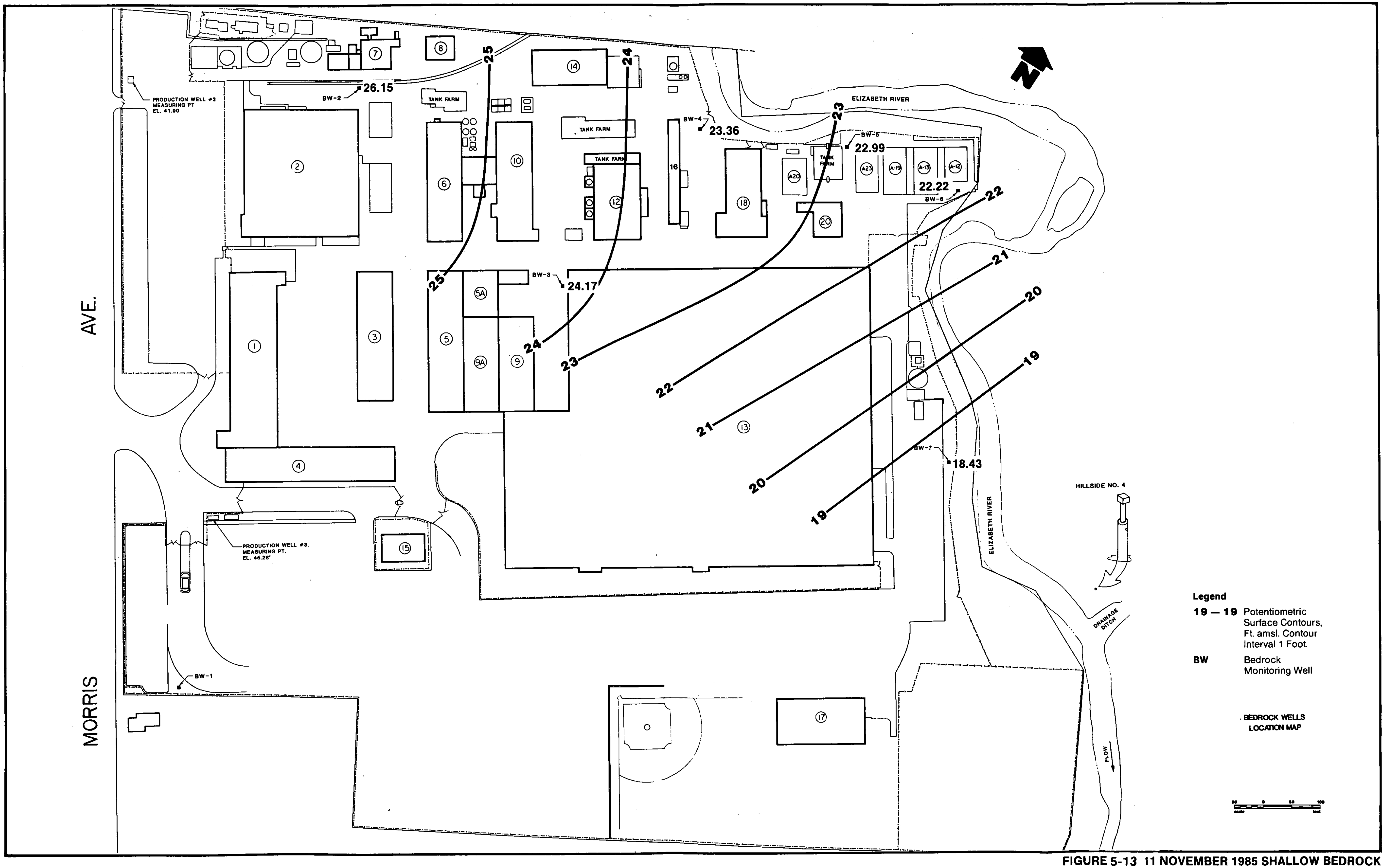


FIGURE 5-13 11 NOVEMBER 1985 SHALLOW BEDROCK (BW) MONITORING WELL POTENTIOMETRIC SURFACE

WESTON DESIGNERS CONSULTANTS

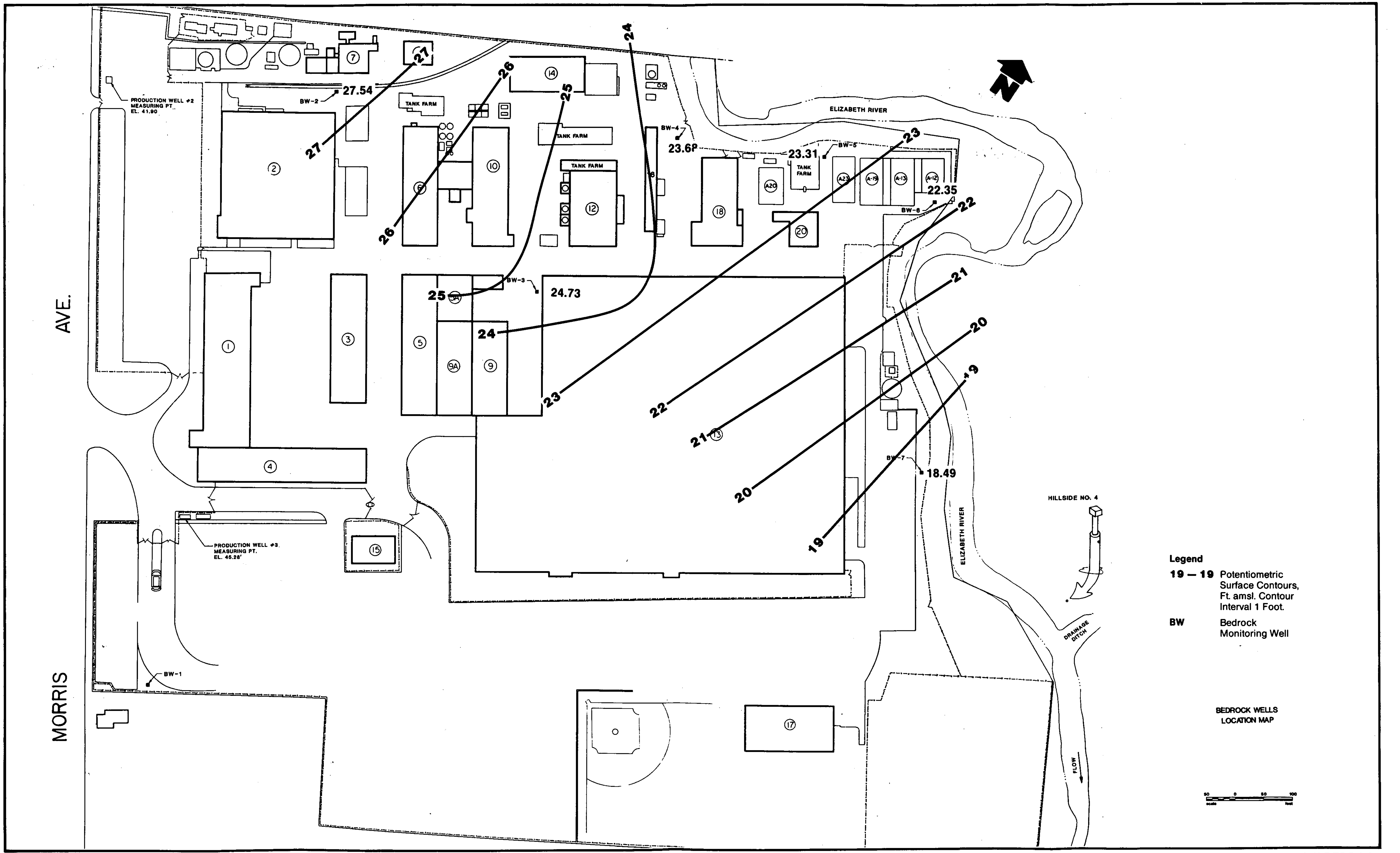


FIGURE 5-14 14 APRIL 1986 SHALLOW BEDROCK (BW) MONITORING WELL POTENTIOMETRIC SURFACE

Figure 5-15 illustrates the water level changes in Hillside No. 4 during the period from February 1985 to November 1985. This graph shows that between August and September the water level in Hillside 4 began to rise. Between February and April, the same rising trend is apparent. This increase in water level begins at the end of October and extends to the middle of April during the period of lowest evapotranspiration and increased infiltration (Nemickas, 1976).

BW-1 was not used in the potentiometric surface maps because it responds directly to changes in pumping in PW-3. This indicates that both wells intercept the same fracture zone and that BW-1 is not part of the hydrogeologic system represented by BW-2 through BW-7.

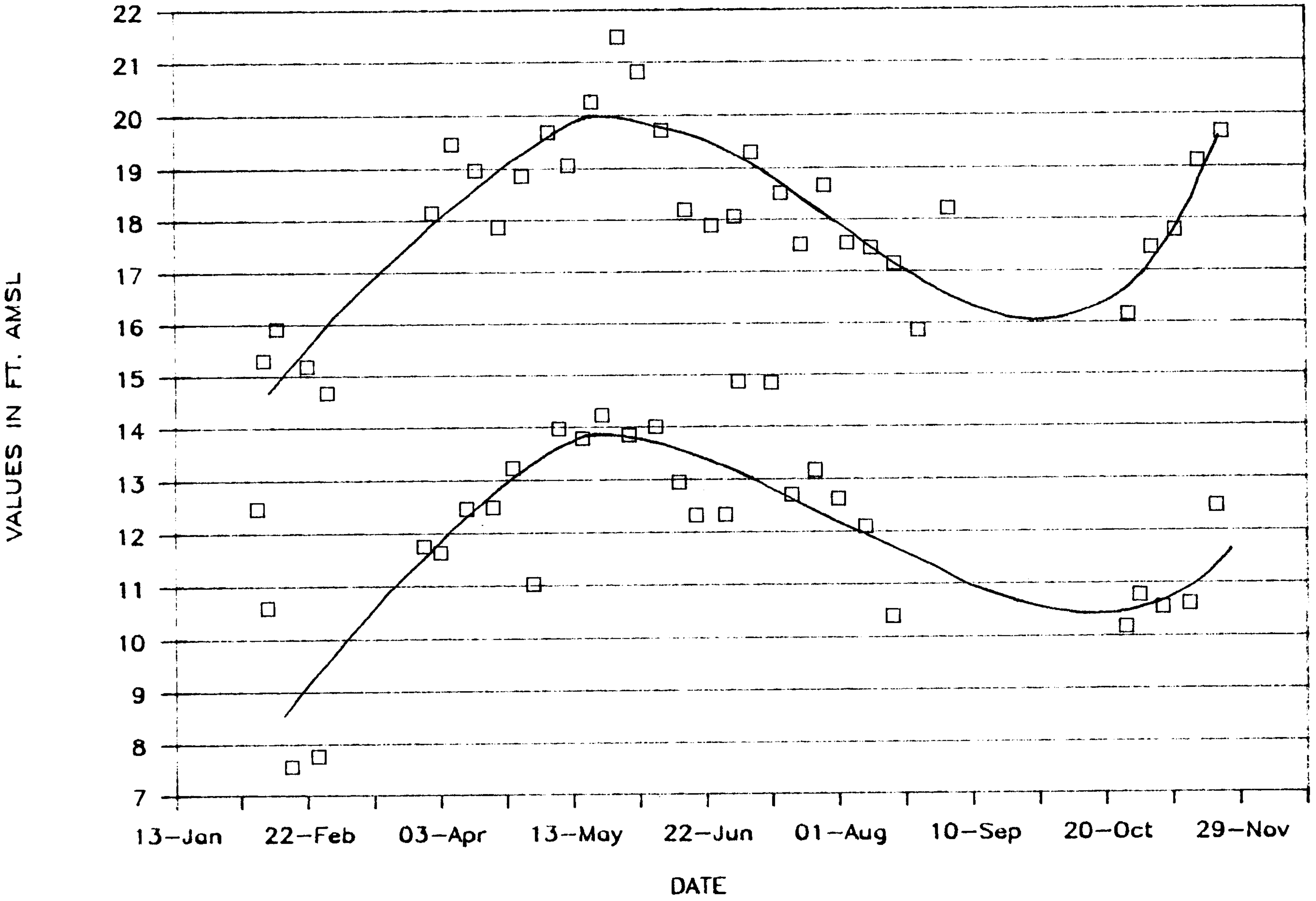
The shape of this surface is probably controlled by fracture patterns and stratification within the bedrock. Pumping at Schering production wells PW-2 and PW-3 does not cause the gradient to shift toward them, probably due to the fact that the pumping wells simply do not intercept the same fracture zones as the shallow bedrock wells. In addition, there may be low-permeability strata between the deeper pumping zones and the shallow bedrock zone. PW-2 is cased to a depth greater than the bottom elevation of the shallow bedrock monitoring wells, thereby reducing the potential for PW-2 to intercept fractures in the shallow zone.

Observation of the pattern of occurrence of volatile organic priority pollutants (VOC's) also points to the fractured nature of the bedrock. BW-2, BW-4, BW-5, and BW-6 all lie along a line trending N69°E and samples from each contain some VOC's. However, the downgradient well, BW-7, has not exhibited the presence of VOC's. This observation strongly suggests fracture control of groundwater flow in the shallow bedrock zone. For example, it is possible that the absence of VOC's in BW-7 results from the constituents moving downward and passing under the well. If this were the case, then Hillside No. 4, which is 400 feet deep, might intercept a fracture with a relatively shallow dip of less than 45°. However, data from Hillside No. 4 are inconclusive at this time. Chloroform and toluene have been detected sporadically in three samples. These observations indicate that the fracture probably has a steep dip of 50° or greater. The literature cites values of 70° to 90° for dip, thereby supporting the conclusion that this fracture has a very steep dip which is not intercepted directly by BW-7 or Hillside No. 4.

FIGURE 5-15

HILLSIDE FOUR OBSERVATION WELL [1]

WATER LEVEL ELEVATIONS 1985



1. The upper curve represents the trend in high water levels and the lower curve represents the trend in low water levels as measured in Hillside No. 4

Finally the pattern of flow in the Elizabeth River suggests the presence of fractures in the bedrock. In Section 3, the possible fracture control of the major bend in the Elizabeth River was discussed. This bend trends along a line striking about N50°E and is in line with the regional strike of the beds. Examination of aerial photos shows several sharp bends in the river course which are suggestive of fracture control.

In summary, lateral groundwater movement in the shallow bedrock zone is to the east and is apparently controlled by fractures in the bedrock. Vertical permeability in the upper bedrock zone was estimated using data from a pump test and is discussed below. Although groundwater flow rates are difficult to calculate in fractured flow systems (due to the complicated and largely unknown fracture pattern), the velocity was calculated to be 6 to 15 ft/day as shown in Appendix J.

5.3.4.4 Analysis of the Brunswick Formation Pump Tests Data

Two aquifer-pumping tests have been conducted on bedrock wells at the Schering facility. One test was completed in September 1984 and the other in October 1985. These tests had four primary goals:

- Determine hydraulic properties of the shallow bedrock aquifer underlying the Schering facility, including boundary conditions, transmissivities, and storativities.
- Compare results of both tests to check the validity and consistency of the data.
- Provide some of the data required to assess the potential for downward flow of groundwater (and migration of contaminants) from the unconsolidated deposits to the underlying Brunswick Formation.
- Provide data needed to evaluate the feasibility of possible remedial actions.

Schering's Production Well 3 (PW-3) was used as the pumping well in both aquifer tests. The effect of pumping on the Brunswick Formation was closely monitored in wells screened in the shallow alluvium and in wells penetrating the bedrock. Drawdowns from wells PW-2, H-4, and BW-1 were analyzed using the Theis equation to determine the aquifer characteristics of the Brunswick Formation. Drawdown measurements were also collected in several other wells. A complete description of the aquifer-pumping test procedure is provided in Subsection 4.5.2. The pump test data calculations are included in Appendix J.

Groundwater movement in the Brunswick Formation is dependent on numerous physical properties of the rocks themselves. These include the variations in fracture orientations, lengths and density, roughness, and tortuosity. Also important are the interconnectedness of the fractures, aperture relationships, and stratigraphic bedding properties. It is important to understand how these characteristics will affect the quantitative analysis.

The quantitative analysis of fracture flow can be treated with a continuum approach or with a noncontinuum approach, based on the hydraulics of flow in the individual fractures. The continuum approach allows the spatial definition of values for porosity, storativity and hydraulic conductivity to be assigned. This method is valid as long as the fracture spacing is sufficiently dense that the fractured media acts in a hydraulically similar fashion to granular porous media. If the fracture spacings are irregular in a given direction, the media will exhibit trending heterogeneity. If the fracture spacings are different in one direction than they are in another, the media will behave anisotropically. The selection of equations or computing procedures to be used for the flow analysis is governed largely by the physical condition of the aquifer, because they establish the hydraulic boundaries of the system.

After careful evaluation of the subsurface geology and hydrogeologic properties of the Brunswick Formation, it was concluded that the aquifer characteristics could be satisfactorily determined using equations derived for continuum conditions.

The non-equilibrium well formula developed by Theis (1935) was used to examine the data collected from the 1984 and 1985 aquifer tests. The Theis formula takes into account the effect of pumping time on well yield and eliminates the need for drawdowns in observation wells to reach equilibrium with the system. The following assumptions are inherent within the Theis solution:

- The aquifer is of infinite areal extent.
- Transmissivity and storativity are uniform in all directions.
- Pumping and observation wells fully penetrate the aquifer.
- The pumping and observation wells are of infinitely small diameter.
- No recharge occurs to the system.

- Flow to the pumping well is radial.
- There are no sources or sinks except the pumping well.
- Water is not compressible and the aquifer is elastic.

Obviously no natural system will meet all of the above criteria and aquifer characteristics determined with this method will be subject to some degree of error. However, it should be recognized that these and many other idealizations are necessary before mathematical analogs can properly represent the physical phenomena associated with groundwater movement. Therefore, it becomes necessary to explain any existing digressions between field observations and theoretical predictions derived from mathematical interpretations.

From the Theis formula the most important properties of the aquifer can be quantified; that is, its ability to store and transmit water. These two characteristics, referred to as the coefficient of storage and the transmissivity, generally provide the foundation on which quantitative studies are constructed. Furthermore, quantitative knowledge of these characteristics facilitate measurement of hydrologic properties, such as recharge, leakage, groundwater velocities, and evapotranspiration.

The storativity (S) of an aquifer is defined as the volume of water released from or taken into unit storage per unit surface area of the aquifer per unit change in the component of head normal to that surface.

For unconfined aquifers, storativity is called specific yield (Sy) and is defined as the volume of water that an unconfined aquifer releases from storage per unit surface area of the aquifer per unit decline in the water table. Therefore, water released from storage in an unconfined aquifer is derived predominantly from the draining of the interstitial pores thus enabling a large volume of water to be removed before a measurable drop in the water table occurs.

In confined aquifers however, assuming the aquifer remains saturated, changes in pressure produce only small changes in storage volume. Thus, the hydrostatic pressure within an aquifer partially supports the weight of the overburden, while the solid structure of the aquifer provides the remaining support. When the hydrostatic pressure is reduced, such as by pumping water from a well penetrating the aquifer, the aquifer load increases. A compression of the aquifer results and forces some water from it. In addition, the lowering of the pressure causes a small expansion and subsequent release of water. Since potential yields from both of these processes are low, the removal of small volumes of water from the aquifer will result in large decreases in the potentiometric surface.

Nemickas (1976) reported that groundwater in the Brunswick Formation occurs under both confined and unconfined conditions in the Union area. Storativity values calculated from the aquifer-pumping tests performed within the Brunswick Formation (WESTON, 1984 and 1985) are listed in Table 5-4 and indicate that the groundwater is under semi-confined conditions. Furthermore, prior to the aquifer-pumping tests, water levels in the bedrock monitoring wells had some drawdown approximately one-half to one hour after the pumping tests were begun. If true confined conditions prevailed, the response in the bedrock wells would have occurred almost instantaneously. This observation also indicates that the wells, PW-3, PW-2, BW-1, and H-4 all intercept a fairly well developed fracture system which is not as well connected to the system penetrated by the other shallow bedrock monitoring wells.

After pumping for 900 to 1,100 minutes during the 1985 aquifer test, an abrupt increase in drawdown rates was observed in the deep monitoring wells penetrating the Brunswick Formation. Similar changes in drawdown rates, noted at approximately the same time after pumping began, during the 1984 aquifer test, suggest that the deflection is representative of the physical boundary characteristics of the aquifer and not from extraneous influences such as other pumping wells outside the study area. The most reasonable explanation for the sharp deflection is that the outer extent of the water producing fracture zone had been reached and the yields from the poorly fractured rocks were lower, resulting in greater drawdowns.

The distance that measurable drawdowns occurred in observation wells, in response to pumping PW-3, suggests that the radius of influence extends, at a minimum, underneath the entire Schering facility. Theoretical distance-drawdown calculations indicate that if PW-3 was pumped at a rate of 400 gpm for 100 minutes the cone of depression, excluding outside influences, would extend approximately 8,000 feet. However, classical interpretations of expected drawdowns are subject to some degree of error due to the inhomogeneity of the fractured rocks.

Table 5-4

Hydrogeologic Characteristics of the Brunswick Formation Monitor Wells

Location	Transmissivity (gal/day/ft)	Storativity	Total Drawdown at the Conclusion of the Test (feet)
1984 Pump Test Data			
PW-1	165,972	4.9×10^{-3}	1.78
PW-2	16,597	1.2×10^{-4}	18.87
H-4	40,110	4.8×10^{-4}	13.15
1985 Pump Test Data			
PW-2	30,560	1.19×10^{-4}	18
Hillside No. 4	45,840	6.42×10^{-4}	6.5
BW-1	12,390	1.50×10^{-3}	17

Transmissivity (T) is expressed as the rate of flow of water, at the prevailing water temperature, through a vertical strip of the aquifer, one foot wide extending the full saturated height of the aquifer under a hydraulic gradient of 100 percent.

In general, calculated transmissivity values from both aquifer tests (WESTON, 1984 and 1985) are fairly consistent as shown in Table 5-4. The notable exception is PW-1, which has a relatively large transmissivity value (165,972 gpd/ft). However, the storativity value (4.9×10^{-3}) is also an order of magnitude greater than the values obtained for the other bedrock monitoring wells. This suggests that a greater volume of water has been derived through leakage of the overlying alluvium, resulting in an anomalously high transmissivity value. Examination of T values shown in Table 5-4 shows that the ratio of the T at Hillside No. 4 to T at PW-2 is 2.4 and 1.5 for the 1984 and 1985 data, respectively. This observation is consistent with what would be expected in an anisotropic system where the aquifer's ability to transmit water is greater in one direction than another. The line connecting PW-3 and Hillside No. 4 has a strike of N64°E, which is in the direction of the strike of the beds and the strike of the primary jointset in the bedrock. Therefore, while the value of T at H-4 probably is not the maximum value of T, it indicates that transmissivity is 2 to 3 times greater in the direction of the strike than in the direction perpendicular to the strike.

5.3.4.5 Vertical Hydraulic Conductivity in the Upper Zone of the Brunswick Formation

Data from the pump test were analyzed to determine vertical conductivity in the Brunswick using the ratio method of Neuman and Witherspoon (1972). The calculations and discussion of the method are included in Appendix J. Data from PW-2, a deep bedrock monitoring well, and BW-2, a shallow monitoring well, were used in the method. Using drawdown data from these wells and assuming a storativity of 1.19×10^{-4}, a K of 1.10×10^{-3} ft/day was calculated. The storativity used was calculated from the pump test data at BW-1 (Table 5-4). This K is representative of the vertical permeability in the aquifer between the open borehole in BW-2 to a depth of 200 feet below ground surface. This depth of 200 feet was chosen because Nemickas (1976) observed that the most productive zone for groundwater in the Brunswick is between 200 and 600 feet below the ground surface. This K value is very low and indicates that lateral groundwater movement is greater than the vertical movement in the shallow bedrock. This value has been incorporated into the groundwater flow model to help in determining the probable groundwater flow directions and rates.

5.3.5 Numerical Groundwater Modeling

5.3.5.1 Overview

Groundwater modeling techniques are being applied as part of the RI/FS being conducted by WESTON at Schering Corporation's Union, New Jersey facility. The purpose of the modeling is to describe the complex hydrologic flow system in three dimensions and to assess its control of contaminant migration in the vicinity of Schering. Such an understanding will greatly aid in assessing the potential for off-site contaminant migration and in evaluating the effectiveness of proposed remedial action alternatives. The model developed for the RI is a regional model that is intended to simulate the regional groundwater flow conditions and their influence on the site. Therefore, the site itself has not been modeled in full detail.

Numerical groundwater models offer an effective method to quantitatively integrate hydraulic characteristics of groundwater systems which vary in three-dimensional space and time. These models allow a system-wide assessment of groundwater flow directions, rates, and fluxes.

5.3.5.2 Code Selection

The computer code "A Modular Three-Dimensional Finite-Difference Groundwater Flow Model" (MODFLOW) developed by the U.S. Geologic Survey (USGS) was chosen to model the groundwater flow system in the vicinity of Schering (McDonald and Harbaugh, 1984). MODFLOW is a thoroughly documented, verified, and validated numerical model capable of simulating groundwater flow in three dimensions.

The model incorporates all the important spatially and temporally variable hydrologic features of a complex flow system, including boundary and initial conditions, multiple layers, irregular geometry, anisotropy, recharge, pumping wells, and rivers.

5.3.5.3 Available Data

The data collected throughout the RI provide the basis for the development of a three-dimensional groundwater flow model. These data include:

- Historical data, including site maps and aerial photographs.
- Regional geologic and hydrogeologic data (previous geological studies, technical papers, and maps).
- Well logs, including those available from wells constructed at Schering and in the surrounding area.

- Regional aquifer use data, NJDEP diversion permits, well records, State of New Jersey water year reports.
- Aquifer test results, from tests conducted at Schering, and from published sources (i.e., diversion permits, technical papers).
- Groundwater surface elevations obtained from measurements at Schering and from regional observation well records.
- Stage and flow measurements taken on the Elizabeth River.
- Water budget, including times and rates of annual groundwater recharge for Union County, New Jersey U.S. Geological Survey (USGS).

5.3.5.4 Conceptual Model Approach

The first step used to model the plant site was to formulate a conceptual understanding of the physical system to be analyzed. This was done by evaluating the available data to identify the important system features which control the occurrence and movement of groundwater and contaminants. The characteristics of the flow system that affect groundwater movement include the physical framework, hydrologic properties, recharge and discharge areas, and chemical properties. The conceptual model was based on regional geologic conditions, the full complement of data collected during the RI and previous studies, field observations, and topographic maps and aerial photographs.

After formulating the conceptual model of the physical system, the controlling system features or characteristics were identified and translated into a mathematical model. The mathematical model is a representation of the natural system. This conceptual model consists of partial differential equations based on conservation of mass and momentum with appropriate boundary and initial conditions that closely describe the natural system. Boundary conditions are mathematical representations of hydraulic and chemical conditions at the physical boundaries of the modeled flow system. At impermeable boundaries, the groundwater flow is zero. At constant-head boundaries, the water level elevation remains constant. These are examples of boundary conditions included in the model.

Development of the numerical model involves subdividing the area of interest into regular geometric sub-areas, called nodes, which have uniform characteristics. This process is called discretization. Values for hydrogeologic properties are assigned to these nodes, and these values are incorporated into the model. The model selected for use must be based on a mathematical code which includes all the important system characteristics identified in the development of the conceptual model. The computer code then solves sets of simultaneous equations (one or more per each node) at prescribed time steps to determine the distribution of key hydraulic and chemical parameters in space and time.

5.3.5.5 Flow Model Configuration

The area included in the Schering model is 12.9 square miles. This large area was chosen to encompass the major regional pumping centers in the model and to define appropriate boundary conditions.

The model array consists of a variably-spaced, three-dimensional finite-difference grid of 22 rows, 28 columns and 3 layers (1,848 nodes). The grid was oriented parallel to the major axis of aquifer transmissivity, which coincides approximately with bedrock strike (N50°E) and major fracture trends (N45°E). The grid spacing was chosen to obtain an accurate solution, to incorporate the important features of the flow system, and to simplify future contaminant transport modeling. Two adjacent USGS 7-1/2 minute quadrangle topographic maps (Roselle, New Jersey, 1981, and Elizabeth, New Jersey 1981) were combined to form the base map. The outline of the model grid is shown in Plate 4.

The site boundary conditions established in each of the three layers are illustrated in Plate 8. These conditions include:

- The river node locations, established to model the Elizabeth River in layer 1.
- The relationship of the model grid to the underlying bedrock surface which forms the bottom of layer 1 and the top of layer 2.
- No flow boundaries.

The model domain was divided into cells defined by the finite-difference grid. Finite-difference theory assumes that hydrologic properties are uniform within each grid cell. Because of this, areas within the model domain that show rapid changes in hydrogeologic properties or areas of particular interest are subdivided (discretized) into still smaller cells. The model was subdivided into grid blocks with dimensions of 158 ft x 158 ft. The size of the grid blocks generally increases with increasing distance from the plant.

The area was further discretized into three layers in the vertical dimension. Each layer represents a specific geologic zone for which aquifer properties have been measured. The three layers are defined as follows:

Layer 1 - Unconsolidated glacial outwash deposits, having an unconfined water surface.

Layer 2 - Shallow bedrock, having a semi-confined water surface defined by the top of bedrock to a depth of 50 ft.

Layer 3 - Deep bedrock, Brunswick Formation, having a confined water surface defined by the base of layer 2 and extending to 600 ft.

Aquifer tests conducted at the Schering site indicated that the horizontal to vertical anisotropy of hydraulic conductivity is a significant factor controlling groundwater flow. By utilizing a three-dimensional model, system anisotropy and layering effects can be incorporated into the model.

5.3.5.6 Boundary Conditions

Two types of boundary conditions were used in the Schering model. These were constant head (water level), and specified flux (flow rate) boundaries. Constant head boundary conditions fix the water elevation in a specified grid cell for the duration of the simulation. Specified flux boundary conditions are used to simulate wells and areas receiving recharge. Constant flux consists of specifying an amount of water entering or leaving a cell from an external source or sink.

River nodes were used to simulate the Elizabeth River in layer 1. A river node is a constant head node with a conductance term allowing leakage between the river bottom and the aquifer. Constant head nodes were also used along the northwestern edge of the model in all three layers. In addition, constant head nodes were used in the northeast corner of the model area since this condition best approximated observations.

A no-flow boundary is a type of specified flux boundary condition in which no water is allowed to pass through a particular cell face. A no-flow boundary has a specified flux of zero. No-flow conditions were applied in nodes to the west of the Elizabeth River drainage basin boundary in layer 1. No-flow boundaries were also applied in layer 1 where the bedrock outcrops at the surface, because at these locations, layer 1 does not exist.

Constant flux nodes were located at pumping wells. A total of 17 pumping centers were simulated. Production rates and grid locations of each pumping center are shown in Plate 8. The pumping rate used to simulate each well was specified for the layer from which the well discharges water. The layer in which a pumping well is located is based on the elevation of the open interval of the well and the elevation of the vertical layer boundaries at that node.

The final specified flux boundary condition is the recharge rate, which is applied to the uppermost active cell in each vertical column. Constant head nodes intercept recharge and prevent deeper infiltration. Based on typical measurements and estimates for this hydrogeologic setting, recharge was defined over the entire model area at a rate of 7.5 inches/year. Recharge was then reduced over the Schering site to 1.5 inches/year to improve model calibration. Lower recharge is likely at the plant because large areas are covered by pavement and buildings.

5.3.5.7 Aquifer Properties

To simulate groundwater flow in three dimensions, hydraulic conductivity in the X-, Y-, and Z-directions was defined for each grid cell. Since data are not sufficient to assign unique values of hydraulic conductivity to each cell, estimated properties are assigned to entire layers or groups of cells.

In layer 1, a hydraulic conductivity of 20 feet per day was assigned to each node in both X- and Y-directions. Initially, a value of 14 ft/day was used based on the results of piezometer tests conducted at Schering. The final value of 20 ft/day was arrived at by systematic trial and provides the best overall model calibration. In the Z-direction, a vertical conductance term was applied between nodes in layer 1 and layer 2. The vertical conductance is the vertical hydraulic conductivity between nodes in adjacent layers divided by the vertical distances between the nodes in each layer. A value for vertical conductance equal to 3×10^{-5} per day was assigned to each node in layer 1. This value was computed using the vertical hydraulic conductivity computed by analyzing pumping test data using the ratio method.

In layer 2, a hydraulic conductivity of 50 feet per day in the X-direction was assigned to each node. This value was computed using the transmissivity computed at BW-1 from pump test data and the thickness of layer 2 (50 ft). This value was multiplied by 0.2 (based on an anisotropy factor estimated from aquifer pumping tests) to obtain 10 feet per day for hydraulic conductivity in the Y-direction. A vertical conductance term of 1×10^{-4} per day was assigned to each node in layer 2. This number represents the vertical conductance between layer 2 and layer 3.

In layer 3, transmissivity values in the X-direction were assigned to each node. These values were multiplied by 0.3 (which was an anisotropy factor) to obtain transmissivity in the Y-direction. Other values for transmissivity were assigned to nodes where aquifer pumping test results were available such as at Schering-Kenilworth and the Elizabethtown Water Company pumping centers at Chandler Avenue, First Avenue, St. Walburga, Richfield Avenue, and Quinton Avenue.

5.3.5.8 Flow Model Calibration and Sensitivity Analysis

Application of a numerical model to a field problem requires an evaluation of how well the site conditions are incorporated into the model. This process is called model calibration. The model is generally used to simulate certain sets of hydrologic conditions in both steady and transient states for which the aquifer response is known. The calculated model response is compared to the observed response. If the comparison is satisfactory, no additional calibration is needed and the model is ready to be used for predictions. The accuracy of the model predictions is related primarily to how well the model represents the real system, which, in turn, is related partly to how well the model has been calibrated.

The initial calibration was accomplished by comparing computed piezometric surface to water levels measured in each of the three layers in October 1985. Calibration was performed assuming steady-state conditions with all major pumping centers running. Additional calibration for the FS study will be performed for transient conditions.

Water levels used in the model calibration were measured in October 1985 and this time represents a seasonal low for aquifer water levels. Aquifer tests were also conducted in October 1985. Aquifer response to pumping is best determined at times of seasonal lows because possible effects from uncontrolled recharge are minimal (e.g., spring meltwater, early summer flooding).

A satisfactory steady-state calibration for the October 1985 conditions was obtained as a result of the calibration process. The calibration results are shown in Table 5-5. The computed heads in layer 1 and the measured heads in layer 1 are compared in Plate 9, Sheet 3.

The calculated water levels approximate the observed water levels within an acceptable tolerance or error. Twenty-two wells were used as calibration targets. As shown in Table 5-5, all calibration targets were approximated within a tolerance of ±5 ft except for the Exxon well in layer 1 and BW-1 in layer 2. Unlike the other BW's, BW-1 appears to be hydraulically connected to PW-3, probably through a fracture zone. Computed water levels in 16 of the 22 wells were within ±2 ft of the observed water level. All input data used in the model calibration, and the resulting model output, are included in Appendix L.

The sensitivity of the model to changes in aquifer properties and boundary conditions was analyzed to assess model uncertainty. The sensitivity analysis was performed by systematically changing the value of one model parameter or boundary condition and observing the response of the calibrated model to this change. The parameters that varied in the model were as follows:

- Horizontal and hydraulic conductivity.
- Vertical conductance.
- Recharge.
- Boundary conditions.

The model was most sensitive to changes in recharge and horizontal hydraulic conductivity in layer 1, and to horizontal hydraulic conductivity and vertical conductance in layers 2 and 3.

5.3.5.9 Groundwater Flow Modeling Results

The model results show groundwater flow in the unconsolidated deposits towards the Elizabeth River in the vicinity of the Schering facility. A contour plot of the potentiometric surface in the unconsolidated deposits (layer 1) is shown in Plate 9, Sheet 1. Plate 9, Sheet 2 shows isometric, three-dimensional perspective plots of the heads in each layer. These data clearly show groundwater flow in the unconsolidated deposits towards the Elizabeth River in the vicinity of Schering. The model also predicts a groundwater divide to the northwest of the facility. Since the location of this flow divide is between Schering and the Hummocks well field, groundwater from Schering will not flow into this or any other public supply well field.

Table 5-5

Model Calibration Results

Layer	Location	Row	Column	Observed Water Level (10/85)	Computed Water Level	Residual (Observed - Computed)
1	Exxon	7	5	84	90	-6
1	Texaco	8	14	35	39	-4
1	Schering Union					
	MW-7	17	21	21	21	0
	MW-10	15	17	29	30	-1
	MW-11	17	14	33	35	-2
	MW-13	14	21	22	22	0
	MW-15	12	15	33	35	-2
	MW-16	12	16	32	33	-1
	MW-17	15	14	33	36	-3
	MW-20	13	17	31	30	1
	MW-21	14	18	28	28	0
	MW-23	12	18	26	28	-2
	MW-25	14	19	26	26	0
	MW-27	14	20	24	24	0
2	Schering Union					
	BW-1	17	12	-8	20	-28
	BW-2	12	14	26	21	5
	BW-3	14	16	22	21	1
	BW-4	12	18	23	21	2
	BW-5	12	20	23	21	2
	BW-6	13	20	22	21	1
	BW-7	16	20	17	20	-3
3	Hillside No. 4	17	22	11	10	1

The model also indicates that flow in the shallow zone of the Brunswick Formation (layer 2) is to the east and away from the Hummocks well field and other public supply wells.

The flow model shows that Schering Production Wells 2 and 3 strongly influence groundwater flow in layer 3 in the vicinity of the Schering facility. Using the potentiometric surface data for layer 3, as shown in Plate 9, Sheet 1, a lateral groundwater flow velocity range of 0.31 ft/day to 0.8 ft/day (100 ft/yr to 280 ft/yr) was computed in the vicinity of Schering. A horizontal gradient of 4.2×10^{-3} was computed using model results and an effective porosity of 2 to 5 percent was assumed. The model also shows another major influence on layer 3 is the pumping wells at Schering's facility in Kenilworth, New Jersey. The Hummocks well field has little, if any, influence on layer 3 because its wells pump primarily from the Kenilworth-Newark Valley and to a lesser extent from layer 2.

The model will be used continuously in the FS for testing various remedial alternatives. Simulations will be made to evaluate the effectiveness of the different proposed alternatives (including no-action) and to provide additional data to assist in ranking. This technical ranking will be combined with economic considerations to select an acceptable remedial plan.

Section 6
Nature and Extent of Environmental Concerns

6. Nature and Extent of
Environmental Concerns

SECTION 6

NATURE AND EXTENT OF ENVIRONMENTAL CONCERNS

6.1 OVERVIEW

The findings of the Remedial Investigation (RI) have allowed the identification and description of environmental concerns at the Schering facility. In the RI/FS Workplan (WESTON, 1985), four zones of the facility were designated for an RI to determine if they constituted significant environmental concerns. These zones were:

- Zone 1: the area east of Building 10 and north of Building 13 where volatile organic priority pollutant compounds (VOCs) had been detected in unsaturated sediments and groundwater during the Phase I work. (Area = 4.88 acres)

- Zone 2: the area where one sediment sample showed elevated levels of chromium. (Area = 1.32 acres)

- Zone 3: the area in the vicinity of MW-7 where a sediment sample showed several base/neutral (B/N) priority pollutants. (Area = 0.18 acres)

- Zone 4: the area around Building 7 where groundwater samples from a bedrock well (PW-1, now abandoned) showed VOCs. (Area = 0.71 acres)

The findings of the RI show that the occurrence of VOCs in the groundwater and sediment present significant environmental concerns. The findings also show that the elevated chromium in Zone 2 and the base/neutrals in Zone 3 do not present significant environmental concerns.

The groundwater in the unconsolidated deposits and the shallow bedrock zone (approximately 65 feet below ground surface) in the vicinity of Building 7 and the northeast sector of the plant have been impacted by a limited number of volatile organic priority pollutants, chiefly: benzene, toluene, chloroform, methylene chloride and carbon tetrachloride. Seventeen tentatively identified, non-priority pollutant volatile organic compounds were detected in the February 1986 groundwater samples. These compounds and, as yet, unidentified base/neutral and acid extractable non-priority pollutants, will be identified and quantified as part of the on-going water quality investigation. Sources of the organic chemicals in the groundwater include past materials handling practices and underground utility problems which have been discontinued or remedied.

Volatile organic compounds, chiefly benzene and toluene, have impacted the unsaturated sediments in the vicinity of Building 7 and the northeast sector of the plant. This problem resulted from a variety of past materials handling practices which were discontinued more than 10 years ago.

Off-site migration of volatile organic priority pollutants has occurred in the unconsolidated deposits, but it is limited to a relatively narrow area adjacent to the Elizabeth River. The potential exists for the off-site migration of contaminants in the shallow bedrock zone via flow along fractures. However, available data indicate that there are no groundwater users directly downgradient along the probable direction of migration.

Two areas of the facility investigated during the RI do not present a threat to the environment:

- Zone 2: The area of the former surface impoundments, in the area now occupied by Building 14, is not serving as a source of chromium contamination to the environment.

- Zone 3: The area in the vicinity of MW-7, east of Building 13, was filled during development of the site. This fill contained demolition debris including asphalt and bricks. Coal tars, a common component of asphalt, are believed to be the source of the low level of base/neutral priority pollutants identified in two of the ten samples collected in this area. These isolated pockets of base/neutrals have no impact on groundwater quality as indicated by the results of groundwater sample analyses completed over a two year period.

- The surface water investigation found no significant levels of volatile organic priority pollutants in samples collected from the Elizabeth River upstream, and downstream of the Schering facility.

- The air investigation showed levels of total hydrocarbon above background readings only during drilling operations which provided a pathway to the subsurface and only in the immediate vicinity of the drilling rig.

This section is organized to discuss the environmental concerns in order of priority:

- Significant environmental concerns.
  - VOCs in groundwater.
  - VOCs in sediment.
- Areas found not to be of concern.
  - Chromium in the former surface impoundment area.
  - Base/neutrals in the sediment near MW-7.

Within each section the following points are addressed:

- Nature and Extent of Concern
- Potential Sources
- Migration Potential (if appropriate)

On-going investigations are discussed where appropriate.

6.2 GROUNDWATER QUALITY AT THE SCHERING FACILITY

6.2.1 Overview

The groundwater sampling program conducted during Phase II and the RI has provided data on three distinct hydrogeologic units:

- The unconsolidated deposits both on-site and off-site are monitored with 28 monitoring wells and 20 piezometers.
- The seven shallow bedrock monitoring wells installed on the Schering facility are completed with open boreholes 30 feet into the bedrock aquifer.
- Schering production wells PW-2 and PW-3 and observation well Hillside No. 4 provide groundwater quality data on the deeper bedrock aquifer.

The location of these sampling points are shown in Plate 2.

The sampling program shows groundwater contamination caused by 14 volatile organic priority pollutant compounds. Occurring most frequently and in the highest concentrations are toluene, benzene, chloroform, and methylene chloride. These compounds have been identified in groundwater in the unconsolidated deposits and the shallow bedrock zone beneath the Schering facility. In groundwater samples from three of the four off-site piezometers, these four compounds as well as carbon tetrachloride have been detected.

Benzene, toluene, chloroform, methylene chloride, carbon tetrachloride, and 1,2-Dichloroethane have also been detected in four of the seven shallow bedrock monitoring wells. The two Schering production wells, PW-2 and PW-3, provide samples from the deeper bedrock aquifer and show the consistent albeit low level occurrence of trichloroethylene, tetrachlorethylene, and the occasional occurrence of chloroform. No direct link between the contaminants in the shallow bedrock monitoring wells and contaminants in the deep bedrock has been established. Since benzene, toluene, chloroform, and methylene chloride occur most frequently and in the highest concentrations up to 1,000 ppm, they will be used as indicator parameters to delineate the extent of groundwater contamination at the Schering facility.

The groundwater quality investigation also showed the occurrence of several base/neutral priority pollutants in several locations at concentrations below 100 ppb in the unconsolidated sediments and the shallow bedrock zone. These compounds generally occur in association with high levels of VOCs. Analyses were performed for a variety of inorganic parameters including priority pollutant and Safe Drinking Water Act metals. No environmental concerns are posed by metals or other inorganic compounds.

6.2.2 Groundwater Quality in the Unconsolidated Deposits

6.2.2.1 Occurrence of Volatile Organic Priority Pollutants

Fourteen volatile organic priority pollutants (VOC's) have been detected in the groundwater samples from the unconsolidated deposits. Table 6-1 lists these compounds and the concentration ranges in the sampling locations where the VOC's were detected. This analysis of the data shows that benzene, toluene, chloroform, and methylene chloride occur most frequently and in the highest concentrations. A summary tabulation of the results of the groundwater sampling in the unconsolidated deposits is included in Appendix M.

Table 6-1 shows that the VOCs were frequently detected at low concentrations ranging from 0.005 ppm (not detected) to 0.1 ppm. VOCs were also frequently detected at concentrations greater than 1 ppm. The frequency of positive samples is, in part, an artifact of the sampling scheme which was designed to delineate the extent of contaminated areas. The sampling locations are not evenly distributed, but rather are grouped in areas of suspected contamination. Thus, statistics from the number of samples showing positive results for any given analysis are not a meaningful measure of the degree of overall site contamination.

Table 6-1

Summary of Volatile Organic Priority Pollutant Occurrence in On-site and Off-site Unconsolidated Deposits

	Concentration Range (ppm)				
Compound	ND< x ≤0.1	0.1< x ≤1	1< x ≤10	10< x ≤100	100< x ≤1000
Benzene	P-2, P-4, PE-6, PE-7, MW-2	PE-2, MW-4, MW-9	P-5, P-6, MW-3, MW-25, MW-27, PE-1	P-10, NW-13, PE-8, MW-20 MW-21	MW-5
Toluene		P-2, MW-15, MW-16	P-4, PE-1, PE-2, MW-13	P-6, MW-3, MW-5, MW-19, MW-25, MW-27	P-5, MW-18, MW-22, MW-19 MW-21
Chloroform	MW-7	P-6, P-14, PE-1, PE-2	MW-3, MW-20	MW-5, MW-21, MW-27	MW-20, MW-25
Methylene Chloride	P-2	P-5, PE-1, MW-3, MW-15	P-6, MW-16, MW-5	MW-18, MW-22 MW-27	
Carbon Tetrachloride	P-14	PE-1, PE-2	P-6	MW-3	
Chlorobenzene	PE-7, MW-26	MW-4	P-5	MW-20	
Ethyl Benzene	P-4, MW-4				
1,2 Dichloroethane	P-14, PE-1				
1,1 Dichloroethane	P-4, MW-10 MW-25				
1,1 Dichloroethylene	P-14, MW-10				
1,1,1-Trichloroethane	MW-10				
Trans-1,2-Dichloroethylene	P-2, MW-15, MW-16, MW-25				
TCE[1]	P-2, MW-15, MW-16				
PCE[2]			MW-25		

[1] TCE = Trichloroethylene.

[2] PCE - Tetrachloroethylene

Upgradient water quality is monitored by the wells listed in Table 6-2. Groundwater flow in the unconsolidated deposits is to the east, across the site and toward the Elizabeth River and then to the east southeast in the direction of the Elizabeth River flow. Volatile organic priority pollutants have not been detected on a consistent basis in any of the upgradient wells. This observation indicates that volatile organic priority pollutants are not migrating onto the Schering facility from off-site sources.

Isoconcentration plots show that the priority pollutant VOC's are concentrated in the northeast sector of the facility to the east of Building 10 and north of Building 13. Plate 10 shows isoconcentration plots for benzene, toluene, methylene chloride, and chloroform contamination in the unconsolidated deposits both beneath the Schering facility and in the area immediately to the east underlying the Woodruffs Section of the Elizabeth River Park. The benzene isoconcentration plot shows that benzene is the most widespread VOC and encompasses most of the area between Buildings 5, 10, and 13.

As shown in Plate 10, the benzene plume, at a concentration greater than the benzene MCL of 5 ppb, covers an area of about 10.5 acres. This includes two areas of off-site migration of 0:48 and 2.2 acres, respectively. (The off-site area is to the east of the west bank of the Elizabeth River and the area on the peninsula outside the Schering perimeter fence.) The toluene plume, at a concentration greater than its RMCL of 2,000 ppb, covers an area of 3.5 acres. This includes two off-site areas of 0.12 and 0.72 acres, respectively. The chloroform plume, at a concentration greater than its MCL of 100 ppb, covers an area of 2.6 acres. Included in this is an off-site area of 0.42 acres. Finally the two methylene chloride plumes above the detection limit of 5 ppb cover an area of 3.81 acres. This includes one off-site area of 0.14 acres adjacent to MW-3. The total site area is about 44.7 acres.

The influence of the groundwater flow direction is evident on the benzene plume and the other VOC plumes. The long axis of each plume is oriented in an easterly direction parallel to the direction of groundwater flow. This is to be expected since groundwater flow is the primary mechanism for contaminant transport. As shown in Table 6-1, the analytical data indicate that only benzene, toluene, chloroform, carbon tetrachloride, and chlorobenzene have been detected off-site. The occurrence of carbon tetrachloride and chlorobenzene, as well as the other VOCs, have not been mapped because they occur in association with either benzene, toluene, chloroform, or methylene chloride.

Table 6-2

Upgradient Groundwater Quality Monitoring Locations[1]

MW-1
MW-8
MW-11
MW-12
MW-14
MW-17
BW-1

---

[1] No volatile organic priority pollutants have been detected at these locations during the groundwater sampling program. See Plate 2 for locations.

6.2.2.2 Occurrence of Extractable Priority Pollutants

Base/neutral (B/N) priority pollutant compounds were detected in the shallow groundwater at concentrations of less than 100 ppb in samples from several wells. Table 6-3 lists the compounds detected and the wells where B/N compounds were detected on a consistent basis. Where detected, the base/neutral priority pollutants occur in association with much higher levels of volatile organic priority pollutants. Acid extractable priority pollutant compounds were not detected on a consistent basis or at significant levels at the Schering facility.

6.2.2.3 Occurrence of Non-Priority Pollutant Organics

Although the identified priority pollutant compounds are limited to a relatively small number, non-priority pollutants are more numerous. A total of 17 non-priority pollutant volatile species listed in Table 6-4 have been tentatively identified. These substances are generally polar compounds with significant water solubilities. Confirmation of these tentative identities will be attempted during the June 1986 sampling event. Substances which are confirmed by standards will be quantified.

Non-priority pollutant extractable compounds are considerably more numerous as indicated by complicated spectra. Tentative identification has been a much more tedious undertaking than for the volatile fraction. When the tentative identification of these compounds is completed the data will be forwarded to NJDEP. The Sampling and Analysis Plan (SAP) for identifying and quantifying some of these VOCs will be submitted to NJDEP as a separate document.

6.2.2.4 Occurrence of Metals and Other Inorganic Compounds

A variety of inorganic parameters, listed in Table 4-2, were analyzed to define water quality in the unconsolidated deposits. The results of these analyses are included in Appendix N. Of primary concern among these parameters was chromium which had been detected in high concentrations (>100,000 ppm) in isolated sediment samples near Building 14. Analysis of groundwater samples from wells hydraulically downgradient from this area have shown no chromium concentrations above the interim primary maximum concentration level of 0.05 mg/L.

The occurrence of iron and manganese is a natural geochemical phenomena due to the groundwater moving through the iron and manganese rich unconsolidated sediments. The high iron and manganese content of the sediments is confirmed by sediment analyses from borings at the Schering facility.

Table 6-3

Summary of the Occurrence of Base/Neutral Organic Priority Pollutants in Groundwater

Compound	Location (Concentration Range: 5 to 100 ppb)
Bis(2-chloroethyl)ether	PE-1, PE-2 BW-5
Bis(2-ethylhexyl)phthalate	MW-9
1,2-dichlorobenzene	P-5, MW-21 MW-22
Isophorone	MW-5
Butyl benzyl phthalate	MW-9

[1] See Plate 2 for sampling locations.

TABLE 6-4

LOCATIONS WHERE TENTATIVELY IDENTIFIED COMPOUNDS WERE DETECTED IN THE FEBRUARY/MARCH SAMPLING OF GROUNDWATER FOR VOLATILE ORGANICS

	RRT	UNCONSOLIDATED DEPOSITS, ON SITE										OFFSITE			SHALLOW BEDROCK WELLS			
COMPOUND	(MINUTES)	P-2	P-4	P-13	MW-2	MW-9	MW-12	MW-15	MW-16	MW-23	MW-26	PE-3	PE-4	PE-7	BW-2	BW-3	BW-4	BW-6
METHYL ALCOHOL (1)	4	----UNKNOWN----																
ACETONE	9	X	X															
DIMETHYL SULFIDE	9	X						X										
ISOPROPYL ALCOHOL	10.5	X																
METHYL ACETATE	11	X						X	X									
TETRAHYDROFURAN (THF)	12											X	X	X				
ETHYL ETHER	13		X		X	X	X			X	X			X		X	X	X
2-BUTANONE (MEK)	14.5	X																
2-BUTONOL	15	X																
1,4-DIOXANE	16					X												
ISOPROPYL ETHER	20		X	X												X		
METHYL n-BUTYRATE	20.5	X						X										
2-METHYL-3-PENTANONE	22	X																
2,4-DIMETHYL-3-PENTANONE	24.5	X																
5-METHYL-2-HEXANONE	29.5	X																
METHYL HEXANOATE	32	X																
n-BUTYL ETHER	37	X	X		X	X				X					X		X	

RRT = RELATIVE RETENTION TIME ON GC COLUMN

(1) = SUSPECTED BUT CAN NOT BE MEASURED USING EPA METHOD 624.
SUSPECTED DUE TO HISTORY OF USE ON SITE AND APPARENTLY
LARGE PEAK SIZE ON SOME SAMPLES.

The elevated zinc levels in the samples from MW-1 through MW-6S, MW-6D, MW-7 through MW-13 are probably due to the use of galvanized screen in the construction of these monitoring wells when they were installed in 1984. Comparison of results with those from samples obtained from the 14 stainless steel monitoring wells installed in 1985 shows levels of zinc consistently below the drinking water standard in the newer wells. The groundwater pH, which affects the solubility of metals, was determined immediately after the sample was collected. These values fell in a range from 6 to 8 pH units.

6.2.2.5 Potential Source Areas

Past materials handling practices and plant sewer leaks are believed to be the main sources of the organic compounds detected in groundwater samples from the unconsolidated deposits. As discussed in Section 2 and illustrated in Plate 3, the area east of Building 10 and north of Building 13 was used for a variety of materials and waste handling practices.

Drums containing raw materials, intermediates, products, and wastes were stored on unpaved areas now occupied by Buildings 12 and 18.

An open pit in the area east of Building 16 was used for the disposal of a variety of chemical wastes including spent solvents.

Building drains in Building 10 were dissolved by exposure to acids, thereby allowing chemicals to enter the soil underlying the building.

The area adjacent to Building 7 was used as a railroad siding for handling methylene chloride, chloroform, acetone, butyl ether, methanol, acids and ethylene dichloride in bulk. Spillage during the handling of these materials is a possible source of the methylene chloride, chloroform, and possibly the other VOCs observed in samples from BW-2, MW-15, MW-16, and P-2.

Interviews with long-time plant personnel indicate that the industrial sewers leaked, thereby releasing wastes into the environment. This problem was recognized and addressed in the mid-1970's. Extensive pipe maintenance is now done annually to protect against leaks.

These source areas all involve past materials and waste handling practices which have been changed or terminated, thereby preventing introduction of additional compounds into the environment. The only existing source areas for organic priority pollutants are two localized pockets of free phase toluene and free phase toluene and benzene detected at MW-24 and P-9, respectively (see Plate 3).

Given the hydrogeologic and groundwater sample data, the source of the volatile organic priority pollutants detected off-site in PE-1, PE-2, PE-7, and PE-8 has been identified as groundwater underlying the site which migrates towards these sampling locations. The benzene detected at PE-6, the piezometer farthest to the east of Schering, may be groundwater migrating from beneath the Schering facility or from an upgradient source. The source is not clearly identifiable because the groundwater flow data presently available indicate flow is normally to the west and towards the Elizabeth River in the area of PE-6. This observation is based on data collected during January, February, March, and April 1986. The January data, however, show groundwater flow from beneath the Schering facility and towards PE-6. Water levels in this area will continue to be measured and analyzed to determine the extent and duration of seasonal shifts in groundwater flow patterns.

The industrial sewer and the lateral leading to the Hillside Township sewer may be acting as a conduit for migration of VOCs from the vicinity of MW-24 and MW-3 toward PE-1 and PE-2. Construction diagrams indicate that the clay pipe of the sewer was surrounded by crushed stone (a standard construction practice). This crushed stone, which is believed to be more permeable than the surrounding sediments, would promote groundwater flow, and hence transport VOCs, toward the Elizabeth River and PE-1 and PE-2. (See Plate 3 for locations.)

6.2.3 Groundwater Quality in the Shallow Bedrock Zone

6.2.3.1 Occurrence of Volatile Organic Priority Pollutants

Six volatile organic priority pollutants (VOCs) have been detected in four of the wells which monitor the shallow bedrock zone to a depth of about 65 feet beneath the Schering facility. Appendix M includes a complete data summary for analyses from the shallow bedrock monitoring wells.

Hydraulic gradient data indicate that groundwater flow in the shallow bedrock zone is to the east and southeast toward the Elizabeth River. Table 6-5 summarizes the results of three rounds of groundwater sample analyses from the bedrock monitoring wells (August, November 1985, and February 1986). BW-1 and BW-3 provide upgradient monitoring points. No volatile organic priority pollutants have been detected in samples from these wells. BW-2 is also an upgradient well but, as shown in Table 6-5, samples from this well show levels of chloroform and methylene chloride above 10 ppm. However, the results of the RI show that their source was probably the area next to BW-2, not an upgradient source to the west of Schering. Although BW-7 is a downgradient well, it also shows no VOCs. This indicates that the flow of groundwater and hence the movement of VOCs is controlled by fractures in the bedrock.

Table 6-5

Shallow Bedrock Monitoring Well Volatile Organic Priority Pollutant Analyses Summary

COMPOUND	ND	ND < X <1 PPM	1 PPM < X < 10 PPM	10 PPM < X < 100 PPM	100 PPM < X < 1000 PPM	TOTALS
BENZENE	BW-1 BW-3 BW-7		BW-4			1
TOLUENE	BW-1 BW-3 BW-7		BW-4 BW-6	BW-5		3
CHLOROFORM	BW-1 BW-3 BW-7		BW-4		BW-2	2
METHYLENE CHLORIDE	BW-1 BW-3 BW-7	BW-6	BW-4	BW-2 BW-5		4
CARBON TETRACHLORIDE	BW-1 BW-3 BW-7		BW-4			1
1,2 DICHLOROETHANE		BW-4				1
TOTALS	3	2	2	2	1	

ND - NOT DETECTED

Samples from monitoring wells BW-4, BW-5, and BW-6 have consistently shown benzene, toluene, chloroform, methylene chloride, and carbon tetrachloride at concentrations above 1 ppm.

Samples from BW-4 show six different compounds, with five at concentrations above 1 ppm. BW-5 and BW-6 both showed toluene, chloroform and methylene chloride with higher concentrations in BW-5.

6.2.3.2 Potential Sources

The source of the volatile organic priority pollutants observed in the shallow bedrock monitoring wells is groundwater flowing vertically downward from the overlying unconsolidated sediments. Generally, where these sediments and groundwater have been impacted, the underlying shallow bedrock zone has also been impacted. The unconsolidated sediments and groundwater in the vicinity of BW-1, BW-3, and BW-7 are uncontaminated (see Appendix N, data for MW-11, MW-10, and MW-7) as is groundwater from BW-1, BW-3, and BW-7. BW-2, BW-4, BW-5, and BW-6 are in the vicinity of groundwater in the overlying unconsolidated deposits which has been impacted by volatile organic priority pollutants.

The mechanisms for vertical movement of volatile organic priority pollutants are:

- Flow along vertical fractures.
- Flow along the bedrock monitorng well casing.

Vertical migration along fractures in the bedrock is considered to be the most probable pathway as a vertical head exists from the unconsolidated zone to the bedrock throughout the site. Each bedrock monitoring well was carefully constructed so as to restrict the potential for vertical migration by flow along the casing and grouting off the unconsolidated deposits.

6.2.3.3 Occurrence of Non-Priority Pollutants

As shown in Table 6-4, several tentatively-identified, non-priority pollutant VOC's have been detected at four of the seven bedrock monitoring well locations. The program for identifying these compounds is discussed in Subsection 6.2.6.

6.2.4 Groundwater Quality in Deeper Bedrock Zone

6.2.4.1 Occurrence of Volatile Organic Priority Pollutants (VOCs)

The two Schering production wells, PW-2 and PW-3, and Hillside No. 4 (H-4) provide sampling locations for obtaining groundwater quality data to a depth of approximately 600 feet in the Brunswick Formation bedrock aquifer. Appendix M includes a complete data summary for analyses from these wells.

Construction data are provided for these three wells on Plate 2 which also shows their locations. Comparing the construction data shows that PW-2 is cased to a depth below the bottom of each of the shallow bedrock monitoring wells. This construction should provide at least some isolation of PW-2 from the shallow bedrock zone. In addition, the deeper open borehole of PW-2 provides access to much more of the aquifer than the shallow bedrock monitoring wells.

The analytical results for PW-2 (see Table 6-6) and PW-3 (see Table 6-7) show the consistent occurrence of tetrachloroethylene (PCE), trichloroethylene (TCE), and chloroform at concentrations below 0.1 ppm. No benzene, toluene, methylene chloride, or carbon tetrachloride have been detected in samples from PW-2 and PW-3. These results contrast sharply with those for the overlying unconsolidated and shallow bedrock groundwater samples which show concentrations of benzene, toluene, chloroform, carbon tetrachloride and methylene chloride above 1 ppm. In addition, TCE and PCE have been detected only in the unconsolidated deposits in the vicinity of Building 7 and at MW-25, areas which are not associated with the locations of wells PW-2 and PW-3. At MW-25 concentrations were above 1 ppm, while in the Building 7 area the concentrations have consistently been below 0.1 ppm. Priority pollutant base/neutral or acid extractable compounds are not considered a problem in the production wells.

Volatile organic priority pollutants have been observed only sporadically and at levels well below 0.1 ppm in three rounds of groundwater sampling from Hillside No. 4. In samples collected in August and November 1985, chloroform was detected at 13 and 18 ppb, respectively. In the November sample, methylene chloride and toluene were detected at 6 and 56 ppb, respectively. No volatile organic priority pollutants were detected in the February 1986 sample. No base/neutral and acid extractable pollutants have been detected in these samples. Data from field blanks, which were prepared using deionized water supplied by Schering, show low levels of chloroform, 5 to 20 ppb, which are believed to be caused by chlorinated water

Table 6-6

Production Well 2 Water Sample Data Summary for Priority Pollutant Organic Analyses

PRODUCTION WELL LOCATION**********	PW-2	PW-2	PW-2	PW-2	PW-2	PW-2	PW-2	PW-2
SAMPLE COLLECTION DATE************	29-Feb-84	27-Mar-84	30-Mar-84	25-Apr-84	07-May-84	07-May-84	01-Apr-85	06-Sep-85
VOA (METHOD 624) (1)	**							
AROMATIC HYDROCARBON	NA	NA	NA	NA	NA	<1	NA	NA
CHLOROFORM	ND	41	183	ND	5	6	ND	ND
1,2-DICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	6
METHYLENE CHLORIDE	ND	ND	ND	ND	ND	ND	ND	ND
TETRACHLOROETHANE	ND	ND	ND	14	20	19	11	25
TOLUENE	ND	ND	ND	ND	ND	ND	ND	ND
TRICHLOROETHYLENE	16	9	38	43	37	ND	27	58
XYLENE	ND	ND	ND	ND	ND	ND	NG	<300
VOA DETECTION LIMIT***************	5 PPB	5 PPB	5 PPB	5 PPB	5 PPB	5 PPB	5 PPB	5 PPB
A/E (METHOD 625)	**							
4-CHLORO-3-METHYLPHENOL	NA	ND	ND	NA	NA	NA	ND	ND
ACID EXTRACTABLE DETECTION LIMIT		20 PPB	20 PPB				20 PPB	20 PPB
B/N (METHOD 625)	**							
BIS(2-CHLOROETHYL)ETHER	NA	ND	ND	NA	NA	NA	ND	ND
BIS(2-CHLOROETHOXY)METHANE	NA	ND	ND	NA	NA	NA	ND	ND
BIS(2-ETHYLHEXL)PHTHALATE	NA	ND	ND	NA	NA	NA	39	ND
1,2-DICHLOROBENZENE	NA	ND	ND	NA	NA	NA	ND	ND
1,4-DICHLOROBENZENE	NA	ND	ND	NA	NA	NA	ND	ND
BASE NEUTRAL DETECTION LIMIT******		20 PPB	20 PPB				20 PPB	20 PPB
LABORATORY SAMPLE ID NUMBER	22984	4	11	42584	21923	WELL 2	33712	43830

(1) ALL VALUES IN PARTS PER BILLION (ppb)

(2) BW-2 IS THE CLOSEST BEDROCK MONITORING WELL TO PRODUCTION WELL 2 AND IS HYDRAULICALLY CONNECTED TO IT. SEE PLATE 2.

ND = NOT DETECTED

NA = NOT ANALYZED

Table 6-6
(continued)

			SHALLOW BEDROCK MONITORING WELL BW-2				
PRODUCTION WELL LOCATION************	PW-2	PW-2	BW-2	BW-2 DUP	BW-2	BW-2	BW-2 DUP
SAMPLE COLLECTION DATE**************	15-Nov-85	05-Feb-86	16-Aug-85	16-Aug-85	19-Nov-85	13-Feb-86	13-Feb-86
VOA (METHOD 624) (1)							
AROMATIC HYDROCARBON	ND	ND	ND	ND	ND	ND	ND
CHLOROFORM	ND	ND	64000	62000	105000	190000	230000
1,2-DICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND
METHYLENE CHLORIDE	ND	ND	39000	33000	44500	96000	110000
TETRACHLOROETHANE	14	9	ND	8700	ND	ND	ND
TOLUENE	ND	ND	ND	ND	ND	ND	ND
TRICHLOROETHYLENE	30	24	ND	ND	ND	ND	ND
XYLENE	<10	<10	<5	<5	<5	<10000	<10000
VOA DETECTION LIMIT*****************	5 PPB	5 PPB	5 PPB	5000 PPB	2000 PPB	5000 PPB	5000 PPB
A/E (METHOD 625)							
4-CHLORO-3-METHYLPHENOL	NG	NA	120	ND	NG	ND	NA
ACID EXTRACTABLE DETECTION LIMIT	20 PPB		20 PPB	20 PPB	20 PPB	20 PPB	NA
B/N (METHOD 625)							
BIS(2-CHLOROETHYL)ETHER	ND	ND	ND	ND	ND	ND	ND
BIS(2-CHLOROETHOXY)METHANE	ND	ND	ND	ND	ND	ND	ND
BIS(2-ETHYLHEXL)PHTHALATE	ND	ND	ND	350	ND	ND	ND
1,2-DICHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND
1,4-DICHLOROBENZENE	ND	ND	ND	ND	ND	ND	ND
BASE NEUTRAL DETECTION LIMIT********	20 PPB	20 PPB	20 PPB	20 PPB	20 PPB	20 PPB	20 PPB
LABORATORY SAMPLE ID NUMBER	47873	49899	43827	43838	47885	51961	51967

(1) ALL VALUES IN PARTS PER BILLION
(2) BW-2 IS THE CLOSEST BEDROCK MONITORING WELL TO PRODUCTION WELL 2 AND IS HYDRAULICALLY CONNECTED TO IT. SEE PLATE 2.
ND = NOT DETECTED
NA = NOT ANALYZED

Table 6-6
(continued)

	HILLSIDE # 4		
PRODUCTION WELL LOCATION************	HS-4	HS-4	HS-4
SAMPLE COLLECTION DATE**************	17-Aug-85	27-Nov-85	20-Feb-86
VOA (METHOD 624) (1)	**********	**********	**********
AROMATIC HYDROCARBON	ND	ND	ND
CHLOROFORM	13	18	ND
1,2-DICHLOROETHANE	ND	ND	ND
METHYLENE CHLORIDE	ND	6	ND
TETRACHLOROETHANE	ND	ND	ND
TOLUENE	ND	56	ND
TRICHLOROETHYLENE	ND	ND	ND
XYLENE	NA	NA	NA
VOA DETECTION LIMIT****************	5 PPB	5 PPB	5 PPB
A/E (METHOD 625)	**********	**********	**********
4-CHLORO-3-METHYLPHENOL	ND	NA	NA
ACID EXTRACTABLE DETECTION LIMIT	20 PPB	20 PPB	20 PPB
B/N (METHOD 625)	**********	**********	**********
BIS(2-CHLOROETHYL)ETHER	ND	ND	ND
BIS(2-CHLOROETHOXY)METHANE	ND	ND	ND
BIS(2-ETHYLHEXL)PHTHALATE	24	ND	ND
1,2-DICHLOROBENZENE	ND	ND	ND
1,4-DICHLOROBENZENE	ND	ND	ND
BASE NEUTRAL DETECTION LIMIT********	20 PPB	20 PPB	20 PPB
LABORATORY SAMPLE ID NUMBER	43834	48736	52050

(1) ALL VALUES IN PARTS PER BILLION
(2) BW-2 IS THE CLOSEST BEDROCK MONITORING WELL TO PRODUCTION WELL 2 AND IS HYDRAULICALLY CONNECTED TO IT. SEE PLATE 2.
ND = NOT DETECTED
NA = NOT ANALYZED

Table 6-7

Production Well 3 Water Sample Data Summary for Priority Pollutant Organic Analyses

PRODUCTION WELL LOCATION**********	PW-3	PW-3	PW-3	PW-3	PW-3	PW-3	PW-3
SAMPLE COLLECTION DATE************	29-Feb-84	27-Mar-84	30-Mar-84	07-May-84	07-May-84	01-Apr-85	15-Aug-85
VOA (METHOD 624) (1)							
AROMATIC HYDROCARBON	NA	NA	NA	ND	<1	ND	ND
CHLOROFORM	6	194	33	10	ND	ND	6
DICHLOROBROMETHANE	ND	ND	ND	ND	ND	6	ND
METHYLENE CHLORIDE	ND	60	ND	ND	ND	ND	ND
TETRACHLOROETHANE	ND	36	7	22	ND	ND	12
TRICHLOROETHYLENE	39	68	22	75	ND	ND	ND
XYLENE	ND	ND	ND	ND	ND	NA	<5
VOA DETECTION LIMIT***************	5 PPB	5 PPB	5 PPB	5 PPB	5 PPB	5 PPB	5 PPB
A/E (METHOD 625)							
4-CHLORO-3-METHYLPHENOL	NA	ND	ND	NA	NA	ND	ND
ACID EXTRACTABLE DETECTION LIMIT		20 PPB	20 PPB			20 PPB	20 PPB
B/N (METHOD 625)							
BIS(2-CHLOROETHYL)ETHER	ND	ND	ND	ND	ND	ND	72
BIS(2-ETHYLHEXL)PHTHALATE	ND	ND	ND	ND	ND	22	ND
BASE NEUTRAL DETECTION LIMIT******	20 PPB	20 PPB	20 PPB	20 PPB	20 PPB	20 PPB	20 PPB
LABORATORY SAMPLE ID NUMBER	32984	5	12	21924	WELL 3	33711	43826

(1) ALL VALUES IN PARTS PER BILLION (ppb)
(2) BW-1 IS THE CLOSEST BEDROCK MONITORING WELL TO PRODUCTION WELL 3. SEE PLATE 2.
ND = NOT DETECTED
NA = NOT ANALYZED

Table 6-7
(continued)

					SHALLOW BEDROCK MONITORING WELL BW-1			
PRODUCTION WELL LOCATION	PW-3	PW-3	PW-3	¦	BW-1	BW-1 DUP	BW-1	BW-1
SAMPLE COLLECTION DATE	13-Nov-85	05-Feb-86	21-Feb-86	¦	13-Aug-85	13-Aug-85	14-Nov-85	12-Feb-86
VOA (METHOD 624) (1)								
AROMATIC HYDROCARBON	ND	ND	ND	¦	ND	ND	ND	ND
CHLOROFORM	28	ND	ND	¦	ND	ND	ND	ND
DICHLOROBROMETHANE	8	ND	ND	¦	ND	ND	ND	ND
METHYLENE CHLORIDE	ND	ND	ND	¦	ND	ND	ND	ND
TETRACHLOROETHANE	ND	ND	15	¦	ND	ND	ND	ND
TRICHLOROETHYLENE	ND	ND	36	¦	ND	ND	ND	ND
XYLENE	<10	ND	<10	¦	NG	NG	<10	<10
VOA DETECTION LIMIT	5 PPB	5 PPB	5 PPB	¦	5 PPB	5 PPB	5 PPB	5 PPB
A/E (METHOD 625)								
4-CHLORO-3-METHYLPHENOL	NA	NA	NA	¦	ND	ND	NA	NA
ACID EXTRACTABLE DETECTION LIMIT				¦	20 PPB	20 PPB		
B/N (METHOD 625)								
BIS(2-CHLOROETHYL)ETHER	ND	ND	NA	¦	ND	ND	ND	ND
BIS(2-ETHYLHEXL)PHTHALATE	ND	ND	NA	¦	21			
BASE NEUTRAL DETECTION LIMIT	20 PPB	20 PPB	NA	¦	20 PPB	20 PPB	20 PPB	20 PPB
LABORATORY SAMPLE ID NUMBER	47874	49898	52156	¦	43694	43697	47875	51685

(1) ALL VALUES IN PARTS PER BILLION

(2) BW-1 IS THE CLOSEST BEDROCK MONITORING WELL TO PRODUCTION WELL 3. SEE PLATE 2.

ND = NOT DETECTED

NA = NOT ANALYZED

being used as feedstock for their deionizer beds. At the present time it appears that the volatile organic priority pollutants mentioned above may have impacted Hillside No. 4. However, because of the sporadic nature of these results, the extent of VOCs in the deep bedrock cannot be conclusively defined until data from sampling planned for June and August 1986 are available.

6.2.4.2 Potential Source Areas

There are two potential sources of the volatile organic priority pollutants observed in the Schering production wells and Hillside No. 4:

- Contaminants may have migrated vertically downward from the unconsolidated deposits.
- Contaminants from sources off-site may have been drawn into the Schering production wells.

The potential for the unconsolidated deposits to serve as a source for contaminants in the deep bedrock aquifer will be evaluated by comparing and contrasting groundwater analytical data and evaluating potential mechanisms for vertical movement of contaminants.

As discussed in Subsection 6.2.3, vertical groundwater migration has carried VOC's into the shallow bedrock zone. The VOC's in this zone could serve as a source for VOC's, such as chloroform, which has been detected in PW-2, PW-3, and Hillside No. 4. In contrast, however, the other VOC's, such as benzene, toluene, and methylene chloride, which are present in highest concentration in the unconsolidated and shallow bedrock zones, have not been detected in the production wells. Data from the February 1986 sampling of PW-2 and BW-2 are presented for comparison in Table 6-6. Data from PW-3 and BW-1 are presented for comparison in Table 6-7. Secondly, while PCE and TCE have been found consistently in PW-2 and PW-3, they occur only in isolated locations in the unconsolidated zone, in P-2, MW-16, and MW-15 near Building 7 and at MW-25 next to Building 18, and generally at levels below 0.1 ppm. If the unconsolidated deposits are the source of the PCE and TCE in the two production wells, then benzene, toluene, and methylene chloride would be expected to be present in PW-2 and PW-3 since these compounds occur more frequently and in higher concentrations.

There are four possible explanations for these differing observations:

- If PCE, TCE and chloroform were introduced into the groundwater system before compounds such as benzene and toluene, they would have had more time to migrate to the deep bedrock zone.

- PCE, TCE and chloroform may move more rapidly through the groundwater system than compounds such as benzene and toluene.

- VOC's may have been introduced into the shallow bedrock zone via Schering Production Well 1 (in Building 7) prior to its abandonment in 1985. Samples collected from this well in 1984 showed chloroform above 1 ppm as well as benzene, methylene chloride, and toluene; however, no TCE or PCE were detected.

- The source of PCE, TCE, and chloroform may be off-site and upgradient (to the west) of the Schering facility.

Little specific information is available from the site history about the timing of any releases of VOCs to the environment. It is known that the facility began operations in 1939, that a pit was used for disposal of wastes in the 1940's, and that drum storage took place in the open and on unpaved areas until the early 1970's.

Factors influencing the mobility of organic compounds in groundwater include octanol-water partition coefficient (K_{ow}), solubility and density. Comparison of K_{ow} values for TCE, PCE, chloroform, toluene, benzene, methylene chloride, and carbon tetrachloride shows that TCE and PCE have relatively high K_{ow}'s while methylene chloride has the lowest K_{ow} of all the compounds. In general, the lower the K_{ow}, the more mobile a compound. K_{ow}'s are an important factor; therefore, methylene chloride would be expected to have the fastest migration time to the production wells. Solubility is inversely related to K_{ow}; while methylene chloride has a low K_{ow} (0.91), it has a high solubility. Based on solubility, methylene chloride would be expected to have a good opportunity to migrate to the production wells. Chlorinated compounds such as TCE and PCE have a higher density than compounds such as benzene in the immiscible phase; hence, they will tend to sink in the groundwater system while benzene tends to float. Therefore, based on density differences, TCE and chloroform might move downward into the deep bedrock faster than would toluene and benzene. PW-1 may have become contaminated with VOC's by direct disposal of wastes in the well. However, PCE and TCE were not detected in samples from this well indicating that, if these two compounds had been introduced to PW-1, they had moved away from the well under the influence of pumping from PW-2 and PW-3.

There are two mechanisms whereby the VOCs may have moved vertically from the unconsolidated deposits or shallow bedrock zone to the production wells:

- Contaminated groundwater may move vertically along the well casing and down into the well.
- Contaminated groundwater may move vertically downward, primarily along fractures in the rocks, and enter the production wells.

The pumping stress caused by Schering production wells would aid contaminant migration by either of these mechanisms.

Vertical flow of groundwater along the well casing may be occurring at PW-2, PW-3 or Hillside No. 4. Details on the construction of these wells are not available and it is not known, for example, if the casing were grouted into bedrock. However, this mechanism seems an unlikely explanation for the observations in PW-2 and PW-3 because groundwater in the immediate vicinity of these wells has not been impacted with volatile organic priority pollutants. Data from MW-1 (adjacent to PW-2), MW-11, and BW-1 (adjacent to PW-3) consistently show no detectable levels of volatile organic priority pollutants.

Vertical migration along the casing may be the explanation for the sporadic detection of VOCs observed in Hillside No. 4. BW-7 is free of VOCs and is immediately upgradient of Hillside No. 4, indicating that VOCs are not migrating directly downgradient towards Hillside No. 4. However, VOCs may be migrating toward Hillside No. 4 in the unconsolidated sediments on the east side of the Elizabeth River. No unconsolidated-deposit monitoring wells are installed in the vicinity of Hillside No. 4. Available data indicate that the casing at Hillside No. 4 extends only to the bedrock. This would allow any VOCs in the unconsolidated sediments to enter the well more easily than if the casing were installed into the bedrock.

Downgradient and vertical migration of the VOCs along fractures in the Brunswick Formation is the other possible route for the travel of VOCs from the unconsolidated deposits to the production wells or Hillside No. 4.

Available data suggest that vertical groundwater migration along fractures is slow, or that PW-2, PW-3 and Hillside No. 4 do not intercept fracture zones affected by VOCs from the unconsolidated deposits or shallow bedrock zone. This assessment is based on potentiometric surface data from BW-2 through BW-7 that indicates groundwater flow in the shallow bedrock zone is away from the production wells and toward Hillside No. 4.

Potentiometric surface data from BW-2 through BW-7 show a groundwater flow direction away from the production wells. Flow direction towards the production wells would be expected if they were influencing groundwater flow in the shallow bedrock zone monitored by BW-2 through BW-7.

as written OK
not proved

Given this somewhat contradictory and inconclusive evidence, an off-site and upgradient (to the west) source cannot be ruled out at this time. Likewise, the presence of VOCs in the shallow bedrock zone makes this zone an ongoing potential, if not actual, source of VOCs to the deep bedrock.

6.2.5 Migration of Volatile Organic Priority Pollutants

6.2.5.1 Overview

The direction and rate of migration of volatile organic priority pollutants (VOCs) at the Schering facility are controlled primarily by the direction and rate of lateral groundwater movement in the unconsolidated deposits and Brunswick formation. Vertical movement of groundwater is the chief mechanism for movement of VOCs from the unconsolidated deposits into the underlying Brunswick formation. Understanding migration directions and rates will allow effective remedial actions to be designed to address the problem areas. Data collected on-site have been incorporated into a groundwater flow model to help determine the likely direction of groundwater flow.

6.2.5.2 Migration Potential in the Unconsolidated Deposits

As illustrated in Plates 6 and 7, groundwater flow in the unconsolidated deposits is generally toward the Elizabeth River from both the east and the west sides of the river in the vicinity of Schering. The effect of groundwater movement on the plumes of benzene, toluene, chloroform, and methylene chloride is illustrated in Plate 10. The long axes of these plumes are clearly aligned in an easterly direction, parallel to the direction of groundwater flow. The movement of groundwater under the Schering facility and the Elizabeth River has carried volatile organic priority pollutants to the Woodruffs section of the Elizabeth River Park in the vicinity of PE-1 and PE-2, PE-7 and PE-8, and possibly PE-5 and PE-6.

not proved

While groundwater underflow has apparently carried VOCs from beneath the Schering site, groundwater flow toward the river from the east of Schering has also served to contain these substances to a narrow area adjacent to the river. The potentiometric surfaces for the piezometer data from February, March, and April, 1986 are shown in Plate 7, Sheets 1 and 2, and clearly illustrate that groundwater movement in the Woodruffs section of the Elizabeth River Park is consistently towards the Elizabeth River.

This groundwater flow pattern has served to contain off-site contaminant migration in the vicinity of PE-1, PE-2, and PE-7 and PE-8. This flow pattern also accounts for the lack of VOCs in PE-3 and PE-4. Observation of the potentiometric surfaces in Plate 7 shows a consistent flow of groundwater from the area of PE-3 and PE-4 toward the Elizabeth River. With these piezometric levels, volatile organics originating at Schering cannot reach PE-3 and PE-4 because groundwater from the site is not flowing toward these piezometers.

Seasonal fluctuations in the water table could change the gradients and may allow groundwater flow, and hence VOC migration, toward PE-5 and PE-6. A low level (50 ppb) of benzene was observed in PE-6 in the groundwater sample collected in February 1986. Observation of the potentiometric surface for the shallow piezometer in January 1986 shows groundwater flow beneath the Elizabeth River and downgradient toward PE-5 and PE-6. This flow could carry VOCs detected in PE-7 and PE-8 toward PE-6. However, comparison of the January potentiometric surface with those of later months shows that the ground flow direction reverses in the later months and flows toward the Elizabeth River. Assuming that there are no sources of benzene on the east side of the river, flow toward the Elizabeth River would serve to transport VOC's away from the vicinity of PE-5 and PE-6. Upgradient sources of the benzene in PE-6 cannot be ruled out because no sampling points are available to the east, upgradient, of PE-5 and PE-6.

Contaminant migration to the northeast of Schering appears to be limited by a natural groundwater flow pattern to a narrow area adjacent to the river. The full extent of migration to the east southeast, in the direction of Elizabeth River flow, is unknown because no unconsolidated deposit monitoring wells are available south of PE-7 and PE-8.

The groundwater flow model described in Section 5 has been used to determine the possible directions and velocities of groundwater flow and contaminant migration. Field data indicate a component of groundwater flow in the direction of Elizabeth River flow close to the river. Using the model, a groundwater flow velocity ranging from 20 to 60 feet per year was calculated in the unconsolidated sediments in the direction of river flow.

Given that the Schering facility has been in operation since 1939, a period of 47 years, groundwater starting at the site in 1939 could have migrated a maximum of about 3,000 feet in the direction of Elizabeth River flow by 1986; however, releases to groundwater may not have occurred until the site had been operating a few years. Also, due to adsorption, many compounds may move more slowly than groundwater. To refine these estimates of migration potential, a solute transport model will be used during the Feasibility Study to aid in evaluating remedial activities.

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6.2.5.3 Migration of Volatile Organic Priority Pollutants in the Brunswick Formation

Groundwater flow and contaminant migration directions in the Brunswick formation bedrock aquifer are largely controlled by fractures in the rock. Data collected during the RI show that VOCs have migrated vertically from the unconsolidated deposits into the shallow bedrock zone monitored by BW-2, BW-4, BW-5, and BW-6 (see Plate 2). These wells extend to a total depth of about 64 feet beneath the site. These wells are aligned along a line striking N69°E. Observations made from aerial photographs of the Schering facility and vicinity show strong indications of fractures trending along a strike of approximatley N45°E and N20°W. While the line connecting BW-2, BW-4, BW-5, and BW-6 is not exactly parallel to either the strike of the beds or the primary joint set, the line is in the same general trend.

Fracture control of contaminant migration explains why BW-7 and Hillside No. 4 have not been impacted by VOCs. The potentiometric surface in the bedrock monitoring wells dips towards BW-7 and Hillside No. 4. Hence, groundwater flow would be expected to carry chemical constituents toward BW-7 and Hillside No. 4. However, water samples from both wells have consistently been free of volatile organic priority pollutants.

These observations suggest the following:

- The VOCs in the shallow bedrock zone are concentrated in a fracture zone which has a general strike of N50°E to N70°E.
- The VOCs are sinking in the bedrock and moving down gradient. In this case, BW-7 may not be deep enough to intercept this sinking plume.

The closest groundwater user is the Emeloid Company, which operates two wells located 2,700 feet north northeast on a line trending N30°E from the Schering facility. In 1985, the two wells produced an average of about 50 thousand gallons per day. Water quality data are not available for these wells.

While observations from the Schering production wells and Hillside No. 4 do not conclusively show the presence of the same VOCs found in the shallow bedrock, there is a downward gradient from the shallow bedrock to the deep bedrock aquifer; therefore, VOCs could be migrating downward to or toward the Schering production wells.

The groundwater modeling effort shows that groundwater flow in the Brunswick formation in the shallow bedrock zone is away from the Hummocks Well field and other public supply wells. This shallow zone extends to a level about 75 feet below the surface. In the deep bedrock zone, 75 feet to 600 feet below the surface, the Schering production wells appear to dominate groundwater flow in the vicinity of the Schering facility. Thus, contaminants migrating vertically in the immediate vicinity of the Schering facility are likely to be captured by the Schering production wells.

6.2.5.4 Summary of Migration Potential

Data collected during the RI show that:

- VOC migration in the unconsolidated deposits is controlled by the direction of groundwater movement.
- Chemical constituents are concentrated in the northeast sector of the plant and move to the northeast, east, and beneath the Elizabeth River.
- Migration from Schering to the east is limited by a westerly groundwater flow on the east side of the Elizabeth River.

- The full extent of VOC migration to the east southeast, in the direction of Elizabeth River flow, has not been fully defined at the present time, but will be estimated during additional groundwater modeling in the Feasibility Study.
- VOC migration in the shallow bedrock appears to be strongly controlled by a fracture zone with a strike in the range of N50°E to N70°E. Available data show no groundwater users directly downgradient to the east along this trend.
- The vertically-downgradient head between the shallow bedrock and the deep bedrock zone creates the potential for vertical flow of groundwater from the shallow to the deep zone.
- VOCs in the unconsolidated deposits and shallow bedrock zone may not be the source of VOCs identified in Schering's PW-2, PW-3, and Hillside No. 4. The source may be either to the east or west of Schering and hydraulically upgradient.

The ongoing groundwater modeling effort will address the potential for off-site contaminant migration via both the unconsolidated deposits and the Brunswick formation.

6.3 OCCURRENCE OF VOLATILE ORGANIC PRIORITY POLLUTANTS IN THE UNSATURATED SEDIMENTS

6.3.1 Overview

The soil borings conducted during the RI were designed primarily to define the extent and nature of volatile organic priority pollutants in the unsaturated soils. To achieve this goal, sediment samples were collected from 65 borings at various locations on the site as shown in Plate 1. Appendix N includes a complete summary of sediment sample analyses conducted during the Phase II and RI field programs. Table 6-8 summarizes the numbers of samples collected in each zone and analyzed for VOCs. As this table illustrates, the search for VOCs was focused in Zone 1.

Zone 1 is by far the largest zone. It occupies 4.88 acres or 10.93 percent of the total facility area of 44.6603 acres. Together, all four zones occupy a total area of 7.09 acres, which represents 15.88 percent of the total facility area.

Table 6-8

Summary of Results of Volatile Organic Priority Pollutant Analyses Conducted on Sediment Samples

Zone[1]	Total Samples Phase II	Total Samples RI	Total Samples per Zone	Total VOC Analyses[2] per Zone	VOCs[3] Detected	ND[4]	NA[5]
1	19	41	60	55	38	16	5
2	4	27	31	12	5	4	19
3	2	8	10	2	1	1	8
4	3	7	10	9	6	2	1
Totals	28	83	111	78	50	23	33

[1] See Plate 1 for location.
[2] Analyses in unsaturated sediment only.
[3] VOA's = Volatile organic priority pollutants.
[4] ND = VOCs not detected in samples.
[5] NA = VOCs not analyzed for in sample.

A total of 15 VOCs were detected in the sediment samples. The number of detections in each zone for a given compound are shown in Table 6-9. These data show that toluene, benzene, chloroform, and methylene chloride occur most frequently and predominantly in Zone 1.

Because toluene and benzene occur in the largest number of samples, occurrences of these compounds will be used as indicator parameters. This means that, where these compounds occur, other compounds are either not a problem or occur in concentrations significantly lower than either benzene or toluene.

6.3.2 Nature and Extent of VOC Occurrence

The soil sampling program conducted during the RI showed the consistent occurrence of toluene and benzene at concentrations often exceeding 1 ppm in unsaturated sediments in the area to the east of Building 10 and north of Building 13. This is the area outlined as Zone 1 in Plate 3. The occurrence of toluene in the unsaturated sediments is shown in Plate 11. Four distinct areas impacted by toluene are noted:

- In the area around Building 7, 2 of 10 samples had toluene above 1 ppm (Zone 4 in Plate 1).
- The area between Buildings 10, 18, and 14 showed the most consistent occurrence of toluene above 1 ppm.
- The area east of Buildings 18 and 20 and the area presently occupied by drum sheds show toluene at levels generally less than 1 ppm.
- The highest level of toluene (up to 2,000 ppm) occurred in the area immediately adjacent to the loading bay area in the northeast corner of Building 13. However, this appears to be a highly localized pocket as samples further to the south show no toluene.

As shown in Table 6-9, benzene occurred in many of the samples analyzed for volatile organic compounds during the Phase II and RI work. The distribution of benzene is shown in Plate 12. Two distinct areas and two localized pockets of benzene are noted:

- The area to the east of Building 20, shed A-20, and the peninsular area north and east of Building 13 contained most of the benzene observed at the highest readings. Toluene concentrations ranged from less than 1 ppm in the peninsular area to 1,240 ppm near the loading dock in Building 13.

Table 6-9

Summary of the Occurrence of Volatile Organic Priority Pollutants In Sediment Samples

	Compound	Number of Detections in Each Zone (area in acres)[1]			
		1 (4.88)	2 (1.32)	3 (0.18)	4 (0.71)
1.	Benzene	22	2	1	ND
2.	Carbon Tetrachloride	4	ND	ND	ND
3.	Chlorobenzene	5	ND	ND	ND
4.	Chlorodibromomethane	2	ND	ND	ND
5.	Chloroform	16	3	ND	2
6.	Dichlorobromomethane	1	ND	ND	ND
7.	1,2 Dichloroethane	2	ND	ND	1
8.	1,1 Dichloroethylene	1	ND	ND	ND
9.	1,2 Dichloropropane	2	ND	ND	ND
10.	Ethylbenzene	4	ND	ND	ND
11.	Methylene chloride	8	2	ND	ND
12.	Tetrachloroethylene	1	1	ND	ND
13.	Toluene	32	4	1	3
14.	1,1,2 Trichloroethane	3	ND	ND	ND
15.	Trichloroethylene	1	ND	ND	ND

[1] Total facility area 44.6603 acres.

ND = Not detected.

- The area between Buildings 16 and 18 had two samples with benzene concentrations of 1.2 and 17 ppm.
- At boring 1-35 between Buildings 10, 12, 11, and 13, a benzene concentration of 15.5 ppm was measured.
- At boring 2.8 near Building 14, a level of 2.8 ppm of benzene was measured.

Comparison of Plates 11 and 12 shows that the areas of benzene and toluene occurrence overlap with the exception that benzene was not detected in the area around Building 7.

Fifteen volatile organic priority pollutants (VOCs) including benzene and toluene were detected in the 78 sediment samples analyzed for VOCs during the Phase II and RI work. This analysis shows that toluene and benzene, either individually or together occurred in 46 percent of all the samples where VOC's were detected in the four study zones which represent 15 percent of the site land area. Furthermore, an additional 38 percent of the samples contained benzene and toluene either individually or together and at least one of the 13 other VOC's. Therefore, fully 84 percent of the samples from the zones may be characterized by the presence of either benzene or toluene. The remaining 16 percent of the samples where VOC's were detected had a least one of the other 13 VOC's. Of these 13, chloroform and methylene chloride occurred in 27 and 13 percent of the samples, respectively. The occurrence of these compounds is not mapped because they occur in the same areas where benzene and toluene have been observed. The remaining nine compounds listed in Table 6-9 all occur in 6 percent or less of the samples in which VOC's were detected. These nine compounds also occur in the same areas impacted by benzene and toluene.

6.3.3 Potential Source Areas

The Union facility has historically utilized a significant number and quantity of various volatile organic compounds in its diverse pharmaceutical manufacturing processes. The history of the facility and the use of various chemicals at the site is discussed in more detail in Section 2. Potential sources for the volatile organic priority pollutants observed in the unsaturated soils are shown in Plate 3 and include:

- The waste solvent pits (east of Building 16) utilized in the early 1950's.

- The industrial sewers servicing Buildings 6, 10, 16, and the lateral to the Hillside sewer.
- The drum storage area between Buildings 6 and 16.
- The settling basin north of Building 10.
- The above ground toluene storage tanks adjacent to and north of Buildings 10 and 16.
- The rail car liquid transfer facility and associated storage tanks adjacent to Building 7.

These sources resulted from materials handling (e.g., spills) and facility operation (e.g., pipe leaks) problems. These problems have been addressed during on-going development and modernization of the facility. The only source which may be contributing to continuing soil contamination is the free phase toluene in the vicinity of MW-24 and the free phase toluene and benzene in PW-9. The free phase solvent layers floating on the water table may be impacting the unsaturated soils through capillary movement of the volatile compounds.

6.3.4 Interim Remedial Measures (IRM) To Address the Free Phase Solvent Pockets

6.3.4.1 Overview

The free-phase solvents were discovered in October (MW-24) and December 1985 (P-9) during routine water level monitoring. Subsequent analyses of samples identified toluene in MW-24 and toluene and benzene in P-9. After Schering discovered the free-phase solvents in the vicinity of MW-24 and P-9, WESTON was tasked with preparing an IRM Workplan to address this situation. The IRM Workplan was submitted for concurrence to Mr. Peter Lynch of the NJDEP on 10 April 1986.

6.3.4.2 Current Status of the Remediation

The free-phase solvent layer is being removed from MW-24 and P-9 by a weekly program of pumping or bailing these wells. Schering staff are recording the following information for each recovery event:

- Date pumping or bailing was conducted.
- Depth to solvent.
- Depth to water.
- Volume of liquid recovered.

Schering is disposing of the recovered liquids in the plant boiler which is licensed for solvent burning for energy recovery.

Figure 6-1 illustrates the changing thickness of the toluene layer in MW-24. As this figure illustrates, the thickness of the layer has decreased steadily since it was discovered. The original thickness of 10 feet may have been representative of a toluene-water emulsion rather than a pure toluene layer. This emulsion may have been created by development of the well in late August 1985. As the emulsion separated, the apparent thickness of the layer steadily decreased. During the last pumping, no floating layer was apparent, but the odor and color of the water suggested the presence of toluene. Weekly measurements and pumping will continue to remove toluene form the subsurface.

The layer of toluene and benzene at P-9 is less than one-foot thick. This layer is being removed periodically by bailing and the surrounding wells are being checked for floating layers. No floating layers other than those in MW-24 and P-9 have been discovered in other monitoring wells or piezometers. Both of these free phase areas will receive a high priority in planning the remedial action during the FS.

6.4 AREA FORMERLY OCCUPIED BY FOUR SURFACE IMPOUNDMENTS

6.4.1 Overview

Soil and groundwater sampling conducted in this area during the RI has documented that there is no environmental impact as a result of residual surface impoundment material. A summary of these analyses is included in Appendix N.

Four surface impoundments were operated by Schering Corporation as part of waste treatment operations during the late 1940's to early 1950's in the area of Building 14. These operations were terminated around 1953 or 1954. The impoundments were removed and Building 14 was constructed on the site in 1958. The fact that there is no direct environmental impact from any residual impoundment material is due to two factors:

- The majority of the impoundment material was removed in the process of decommissioning the impoundment and preparing the foundation area for Building 14.
- The chemistry of the residual impoundment material renders it immobile in the environment.

These conclusions are based on historical information, geologic data and chemical analyses.

TOLUENE LAYER IN MW-24, 5-Oct-85 TO 20-May-86

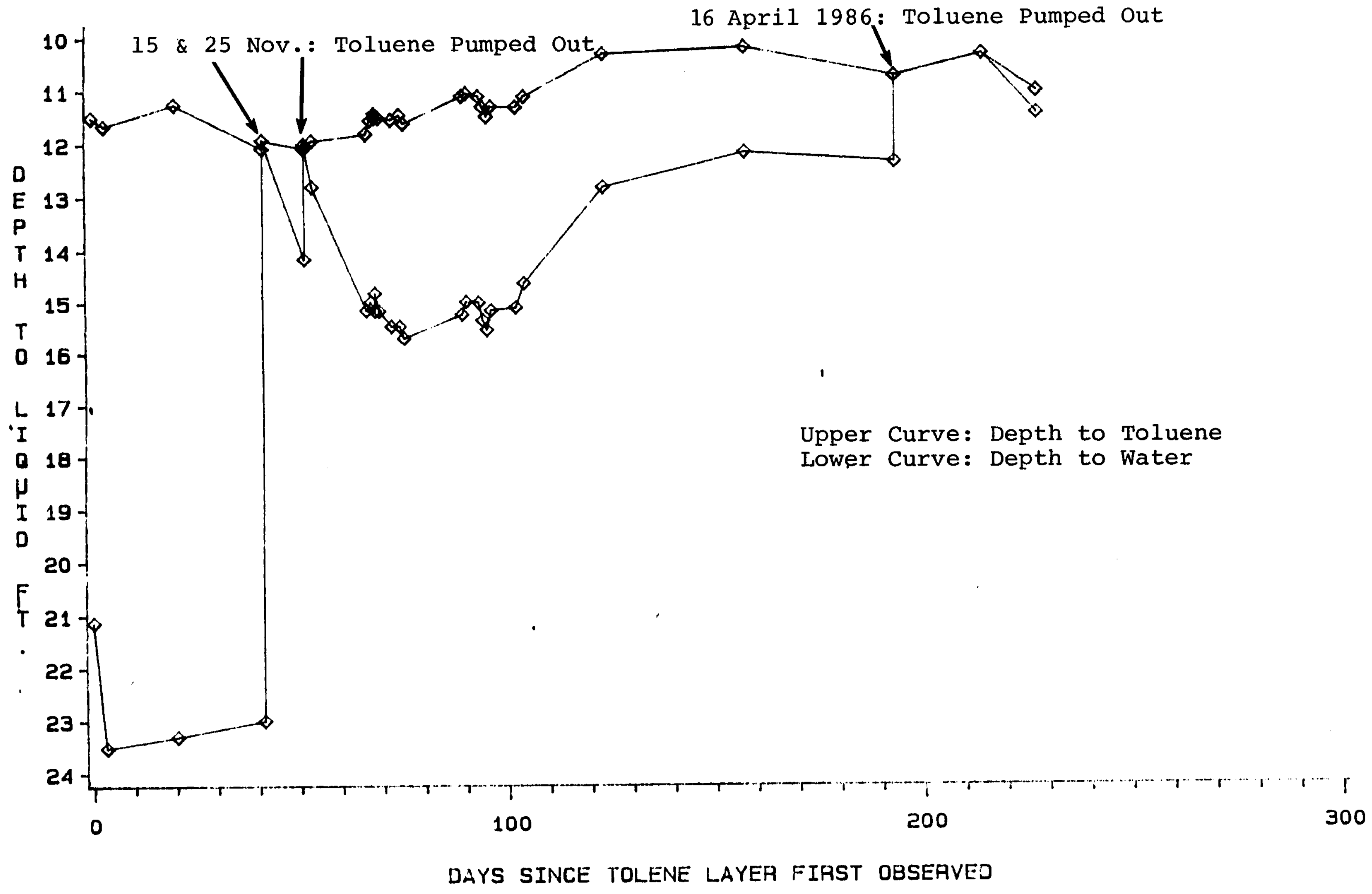


FIGURE 6-1

6.4.2 History of the Surface Impoundments

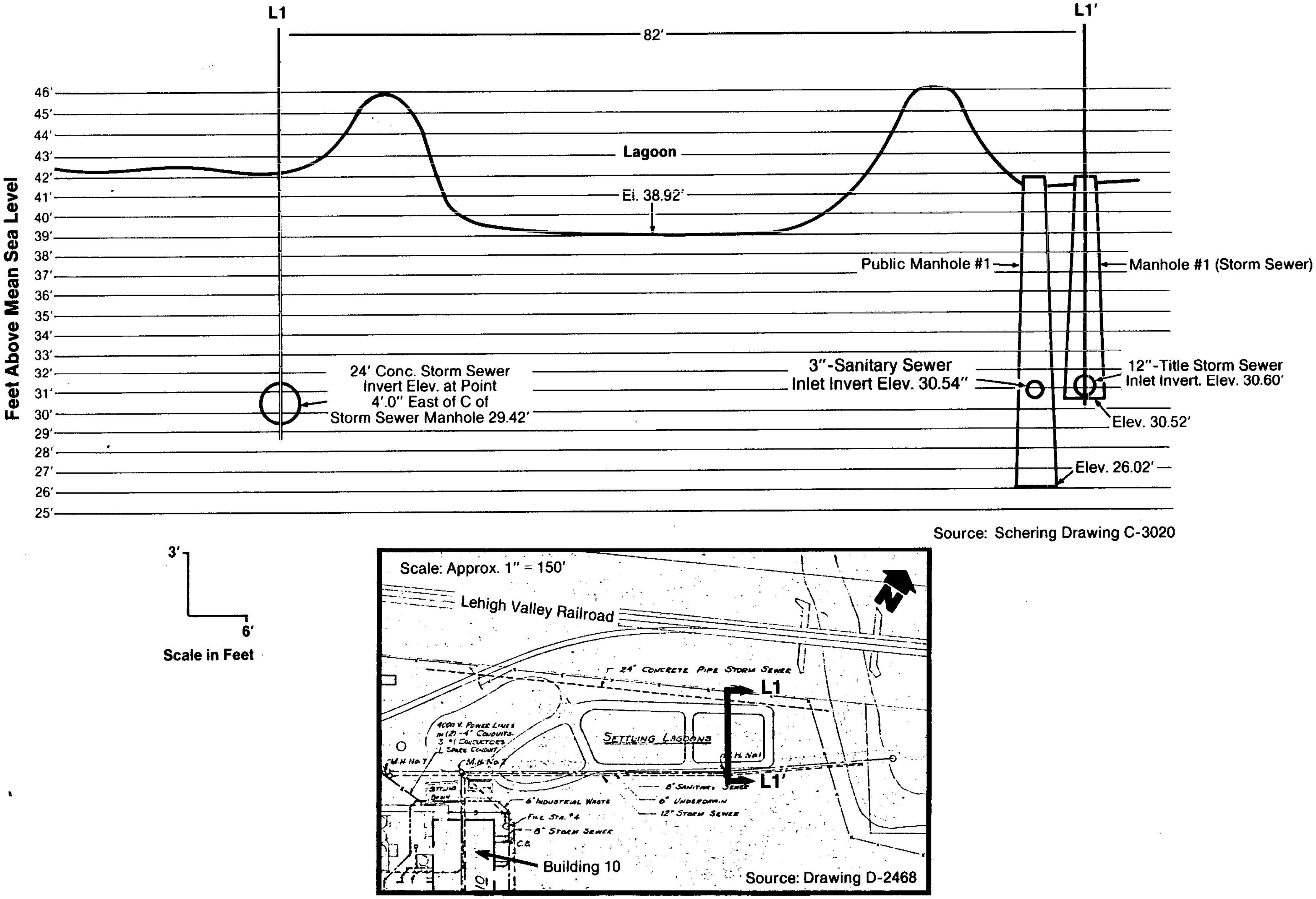
Interviews conducted with long-term plant personnel indicate that the surface impoundments were in operation from the mid to late 1940's until 1953 or 1954. Schering drawing D-1714 confirms that by no later than July 1954 the impoundments had been removed. Schering drawing D-2468 dated 16 January 1949 shows the outline of the four surface impoundments. A portion of this drawing is shown in the bottom half of Figure 6-2. This figure also includes the cross section L1-L1', showing that the banks of the impoundment were about seven feet high and that the elevation of the bottom of the impoundment was approximately 40 feet above mean sea level.

Figure 6-3 illustrates how surface topography has changed over the course of site development in the area. The upper diagram in Figure 6-3 shows site topography in 1937. Comparison with the bottom elevation given in cross section L1-L1' shows that between 8 and 10 feet of fill was emplaced prior to, or during, construction of the surface impoundments. The lower diagram in Figure 6-3 shows that the impoundments were decommissioned in the early 1950's and Building 14 was constructed in 1958. The finished grade varied from 42 feet west of Building 14 to 40 feet above mean sea level east of Building 14. This finished grade of 40 feet to the east of Building 14 is virtually identical to the impoundment bottom elevation shown in cross section L1-L1' (Figure 6-2).

Historical information indicates that during the course of normal operation a dragline was used approximately on an annual basis to remove settled solids from the impoundments. These facts support the conclusion that most of the waste material in the impoundments was probably removed in 1954 and during the subsequent grading of the area and construction of Building 14 in 1958.

6.4.3 The Chemistry of Wastes

Interviews with long-time plant personnel and samples collected during Phase II and the RI indicate that "green mother liquor," a caustic neutralized waste from the oxidation of cholesterol with chromic and sulfuric acids, was pumped from the various manufacturing buildings via flexible hoses and collected in the impoundments. There is no evidence that sewers were used to deliver waste to the impoundments. In the impoundments, solids were allowed to settle and liquids allowed to evaporate and infiltrate into the unconsolidated deposits. Historical information indicates that there were no outfalls from the impoundments. The solids collecting on the impoundment bottom reportedly formed a blue-green cake. Since the chromic acid was used to oxidize cholesterol, the chromium was reduced from the hexavalent species (Cr^{+6}) to the trivalent cation (Cr^{+3}).

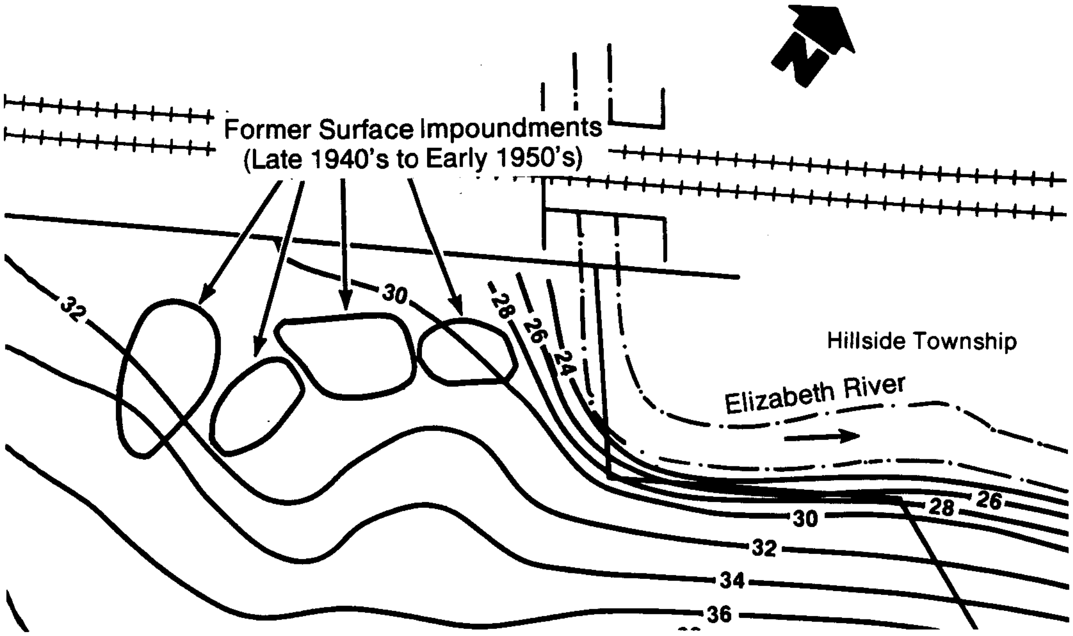


Source: Schering Drawing C-3020

Source: Drawing D-2468

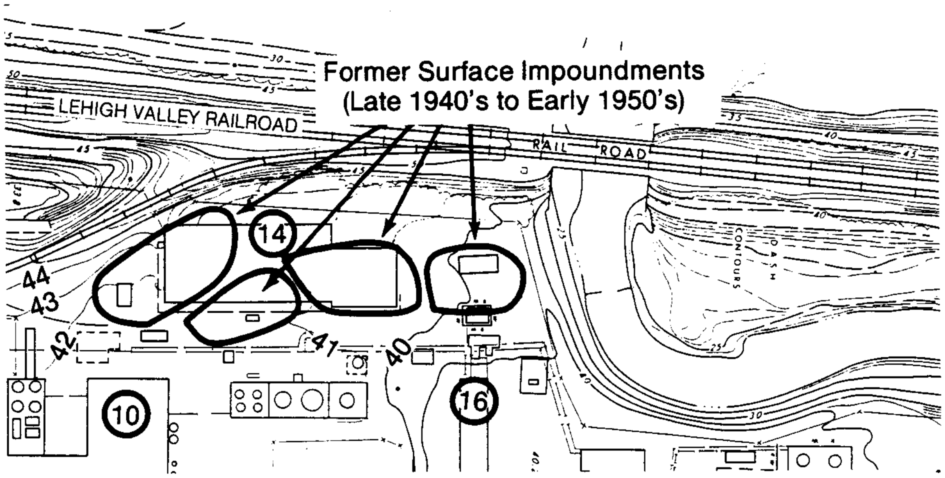
FIGURE 6-2 SECTION L1-L1'

Location of Surface Impoundments and Site Topography
in 1937 (Pre-Development)



(See Figure 5-6 for complete map)

Location of Surface Impoundments and Site Topography
in 1977 (Unchanged as of 1986).



(See Figure 5-7 for complete map)

Approximate Scale
1" = 150'

FIGURE 6-3 LOCATION OF SURFACE IMPOUNDMENTS WITH RESPECT TO CHANGING SITE TOPOGRAPHY

Wastewater streams containing some water-soluble fraction of organic solvents may have also been collected in the surface impoundments. It is likely that the majority of the solvents evaporated into the atmosphere. In addition, if there were any sediments contaminated with volatile organic priority pollutants, they would have been removed during decommissioning of the surface impoundments.

6.4.4 Remedial Investigation Findings

6.4.4.1 Soil Sampling Program

The results of the RI show that no adverse environmental impact is occurring at the Schering facility as a result of residual materials from the operation of the surface impoundments. Operation of the impoundments apparently caused some elevation of chromium levels in sediments beneath the impoundments as compared to values found elsewhere on-site. However, neither these chromium levels in the sediment nor remnants of the blue-green clayey impoundment bottom material are degrading groundwater quality. Evidence for these conclusions has been drawn from eighteen soil borings and four monitoring wells in the vicinity of Building 14.

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BE[illegible]

A total of 98 analyses were conducted for priority pollutant and Safe Drinking Water Act metals in soil samples collected during the RI and Phase II field programs from the four zones shown is Plate 1. The distribution of these analyses in the zones is summarized in Table 6-10.

Remnants of blue-green clayey material were observed in a series of borings conducted during Phase II and the RI field programs. Discovery of an approximately one-foot thick layer of the blue-green clayey material in the boring for MW-2 in 1984 led to the subsequent installation of 17 borings to determine the lateral and vertical extent of this material. The locations of these soil borings are shown in Figure 6-4. This figure also delineates the locations and elevations where this blue-green clayey material was observed. The fact that this clayey material is most probably relic waste from the impoundments is reinforced by the fact that the material is quite different in color and texture than the naturally occurring dark reddish brown, clayey silt, and sandy clays in the vicinity of Building 14. Figure 6-4 shows the outlines of the four impoundments as taken from Schering drawings. As can be seen from the figure, every effort was made to penetrate the former impoundment areas during the RI activities. The GPR study results discussed in Subsection 5.2 confirm that these borings were correctly located.

Table 6-10

Summary of Results of Priority Pollutant Metals and Safe Drinking Water Act Metals Analyses Conducted on Sediment Samples

Zone[1]	Total Samples Collected[2] Phase II	RI	Total	Total Samples Analyzed for Metals
1	19	41	60	35
2	4	27	31	31
3	2	8	10	2 (Phase II only)
4	3	7	10	10
	28	83	111	98

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[1] See Plate 1 for location.
[2] Samples collected from all four zones; combined area of zones equals 15 percent of facility area.

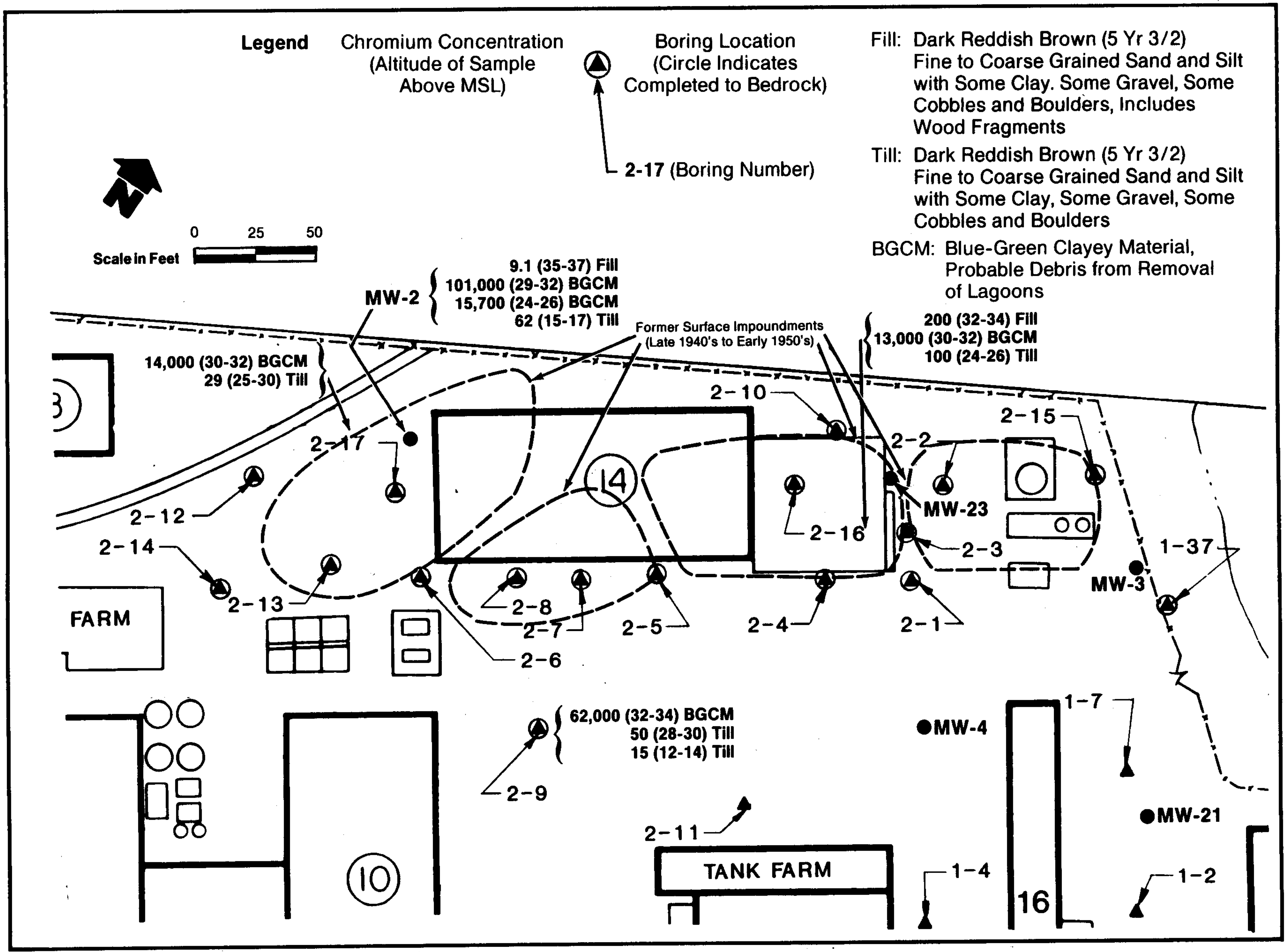

FIGURE 6-4 CHROMIUM CONCENTRATIONS AND LOCATIONS OF BLUE-GREEN CLAYEY MATERIAL (ALL VALUES IN PPM)

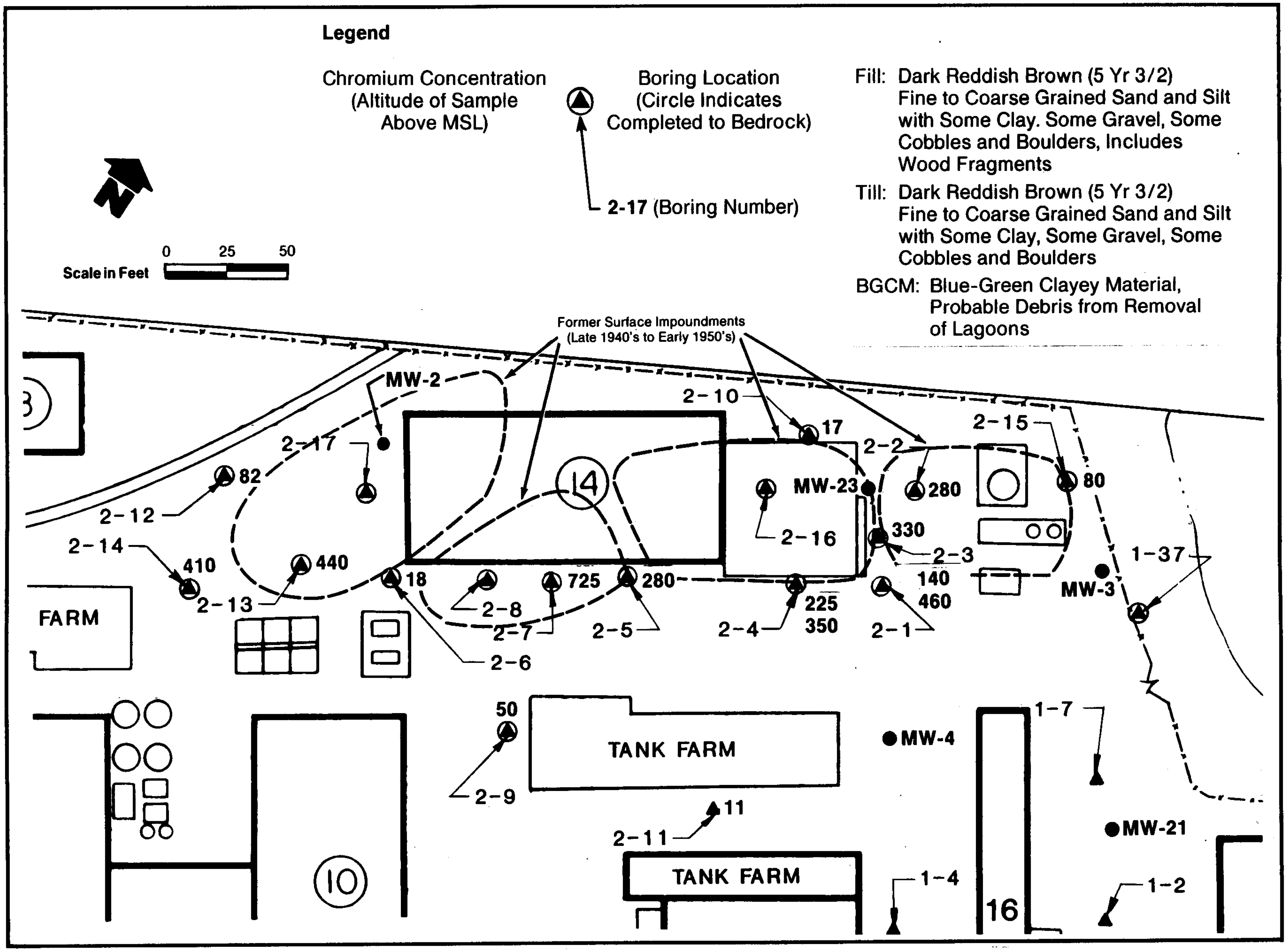

FIGURE 6-5 CHROMIUM CONCENTRATIONS IN SOIL IN THE FORMER SURFACE IMPOUNDMENT AREA (ALL VALUES IN PPM) SAMPLES FROM 22 TO 32 FEET ABOVE SEA LEVEL

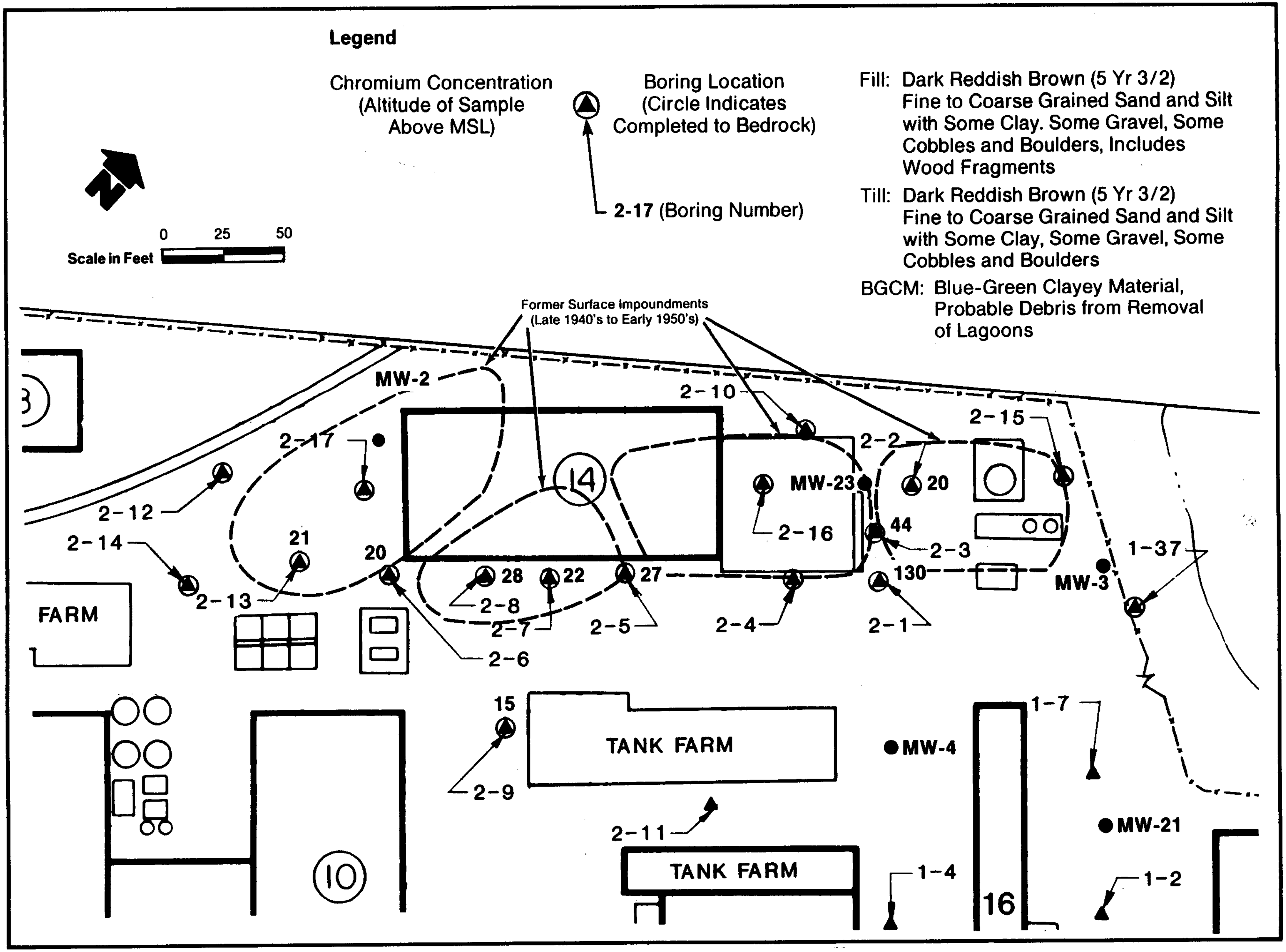

FIGURE 6-6 CHROMIUM CONCENTRATIONS IN SOIL IN THE FORMER SURFACE IMPOUNDMENT AREA (ALL VALUES IN PPM) SAMPLES FROM 8 TO 17 FEET ABOVE SEA LEVEL

Table 6-11

Summary of Statistics for Site Chromium Data

Class[1]	N[2]	Logarithmic Mean of Chromium Concentration	Standard Deviation
1	29	1.92	0.5332
2	35	1.08	0.4623
3	6	4.46	0.3730

[1] See Table O-1 for chromium data.
[2] N = number of observations.

Analyses of soil samples collected during the RI revealed that high chromium concentrations in the sediments ranging from 15,700 to 101,000 mg/kg dry weight were restricted to the sporadically encountered blue-green clayey material. Figure 6-4 shows the four locations where this material was detected, the elevation and the chromium concentration. Also shown are the chromium concentrations of samples collected from above and below the blue-green clayey material.

In addition, Figures 6-5 and 6-6 illustrate the pattern of chromium concentrations in sediment samples collected from borings in the vicinity of Building 14. Comparison of the data in these figures shows that while chromium concentrations are high in the blue-green clayey material, they decrease with increasing depth.

To assess whether or not the blue-green clayey material or infiltration of chromium laden water during impoundment operation have caused any change in the natural chemistry of the soil, a series of statistical analyses were conducted by WESTON. The analytical results for samples collected in the former surface impoundment area were compared to results for samples collected elsewhere on-site. There is no evidence that chromium wastes were collected or disposed of elsewhere on the site. Hence, the samples collected outside the former surface impoundments represent naturally occurring chromium levels in the sediment.

Table O-1 in Appendix O presents the analytical data which have been grouped into three classes:

1. Sediment samples collected in the vicinity of the surface impoundments which are not blue-green clayey material.

2. Sediment samples collected on-site but not in the former surface impoundment area.

3. Blue-green clayey material.

If the collection of chromic wastes in the surface impoundments has had no impact on chromium levels in the underlying soils, then the means of class 1 and class 2 should not be significantly different. Before taking the mean, the data were normalized by taking the log of the chromium values. Table 6-11 lists the means and standard deviations of the log values in each class. A Student t test for comparing the mean values of samples of different sizes was used to compare the means of class 1 and class 2. The calculation of the t statistic is included in Appendix O.

The mean values were found to be significantly different and support the conclusion that chromic waste collection in the impoundments caused elevation of chromium levels in the sediment beneath the former surface impoundments. To evaluate why the means are different, a correlation procedure was conducted. Table O-2 in Appendix O summarizes the data for the correlation between chromium, altitude and the log of chromium in class 1 and class 2. The results show a correlation between chromium and altitude in class 1. This correlation is explained by reference to Figure 6-5 and Figure 6-6 which show that higher chromium concentrations were found in the altitude range of 22 to 32 feet and lower concentrations were found in the altitude range of 8 to 17 feet above mean sea level.

Comparison of the values in the 8 to 17 foot range in class 1 with values in class 2 as listed in Table O-1 shows that they are similar, suggesting that naturally-occurring chromium levels prevail in the 8 to 17 foot altitude range.

Connor and Shacklette (1975) report a range of chromium concentrations in uncultivated soils of 11 to 78 ppm. For shale, they report a range of 62 to 130 ppm. Since the site is underlain by the shale and siltstone of the Brunswick formation and much of the sediment on-site was derived from erosion or weathering of this unit, the values in class 2 and in the 8 to 17 foot altitude range of class 1 are similar to those reported by Connor and Shacklette (1975). The statistics in Table O-2 show no correlation between altitude and chromium concentration in the class 2 samples. This lack of correlation would be expected in natural sediments unaffected by chromic wastes.

6.4.4.2 Groundwater Sampling Program Results

The results of the groundwater sampling program show that neither the blue-green clayey material nor elevated soil chromium levels in the surface impoundment area are degrading groundwater quality. The primary reason for this is that the chromium in the sediment and the blue-green clayey material is in the trivalent state which is essentially immobile in the environment. This conclusion was reached after considering the chemistry of the impoundments and is supported by the results of EP toxicity tests and groundwater sample results.

EP toxicity tests were conducted on samples of the blue-green clayey material and sediment drilling cuttings generated during the installation of monitoring wells, soil borings and piezometers on the site. The results of the EP toxicity tests are presented in Table 6-12. The result of the test on blue-green clayey material showed leachate levels well below the EP maximum chromium leachate concentration of 5.0 ppm. A leachate level above 5.0 ppm for chromium would characterize the material as a hazardous waste. As stated in the Phase II report (WESTON, 1984), one sample of blue-green clayey material with 27,000 mg/kg dry weight of chromium was analyzed and found to contain only 0.1 mg/kg dry weight (or 0.0037 percent) hexavalent chromium (Cr^{+6}). Complete data reports on all the EP toxicity test analyses are included in Appendix P.

The groundwater sample results confirm that the chromium in the sediment and the blue-green clayey material are immobile. As shown in Figure 6-3, MW-2 was installed in the western most impoundment and is screened through the interval where the blue-green clayey material was encountered. Figure 6-3 also shows that MW-23 was positioned in the eastern most impoundment. MW-3 and MW-4 are positioned near the surface impoundment area. Groundwater flow at the site is from west to east, from MW-2 toward MW-3. Table 6-13 summarizes the analytical results for groundwater samples collected during 1984, 1985, and 1986 at MW-2, -3, -4, and -23. The maximum concentration detected in any of the samples was 0.05 ppm. This level was detected once in March 1985 in a sample from MW-2. The levels have all been consistently below the EPA proposed Recommended Maximum Contaminant Level of 0.12 ppm and the current NJDEP Primary Drinking Water Standard of 0.05 ppm for chromium.

TABLE 6-12

SEDIMENT SAMPLE CHROMIUM CONCENTRATIONS AND LEACHATE DATA FOR EP TOXICITY TESTS (ALL VALUES IN PPM)

PARAMETER	MW-2.6 (1) SEDIMENT	MW-2.6 (1) LEACHATE	MW-2.6 DUPLICATE SEDIMENT	MW-2.6 DUPLICATE LEACHATE	MW-6S, 6D, 7 COMPOSITE (2) SEDIMENT	MW-6S, 6D, 7 COMPOSITE (2) LEACHATE	EPA MAXIMUM LEACHATE CONCENTRATION
CHROMIUM	101000	0.25	44000	<0.1	10 TO 109	<0.02	5
ARSENIC	55	<0.01	NA	NA	<4 TO 22	<0.01	5
BARIUM	71	NA	NA	1.3	10 TO 1050	<0.03	100
CADMIUM	3.5	<0.002	NA	NA	<0.1 TO 1.6	<0.01	1
LEAD	139	<0.08	NA	NA	5 TO 690	0.016	5
MERCURY	<0.1	0.006	NA	NA	<.02 TO 0.093	<0.002	0.2
SELENIUM	197	<0.01	NA	NA	<0.01 TO 0.3	<0.01	1
SILVER	1.3	<0.002	NA	NA	<0.2 TO 1	<0.02	5

NA = NOT ANALYZED
ALL SEDIMENT VALUES IN Mg/Kg DRY WT.
ALL LEACHATE VALUES IN PPM

(1) EP TOXCICITY TEST CONDUCTED ON BLUE-GREEN CLAYEY MATERIAL
(2) EP TOXCICITY TEST ON A COMPOSITE OF DRILLING CUTTINGS (SEDIMENT) GENERATED DURING INSTALLATION OF MONITORING WELLS

Table 6-13

Groundwater Sample Data for Wells in the Vicinity of the Former Surface Impoundments

SAMPLING LOCATION AND DATE	DRINKING WATER STANDARDS (2)		UPGRADIENT WELL (3) MW-2	MW-2	MW-2	MW-2 PTL	MW-2	MW-2	MW-2
METALS (PPM)	(mg/l)		7/84	8/84	3/85	3/85	8/6/85	11/21/85	2/11/86
ANTIMONY	NA	NA	<0.03	<.07	<0.02	0.07	<0.03	<0.03	<0.03
ARSENIC	0.05	NA	<0.01	<.01	0.01	<0.01	<0.01	<0.01	<0.01
BARIUM	1.0	RMCL=1.5	0.11	0.051	0.09	0.13	0.4	0.05	0.06
BERYLLIUM	NA	NA	<0.002	<.002	<0.001	<0.01	<0.01	<0.01	<0.01
CADMIUM	0.01	RMCL=.005	0.002	<.002	<0.02	<0.01	<0.01	<0.01	<0.01
CHROMIUM	0.05	RMCL=.12	<0.01	<.02	0.05	0.01	<0.02	<0.02	<0.02
COPPER	1.0	RMCL=1.3	0.009	0.012	<0.007	0.02	<0.02	<0.02	<0.02
IRON	0.3	NA	0.07	0.51	0.23	0.67	0.04	4.4	2
LEAD	0.05	RMCL=.02	0.02	0.008	0.02	0.32	<0.03	<0.03	<0.03
MANGANESE	0.05	NA	0.5	0.28	0.22	0.35	1.3	0.3	0.09
MERCURY	.002	RMCL=.003	<.001	0.002	<0.002	<0.001	<0.002	<0.002	<0.002
NICKEL	NA	NA	<0.01	0.008	0.03	0.04	<0.03	<0.02	<0.02
SELENIUM	.01	RMCL=.045	0.02	<.01	<0.01	<0.01	<0.01	<0.01	<0.01
SILVER	0.05	NA	<0.004	<.003	<0.003	<0.01	<0.02	<0.01	<0.01
SODIUM	NA	NA	128	138	200	210	190	150	81
THALLIUM	NA	NA	<0.03	<.017	<0.08	0.045	<0.08	<0.08	<0.08
ZINC	5	NA	2.4	2.53	0.11	1.17	0.17	0.04	<0.02
			MW-2	MW-2	MW-2	MW-2 PTL	MW-2	MW-2	MW-2
INTERNATIONAL TECHNOLOGY SAMPLE NUMBER			25887		31189	37735 PTL #	43200	48658	51682

(1) OIL AND GREASE ANALYSES FOR 1984 SAMPLE
(2) FEDERAL DRINKING WATER STANDARDS (NJ ADOPTED)
(3) MW-2 INSTALLED IN WESTERN MOST SURFACE IMPOUNDMENT & BLUE-GREEN CLAYEY MATERIAL WAS FOUND IN THE BORING.
(4) MW-23 PLACED IN EASTERN MOST IMPOUNDMENT.
NA = NOT APPLICABLE, ND = NOT DETECTED
BMDL = BELOW MINIMUM DETECTION LIMIT
RMCL = EPA RECOMMENDED MAX. CONCENTRATION LEVEL

Table 6-13
(continued)

SAMPLING LOCATION AND DATE	DRINKING WATER STANDARDS (2)		DOWNGRADIENT WELL MW-3	MW-3 ETC	MW-3	MW-3 ETC	MW-3	MW-3	MW-3	MW-3
METALS (PPM)	(mg/l)		7/84	7/84	8/84	8-22-84	3/85	8/9/85	11/27/85	2/14/86
ANTIMONY	NA	NA	<0.03	BMDL	<.07	ND	<0.02	<0.03	<0.03	<0.03
ARSENIC	0.05	NA	<0.01	BMDL	<.01	0.009	<0.01	0.02	<0.01	<0.01
BARIUM	1.0	RMCL=1.5	1.6	1.4	0.61	1.5	0.76	0.42	0.19	0.58
BERYLLIUM	NA	NA	<0.002	ND	<.002	ND	<0.001	<0.01	<0.01	<0.01
CADMIUM	0.01	RMCL=.005	<0.002	ND	<.002	ND	<0.02	<0.01	<0.01	<0.01
CHROMIUM	0.05	RMCL=.12	<0.01	0.03	0.03	0.04	<0.05	0.02	<0.02	0.03
COPPER	1.0	RMCL=1.3	0.006	BMDL	0.018	0.012	0.009	<0.01	<0.02	<0.02
IRON	0.3	NA	0.38	0.4	0.14	9.9	0.14	0.5	0.3	2
LEAD	0.05	RMCL=.02	0.01	BMDL	<.008	BMDL	<0.02	<0.03	<0.03	<0.03
MANGANESE	0.05	NA	12.5	9.9	1.72	6.9	2.8	2.8	2.3	3.8
MERCURY	.002	RMCL=.003	0.001	0.001	<.002	ND	<0.002	<0.002	<0.002	<0.002
NICKEL	NA	NA	<0.01	BMDL	0.008	ND	<0.05	<0.02	<0.02	<0.02
SELENIUM	.01	RMCL=.045	<0.01	BMDL	<.01	BMDL	<0.01	<0.01	<0.01	<0.01
SILVER	0.05	NA	<0.004	BMDL	<.003	ND	<0.003	<0.01	<0.01	<0.01
SODIUM	NA	NA	283	360	124	150	710	120	58	94
THALLIUM	NA	NA	<0.03	ND	<.017	ND	<0.08	<0.08	<0.08	<0.08
ZINC	5	NA	6.2	6.8	3.2	8.7	1	0.45	0.16	0.23
			MW-3	MW-3 ETC	MW-3	MW-3 ETC	MW-3	MW-3	MW-3	MW-3
INTERNATIONAL TECHNOLOGY SAMPLE NUMBER			22839	F0416		F1762	33725	43395	48741	51965

(1) OIL AND GREASE ANALYSES FOR 1984 SAMPLE
(2) FEDERAL DRINKING WATER STANDARDS (NJ ADOPTED)
(3) MW-2 INSTALLED IN WESTERN MOST SURFACE IMPOUNDMENT & BLUE-GREEN CLAYEY MATERIAL WAS FOUND IN THE BORING.
(4) MW-23 PLACED IN EASTERN MOST IMPOUNDMENT.
NA = NOT APPLICABLE, ND = NOT DETECTED
BMDL = BELOW MINIMUM DETECTION LIMIT
RMCL = EPA RECOMMENDED MAX. CONCENTRATION LEVEL

Table 6-13
(continued)

SAMPLING LOCATION AND DATE	DRINKING WATER STANDARDS (2)		DOWNGRADIENT WELL					
			MW-4	MW-4	MW-4 DUP	MW-4 ETC	MW-4	MW-4 PTL
METALS (PPM)	(mg/l)		7/84	8/84	8-22-84	8-22-84	3/85	3/85
ANTIMONY	NA	NA	<0.03	<.07	<0.07	BMDL	<0.02	0.05
ARSENIC	0.05	NA	<0.01	<.01	<0.01	BMDL	<0.01	<0.01
BARIUM	1.0	RMCL=1.5	0.58	0.335	0.26	0.47	0.36	0.43
BERYLLIUM	NA	NA	<0.002	<.002	<0.002	ND	0.001	<0.01
CADMIUM	0.01	RMCL=.005	0.005	<.002	<0.002	BMDL	<0.02	<0.01
CHROMIUM	0.05	RMCL=.12	<0.01	<.02	<0.02	BMDL	<0.05	0.03
COPPER	1.0	RMCL=1.3	0.007	0.011	0.015	0.033	0.02	0.035
IRON	0.3	NA	138	56.9	54.3	84	64	25.2
LEAD	0.05	RMCL=.02	0.02	0.018	<0.008	BMDL	0.04	0.39
MANGANESE	0.05	NA	26	20.7	14.8	28	29	9.9
MERCURY	.002	RMCL=.003	<0.001	<.002	0.002	ND	<0.002	<0.001
NICKEL	NA	NA	0.11	0.016	<0.008	ND	0.08	0.11
SELENIUM	.01	RMCL=.045	<0.01	<.01	<0.01	BMDL	<0.01	<0.01
SILVER	0.05	NA	0.005	<.003	<0.003	ND	<0.003	<0.01
SODIUM	NA	NA	167	150	148	180	160	84
THALLIUM	NA	NA	<0.03	<.017	<0.017	ND	<0.08	0.032
ZINC	5	NA	4.1	0.74	0.93	1.6	0.07	0.69
			MW-4	MW-4	MW-4 DUP	MW-4 ETC	MW-4	MW-4 PTL
INTERNATIONAL TECHNOLOGY SAMPLE NUMBER			25889		26983	F1763	33724	37735 PTL #

(1) OIL AND GREASE ANALYSES FOR 1984 SAMPLE
(2) FEDERAL DRINKING WATER STANDARDS (NJ ADOPTED)
(3) MW-2 INSTALLED IN WESTERN MOST SURFACE IMPOUNDMENT & BLUE-GREEN CLAYEY MATERIAL WAS FOUND IN THE BORING.
(4) MW-23 PLACED IN EASTERN MOST IMPOUNDMENT.
NA = NOT APPLICABLE, ND = NOT DETECTED
BMDL = BELOW MINIMUM DETECTION LIMIT
RMCL = EPA RECOMMENDED MAX. CONCENTRATION LEVEL

Table 6-13
(continued)

SAMPLING LOCATION AND DATE	DRINKING WATER STANDARDS (2)		DOWNGRADIENT WELL MW-4	MW-4	MW-4	(4) MW-23	MW-23
METALS (PPM)	(mg/l)		8/9/85	11/22/85	2/11/86	11/22/85	2/5/86
ANTIMONY	NA	NA	<0.03	<0.03	<0.05	<0.03	<0.03
ARSENIC	0.05	NA	<0.01	<0.01	<0.01	<0.01	<0.01
BARIUM	1.0	RMCL=1.5	0.25	0.17	0.35	0.13	0.12
BERYLLIUM	NA	NA	<0.01	<0.01	<0.01	<0.01	<0.01
CADMIUM	0.01	RMCL=.005	<0.01	<0.01	<0.01	<0.01	<0.01
CHROMIUM	0.05	RMCL=.12	<0.02	<0.02	<0.02	<0.02	<0.02
COPPER	1.0	RMCL=1.3	0.02	<0.02	<0.02	<0.02	<0.02
IRON	0.3	NA	130	80	140	120	3
LEAD	0.05	RMCL=.02	<0.03	<0.03	<0.03	<0.03	<0.03
MANGANESE	0.05	NA	20	14	21	2.1	2.5
MERCURY	.002	RMCL=.003	<0.002	<0.002	<0.002	<0.002	<0.002
NICKEL	NA	NA	0.03	0.31	<0.02	<0.02	<0.02
SELENIUM	.01	RMCL=.045	<0.01	<0.01	<0.01	<0.01	<0.01
SILVER	0.05	NA	<0.01	<0.01	<0.01	<0.01	<0.01
SODIUM	NA	NA	120	80	54	60	32
THALLIUM	NA	NA	<0.08	<0.08	<0.08	<0.08	<0.08
ZINC	5	NA	0.11	0.57	0.03	0.16	0.09
			MW-4	MW-4	MW-4	MW-23	MW-23
INTERNATIONAL TECHNOLOGY SAMPLE NUMBER			43394	48725	51532	48729	51523

(1) OIL AND GREASE ANALYSES FOR 1984 SAMPLE
(2) FEDERAL DRINKING WATER STANDARDS (NJ ADOPTED)
(3) MW-2 INSTALLED IN WESTERN MOST SURFACE IMPOUNDMENT & BLUE-GREEN CLAYEY MATERIAL WAS FOUND IN THE BORING.
(4) MW-23 PLACED IN EASTERN MOST IMPOUNDMENT.
NA = NOT APPLICABLE, ND = NOT DETECTED
BMDL = BELOW MINIMUM DETECTION LIMIT
RMCL = EPA RECOMMENDED MAX. CONCENTRATION LEVEL

6.5 THE OCCURRENCE OF BASE/NEUTRAL PRIORITY POLLUTANTS IN SEDIMENT IN THE VICINITY OF MW-7

6.5.1 Overview

Soil and groundwater sampling has been conducted in the vicinity of monitoring well MW-7 to determine the extent of base/neutral priority pollutants in the sediment and groundwater. The results of the sampling programs show no impact on groundwater by priority pollutant base/neutral compounds in this area. The soil sampling program showed only the isolated occurrence of seven base/neutral priority pollutants in the fill material emplaced in this area. The source of these compounds is believed to be coal tar derivatives from construction materials disposed of as part of the fill. Appendix N includes a complete data summary for all of these analyses.

A total of 70 analyses for base/neutral priority pollutant organic compounds were conducted on sediment samples collected during the Phase II and RI field programs. Table 6-14 summarizes the number of these analyses conducted in each of the four zones defined for RI field work. In 44 percent of the analyses completed on samples from the four zones of the facility, only Bis(2-ethylhexyl)phthalate was detected. These zones occupy 15 percent of the facility area. Concentrations ranged from 1 ppm to 37 ppm. In 47 percent of the analyses, no base/neutral priority pollutants were detected. In only 9 percent, or 6 of the analyses, were base/neutral compounds other than bis(2-ethylhexyl)phathalate detected.

6.5.2 Nature and Extent of Contamination

The results of the RI soil boring and sampling program show that seven base/neutral priority pollutants occur in a limited "pocket" in the vicinity of MW-7. The location of MW-7 and soil borings completed during the Phase II and RI field programs are shown in Figure 6-7. Also shown are locations of soil borings completed during foundation studies conducted prior to 1984 by Schering contractors. The groundwater sampling conducted during 1984, 1985, and 1986 has shown that the base/neutral compounds occurring in the soil are not impacting groundwater quality.

The area shown in Figure 6-7 was designated as Zone 3 and included in the RI as a result of the Phase II field investigation. That investigation showed the occurrence of three base/neutral priority pollutants in one of two samples collected during the boring for MW-7. The data for these samples are shown in Table 6-15. During the RI three additional soil borings, 3-1, 3-2, and 3-3, were completed to determine the lateral and vertical extent of the occurrence of any base/neutral priority pollutants.

Table 6-14

Summary of Results of Base/Neutral Priority Pollutant Organic Analyses Conducted on Sediment Samples

Zone[1]	Total Samples Phase II	Total Samples RI	Total	Total B/N[2] Analyzed	B/N's Detected Phathalates	B/N's Detected Other	ND[3]	NA[4]
1	19	41	60	34	13	0	21	26
2	4	27	31	23	10	4	9	8
3	2	8	10	10	6	2	2	0
4	3	7	10	3	2	0	1	7
	28	83	111	70	31	6	33	41

[1] See Plate 1 for location.

[2] Analyses on samples of both unsaturated (dry) and saturated (wet) sediment.

[3] ND = No base/neutrals detected.

[4] NA = Not analyzed.

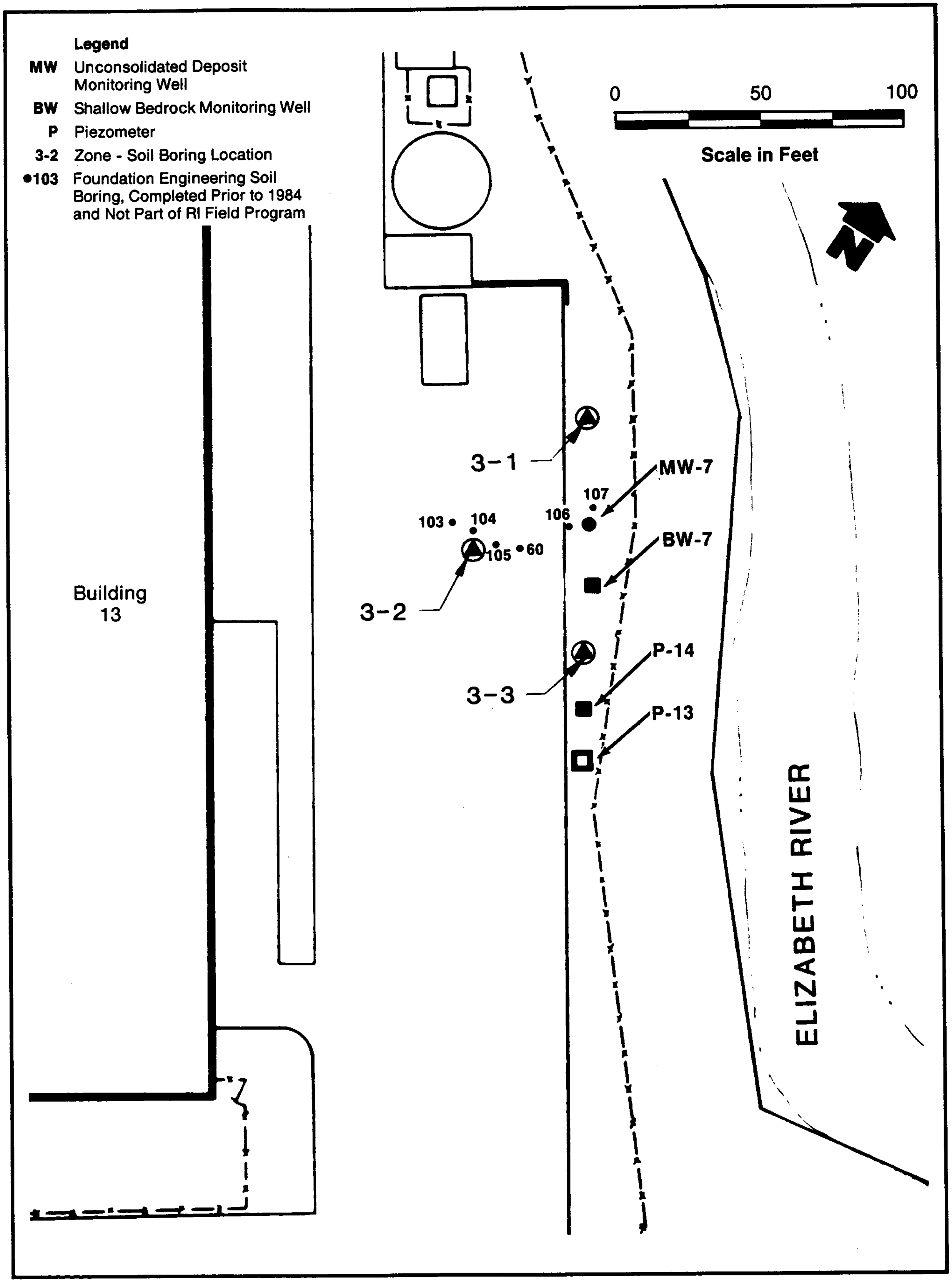

FIGURE 6-7 AREA EXAMINED FOR BASE/NEUTRAL PRIORITY POLLUTANTS (FORMERLY ZONE 3)

Table 6-15

Base/Neutral Priority Pollutant Soil Sampling Results for MW-7 and Vicinity

PARAMETER	3.1.1	3.1.2	3.1.3	3.2.1	3.2.2	3.3.1	3.3.2	3.3.3	7.5	7.8
INORG. (VALUES IN PPM)	5/29/85	5/29/85	5/29/85	5/29/85	5/29/85	5/29/85	5/29/85	5/29/85	6/84	6/84
CYANIDE	NG	NG	NG	NG	NG	NG	NG	NG	NA	NA
PETROLEUM HYDROCARBONS	130	100	96	560	82	450	580	90	207	1220
TOC	3200	2050	170	490	220	4300	4900	220	1250	5300
SULFIDE	NA	NA	NA	NA	NA	NA	NA	NA	<3	<3
ANTIMONY	NA	NA	NA	NA	NA	NA	NA	NA	6.6	<4
ARSENIC	NA	NA	NA	NA	NA	NA	NA	NA	5.8	11
BARIUM	NA	NA	NA	NA	NA	NA	NA	NA	10	1050
BERYLLIUM	NA	NA	NA	NA	NA	NA	NA	NA	0.42	0.56
	NA	NA	NA	NA	NA	NA	NA	NA		
CADMIUM	NA	NA	NA	NA	NA	NA	NA	NA	0.16	0.14
CHROMIUM	NA	NA	NA	NA	NA	NA	NA	NA	21	109
COPPER	NA	NA	NA	NA	NA	NA	NA	NA	46	635
IRON									15000	8980
LEAD	NA	NA	NA	NA	NA	NA	NA	NA	22	690
MANGANESE	NA	NA	NA	NA	NA	NA	NA	NA	394	260
MERCURY	NA	NA	NA	NA	NA	NA	NA	NA	0.056	0.093
NICKEL	NA	NA	NA	NA	NA	NA	NA	NA	20	76
	NA	NA	NA	NA	NA	NA	NA	NA		
SELENIUM	NA	NA	NA	NA	NA	NA	NA	NA	<.01	0.25
SILVER	NA	NA	NA	NA	NA	NA	NA	NA	<.1	1
SODIUM	NA	NA	NA	NA	NA	NA	NA	NA	105	185
THALLIUM	NA	NA	NA	NA	NA	NA	NA	NA	2.8	<2
ZINC									70	900
AMMONIA-N	NA	NA	NA	NA	NA	NA	NA	NA	13	66
TKN	NA	NA	NA	NA	NA	NA	NA	NA	186	302
ORGANIC-N	NA	NA	NA	NA	NA	NA	NA	NA	173	236
PHENOLS	NA	NA	NA	NA	NA	NA	NA	NA	0.06	0.09
VOA'S (VALUES IN PPM)	3.1.1	3.1.2	3.1.3	3.2.1	3.2.2	3.3.1	3.3.2	3.3.3	7.5	7.8
BENZENE	NA	NA	NA	NA	NA	NA	NA	NA	ND	0.054
TOLUENE	NA	NA	NA	NA	NA	NA	NA	NA		0.051
DETECTION LIMIT									.025PPM	.025PPM
BASE NEUTRALS (VALUES IN PPM)	3.1.1	3.1.2	3.1.3	3.2.1	3.2.2	3.3.1	3.3.2	3.3.3	7.5	7.8
BIS(2-ETHYLHEXYL)PHTHALATE	2.87	1.66	3.74	2.62	2.95	2.58	ND	1.77	ND	ND
BENZO(a)ANTHRACENE	ND	ND	ND	ND	ND	1.81	ND	ND	ND	ND
BENZO(b)FLUORANTHENE	ND	ND	ND	ND	ND	1.47	ND	ND	ND	6.4
BENZO(a)PYRENE	ND	ND	ND	ND	ND	1.9	ND	ND	ND	ND
FLUORANTHENE	ND	ND	ND	ND	ND	2.45	ND	ND	ND	8.4
PHENANTHRENE	ND	ND	ND	ND	ND	1.62	ND	ND	ND	ND
PYRENE	ND	ND	ND	ND	ND	1.51	ND	ND	ND	5.9
DETECTION LIMIT = 1 PPM	ND	ND	ND	ND	ND					
SAMPLE DEPTH	8'-10'	14'-16'	23'-25'	8'-10'	23'-25'	8'-10'	14'-16'	23'-25'	8'-10'	15'-17'
PAS SAMPLE NUMBER	40159	40160	40165	40161	40162	40163	40164	40168	28556	28558

NA = NOT ANALYZED, ND = NOT DETECTED
VOA = VOLATILE ORGANIC ANALYSIS

The analytical results from the eight soil samples collected in the vicinity of MW-7 are shown in Table 6-15. Samples were collected at three depth intervals below the ground surface: 8 to 10 feet, 14 to 16 feet, and 23 to 25 feet. Base/neutral compounds were detected in sample 3.3.1 at a depth of 8 to 10 feet. None of the other samples showed any base/neutral compounds except bis(2-ethylhexyl)phthalate which has been attributed to laboratory interference. These results indicate that a pattern of base/neutral compounds does not exist in the soils.

The results of the groundwater sampling program confirm that base/neutral priority pollutant contamination is not occurring as the result of occurrence of base/neutrals in the sediments in the vicinity of MW-7. Groundwater sample data for MW-7, PW-13, and PW-14 are shown in Table 6-16. These wells were completed in the unconsolidated deposits and show no base/neutral constituents. Data from BW-7, a bedrock monitoring well installed next to MW-7, also show no base neutral compounds.

6.5.3 Potential Source Areas

Soil borings completed in Phase II and the RI show conclusive evidence that 10 to 15 feet of fill material was emplaced in the vicinity of MW-7 during the development of the site. These findings are supported by observations made from site contour maps from 1937 and 1977 and aerial photographs from 1940, 1951, 1961, 1974, and 1977. A fill isopach map was developed from these sources and is shown in Figure 5-8.

The boring log for boring 3.3 clearly illustrates the fill layer and the original soil horizon. During the boring, pieces of wood and cinder-like material were encountered in the fill layer. The log for foundation study boring 107 showed fragments of coal or coal-like material in the fill material. The two samples where base/neutral compounds were detected were both obtained from within the fill layer. Three samples collected in the depth range of 23 to 25 feet below the surface, or 8 to 10 feet below the fill material, showed no base/neutral compounds.

Table 6-16

Base/Neutral Priority Pollutant Groundwater Sampling Results for MW-7 and Vicinity

MONITORING WELL LOCATION *******	MW-07	MW-07	MW-07	MW-07	MW-07	MW-07
SAMPLE COLLECTION DATE *********	21-Jul-84	23-Aug-84	27-Mar-85	08-Aug-85	14-Nov-85	10-Feb-86
B/N (METHOD 625)	**					
P027 ACENAPHTHENE	ND	ND	ND	ND	ND	ND
P028 ACENAPHTHLENE	ND	ND	ND	ND	ND	ND
P029 ANTHRACENE	ND	ND	ND	ND	ND	ND
BENZO(a)ANTHRACENE (1)	ND	ND	ND	ND	ND	ND
BENZO(b)FLUORANTHENE (1)	ND	ND	ND	ND	ND	ND
BENZO(g.h.i.)PYRENE	ND	ND	ND	ND	ND	ND
P030 BIS(2-CHLOROETHYL)ETHER	55	ND	ND	ND	ND	ND
P031 BIS(2-CHLOROETHOXY)METHANE	ND	ND	ND	ND	ND	ND
P032 BIS(2-ETHYLHEXYL)PHTHALATE	ND	ND	51	ND	ND	ND
P033 4-BROMOPHENYL PHENYL ETHER	ND	ND	ND	ND	ND	ND
P034 BUTYL BENZYL PHTHALATE	ND	ND	ND	ND	ND	ND
P035 2-CHLORONAPHTHALENE	ND	ND	ND	ND	ND	ND
P036 4-CHLOROPHENYL PHENYL ETHER	ND	ND	ND	ND	ND	ND
P037 DI-n-BUTYLPHTHALATE	ND	ND	ND	ND	ND	ND
P038 1,2-DICHLOROBENZENE	201	ND	ND	ND	ND	ND
P039 1,4-DICHLOROBENZENE	ND	ND	ND	ND	ND	ND
P040 DIETHYLPHTHALATE	ND	ND	ND	ND	ND	ND
P041 2,4-DINITROTOLUENE	ND	ND	ND	ND	ND	ND
P042 2,6-DINITROTOLUENE	ND	ND	ND	ND	ND	ND
P044 1,2-DIPHENYLHYDRAZINE	22	ND	ND	ND	ND	ND
FLUORANTHENE (1)	ND	ND	ND	ND	ND	ND
P045 FLUORENE	ND	ND	ND	ND	ND	ND
P046 HEXACHLOROBENZENE	ND	ND	ND	ND	ND	ND
P047 HEXACHLOROETHANE	97	ND	ND	ND	ND	ND
P048 ISOPHORONE	ND	ND	ND	ND	ND	ND
P050 N-NITROSODIPHENYLAMINE	ND	ND	ND	ND	ND	ND
P051 PHENANTHRENE (1)	ND	ND	ND	ND	ND	ND
PYRENE (1)	ND	ND	ND	ND	ND	ND
BASE NEUTRAL DETECTION LIMIT ***	20 PPB	20 PPB	20 PPB	20 PPB	20 PPB	20 PPB
LABORATORY SAMPLE ID NUMBER	22838	26973	31186	43385	47877	51521

ALL VALUES IN PPB

ND = NOT DETECTED

(1) COMPOUND DETECTED IN SEDIMENT
SAMPLE 3.31 OR MW-7.8

Table 6-16
(continued)

	PIEZOMETER		BEDROCK MONITORING WELL			
MONITORING WELL LOCATION *******	P-13	P-14	BW-07	BW-7 PTL	BW-07	BW-07
SAMPLE COLLECTION DATE *********	11-Feb-86	10-Feb-86	14-Aug-85	14-Aug-85	14-Nov-85	10-Feb-86
B/N (METHOD 625)						
P027 ACENAPHTHENE	ND	ND	ND	ND	ND	ND
P028 ACENAPHTHLENE	ND	ND	ND	ND	ND	ND
P029 ANTHRACENE	ND	ND	ND	ND	ND	ND
BENZO(a)ANTHRACENE (1)	ND	ND	ND	ND	ND	ND
BENZO(b)FLUORANTHENE (1)	ND	ND	ND	ND	ND	ND
BENZO(g.h.i.)PYRENE	ND	ND	ND	ND	ND	ND
P030 BIS(2-CHLOROETHYL)ETHER	ND	ND	ND	ND	ND	ND
P031 BIS(2-CHLOROETHOXY)METHANE	ND	ND	ND	ND	ND	ND
P032 BIS(2-ETHYLHEXYL)PHTHALATE	ND	ND	ND	ND	ND	ND
P033 4-BROMOPHENYL PHENYL ETHER	ND	ND	ND	ND	ND	ND
P034 BUTYL BENZYL PHTHALATE	ND	ND	ND	ND	ND	ND
P035 2-CHLORONAPHTHALENE	ND	ND	ND	ND	ND	ND
P036 4-CHLOROPHENYL PHENYL ETHER	ND	ND	ND	ND	ND	ND
P037 DI-n-BUTYLPHTHALATE	ND	ND	ND	ND	ND	ND
P038 1,2-DICHLOROBENZENE	ND	ND	ND	ND	ND	ND
P039 1,4-DICHLOROBENZENE	ND	ND	ND	ND	ND	ND
P040 DIETHYLPHTHALATE	ND	ND	ND	ND	ND	ND
P041 2,4-DINITROTOLUENE	ND	ND	ND	ND	ND	ND
P042 2,6-DINITROTOLUENE	ND	ND	ND	ND	ND	ND
P044 1,2-DIPHENYLHYDRAZINE	ND	ND	ND	ND	ND	ND
FLUORANTHENE (1)	ND	ND	ND	ND	ND	ND
P045 FLUORENE	ND	ND	ND	ND	ND	ND
P046 HEXACHLOROBENZENE	ND	ND	ND	ND	ND	ND
P047 HEXACHLOROETHANE	ND	ND	ND	ND	ND	ND
P048 ISOPHORONE	ND	ND	ND	ND	ND	ND
P050 N-NITROSODIPHENYLAMINE	ND	ND	ND	ND	ND	ND
P051 PHENANTHRENE (1)	ND	ND	ND	ND	ND	ND
PYRENE (1)	ND	ND	ND	ND	ND	ND
BASE NEUTRAL DETECTION LIMIT ***	20 PPB	20 PPB	20 PPB	20 PPB	20 PPB	20 PPB
LABORATORY SAMPLE ID NUMBER	51680	51530	43823	43822	47876	51531

ALL VALUES IN PPB

ND = NOT DETECTED

(1) COMPOUND DETECTED IN SEDIMENT
SAMPLE 3.31 OR MW-7.8

Based on these observations, it has been concluded that the likely source of the base/neutral compounds detected in the two samples in the fill material is coal or coal tars. Coal tars are a common component of building materials such as asphalt, road sealers, and roofing tars. Fill materials placed along the river were comprised chiefly of construction spoils, mostly excavated soils. This is supported by aerial photography, which shows soil piles in the area, and the building construction chronology, which lists a major addition to Building 13 in 1960-1961. It is likely that some concrete and asphalt paving may also have been deposited at this location.

Coal tars have historically been blended with bituminous materials for various paving and road applications, including dust layers, prime casts, tack coats, seal coats, macadam, and hot or cold plant mixes. This was a common practice as U.S. Tariff Commission statistics for 1940 cite that 54.5 percent of the coal tars produced were used for road tars and pitches. These tars are typically a complex mixture of polynuclear aromatic compounds (ERT/Koppers, 1984).

The presence of base/neutral compounds in the soils in the vicinity of MW-7 is not considered an environmental problem due to the high probability that these substances result from construction debris placed in the fill and the immobile nature as evidenced by groundwater quality data.

6.6 SURFACE-WATER INVESTIGATION FINDINGS

6.6.1 Overview

The Elizabeth River adjacent to the Schering facility was included in the RI to determine if groundwater discharges from beneath the Schering facility are having an impact on water quality in the Elizabeth River. Samples were collected at RS-1, upstream, and RS-3, downstream, of the Schering facility. These locations are shown in Plate 2. Collection of the samples was discussed in Subsection 4.4.3. Appendix M includes a complete data summary for all river sample analyses.

6.6.2 Findings of the Remedial Investigation

The results of the inorganic analyses of these samples are tabulated in Table 6-17. These inorganic analyses are consistent with values obtained from the U.S. EPA STORET System for the Ursino Gaging Station located approximately 1 mile downstream of Schering. The organic analyses data are summarized in Table 6-18 and show that volatile organic priority pollutants have been detected in two samples only. One sample was collected in 1984 and contained very low levels of chloroform and methylene chloride. A sample collected at the same location three days later showed all compounds as not detected. The other sample was collected in 1986 and showed a very low level of benzene just above the detection limit of 5 ppb. None of the samples taken from RS-3 downstream of Schering were found to contain any organic priority pollutants. The STORET System did not include any data on organic priority pollutants. The bis(2-ethylhexyl)phthalate identified in samples in early 1985 has been identified as coming from laboratory interference.

The 1982 State Water Quality Inventory Report prepared by the NJDEP describes the Elizabeth River as having "poor" water quality (Robinson, 1983). The data collected from 1977 to 1981 show increasing concentrations of NH_3, fecal coliform, and NH_3/NH_4^+, and a decreasing concentration of BOD. These results show that the Schering facility has no adverse impact on water quality in the Elizabeth River.

Table 6-17

ELIZABETH RIVER WATER SAMPLE ANALYTICAL RESULTS SUMMARY FOR INORGANIC DATA

SAMPLING LOCATIONS AND DATES

PARAMETER	RS-1	RS-1	RS-1	RS-1	RS-1	RS-3	RS-3	RS-3	RS-3	RS-3	URSINO GAGING STATION (1)		
INORGANICS (PPM)	3-27-84	3-30-84	4-1-85	8-16-85	11-27-85	3-27-84	3-30-84	4-1-85	8-16-85	11-27-85	AVERAGE	MAXIMUM	MINIMUM
ACIDITY (AS CaCO3)	NA	NA	4	18	20	NA	NA	6	20	30	NG	NG	NG
ALKALINITY (AS CaCO3)	NA	NA	54	120	42	NA	NA	12	130	44	97	148	24
AMMONIA-N	0.08	0.14	0.09	<0.05	<0.06	0.17	0.06	0.09	<0.05	<0.06	NG	NG	NG
CYANIDE	<0.02	<0.02	<0.03	NA	NA	<0.02	<0.02	<0.03	NA	NA	NG	NG	NG
NITRATE-N	2.3	1	0.69	1.5	1.5	2.1	1.1	0.88	1.2	2.2	NG	NG	NG
NITRITE-N	NA	NA	0.021	0.04	0.03	NA	NA	0.02	0.03	0.03	NG	NG	NG
TOTAL KJEDAHL NITROGEN	0.48	0.45	0.74	0.93	0.45	0.5	0.31	0.65	0.47	0.56	1.182	4.7	0.2
ORGANIC NITROGEN	NA	NA	0.65	NA	NA	NA	NA	0.56	NA	NA	0.736	2.1	0.8
PETROLEUM HYDROCARBONS (2)	2	3	2	3.3	<1	2	3	1	1.3	<1	NG	NG	NG
pH (UNITS)	NA	NA	7.3	NA	NA	NA	NA	6	NA	NA	7.82	8.9	6.7
PHENOLS	0.004	0.006	0.012	<0.002	0.01	0.003	0.006	<0.003	0.005	0.01	0.003	0.005	0
SPECIFIC COND. (umhos)	430	320	230	NG	NG	360	350	200	NG	NG	654	4250	124
TOC	4	12	8	4.8	6.6	4	4	7	5.3	6.1	6.7	21	2.1
COD	24	17	NA	NA	NA	18	21	NA	NA	NA	NG	NG	NG
SULFIDE	NA	NA	<0.03	<0.02	<0.01	NA	NA	<0.03	<0.02	<0.01	0.26	0.5	0
TDS	NA	NA	220	360	100	NA	NA	180	380	110	395	2410	70
METALS (PPM)	RS-1	RS-1	RS-1	RS-1	RS-1	RS-3	RS-3	RS-3	RS-3	RS-3	AVERAGE	MAXIMUM	MINIMUM
ANTIMONY	NA	NA	<0.02	<0.03	<0.03	NA	NA	<0.02	<0.03	<0.03	NG	NG	NG
ARSENIC	NA	NA	<0.01	<0.01	<0.01	NA	NA	<0.01	<0.01	<0.01	0.002	0.004	0.001
BARIUM	NA	NA	0.04	0.06	0.07	NA	NA	0.01	0.05	0.04	NG	NG	NG
BERYLLIUM	NA	NA	<0.001	<0.01	<0.01	NA	NA	0.008	<0.01	<0.01	0.0667	0.01	0
CADMIUM	NA	NA	<0.02	<0.01	<0.01	NA	NA	<0.02	<0.01	<0.01	0.003	0.007	0.001
CHROMIUM	0.32	<0.01	0.04	<0.02	<0.02	0.095	<0.01	0.01	<0.02	<0.02	0.025	0.07	0.01
COPPER	NA	NA	0.02	<0.03	<0.02	NA	NA	0.026	<0.02	<0.02	0.035	0.083	0.001
IRON	NA	NA	0.24	0.07	0.01	NA	NA	0.33	0.06	0.14	0.659	1.7	0.32
LEAD	NA	NA	<0.02	<0.03	<0.03	NA	NA	0.03	<0.03	<0.03	0.014	0.035	0.003
MANGANESE	NA	NA	<0.008	0.02	0.07	NA	NA	0.01	<0.03	0.14	0.121	0.2	0.05
MERCURY	<0.001	<0.001	<0.002	<0.002	<0.002	<0.001	0.001	<0.002	<0.002	<0.002	0.0002	0.0005	0.0001
NICKEL	NA	NA	<0.05	<0.02	<0.02	NA	NA	0.01	0.02	<0.02	0.062	0.23	0.009
SELENIUM	NA	NA	<0.01	<0.01	<0.01	NA	NA	<0.01	<0.01	<0.01	0.001	0.001	0
SILVER	NA	NA	0.004	<0.01	<0.01	NA	NA	0.003	<0.01	<0.01	NG	NG	NG
SODIUM	NA	NA	27	48	15	NA	NA	34	47	13	59.17	820	8.5
THALLIUM	NA	NA	<0.08	<0.08	<0.08	NA	NA	<0.08	<0.08	<0.08	NG	NG	NG
ZINC	0.08	0.109	0.01	<0.02	0.1	0.08	0.122	0.01	<0.02	0.08	0.154	0.37	0.06
I.T. SAMPLE NUMBER	7	14	33713	43833	48986	8	15	33721	43832	48987			

(1) DOWNSTREAM OF SCHERING, VALUES FROM US EPA STORET SYSTEM
(2) OIL AND GREASE ANALYSES IN ALL 1984 SAMPLES
NA = NOT ANALYZED
< = LESS THAN

Table 6-18

Summary of Organic Priority Pollutant Analyses for the Elizabeth River

RIVER STAGE LOCATION ***********	RS-1	RS-1	RS-1	RS-1	RS-1	RS-1	RS-1
SAMPLE COLLECTION DATE**********	27-Mar-84	30-Mar-84	01-Apr-85	16-Aug-85	27-Nov-85	04-Feb-86	21-Feb-86
VOA (METHOD 624)	**						
BENZENE	ND	ND	ND	ND	ND	NA	6
CHLOROFORM	59	ND	ND	ND	ND	NA	ND
METHYLENE CHLORIDE	13	ND	ND	ND	ND	NA	ND
XYLENE	NA	NA	NA	<5	<10	NA	<10
VOA DETECTION LIMIT*************	5 PPB	5 PPB	5 PPB	5 PPB	5 PPB		5 PPB
A/E (METHOD 625)	**						
** NONE DETECTED IN ANY SAMPLE **							
ACID EXTRACTABLE DETECTION LIMIT	20 PPB	20 PPB	20 PPB	20 PPB	NG	NA	NA
B/N (METHOD 625)	**						
BIS(2-ETHYLHEXYL)PHTHALATE	NA	NA	29	42	ND	ND	NA
BASE NEUTRAL DETECTION LIMIT****			20 PPB	20 PPB	20 PPB	20 PPB	
LABORATORY SAMPLE ID NUMBER	7	14	33713	43833	48986	49927	52157

ALL VALUES IN PPB

ND = NOT DETECTED, NG = NOT GIVEN, NA = NOT ANALYZED

Table 6-18
(continued)

RIVER STAGE LOCATION ***********	RS-3	RS-3	RS-3	RS-3	RS-3	RS-3
SAMPLE COLLECTION DATE**********	27-Mar-84	30-Mar-84	01-Apr-85	16-Aug-85	16-Aug-85	04-Feb-86
VOA (METHOD 624)	**********	**********	**********	**********	**********	**********
BENZENE	ND	ND	ND	ND	ND	ND
CHLOROFORM	ND	ND	ND	ND	ND	ND
METHYLENE CHLORIDE	ND	ND	ND	ND	ND	ND
XYLENE	NA	NA	NA	<5	<5	<10
VOA DETECTION LIMIT*************	5 PPB	5 PPB	5 PPB	5 PPB	5 PPB	5 PPB
A/E (METHOD 625)	**********	**********	**********	**********	**********	**********
** NONE DETECTED IN ANY SAMPLE **						
ACID EXTRACTABLE DETECTION LIMIT	20 PPB	20 PPB	20 PPB	NG	20 PPB	NA
B/N (METHOD 625)	**********	**********	**********	**********	**********	**********
BIS(2-ETHYLHEXYL)PHTHALATE	NA	NA	33	ND	ND	ND
BASE NEUTRAL DETECTION LIMIT****			20 PPB	20 PPB	20 PPB	20 PPB
LABORATORY SAMPLE ID NUMBER	8	15	33721	48987	43832	49928

ALL VALUES IN PPB

ND = NOT DETECTED, NG = NOT GIVEN

6.7 AIR INVESTIGATION FINDINGS

6.7.1 Overview

Air monitoring was conducted at the Schering facility during the installation of soil borings and monitoring wells. Air monitoring has also been conducted during groundwater sampling at some monitoring wells and piezometers. The equipment and methodology used in air monitoring is discussed in Subsection 4.4.5. The air monitoring was conducted primarily to protect the health and safety of WESTON, Schering, and Schering contractor personnel working on-site during drilling and sampling activities. The air monitoring data thus collected also serve to provide an assessment of the potential impact of the facility on air quality.

6.7.2 Findings of the Remedial Investigation

During drilling and sampling activities, background levels of total hydrocarbons were only exceeded occasionally. At these times, in accordance with the Health and Safety Plan contained in the RI/FS Workplan, personnel in the hazard area donned full-face respirators with organic vapor cartridges. The hazard area generally included the 20- to 30-square foot area immediately in the vicinity of the augers or monitoring well. At no time was there a hazard to plant personnel in general or anyone off-site. Background levels of total hydrocarbons generally were measured at 6 to 8 ppm at the WESTON trailer and in the Schering parking lot. The instrument readings were recorded on log forms and are included in the appendices with the drilling log forms.

After drilling, soil borings were backfilled with bentonite and capped with asphalt, and the monitoring wells were sealed with caps. Therefore, the opportunity for airborne contaminants to migrate from the subsurface is eliminated. In addition, the majority of areas exhibiting subsurface volatile problems are either paved or covered by structures. The other areas are vegetated with either grass or trees. In summary, monitoring data indicate no air quality impact from the site, and no pathway by which airborne contaminants could migrate from the subsurface to the atmosphere.

Section 7
Public Health and Environmental Concerns

7. Public Health and Environmental Concerns

SECTION 7

PUBLIC HEALTH AND ENVIRONMENTAL CONCERNS

7.1 OVERVIEW

Risk assessment defines the magnitudes and probabilities of harm to public health and the environment due to releases of hazardous substances. The risk assessment focuses on existing conditions in the study area. It utilizes chemical-analytical results and other information obtained during the RI to determine normal exposure routes. The risk assessment concentrates on those compounds that occur most consistently, in the highest concentrations, and are the most mobile or the most toxic. Such compounds discovered at the Schering facility include benzene, carbon tetrachloride, chloroform, methylene chloride, toluene, 1,2-dichloroethane, trichloroethylene, and bis(2-chloroethyl) ether. The assessment for Schering includes a qualitative to semi-quantitative evaluation of public health risk. This evaluation includes hazard identifications and exposure assessments under existing conditions for compounds identified at the facility.

After the public health and environmental factors have been assessed, the Remedial Investigation is utilized as the basis to define the goals to be attained by cleanup technologies evaluated in the subsequent Feasibility Study (FS). During the FS, each remedial alternative and its associated impacts will be compared to the "No Action" Alternative and its associated impacts.

7.2 HAZARD IDENTIFICATION

The objectives of this subsection are to compile the available data concerning the hazardous substances at the facility and to identify those contaminants that could pose potential concerns to exposed populations. Exposure hazard profiles of the eight compounds cited previously are contained in this subsection.

7.2.1 Benzene

Benzene is an organic chemical used directly as a solvent for waxes, resins, oils, inks, paints, plastics, and rubbers. It is also used in the manufacturing of detergents, explosives, pharmaceuticals, dyes, and varnishes. There is no evidence of large scale use of benzene at the Schering facility.

Benzene is moderately soluble in water (1,800 mg/L at 20°C) and has a specific gravity of 0.879 (at 20°C). At concentrations of greater than 100 ug/L in aerobic groundwater and up to the biota toxic limit, benzene will probably undergo various degrees of biotransformation. At lower concentrations (<10 ug/L), there is less possibility of biotransformation (Wilson, 1983). In anaerobic water, no biotransformation of benzene has been observed.

Chronic exposure to benzene, a known human carcinogen, commonly occurs through inhalation. Exposure to benzene can affect the central nervous system, respiratory system, blood, skin, eyes, and bone marrow. Cases of myeloid leukemia have been reported in the literature (Sax, 1979). The LD_{50} (animal) for benzene is 3,800 mg/kg, and it is considered toxic at this level.

7.2.2 Carbon Tetrachloride

Carbon tetrachloride is a fully-halogenated, aliphatic hydrocarbon, used as a solvent for oils, fats, lacquers, rubbers, waxes, and resins. It is also used as a dry cleaning agent and fire extinguisher. Carbon tetrachloride has been utilized in the past at the Schering facility.

Carbon tetrachloride is slightly soluble in water (800 mg/L at 20°C). Although Wilson, et al. (1983) found no evidence of biotransformation in aerobic water, Parsons (1983) found that carbon tetrachloride was transformed to chloroform in a muck (sic) soil in Florida. The specific gravity is 1.595 at 20°C; therefore, carbon tetrachloride above saturation concentrations will tend to sink in the groundwater.

Carbon tetrachloride is a known persistent human carcinogen. Exposure can occur through inhalation, ingestion, or skin absorption. Exposure to carbon tetrachloride can affect the central nervous system, lungs, liver, kidneys, and skin. Visual problems can also occur (Merck, 1983). The LD_{50} (animal) for carbon tetrachloride is 1,770 mg/kg, and it is considered toxic at this level.

7.2.3 Chloroform

Chloroform is a halogenated, aliphatic hydrocarbon used directly as a solvent and in the extraction and purification of various pharmaceuticals. Chloroform is currently utilized at the Schering facility.

Chloroform is soluble in water (9,600 mg/L at 20°C) and is not biodegradable in water. It tends to sink in the groundwater system due to its specific gravity (1.483 at 20°C) when its concentration exceeds saturation. Chloroform is relatively mobile and persistent in the environment.

Chloroform is a known human carcinogen. Exposure generally occurs through inhalation and ingestion. Exposure to high concentrations of chloroform through inhalation can affect the liver, kidneys, heart, skin, and eyes. The LD_{50} (animal) for chloroform is 800 mg/kg, and it is considered a persistent, moderate toxic at this level.

7.2.4 Methylene Chloride

A halogenated aliphatic hydrocarbon, methylene chloride is used directly as a paint remover and a degreaser, and as a solvent for oils, fats, waxes, bitumens, and cellulose acetates and esters. Methylene chloride is currently used at the Schering facility.

Methylene chloride is very soluble (16,700 mg/L at 20°C) in water and has a low retardation factor. At high concentrations (>100 ug/L), it is possible for biotransformation to occur (Wilson, 1983). At low concentrations (<10 ug/L), biotransformation is unlikely to occur. It has a specific gravity of 1.336 (at 20°C).

Methylene chloride is a suspected human carcinogen. Exposure is mainly through inhalation which causes narcosis by attacking the central nervous system and the cardiovascular system. The LD_{50} (animal) for methylene chloride is 167 mg/kg, and it is considered persistent and very toxic at this level.

7.2.5 Toluene

Toluene is an alkylbenzene used directly as a solvent for paints, lacquers, gums and resins, and as a chemical feed for phenol and nitrotoluene. It is used in the manufacturing of benzoic acid, benzaldehyde, explosives, dyes, and many other organic compounds (Merck, 1983). Toluene is currently used at the Schering facility.

Toluene is slightly soluble in water (530 mg/L at 20°C) and has a specific gravity of (0.867 at 20°C). In aerobic groundwater, Wilson (1983) found that, at concentrations greater than 100 ug/L, biotransformation of toluene is probable. At low concentrations (40 ug/L), biotransformation is less likely.

Toluene is not a known or suspected carcinogen. Acute exposure to toluene, mainly through inhalation, may affect the central nervous system, liver, kidneys, and skin. The LD_{50} (animal) for toluene is 5,000 mg/kg, and it is acutely toxic at this level.

7.2.6 1,2-Dichloroethane

1,2-dichloroethane is a halogenated, aliphatic hydrocarbon which is used directly as a solvent for resins, asphalts, bitumens, and particularly rubber. It is also used as a degreaser in the petroleum and textile industries. In manufacturing, 1,2-dichloroethane is used in making PVC, nylon, viscose rayon, styrene, butadiene rubber, and various plastics. There is no documentation relating to the use of 1,2-dichloroethane at the Schering facility.

1,2-dichloroethane is soluble in water (8,300 mg/L at 20°C) with a low retardation factor. The compound tends to sink within the groundwater system when its concentration exceeds saturation, due to its specific gravity of 1.235 (at 20°C). At high concentrations (>100 ug/L) in aerobic water, biotransformation of 1,2-dichloroethane is possible (Wilson, 1983). At lower concentrations (<10 ug/L), this phenomenon was not observed (Wilson, 1983).

1,2-dichloroethane is a known human carcinogen. Exposure through inhalation can cause irritation of the respiratory tract and conjunctivia, corneal clouding, equilibrium disturbances, narcosis, and abdominal cramps (Merck, 1983). However, because 1,2-dichloroethane has a distinctive odor, its presence can be discerned at relatively safe concentrations. Exposure, therefore, is more common through oral or dermal routes. The LD_{50} (animal) for the compound is 770 mg/kg, and it is considered a moderate toxic at this level.

7.2.7 Trichloroethylene

Trichloroethylene, commonly known as TCE, is a halogenated, aliphatic hydrocarbon which is used directly as a solvent for degreasing, extracting caffeine from coffee, and as a dry cleaning agent. It is a chemical intermediate in the production of pesticides and in the manufacture of organic chemicals and pharmaceuticals.

TCE is slightly soluble in water (1,100 mg/L at 20°C) with a low retardation factor. TCE tends to sink in the groundwater system when its concentration exceeds saturation, due to its specific gravity of 1.464 (at 20°C). TCE is very mobile in the environment. The concentration of TCE will diminish at a somewhat slow rate and will metabolize to chlorinated acetic acids (Wilson, 1983); therefore, TCE is considered a persistent compound in the environment.

TCE is a known, persistent human carcinogen. Exposure commonly occurs through inhalation. Moderate exposure may cause symptoms similar to alcohol inebriation with higher concentrations having a narcotic effect (Merck, 1983). Chronic exposure may cause damage to the liver and other organs. The LD_{50} (animal) for TCE is 4,920 mg/kg, and it is considered toxic at this level.

7.2.8 Bis(2-chloroethyl)ether

A base/neutral compound, bis(2-chloroethyl)ether is used directly in dry cleaning, textile scouring, and soil fumigation. It is also used as a solvent and in the manufacture of paints, varnishes, lacquers, soaps, and finish removers. Bis(2-chloroethyl)ether is not used at the Schering facility; however, it may be a degradation product of other ethers utilized at the facility.

Bis(2-chloroethyl)ether is very soluble (10,200 mg/L at 20°C) with a low retardation factor. It has a specific gravity of 1.22 (at 20°C). The compound is quite mobile and moderately persistent in the environment, but will degrade.

Bis(2-chloroethyl)ether is a known human carcinogen. Exposure to the compound can be strongly irritating to skin, eyes, and mucous membranes (Merck, 1983). The LD_{50} (animal) for bis(2-chloroethyl)ether is 75 mg/kg, and it is considered very toxic at this level.

7.3 EXPOSURE ASSESSMENT

The exposure assessment identifies potential human exposure pathways at the Schering facility. For a potential exposure to occur, there must be:

- A contaminant release to the environment.
- A transport medium in the environment.
- An exposure point for potential human contact with the contaminated medium.
- A human exposure route (e.g., ingestion, inhalation, or dermal) at the exposure point.

Previous sections of this report have described various, potential contamination sources at the Schering facility. Groundwater is considered to be the only exposure pathway of concern. The air investigation has shown that the only releases to the atmosphere occurred during drilling or digging operations. The air pathway is effectively blocked by overlying buildings and pavement. WESTON's surface water investigations have confirmed that there are no downstream potable water users on the Elizabeth River nor have these compounds been detected in surface water samples. Therefore, discussion of potential exposure will focus on the groundwater in the unconsolidated deposits and in the underlying fractured bedrock (Brunswick Formation).

In assessing the potential exposure to contaminants, it is important to compare observed concentrations with established criteria. This allows a basis for evaluating the degree of potential exposure to the population. The following discussion presents these criteria and discusses their applicability to the Schering facility.

7.3.1 National Interim Primary and Secondary Drinking Water Standards and Maximum Contaminant Levels (MCL's)

Primary standards under the Federal Safe Drinking Water Act (SDWA) are promulgated as Maximum Contaminant Levels (MCL's), which represent the maximum allowable levels of certain compounds in public water systems. They are generally based on lifetime exposure to the compound for a 70-kg (154 pound) adult who consumes 2 liters (0.53 gallons) of water per day. Interim health-based MCL's have been established by EPA for 7 organic and 9 inorganic chemicals as presented in Appendix M (Table M-1).

The National Secondary Drinking Water Regulations are intended to control compounds in drinking water that primarily affect the aesthetic qualities (e.g., odor and appearance) relating to the public acceptance of drinking water. At considerably higher concentrations of these compounds, health implications may also exist as well as aesthetic degradation. The secondary MCL's established by EPA are also presented in Appendix M (Table M-2) for 12 parameters. Unlike the primary standards, they are not Federally enforceable, but are intended as guidelines for the states. The SDWA provides that revisions to the interim primary drinking water regulations are to be developed in two steps. First, EPA establishes Recommended Maximum Contaminant Levels (RMCL's), and then it sets revised MCL's as close to the RMCL's as technically and economically feasible.

RMCL's are nonenforceable health goals at which no known or anticipated adverse effects on the health of the population will occur, allowing an adequate margin of safety. RMCL's have no legal impact on public water systems or the public at large. Public water systems are not required to remove contaminants to the RMCL's nor to take other actions regarding those contaminants. RMCL's serve only as goals for the U.S. EPA in the course of setting MCL's and are, therefore, initial steps in the MCL rulemaking process.

On 3 November 1985, EPA published final RMCL's for the eight volatile synthetic organic compounds listed in Appendix M (Table M-3). RMCL's for substances considered to be probable human carcinogens were set at zero; and RMCL's for other substances were set based on chronic toxicity or other data. At the same time, EPA proposed MCL's for these compounds as presented in Appendix M (Table M-4). Finally, EPA also proposed RMCL's for the 11 inorganic chemicals and 26 synthetic organic chemicals presented in Appendix M (Table M-5).

Primary and secondary MCL's are established for tap water and should not be used as standards for groundwater quality where interception, natural attenuation, and/or appropriate treatment is employed prior to utilization as potable water. Nevertheless, MCL's can be utilized as a benchmark or guideline to establish levels of concern for various contaminants in groundwater. For example, if groundwater quality data near a source indicate a contaminant level in excess of an MCL, interception, natural attenuation, treatment, or other remedial factors should be evaluated to determine whether the MCL can be consistently met at the drinking water tap.

The New Jersey Department of Environmental Protection has adopted regulations conforming to the National Primary and Secondary Drinking Water Standards and has established identical MCL's. Therefore, the preceding discussion concerning Federal drinking water requirements is also applicable to State requirements.

7.3.2 Unconsolidated Deposits

Groundwater in the unconsolidated deposits beneath the Schering facility occurs under water table conditions and flow is to the north and east, towards the Elizabeth River. The field data and hydrogeologic modeling also suggest that there is a component of groundwater underflow at certain points along the river (i.e., not all groundwater is discharged to the river, some flows under the river). This is substantiated by concentrations of organics found in PE-1, PE-2, PE-7 and PE-8, all located on the east side of the river. On the east side of river, the groundwater flow shifts to the west and slightly south, somewhat more parallel to the river.

The concentration ranges of the contaminants of concern are presented in Table 7-1. In samples where they were detected, benzene, chloroform, carbon tetrachloride, trichloroethylene, and 1,2-dichloroethane have, on average, exceeded their respective proposed primary maximum contaminant levels (MCL) during the period of July 1984 to February 1986. Methylene chloride and bis(2-chloroethyl)ether exceeded the Clean Water Act recommended water-quality criteria for fish and drinking water at least once. Toluene exceeded its proposed recommended maximum contaminant level (RMCL) at least once during the period of study. As illustrated in Plate 10 and shown by the area given in Table 7-1, benzene affects less than 20 percent of the site. The other compounds affect less than 10 percent of the total site. The off-site areas affected are also limited to relatively small areas of less than one acre with the exception of benzene. In addition, these off-site areas are restricted to the Elizabeth River Park adjacent to Schering where there are no groundwater users.

Although these eight contaminants have exceeded their respective criteria or standards at least once, there are no known potential groundwater receptors downgradient of the site. If there are groundwater receptors downgradient, the processes of adsorption, dilution, and dispersion would aid in attenuating the contaminant concentrations.

7.3.3 Shallow-Bedrock Deposits

Groundwater in the shallow bedrock occurs under semi-confined conditions. The regional component of flow in the fractured bedrock appears to be to the east, towards the Elizabeth River. This flow direction is away from the Hummocks Well Field and other major well fields in the area. Results of the hydrogeologic model developed for the study area, as discussed in Sections 5 and 6, confirm these conditions.

Table 7-2 lists the ranges of concentrations and frequencies of occurrence of the contaminants of concern. Each of the detected compounds exceeded its water-quality standard or criteria at least once from July 1984 to February 1986. However, the ranges of concentrations found for benzene, carbon tetrachloride, and chloroform decrease by at least an order of magnitude from the unconsolidated deposits to the shallow bedrock. Toluene and methylene chloride concentration ranges also decrease in the shallow bedrock, but not as significantly. The concentration range for bis(2-chloroethyl)ether shows a slight increase in the shallow-bedrock monitor wells. Available data indicated that the shallow-bedrock area affected by these contaminants is limited to a relatively narrow horizontal area defined by the line connecting BW-2, BW-4, BW-5 and BW-6 as shown in Plate 10.

Table 7-1

Occurrence of Contaminants of Concern in Groundwater in the Unconsolidated Deposits

	Concentration Range (ppb)[a]							
Compound	Low	Percent of Samples Where Compound Was ND[b]	Mean[c]	Median[c]	High	MCL (ppb)	Affected Area[d] Total	Affected Area[d] Off-Site
Benzene	ND	55.11	1,791	2,100	290,000	5	10.5	2.68
Chloroform	ND	64.20	1,463	5,200	1,100,000	5 100[e]	2.6	0.42
Toluene	ND	52.27	6,469	8,243	580,000	2,000[g]	3.5	0.84
Methylene Chloride	ND	64.77	1,949	3,000	250,000	150[f]	3.81	0.14
Carbon Tetrachloride	ND	83.52	533	320	116,000	5		
1,2-Dichloroethane	ND	93.75	33.5	30	1,200	5		
Trichloroethylene	ND	96.02	40.7	50	1,200	5 NA		
Tetrachloroethylene	ND	93.18	179	1,050	1,750	5 NA		
Bis(2-chloroethyl) ether	ND	94.32	54	56	300	NA		

[illegible] ether

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[a] ppb = parts per billion.
[b] N = 176 sample results. Includes all data from July 1984 to March 1986.
[c] Mean and median were calculated by first normalizing the data by taking the log, computing the statistics of the log values, and then taking the anti-log. Statistics were computed only for samples where compounds were detected.
[d] Total Site Area = 44.7 acres.
[e] Standard for total trihalomethanes (bromidichloromethane, bromoform, and chloroform).
[f] Safe Drinking Water Act Health Advisory Chronic Exposure Limit.
[g] Proposed Recommended Maximum Contaminant Level (RMCL).
ND = Not detected.
NA = Not applicable

Table 7-2

Occurrence of Contaminants of Concern in Groundwater in the Shallow-Bedrock Zone

	Concentration Range (ppb)[a]					
Compound	Low	Percent of Samples Where Compound Was ND[b]	Mean[c]	Median[c]	High	MCL (ppb)
Benzene	ND	60.71	3,172	4,500	7,000	5
Carbon Tetrachloride	ND	82.14	587	1,300	1,800	5
Chloroform	ND	42.86	656	375	230,000	100[e] 5
Methylene Chloride	ND	42.86	2,938	3,960	110,000	150[f] 5
Toluene	ND	67.86	2,593	2,600	132,000	2,000[g]
Bis(2-chloroethyl) ether	ND	82.14	49	53	300	NA

[a] ppb = parts per billion.

[b] N = 28 sample results. Includes all data from July 1984 to March 1986.

[c] Mean and median were calculated by first normalizing the data by taking the log, computing the statistics of the log values and then taking the anti-log. Statistics were computed only for samples where compounds were detected.

[e] Standard for total trihalomethanes (bromidichloromethane, bromoform, and chloroform).

[f] Safe Drinking Water Act Health Advisory Chronic Exposure Limit.

[g] Proposed Recommended Maximum Contaminant Level (RMCL).

ND = Not detected.

NA = Not applicable.

Some of the contaminants of concern have been detected in samples from Schering's production wells as shown in Table 7-3. However, as discussed previously, these compounds cannot be directly attributed as originating from the Schering facility. Trichloroethylene, on the average, occurs in PW-2 and PW-3 at a level above the proposed MCL of 5 ppb. Chloroform generally occurs below the current standard for trihalomethanes of 100 ppb. There is currently no set standard for tetrachloroethylene. It must be noted that Schering's production wells have never been used as potable water sources.

Production well #1

5 ppb.

5 ppb

Table 7-3

Occurrence of Contaminants of Concern in Schering Production Wells

	Concentration Range (ppb)[a]					
Compound	Low	Percent of Samples Where Compound Was ND[b]	Mean[c]	Median[c]	High	MCL (ppb)
Chloroform	ND	47.83	16	11	194	100[e]
Trichloroethylene	ND	43.38	35	37	75	NA
Tetrachloroethylene	ND	43.38	14	14	36	NA

[a] ppb = parts per billion.

[b] N = 23 sample results. Includes all data from February 1984 to February 1986.

[c] Mean and median were calculated by first normalizing the data by taking the log, computing the statistics, and then taking the anti-log. Statistics were computed only for samples where compounds were detected.

[e] Standard for total trihalomethanes (bromidichloromethane, bromoform, and chloroform).

ND = Not detected.
NA = Not applicable.

Section 8
Conclusions and General Response Actions

SECTION 8

CONCLUSIONS AND GENERAL RESPONSE ACTIONS

8.1 CONCLUSIONS AND GENERAL RESPONSE ACTIONS

The principal conclusions for the Schering Remedial Investigation are presented within the following categories:

Conclusions of Environmental Significance:

1. **Volatile organics exist in the shallow groundwater.** Groundwater quality investigations in the unconsolidated deposits determined that elevated levels of volatile organic priority pollutants occurred in groundwater primarily located in the northeast sector of the plant and have migrated off-site to a relatively narrow area adjacent to the Elizabeth River.

2. **Concentrations of volatile organics decrease with depth.** Volatile organics with reported total concentrations as high as 1,000 ppm were detected in groundwater in unconsolidated sediments. Investigations determined that a narrow band of the same volatile organic priority pollutants that were found in the unconsolidated deposits also occurred in the shallow-bedrock zone in the northeast area of the plant. Concentrations of organics in this shallow-bedrock zone generally ranged from 1 to 100 ppb.

3. **Unsaturated sediments contain similar volatile organics.** Sediment sampling in the unsaturated zone identified some of the same volatile organic priority pollutants found in the groundwater.

4. **Surface waters are unaffected.** The surface water investigation found no significant concentrations of volatile organic priority pollutants in samples collected from the Elizabeth River upstream and downstream of the Schering facility.

5. **The area of the former surface impoundments does not represent a concern.** The area of the former surface impoundments was evaluated to determine the existence of chromium wastes in the soil. After extensive soil borings and sample analyses, it has been determined that this area does not represent an environmental concern since the chromium sludges were only found in thin horizontal lenses in widely separated boreholes. This indicates that the past cleanup was accomplished satisfactorily.

6. **Base/neutral compounds adjacent to the Elizabeth River are not a source of contamination.** Former Zone 3 (defined in the RI Workplan) was evaluated to determine the significance of base/neutral compounds in the soil. Extensive soil borings and sampling revealed that the compounds were related to pockets of fill materials that contained asphalt or macadam, and do not reflect contamination of the soil.

Hydrogeologic Conclusions:

1. **Primary groundwater flows are to the north and east.** Groundwater flow directions in the unconsolidated and consolidated strata in the plant area are north and east towards the Elizabeth River.

2. **Shallow groundwater discharges to the Elizabeth River.** Groundwater in the unconsolidated deposits discharges principally to the Elizabeth River, while bedrock groundwater continues flowing north and east beneath the river.

3. **Hydraulic properties are summarized in Table 8-1.**

8.2 DATA SUFFICIENCY

8.2.1 Completeness

A substantial number of soil borings, monitoring wells, and piezometers were installed during the Phase II and RI programs. Table 8-2 summarizes the installations completed during Phase II and the RI. Ten piezometer pairs were completed during the RI including those piezometers suggested by NJDEP to define potentiometric surfaces on the east side of the Elizabeth River. During the RI, 106 drill-hole installations were completed. **These soil borings, piezometers, and monitoring wells provided an extensive network on-site to assure accuracy of the analyses and conclusions presented in this report.**

Table 8-1

Average Hydraulic Properties Resulting from Field Data and Modeling

Unit	Thickness (ft)	Horizontal Hydraulic Conductivity (ft/day)	Vertical Hydraulic Conductivity (ft/day)	Horizontal Hydraulic Gradient	Vertical Hydraulic Gradient	Horizontal Velocity (ft/day)	Vertical Velocity (ft/day)
Unconsolidated Deposits (Layer 1 in Model)	25	20[1]	1.0×10^{-3}	0.01 - 0.008	0.1	0.43 - 1.3	2.7×10^{-5} - 2.7×10^{-4}
Shallow Bedrock (Layer 2 in Model)	50	50	1.2×10^{-3}	0.006	0.2	6 - 15	0.005 - 0.01
Deeper Bedrock (Layer 3 in Model)	600	3.7[2]	0.033	0.004	0.04	0.3 - 0.8	0.03 - 0.07

[1] Average of 12.92 ft/day computed on-site.
[2] Computed from average transmissivity of 2,219 ft^2/day underlying the Schering site.

Table 8-2

Phase II and RI Drilling Summary

Activity	Phase II	RI
Unconsolidated-Deposit Monitoring Wells	14	14
Shallow-Bedrock Monitoring Wells	---	7
Soil Borings	14	65
Shallow Piezometers (On-Site)	---	6
Deep Piezometers (On-Site)	---	6
Shallow Piezometers (Off-Site)	---	4
Deep Piezometers (Off-Site)	---	4

A key element of the RI Workplan was an extensive Sampling and Analysis Plan. Comprehensive sets of analytical parameters were specified for samples obtained from the various environmental media. Based on a detailed review of the field data, QA/QC samples, and repetitive analyses summarized in the appendices to this report, **it is WESTON's conclusion that priority pollutant and indicator parameter analyses are accurate and complete.**

8.2.2 Analytical QA/QC

The February 1986 analytical data were compared to previously-collected data to evaluate the consistency among sampling events, with the February 1986 QA/QC data package serving as a benchmark. Additionally, data obtained from laboratory duplicates, QA/QC verification procedures, and samples split with NJDEP were reviewed to evaluate interlaboratory consistency and reproducibility.

Overall consistency and reproducibility of data are excellent. The analytical data and QA/QC procedures conformed to the requirements established by the Sampling and Analysis Plan and are fully acceptable.

8.2.3 Continuing Sampling and Analytical Efforts

Schering intends to expand the existing data base for the Union facility by voluntarily accomplishing two additional tasks. The first task is the identification and quantification of non-priority pollutant constituents observed in the groundwater. A total of 10 non-priority pollutant volatile organic compounds have been tentatively identified. These substances are predominantly polar compounds such as acetone, methanol, and butyl ether, all of which have relatively high water solubilities. Schering plans to obtain Standard Reference Materials (SRM's) for the majority of these non-priority pollutant substances so that eventual confirmations of the tentative identities can be made.

Approximately 25 non-priority pollutant acid/base/neutral extractable compounds have also been observed in the spectra. It is likely that these substances comprise a wide variety of pharmaceutical manufacturing intermediates. Tentative identifications will, therefore, be a more time-consuming process. After tentative identities have been established, a limited number of the compounds will be selected for confirmatory and quantitative analyses at a later date. Compounds will be selected based on four criteria: toxicity, mobility in the environment, ease of analysis (availability of a standard), and relative peak height in the chromatograms. It is expected that the confirmation and quantification will be completed within the subsequent Feasibility Study effort.

The second task is continuation of the groundwater and surface water sampling program. Existing locations will be sampled quarterly, and analyses will be conducted for key parameters as a result of the experience gained to date for specific sampling locations. This continued monitoring program is being conducted primarily to expand the data base available for the conceptual design stages of the Feasibility Study. Schering plans to conduct future sampling through the first quarter of 1987.

8.3 SPECIFIC FINDINGS AND PRELIMINARY RESPONSE ACTIONS

8.3.1 Groundwater Contamination

Groundwater contamination by volatile organic compounds has been detected both on-site and off-site in the following areas:

8.3.1.1 On-site Groundwater

Unconsolidated deposits

- Volatile organic compounds, primarily benzene, toluene, chloroform, methylene chloride, and carbon tetrachloride have been detected at concentrations greater than 1 ppm in the area to the east of Building 10 and to the north of Building 13.

Shallow Bedrock

- Volatile organic compounds, primarily benzene, toluene, chloroform, methylene chloride, and carbon tetrachloride have been detected at concentrations greater than 1 ppm near Buildings 7, 16, and 18 in monitoring wells BW-2, BW-4, BW-5, and BW-6. In each case, at least 1 compound was detected above 1 ppm.

Deep Bedrock Aquifer

- Of the major volatile organic groundwater contaminants, only chloroform was detected in samples from PW-2 and PW-3. Of a total of 11 occurrences, only 2 have been above the NJDEP drinking water standard for trihalomenthanes (100 ppb). (Samples collected at Hillside 4 in August and November 1985 and February 1986 have shown concentrations of toluene and chloroform in the range of 10 to 50 ppb.)

8.3.1.2 Off-Site Groundwater

Groundwater samples from the unconsolidated deposits on the east side of the Elizabeth River, across from the Schering facility, have shown volatile organic contamination. Analytical data from the PE-Series (off-site) piezometers indicated the presence of volatile organics in concentrations exceeding a total of 1 ppm. Compounds included benzene, toluene, methylene chloride, chloroform and carbon tetrachloride. There are no known domestic or public-supply wells in the unconsolidated deposits in this area. Further, the surface waters of the Elizabeth River are not affected as determined by samples collected upstream and downstream of the Schering plant.

8.3.1.3 Potential Sources of Groundwater Contamination

On-site groundwater has probably been impacted by the same sources which contaminated the unsaturated soils. The industrial sewers and the lateral leading to the Hillside sewer system may have acted as conduits for transporting contaminants. Construction details for the sewers showed that the piping was surrounded by crushed stone. Interviews with long-term employees indicated leaks in the sewers. Of additional interest is the fact that the lateral to the hillside sewer passes through the area of the plant most affected by volatile organic compounds. Thus, it is believed that the ballast surrounding the sewer lines may have contributed to the transport of volatile organics.

The area adjacent to Building 7 was used in the past as a railroad siding for handling solvents and liquids in bulk. Spillage during handling of these materials may have contributed to methylene chloride, chloroform, and possibly other contaminants observed in samples from monitoring wells in this area. The free-phase toluene observed in MW-24 and the toluene and benzene observed in P-9 are probable localized sources of groundwater contamination.

Potentiometric surfaces show that the groundwater gradient slopes from on-site source areas towards (and under) the Elizabeth River. The plant sewer lateral ties into the Hillside sewer in the vicinity of piezometers PE-1 and PE-2, which have exhibited off-site concentrations of volatile organics above 1 ppm. PE-7 and PE-8 are adjacent to, and hydraulically downgradient from, P-9 where a free-phase toluene and benzene layer has been detected. The general area of the Schering facility adjacent to PE-7 and PE-8 has shown elevated concentrations of volatile organics.

8.3.1.4 General Response Actions for Groundwater

Groundwater quality of the unconsolidated deposits underlying the northeastern portion of the Union facility has been affected by a limited number of volatile organic priority pollutants occurring at elevated concentrations. The on-site groundwater has transported some of the organic chemicals under the Elizabeth River to two of four monitoring locations in the Elizabeth River Park where compounds have been detected at concentrations exceeding 1 ppm.

Groundwater present in the shallow bedrock underlying the plant site showed volatile organic priority pollutant concentrations exceeding 1 ppm in 4 of 7 monitoring wells.

Groundwater in the deep bedrock has exhibited volatile organic constituents, limited to toluene and chloroform, at concentrations slightly above detection limits; however, detection of these compounds has been inconsistent.

The RI concludes that contaminated groundwater is the primary environmental concern at the site. A preliminary list of potential remedial responses and associated technologies, as well as responses considered non-viable for the Schering site, are presented in Table 8-3. The Feasibility Study will provide detailed screening and evaluation of remedial responses and applicable technologies.

8.3.2 Soil Contamination

Unsaturated soils located to the east of Building 10 and to the north of Building 13 exhibited volatile organic (toluene and benzene) contamination at concentrations consistently greater than 1 ppm. Elevated levels of TOC, oil and grease, and phenols were detected in the deposits in the area of the former surface impoundments near Building 14. Similarly, the areas adjacent to Building 7 and the abandoned railroad spur have shown concentrations of toluene above 1 ppm.

8.3.2.1 Potential Sources of Soil Contamination

The Union facility has historically utilized significant quantities of various organic chemicals in its diverse manufacturing processes. Potential sources for the compounds observed in the unsaturated soils include:

- The waste solvent pits (east of Building 16) used during the early 1950's.
- The industrial sewers servicing Buildings 6, 10, and 16 and the lateral to the Hillside sewer.

Table 8-3

General Response Actions for Groundwater Remediation

Applicable Response Actions and Technologies

• No Action	Periodic monitoring and analysis
• Pumping	Groundwater removal
• Collection	Interceptor trenches, french drains
• On-Site Treatment	Incineration, air stripping, carbon adsorption
• Off-Site Treatment	Incineration, biological
• In Situ Treatment	Biological

Response Actions Not Considered Applicable

• Diversion	The predominantly developed and paved nature of the facility minimizes surface water infiltration.
• Containment	Effectiveness of physical barriers or capping is doubtful given site conditions.
• Storage	Temporary storage in tanks possible, but would require significant capacity.
• Off-Site Disposal	Free liquids are banned from landfills.

- The drum storage area between Buildings 10 and 16.
- The concrete settling basin north of Building 10.
- The above-ground toluene storage tanks (undiked until the late 1950's).
- The rail car liquid transfer facility and associated storage tanks adjacent to Building 7.

8.3.2.2 General Response Action for Soil

Based on these observations, a number of general remedial response actions potentially applicable to soil remediation have been identified. Table 8-4 presents a preliminary list of response actions proposed for the unsaturated soils. The Feasibility Study will provide further details regarding the screening and evaluations of response actions. Although volatile organic contamination in the soil has been separated from volatile organic groundwater contamination (primarily for the purpose of scoping response actions), the FS will likely consider both soil and groundwater media as a unit in developing and evaluating remedial alternatives.

8.3.3 Areas of No Environmental Concern

Based on the results of the RI, the following areas present no environmental concerns at the site; therefore, they will not require remedial actions.

8.3.3.1 Former Surface Impoundments

The area underlying Building 14, and the immediately-adjacent areas to the east and west, was the site of four surface impoundments in service during the 1940's to early 1950's. Soil samples from the 10-12 and 15-17 foot depth intervals of MW-2 revealed total chromium concentrations as high as 101,000 ppm. These samples were of a blue-green clayey material observed in the soil borings at these depths. This material was quite distinct from the typical reddish-brown clayey silt. EP Toxicity Analyses revealed leachate concentrations of 0.25 ppm of total Cr, well below the action level of 5.0 ppm. Soil borings exhibited elevated concentrations of chromium only in selected boreholes in lenses less than 3" thick. These concentrations of chromium decrease immediately with depth beneath the area once occupied by the surface impoundments. Chromium has not been detected above drinking water standards in any water samples collected on- or off-site.

Table 8-4

General Response Actions for Soil Remediation

Applicable Response Actions and Technologies

No Action	Periodic monitoring and analysis
Containment	Capping, barriers
On-Site Treatment	Incineration, stripping
Off-Site Treatment	Incineration
In Situ Treatment	Soil flushing, air stripping, biological
Partial Removal	Excavating and backfilling
Off-Site Disposal	Landfilling, land application

Response Actions Not Considered Applicable

Pumping, Collection	Groundwater pathway addressed separately (see Table 8-3).
Diversion	Sediment/surface water transport not occurring. Areas of concern are paved.
Complete Removal	Former surface impoundments underlie Building 14. Soil contamination north of Building 13 probably underlies Building 16.
Storage	Temporary storage in-place. Area is paved eliminating releases to surface water and air pathways.

8.3.3.2 Base/Neutral Compounds in Soil

A localized "pocket" of base/neutral extractable compounds was detected in the soils at MW-7 in the 15 to 17 foot depth interval. Soil samples were within the fill material deposited in this area prior to 1961. Samples from below the fill layer did not show any B/N compounds except bis(2-ethylhexyl)-phthalate. Subsequent analysis detected base/neutral compounds in nearby soil boring 3-3 at the 8 to 10 foot depth interval. The B/N compounds are apparently immobilized in the soil matrix and result from pieces of asphalt paving in the fill materials. This conclusion was confirmed by referring to the soil boring logs which described chunks of paving materials present in the drilling cuttings and soil samples. The results of the groundwater sampling program showed that none of the B/N compounds detected in the soils have been found in groundwater samples.

8.4 SUMMARY

The preliminary lists of applicable response actions shown in Tables 8-3 and 8-4 will be evaluated in further detail for their respective areas of concern. This detailed assessment will be undertaken as part of the FS for the Schering facility, which will commence after acceptance and approval of this RI report by NJDEP.

Section 9
References

SECTION 9

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