NEW YORK ELECTRIC & GAS CORPORATION
INVESTIGATION OF THE FORMER
COAL GASIFICATION SITE
GENEVA, NEW YORK

TASK 1 REPORT
PRELIMINARY SITE EVALUATION

TRC Environmental
Consultants, Inc.

TRC Project No. 3292-N61-11

Final Draft

May 14, 1986

800 Connecticut Boulevard
East Hartford, CT 06108
(203) 289-8631

TABLE OF CONTENTS

SECTION PAGE

APPENDICES

LIST OF FIGURES

LIST OF TABLES

1.0 INTRODUCTION

On October 9, TRC Environmental Consultants, Inc., under contract to the New York State Electric and Gas Corporation (NYSEG) received authorization to initiate an investigation of the former coal gasification site in Border City (Geneva), New York. Under terms of the contract, TRC is to provide NYSEG with an investigation made up of five separate Tasks. This report documents the results of Task 1, the Preliminary Site Evaluation.

The primary purpose of Task 1 is to prepare a concise history of the site activities during the plant's 31 years of operation to identify those areas of the property which may be contaminated by waste products from the plant. In addition, the Task 1 investigations were directed to: 1. evaluate potential sources of on-site organic vapor emissions, 2. determine potentially sensitive receptors within one mile of the site, and 3. prepare a preliminary health risk evaluation. This information will be used to develop an investigative strategy that is detailed in the Field Work Plan. This plan is implemented in Task 2 upon approval from NYSEG.

The information collected for the Task 1 Report was gathered from available published data, previous site work, and three visits to the area by TRC staff and subcontractors. During November 12-14, 1985, a site visit was made by TRC personnel to contact the following people/agencies: NYSEG service manager and operations supervisor, Seneca County Historian, Seneca County Health Department, Seneca County Clerk's Office, Waterloo Public Library, Geneva Historical Society, Geneva Public Library, Geneva Board of Education, and Border City Water and Sewer Department. In addition, two retired employees were interviewed: Mr. August Johns and Mr. Frank Kierst. Other work performed during this time period included delineating the site area for the surveying contractor and preparing a site area land use map.

During the weeks of November 18-22 and December 9-13, the site geophysical surveys were performed under the supervision of TRC.

The Task 1 data are presented in the following sections: 2.0 Site History, 3.0 Site Setting, 4.0 Preliminary Site Data, 5.0 Conclusions and Recommendations and 6.0 References. The Field Work Plan for Task 2 is provided separately.

2.0 SITE HISTORY

During the week of November 11-15, 1985, members of TRC Environmental Consultants, Inc. visited the Geneva area to gather information on the history of the Geneva coal gasification plant operations. Copies of maps, newspaper articles, correspondence regarding the site, and ownership information were obtained primarily from the Waterloo and Geneva Historical Societies and libraries.

Two retired NYSEG employees, Mr. August Johns and Mr. Henry Kierst, were interviewed to develop a complete history of the plant processes. Mr. August Johns, a retired maintenance man, worked in various areas of the facility during the ten years prior to the plant closure. Mr. Johns had a large collection of 1920's photographs of the plant from which he described the various plant operations. Mr. Johns' experience was mainly with the coking operation, by-products operation and the purifier operation. Mr. Kierst, also employed during the last 10 years of operation, supported the information given by Mr. Johns and described other operations which he observed as a relief man working in many areas of the plant.

The review of the site conditions and unit operations helped to determine potential sources of waste, areas in which they were handled, and disposal practices. The information collected during TRC's visit to the area is summarized and presented in the following four sections.

2.1 Site Chronology

The original plant was built during the period 1901-1903 by the Empire Coke Company. The Border City site was selected because of the potential market for coke and gas and the existing railroad system (Geneva Times, 1903). A 100-acre tract of land was purchased, with five acres required for the factory itself. The facilities at the original Gas Plant in 1903 consisted of 31 coke ovens and two large gas receivers with a total gas storage of 200,000 cubic feet (Geneva Times, 1903). Figure 2-1 shows locations of the original site structures. Expansions were made in 1909 which increased the total number of coke ovens to 46 (Geneva Times, 1909). Further expansions made later included a blue gas operation with a holder in the northern portion of the site.

In April of 1914, Empire Gas and Electric bought Empire Coke Company. The site remained as Empire Gas and Electric Company until August of 1924 (Geneva Times, 1924 and August Johns, 1985, personal communication) when Mr. Philips of New York and Mr. Olmstead of Pennsylvania purchased the controlling interest in the company. It was not until 6 months later, however, that stock was transferred and New York Central Electric Corporation gained control. Figure 2-2 is a 1925 map showing the location of the major structures. Two weeks before New York Central Electric Company acquired the property, a fire destroyed four wooden conveyors, two coke ovens, and the coal storehouse. The damaged equipment was replaced in 1926 and the coal gasification operations continued until August 29, 1934 when gas production was terminated. A chronology of events at the site is summarized in Table 2-1. The sequence of site ownership is summarized in Table 2-2.

2.2.1 Geneva Plant Operations

The following paragraphs briefly describe the sequence of the operation from the arrival of the coal to the disposal of the wastes. Bituminous coal arrived at the Geneva plant by rail. It was weighed and stored in piles in a coal storage area northwest of the coke ovens. The coal was then crushed and sent to Semet-Solvay ovens where it was heated to about 2000°F. Each oven was fired for 18 hours. The coke was then pushed out the back of the ovens and quenched by water. The wastewater generated from this quenching originally went to a stream, which flowed from the site to Seneca

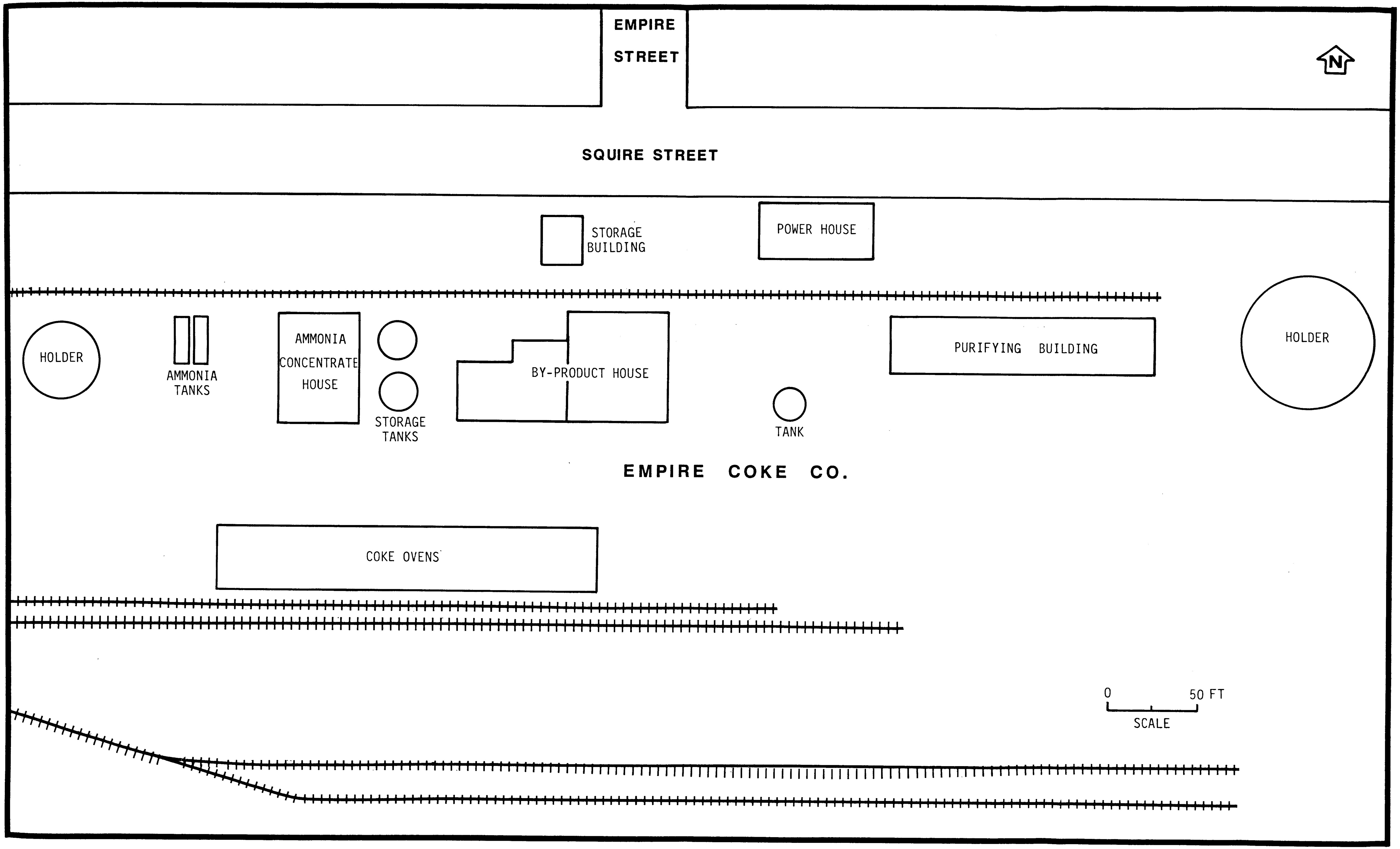
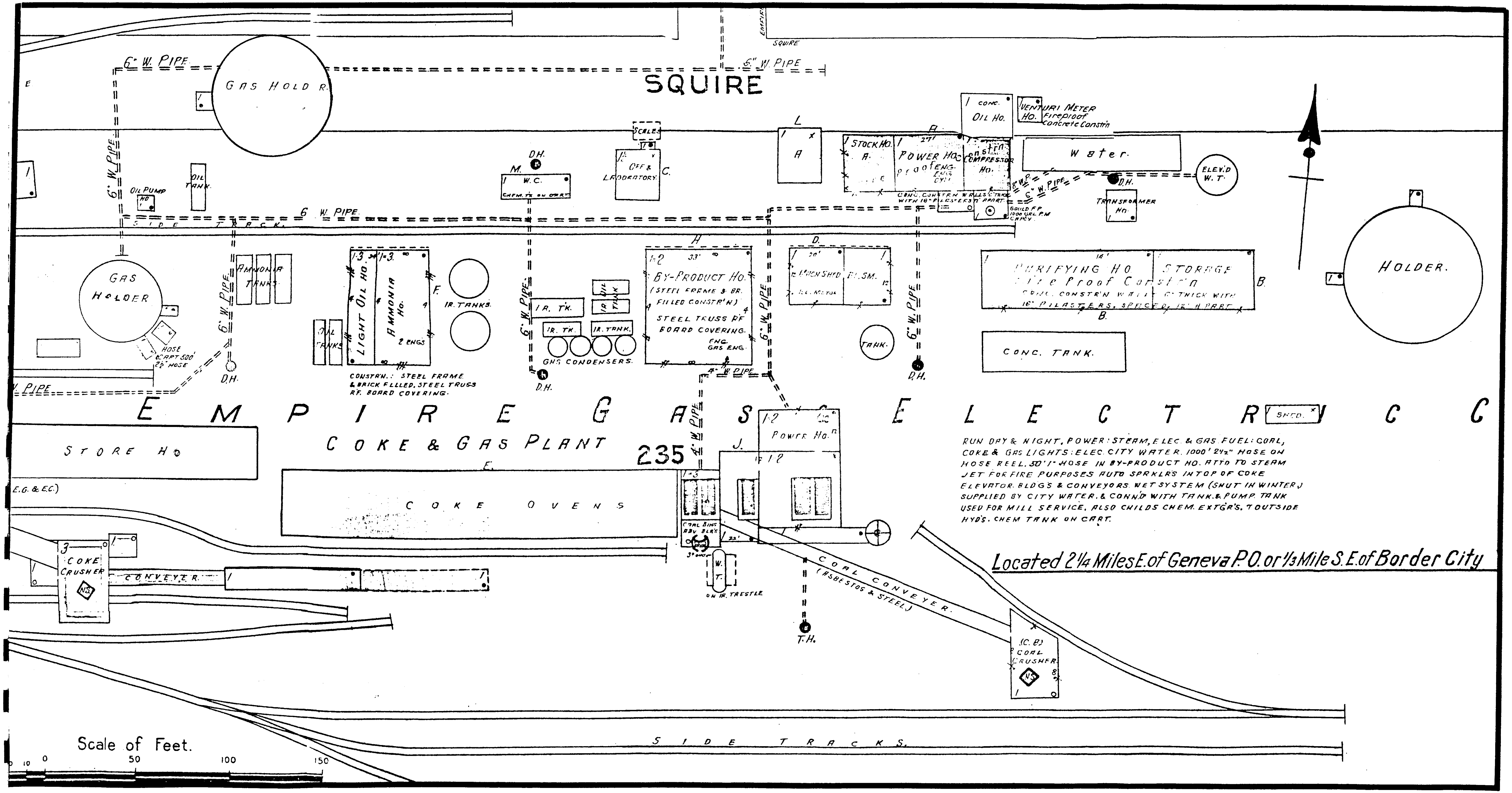


Figure 2-1. Empire Coke Co. (1904 New Century Atlas)



RUN DAY & NIGHT, POWER: STEAM, ELEC. & GAS. FUEL: COAL, COKE & GAS LIGHTS: ELEC. CITY WATER. 1000' 2½" HOSE ON HOSE REEL. 50' 1" HOSE IN BY-PRODUCT HO. ATTD TO STEAM JET FOR FIRE PURPOSES AUTO SPRKLR'S IN TOP OF COKE ELEVATOR. BLDG'S & CONVEYORS. WET SYSTEM (SHUT IN WINTER) SUPPLIED BY CITY WATER. & CONN'D WITH TANK. & PUMP. TANK USED FOR MILL SERVICE. ALSO CHILDS CHEM. EXTGR'S. 7 OUTSIDE HYD'S. CHEM TANK ON CART.

Located 2¼ Miles E. of Geneva P.O. or ⅓ Mile S.E. of Border City

Figure 2-2. Empire Gas & Electric Co.
(1925 Sanborn Maps)

TABLE 2-1

CHRONOLOGICAL LIST OF EVENTS OF THE GENEVA SITE

April 1903 -	Empire Coke Co. organized at Border City - manufacturer of gas and coke to supply Geneva, Waterloo, Seneca Falls and Auburn. Capital $1 million. President Edward Palmer.
May 1903 -	Franchise and plants of Seneca Falls and Waterloo Gas Light Co. transferred to Empire Co. Geneva.
April 1909 -	Empire Coke Company broke ground for extensive enlargements and improvements.
July 1909 -	Empire Coke Plant installed 15 new ovens with a capacity of nine tons. Improvements to the plant cost about $200,000.
April 1914 -	Empire Gas and Electric Co. buys out Empire Coke Co. in Border City.
April 1920 -	Empire Gas and Electric Company and Empire Coke Company of Geneva applied for right of coke company to sell its business to the gas and electric company. It had $860,000 common stock, $240,000 preferred stock to be issued to Coke Co. as payment for its property and $20,000 for working capital. Included in the transfer were 120 acres of land with railroad and barge canal terminal facilities, 46 coke ovens, gas cleaning and purifying machinery, gas holders, power house, compressing plant, railroad facility, storehouse, office building, etc.
August 1924 -	E.H. Palmer, president of the Empire Gas and Electric Company sold the controlling interest of Empire Coke Company to E.L. Philips and G.W. Olmstead of New York for $2,656,000.
January 1925 -	Fire at Empire Coke Company destroyed 2 large coal conveyors, 2 small conveyors, 2 ovens, coal store house, loss $35,000.
February 1925 -	One of the largest business transactions in the town of Waterloo with the transfer of common and preferred stock of Empire Coke Co. to E.L. Philips of New York and G.M. Olmstead of Ludlow PA. A payment of $3,426,100 to owners of stock in area gave control of the company to New York Central Electric Corp. which operated in territory south of that served by the facility.

TABLE 2-1
(Continued)

CHRONOLOGICAL LIST OF EVENTS OF THE GENEVA SITE

April 1925 -	New gas main installed from Geneva through Waterloo and Seneca Falls to Auburn. The main ran along south side of canal and under Cayuga Lake. Geneva plant made gas used in Auburn and Palmyra.
March 1926 -	Electric & Gas Co. at Border City planned to spend $500,000 in expansion and improvement for the year.
1927 -	A deep injection well for disposal of coke quench water was drilled near the concrete sludge basin. The well was 336 feet deep and 8 inches in diameter. (Personal communication with retired NYSEG employees indicates the sludge pit was constructed in 1923. This means that either the well was installed after the pit or there is a conflict in the dates recalled.)
August 1934 -	Electric & Gas Company at Border City officially closes it Coal Gasification operation.

Sources: Geneva Times Newspaper, 1903-1934
Personal Communication, Seneca City Historian, Nov. 1985.

TABLE 2-2

GENEVA SITE OWNERSHIP RECORD

May 6, 1903 - Empire Land Company to Empire Coke Company. (Ownership prior to Empire Land Company not known.)

June 5, 1903 - East Geneva Land Company to Empire Coke Company. (Ownership prior to East Geneva Land Company not known.)

March 9, 1932 - Henry O. Palmer and Geneva Trust Company, as executors of the Last Will and Testament of Edward H. Palmer, deceased, and Cornelia H. Palmer, widow, to Empire Gas and Electric Company. It is our understanding that Empire Gas and Electric Company became part of New York State Electric and Gas when the latter was formed.

Lake. In May of 1923, at the State's request, a concrete sludge basin was constructed near the coke ovens (Johns, personal communication, 1985). The water from the sludge basin was then pumped down a deep well into the bedrock. (Note: Well log in Crain (1974) indicates injection well was drilled in 1927). After the coke was quenched, it was graded and stored in the coke bins until it was shipped out by railroad.

Gas produced from the heating of the coal was collected from the top of the ovens. The superheated gas was then sent to cooling coils where the liquid and gas components were separated.

The liquid components were sent to the AC (Ammonia Concentrate) Building where light oils (benzol), ammonia and tar were separated from the liquid. These by-products were stored in tanks, and later were sold and transported off-site by railroad car.

The gaseous portion went through a series of screens and scrubbers in the BP (By-Product) building where tars would be separated and held in a tar tank. Wooden and metal screens were used to collect the heavier tar fraction. About once or twice a year the slats were removed and cleaned, as were the insides of the scrubber tanks. This hard pitch, along with the wooden slats, were disposed of in the on-site disposal area.

The gas was sent to the purifier building where boxes of wood shavings, impregnated with iron oxide, were used in the final gas purification. These shavings were replaced twice a year with fresh shavings. The purifier wastes were disposed of on-site. The final gas product was stored in gas holders for distribution.

The blue gas operation was infrequently used when the rest of the plant could not accommodate demands. The blue gas, which has a lower BTU value than the other coking process gases, was used only as a back-up fuel for the Semet-Solvay ovens. No details were available concerning the purification or scrubbing of the blue gas. Figure 2-3 illustrates the coking process in a flow diagram of materials through the facility. Much of the information presented in this figure was obtained from Kierst & Johns, personal communication.

2.2.2 Summary of Waste Generation and Disposal

The Geneva coke plant produced both liquid and solid wastes, which were disposed of on-site. The majority of the solid wastes generated at the plant were transported by hand or in wheelbarrows to a disposal area south and southeast of the 300,000 cubic foot gas holder in the eastern portion of the property. Once a year topsoil was placed over the disposal area and the land was graded (Johns, personal communication, 1985). Figure 2-4 depicts the building locations and waste disposal sites.

The major source of solid waste at the facility was the iron oxide impregnated shavings from the purifying building. These shavings, which were used in the final gas purification process, were disposed of on-site roughly twice a year. A secondary source of solid wastes disposed of on-site twice yearly was the tars (pitch) which accumulated on wooden and metal screens used in the BP and AC buildings. A large amount of other, apparently innocuous, miscellaneous waste material such as construction debris was also disposed of on-site.

There were several sources of liquid wastes at the Geneva coke plant. One source of liquid wastes was from the quenching of hot coke in water. Initially, the coke was lowered into an unlined pit and water was sprayed over the hot embers. The quenching water was discharged to a nearby stream which led to the canal south of the site and from there to Seneca Lake. In May 1923, a concrete sludge basin was constructed at this site (as required by the state). The quenching waste water was pumped to this sludge basin and allowed

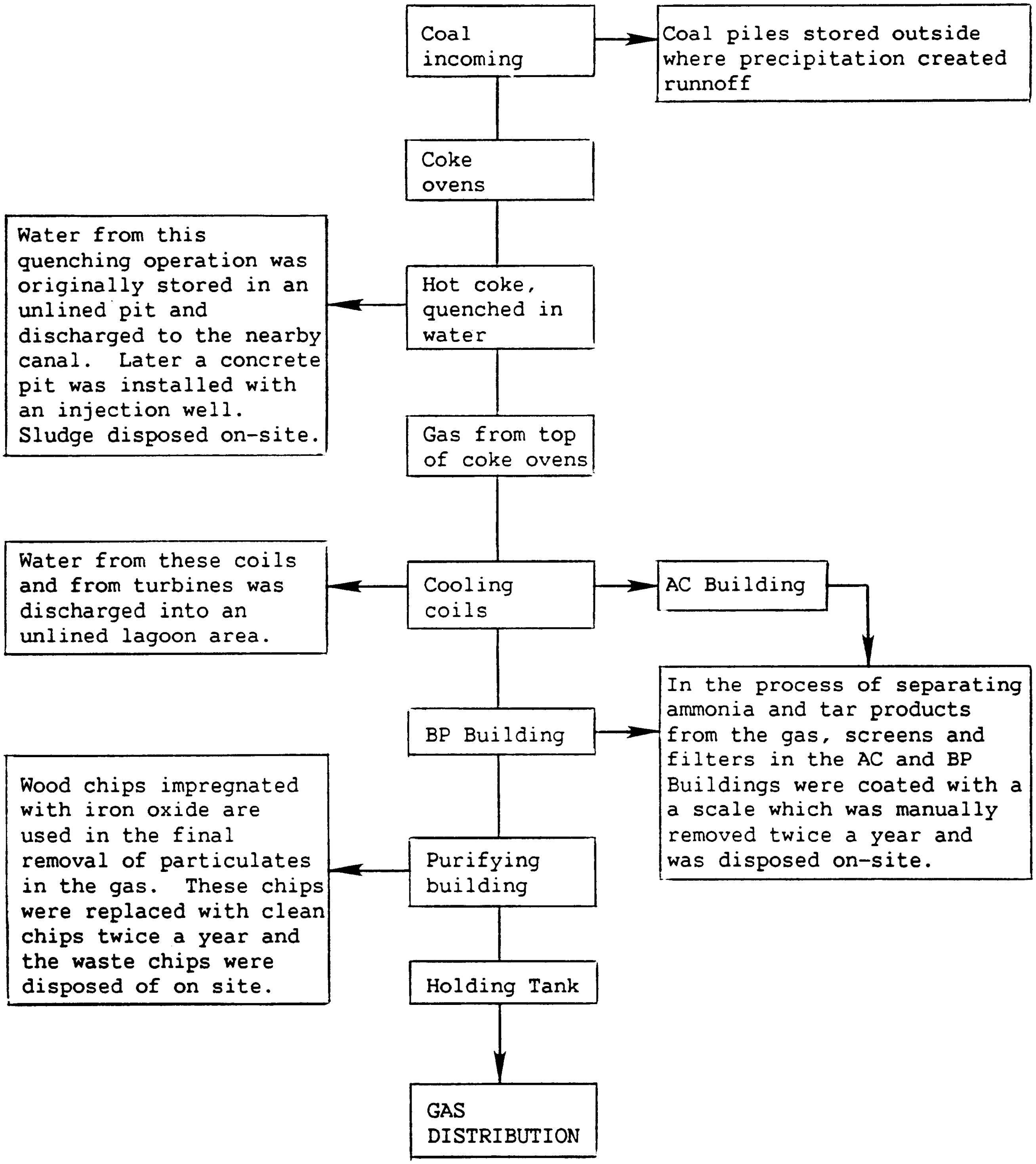


Figure 2-3. Waste Generation Flow Diagram
Geneva Coal Gasification Plant

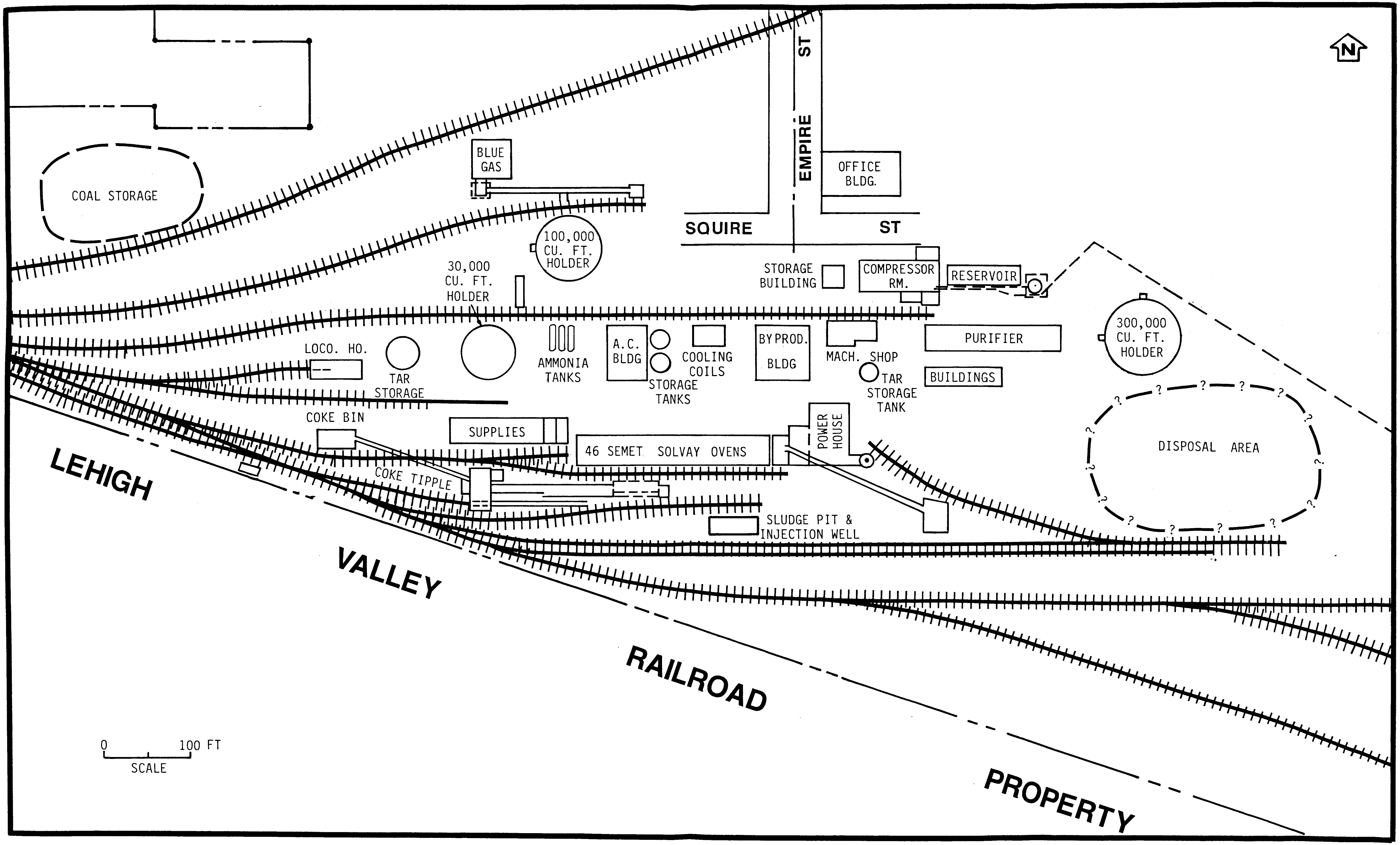


Figure 2-4. Empire Coke Co. Waste Sources and Disposal Areas (1920-1930 Sanborn Maps)

to separate. The cleaner top layer was discharged to the nearby stream while the lower liquid layer was pumped into an injection well (Johns and Kierst, personal communication, 1985). The injection well was an 8" diameter, 336 foot well cased to the rock surface at a depth of 200 feet (Crain, 1974). There is an apparent discrepancy in dates for the injection well drilling. Kierst and Johns thought it was 1923, while the drilling record shows it to be 1927. The latter is most probably the correct date. The well was located in the eastern corner of the sludge basin. The solids remaining in the sludge basin were removed every 6 months and stored in a holder near the AC Building. The solids were either disposed of on-site or in the city dump at the north end of Seneca Lake.

Other sources of liquid wastes include discharges from the cooling coils and turbines which were piped underground to a small holding area. This water was generally of good quality but was at a high temperature. Much of the water evaporated. The remainder was discharged to the local stream. Uncontrolled run-off from on-site coal piles would have occurred during periods of significant precipitation. The final source of liquid waste was the wastewater from drip boxes, located under equipment or gas lines to collect leakage condensation. The waste water from the drip boxes was normally disposed of in the sludge pit.

2.2.3 Chemical Characteristics of Wastes

To accurately assess the impact that the plant had on the nearby soil and water, the chemical characteristics of the wastes which were disposed of must be understood. The wastes of greatest potential for environmental concern are the coke quench water, which was pumped into the on-site injection well, and the tars and purifier wastes which were disposed of in the southeast portion of the site. This section includes general chemical data on each of these types of waste as reported in available references.

The continued need for coke in the steel industry has meant an on-going problem with the treatment and disposal of coke quench water. Effluent limitation guidelines for the iron and steel industries were issued in 1982 (Environmental Protection Agency, 1982). The development document (Environmental Protection Agency, 1982b) for these guidelines includes chemical analyses of untreated coke quench water which is assumed to be similar to that which was disposed of at the Geneva site. This assumption is made because to coking processes that were used at Geneva are similar to those processes used today.

The chemical quality of coke quench water depends largely on the quality or the make-up water used in quenching. Modern coke plants commonly use process wastewaters for quenching. It is believed that the Geneva coke plant used fresh water as its sole source of coke quench water. Table 2-3 is a summary of analytical data for wastewaters from coke quenching processes. For purposes of identifying potential constituents and their concentrations that may have been injected, it can be assumed that the quality of coke quenching water at the Geneva coke plant was similar to the average quality shown in the fresh water make-up column of Table 2-3.

The volumes of coke quenching water produced at the Geneva plant can be assumed to be similar to those produced at modern coking operations, or 50-200 gallons wastewater per ton of coke production. No data was found listing the annual coke production at the Geneva plant.

Other liquid wastes from the coking process include: excess flushing liquors, benzol plant wastewaters, final cooler wastewaters, desulfizer wastewaters, and tar decanter wastewaters (Environmental Protection Agency, 1982b). These waste waters have been shown to contain ammonia, cyanides,

TABLE 2-3

SUMMARY OF ANALYTICAL DATA FROM SAMPLED PLANTS
ORIGINAL GUIDELINES STUDY
BY-PRODUCT COKEMAKING OPERATIONS
NET CONCENTRATION OF POLLUTANTS IN WASTEWATERS FROM QUENCHING[1]

		Discharged Water Quality Using	
		Fresh Water Make-up	Waste Water[2] Make-up
Sample Point(s)		5-4	3-4
Flow (Gal/Ton)		498	448(3)
	Suspended Solids	703	(11)(4)
	Oils & Greases	9.6	84
	Ammonia (N)	1.94	92
	Sulfide	<0.02	135
	Thiocyanate	<3	10
	ph (Units)	7.6	8.5
117	Beryllium	<0.04	<0.04
121	Cyanides	4.0	51
191	Phenolic	1.46	150

---

(1) All values are in mg/l unless otherwise noted.

(2) Sample contains wastewaters from benzol plant and from final cooler blowdowns.

(3) Flow consists of 45.4 GPT final cooler discharge, 107 GPT benzol wastewater, and 296 GPT of recycled quenchwaters.

(4) Non-representative sample for suspended solids, which were conveyed along the bottom of the sampling sluiceway.

Source: Environmental Protection Agency, 1982b.

phenolic compounds, sulfides, oil and greases, acids and alkalis, and many toxic organic pollutants.

It is believed that these other liquid wastes were discharged directly to the nearby stream. These wastes have most probably been flushed clear of the site. Any liquid wastes spilled on-site or not discharged to the stream may have contributed pollutants to the soil and water at the site which could still be present. A chemical characterization of these wastes is provided in Table 2-4. This is important if their potential presence in the soil and ground water is to be considered.

Table 2-4 is a list of the pollutants commonly found in liquid wastes at coke plants. The total discharge of raw wastewater from modern coking operations (including coke quenching water) averages about 150 gallons per ton of coke produced (Environmental Protection Agency, 1982b).

It can be speculated that the volumes of wastewater discharged from the Geneva coke plant to the nearby stream were close to this.

During its study of the coke making industry, the Environmental Protection Agency selected several wastewater pollutants from the coke making industry which can be used as "indicators" for the presence of other pollutants. The EPA uses these indicator pollutants to regulate a group of 29 pollutants included in Table 2-4 (Environmental Protection Agency, 1982b).

> "Benzene was selected to indicate the presence of volatile toxic organic pollutants; phenols (4APP) to indicate the presence of acid extractable toxic organic pollutants; and napthalene and benzo(a)pyrene to indicate the presence of base/neutral compounds." (Environmental Protection Agency, 1982b).

2.3 Plant Closure

The plant officially closed on August 29, 1934. In the early part of 1936, the ovens were torn down and disposed of as scrap (Johns, personal

TABLE 2-4

CHEMICAL COMPOUNDS COMMONLY FOUND IN LIQUID WASTES FROM THE BY-PRODUCT COKEMAKING INDUSTRY

Acenaphthene
Acrylonitrile
Benzene
2-Chloronaphthalene
2,4,6-Trichlorophenol
Parachlorometacresol
Chloroform
2-Chlorophenol
2,4-Dimethylphenol
2,4-Dinitrotoluene
2,6-Dinitrotoluene
Ethylbenzene
Fluoranthene
Methylene Chloride
Isophorone
Naphthalene
2-Nitrophenol
4,6-Dinitro-o-cresol
Pentachlorophenol
Phenol
Bis-(2-ethylhexyl)phthalate
Butyl Benzyl Phthalate
Di-n-butyl Phthalate
Di-n-octyl Phthalate
Diethyl Phthalate
Dimethyl Phthalate
Benzo(a)anthracene
Benzo(a)pyrene
Benzo(k)fluoranthene
Chrysene
Acenaphthylene
Anthracene
Benzo(ghi)perylene
Fluorene
Phenanthrene
Dibenzo(a,h)anthrancene
Indeno(1,2,3-cd) pyrene
Pyrene
Toluene
Antimony
Arsenic
Cadmium
Chromium
Copper
Cyanide
Lead
Nickel
Selenium
Silver
Zinc
Xylene

Source: Environmental Protection Agency, 1982b.

communication, 1985). Until this time the ovens were used as dry storage. Most of the steel at the site was removed for scrap during World War II. The holder was used as storage for natural gas until the middle 1950s. The purifier building, the compressor building, and the original office buildings remain on the site. Very little additional information is available on the demolition of the original plant.

2.4 Present Conditions

The site is currently used by New York State Electric and Gas as a gas and utility substation. Maintenance and utility trucks are stored on-site and an office building is used for accounting and bill payment. The site is also used for the storage of large utility poles, transformers, gas pipes, and various utility scrap materials such as old transformers and pylons.

3.0 SITE SETTING

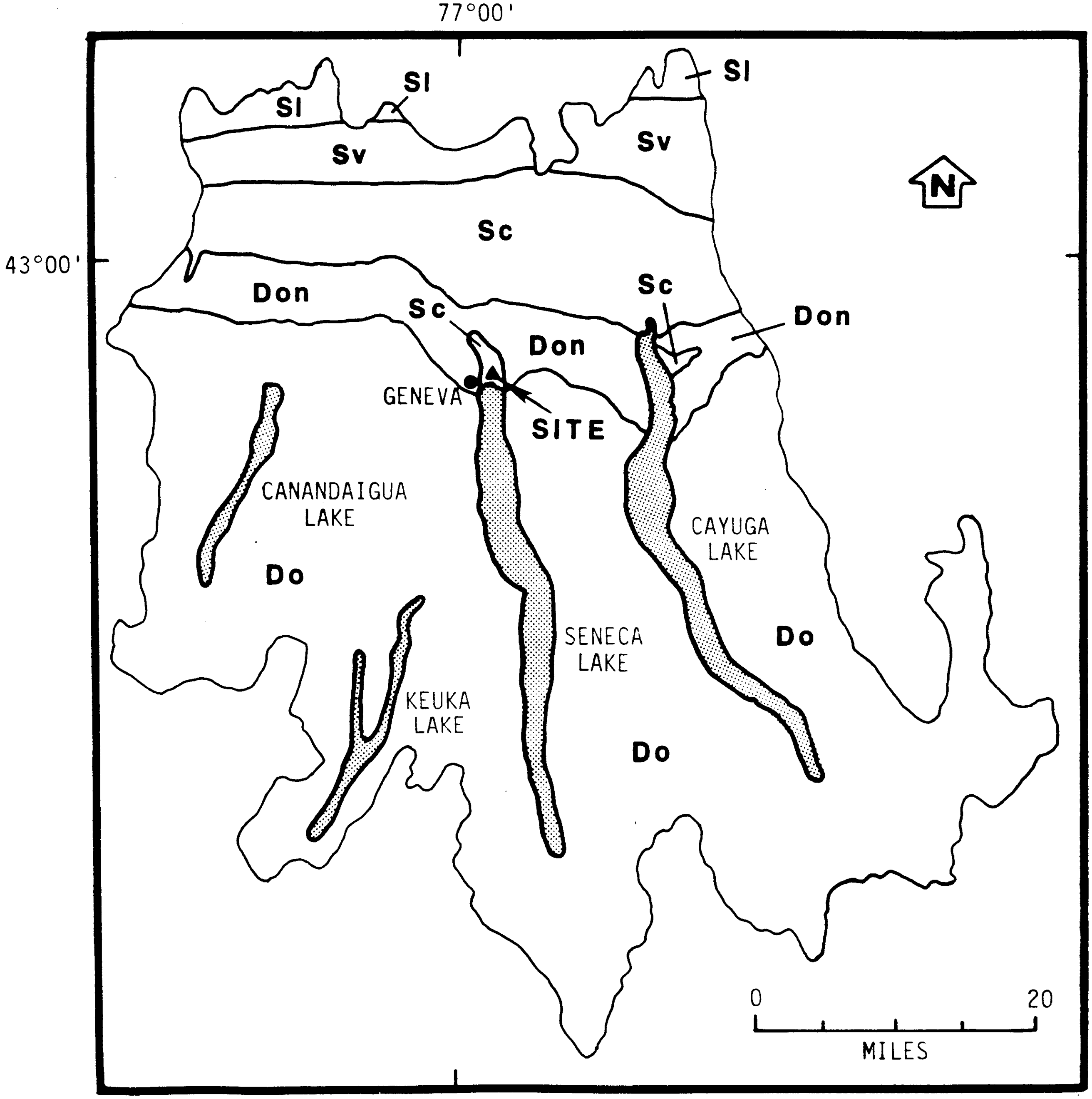
3.1 Physiography

The Geneva site is situated at the border of two regional physiographic provinces. To the north is the Central Lowland, a poorly-drained, fairly level plain. To the south is the Appalachian Plateau, which is characterized by rolling hills and uplands separated by large and broad stream and lake valleys (Crain, 1974). The Finger Lakes are the most notable geographic feature in the area. The city of Geneva is located on the northwest shore of one of the largest of these lakes, Seneca Lake. The lake is no more than 2 to 3 miles wide but stretches 35 miles along the North-South trend of the valley. The depth of Seneca Lake is more than 600 feet in some areas (Crain, 1974). Because of their great depth, Seneca Lake and the other Finger Lakes provide some of the largest volumes of water storage in New York State.

3.2 Regional Setting

3.2.1 Bedrock Geology

The bedrock in the northern Appalachian Plateau/Southern Central Lowlands consists of Devonian and Silurian (350-440 million year old) marine sedimentary sequences. Rock types include shales, siltstones, sandstones, and carbonates. The rocks generally dip about 50 feet per mile to the south (Crain, 1974). Because of this dip, the age of exposed rocks gets progressively younger to the south (see Figure 3-1). A stratigraphic column of the regional bedrock with physical descriptions is given in Figure 3-2. Relief of the bedrock surface may be as great as 3000 feet (Crain, 1974). Bedrock is exposed at the surface along some valley walls but is deeply buried by unconsolidated glacial sediments within the major valleys.



Map Modified From Crain, 1974

LEGEND

YOUNGER **Do** - Other Devonian Formations including Hamilton, Tully, Genessee, Sonyea, Java, and West Falls Formations

Don - Onondaga Limestone and Silurian Carbonates

Sc - Camillus Shale

Sv - Vernon Shale

OLDER **Sl** - Lockport Dolomite

Figure 3-1. Bedrock Geology of the Western Oswego River Basin.

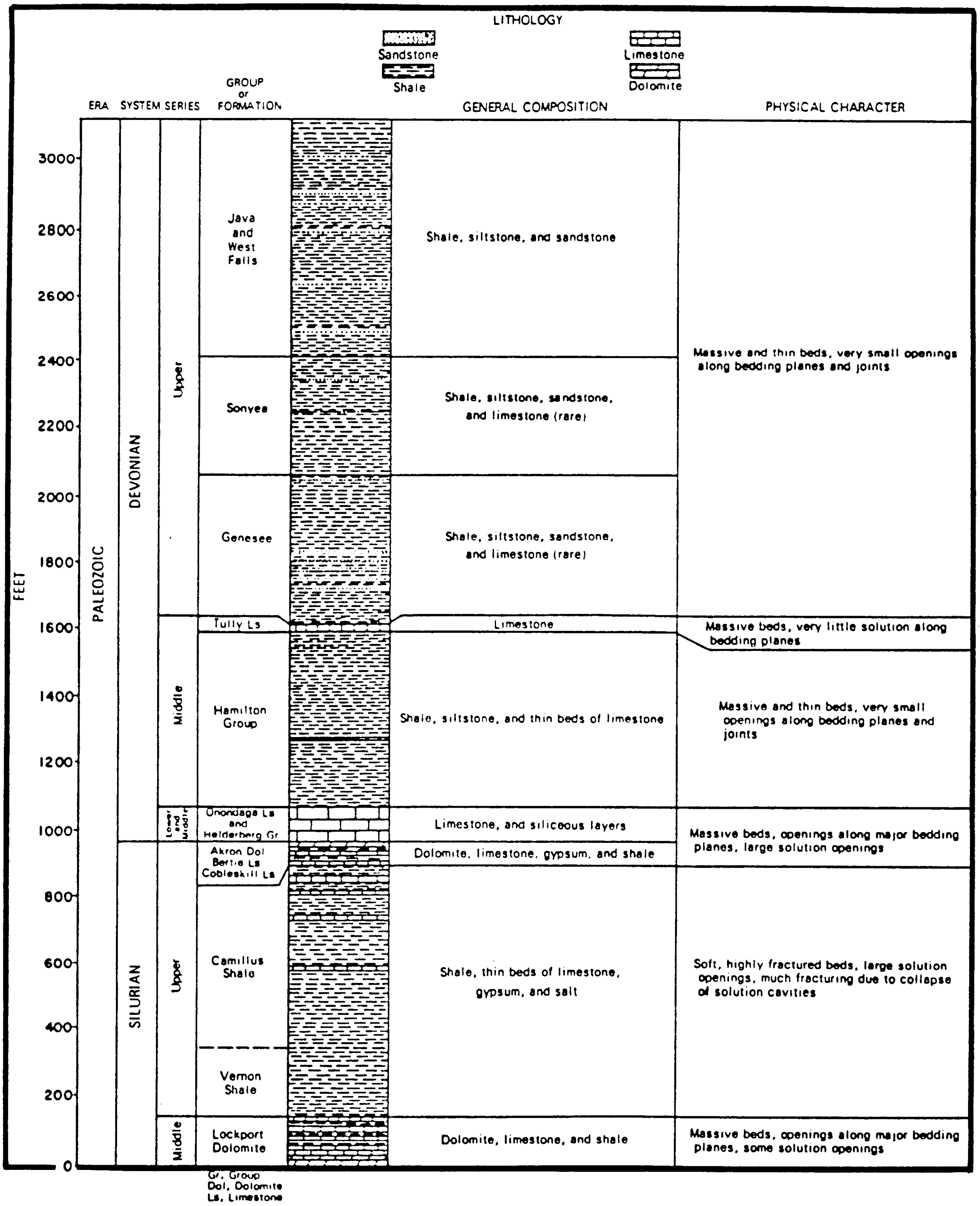


Figure 3-2. Generalized Stratigraphic Column of Bedrock in the Western Oswego River Basin. (from Crain, 1974).

3.2.2 Surficial Geology

The surficial geology of the Geneva area was dramatically affected by the continental ice sheets which covered the area during portions of the last million years. The ice sheets smoothed over the uplands and scoured out the existing valleys, most visibly in the areas now occupied by the Finger Lakes. Sediments deposited by glacial ice and meltwaters from the ice are extensive in the area.

Thick accumulations of till were deposited directly by glacial ice. Because of its mode of deposition, till deposits are characteristically unsorted, denser than stratified drift deposits, and therefore fairly impermeable. Till is common in the Geneva area but is often covered or absent in valley bottoms. The till may be as thick as 200 feet in some places (Crain, 1974).

The glacial deposits in the valleys of the Geneva area are dominated by water-lain sediments (stratified drift). As such, these deposits are fairly well sorted. The range in grain size in any specific layer is dependent on the energy of the water which carried the materials. In the area north of Seneca Lake, for instance, well logs indicate alternating layers of silt/clay and sand. It can be assumed that the finer sediments were deposited under lacustrine (lake) conditions while the coarser deposits were deposited under fluvial/deltaic conditions. The entire low-lying area north of Seneca Lake is thought to be part of a large delta built into glacial Lake Newberry, the predecessor of the present Seneca Lake. The water level in Lake Newberry was considerably higher than the present lake (Hutton, 1972). Figure 3-3 demonstrates the complexity of the unconsolidated sediments in the Geneva area.

Post-glacial deposits in the area include alluvium, muck and peat deposits. Alluvium is predominantly poorly-sorted coarse gravel and sand. The alluvial deposits are thickest along the lower ends of valleys discharging

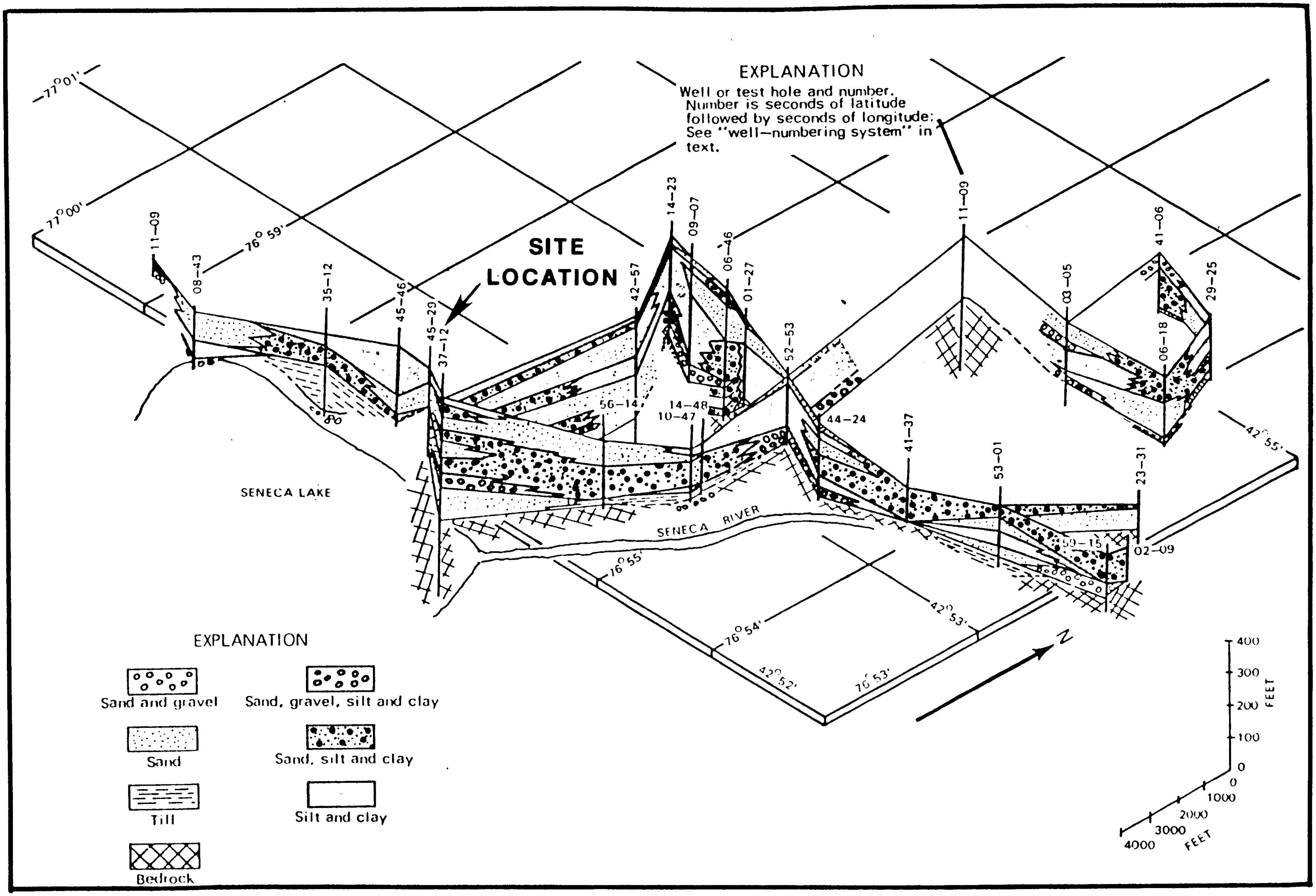


Figure 3-3. Unconsolidated Deposits at Selected Locality in the Western Oswego River Basin, North of Seneca Lake. (from Crain, 1974).

into the Finger Lakes (Mozola, 1985). Muck and peat are organic-rich deposits which collect under anaerobic conditions in poorly-drained areas such as those which exist at the north ends of Seneca and Cayuga Lakes.

3.2.3 Soil

The soil types in the region are highly variable because of the diversity of surficial deposits. In the area immediately north of Seneca Lake, soils are classified in the Arkport-Claverack association (Hutton, 1972). The soils of this association are developed primarily from fine sand and gravel or lacustrine silts and clays.

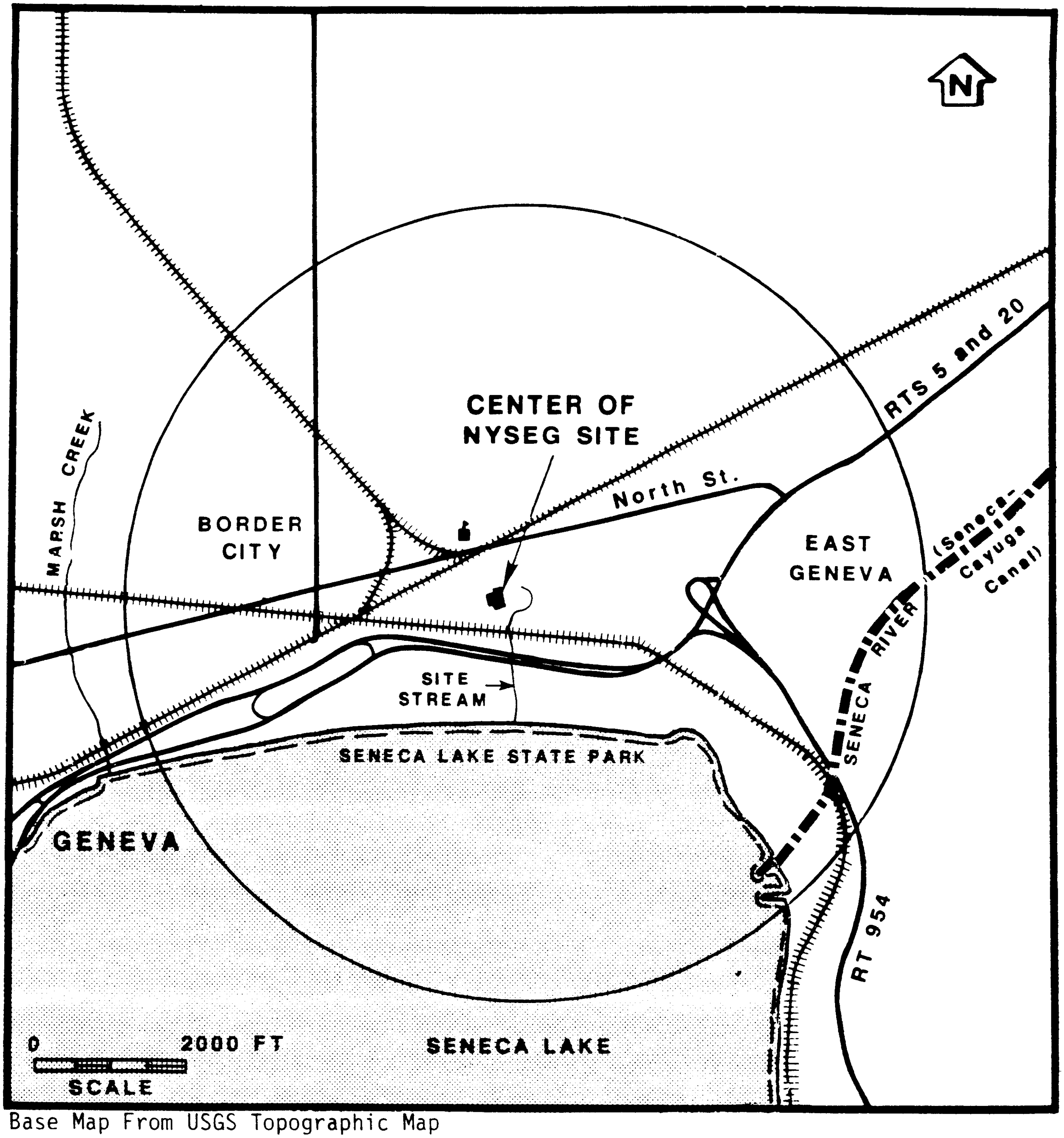
3.2.4 Surface Water

The surface water hydrology of the site area is dominated by Seneca Lake. The site is approximately 1500 feet from the north shore of the lake. In addition to the lake, Marsh Creek is about 5000 feet west of the site and the Seneca River about 4000 to 5000 feet east of the site. Marsh Creek flows south into the lake and the Seneca River flows northeast out of Seneca Lake. Small streams such as the unnamed stream in the eastern portion of the site are common. Figure 3-4 shows the location of the lake, stream, and river. The rest of the area is poorly drained with numerous marshes and small ponds.

3.2.5 Ground Water

There are two important aquifers in the Geneva area. In the center of the valleys where glacial deposits are thick, the unconsolidated materials serve as an aquifer. In inter-valley areas, where relatively thin deposits of low-permeability till cover bedrock, the bedrock is most commonly used as an aquifer.

Two distinct bedrock formations are used as aquifers in the Geneva area. The Onondaga Limestone is close to the surface east and west of the site along



Base Map From USGS Topographic Map

(circle indicates 1 mile radius from site center)

Figure 3-4. Location of Streams, Lakes and Rivers.

the Seneca Lake valley walls. Reported well yields range from 1 to 200 gallons per minute for 42 wells in the Onondaga Limestone Formation in Seneca County (Mozola, 1951). Two wells along the eastern valley wall of Seneca Lake within 2 miles of the site have produced yields of 20 and 30 gpm from the Onondaga formation. Figure 3-5 shows the location of wells in the site area. Logs for wells within one mile of the site are given in Table 3-1. As shown on Table 3-1, the injection well (37-12) is the only well completed in the Camillus shale. Two other wells (56-14 and SE-233) are bedrock wells completed in the Onondaga Limestone. All other reported wells within one mile of the site are completed in the glacial unconsolidated sediments.

Glacial scouring along the axis of Seneca Lake has removed the Onondaga Limestone in the vicinity of the site and exposed the underlying Camillus Shale (see Figure 3-1). The Camillus Shale is a productive aquifer. Well yields from the Camillus have been reported to be as high as 1000 gpm (Crain, 1974). Average yield from the Camillus Formation in Seneca County is 45 gallons per minute. The high permeability of the Camillus shale is normally attributed to the solution of interbedded salt and gypsum. An interesting feature of the formation is that well yields may actually increase with time and continued pumpage due to solution of gypsum and salt in the vicinity of the pumping well.

Well logs from wells completed in the Onondaga and Camillus Formations commonly report a slight sulfur odor. Analyses of four groundwater samples from the Camillus shale in Seneca County average 1480 ppm dissolved solids with an average hardness of 865 ppm. Both of these averages are well above acceptable limits for potable water (Mozola, 1951). Salinity may also be a problem owing to the dissolution of salt within the formation. The maximum chloride content reported for groundwater from the Camillus shale is 74 ppm.

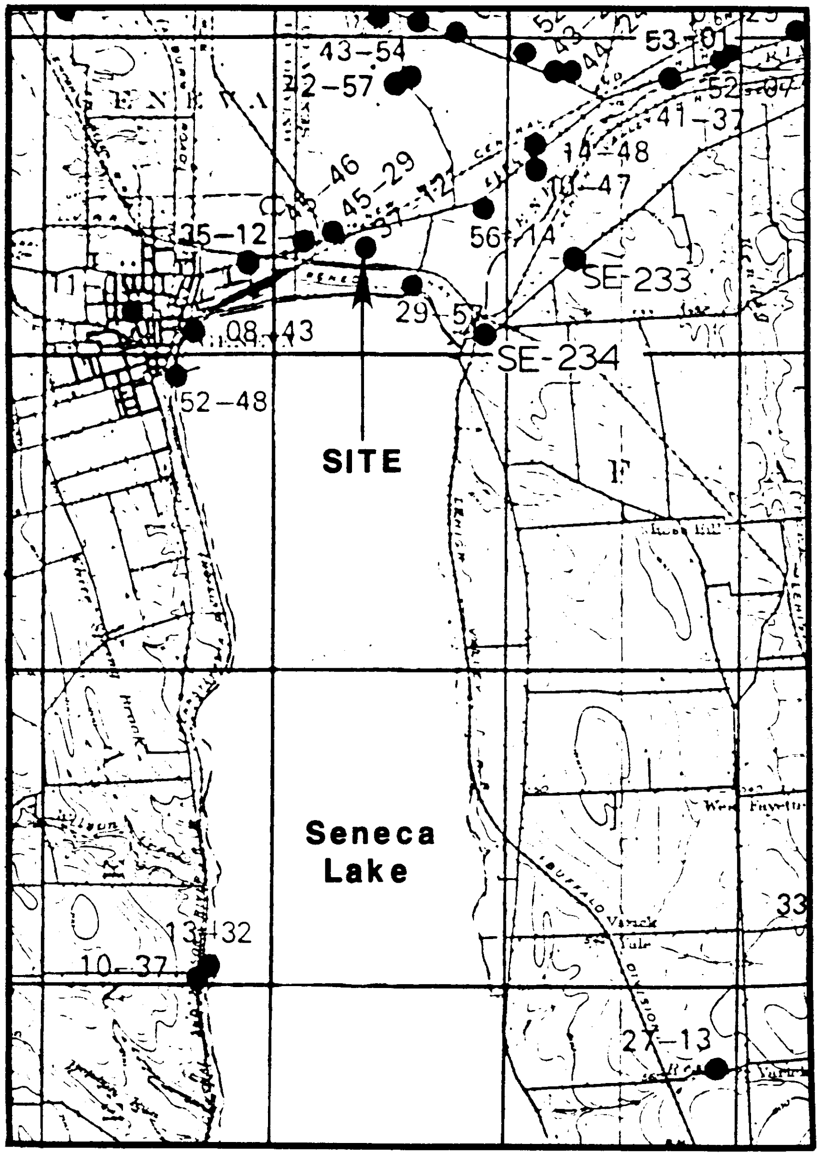


Figure 3-5. Locations for Which Well Logs Exist. Logs are Given in Table 3-1.

TABLE 3-1

AVAILABLE WELL-LOGS FOR AREA WITHIN ONE MILE OF SITE
WELL LOCATIONS ARE SHOWN IN FIGURE 3-5

Well Number	Date Drilled	Use	Well Depth (ft)	Depth to Rock (ft)	Casing Diam (in)	Water-Bearing Material	Depth to Water (ft)	Yield (gpm)
37-12	1927	Waste Injection	336	200	8	Camillus Shale	+1	11
45-29	1946	Commercial	135	--	6	Sand and Gravel	10	50
35-12	1933	Industrial	135	--	6	Sand and Gravel	10	7
56-14	1947	Domestic	113	110	6	Onondaga Limestone	9	30
42-57	--	Stock	268	--	6	Sand and Gravel	28	75
29-57	1946	Unused	135	--	8	Gravelly Clay	--	--
08-43	1950	Unused	91	--	3	Sand	--	--
11-09	--	Unused	30	--	6	Sand and Gravel	--	15
52-48	1950	Unused	102	--	3	Silty Sand and Gravel	--	--
10-47	1946	Domestic	87	--	6	Sand and Gravel	9	50
14-48	1946	Unused	76	--	6	Sand and Gravel	9	60
43-54	--	Unused	13	--	30	Sand	10	--
SE-234	--	Gas Exploration	1400+	5	6	Onondaga and Camillus	--	--
SE-233	--	Farm	108	8	6	Onondaga Limestone	20	20

Sources: Crain, 1974
Mozola, 1951

Water withdrawn from the Onondaga Limestone is of somewhat better quality. Average hardness in Seneca County is reported to be 317 ppm while the dissolved solids average 557 ppm (Mozola, 1951).

The bedrock aquifers are commonly confined by the relatively impermeable silts and clays which overlay them. Wells which penetrate the confining layers commonly flow freely at the surface because of these artesian conditions. The regional flow of groundwater within the bedrock can be assumed to be toward the regional groundwater sink, Seneca Lake.

Unconsolidated deposits serve as an important aquifer in the center of the valleys in the Geneva area. Regional groundwater flow in the unconsolidated aquifer can be assumed to be toward Seneca Lake. As was shown in Figure 3-3, the nature of these valley-fill deposits is complex, with clays, silts, and coarser stratified drift deposits highly interlayered. The yield of any well in the unconsolidated deposits depends upon the character of the materials intercepted. Wells which intercept thick accumulations of coarse-grained materials will produce much higher yields than wells drilled through accumulations of silts and clays. The deltaic deposits north of Seneca Lake tend to be too fine grained to produce large well yields. One well in the area has been pumped at 200 gpm but yields are typically much lower (10-50 gpm).

Water samples from 10 wells in the glacial lake plain north of Seneca Lake have a range of dissolved solids of 389 to 4448 ppm. Total hardness ranges from 20 to 1900 ppm. The closest well for which chemical analyses are published was drilled through deltaic sediments to a depth of 135 feet approximately 1 mile west of the site. The average results of chemical analyses on the water taken from this well between 1952 and 1955 are as follows: Iron - 1.2 ppm, Bicarbonate - 358 ppm, Chloride - 7.5 ppm, Hardness as $CaCO_3$ - 1110 ppm, pH - 7.4 (Mack and Digman, 1962).

3.3 Site Setting

3.3.1 Bedrock Geology

Information about the bedrock geology was available from the log of one deep well drilled at the site in 1927 and a seismic refraction survey done for TRC by Weston Geophysical in the fall of 1985. The deep well, which was drilled at the present location of the parking lot south of the main NYSEG office building, intercepted the Camillus shale at a depth of 200 feet (Crain, 1974). The seismic refraction survey confirmed this. The seismic survey also suggested that bedrock in the eastern part of the site may be slightly closer to the surface (175 ft) than in the western part of the site (200 ft). A complete discussion of the seismic refraction work is given in Section 4.1.1 and Appendix A.

3.3.2 Surficial Geology

The surficial geology at the site is predominantly fill overlying silty clay. Twenty-one shallow (5 to 8 ft) borings were recently drilled on-site. See Figure 3-6 for locations. These borings usually encountered brown sandy cobbles or brown sandy gravel, some cobbles, trace sand overlying dark brown sandy gravel and brown silty clay (Woodward-Clyde, 1984). The brown sandy cobble layer is generally 3 to 5 feet thick and is primarily construction/demolition debris. The driller's log for the deep well drilled on-site in 1927 is as follows (Mozola, pg. 39, 1951):

	Thickness (ft)	Depth (ft)
Clay	12	0 - 12
Clay and quicksand	20	12 - 32
Quicksand	18	32 - 50
Clay and sand	20	50 - 70
Quicksand	30	70 - 100
Quicksand and clay	25	100 - 125
Clay and gravel	25	125 - 150
Quicksand	50	150 - 200
Onondaga limestone	136	200 - 336

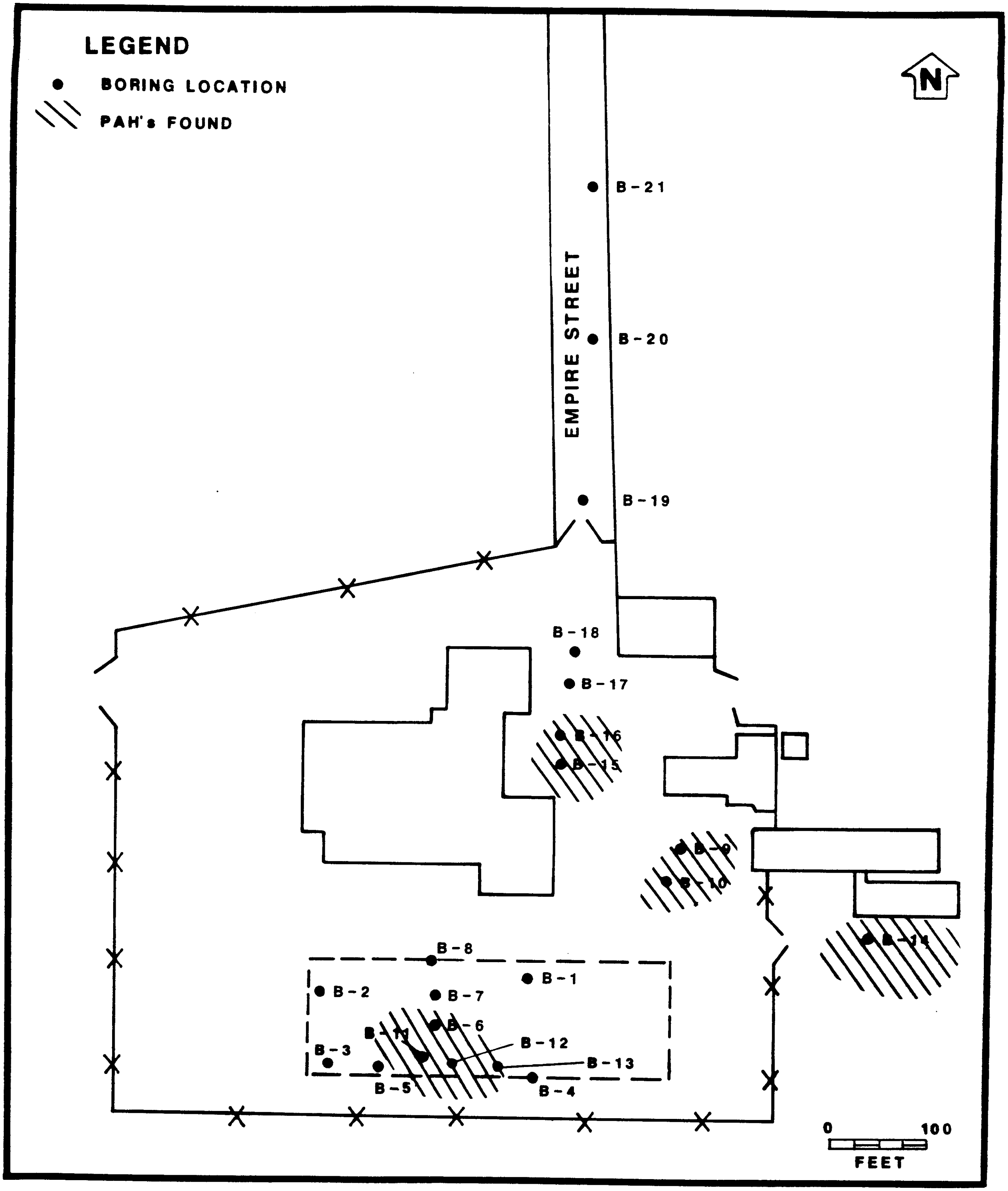


Figure 3-6. Location of Previous Soil Borings and Areas Known to Have PAH's. (Data from Wood-Clyde, 1984 et seq)

This log reveals that the thickness of stratified drift is 200 feet, most of drift is fine grained, and no till (hardpan) layer is present. Artesian conditions are indicated by references to quicksand. The Camillus shale was misidentified as Onondaga limestone. The exact location of the deep on-site well is unknown.

3.3.3 Soil

The soil in the vicinity of the site is largely mapped as "made land" but also includes silt loam soils from the Schoharie, Collamer, and Odessa series (Hutton, 1972). The Schoharie and Odessa soils are developed on Calcareous reddish clay and silt. The difference between the two is that the Schoharie soils are moderately well drained while the Odessa series is poorly drained. The Collamer series soils are moderately well drained and are derived from silt and very fine sand containing a large amount of silt (Hutton, 1972). Most soils in the area are developed on 0 to 3 percent slope but some soils are mapped on 3 to 8 percent slopes.

3.3.4 Surface Water

The surface water in the immediate area of the plant flows to a small stream on the eastern edge of the site facilities area. This stream starts in the wetlands in the northern part of the site and enters a well-defined channel at the employees parking lot, flows south to the NYSEG property boundary, and then enters a culvert which extends from the railroad embankment to the south side of Routes 5 and 20 (See Figure 3-7). At that point it becomes an open stream. As it flows south and passes the Seneca Lake State Park entrance road, it enters an open, lined culvert. It flows through this culvert to the lake.

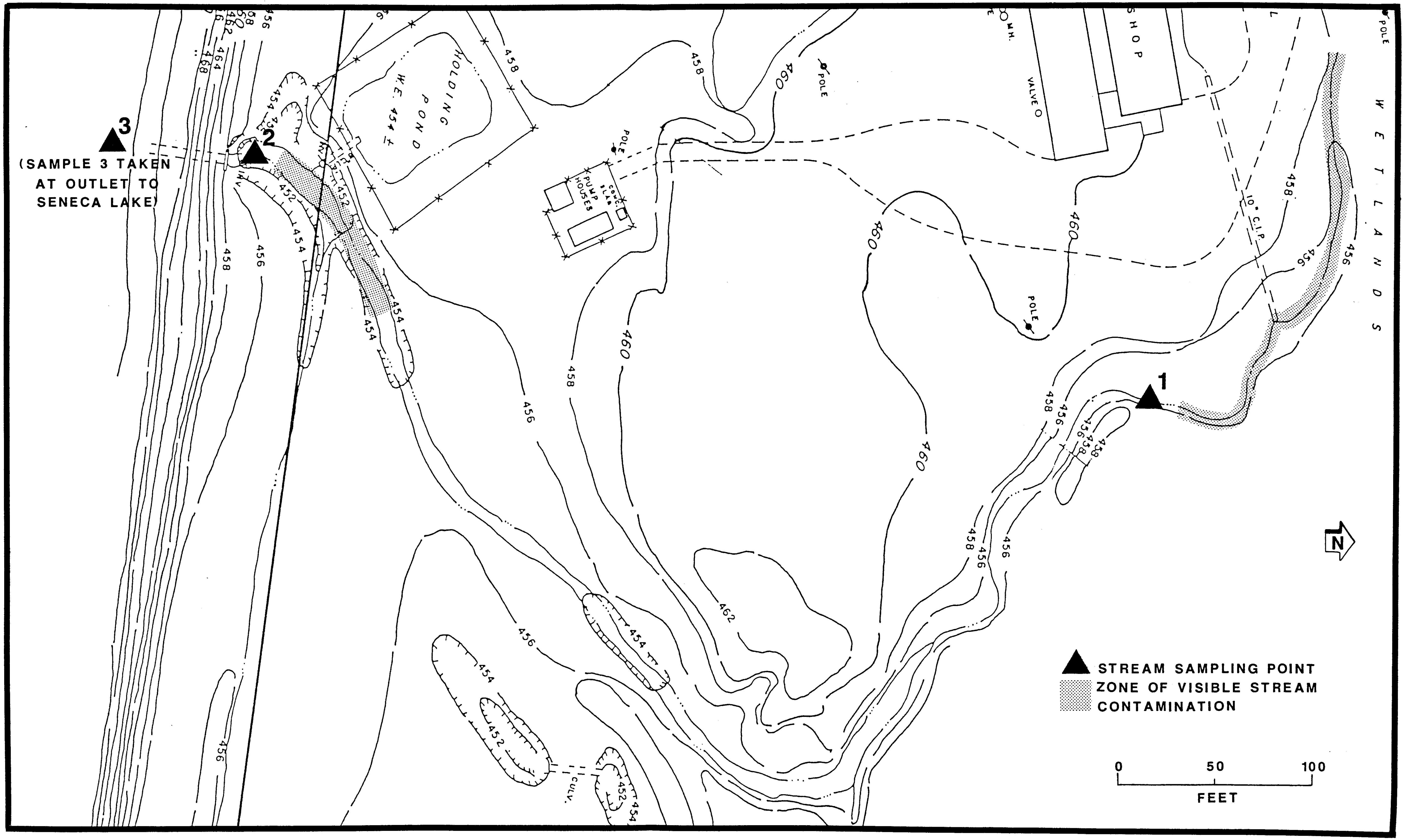


Figure 3-7. Location of Contaminated Areas in Stream East of the Site. Points Which Will be Sampled are Indicated.

This site stream was walked from the railroad embankment upstream to the parking lot and examined for signs of coal tar contamination. For most of its length the stream has been dredged, with the spoil bank being on the eastern edge of the stream. The date of dredging is unknown, as are the persons performing this work, but most probably the dredging occurred after the plant closing because the trees growing on the spoil bank are mostly 3-6" in diameter.

The water depth in the stream ranged from 3-10" and averaged about 6". The bottom was mostly soft, tan clayey muck. Hydrocarbons were found in the bottom sediments in two separate reaches of the stream as evidenced by small slicks which floated to the surface. The smell of the sediments was characteristic of coal tars. The first reach is from the railroad embankment to just above the road leading to the sewage treatment plant and the second is from the parking lot down to about the compressor house (see Figure 3-7). The stream in between these two reaches contained no visible hydrocarbons. In addition, no hydrocarbons were noticed in the stream south of Routes 5 and 20. Probes into the top 12" of the embankment also showed no evidence of hydrocarbons.

3.3.5 Ground Water

Well yields for several wells drilled in close proximity to the site are presented in Table 3-1. The locations of these wells are shown in Figure 3-5. Well 29-57, which is potentially downgradient of the site, is no longer used and was apparently destroyed when Seneca Lake Park was developed (Conley, 1986). Wells which tap the unconsolidated aquifer near the site have produced yields of 7 to 75 gpm (Crain, 1974). The average well on the glacial lake plain in Seneca County yields 15 gpm (Mozola, 1951).

The thickness of the unconsolidated sediments is 200 feet directly beneath the site and thins toward the edges of the valley. The water table is normally within 5 feet of the surface in the site area, therefore saturated thickness approaches the total thickness of the unconsolidated sediments. The stratification of the unconsolidated deposits into coarse and fine zones commonly creates confined conditions within the aquifer. This stratification also creates anisotropy within the aquifer with ground water flowing much more readily in the horizontal direction than in the vertical direction.

3.4 Area Water Use

The water use within a one mile radius of the site was evaluated to determine the groundwater use and potential receptors. The information source for the use was Roger Dafler, Supervisor, Border City Water and Sewer Department. Mr. Dafler has been working on the water and sewer lines for about thirty years and is very familiar with the systems.

The major municipalities near the site (including Geneva and Waterloo) draw their water from Seneca Lake. Figure 3-8 shows the position of the municipal pumping stations in the northern part of Seneca Lake. The intakes for the pumping stations for the cities of Geneva and Waterloo are located in Seneca Lake near the west and east banks of the lake, respectively, approximately three miles south of the northern shore. The pumping station for the town of Geneva is served by a well near the west shore of the lake approximately seven miles south of the lake's north shore. There are no municipal water intakes within two miles of the north shore of Seneca Lake.

The entire area within a one mile radius of the site is on the Geneva city water and sewer system except for 5 houses on Lake Drive North and Lake Drive South and for 1 farm house north of the site which depend upon domestic wells for their water supply (Figure 3-9). As was described in Section 3.2.5, the regional groundwater flow is assumed to be toward Seneca Lake. Therefore, the

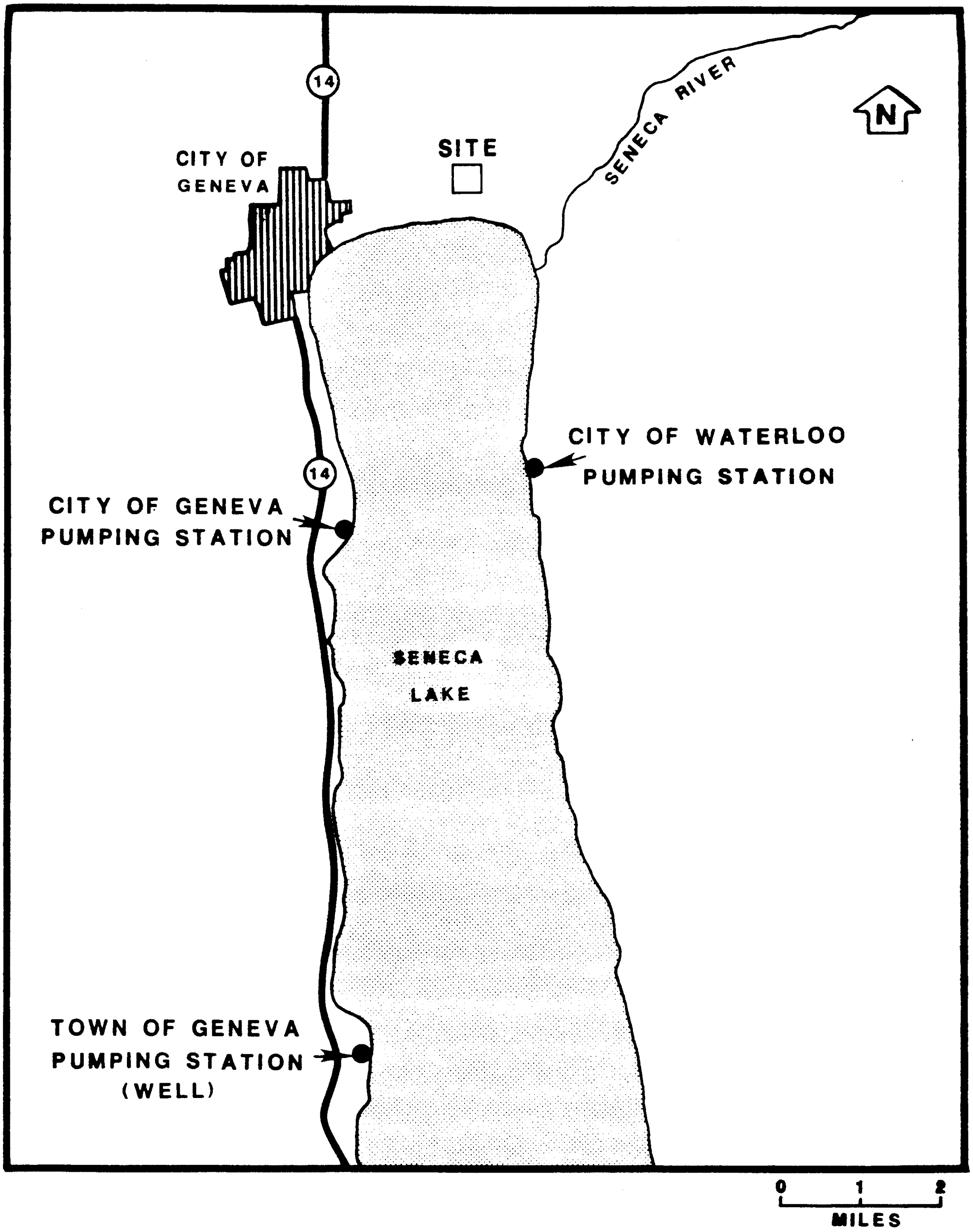
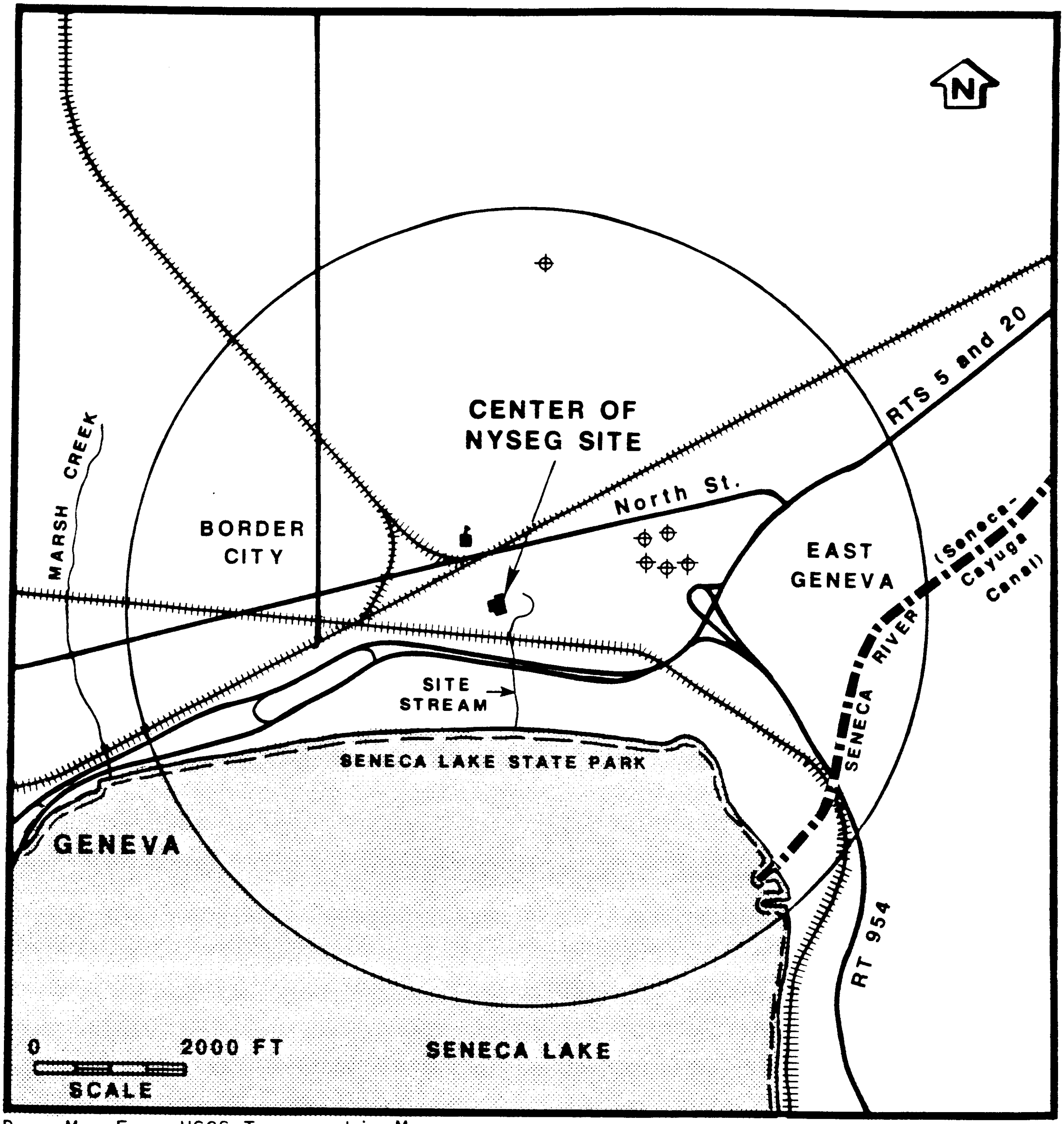


Figure 3-8. Location of Municipal Pumping Stations in Northern Part of Seneca Lake. (Dafler, 1985)



Base Map From USGS Topographic Map

⊕ LOCATION OF DOMESTIC WELL

Figure 3-9. Location of Domestic Wells Within 1 Mile of the Geneva Site. (Dafler,1985) farm house is upgradient of the site and the five houses are roughly "evengradient" with the site.

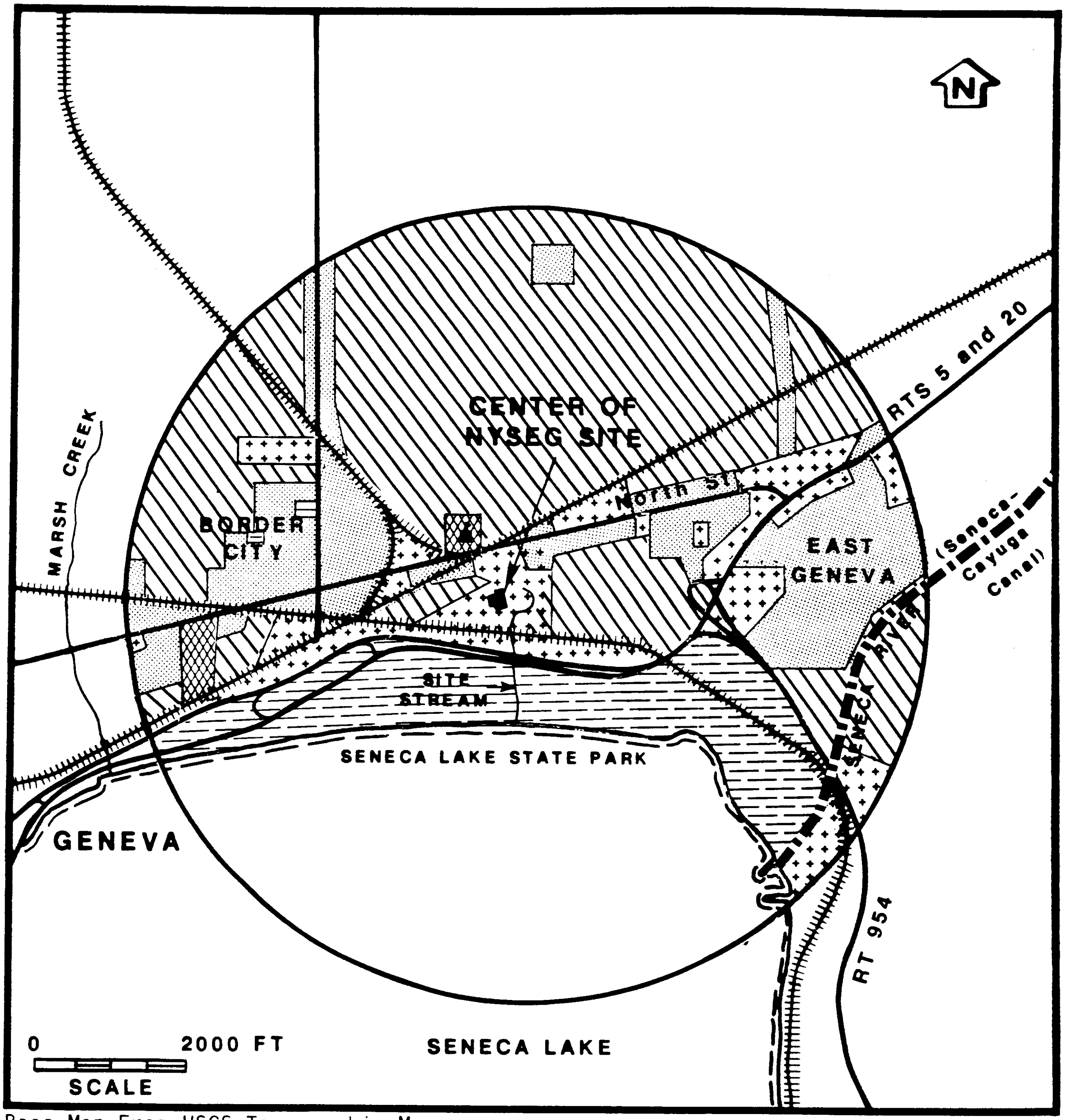
A referendum will be proposed in the near future to put the 5 houses on city water. This referendum is in no way related to the current investigation or any environmental problems which may exist on the NYSEG property.

3.5 Area Land Use

An analyses of the land use within a one mile radius of the Geneva Coal Gasification Plant was done by members of TRC in November of 1985. A land survey map (Figure 3-10) was prepared by using a Geneva, NY 7-1/2 minute Quadrangle map and traveling by car throughout the area. The land use evaluation in this area will identify sensitive areas such as schools, hospitals and nursing homes and will aid in the evaluation of risk assessment for remedial action alternatives.

Approximately one third of the area within the one mile radius of the site is Seneca Lake State Park or part of Seneca Lake itself. This recreational area is used by residents for swimming, boating and picnicking. Development of this park was initiated by the City of Geneva in 1922. Prior to this time, the land use was primarily industrial, including a large brewery and a barrel making factory.

The original barge canal, constructed in about 1825, passed through the center of the area which is presently the state park. The canal was actively used through the turn of the century by boats and barges pulled by animals which walked along a track adjacent to the canal. With the onset of steam and gasoline engines, waterway traffic abandoned the barge canal north of the lake in favor of the more direct route from the lake into the Seneca River (Seneca-Cayuga Canal). The barge canal, north of the lake, became a dumping ground for miscellaneous trash. A short, unfilled section of the old barge canal remains at the eastern end of the State Park.



Base Map From USGS Topographic Map

Figure 3-10. Land Use Map

Most of the remaining land in the area surrounding the Geneva facility is agricultural or open space. In October during our site visit, indicators of corn and hay crops were present in some areas while other fields appeared to be fallow.

Border City and East Geneva, two towns near the site, are combination industrial/residential communities. The Border City area is approximately 2000 feet west of the existing substation. Buildings along North Street in Border City are largely single family residential dwellings. Land areas adjacent to the numerous railroads in the area are generally commercial, with industrial sites including a shampoo/hair product company, concrete and building product facilities and a few small light industrial companies. Also within Border City is a large, low-income housing complex and a cemetery. An elementary school with an enrollment of approximately 500 students is located on North Street about 1000 feet west of the site boundary.

The edge of the community of East Geneva begins approximately 3000 feet east of the site. A more concentrated residential community, East Geneva has several mobile home parks. Industrial complexes in this area include a shopping center, a drive-in theater, and restaurants. The Cayuga-Seneca Canal (Seneca River) passes through East Geneva and is an inlet to Seneca Lake with boat docks and marinas concentrated at the junction of the lake and the canal. The present land use in the immediate area of the NYSEG Geneva area operations center is mostly open space with much of this area being poorly-drained and having standing water during rainy periods. A few single family dwellings are present along North Street.

In summary, the area within the one mile radius of the Geneva facility has a low population density with no major commercial or industrial facilities. At least fifty percent of the area within the boundary is agricultural/open space, Seneca Lake State Park Land or Seneca Lake.

4.0 PRELIMINARY SITE DATA

4.1 Geophysical Surveys

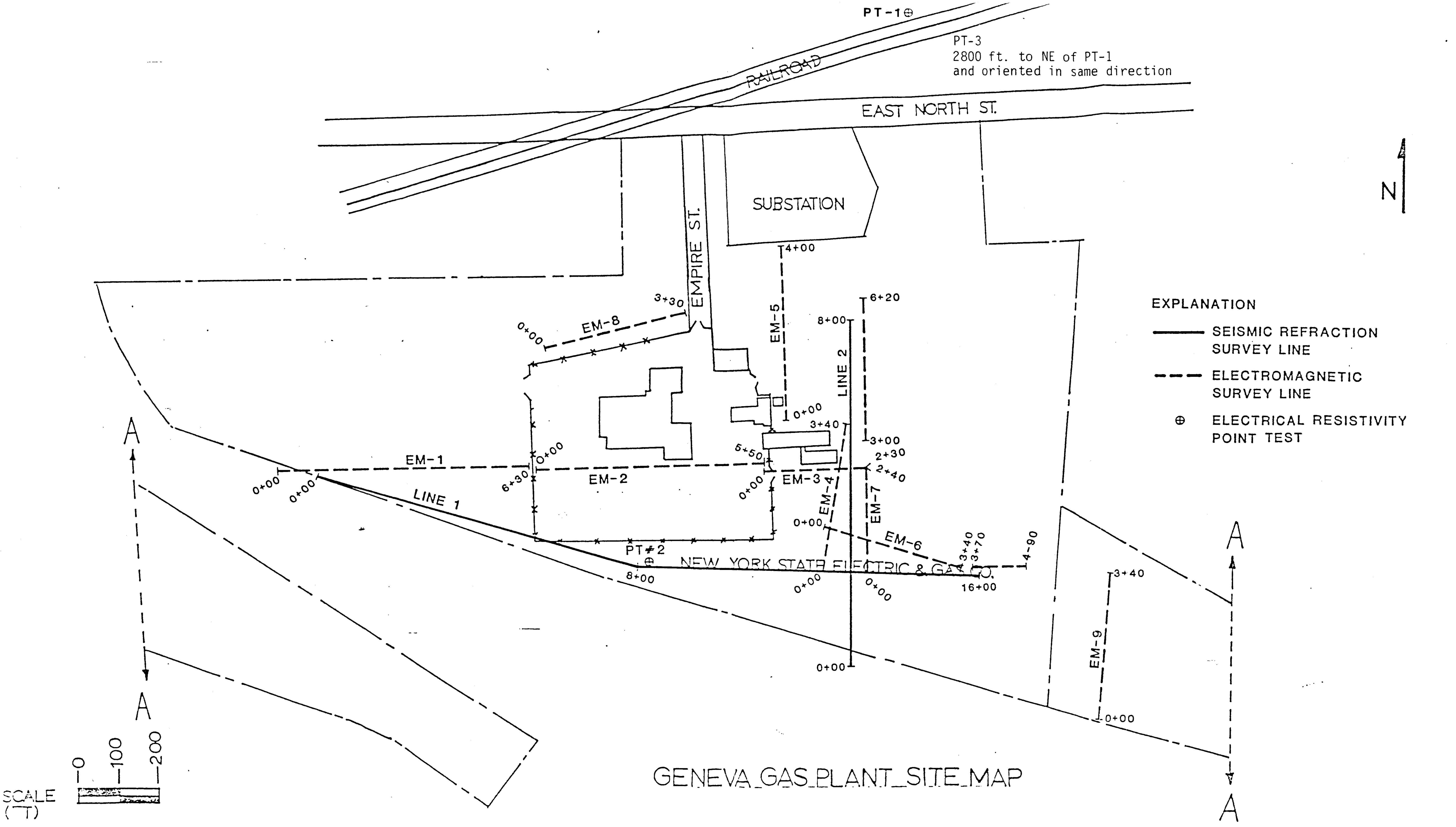
Geophysical surveys were performed by personnel from TRC and Weston Geophysical Corporation on November 17-21 (Phase I) and December 9-13 (Phase II). This section of the report is a summary of the two phases of geophysical work performed at Geneva. The complete Weston report for the geophysical program is presented in Appendix A.

Geophysical work included seismic refraction, electrical resistivity, and electromagnetic survey methods. Results from each of these methods are summarized in the following sections.

4.1.1 Seismic Refraction Survey

Two days of seismic refraction profiling were done during the first phase of the geophysical survey. The objective of the seismic work was to determine if a glacial till layer is present beneath the NYSEG site and to determine the depth and nature of the bedrock surface.

Two seismic refraction profiles were completed. The first profile was oriented roughly east-west along the southern NYSEG property boundary. A shorter cross-profile was oriented north-south through the marsh east of the compressor building and old purifier house. Exact locations of the two seismic lines are included in Figure 4-1. Each of the seismic arrays consisted of a spread of 24 geophones electrically connected to a seismograph near the center of the array. The seismic signals were generated with explosives equivalent to 1/3 to 2/3 sticks of dynamite. Shot points were situated at several locations along each spread including one location 800 feet west of the end of the longer spread. This longest shot was made to assure adequate definition of the bedrock surface.



GEOPHYSICAL INVESTIGATIONS GENEVA SERVICE CENTER GENEVA, NEW YORK prepared for TRC ENVIRONMENTAL CONSULTANTS	PLAN MAP OF SPECIFIC COVERAGE WESTON GEOPHYSICAL CORPORATION DECEMBER 1985 Figure 4-1

The seismic refraction survey showed that bedrock is located at a depth of 175 feet near the eastern edge of the NYSEG property and approximately 200 feet near the western edge of the property. Bedrock beneath Line 2 appeared to be nearly flat at a depth of 175 feet. The seismic velocities of the bedrock (14,000-15,000 ft/sec) were indicative of massive, relatively unweathered, unfractured rock. Materials above the bedrock surface had consistent velocities of 5000 ft/sec suggesting saturated alluvial and/or fluvial deposits. No velocity layers suggestive of dense glacial till were identified. In general, the depths and stratigraphy determined during the seismic refraction survey were consistent with those given in the log of the on-site well.

4.1.2 Electrical Resistivity Survey

Four electrical resistivity point tests (soundings) were performed at the Geneva site during the two phases of geophysics. In Phase I, a Bison earth resistivity meter was used to perform point tests north of the site parallel to the railroad tracks (PT-1) and near the southern NYSEG property boundary parallel to seismic line 1 (PT-2) (Figure 4-1). Point Test No. 1 was performed to determine the background electrical characteristics of the materials in the area while Point Test No. 2 was done to determine if contamination has moved downgradient from the Geneva Service Center.

In Phase II, a Scrintex high-powered resistivity system was used to do one point test (PT-3) in roughly the same location as PT-1 while a second point test (PT-4) was performed on an East-West line south of these point tests. These locations are shown in Figure 4-1. The higher powered Scintrex system was used for the second phase of the geophysics because of the greater depth of penetration and the higher degree of accuracy of this instrument. Point Test No. 3, north of the Service Center, was done to determine background resistivity values at depth. Point Test No. 4 was done to determine if shallow contaminants origiating at the Service Center have migrated as far as the State Park across Routes 5 and 20 and if contamination associated with the rock injection well is migrating upward into the unconsolidated sediments.

Apparent resistivity readings recorded in the field were interpreted with the aid of a computer model which matches field data to modeled results. Comparisons of field and modeled data are presented in the Weston Report which is included as Appendix A. The conclusions are discussed below. Data from Point Test No. 2 suggest the presence of highly conductive materials within 30 feet of the surface. Because coal tar contamination is generally associated with high conductivity (low resistivity), these findings may indicate conditions similar to those found around the Geneva Service Center structures. Conductivity values above background levels were also found below a depth of approximately 120 feet in Point Test No. 4 in Seneca Lake State Park. These high conductivity values at depth could be from a number of factors such as finer grained materials than at PT-3, or Camillus Shale ground water (high in total dissolved solids) moving upward into the unconsolidated sediments, or high conductivity water originating from the injection well.

4.1.3 Electromagnetic Survey

Electromagnetic measurements were taken along a total of 18 survey lines (Figure 4-1) using a Geonics EM-31 attached to a continuous chart recorder and on survey line EM-16 using an EM-34. The EM-31 has a fixed coil spacing of 3.6 meters which allows a maximum depth of investigation of approximately 18 feet. The EM-31 survey was done to evaluate the extent of conductive materials on site as well as the possible southward migration of conductive contamination. The EM-34, with a maximum exploration depth of 100 feet, was used to search for possible deeper contamination downgradient from the site.

A contoured map of the conductivity values recorded at the Geneva site is presented in Appendix A, Figure 3. There are four areas in which higher than background (30-50 millimhos/meter) conductivities were recorded. The most significant anomaly was detected in and around the Geneva Service Center. The anomaly is centered South of the present buildings at the Service Center and is elongated in an East-West direction.

Two areas which have conductivities exceeding 100 mmhos/meter are present in the State Park. The largest area is located in the Western portion of the Park just east of the entrance from Routes 5 and 20. A smaller area of high conductivity was located close to the shore of Seneca Lake due south of the Service Center. Background conductivities were detected between the Service Center and each of these anomalies. Therefore, both of these anomalies appear to be unrelated to contamination from the Service Center. A final area of high conductivity was located southwest of the Service Center in the median strip of Routes 5 and 20. This anomaly also appears to be unrelated to possible contamination at the Service Center.

The high conductivity values found in the vicinity of the Service Center indicate the possibility that extensive near-surface contamination exists. Borings and test pits which will be done during Task 2 will allow the conductivity measurements to be correlated with observed soil conditions.

4.2 Site Air Quality

As part of the preliminary site investigations, a site air quality survey was conducted on November 21, 1985. This survey was conducted to determine the ambient levels of organic vapors within the site buildings as well as around the site. An organic vapor analyzer (Century Model 128) was used to perform the survey. In addition to the site survey, the organic vapor emissions from excavations for a sewer line were measured.

The air quality survey was conducted on November 21, 1985, after the sewer line excavation had been backfilled. The OVA was calibrated on the 10x scale with zero air and 19 ppm benzene using an air standard provided from Tedlar bags. The ambient readings around the site were determined before doing the indoor survey, and they were less than 1 ppm.

Table 4-1 lists organic vapor levels detected at specific areas within buildings on the NYSEG property. The table also includes organic vapor levels outside the various buildings. In all but a few instances the organic vapor levels are less than 3 ppm. The exceptions to this are the meter storage room (10 ppm), coffee room in meter building (7-9 ppm), new office control room in compressor building (12 ppm), pipe room transmission room in Compressor Building (150 ppm), and the second floor SP&C department in the old office building (3.7 ppm). The meter building was once the purifier building where coal tar pitch and other impurities were removed from the gas stream. This use may be the source of the higher (relative to the office buildings) organic vapor concentrations. Alternatively, the high readings may be due to slight leakage of natural gas in the compression process. The value of 150 ppm in the transmission room, a location where small leaks might be expected, supports this idea. Draeger Tube analyses for Toluene and H_2S in the compression room showed no measurable levels of these constituents.

OVA readings in areas normally frequented by NYSEG personnel for extended lengths of time do not exceed 12 ppm. In the worst case, we can assume that all of the measured organic vapors were benzene, a known carcinogen. If this were the case, the levels measured would be at or below the threshold limit value (TLV) of established by the American Conference of Industrial Hygienists for benzene. The 10 ppm measured levels of organic vapors do not, therefore, constitute a health hazard.

TABLE 4-1

PRELIMINARY AIR QUALITY SCREENING GENEVA SITE

Building	Location	Organic Vapor Levels (ppm)	Outdoor Ambient Organic Vapor Levels (ppm)
New Office Building	2nd floor office space	0-0.5	0.5
New Office Building	2nd floor storage area	0.5	0.5
New Office Building	1st floor stores UC&M	1.0-1.3	0.2
New Office Building	1st floor hallway	0.9	0.2
New Office Building	1st floor garage	2.8-3.2	0.2
Meter Building	1st floor loading dock	2.5-3.0	0.2
Meter Building	Meter Storage	10	0.5
Meter Building	Coffee Room	7-9	0.5
Compressor Building	Calibration Room	1.0	0.5
Compressor Building	New office Control Room	12	0.5
Compressor Building	Transmission Room	150	0.5
Compressor Building	Welding Shop	0.7	0.5
Compressor Building	Storage area	2.2-2.4	
Old Office Building	2nd floor SP&C Dept.	3.7	0.5
Old Office Building	2nd floor Elect & Gas Disp.	1.6	0.5

TABLE 4-1 (Continued)

PRELIMINARY AIR QUALITY SCREENING GENEVA SITE

Building	Location	Organic Vapor Levels (ppm)	Outdoor Ambient Organic Vapor Levels (ppm)
Old Office Building	2nd floor offices	2.6-2.8	0.5
Old Office Building	2nd floor classroom	2.8	0.5
Old Office Building	Stairs 2nd floor	2.3	0.5
Old Office Building	1st floor conference room	1.5	0.5
Old Office Building	Janitor Room 1st floor	1.8	0.5
Old Office Building	Store Room	1.5	0.5
Old Office Building	Electric Meter Dept.	1.2-2.0	0.5
Old Office	Hall 1st floor	1.2	0.5

4.3 Water and Soil Quality

NYSEG collected 11 soil samples and 1 ground-water sample during 1984 and had them analyzed for total phenolics, aromatics (602 series), and PNAHs (612 series). Tables 4-2 and 4-3 summarize the data and Figure 3-6 shows the location of the sampling points.

The results of the analyses indicate that compounds characteristic of coal tar sites are present in significant amounts in the soils in a few borings: B-11, site of the former sludge basin; B-12, site of the former pump station; and B-14, in former dump area. These compounds are present in smaller quantities in B-15, near original office building; B-16, 100 ft north of B-15; and B-17, 200 ft north of B-15. Borings B-15 through B-21 are north of the old plant area processing areas.

The one water sample was from boring B-13, site of the former clear water basin. The sample showed compounds characteristic of coal gasification sites, although in lower levels than many of the soil samples.

A visual inspection of the site revealed evidence of near surface contamination south of the gas holder and purifying building. Rocks coated with ferric ferrocyanide ("blue billy") were found throughout that area.

TABLE 4-2

BORING HNu READINGS
GENEVA SITE

Boring	Date	Depth* (ft)	HNu Reading** (ppm)
B-1	5/8/84	1.0	0.2
		2.0	0.0
		3.0	0.0
B-2	5/8/84	0.5	0.0
		3.0	0.2
		6.0	0.4
B-3	5/8/84	0.5	0.0
		3.5	0.4
		5.5	0.1
B-4	5/8/84	1.0	0.0
		4.0	0.1
B-5	5/8/84	1.5	0.4
		3.5	0.2
B-6	5/8/84	1.0	0.2
		5.0	0.1
B-7	5/8/84	0.5	0.1
		2.5	0.1
B-8	5/8/84	1.5	0.0
		5.0	0.0
B-9	5/8/84	1.0	0.1
		3.0	0.8
B-10	5/8/84	1.0	5.0
		3.0	6.0
B-11	6/6/84	1.0	0.0
		5.5	0.2
		7.0	0.5
B-12	6/6/84	1.5	0.0
		4.0	0.2
B-13	6/6/84	2.0	0.0
		6.0	0.6

TABLE 4-2
(Continued)

BORING HNu READINGS
GENEVA SITE

Boring	Date	Depth* (ft)	HNu Reading** (ppm)
B-14	6/6/84	1.0	0.0
		4.0	1.0
B-15	9/21/84	1.0	0.0
		3.5	0.0
		5.5	0.0
B-16	9/21/84	1.5	0.0
		4.0	0.5
B-17	9/21/84	1.0	0.0
		3.5	0.0
B-18	9/21/84	1.0	0.0
		5.5	0.0
B-19	9/21/84	---No Readings Taken---	
B-20	9/21/84	1.0	0.0
		5.0	0.0
B-21	9/21/84	1.5	0.0
		6.0	0.0

Source: Woodward Clyde, 1984.

* Depth of auger.
**Reading taken at top of borehole.

TABLE 4-3

PREVIOUSLY PERFORMED ANALYSES
GENEVA SITE

Sample No.	B-11	B-12	B-13	B-14	B-15	B-16	B-17	B-18a	B-18b	B-19	B-20	B-21
Sample Depth	6'	6-8'	6-9'	NA	NA	NA	NA	1.5'	4.5'	2.5'	NA	NA
Sample Date	6/6/84	6/6/84	6/6/84	6/6/84	9/21/84	9/21/84	9/21/84	9/21/84	9/21/84	9/21/84	9/21/84	9/21/84
Medium Sampled	Soil	Soil	Water	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil
Concentrations	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)
Benzene	0.010	0.180	0.0054	7.1	0.030	5.3	0.063	0.020	<0.005	<0.005	<0.005	<0.005
Toluene	0.0048	0.055	0.0019	11.9	0.012	4.8	0.026	0.013	<0.005	<0.005	<0.005	<0.005
Ethylbenzene	0.0015	0.120	0.0011	7.0	<0.005	0.21	0.11	0.0081	<0.005	<0.005	<0.005	<0.005
Chlorobenzene	<0.010	<0.100	<0.010	<10	<0.05	<0.5	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
1,4-Dichlorobenzene	<0.010	<0.100	<0.010	<10	<0.05	<0.5	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
1,3-Dichlorobenzene	<0.010	<0.100	<0.010	<10	<0.05	<0.5	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
1,2-Dichlorobenzene	<0.010	<0.100	<0.010	<10	<0.05	<0.5	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
m&p-xylene	0.0052	0.170	0.0028	13.1	0.0046	2.6	0.048	0.059	<0.005	<0.005	<0.005	<0.005
o-xylene	0.0016	0.110	0.0016	7.1	0.0033	0.71	0.027	0.023	<0.005	<0.005	<0.005	<0.005
Styrene	0.0019	0.036	<0.002	1.7	<0.005	0.49	0.018	0.019	<0.005	<0.005	<0.005	<0.005
n-Propylbenzene	<0.002	0.028	<0.002	0.4	<0.005	0.086	0.017	0.015	<0.005	<0.005	<0.005	<0.005
Naphthalene	8.2	20.0	0.30	1250	0.0013	0.099	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Acenaphthylene	17.0	21.0	0.21	510	<0.001	0.046	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Acenaphthene	13.0	22.0	0.47	90	<0.001	0.016	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Fluorene	22.0	38.0	1.30	1300	<0.001	0.013	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Phenanthrene/ Anthracene	18.0	280.0	0.75	2790	<0.001	0.41	0.0012	<0.001	<0.001	<0.001	<0.001	<0.001
Fluoranthene	21.0	420.0	0.74	1110	0.0015	0.23	0.0028	<0.001	<0.001	<0.001	<0.001	<0.001
Pyrene	17.0	370.0	0.60	2260	0.0011	0.20	0.0022	<0.001	<0.001	<0.001	<0.001	<0.001
Benzo(a)anthracene	16.0	140.0	0.51	320	0.020	0.39	0.0088	<0.001	0.0043	0.018	0.003	0.017
Chrysene	14.0	130.0	0.44	240	0.051	0.13	0.014	<0.001	0.014	0.066	0.0093	0.11
Benzo(b)fluoranthene/ Benzo(k)fluoranthene	18.0	34.0	0.76	260	0.012	0.21	0.0065	<0.001	<0.001	<0.001	<0.001	<0.001
Benzo(a)pyrene	11.0	30.0	0.38	170	0.001	0.21	0.0031	<0.001	<0.001	0.014	<0.001	<0.001
Dibenzo(a,h)anthracene/ Indeno(1,2,3-cd)pyrene	11.0	13.0	0.32	86	<0.001	0.094	0.0011	<0.001	<0.001	<0.001	<0.001	<0.001
Benzo(g,h,i)perylene	<5	12.0	0.14	78	<0.001	0.41	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Total Phenolics	0.205	37.5	0.023	3.38	0.75	30	0.14	0.14	0.06	0.04	<0.04	<0.04

Analyses Performed by General Testing Corporation

5.0 CONCLUSIONS, UNKNOWNS, AND RECOMMENDATIONS

The following sections briefly detail the conclusions that can be made, the unknowns that need to be resolved, and recommendations for future work.

5.1 Conclusions

Following is a summary of the conclusions that can be made from the data collected to-date.

- There presently exist known areas of PAH contamination in soils as identified from the Task 1 investigations and previous work performed on-site. The Task 1 data also indicates that PAHs may be present in the site stream.
- The presence of a coke quench-water injection well has been confirmed by employees and State well records.
- Volatile air quality impacts appear to be minor and to present minimal risk to on-site workers. One potentially high reading was found in an area not normally frequented by employees. It is thought that this reading was caused by minor natural gas leakage.
- The primary potential contaminant pathways identified to date are ground water, surface water, stream sediment, and possibly fugitive dust from old disposal areas, and biota from stream.
- The site can be divided into two levels of potential contamination: a near surface level because of on-site disposal and incidental spills and a deeper level related to the injection well.

5.2 Unknowns

Following is a summary of the unknown factors that have been identified during the Task 1 work.

- The extent of contamination in the near surface and deep levels. Also, the quality and quantity of the materials disposed of at both levels and the extent of any plume that may exist because of disposal.
- Details on local potable water well construction and the quality of water.
- The unconsolidated sediment and bedrock stratigraphy and how it may control contaminant migration.

- The method by which suspected tars got into the stream sediments. If contamination in the stream is the result of direct disposal, then the level of contamination will not increase over time. If, however, the contamination is the result of seepage originating from another source, then the degree of contamination would change with time.

5.3 Recommendations

It is recommended that the Task 2 field work as identified in the September 17, 1985 revision be performed with the following modifications and additions.

- The air quality program will be focused to quantify compounds and emission rates for use in evaluation of potential risks due to various remediation alternatives.
- Test pits as shown in the work plan will be adjusted to investigate the disposal area southeast of the gas holder, the spoil bank from the stream dredging, the stream bank near the sewage treatment plant, and the extreme western part of the site property.

Pending evaluation of data collected during Task 2, consideration will be given to performing the following work efforts during Task 3.

- A deep monitoring well should be installed near the old injection well to determine if contamination exists in the deeper level.
- A ecological evaluation of the stream should be considered. This evaluation would determine the bioaccumulation potential for subsequent risk assessment.

6.0 REFERENCES

American Conference of Governmental Industrial Hygienists, Documentation of Threshold Limit Values, 1984-85 Edition.

Conley, P., 1986, Personal communications with Patrick Conley, Seneca Lake State Park Manager, March, 1986.

Crain, L.J., 1974, Groundwater Resources of the Western Oswego River Basin, New York: State of New York Department of Environmental Conservation Basin Planning Report ORB-5, 137p.

Dafler, R., 1985, Personal communications with Roger Dafler, Supervisor of the Border City Water and Sewer Department, November, 1985.

DeRosa, Chris, 1982, Memo in Health Effects Assessment for the 129 Priority Pollutants. To James T. Bachmaier.

Geneva Times, 1903-1934, Various articles regarding operation of Empire Coke Company

Hutton, F.Z., Jr., 1972, Soil Survey, Seneca County, New York: U.S. Government Printing Office, Washington, DC, 143 p.

Johns, A., 1985, Personal communications with August Johns, retired maintenance worker from Empire Coke Company, November, 1985.

Kierst, H., 1985, Personal communications with Henry Kierst, retired relief man from Empire Coke Company, November, 1985.

Mack, F.K. and R.E. Digman, 1962, The Groundwater Resources of Ontario County, New York: State of New York Water Resources Commission, Bulletin GW-48, 99 p.

Menzie, Charles, 1985. An Assessment of Health Risks Associated with Redevelopment of Site Along Commercial Street, Malden, MA. Prepared for TRC Environmental Consultants, Inc., June.

Morgan, J.J., 1945, Water gas: In Lowry, H.H., ed., Chemistry of Coal Utilization, John Wiley and Sons, New York, 1868 p.

Mozola, A.J., 1951, The Groundwater Resources of Seneca County, New York: New York Water Power and Control Commission Bulletin GW-26, 99 p.

New York State Air Guide 1. Guidelines for the Control of Hazardous Ambient Air Contaminants. New York State/Department of Environmental Conservation, 1983-84.

The Companies Corp. of Expert Engineers and Draughtsmen, 1904, New Century Atlas of Ontario County New York; Philadelphia, Century Map Co.

Wilson, D.C., and Stevens, C., 1981. Problems Arising from the Redevelopment of Gas Works and Similar Sites.

Woodward-Clyde Consultatnts, 1984. Report of Investigations of NYSEG Geneva Service Center, May.

Woodward-Clyde Consultants, 1984. Report of Investigations of NYSEG Geneva Service Center, August.

Woodward-Clyde Consultants, 1984. Report of Investigations of NYSEG Geneva Service Center, November.

APPENDIX A

GEOPHYSICAL INVESTIGATIONS
BY
WESTON GEOPHYSICAL CORPORATION

Weston Geophysical
CORPORATION

February 14, 1986
WGC - R776

TRC ENVIRONMENTAL CONSULTANTS, INC.
800 Connecticut Boulevard
East Hartford, CT 06108

Gentlemen:

In accordance with your authorization to proceed, geophysical investigations have been conducted in the vicinity of the New York State Electric & Gas [NYSEG] Geneva Service Center.

We are pleased to submit for your review and comment this draft report presenting the results and findings of the geophysical investigations.

Sincerely,

WESTON GEOPHYSICAL CORPORATION

Paul S Fisk

Paul S. Fisk

PSF:wpt-0291J3

Post Office Box 550 • Westboro, Massachusetts 01581 • (617) 366-9191 • Telex No. 920491

Weston Geophysical
CORPORATION

April 5, 1986
WGC - R776

TRC ENVIRONMENTAL CONSULTANTS, INC.
800 Connecticut Boulevard
East Hartford, CT 06108

Gentlemen:

Please find enclosed the corrected text, new covers, and Figures 5, 6, 8, and 9.

Sincerely,

WESTON GEOPHYSICAL CORPORATION

Paul S Fisk

Paul S. Fisk

PSF:pj -0291J

Lyons Street • Post Office Box 550 • Westboro, Massachusetts 01581 • (617) 366-9191 • Telex No. 920491

DRAFT

GEOPHYSICAL INVESTIGATIONS
GENEVA SERVICE CENTER
GENEVA, NEW YORK

Prepared for

TRC ENVIRONMENTAL CONSULTANTS, INC.

FEBRUARY 1986

Weston Geophysical
CORPORATION

TABLE OF CONTENTS

LIST OF FIGURES

1.0 INTRODUCTION & PURPOSE

A two-phased geophysical investigation was conducted in the vicinity of the New York State Electric & Gas [NYSEG] Geneva Service Center in Geneva, New York during the periods of November 18 through 22 and December 10 through 14, 1985. The Phase I investigation used seismic refraction, electromagnetic terrain conductivity [EM], and electrical resistivity survey methods. The Phase II investigation used electromagnetic terrain conductivity and electrical resistivity survey methods.

The purpose of the Phase I investigation was to evaluate the subsurface hydrogeologic conditions and determine the detectability and direction of migration of possible coal tar contamination. The Phase I investigation also assessed which geophysical survey methods should be used in Phase II and where the Phase II geophysical investigation would be most useful.

On the basis of the Phase I results, additional EM and electrical resistivity testing were recommended for Phase II. The objective of the Phase II program was to determine the horizontal and lateral extent of the low resistivity/high conductivity measurements associated with probable areas of contamination detected in the Phase I investigation.

2.0 LOCATIONING & SURVEY CONTROL

The area of investigation is shown on Figure 1, a segment of the Geneva North and Geneva South, New York, United States Geological Survey Quadrangle Maps. The locations of the geophysical survey lines for the Phase I and Phase II investigations are shown on Figure 2. The locations of the geophysical survey lines were determined by measurements and compass bearings referenced to on-site cultural features. The basic map used for Figures 2 and 3 is a composite sketch based on USGS Geneva North and South Quadrangle sheets, a NYSEG map entitled "Border City Property", and field observations.

3.0 METHODS OF INVESTIGATION

This investigation was conducted using a combination of geophysical methods. Each of these survey methods respond to different physical characteristics of the earth materials; correlation of the data from these multiple surveys with borehole and trenching information provides the most complete evaluation of site conditions.

3.1 Electromagnetic Terrain Conductivity

The EM survey method was used to determine the location and extent of coal tar contamination. Typically, contaminants will affect the electrical properties of subsurface materials and ground water. Pure coal tars are highly resistive. However, it has been Weston Geophysical's experience that contamination plumes at coal tar sites throughout the Northeast are usually associated with conductive subsurface conditions. The high conductivity is probably due to contaminants other than coal tar which are contained in the plumes.

EM instruments measure the conductivity of subsurface materials and are therefore suitable for locating and tracing contaminants. An EM-31 with a continuous chart recorder was used in the Phase I survey. The EM-31 has a fixed coil separation of 3.7 meters, operates in the vertical dipole mode and has a depth of investigation of approximately 8 to 18 feet. The Phase II EM survey was conducted with the EM-31 and EM-34 instruments. The EM-34 has a variable coil spacing and orientation. Varying coil orientations and separation distances allow the EM-34 to investigate different depth ranges. A discussion of the EM survey technique is included as Appendix B to this report. Approximate exploration depths of the EM-31 and EM-34 for the various coil spacings and configurations are presented below.

TYPE	INTERCOIL SPACINGS [METERS]	APPROXIMATE EXPLORATION DEPTH [FEET]	
		HORIZONTAL DIPOLE MODES	VERTICAL DIPOLE MODES
EM-31	3.7	-	8 - 18
EM-34-3	10	15 - 25	40 - 50
EM-34-3	20	40 - 50	90 - 100

3.2 Electrical Resistivity

Electrical resistivity measurements were made with a Bison earth resistivity meter and a Scintrex high-powered resistivity system. Vertical electrical soundings or point tests were made using the Lee modification of the Wenner electrode configuration. Resistivity point test data provide information on the variation of resistivity with depth.

Interpretation of the resistivity data is accomplished by computer comparison of field resistivity curves with theoretical resistivity models resulting in a resistivity profile [thickness and values of the different resistivity layers] at the center of the point test. A discussion of the electrical resistivity technique is included as Appendix B.

3.3 Seismic Refraction

Seismic refraction data were obtained with a 24-trace SIE refraction system, using 800-foot spread lengths with 20- and 40-foot geophone spacings and an explosive energy source. Seismic results will provide information on the depth to the water table and bedrock and general material identification based on seismic velocities. A discussion of the seismic refraction profiling technique and method of data interpretation is included in Appendix C.

4.0 DISCUSSION OF RESULTS

4.1 Phase I

Electromagnetic [EM]

Electromagnetic [EM] measurements were obtained on nine [9] EM survey lines [EM-1 through EM-9] in Phase I using an EM-31 and a continuous chart recorder. The locations of these lines are shown in Figure 2. The results of the Phase I EM-31 survey are presented with Phase II EM-31 results as a conductivity contour map [Figure 3]. Relatively high and erratic [100 to 920 mmhos/meter] conductivity values were measured on EM Survey Lines 1, 2, 3, 4, 5 [Stations 0+0 to 3+40], 7 [Stations 0+0 to 2+40], and 8. EM Survey Lines 9, 7 [Station 3+0 to 6+20] and 6, [Stations 3+70 to 4+90] at the eastern end of the survey area have the lowest [30 to 40 mmhos/meter] and most consistent measured conductivity values. The Phase I EM results indicate that the high conductivity associated with past site practices exists throughout the area surveyed with the exception of the easternmost area. The results indicated that the Phase II program should include EM measurements to further evaluate high conductivity values detected in Phase I.

Electrical Resistivity

Two electrical resistivity point tests were performed in Phase I. Point Test No. 1 was located at the north side of the survey area to determine background resistivity values and Point Test No. 2 was located at the south side of the survey area to identify the depth of anomalously high conductivity values identified by the Phase I EM Survey. The results of the electrical resistivity testing are presented in model form in Figures 5 and 6. The measured apparent resistivity values, as well as the modeled resistivity layering [Figure 5] indicate that relatively higher resistivity values [100 to 200 ohm-feet] in the near-surface materials were detected by Point Test No. 1 whereas the modeled results for Point Test No. 2 [Figure 6] indicate that lower resistivity [high conductivity] materials are present near surface. Point Test Nos. 1 and 2 identified a higher resistivity layer [approximately 250 ohm-feet] below a depth of 30 feet. Since soils contaminated by coal tar are generally associated with low resistivity/high conductivity conditions, the electrical resistivity point test No. 2. indicates the possibility of near-surface contamination to a depth of approximately 30 feet.

Seismic Refraction

The results of the seismic refraction portion of the survey are shown as profiles in Figure 7. These profiles show that the bedrock is approximately 200 feet deep at the west end [Station 0+0] of Line 1 and approximately 175 feet deep at the east end [Station 16+0] of Line 1. Bedrock on Line 2 is relatively flat and at the depth of approximately 175 feet. The seismic velocity [14,000 to 15,000 ft/sec.] measured for the bedrock is indicative of massive, relatively unweathered, unfractured bedrock. The bedrock is overlain by water-saturated alluvial or fluvial deposits [5,000 ft/sec.] to within 3 to 5 feet of ground surface. The upper 3 to 5 feet of materials [1200/± ft/sec] are unsaturated fluvial or alluvial deposits. The seismic data did not detect any velocities indicative of dense glacial till deposits.

4.2 Phase II

Electromagnetic [EM]

EM measurements in Phase II were obtained on nine [9] EM survey lines [EM-10 through EM-18] using the EM-31 and on one line [EM-16] using the EM-34. The locations of these lines are shown in Figure 2. The results of the Phase II EM-31 survey are presented with the Phase I EM-31 data as a conductivity contour map [Figure 3].

The conductivity contour map, Figure 3, indicates four areas of higher than background [30 to 50 millimhos/meter] conductivity. Each of these four areas is considered to be anomalous. The highest conductivity values [400 to 500 millimhos/meter] were detected in and around the Geneva Service Center. This anomaly appears to be associated with the past practices at the Geneva Service Center and indicates that the contamination was either deposited directly or has migrated westerly. The anomaly appears to be unrelated to the other anomalous areas since low conductivity values were measured between the Service Center anomaly and the other detected anomalies.

A large area approximately 1,500 feet southwest of the Geneva Service Center area has conductivity values exceeding 100 mmhos/meter. The reason for this high conductivity is unknown. These high conductivity values appear to be unrelated to contamination at the Geneva Service Center, because background conductivity was detected between this area and the Service Center anomaly.

Two other highly conductive [100 mmhos/meter] areas were detected by the EM-31 investigation. One area is at the west end of the survey area and the other at the southern end of the survey area. These anomalous areas were identified but not mapped out in detail because both areas appear to be unrelated to the Geneva Service Center.

EM-34 data were obtained on EM Line 16 to determine the possibility of a high conductivity plume migrating at depth [below the depth of investigation of the EM-31] from the Service Center area. The coil spacings and orientations noted in Section 3.1 were used along Line 16. These data [Figure 4] indicate that the high conductivity detected at the Service Center has not migrated to the south below a depth of 20 to 25 feet. The data also indicate an area of higher conductivity to the west of the Service Center which is unrelated to the Service Center EM anomalies and appears to extend to depth.

Electrical Resistivity

Point Tests Nos. 3 and 4 were conducted to determine if coal tar contamination is rising from the bedrock downgradient of a deep injection well on the NYSEG property. Point Test No. 3, north of the Service Center, was conducted to determine background resistivity values of the bedrock and materials above the bedrock. Point Test No. 4, south of the injection well, was conducted to determine if conductive materials indicative of coal tar contamination are present within the bedrock or in the materials above the bedrock.

Resistivity values detected at depth within the overburden materials are in the order of 600 ohm feet at Point Test No. 3 compared to values in the order of 300 ohm-feet at Point Test No. 4. The lower resistivity values at Point Test No. 4 suggest that contamination could be migrating upward from the bedrock or that overburden materials are different in the area of Point Test No. 3. Lower resistivity values are usually indicative of finer grained materials.

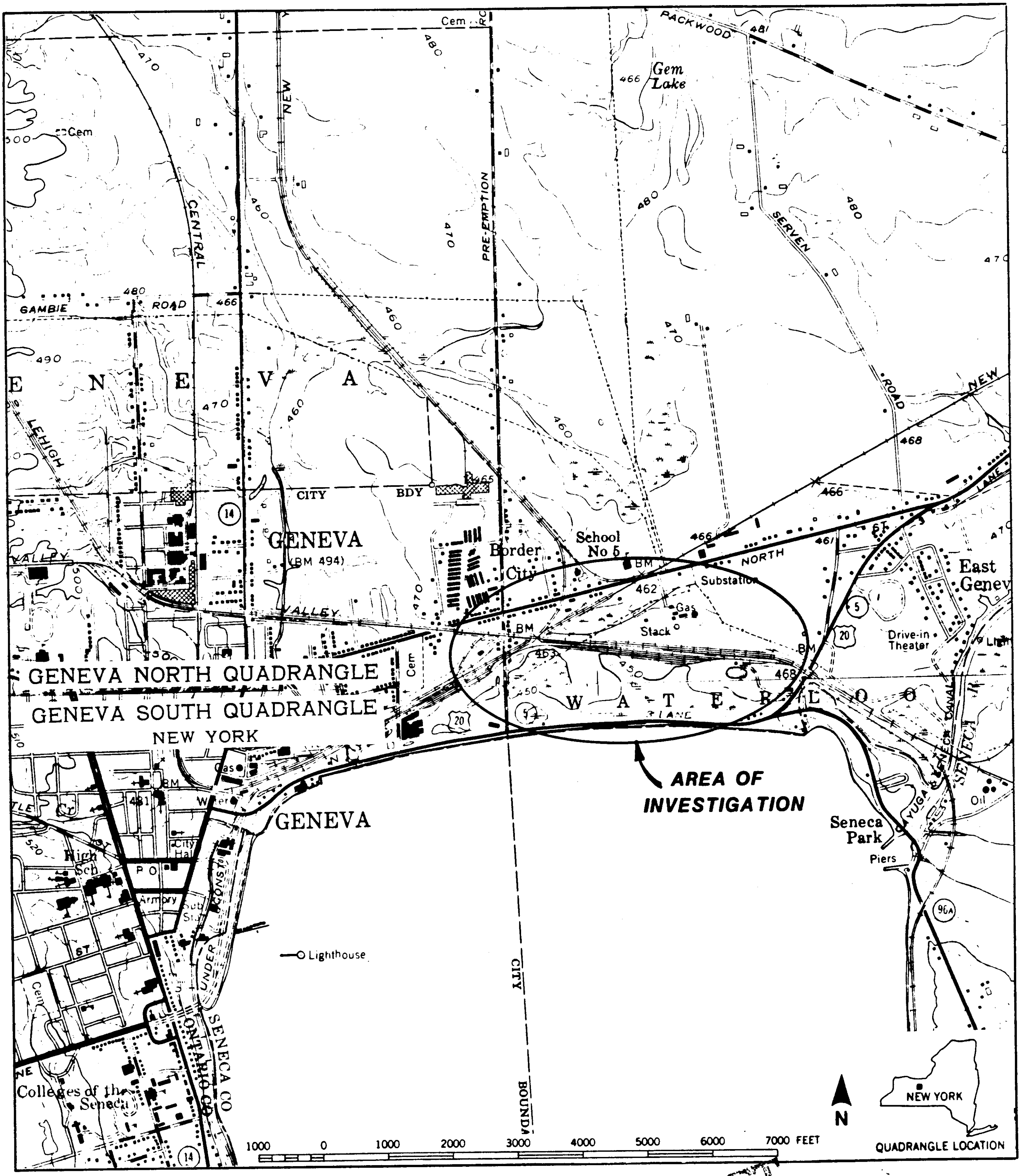
5.0 SUMMARY

The geophysical investigations conducted at the Geneva Service Center suggest an area of soil and ground water contamination in and around the Service Center. Contamination identified by EM measurements [high conductivity] was either deposited directly or has migrated approximately 1,000 to 1,500 feet to the west. Other highly conductive areas [possibly due to contamination] detected by this investigation appear to be unrelated to the Geneva Service Center.

Electrical resistivity testing indicates lower resistivity values at depth downgradient of an injection well. This finding indicates that contamination may be migrating up from the rock or it could represent a change in overburden material. Test drilling would be required to identify the source of the anomaly.

The seismic refraction survey indicated that the bedrock in the vicinity of the Geneva Service Center is approximately 175 to 200 feet deep and relatively massive and unweathered. The seismic data did not detect any velocities indicative of dense glacial till deposits.

FIGURES



DRAFT

GEOPHYSICAL INVESTIGATIONS GENEVA SERVICE CENTER GENEVA, NEW YORK prepared for TRC ENVIRONMENTAL CONSULTANTS, INC.	AREA OF INVESTIGATION WESTON GEOPHYSICAL CORPORATION FEBRUARY 1986 FIGURE 1

NOTE: BASEMAP IS COMPOSITE SKETCH BASED ON
U.S.G.S. GENEVA SOUTH QUADRANGLE SHEET,
N.Y.S.E.&G. MAP TITLED "BORDER CITY PROPERTY"
AND FIELD OBSERVATIONS.

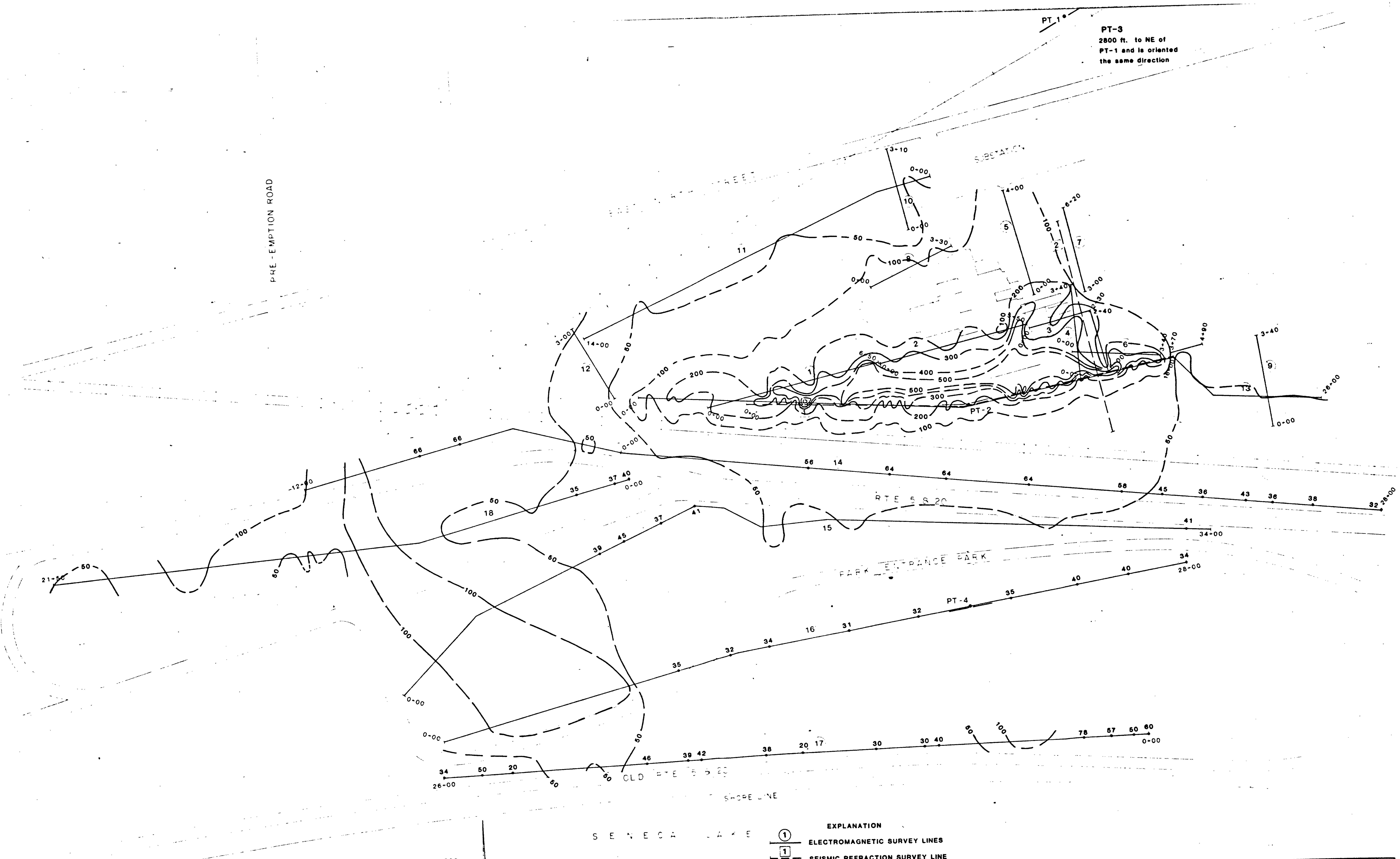
EXPLANATION

①	ELECTROMAGNETIC SURVEY LINES
1	SEISMIC REFRACTION SURVEY LINE
PT-4	ELECTRICAL RESISTIVITY POINT TEST LOCATION AND DIRECTION OF ELECTRODE FROM CENTER POINT

GEOPHYSICAL INVESTIGATIONS
GENEVA SERVICE CENTER
GENEVA, NEW YORK
prepared for
TRC ENVIRONMENTAL CONSULTANTS, INC.

PLAN MAP OF
SPECIFIC COVERAGE

WESTON GEOPHYSICAL CORPORATION
MARCH 1986 FIGURE 2



PT-3
2800 ft. to NE of
PT-1 and is oriented
the same direction

0 100 500
SCALE IN FEET

NOTE: BASEMAP IS COMPOSITE SKETCH BASED ON U.S.G.S. GENEVA SOUTH QUADRANGLE SHEET, N.Y.S.E.&G. MAP TITLED "BORDER CITY PROPERTY" AND FIELD OBSERVATIONS.

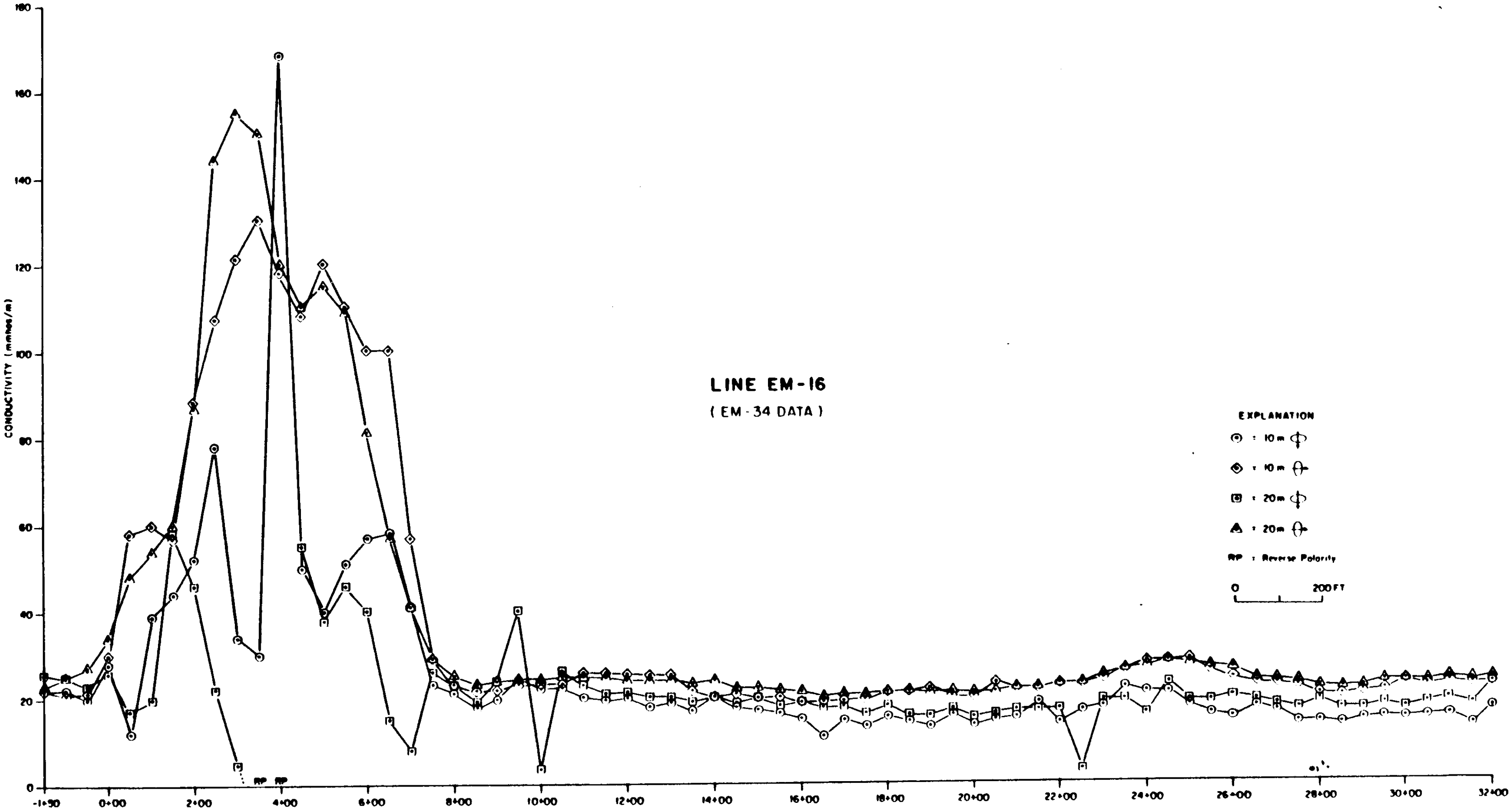
EXPLANATION

①	ELECTROMAGNETIC SURVEY LINES
1	SEISMIC REFRACTION SURVEY LINE
PT-4	ELECTRICAL RESISTIVITY POINT TEST LOCATION AND DIRECTION OF ELECTRODE FROM CENTER POINT
50	CONDUCTIVITY CONTOUR contour interval 50, 100 mmhos/m.
34.	SPOT CONDUCTIVITY VALUE

GEOPHYSICAL INVESTIGATIONS
GENEVA SERVICE CENTER
GENEVA, NEW YORK
prepared for
TRC ENVIRONMENTAL CONSULTANTS, INC.

CONDUCTIVITY CONTOUR MAP

WESTON GEOPHYSICAL CORPORATION
MARCH 1986 · FIGURE 3



GEOPHYSICAL INVESTIGATIONS
GENEVA SERVICE CENTER
GENEVA, NEW YORK
prepared for
TRC ENVIRONMENTAL CONSULTANTS, INC.

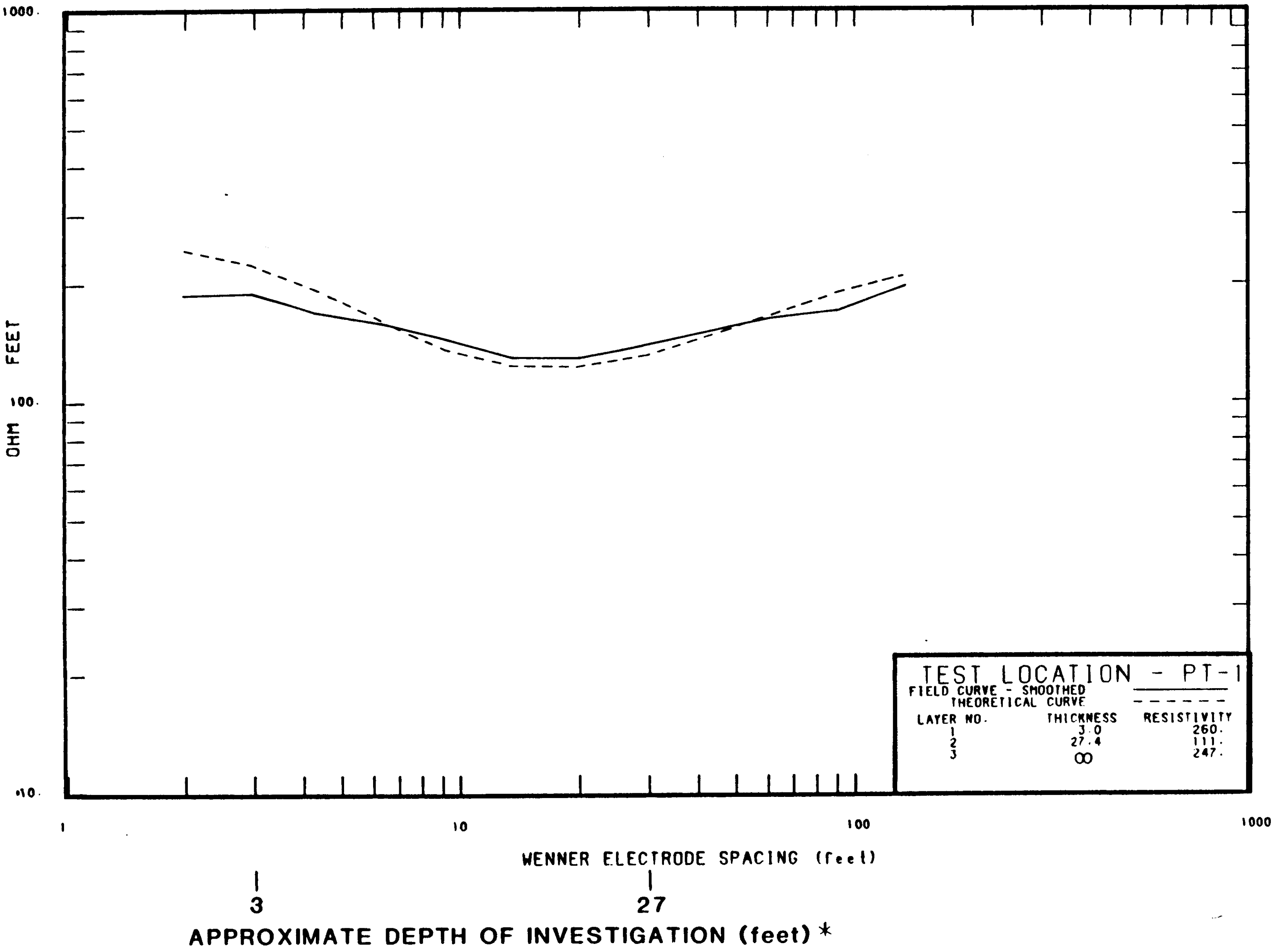
CONDUCTIVITY PROFILE
EM LINE 16

WESTON GEOPHYSICAL CORPORATION
FEBRUARY 1986 FIGURE 4

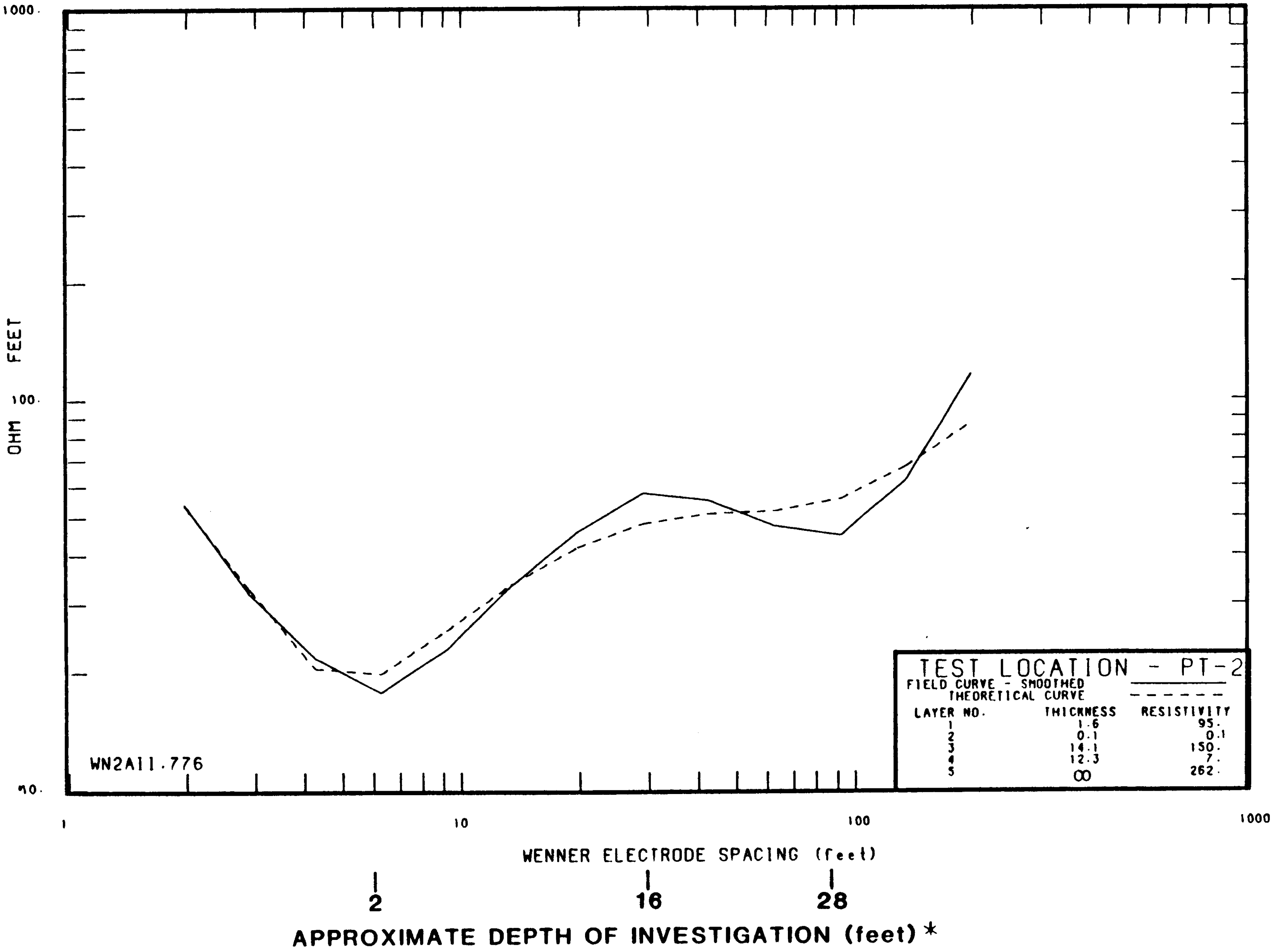
GEOPHYSICAL INVESTIGATIONS
GENEVA SERVICE CENTER
GENEVA, NEW YORK
prepared for
TRC ENVIRONMENTAL CONSULTANTS, INC.

RESISTIVITY POINT TEST #1

WESTON GEOPHYSICAL CORPORATION
MARCH 1986
FIGURE 5



* DEPTH OF INVESTIGATION DEPENDENT ON RESISTIVITIES OF MATERIALS.



LAYER NO.	THICKNESS	RESISTIVITY
1	1.6	95.
2	0.1	0.1
3	14.1	150.
4	12.3	7.
5	∞	262.

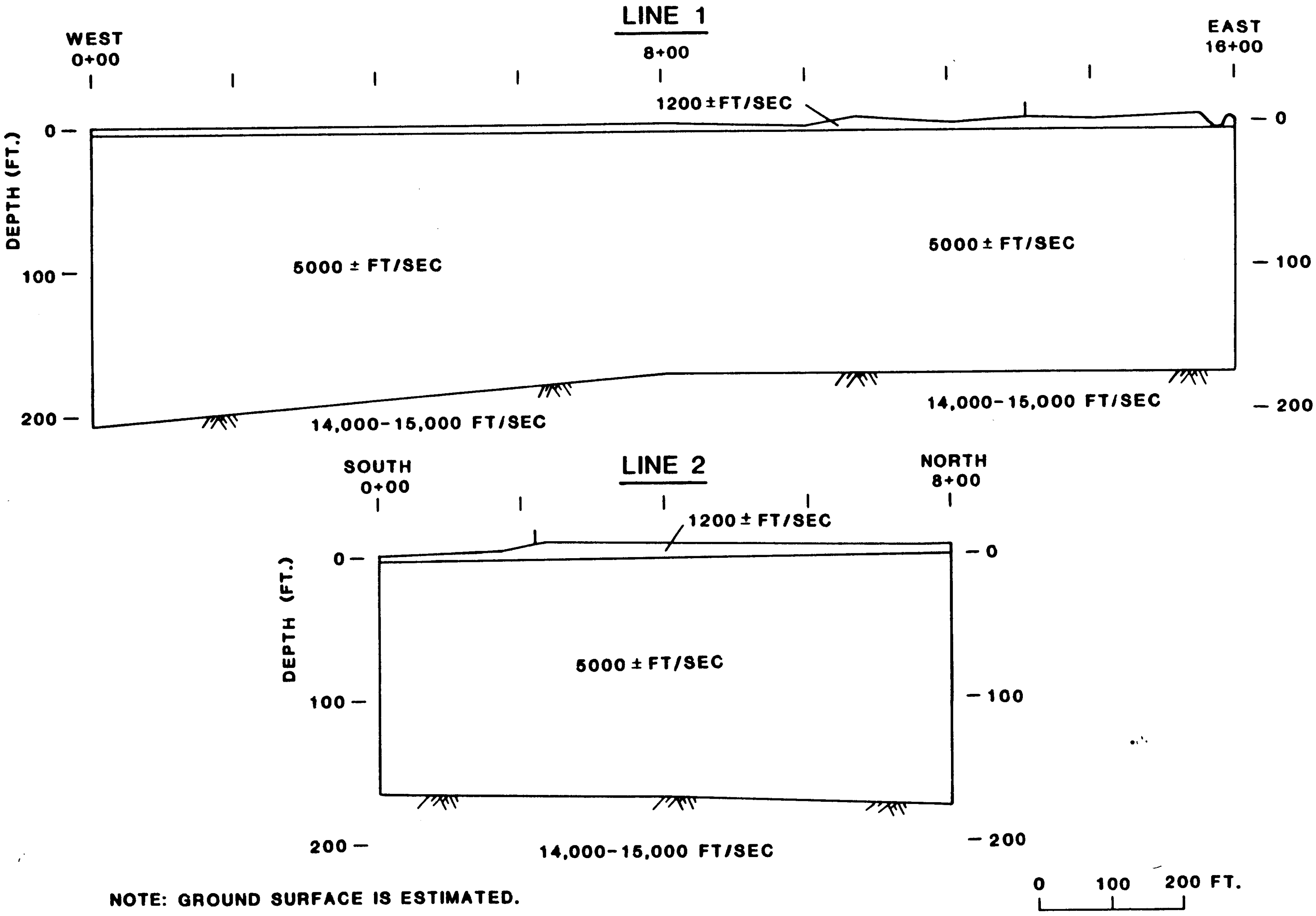
*DEPTH OF INVESTIGATION DEPENDENT ON RESISTIVITIES OF MATERIALS.

GEOPHYSICAL INVESTIGATIONS
GENEVA SERVICE CENTER
GENEVA, NEW YORK
prepared for
TRC ENVIRONMENTAL CONSULTANTS, INC.

RESISTIVITY POINT TEST #2

WESTON GEOPHYSICAL CORPORATION
MARCH 1986

FIGURE 6



NOTE: GROUND SURFACE IS ESTIMATED.

GEOPHYSICAL INVESTIGATIONS
GENEVA SERVICE CENTER
GENEVA, NEW YORK
prepared for
TRC ENVIRONMENTAL CONSULTANTS, INC.

DRAFT

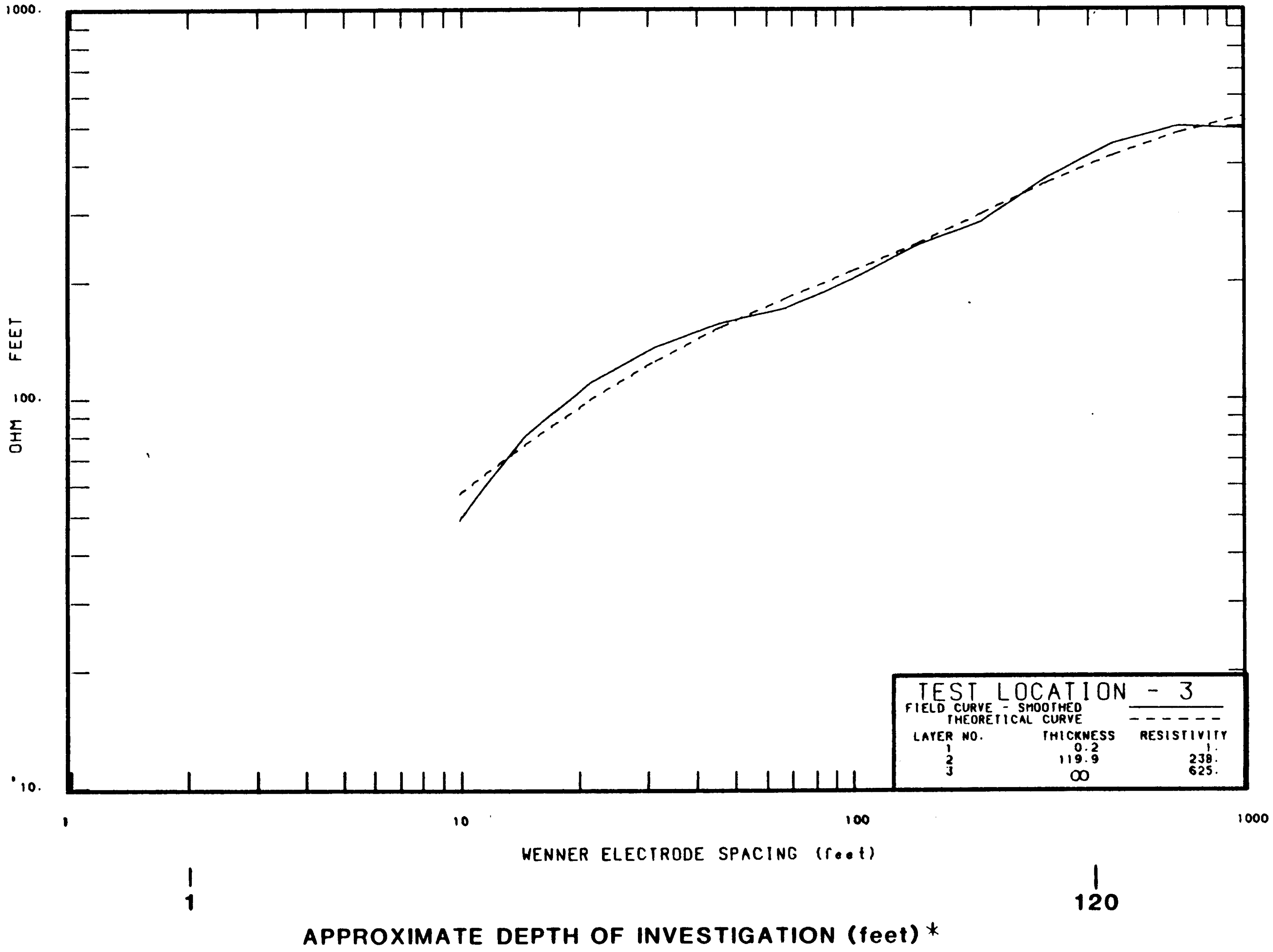
SEISMIC REFRACTION PROFILES

WESTON GEOPHYSICAL CORPORATION
FEBRUARY 1986
FIGURE 7

GEOPHYSICAL INVESTIGATIONS
GENEVA SERVICE CENTER
GENEVA, NEW YORK
prepared for
TRC ENVIRONMENTAL CONSULTANTS, INC.

RESISTIVITY POINT TEST #3

WESTON GEOPHYSICAL CORPORATION
MARCH 1986
FIGURE 8

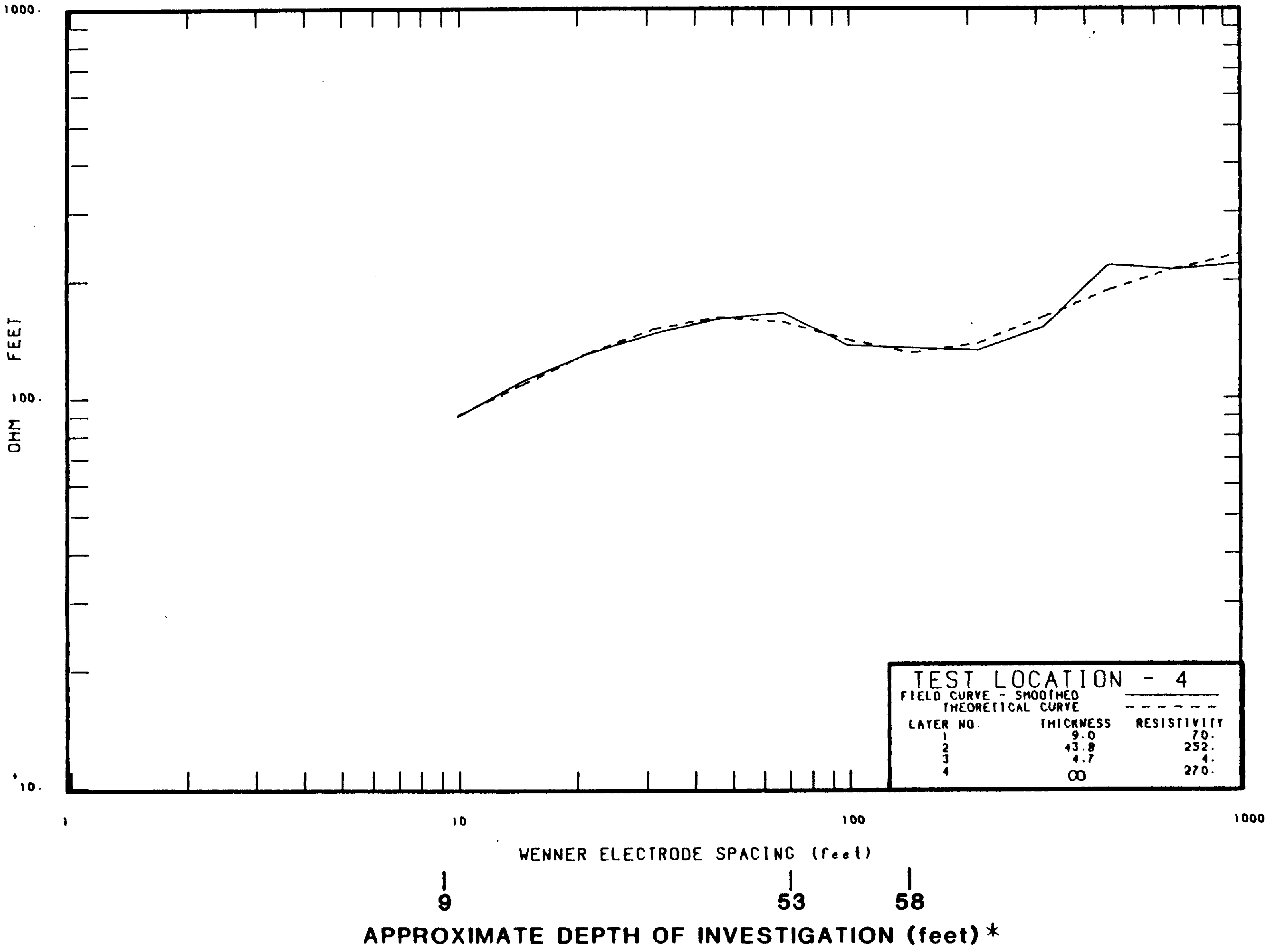


*DEPTH OF INVESTIGATION DEPENDENT ON RESISTIVITIES OF MATERIALS.

GEOPHYSICAL INVESTIGATIONS
GENEVA SERVICE CENTER
GENEVA, NEW YORK
prepared for
TRC ENVIRONMENTAL CONSULTANTS, INC.

RESISTIVITY POINT TEST #4

WESTON GEOPHYSICAL CORPORATION
MARCH 1986 FIGURE 9



LAYER NO.	THICKNESS	RESISTIVITY
1	9.0	70.
2	43.8	252.
3	4.7	4.
4	∞	270.

*DEPTH OF INVESTIGATION DEPENDENT ON RESISTIVITIES OF MATERIALS.

APPENDIX A

ELECTROMAGNETIC TERRAIN CONDUCTIVITY METHOD OF INVESTIGATION

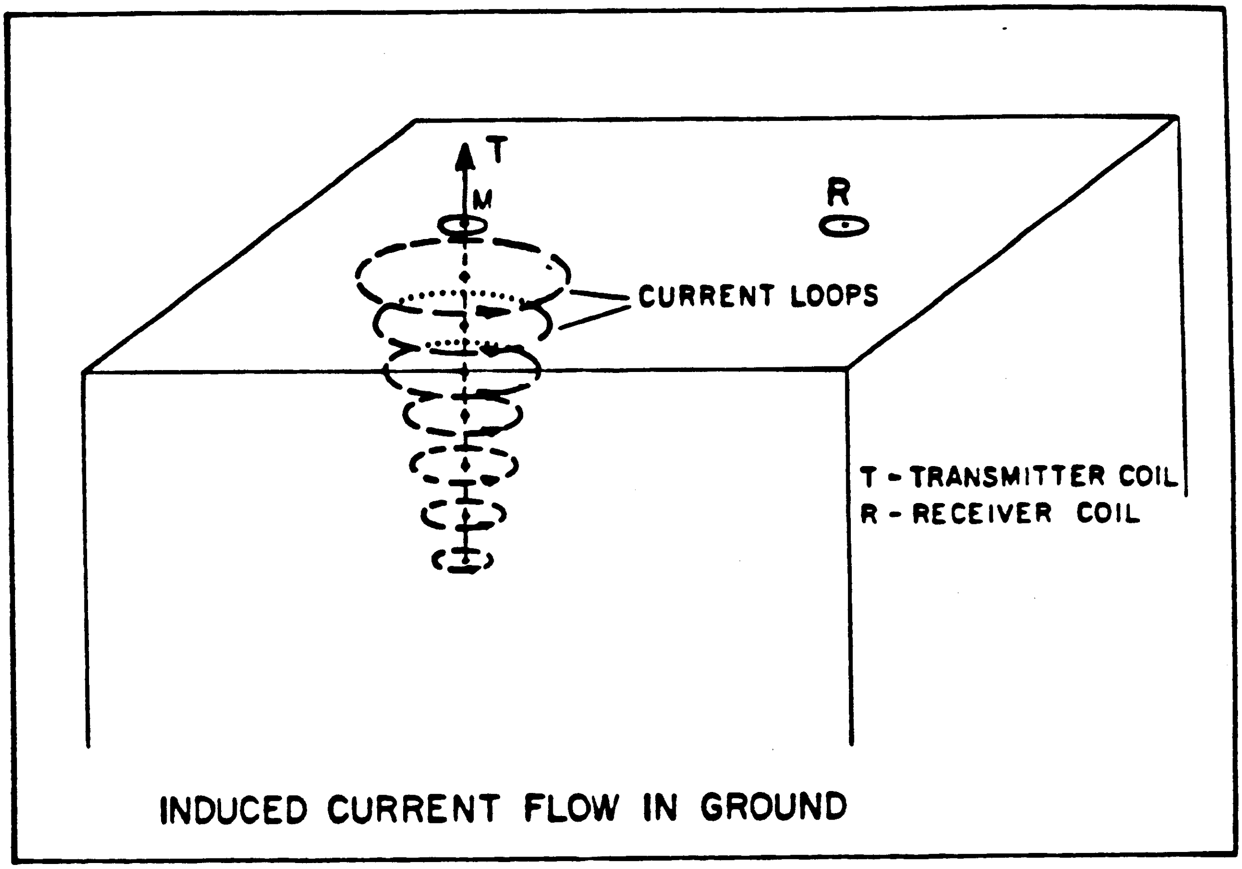
GENERAL CONSIDERATIONS

The electromagnetic terrain conductivity [EM] survey is a method of obtaining subsurface information through electric measurements made at the surface of the earth. The parameter measured with this technique is the apparent conductivity of the subsurface. The conductivity meter consists of receiver coil and a separate transmitter coil which induces an electrical source field [a circular eddy current loop] in the earth [Figure A-1]. Each one of the current loops generates a magnetic field proportional to the value of the current flowing within the loop. A part of the magnetic field from each current loop is intercepted by the receiver coil and converted to an output voltage which is linearly related to terrain conductivity. The instrument is calibrated to permit direct reading of conductivity values in millimhos per meter. The conductivity meter has a variable operating frequency, from 9.8 KH_z for the EM31 to a range of 6.4 KH_z to 0.4 KH_z for the EM34-3. The measurement precision is ± 2% of full scale with a measurement accuracy of + 5% at 20 millimhos per meter. The operating frequency of the EM34-3 decreases as the coil spacing increases. Coil spacings of 10, 20 and 40 meters are standard with the EM34-3.

Geologic materials have unique electrical characteristics and lateral variations in conductivity values indicate a change in subsurface conditions. The relative conductivity of earth materials is proportional to their content of water and dissolved salts or ions. Accordingly, dry sands and gravels, and massive rock formations would have low conductivity values; conversely, most clays and materials with a high ion content would have high conductivity values.

FIELD PROCEDURE FOR DATA ACQUISITION

Conductivity measurements are generally made at 10 meter spacings along a survey line to yield good spatial resolution. Readings taken with the EM31 at a height of one meter above ground surface are sufficiently accurate but for maximum accuracy the instrument can be read at the ground surface. Readings obtained with the EM34-3 are commonly made with the coils in the vertical coplanar configuration, horizontal dipole mode [HDM]. Deeper, approximately 15 meters vs. 7.5 meters, penetration with an equivalent coil spacing can be achieved by using the horizontal coplanar configuration, vertical dipole mode [VDM].



Horizontal coplanar configuration (vertical dipole mode)

Figure 1

APPENDIX B

A BRIEF DESCRIPTION OF THE ELECTRICAL RESISTIVITY SURVEY METHOD OF INVESTIGATION

INTRODUCTION

Electrical resistivity measurements obtained at ground surface may be used to evaluate subsurface materials. The resistivity of earth materials is inversely proportional to their temperature, permeability, porosity, water content, and salinity or ion content. Dry sands, gravels, and massive unweathered rock exhibit relatively high resistivities whereas clays, water-saturated sediments or weathered rock have lower resistivities. Therefore, resistivity surveying is a good technique for mapping the water table, tracing ground water contaminant plumes, delineating zones of weathered bedrock, fractures or solution cavities, determining depth to bedrock, and locating bedrock and sediment lithologic contacts [particularly mineralized zones].

The "apparent" resistivity value of a particular material, as measured in the field, is a function of the material's true resistivity, the thickness of the unit, thicknesses and resistivities of adjacent layers, and the electrode spacing. Apparent resistivity values are calculated based on the configuration of current and potential [Figure 1] electrodes. Interpretation of electrical resistivity data is based upon either comparison of field derived apparent resistivity values with an appropriate theoretical case or inverse modeling performed by a computer.

FIELD PROCEDURES

Two field techniques, point tests [vertical sounding] and [lateral] profiling, are conducted during most resistivity surveys. A resistivity point test is analogous to drilling; the results of a point test consist of a vertical profile of units defined by resistivity characteristics, similar to a lithologic sequence developed from drilling data. Resistivity profiling is used to trace the lateral extent of a particular condition, such as a contaminant plume, water table, mineralized zone, etc.

A point test is conducted by incrementally increasing the spacing between electrodes, maintaining the chosen configuration about a single point [Figure 1]. Resistivity measurements obtained at greater electrode separations are sampling deeper in the earth. Resistivity profiling requires moving a fixed array of electrodes along a prearranged traverse. Three of the most commonly used electrode configurations are described and discussed in the following sections and shown on Figure 1.

WENNER CONFIGURATION

The Wenner Configuration, one of the most widely used electrode arrangements, consists of four equally spaced electrodes [Figure Ia]. An electric current is applied across the outer electrodes and the change in voltage is measured between the inner pair of potential electrodes. The Wenner Configuration has less penetration than a Schlumberger or dipole-dipole array and is more sensitive to lateral changes. It is a reasonable compromise between the various electrode arrays for detecting both vertical and horizontal changes if used with Lee Partitioning Configuration.

- LEE PARTITIONING CONFIGURATION

  A third potential electrode is added to the center of the Wenner Configuration to create the Lee Partitioning Configuration [Figure Ib]. Three measurements of the change in voltage are taken at each positioning of the array; readings are made between P_1-P_2, P_0-P_1 and P_0-P_2.

SCHLUMBERGER CONFIGURATION

The Schlumberger Configuration is a four electrode array [Figure 1-II] in which the distance between the outer current electrodes is at least five times the distance between the inner potential electrodes. A single measurement of voltage change is taken between the potential electrodes, similar to the Wenner method. Penetration is better than Wenner and the method is much less affected by horizontal [lateral] changes. It is almost exclusively used for vertical sounding.

DIPOLE-DIPOLE

The dipole-dipole configuration of electrodes [Figure 1-III] allows deep penetration with a distinct logistical advantage in that the current electrodes can remain fixed while only the potential electrodes need be moved.

The choice of configuration depends on the type of survey, point test and/or profiling, as well as the projected target. The Wenner Configuration is useful for both point test and profiling surveys in a variety of settings. If local, lateral variations in resistivity between potential electrodes are expected, the Lee Partitioning Configuration should be used. The Schlumberger Configuration is employed for vertical soundings or in conjunction with Wenner soundings or constant spacing to discriminate between lateral and vertical variations in resistivity.

The dipole-dipole configuration is best adapted to detecting such anomalies as ore bodies at depth.

DATA INTERPRETATION

The interpretation of resistivity sounding data by Weston Geophysical is accomplished by computer modeling of the field data curves. Wenner and Schlumberger soundings are interpreted by a numerical inversion process which models subsurface structure, in terms of resistivity variation with depth, by varying an initial trial model until the theoretical resistivity values accurately fit the field data. Weston interprets dipole-dipole data by forward modeling using a two-dimensional finite-element program; the two-dimensional geo-electric model is varied by the interpreter to match the dipole-dipole field data.

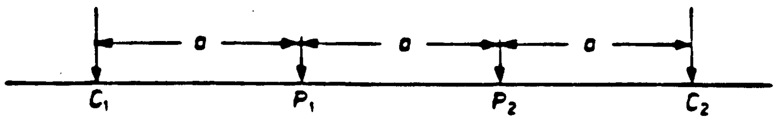
An example of Wenner field data and a computer-generated theoretical curve is shown in Figure 2.

ELECTRICAL RESISTIVITY ELECTRODE CONFIGURATIONS

Ia WENNER

$\rho_a = 2\pi a \, \Delta V/I$

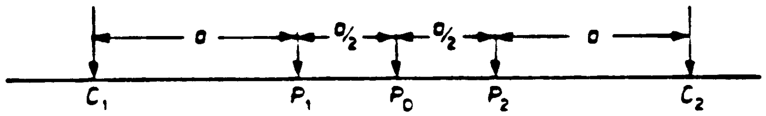
ΔV taken between $P_1 P_2$



Ib LEE MODIFICATION OF WENNER

$\rho_a = 4\pi a \, \Delta V/I$

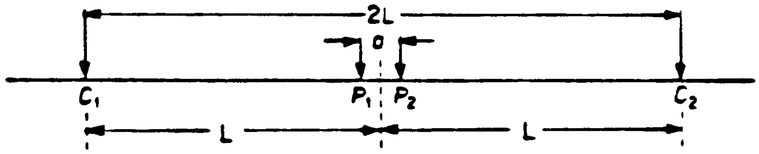
ΔV taken between $P_1 P_0$ and $P_0 P_2$



II SCHLUMBERGER

$\rho_a = \frac{\pi L^2}{a} \frac{\Delta V}{I}$

ΔV taken between $P_1 P_2$



III DIPOLE-DIPOLE

$\rho_a = \pi (a^3/b^2 - a) \, \Delta V/I$

ΔV taken between $P_1 P_2$

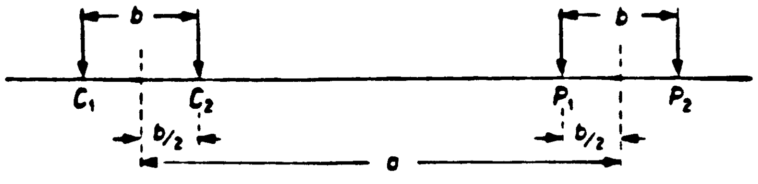
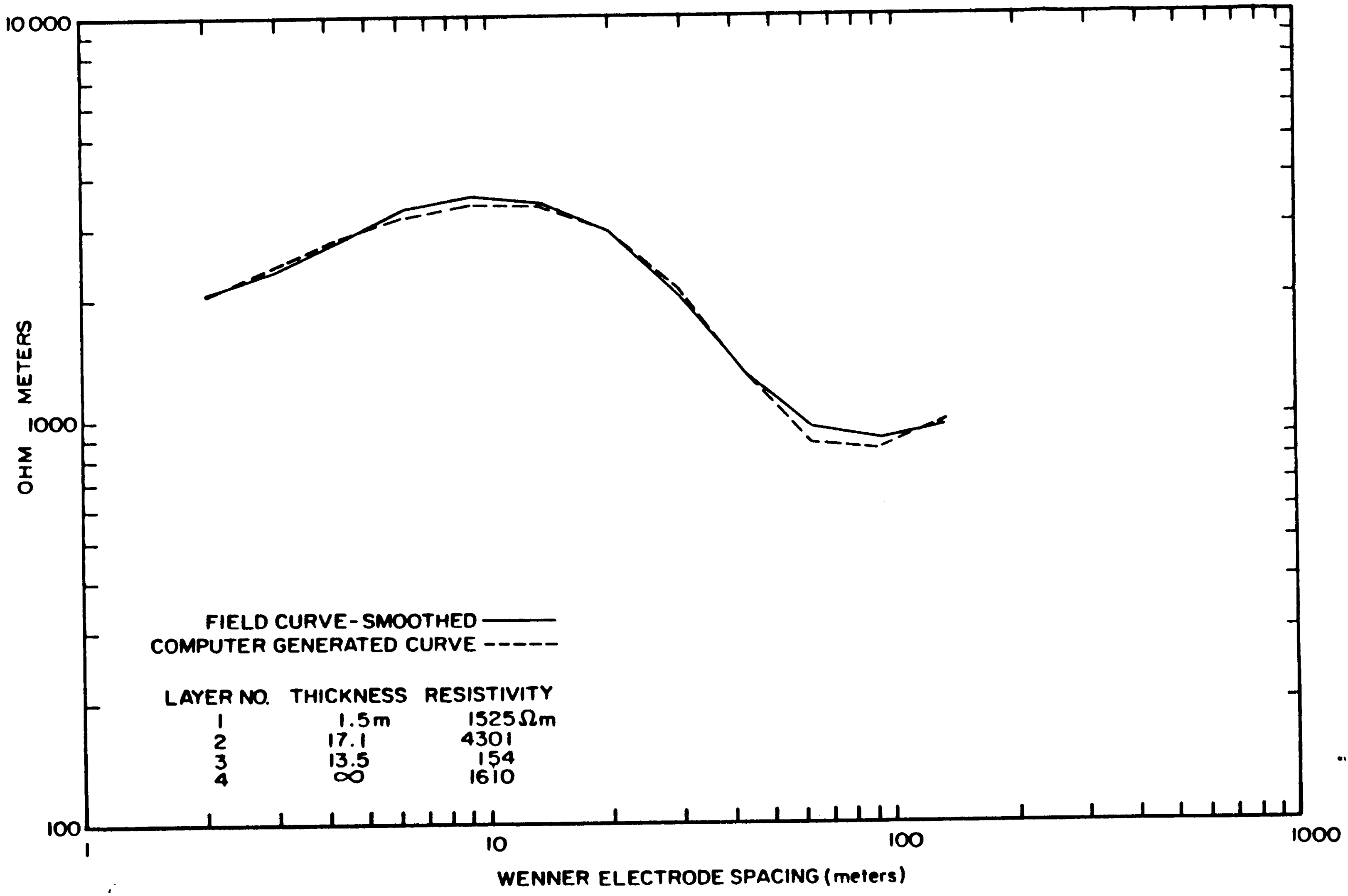


FIGURE 1

Weston Geophysical



LAYER NO.	THICKNESS	RESISTIVITY
1	1.5m	1525Ωm
2	17.1	4301
3	13.5	154
4	∞	1610

Weston Geophysical

RESISTIVITY MODEL
FIGURE 2

APPENDIX C

SEISMIC REFRACTION SURVEY METHOD OF INVESTIGATION

GENERAL CONSIDERATIONS

The seismic refraction survey method is a means of determining the depths to a refracting horizon and the thickness of major seismic discontinuities overlying the high-velocity refracting horizon. The seismic velocities measured by this technique can be used to calculate the mechanical properties of subsurface materials [moduli values], as well as for material identification and stratigraphic correlation.

Interpretations are made from travel time curves showing the measurement of the time required for a compressional seismic wave to travel from the source ["shot"] point to each of a group of vibration sensitive devices [seismometers or geophones]. The geophones are located at known intervals along the ground surface, as shown in Diagram A. Various seismic sources may be used, including a drop weight, an air gun, and small explosive charges.

FIELD PROCEDURE FOR DATA ACQUISITION

Weston Geophysical Corporation uses a seismic recording technique of continuous profiling and overlapping spreads for engineering and ground water investigations. The seismic refraction equipment consists of a Weston Geophysical trace amplifier, Model USA780, with either a WesComp 11™ [a field computer system developed by Weston], or a recording oscillograph.

Continuous profiling is accomplished by having the end shot-point of one spread coincident with the end or intermediate position shot-point of the succeeding spread. The spread length used in a refraction survey is determined by the required depth of penetration to the refracting horizon. It is generally possible to obtain adequate penetration when the depth to the refracting horizon is approximately one-third to one-quarter of the spread length.

In general, "shots" are located at each end and at the center of the seismic spread, Diagram B. The configuration of the geophone array and the shot point positions are dependent upon the objectives of the seismic array.

As mentioned above, seismic energy can be generated by one or more of several sources.

The seismometer or geophone is in direct contact with the earth and converts the earth motion resulting from the shot energy into electric signals; a moving coil electromagnetic geophone is generally used. This type of detector consists of a magnet permanently attached to a spiked base which can be rigidly fixed to the earth's surface. Suspended within the magnet is a coil wrapped mass. Relative motion between the magnet and coil produces an electric current, with a voltage proportional to the particle velocity of the ground motion.

The electric current is carried by cable to the recording device which provides simultaneous monitoring of each of the individual geophones. The operator can amplify and filter the seismic signals to minimize background interference. For each shot the seismic signals detected by a series of geophones are recorded on either photographic paper or magnetic tape, depending on job requirements. Included on each shot record is a "time break" representing the instant at which the shot was detonated.

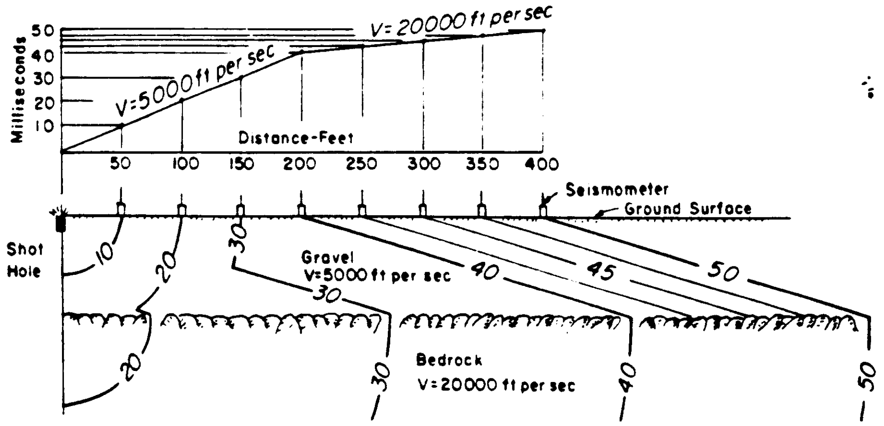
INTERPRETATION THEORY

The elastic wave measured in the seismic refraction method, the "P" or compressional wave, is the first arrival of energy from the source at the detector. This elastic wave travels from the energy source in a path causing adjacent solid particles to oscillate in the direction of wave propagation. Diagram A shows a hypothetical subsurface consisting of a lower velocity material above a higher velocity material. At smaller distances between source and detector the first arriving waves will be direct waves that travel near the ground surface through the lower velocity material. At greater distance, the first arrival at the detector will be a refracted wave that has taken an indirect path through the two layers. The refracted wave will arrive before the direct wave at a greater distance along the spread because the time gained in travel through the higher-speed material compensates for the longer path. Depth computations are based on the ratio of the layer velocities and the horizontal distance from the energy source to the point at which the refracted wave overtakes the direct wave.

Generally the interpretation is by one or more of several methods [W.M. Telford, et al, 1976] ray-tracing, wave front methods, delay times, critical distances. etc. In addition, either a forward or inverse interpretation can be performed using Weston's computer. Since successful refraction interpretation is based on experience, all interpretation of refraction data is performed or thoroughly reviewed by a senior staff geophysicist.

Reference

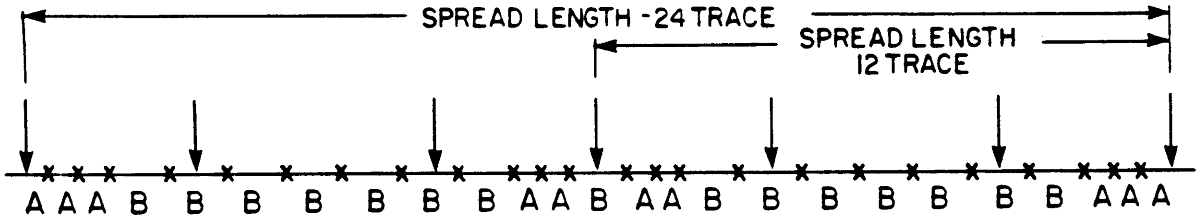
Telford, W.M.; Geldart, L.P.; Sheriff, R.E. and Keys, D.A., 1976, Applied Geophysics: Cambridge University Press.



Plot of Wave Front Advance in Two Layered Problem

Linehan, Daniel, Seismology Applied to Shallow Zone Research, Symposium on Surface and Subsurface Reconnaissance, Special Technical Publication No. 122, American Society for Testing Materials, 1951.

Diagram A



SPREAD LENGTH	GEOPHONE LOCATION A	B
400' - 24 TRACE or 200' - 12 TRACE	10	20
600' - 24 TRACE or 300' - 12 TRACE	15	30
1000 - 24 TRACE or 500' - 12 TRACE	25	50

LEGEND

↓ = GENERAL LOCATION OF "SHOT" POINT

x = GEOPHONE LOCATION

Geophone Interval-Spread Length Relationship

Diagram B