PREPARED FOR:

W.R. GRACE & Co.

REVIEW OF EPA REPORT TITLED

"WELLS G & H SITE
REMEDIAL INVESTIGATION REPORT
PART 1
WOBURN, MASSACHUSETTS"

VOLUME 3: APPENDIX C - PART 1
(C-2.1 TO C-2.25)

GeoTrans, inc.
GROUNDWATER SPECIALISTS

6 Lancaster County Road
Suite Four
Harvard, Massachusetts 01451
508 772 7557

JULY, 1987

REPRINTED DECEMBER, 1989

REVIEW OF EPA REPORT TITLED

"Wells G and H Site
Remedial Investigation Report
Part I
Woburn, Massachusetts"

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(C-2.1 to C-2.25)

Prepared for
W.R. GRACE & CO.

July, 1987

GEOTRANS, INC.

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C-2.1 Excerpts from 1958 Whitman and Howard, Inc. report titled, "Report on Improvements to the Water System of the City of Woburn, Massachusetts".

REPORT

ON IMPROVEMENTS TO THE WATER SYSTEM

Of The

CITY OF WOBURN, MASSACHUSETTS

WHITMAN & HOWARD, INC.
ENGINEERS
89 Broad Street
Boston, Mass.

AUGUST, 1958

EXISTING GROUND WATER SUPPLIES

Investigations have been made to determine the location and character of existing ground water supplies in Woburn. In an effort to insure that as complete a picture as possible is presented, available information on industrial, as well as public water supplies, is presented herewith.

Industrial Supplies

The known major industrial ground water supplies in Woburn have been investigated and are reported on as follows:

Location 1 - Atlantic Gelatin Division of General Foods Corporation

This plant has five wells in the Aberjona Valley. Four are in use and one is under construction. Pertinent data is as follows:

Well No.	Yield g.p.m.	Depth feet	Hardness p.p.m.	Chlorides p.p.m.
1	320	65	75	30
2	840	98	94	30
3	230	84	66	130
4	155	51	160	30
5	500 est.	152	-	-

NOTE: Wells 1, 2, 3, and 5 are actually located in Winchester, just over the Woburn line.

Due to evidence of previous or present pollution of the aquifer (demonstrated by the high chloride content), the water from these wells is not used for drinking purposes.

Location 2 - John J. Riley Co., Tannery

One well rated at 500 gallons per minute about 40 feet deep. The water is polluted and is used for industrial purposes only.

Location 3 - Consolidated Chemical Industries.

Six wells are located along the shore of Mishawum Pond. Two of these are not abandoned. Of the remaining four, two are 50 feet deep and yield a total of about 350 gallons per minute. The other two are 90 feet deep and yield a total of about 1,050 gallons per minute under ideal conditions. The water from the two deep wells is reported to be of good quality.

Location 4 - Independent Tallow Company

This well field has a yield of about 250 gallons per minute. Water shows indications of pollution and a high iron content has been reported (about 0.6 p.p.m.).

Location 5 - Sylvania Electric Products, Inc.

Three wells are driven here with a total estimated capacity of about 1 m.g.d. Two of the wells are within 150 feet of a 24-inch sewer, and an application for use of the water for drinking purposes was turned down by the Department of Health.

Public Ground Water Supplies

The public water supply for the City of Woburn is presently obtained from wells located in close proximity to Horn Pond in the locations shown on the map entitled "Water System, Woburn, Mass." The wells now in use are described as follows:

Well A2

Important data on Well A2 is summarized as follows:

Year constructed	1937
Depth	90 feet
Rated yield	2.9 m.g.d.
Original specific capacity	600 g.p.m.p.f.*
Present yield (dependable)(1957)	2.3 m.g.d.
Present specific capacity (1957)	170 g.p.m.p.f.*
Length of screen	37.5 feet

* Gallons per minute per foot of drawdown

ABANDONED WELL SUPPLIES

Old supplies, now abandoned, are the filter galleries lying just east of the pumping station, a driven well field lying close to Well D, and old Wells A and C. In an area such as the Horn Pond well field, no benefit will be derived from returning to past practices as driven well fields and filter galleries. However, considerable promise lies in the area of old Well C (abandoned because it was not properly constructed and pumps sand) and of old Well A (abandoned because it was not constructed in accordance with modern practice in well work and because it is interfered with by Well A2).

Well C was originally constructed in fine sand (reportedly) and was 70 feet deep. Well A was only 40 feed deep (as against Well A2, 90 feet deep while less than 150 feet away).

CONCLUSIONS

On the basis of the facts presented in the foregoing sections, the following conclusions may be drawn with respect to the ground water potential of the City of Woburn.

1. Much of the ground water potential of the City of Woburn has been meticulously investigated in the past.
2. The Aberjona River valley still has a potential for ground water supply for certain industrial used, but the ground waters of this valley are, in general, too polluted to be used for a public water supply.
3. Based on knowledge of previous investigations, the Horn Pond area is, undoubtedly, the best potential source for an additional public ground

water supply. In this connection, Appendix 1 contains data on investigations on the effect of increased ground water withdrawals from this area on the level of Horn Pond, and recommendations made with respect thereto.

4. An unexplored area lies west of Mishawum Pond, between the Pond and the Reading-Woburn line.

5. In view of the built-up character of the City of Woburn, it does not appear practical to test in areas other than those described in 3 and 4 above, as no other areas appear to be remote enough from sources of pollution to warrant development.

RESULTS OF RECENT TEST WELL INVESTIGATIONS:

A number of test wells were driven, a new gravel packed well has been constructed and three major pumping tests have been conducted since the start of our investigations into the water system of the City of Woburn.

Logs of the wells, showing soil strata encountered, etc., are presented herewith in Appendix 3. Analyses of water obtained from certain wells are given in Appendix 4. A plan showing test well locations, the graph of a pumping test and other data are contained in Appendix 5.

The results of the investigations are summarized as follows:

1. A test well (No. 6) was driven close to abandoned Well C to a depth of 70 feet. Water quality was poor. Iron Content was 0.33 parts per million (p.p.m.) and manganese was 0.22 p.p.m.

2. A test well (No. 7) was driven to a depth of 125 feet about 115 feet east of old Well A. The yield of water was not great enough to warrant development of this location.

3. A test well (No. 8) and observation well (No. 8 Ob.) were driven to a depth of 94

C-2.2 November 1963 letter from Whitman and Howard to Massachusetts Department of Public Health regarding Woburn test wells.

no bact analysis

WHITMAN & HOWARD, INC.
EST. 1869 · INC. 1924
ENGINEERS
89 Broad Street, Boston 10, Massachusetts
HAncock 6-1633

CHANNING HOWARD (1867-1958)
PAUL F. HOWARD
EDWIN M. HOWARD
C. ROGER PEARSON
C. R. WICKERSON
L. M. PITTENDREIGH

San Eng
10

November 12, 1963

State Department of Public Health
State House
Boston, Massachusetts

Gentlemen:

A total of seventeen sites have been tested by means of 2-1/2" test wells for an additional ground water supply for the City of Woburn. The location of these wells is shown on the attached map.

Of the areas tested the following wells showed water bearing formation having excellent transmissability; the balance of the wells were shallow or penetrated impervious material:

Well No.	Depth of Well (Feet)	Transmissability of Water Bearing Material (gallons per foot of drawdown)
5	45	63
8	40	40
9	65	35
16	88	100

The most promising area from these preliminary tests is in the vicinity of Well No. 16 on land near the Rod & Gun Club. The water quality from Well No. 16 is shown on the attached analysis from the State Department of Public Health. It is low in iron and manganese.

No. 9 which is also in the general vicinity of No. 16 was low in iron and manganese as shown on the attached analysis.

Well No. 8 located south of Salem Street at the rear of a truck terminal was driven in good water bearing formation which was low in iron and manganese.

Our 95th Year of Continuous Service

As a result of these tests we would like your approval of sites 16, 9, and 8 in order that we may conduct an extended pumping test on 8-inch wells or groups of wells in order to establish quantity of water available.

The City of Woburn is critically in need of an additional water supply and your immediate action on this matter would be greatly appreciated.

Very truly yours,

WHITMAN & HOWARD, INC.

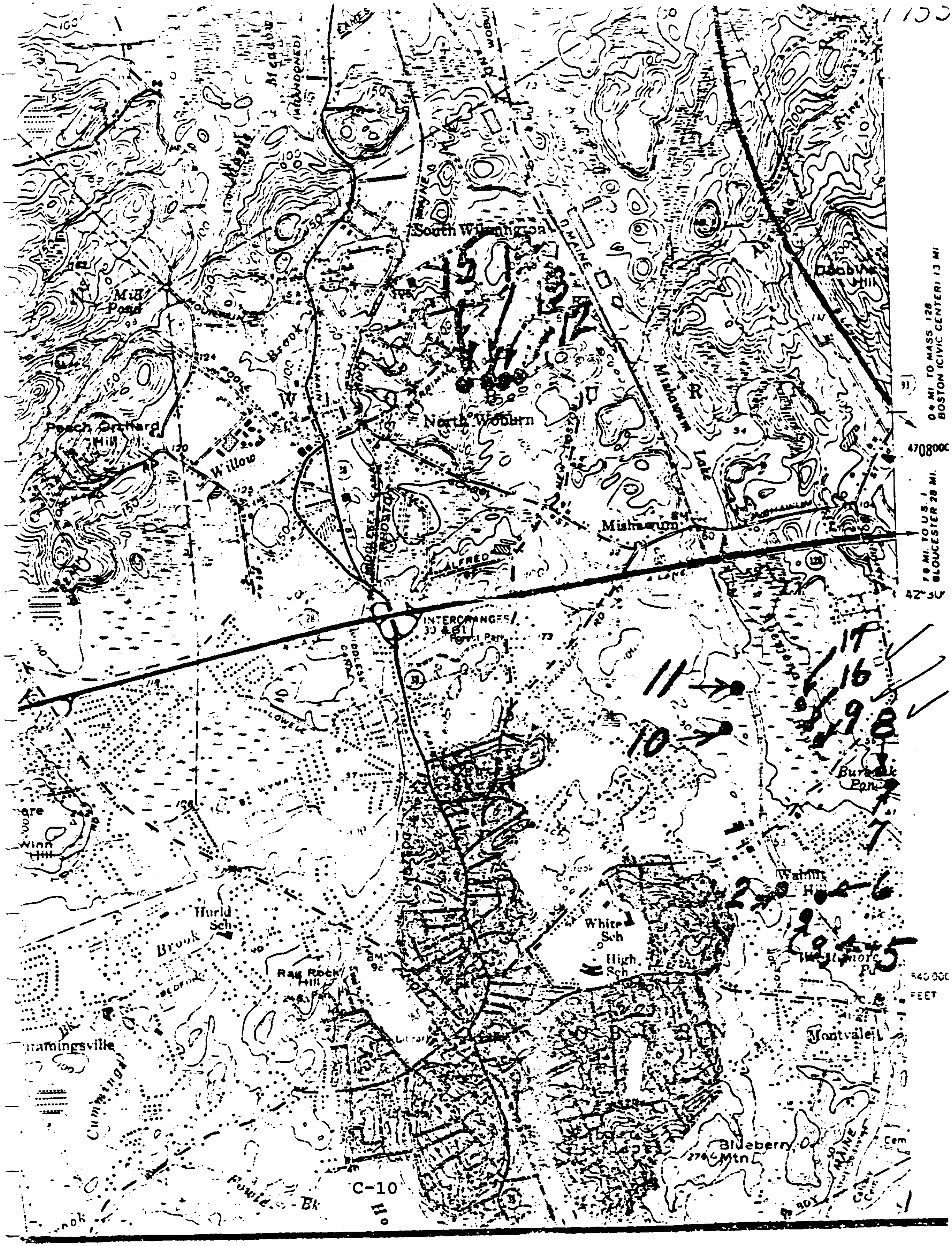
By

enclosure

cc: Mr. Albert Wall, Supt.
Woburn, Mass.

Mr. Herbert Nickerson
Tewksbury, Mass.

Mr. George Olson, City Eng.
Woburn, Mass.


Meadow
(ABANDONED)
South Wilmington
Mill Pond
Poole
Brook
Peach Orchard Hill
Willow
North Woburn
Maine
Mishawum
Mishawum Lake
Dobbins Hill
0.4 MI. TO MASS. 128
BOSTON (CIVIC CENTER) 13 MI.
4708000
7.8 MI. TO U.S. 1
GLOUCESTER 28 MI.
42°30'
Alfred
INTERCHANGES 30 & 31
Forest Park
Lowell
Burbank Pond
Winn Hill
Hurld Sch
Brook
Rag Rock Hill
White Sch
High Sch
Walnut Hill
Horn Pd
540 000 FEET
Montvale
Cummingsville
Cummings
Blueberry Mtn
Cem
Fowle Bk
15
14
13
12
11
10
17
16
9
8
7
1
2
3
4
6
5

C-10

LAWRENCE EXPERIMENT STATION
MASSACHUSETTS DEPARTMENT OF PUBLIC HEALTH
WATER ANALYSIS (Milligrams Per Liter)

WOBURN

Collector: PORTER & DESMON

Source A 2½" TEST WELL #10
Source B 2-1/2" TEST WELL #9 No. OF SALEM ST.
Source C TEST WELL #8 SALEM ST. - 40' DEEP -40 GPM
Source D
Source E
Source F

	A	B	C	D	E	F
Sample No.	460362	460468	460420			
Date of Collection	11/1/63	10/14/63	--			
Date of Receipt	11/4	10/15	10/11/63			
Turbidity	0	0	0			
Sediment	0	0	0			
Color	5	5	5			
Odor	1 Ch	0	0			
pH	6.4	6.4	6.6			
Alkalinity - M.O.	22	21	41			
phth						
Hardness	112	82	88			
Iron	.08	.10	.06			
Manganese	.02	.02	.02			
Free Ammonia - N	.02	.01	.01			
Nitrite - N	.000	.000	.004			
Nitrate - N	6.4	2.5	1.8			
Chloride	21.	7.5	39.			
Fluoride						
Phosphate - Total						
Ortho						
ABS						
Bacterial Sample Date of Receipt						
Coliform - MPN						
MF						
Micro-Amorphous Std. Units per ml.						

C-2.3 May and June 1968 correspondence and notes regarding improper disposal of manure near wells G and H.

June 12, 1968

[illegible]
[illegible]
[illegible]

Re: Woburn Public Water Supply
Improper Disposal of Manure
Upstream from Rifle Range Wells

[illegible]

[illegible] Department of Public Health, in response to the [illegible] [illegible] an examination to be made by one of [illegible] improper dumping of manure from a piggery [illegible] tributary to the [illegible] supply upstream from the so called [illegible]

[illegible] manure from a [illegible] [illegible] J. and John C. [illegible] being dumped into a swampy area [illegible] so called Rifle Range [illegible] the City of Woburn.

[illegible] the improper disposal [illegible] a menace to the public health [illegible] and recommends that [illegible] improper dumping to cease and all manure already [illegible]

[illegible] to be informed of your action in this [illegible]

Very truly yours,

John S. Collins
Director
Division of Sanitary Engineering

[illegible] F. Brownell,
Director
Division of Conservation Services
100 Cambridge Street
Boston, Massachusetts

c-Division of Water Pollution Control
100 Cambridge Street
Boston, Massachusetts

JUN 13 1968

511 Reply Draft - TFM - May 31, 1968

5, H. 0/4

Board of Health and Charities
Woburn, Massachusetts

Re: Woburn Public Water Supply -
Improper Disposal of Manure Upstream
from Rifle Range Wells

Gentlemen:

The Department of Public Health in response to the verbal request of your sanitarian has caused an examination to be made by one of its engineers intothe alleged improper dumping of manure from a piggery into a brook tributary to the Abijona River upstream from the so called rifle range gravel packed wells.

The examination revealed that the manure from a former piggery locatted of Olympia Avenue and operated by Eugene J. and John C. Murphy, 80 Brentwood Road, Woburn, was being dumped into a swampy area on a tributary of the Abijona River upstream from the so called fx rifle range gravel packed wells, a source of water supply for the dity of Woburn.

The Department is of the opinion that the improper disposal of piggery manure constitutes a nuisance and a menace to the public health and a danger to the public water supply wells located downstream and recommends that your board order all such improper dumping to cease and all manure already dumped to be removed

The Department requests that it be informed of your action in this matter on or before June 17, 1968.

Very truly yours,

John C. Collins
Director
~~[illegible]~~ Division of Sanitary Engineering

M/Rm/c

cc: Board of Water Commissioners
Woburn, Mass.

Mr. Arthur W. Brownell, Director
Division of Conservation Services
100 Cambridge Street
Boston, Mass.

NOTES RELATIVE TO: Woburn - Water Supply - Disposal of Pig
Manure in Brook Tributary to Aberjona River

BY: Joseph X. Conley

DATE: May 20, 1968

The following are notes relative to the transfer of decomposing pig manure from the site of the former Murphy Piggery off Olympia Avenue in Woburn, to a marsh and small pond on land located across Olympia Avenue.

Application was made in a phone call from Mr. Edward App, Sanitarian for the Board of Health in Woburn. On Friday, May 10, 1968, the writer accompanied by Mr. App, examined the site and found that an estimated 20 loads of manure had been dumped into a small pond in the marsh.

On the previous day, Thursday, May 9, 1968, Mr. App received a telephone complaint about dumping into the marsh. On investigation, Mr. App had the Woburn Police Department notify the contractor to stop the dumping. On Friday, the writer notified the Massachusetts Department of Natural Resources of the dumping because there is a violation of Chapter 220, Acts of 1965. A uniformed officer from that Department responded to the call that afternoon and stated that a notice would be sent to the owners to cease dumping on the site. Mr. Thomas McLoughlin of this office and Mr. Coogan's office were also notified by this writer because of the close proximity of the area to the Rifle Range Wells, part of the Woburn public water supply.

The manure has been dumped into a small pond and a marsh drained by a flowing brook that drains into the Aberjona River upstream from the Rifle Range Wells. In as much as the City of Woburn faces the danger of the loss of the two gravel pack wells at this location because of evidence of organic pollution, the writer strongly recommends that the manure be removed from the place where it has been dumped to an area off the watershed of the Aberjona River.

The owners of the land where the manure has been dumped and also the owners of the former piggery are: Eugene J. & John C. Murphy, 80 Brentwood Road, Woburn, Massachusetts.

The distance from well "H" to the site of the dumpings is 1700 feet. See attached state sheet for locations.


Parker Jr High Sch
MAINE
Horn Pond
Sanford Hall
Joshua Eaton Sch
Woburn
Middlesex Canal
Lake
Mishawum
WOBURN
TE OF
RE
PING
Robin Hood Sch
Kimballs
Walnut Hill
WOBURN
Montvale
W O B U R N
Montvale
BOSTON
Woburn Highlands
Shannon Hill
Winchester
8

C-2.4 July 1968 letter from Massachusetts Department of Health to Mr. Joseph McLaughlin regarding East Woburn complaints of chlorine taste in public supply wells.

D

The Commonwealth of Massachusetts
Department of Public Health
State House, Boston 02133

July 30, 1968

Mr. Joseph F. McLaughlin
"Tell It To Joe"
Boston Herald Traveler
300 Harrison Avenue
Boston, Massachusetts

Re: WOBURN - Public Water Supply
Complaint of Chlorine Taste,
East Woburn.

Dear Mr. McLaughlin:

The Department of Public Health, in response to the request made in your letter dated July 1, 1968, has caused an investigation to be made by one of its engineers into alleged chlorine tastes in the municipal water supply in East Woburn.

Please be advised that the public water supply for the City of Woburn is obtained from gravel developed wells. Two of these wells, located in East Woburn and known locally as the "Rifle Range" Wells, are situated in a swampy area near the Aberjona River.

In the summer of 1967, it was necessary for the Department to recommend to officials of the City of Woburn that both of these wells be taken out of service, due to the poor bacterial quality of the water supplied therefrom. The Department has indicated to the City of Woburn that these wells may not be used as sources of public water supply without continuous chlorination to assure the safety of the water.

On April 3, 1968, chlorination facilities were installed at one of these wells. Initially, this caused many complaints of chlorine taste from residents of East Woburn. The chlorine dosage has since been adjusted so that the bacterial quality of the water can be controlled, while keeping complaints of chlorine taste to a minimum.

I trust that the foregoing information will be helpful to you and your readers.

Very truly yours,

John C. Collins
Director
Division of Sanitary Engineering

#860-68

C/Ems

L. F.

C-2.5 September 1971 Water Quality Analysis sheet regarding arsenic barrel disposed of at Olympia Avenue near the Aberjona River.

LAWRENCE EXPERIMENT STATION
MASSACHUSETTS DEPARTMENT OF PUBLIC HEALTH
SPECIAL EXAMINATION

WOBURN :

Collector: [redacted]

Source A Genevieve Doherty - Town water - 300R Salem St.

Source B Water collected in suspected Arsenic Barrel - Olympia Ave. - near Aberjona River

Source C

Source D

Source E

Source F

	A	B	C	D	E	F
Sample No.	511686	511687				
Date of Collection	9/20/71	9/20/71				
Date of Receipt	9/20/71	9/20/71				
Arsenic, mg/l	0.00	1000.				

REMARKS:

C-2.6 February 1973 letter from Massachusetts Board of Health to Woburn Conservation Commission regarding sodium chloride in drinking water.

FACSIMILE

February , 1973

Woburn Conservation Committee
City Hall
Woburn, MA 01801

Attn: Mrs. Patricia Brady

Re: Woburn - Public Water Supply
Sodium and Chloride Levels

Dear Mrs. Brady:

Enclosed is information concerning sodium chloride in drinking water which will be self-explanatory for the most part.

We have enclosed a copy of an analysis of the Woburn Public Water Supply for 1972 to illustrate the current condition of the supply. However, the statistics for all public water supply systems for 1972 have not yet been prepared, and reference will have to be made to 1971 data to show the relative condition of the supply.

Massachusetts has over 1,000 individual sources serving some 380 public water supply systems. Of these, only 23 contained over 30 parts per million of sodium on the basis of 1971 analyses. Since the trend of pollution by road salt is upwards, it is safe to assume that more sources will be in this category when the 1972 figures are compiled.

Nevertheless, all six sources shown on the analysis sheet submitted are either at the 30 parts per million level, or are very close to it. This illustrates that Woburn is one of the communities in the Commonwealth where corrective action is most needed to reverse the trend of increasing salinity.

If you have further questions concerning this problem after reviewing the material submitted, we will be pleased to discuss the matter with you further.

Very truly yours,

John C. Collins
Director
Division of Environmental Health

Enclosures

cc: Woburn Water Department
Public Works Department, Woburn, Massachusetts

FACSIMILE

Woburn Chloride Analyses

YEAR	NO. OF SAMPLES	RANGE	MEAN	MEDIAN
1952	18	10.4- 15.4	13.3	14.0
1953	18	9.2- 16	13.1	13.0
1954	0			
1955	0			
1956	10	10- 15	12.1	12.0
1957	17	13- 19	15.3	15.0
1958	16	14- 19	17.05	18.0
1959	10	18- 23	20.5	21.0
1960	6	17- 21	19.84	20.0
1961	21	12- 32	24.2	27.0
1962	10	15- 42	33.20	36.0
1963	22	17- 60	35.78	36.0
1964	30	18- 55	45.06	48.0
1965	24	32- 70	58.05	59.5
1966	20	40- 79	62.40	65.0
1967	19	44- 82	66.73	72.00
1968	22	44-120	71.41	71.00
1969	26	50-185	98.5	86.5
1970	27	50-140	87.8	90.0
1971	16	66-180	115.0	110.0

C1

February [illegible], 1973

Woburn Conservation Committee
City Hall
Woburn, Massachusetts 01801

Re: [illegible] - Public Water Supply;
Sodium and Chloride Levels

Attention: Mrs. Patricia Brady

Dear Mrs. Brady:

Enclosed is information concerning sodium chloride in drinking water which will be self-explanatory for the most part.

We have enclosed a copy of an analysis of the Woburn Public Water Supply for 1972 to illustrate the current condition of the supply. However, the statistics for all public water supply systems for 1972 have not yet been prepared and reference will have to be made to 1971 data to show the relative condition of the supply.

Massachusetts has over 1000 individual sources serving some 380 public water supply systems. Of these, only 23 contained over 50 parts per million of sodium on the basis of 1971 analyses. Since the trend of pollution by road salt is upwards, it is safe to assume that more sources will be in this category when the 1972 figures are compiled.

Nevertheless, all six sources shown on the analysis sheet submitted are either at the 50 parts per million level or are very close to it. This illustrates that Woburn is one of the communities in the Commonwealth where corrective action is most needed to reverse the trend of increasing salinity.

If you have further questions concerning this problem after reviewing the material submitted, we will be pleased to discuss the matter with you further.

Very truly yours,

John C. Collins
Director
Division of Environmental Health

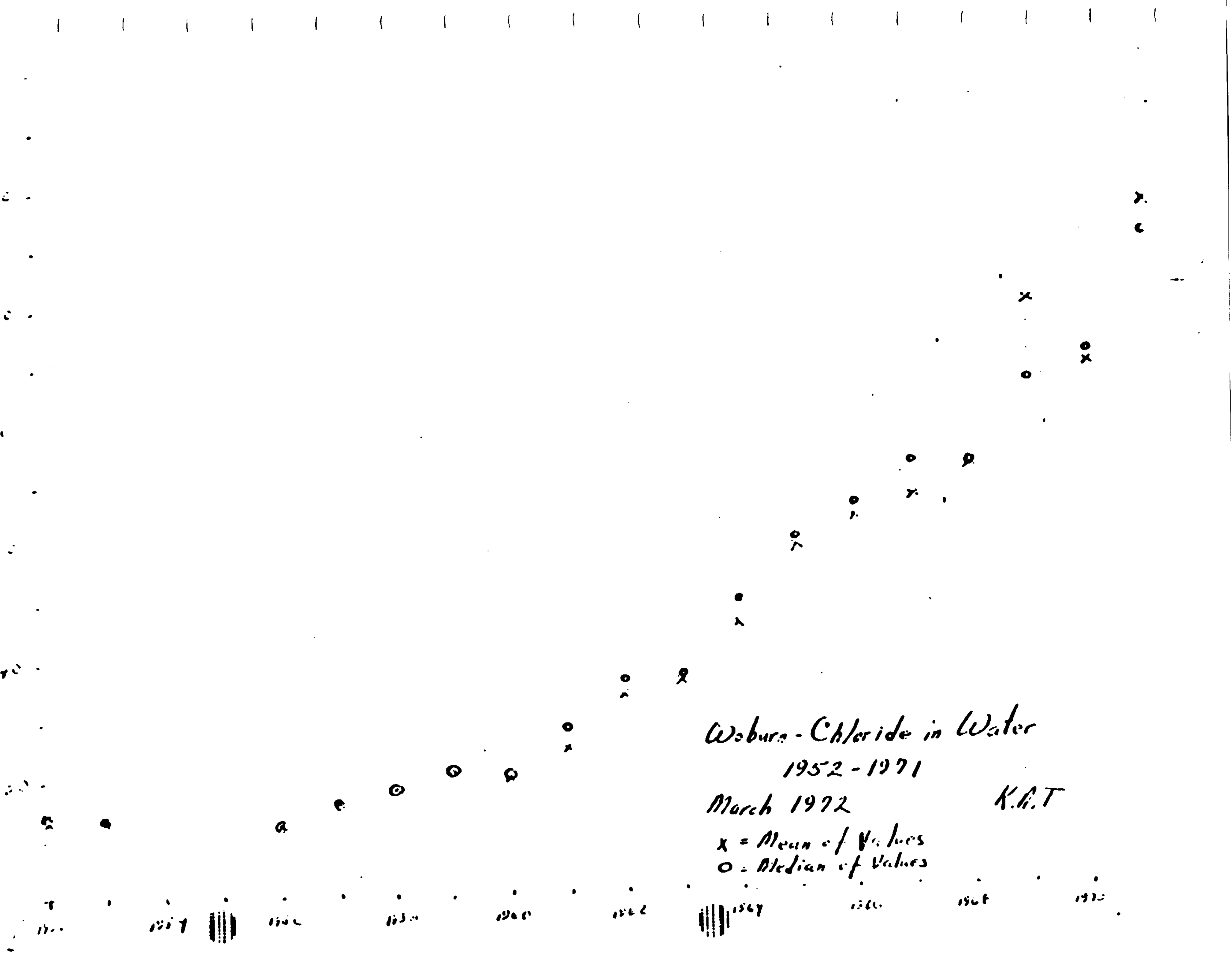
Enclosures
cc: Woburn Water Department
cc: Public Works Department
Woburn, Massachusetts

C/Spew/oes

DEFENDANT'S
EXHIBIT
G-155

Woburn Chloride Analyses

YEAR	NO. OF SAMPLES	RANGE	MEAN	MEDIAN
1952	18	10.4-15.4	13.3	14.0
1953	18	9.2-16	13.1	13.0
1954	0			
1955	0			
1956	10	10-15	12.1	12.0
1957	17	13-19	15.3	15.0
1958	16	14-19	17.05	18.0
1959	10	18-23	20.5	21.0
1960	6	17-21	19.94	20.0
1961	21	12-32	24.2	27.0
1962	10	15-42	33.20	36.0
1963	22	17-60	35.78	36.0
1964	30	18-55	45.06	46.0
1965	24	32-70	58.05	59.5
1966	20	40-79	62.40	65.0
1967	19	44-82	66.73	72.0
1968	22	44-120	71.41	71.0
1969	26	50-185	98.5	86.5
1970	27	50-140	87.8	90.0
1971	16	66-180	115.	110.



Woburn - Chloride in Water
1952 - 1971
March 1972
K.A.T

x = Mean of Values
O = Median of Values

C-2.7 Massachusetts Drinking Water Regulations 310 CMR 22.00 September 30, 1985.

The Commonwealth of Massachusetts
SECRETARY OF STATE

B-2.7

REGULATION FILING AND PUBLICATION

1. **REGULATION CHAPTER NUMBER AND HEADING:**

310 CMR 22.00 - 29.00, 34.00

2. **NAME OF AGENCY:**

DEPARTMENT OF ENVIRONMENTAL QUALITY ENGINEERING

3. **THIS DOCUMENT IS REPRINTED FROM THE CODE OF MASSACHUSETTS REGULATIONS AND CONTAINS THE FOLLOWING:**

310 CMR 22.00	Drinking Water
23.00	Sanitary Protection Of Waters Used By The MDC For The Water Supply Of Any Town Or Water Co. Under The Authority M.G.L. c. 92, s. 17
24.00	Aquifer Land Aquisition Program
25.00	State Grants For Drinking Water Filtration Plants
26.00	State Grants For Identifying Sources Of Loss Of Potable Water And For The Rehabilitating Water Supply Distribution Systems
27.00	Underground Water Source Protection
28.00	Water Supply Contamination Correction Program
29.00	Mineral Resource Regulations
34.00	Public Building Water Conservation Grants Program

UNDER THE PROVISIONS OF MASSACHUSETTS GENERAL LAWS, CHAPTER 30A, SECTION 6 AND CHAPTER 233, SECTION 75 THIS DOCUMENT MAY BE USED AS EVIDENCE OF THE ORIGINAL DOCUMENTS ON FILE WITH THE STATE SECRETARY.

COMPILED AS IN FULL FORCE AND EFFECT 9/30/85

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[redacted]

A TRUE COPY, ATTEST:

Michael Joseph Connolly

MICHAEL JOSEPH CONNOLLY,

SECRETARY OF STATE

310 CMR 22.00: DRINKING WATER REGULATIONS

Section

22.01: Purpose and Authority

These regulations are intended to promote the public health and general welfare by ensuring that public water systems in Massachusetts provide to the users thereof water that is safe, fit and pure to drink. These regulations are promulgated pursuant to the authority conferred by General Laws, Chapter 21A, Section 2(28), General Laws, Chapter 92, Section 17 and General Laws, Chapter 111, Section 160. Pursuant to General Laws, Chapter 30A, Sections 1(5), 2 and 3, these regulations are promulgated to set forth those standards and requirements of general application and future effect which shall be used to implement, interpret and enforce General Laws, Chapter 40, Sections 15B, 38, 39B, 39C, 40, 41, and 41A; General Laws, Chapter 111, Sections 2C, 5G, 17, 143, 159, 160A, 160B, 162 and 165; General Laws, Chapter 114, Sections 35 and 36; General Laws, Chapter 140, Sections 32B and 32H; and General Laws, Chapter 165, Sections 4B and 6.

These regulations shall take effect on June 24, 1977. Rules and Regulations For the Purpose of Preventing The Pollution And Securing The Sanitary Protection of Certain Waters Used As Sources of Public Water Supply, approved and adopted by the Department of Public Health on October 11, 1960 and filed with the Secretary of the Commonwealth on June 1, 1961, are repealed as of the effective date of these regulations.

The Department affirms its authority to determine compliance or initiate enforcement actions related to these regulations based upon analytical results and other information compiled by its sanctioned representatives and agencies.

22.02: Definitions

As used in these regulations, the following terms shall have the following meanings:

22.02: continued

(1) Agency means the United States Environmental Protection Agency.

(2) Administrator means the Administrator of the Agency.

(3) Commissioner means the Commissioner of the Department of Environmental Quality Engineering.

(4) Department means the Department of Environmental Quality Engineering of the Commonwealth of Massachusetts.

(5) Person means an individual, corporation, company, association, trust, partnership, the Commonwealth, a municipality, district or other subdivision or body politic of the Commonwealth, any department, agency, or instrumentality of the United States, except that nothing herein shall be construed to refer to or include any American Indian tribe, or the United States Secretary of the Interior in his capacity as trustee of Indian lands.

(6) Contaminant means any physical, chemical, biological or radiological substance or matter in water.

(7) Maximum Contaminant Level means the maximum permissible level of a contaminant in water which is delivered to the free flowing outlet of the ultimate user of a public water system, except in the case of turbidity, where the maximum permissible level is measured at the point of entry to the distribution system. Contaminants added to the water under circumstances controlled by the user, except those resulting from corrosion of piping and plumbing caused by water quality, are excluded from this definition.

(8) Public Water System means a system for the provision to the public of piped water for human consumption, if such system has at least fifteen (15) service connections or regularly serves an average of at least twenty-five (25) individuals daily at least sixty (60) days of the year. Such term includes (1) any collection, treatment, storage, and distribution facilities under control of the operator of such a system and used primarily in connection with such system, and (2) any collection or pretreatment storage facilities not under such control which are used primarily in connection with such system. A public water system is either a "community water system" or a "non-community water system".

(a) Community water system means a public water system which serves at least fifteen (15) service connections used by year-round residents or regularly serves at least twenty-five (25) year-round residents.

(b) Non-community water system means a public water system that is not a community water system.

(9) Sanitary Survey means an on site review of the water sources, facilities, equipment, operation and maintenance of a public water system for the purpose of evaluating the adequacy of such source, facilities, equipment, operation and maintenance for producing and distributing safe drinking water.

(10) Standard Sample means the aliquot of finished drinking water that is examined for the presence of coliform bacteria.

(11) Supplier of water means any person who owns or operates a public water system.

22.02: continued

(12) Dose Equivalent means the product of the absorbed dose from ionizing radiation and such factors as account for differences in biological effectiveness due to the type of radiation and its distribution in the body as specified by the International Commission on Radiological Units and Measurements (ICRU).

(13) Rem means the unit of dose equivalent from ionizing radiation to the total body or any internal organ or organ system. A "millirem (mrem)" is 1/1000 of a rem.

(14) Picocurie (pCi) means that quantity of radioactive material producing 2.22 nuclear transformations per minute.

(15) Gross alpha particle activity means the total radioactivity due to alpha particle emission as inferred from measurements on a dry sample.

(16) Man-made beta particle and photon emitters means all radionuclides emitting beta particles and/or photons listed in Maximum Permissible Body Burdens and Maximum Permissible Concentration of Radionuclides in Air or Water for Occupational Exposure, NBS Handbook 69, except the daughter products of thorium-232, uranium-235 and uranium-238.

(17) Gross beta particle activity means the total radioactivity due to beta particle emission as inferred from measurements on a dry sample.

(18) Laboratory Analyst means a person who is qualified to perform tests in specified disciplines or categories.

(19) Laboratory Supervisor/Consultant means a person with management and technical responsibility, who exercises supervision over technical personnel, evaluates the quality of analytical methods, performs tests requiring special scientific skills and is responsible for the accuracy and reporting of results.

(20) Laboratory Director means the person who has administrative and legal responsibility for the operation of the laboratory.

(21) Halogen means one of the chemical elements chlorine, bromine, or iodine.

(22) Trihalomethane means one of the family of organic compounds, named as derivatives of methane, wherein three of the four hydrogen atoms in methane are each substituted by a halogen atom in the molecular structure.

(23) Total Trihalomethanes means the sum, rounded to two significant figures, of the concentrations in milligrams per liter of the trihalomethane compounds, trichloromethane (chloroform), bromodichloromethane, dibromochloromethane, and tribromomethane (bromoform).

(24) Maximum Total Trihalomethane Potential means the maximum concentration of total trihalomethanes produced in a given water containing a disinfectant residual after seven days at a temperature of 25 C or above.

(25) Disinfectant means any oxidant, including but not limited to chlorine, chlorine dioxide, chloramines, and ozone, which is added to water in any part of the treatment or distribution process, and which is intended to kill or inactivate pathogenic microorganisms.

22.03: Compliance

(1) No source of water used by a public water system, no system of water supply used by a public water system, and no treatment facilities or treatment works used by a public water system shall be deemed by the Department to be safe, fit, or pure, or in any other way approved, and shall not be used either for regular or emergency use, unless the drinking water supplied to the users of such public water system complies with these regulations.

(2) These regulations shall apply to each public water system in the Commonwealth except a public water system which meets all the following requirements:

(a) Said system consists only of distribution and storage facilities (and does not have any collection and treatment facilities);
(b) Said system obtains all of its water from but is not owned by or operated by, a public water system to which such regulations apply;
(c) Said system does not sell water to any person; and
(d) Said system is not a carrier which conveys passengers in commerce.

(3) Where the Department in consultation with the Department of Public Health, determines that (1) a supplier of water is supplying drinking water in violation of these regulations, and (2) an order to cease supplying such water would pose a significantly greater hazard to the public health than the continued supplying of such water in violation of these regulations, the Department may authorize the supplying of such water subject to such conditions as may be imposed by the commissioner, but only for a temporary, non-renewable period not to exceed the amount of time the supplier of water reasonably needs to either eliminate the violation or promptly apply for and obtain a variance or exemption.

(4) The Department shall report all violations of these regulations to the Massacusetts Department of Public Health promptly upon obtaining knowledge of such violations, and shall consult with the Massachusetts Department of Public Health with regard to enforcement actions taken to obtain compliance with these regulations.

22.04: Siting Requirements

No person shall enter into a financial commitment for or initiate construction of either a new public water system or a substantial modification of an existing public water system until said person has first submitted plans for same to the Department and the Department has approved such plans. To the extent practicable, said person shall avoid locating all or any part of the new or substantially modified facility at a site which either:

(1) is subject to a significant risk from earthquakes, floods, fires, or other disasters which could cause a breakdown of the public water system or a portion thereof; or

(2) except for intake structures, is within the floodplain of a 100-year flood or is lower than any recorded high tide where appropriate records exist.

22.05: Maximum Microbiological Contaminant Levels, Monitoring Requirements and Analytical Methods

(1) Table 1 in 310 CMR 22.05 and the accompanying provisions contain maximum contaminant levels permissible in public water systems,

22.05: continued

and describe associated monitoring requirements. Table 3 in 310 CMR 22.05 specifies analytical techniques which shall be followed in analyzing water samples. A supplier of water shall take samples of the water and shall provide for analysis of such samples for such water quality parameters, at no less than the stated frequencies and consistent with the methods described in said tables and accompanying provisions. Based on a history of no coliform bacterial contaimination and on a sanitary survey by the Department showing the water system to be supplied solely by a protected ground water source free of sanitary defects, a community water system serving 25 to 1000 persons, with express written permission from the Department, may reduce the monitoring frequency required in Table A, except that in no case shall it be reduced to less than one sample per quarter, and provided that the Department may revoke such permission whenever the maximum contaminant level prescribed in Table A is exceeded.

(2) Samples taken to determine compliance with the requirements of 310 CMR 22.05 shall be taken at the free flowing outlet of the ultimate user of the public water system, as approved by the Department.

(3) All analytical results shall be rounded to the same number of significant figures as the applicable maximum contaminant level.

(4) The standard sample used in the membrane filter procedure shall be 100 milliliters. The standard sample used in the 5 tube fermentation tube procedure shall be 5 times the standard portion, which standard portion shall be 10 milliliters.

(5) When the coliform bacteria in a single sample analyzed by the membrane filter procedure exceed 4 per 100 milliliters, or occur in 3 or more 10 milliliter portions in a single sample analyzed by the 5 tube fermentation tube procedure, at least 2 consecutive daily check samples from the same sampling point shall be collected and examined. Additional check samples shall be collected daily until the results obtained from at least two consecutive check samples show less than 1 coliform bacteria per 100 milliliters analyzed by the membrane filter procedure or no positive tubes analyzed by the 5 tube fermentation tube procedure.

(6) When the presence of coliform bacteria in water at any particular sampling point has been confirmed by any check sample, the supplier of water shall report to the Department within 48 hours.

(7) For public water systems that are required to sample at a rate of less than 4 per month, the figures given in the maximum contaminant level column of Table 1 in 310 CMR 22.05 shall be based on sampling during a 3-month period rather than the 1-month period otherwise prescribed therein, except that the Department may, in its discretion, require that compliance be based on sampling during a 1-month period.

(8) Check samples collected pursuant to 310 CMR 22.05(5) shall not be included in calculating the total number of samples taken each month to determine compliance with the monitoring frequency requirements set forth in Table 1 in 310 CMR 22.05. The results from all coliform bacterial analyses performed pursuant to this section, except those obtained from check samples and special purpose samples, shall be used to determine compliance with the maximum contaminant levels for coliform bacteria set forth in Table 1 in 310 CMR 22.05. No location at which check samples are taken pursuant to 310 CMR 22.05(5) shall be eliminated from future sampling without express permission of the Department.

22.05: continued

(9) If the coliform bacteria in a single sample analyzed by the membrane filter procedure exceed 4 per 100 milliliters, or occur in 3 or more 10 milliliter portions in a single sample analyzed by the 5 tube fermentation tube procedure, the results of that sample may be excluded in determining whether the maximum contaminant level prescribed in Table A has been exceeded only if all the daily check samples required by 310 CMR 22.05(5) have been collected and examined, and show zero coliform bacteria. Notwithstanding the foregoing, the Department shall have the discretion to require the results of that single sample to be included in determining whether the maximum contaminant level prescribed in Table A has been exceeded whenever the Department deems such action necessary to protect the public health or otherwise carry out the Department's statutory responsibilities.

22.05: continued

Table 1.

MAXIMUM MICROBIOLOGICAL CONTAMINANT LEVELS AND MONITORING REQUIREMENTS (TABLE A)

Contaminant	Maximum Contaminant Level	Monitoring Requency	
		Community Water Systems	Non-Community Water Systems
	Membrane Filter		
Coliform Bacteria	(a) One per 100 milliliters as the arithmetic mean of all samples examined per month; or (b) Four per 100 milliliters in more than one sample when less than 20 are examined per month; or (c) Four per 100 milliliters more than five percent of the samples when 20 or more are examined each month.	Beginning June 24, 1977 at regular time intervals and in numbers proportionate to the population served by the system from representative points in the system. In no event shall the frequency be less than set forth in the following table (Microbiological Monitoring Frequency):	Beginning June 24, 1979 as specified by the Department, but no less than 1 each calendar quarter during which the system provides water to the public.
	Fermentation Tube		
	(a) More than 10 percent of the portions in any month; or (b) Three or more portions in more than one sample when less than 20 samples are examined per month; or (c) Three or more portions in more than five percent of the samples when 20 or more samples are examined per month.		

22.05: continued

TABLE 2.

MICROBIOLOGICAL MONITORING FREQUENCY

Population served:	Minimum number of samples per month
25 to 1,000	1
1,001 to 2,500	2
2,501 to 3,300	3
3,301 to 4,100	4
4,101 to 4,900	5
4,901 to 5,800	6
5,801 to 6,700	7
6,701 to 7,600	8
7,601 to 8,500	9
8,501 to 9,400	10
9,401 to 10,300	11
10,301 to 11,100	12
11,101 to 12,000	13
12,001 to 12,900	14
12,901 to 13,700	15
13,701 to 14,600	16
14,601 to 15,500	17
15,501 to 16,300	18
16,301 to 17,200	19
17,201 to 18,100	20
18,101 to 18,900	21
18,901 to 19,800	22
19,801 to 20,700	23
20,701 to 21,500	24
21,501 to 22,300	25
22,301 to 23,200	26
23,201 to 24,000	27
24,001 to 24,900	28
24,901 to 25,000	29
25,001 to 28,000	30
28,001 to 33,000	35
33,001 to 37,000	40
37,001 to 41,000	45
41,001 to 46,000	50
46,001 to 50,000	55
50,001 to 54,000	60
54,001 to 59,000	65
59,001 to 64,000	70
64,001 to 70,000	75
70,001 to 76,000	80
76,001 to 83,000	85
83,001 to 90,000	90
90,001 to 96,000	95
96,001 to 111,000	100
111,001 to 130,000	110
130,001 to 160,000	120
160,001 to 190,000	130
190,001 to 220,000	140
220,001 to 250,000	150
250,001 to 290,000	160
290,001 to 320,000	170
320,001 to 360,000	180
360,001 to 410,000	190
410,001 to 450,000	200
450,001 to 500,000	210
500,001 to 550,000	220
550,001 to 600,000	230
600,001 to 660,000	240
660,001 to 720,000	250
720,001 to 780,000	260
780,001 to 840,000	270
840,001 to 910,000	280
910,001 to 970,000	290
970,001 to 1,050,000	300
1,050,001 to 1,140,000	310
1,140,001 to 1,230,000	320
1,230,001 to 1,320,000	330
1,320,001 to 1,420,000	340
1,420,001 to 1,520,000	350
1,520,001 to 1,630,000	360
1,630,001 to 1,730,000	370
1,730,001 to 1,850,000	380
1,850,001 to 1,970,000	390
1,970,001 to 2,060,000	400
2,060,001 to 2,270,000	410
2,270,001 to 2,510,000	420
2,510,000 to 2,750,000	430
2,750,001 to 3,020,000	440
3,020,001 to 3,320,000	450
3,320,001 to 3,620,000	460
3,620,001 to 3,960,000	470
3,960,001 to 4,310,000	480
4,310,001 to 4,590,000	490
4,690,001 or more	500

22.05: continued

TABLE 3.

ANALYTIC REQUIREMENTS (TABLE B)

CONTAMINANT	ANALYTICAL METHOD	REFERENCE TO METHOD (1)
Coliform Bacteria	Membrane Filter	pp. 928-935
	5 tube fermentation tube	pp. 913-927

(1) Standard Methods for the Examination of Water and Wastewater, American Public Health Association, 14th Edition, 1976.

22.06: Maximum Inorganic Chemical Contaminant Levels, Monitoring Requirements and Analytical Methods

(1) Tables 1 & 2 in 310 CMR 22.06 and the accompanying provisions contain maximum contaminant levels permissible in public water systems, and describe associated monitoring requirements. Table 3 in 310 CMR 22.06 specifies analytical techniques which shall be followed in analyzing water samples. A supplier of water shall take samples of the water and shall provide for analysis of such samples for such water quality parameters, at no less than the stated frequencies and consistent with the methods described in said tables and accompanying provisions. The requirements set forth in Tables 1 and 2 in 310 CMR 22.06 for Nitrate and Sodium shall apply to all public water systems. The requirements set forth in Tables 1 and 2 in 310 CMR 22.06 for all other inorganic contaminants shall apply only to community water systems.

(2) Samples taken to determine compliance with 310 CMR 22.06 shall be taken at the free flowing outlet of the ultimate user of the public water system, as approved by the Department.

(3) All analytical results shall be rounded to the same number of significant figures as the applicable maximum contaminant level.

(4) Compliance with the maximum contaminant level for nitrate shall be determined on the basis of the mean of two analyses. When a level exceeding the maximum contaminant level for nitrate is found, a second analysis shall be initiated within 24 hours, and if the mean of the two analyses exceeds the maximum contaminant level, the supplier of water shall report his findings to the Department pursuant to 310 CMR 22.15 and shall notify the public pursuant to 310 CMR 22.16.

(5) For all inorganic chemicals except nitrate and sodium, if the results of an analysis made pursuant to 310 CMR 22.06 indicate that the level of any contaminant listed in Table 1 in 310 CMR 22.06 exceeds the maximum contaminant level, the supplier of water shall report to the Department within 7 days and initiate three additional analyses at the same sampling point within one month. When the average of these four analyses, rounded to the same number of significant figures as the maximum contaminant level for the substance in question, exceeds the maximum contaminant level, the supplier of water shall notify the Department pursuant to 310 CMR 22.15 and shall give notice to the public pursuant to 310 CMR 22.16. Monitoring after public notification shall be at a frequency designated by the Department and shall continue until the maximum contaminant level is not exceeded in two successive samples or until a monitoring schedule as a condition to a variance, exemption, or enforcement action shall become effective.

(6) Data for inorganic chemicals in surface waters acquired after June 24, 1976 and data for ground waters acquired after June 24, 1976 may be substituted for the initial analyses required by Table 3 in 310 CMR 22.06 with express written permission of the Department.

22.06: continued

TABLE 1
MAXIMUM CONTAMINANT LEVELS FOR INORGANIC CHEMICALS

CONTAMINANTS		MAXIMUM CONTAMINANT LEVEL MILLIGRAMS PER LITER
Arsenic (As)		0.05
Barium (Ba)		1.
Cadmium (Cd)		0.010
Chromium (Cr+6)		0.05
Lead (Pb)		0.05
Mercury (Hg)		0.002
Selenium (Se)		0.01
Silver (Ag)		0.05
Fluoride (F)		
Temperature Degrees Fahrenheit	**Degrees Celsius**	
53.7 & below	12.0 & below	2.4
53.8 to 58.3	12.1 to 14.6	2.2
58.4 to 63.8	14.7 to 17.6	2.0
63.9 to 70.6	17.7 to 21.4	1.8
70.7 to 79.2	21.5 to 26.2	1.6
79.3 to 90.5	26.3 to 32.5	1.4
Sodium (Na) **Any other provision of these regulations to the contrary notwithstanding, a supplier of water may supply to the users thereof, without obtaining a variance or exemption and without being subject to any enforcement action, water which exceeds this maximum contaminant level for sodium, but only if the supplier of water reports to the Department pursuant to 310 CMR 22.15 and gives notice to the public pursuant to 310 CMR 22.16.**		20.
Nitrate (as N) At the discretion of the Department, nitrate levels not to exceed 20 mg/l may be allowed in a non-community water system if the supplier of water demonstrates to the satisfaction of the Department that: (1) Such water will not be available to children under six months of age; and (2) There will be continuous posting of the fact that nitrate levels exceed 10 mg/l and the potential health effects of such exposure; and (3) Local public health authorities and the Department will be notified by the supplier annually of nitrate levels that exceed 10 mg/l; and (4) No adverse health effects shall result.		10.

22.06: continued:

TABLE 2
MONITORING REQUIREMENTS FOR INORGANIC CHEMICALS

MONITORING REQUIREMENTS FOR INORGANIC CHEMICALS

Contaminants	Community Water Systems Utilizing Surface Water Sources In Whole Or In Any Part	Community Water Systems Utilizing Only Ground Water Sources	All Non-Community Water Systems
Arsenic (As) Barium (Ba) Cadmium (Cd) Chromium (Cr+6) Lead (Pb) Mercury (Hg) Selenium (Se) Silver (Ag) Fluoride (F)	Initial Analysis to be completed by June 24, 1978. Thereafter at 1 year intervals.	Initial Analysis to be completed by June 24, 1979. Thereafter at 3 year intervals.	Not Applicable
Sodium (Na)	Initial Analysis to be completed by June 24, 1978. Thereafter at 1 year intervals. If the level of sodium exceeds 15 milligrams per liter, the analyses shall be repeated quarterly.	Initial Analysis to be completed by June 24, 1979. Thereafter at 3 year intervals. If the level of sodium exceeds 15 milligrams per liter, the analyses shall be repeated quarterly.	Initial Analysis to be completed by June 24, 1979. Thereafter at 3 year intervals. If the level of sodium exceeds 15 milligrams per liter, the analyses shall be repeated quarterly.
Nitrate (as N)	Initial Analysis to be completed by June 24, 1978. Thereafter at 1 year intervals.	Initial Analysis to be completed by June 24, 1979. Thereafter at 3 year intervals.	Initial Analysis to be completed by December 24, 1980. Thereafter at intervals determined by the Department.

22.06: continued

TABLE 3
ANALYTICAL REQUIREMENTS

REFERENCE #1

"Methods of Chemical Analysis of Water and Wastes," EPA Environmental Monitoring and Support Laboratory, Cincinnati, Ohio 45288 (EPA-600/4-79-020), March 1979. Available from ORD Publications, CERL, EPA, Cincinnati, Ohio 45288. For approved analytical procedures for metals, the technique applicable to total metals must be used.

CONTAMINANT	METHODS IN REFERENCE #1
Arsenic (As)	206.2, Atomic Absorption Furnace Technique; or 206.3; or 206.4
Barium (Ba)	208.1; or 208.2, Atomic Absorption Furnace technique
Cadmium (Cd)	213.1; or 213.2, Atomic Absorption Furnace technique
Chromium (Cr+6)	218.1; or 218.2, Atomic Abosrption Furnace technique
Lead (Pb)	239.1; or 239.2, Atomic Absorption Furnace technique
Mercury (Hg)	245.1; or 245.2, Atomic Absorption Furnace technique
Selenium (Se)	270.2, Atomic Absorption Technique; or 270.3
Silver (Ag)	272.1; or 272.2, Atomic Absorption Furnace technique
Fluoride (F)	340.1, Colorimetric SPADNS with Bellack Distillation; or 340.2, Potentiometric Ion Selective Electrode
Sodium (Na)	273.1, Atomic Absorption Direct Aspiration; or 273.2, Atomic Absorption, Graphite Furnace
Nitrate (as N)	352.1; or 353.3; or 353.1, Automated Hydrazine Reduction; or 353.2

REFERENCE #2

"Standard Methods for the Examination of Water and Wastewater," 14th Edition, American Public Health Association, American Water Works Association, Water Pollution Control Federation, 1976.

CONTAMINANT	METHODS IN REFERENCE #2
Arsenic (As)	301-A VII, pp. 159-162; or 404-A and 404-B(4), Spectrophotometric Silver Diethyldithiocarbamate
Barium (Ba)	301-A IV, pp. 152-155, Atomic Absorption - Direct Aspiration
Cadmium (Cd)	301-A II or III, pp. 148-152, Atomic Absorption - Direct Aspiration
Chromium (Cr+6)	301-A II or III, pp. 148-152, Atomic Absorption - Direct Aspiration
Lead (Pb)	301-A II or III, pp. 148-152, Atomic Absorption - Direct Aspiration
Mercury (Hg)	301-A VI, pp. 156-159, Manual Cold Vapor Technique
Selenium (Se)	301-A VII, pp. 159-162, Hydride Generation - Atomic Absorption Spectrophotometry

22.06 Table 3: continued

Silver (Ag)	301-A II, Atomic Absorption - Direct Aspiration
Fluoride (F)	414-B and C, pp. 391-394, Electrode Method or SPADNS Method; or 603, Colorimetric Method with Preliminary Distillation, Automated Complexone Method (Alizarin Fluoride Blue) pp. 614-616
Sodium (Na)	320-A, Flame Photometric Method, pp. 250-253
Nitrate (as N)	419-D, pp. 427-429, Colorimetric Brucine; or 419-C, pp. 423-427, spectrometric Cadmium Reduction; or 605, pp. 620-624, Automated Cadmium Reduction

REFERENCE #3

Techniques of Water-Resources Investigation of the United States Geological Survey, Chapter A - 1. "Methods for Determination of Inorganic Substances in Water and Fluvial Sediments". Book 5, 1979, Stock #024-001-03177-9, Available from Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

CONTAMINANT	METHODS IN REFERENCE #3
Arsenic (As)	I-1062-78, pp. 61-63, Atomic Absorption - Gaseous Hydride
Selenium (Se)	I-1667-78, pp. 237-239
Silver (Ag)	I-3325-78, pp. 365-367, Flouride, Total Colorimetric, Zirconium - Eriochrome Cyanine R

REFERENCE #4

Annual Book of ASTM Standards, part 31 Water, American Society for Testing and Materials, 1976 Race St., Philadelphia, Pennsylvania 19103.

CONTAMINANT	METHODS IN REFERENCE #4
Arsenic (As)	D 2972 - 78A; or D 2972 - 78A
Cadmium (Cd)	D 3557 - 78A or B
Chromium (Cr+6)	D 1687 - 77D
Lead (Pb)	D 3559 - 78A or B
Mercury (Hg)	D 3223 - 79
Selenium (Se)	D 3859 - 79
Fluoride (F)	D 1179 - 79
Sodium (Na)	D 1428 - 64 (a)
Nitrate (as N)	D 992 - 71; or D 3867 - 79B; or D 3867 - 79A

MISCELLANEOUS METHODS FOR FLUORIDE

Automated Electrode Method, "Fluoride in Water and Waste Water," Industrial Method #380-75 WE, Technicon Industrial Systems, Tarrytown, New York 10591, February 1976

Fluoride in Water and Waste Water Industrial Method #129-71 W, Technicon Industrial Systems, Tarrytown, New York 10591, December 1972

22.07: Maximum Organic Chemical Contaminant Levels, Monitoring Requirements and Analytical Methods

(1) Certain Pesticides and Herbicides

(a) Table 1 in 310 CMR 22.07 (1) and the accompanying provisions contain maximum contaminent levels permissible in community water systems and describe associated monitoring requirements for certain chlorinated hydrocarbons and chlorophenoxys. Table 2 in 310 CMR 22.07 (1) specifies analytical techniques which shall be followed in analyzing water samples. A supplier of water for a community water system shall take samples of the water and shall provide for analysis of such samples for such water quality parameters, at not less than the stated frequencies and consistent with the methods described in said tables and accompanying provisions.

(b) Samples taken to determine compliance with 310 CMR 22.07(1) shall be taken at the free flowing outlet of the ultimate user of the community water system, as approved by the Department.

(c) All analytical results shall be rounded to the same number of significant figures as the applicable maximum contaminant level.

(d) If the result of an alalysis made pursuant to Table 1 in 310 CMR 22.07(1) exceeds any maximum contaminant level prescribed in Table 1 in 310 CMR 22.07(1) the supplier of water shall report to the Department within 7 days and shall initiate three additional analyses at the same sampling point within one month. When the average of these four analyses, rounded to the same number of significant figures as the maximum contaminant level for the substance in question, exceeds the maximum contaminant level, the supplier of water shall notify the Department pursuant to 310 CMR 22.15 and shall notify the public pursuant to 310 CMR 22.16. Monitoring after public notification shall be at a frequency designated by the Department and shall continue until the maximum contaminant level has not been exceeded in two successive samples or until a monitoring schedule as a condition to a variance, exemption, or enforcement action shall become effective.

(e) Data for the organic chemicals regulated by 310 CMR 22.07(1) acquired for surface waters after June 24, 1976, and data for ground waters acquired after June 24, 1974 may be substituted for the initial analyses required by Table 1 in 310 CMR 22.07(1) with express written permission of the Department.

22.07: continued

TABLE 1
MAXIMUM CONTAMINANT LEVELS AND MONITORING REQUIREMENTS FOR CHLORINATED HYDROCARBON AND CHLOROPHENOXY PESTICIDES

MAXIMUM CONTAMINANT LEVELS AND MONITORING REQUIREMENTS FOR CHLORINATED HYDROCARBON AND CHLOROPHENOXY PESTICIDES

CONTAMINANTS	MAXIMUM CONTAMINANT LEVEL MILLIGRAMS PER LITER	COMMUNITY WATER SYSTEMS UTILIZING SURFACE WATER OR IN ANY PART	COMMUNITY WATER SYSTEMS UTILIZING ONLY GROUND WATER SOURCES
(a) Chlorinated hydrocarbons: Endrin (1,2,3,4,10, 10-Hexachloro-6,7-epoxy-1,4, 4a, 5,6, 7,8, 8a-octahydro-1,4-endo, endo-5,8 -dimethano naphthalene).	0.0002	Initial analyses to be completed by June 24, 1978. Thereafter at intervals specified by the Department, but in no event less frequently than at 3 years intervals. All samples analyzed shall be collected during the period of the year designated by the Department as the period when contamination by pesticides is most likely to occur.	Analyses shall be completed by those systems specified by the Department.
Lindane (1,2,3,4,5,6-hexachlorocyclohexane, gamma isomer).	0.004		
Methoxychlor (1,1,1-Trichlorocyclohexane, gamma isomer).	0.1		
Toxaphene (C10H10CL8 - Technical chlorinated camphene, 67-69 percent chlorine).	0.005		
(b) Chlorophenoxys: 2,4 - D (2,4-Dichloro phenoxyacetic acid).	0.1		
2,4,5-TP Silvex (2,4,5-Trichlorophenoxypropionic acid).	0.01		

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TABLE 2.

ANALYTICAL REQUIREMENTS FOR CERTAIN CHLORINATED HYDROCARBONS PESTICIDES AND CHLOROPHENOXY PESTICIDES

REFERENCE	METHOD	APPLICABLE TO
Methods for Organochlorine Pesticides and Chlorophenoxy Acid Herbicides in Drinking Water, ORD, Publications CERI, EPA, Cincinnati, Ohio 45268		Chlorinated Hydrocarbons
1977 Annual Book of ASTM Standards, part 31, Water	12-3088 D-3478	Chlorinated Hydorcarbons Chlorophenoxys
Standard Methods for the Examination of Water and Wastewater, 14th Edition, American Public Health Association, American Water Works Association Water Pollution Control Federation, 1976	509-A, pp. 555-565 509-B, pp, 555-569	Chlorinated Hydrocarbons
Techniques of Water - Resources Inveand Chlorophenoxys of the United States Geological Survey, Chapter A-3, "Methods for Analysis of Organic Substances in Water", Book 5, 1972 Available from Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402	Chapter A-3, pp. 24-39	Chlorinated Hydrocarbons

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(2) Trihalomethanes

(a) The maximum contaminant level for total trihalomethanes shall be 0.10 milligrams per liter. This maximum contaminant level shall become effective on promulgation of these Regulations for community water systems serving 10,000 to 74,999 individuals, inclusive. This maximum contaminant level shall not apply to other public water systems.

(b) All community water systems which serve 75,000 or more individuals and which add a disinfectant (oxidant) to the water in any part of the treatment began sampling and analyses for total trihalomethanes by November 29, 1980. All community water systems which serve 10,000 to 74,999 individuals, inclusive, and which add a disinfectant (oxidant) to the water in any part of the treatment process shall begin sampling and analyses for total trihalomethanes by not later than November 29, 1982. Once begun, all sampling and analyses shall be repeated quarterly. Compliance with this maximum contaminant level shall be determined based on a running annual average of quarterly samples collected as prescribed in 310 CMR 22.07(2). If the average of samples covering any 12-month period exceeds the maximum contaminant level, the supplier of water shall report to the Department pursuant to 310 CMR 22.15 and notify the public pursuant to 310 CMR 22.16. Monitoring after public notification shall be at a frequency designated by the Department until a monitoring schedule as a condition to a variance, exemption or enforcement action shall become effective.

(c) For all community water systems utilizing surface water sources in whole or in any part, and for all community water systems utilizing only ground water sources that have not been determined by the Department to qualify for the reduced monitoring requirements of 310 CMR 22.07(2)(e), analyses for total trihalomethanes shall be performed at quarterly intervals on at least four water samples for each treatment plant used by the community water system. All of the samples taken per quarter shall be collected within a 24-hour period. At least 25 percent of the samples shall be taken at locations within the distribution system reflecting the maximum residence time of the water in the system. The remaining 75 percent shall be taken at representative locations in the distribution system, taking into account the number of persons served, the different sources of water and the different treatment methods employed. The results of all analyses per quarter shall be arithmetically averaged and reported to the Department within 30 days of the system's receipt of such results. All samples collected shall be used in the computation of the average, unless the analytical results are invalidated for technical reasons, in which case the results thus invalidated and an explanation of why the results were invalidated shall be included in the report required herein. The Department reserves the right to require results invalidated by the supplier of water to be included in the computation of the average whenever the Department deems such action necessary or appropriate to protect the public health.

(d) Upon the written request of a community water system subject to 310 CMR 22.07(2)(c), the monitoring frequency required by 310 CMR 22.07(2)(c) may be reduced by express written permission of the Department to one sample analyzed for total trihalomethanes per quarter taken at a point in the distribution system reflecting the maximum residence time of the water in the system, upon a written determination by the Department that the data from at least one year of monitoring in accordance with 310 CMR 22.07(2)(c) and local conditions demonstrate that total trihalomethane concentrations will be consistently below the maximum contaminant level. If at any time during which a community water system is subject to 310 CMR 22.07(2)(d), the results from any analysis exceed 0.10 milligrams of

22.07: continued

total trihalomethanes per liter of water and such results are confirmed by at least one check sample taken promptly after such results are received, or if no such check sample is promptly taken, or if the community water system makes any significant change to its source of water or treatment, the community water system shall immediately become subject to 310 CMR 22.07(2)(c) and for at least one year thereafter shall not be eligible for permission to become subject to 310 CMR 22.07(2)(d). The Department reserves the right to order a community water system to increase the monitoring frequency above the minimum prescribed in 310 CMR 22.07(2)(d) whenever the Department deems such action necessary to detect variations of total trihalomethane levels within the distribution system. All the samples thus taken shall be collected within a 24-hour period.

(e) Upon written request of a community water system which would otherwise be subject to 310 CMR 22.07(2)(c) and which utilizes only ground water sources, the monitoring frequency required by 310 CMR 22.07(2)(c) may be reduced by express written permission of the Department to one sample analyzed for maximum total trihalomethane potential per year for each treatment plant used by the community water system, which samples shall be taken at a point in the distribution system reflecting the maximum residence time of the water in the system. The Department may grant such permission only upon express written determination that, based upon the data submitted by the supplier of water, the community water system has a maximum total trihalomethane potential of less than 0.10 milligrams per liter and that, based upon an assessment of the local conditions of the system, the community water system is not likely to approach or exceed the maximum contaminant level for total trihalomethanes. If at any time during which a community water system is subject to 310 CMR 22.07(2)(e) the results from any analysis taken for maximum total trihalomethane potential are equal to or greater than 0.10 milligrams per liter, and such results are confirmed by at least one check sample taken promptly after such results are received, or if no such check sample is promptly taken, the community water system shall immediately become subject to 310 CMR 22.07(2)(c) and for at least one year thereafter shall not be eligible for permission to become subject to 310 CMR 22.07(2)(d) or (e). In the event of any significant change to the community water system's raw water or treatment program, the community water system shall immediately analyze an additional sample for maximum total trihalomethane potential taken at a point in the distribution system reflecting maximum residence time of the water in the system for the purpose of determining whether the community water system must become subject to 310 CMR 22.07(2)(c). The results of all analyses pursuant to 310 CMR 22.07(2)(e) shall be reported to the Department within 30 days of the community water system's receipt of such results. All samples collected pursuant to 310 CMR 22.07(2)(e) shall be used for determining whether the community water system is to be made subject to 310 CMR 22.07(2)(c), unless the analytical results are invalidated for technical reasons, in which case the results thus invalidated and an explanation of why the results were invalidated shall be included in the report required herein. The Department reserves the right to require the results invalidated by the supplier of water to be included in determining whether the community water system is to be made subject to 310 CMR 22.07(2)(c) whenever the Department deems such action necessary or appropriate to protect the public health. The Department reserves the right to order a community water system to increase the monitoring frequency above the minimum prescribed in 310 CMR 22.07(2)(e) whenever the Department deems such action necessary to detect variations of total trihalomethane levels within the distribution system. All of the samples thus taken shall be collected within a 24-hour period.

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(f) The minimum number of samples required to be taken by a community water system pursuant to 310 CMR 22.07(c), (d), or (e) shall be based on the number of treatment plants used by the community water system, except that multiple wells drawing raw water from a single aquifer may, with the express written permission of the Department, be considered one treatment plant for determining the minimum number of samples required.

(g) Sampling and analyses made pursuant to 310 CMR 22.07(2) shall be conducted by one of the methods listed below. Samples for total trihalomethanes shall be dechlorinated upon collection to prevent further production of trihalomethanes, according to the procedures described in the methods listed below. Samples for maximum total trihalomethane potential should not be dechlorinated, and should be held for seven days at 25 C prior to analysis, according to the procedures described in the methods listed below.

1. "The Analysis of Trihalomethanes in Finished Waters by the Purge and Trap Method," Method 501.1, EMSL, EPA, Cincinnati, Ohio.
2. "The Analysis of Trihalomethanes in Drinking Water by Liquid/Liquid Extraction," Method 501.2, EMSL, EPA, Cincinnati, Ohio.

(h) Before a community water system makes any significant modifications to its existing treatment process for the purpose of achieving compliance with 310 CMR 22.07(2)(a), the supplier of water must submit to the Department for its approval a detailed plan setting forth the proposed modification and the safeguards which will be implemented to ensure that the bacteriological quality of the drinking water supplied to consumers by said community water system will not be adversely affected by such modification. Each community water system shall comply with the provisions set forth in the Department-approved plan. Effective November 29, 1979, every plan approved by the Department shall, in addition to any other requirement imposed by the Department, require the community water system modifying its disinfection practice to:

1. Evaluate the water system for sanitary defects and evaluate the source water for biological purity.
2. Evaluate its existing treatment practices and consider improvements that will minimize disinfectant demand and optimize finished water quality throughout the distribution system.
3. Conduct additional monitoring to assure continued maintenance of optimal biological quality in finished water. Examples of when this requirement shall be enforced include when chloramines are introduced as disinfectants or when pre-chlorination is being discontinued. When chlorine dioxide is being used as a disinfectant, additional monitoring for chlorate, chlorite and chlorine dioxide shall be required except when the Department determines expressly and in writing that such monitoring is unnecessary. Standard plate count analyses shall also be required before and after any modifications unless the Department determines expressly and in writing that such analyses are not appropriate.
4. Demonstrate an active disinfectant residual throughout the distribution system at all times during and after the modification.
5. Provide baseline water quality survey data of the distribution system as required by the Department.

22.08: Maximum Turbidity Contaminant Levels, Monitoring Requirements and Analytical Methods

(1) The maximum contaminant level for turbidity, applicable only to public water systems which use water obtained in whole or in any part from surface water sources, shall be measured at representative entry point(s) to the distribution system, and shall be:

22.08: continued

(a) One turbidity unit, as determined by a monthly average pursuant to 310 CMR 22.08 (3) except that five or fewer turbidity units may be allowed if the supplier of water can demonstrate to the Department that the higher turbidity does not do any of the following:
1. Interfere with disinfection; or
2. Prevent maintenance of an effective disinfectant agent throughout the distribution system; or
3. Interfere with microbiological determinations.
(b) Five turbidity units, as determined by the arithmetic mean of two consecutive daily samples pursuant to 310 CMR 22.08 (3).

(2) All analyses shall be conducted in accordance with the following methods:
(a) Nephelometric Method, "Standard Methods for the Examination of Water and Wastewater," American Public Health Association, 14th Edition, pages 132-4, inclusive; or
(b) Nephelometric Method, Method 180.1, "Methods of Chemical Analysis of Water and Wastes". EPA Environmental Monitoring and Support Laboratory, Cincinnati, Ohio 45288 (EPA-600 14-79-020), March 1979.

(3) In no event shall the frequency of sampling be less than as set forth below:
(a) Community water systems subject to 310 CMR 22.08 shall commence sampling by not later than June 24, 1977 and shall take at least one sample per day thereafter. All samples shall be taken at representative entry point(s) to the distribution system.
(b) Non-Community water systems subject to 310 CMR 22.08 shall commence sampling by not later than June 24, 1979 and shall take at least one sample per day thereafter. All samples shall be taken at representative entry point(s) to the distribution system.
(c) If the result of a turbidity analysis pursuant to 310 CMR 22.08 (3)(a) and 22.08(3)(b) indicates that the maximum contaminant level has been exceeded, the sampling and measurement shall be confirmed by resampling as soon as practicable and preferably within one hour. If the repeat sample confirms that the maximum contaminant level has been exceeded, the supplier of water shall report to the Department within 48 hours. The repeat sample shall be the sample used for calculating the monthly average pursuant to 310 CMR 22.08(3)(a) and 22.08(3)(b). If the monthly average of the daily samples exceeds one turbidity unit, or if the average of two consecutive daily samples exceeds five turbidity units, the supplier of water shall notify the public pursuant to 310 CMR 22.16.
(d) If the Department determines that a reduced sampling frequency in a non-community system will not pose a risk to public health, it can reduce the required sampling frequency. The option of reducing the turbidity frequency shall be permitted only in those public water systems that practice disinfection and which maintain an active residual disinfectant in the distribution system, and in those cases where the Department has indicated in writing that no unreasonable risk to health existed under the circumstances of this option.

22.09: Maximum Radionuclide Contaminant Levels, Monitoring Requirements and Analytical Methods

The maximum contaminant levels, sampling requirements and associated monitoring requirements for radionuclides, applicable only to community water systems, shall be as follows:

22.09: continued

(1) For radium-226, radium-228 and gross alpha particle radioactivity

(a) The maximum contaminant level shall be based on the analysis of an annual composite of four consecutive quarterly samples or the average of the analyses of four samples obtained at quarterly intervals. The required sensitivity of analyses shall be defined in terms of a detection limit. The detection limit shall be that concentration which can be counted with a precision of plus or minus 100 percent at the 95 percent confidence level (1.96 where is the standard deviation of the net counting rate of the sample). The maximum contaminant level shall be

1. For combined radium-226 and radium-228, 5 pCi per liter. In no event shall the detection limit exceed 1 pCi per liter.

2. For gross alpha particle activity, including radium-226 but excluding radon and uranium, 15 pCi per liter. In no event shall the detection limit exceed 3 pCi per liter.

(b) All analyses shall be made in accordance with the following methods:

1. Interim Radiochemical Methodology for Drinking Water; Environmental Monitoring and Support Laboratory, EPA-600/4-75-008, USEPA, Cincinnati, Ohio 45268; or

2. For gross alpha particle radioactivity, Method 703 "Gross Alpha and Beta Radioacticity in Water", Standard Methods for the Examination of Water and Wastewater, 14th edition, American Public Health Association, New York, N.Y., 1976; or

3. For total radium, Method 705 "Radium in Water by Precipitation", Standard Methods for the Examination of Water and Wastewater, 14th edition, American Public Health Association, New York, N.Y., 1976; or

4. For radium-226, Method 706 "Radium-226 by Radon in Water", Standard Methods for the Examination of Water and Wastewater, 14th edition, American Public Health Association, New York, N.Y., 1976.

(c) Sampling and analysis shall be done as follows:

1. All samples shall be taken at the free flowing outlet of the ultimate user of the community water system, as approved by the Department. In addition, when so ordered by the Department, a community water system using two or more sources having different concentrations of radioactivity shall monitor source water. Each analysis shall be based on either an annual composite of four consecutive quarterly samples or the average of the analyses of four samples obtained at quarterly intervals. All data shall be rounded to the same number of significant figures as the maximum contaminant level for the substance in question.

a. A gross alpha particle activity measurement may be substituted for the required radium-226 and radium-228 analysis, but only if the measured gross alpha particle activity does not exceed 5 pCi per liter at a confidence level of 95 percent (1.65 where is the standard deviation of the net counting rate of the sample). In localities where radium-228 may be present in drinking water, radium-226 and/or radium-228 analyses shall be required when the gross alpha particle activity exceeds 2 pCi per liter.

b. When the gross alpha particle activity exceeds 5 pCi per liter, the same or an equivalent sample shall be analyzed for radium-226. If the concentration of radium-226 exceeds 3 pCi per liter, the same or an equivalent sample shall be analyzed for radium-228.

2. The frequency of sampling shall in no event be less than as set forth below:

a. Community water systems shall begin initial sampling by no later than June 24, 1979 and shall complete such sampling

22.09: continued

by no later than June 24, 1980. At the discretion of the Department, data acquired after June 24, 1976 may be substituted for the initial analysis required herein.

b. Community water systems shall conduct repeat analyses at least once every four years. At the discretion of the Department when the initial analysis taken in conformance with 310 CMR 22.09(1)(c)2a has established that the average annual concentration is less than half the maximum contaminant level established by 310 CMR 22.09(1)(a), analysis of a single sample may be substituted for the quarterly sampling procedure otherwise required by 310 CMR 22.09(1)(c)1. More frequent monitoring than once every four years shall be conducted, when ordered by the Department, in the vicinity of mining or other operations which may contribute alpha particle radioactivity to either surface or ground water sources of drinking water. A community water system shall conduct an analysis pursuant to 310 CMR 22.09(1)(c)1 within one year of the introduction of a new water source for said system. More frequent monitoring shall be conducted when ordered by the Department in the event of possible contamination by radioactivity in finished water. If the average annual concentration of radium-228 has been assayed at least once using the quarterly sampling procedure required by 310 CMR 22.09 (1)(c)1, repeat monitoring after the initial analysis need not include radium-228, except when otherwise ordered by the Department. When so ordered by the Department, suppliers of water shall conduct annual monitoring of any community water system in which the radium-226 concentration exceeds 3 pCi per liter.

c. If the maximum contaminant level for gross alpha particle activity or total radium is exceeded, the community water system shall give notice to the Department pursuant to 310 CMR 22.15 and shall notify the public as required by 310 CMR 22.16. Monitoring at quarterly intervals shall be continued until the annual average concentration no longer exceeds the maximum contaminant level or until a monitoring schedule as a condition to a variance, exemption, or enforcement action shall become effective.

(2) For beta particle and photon radioactivity from man-made radionuclides

(a) The maximum contaminant level shall be the average annual concentration which produces an annual dose equivalent to the total body or any internal organ greater than 4 millirem per year. The concentration of tritium causing a 4 millirem per year dose equivalent in the total body shall be calculated on the basis of 20,000 pCi per liter. The concentration of strontium-90 causing a 4 millirem per year dose equivalent in the bone marrow shall be calculated on the basis of 8 pCi per liter. The concentration of all other man-made radionuclides causing a 4 millirem per year total body or organ dose equivalent shall be calculated on the basis of a 2 liter per day drinking water intake using the 168 hour data listed in "Maximum Permissible Body Burdens and Maximum Permissible Concentration of Radionuclides in Air or Water for Occupational Exposure", NBS Handbook 69 as amended August 1963, U.S. Department of Commerce. If two or more radionuclides are present, the sum of their annual dose equivalent to the total body or to any organ shall not exceed 4 millirem per year. The maximum contaminant level shall be based on either analysis of a composite of four consecutive quarterly samples or analysis of four quarterly samples. The required sensitivity of analyses shall be defined in terms of a detection limit. The detection limit shall be that concentration

22.09: continued

which can be counted with a precision of plus or minus 100 percent at the 95 percent confidence level (1.96 where is the standard deviation of the net counting rate of the sample). In no event shall the detection limit exceed

1. For tritium, 1,000 pCi per liter.
2. For strontium-89, 10 pCi per liter.
3. For strontium-90, 2 pCi per liter.
4. For iodine-131, 1 pCi per liter.
5. For cesium-134, 10 pCi per liter.
6. For gross beta, 4 pCi per liter.
7. For all other radionuclides, 1/10 of the applicable limit.

(b) All analyses shall be made in accordance with the following methods:

1. Interim Radiochemical Methodology for Drinking Water, Environmental Monitoring and Support Laboratory, EPA-600/4 75-0-8, USEPA, Cincinnati, Ohio 45268; or
2. For all radionuclides except strontium-89, strontium-90, tritium, cesium-134, and uranium.
    - a. Procedure for Radiochemical Analysis of Nuclear Reactor Aqueous Solutions, H. L. Krieger and S. Gold, EPA-R4-73-014, USEPA, Cincinnati, Ohio, May 1973; or
    - b. HASL Procedure Manual, Edited by John H. Harley, HASL 300, ERDA Health and Safety Laboratory, New York, N.Y., 1973; or
3. For strontium-89 and strontium-90, Method 704 "Total Radioactive Strontium and Strontium-90 in Water", Standard Methods for the Examination of Water and Wastewater, 14th edition, American Public Health Association, New York, N.Y., 1976; or
4. For tritium, Method 707 "Tritium in Water", Standard Methods for the Examination of Water and Wastewater, 14th edition, American Public Health Association, New York, N.Y., 1976; or
5. For cesium-134, ASTM D-2459 "Gamma Spectrometry in Water", 1975 Annual Book of ASTM. Standards, Water and Atmospheric Analysis, Part 31, American Society for Testing and Materials, Philadelphia, PA (1975); or
6. For uranium, ASTM D-2907 "Microquantities of Uranium in Water by Fluorometry", 1975 Annual Book of ASTM Standards, Water and Atmospheric Analysis, Part 31, American Society for Testing and Materials, Philadelphia, PA (1975).

(c) Sampling and analysis shall be done as follows:

1. All samples shall be taken at the free flowing outlet of the ultimate user of the community water system, as approved by the Department. These sampling and analysis requirements shall apply to all community water systems using surface water sources in whole or in any part and serving more than 100,000 persons, and all other community water systems which the Department may designate. In addition, supplies of water shall conduct monitoring, as ordered by the Department to determine the concentration of man-made radioactivity in principal watersheds designated by the Department. Each analysis shall be based on either analysis of a composite of four consecutive quarterly samples or analysis of four quarterly samples. All data shall be rounded to the same number of significant figures as the maximum contaminant level for the substance in question. If gross beta particle activity exceeds 50 pCi per liter, an analysis of the sample shall be performed to identify the major radioactive constituents present and the appropriate organ and total body doses shall be calculated to determine compliance with 310 CMR 22.09(2)(a).
2. The frequency of sampling shall in no event be less than as set forth below:

22.09: continued

a. Except as provided in 310 CMR 22.09(2)(c)2c, community water systems shall begin initial sampling by not later than June 24, 1979 and shall complete such sampling by not later than June 24, 1980. At the discretion of the Department, data acquired after June 24, 1976 may be substituted for the initial analysis required herein.

b. Except as provided in 310 CMR 22.09(2)(c)2c, community water systems shall conduct repeat analyses at least once every four years. Compliance with 310 CMR 22.09(2)(a) may be assumed without repeat analysis if the average annual concentration of gross beta particle activity is less than 50 pCi per liter and if the average annual concentrations of tritium and strontium-90 are less than those prescribed in 310 CMR 22.09(2)(a), provided that if both tritium and strontium-90 are present the sum of their annual dose equivalents to bone marrow shall not exceed 4 millirem per year.

c. By not later than June 24, 1979 the supplier of water of any community water system designated by the Department as utilizing waters contaminated by effluents from nuclear facilities shall initiate quarterly monitoring for gross beta particle and iodine-131 radioactivity and annual monitoring for strontium-90 and tritium. Quarterly monitoring for gross beta particle activity shall be based on the analysis of monthly samples, or with the express written permission of the Department a composite of three monthly samples. If the gross beta particle activity in a sample exceeds 15 pCi per liter, the same or an equivalent sample shall be analyzed for strontium-89 and cesium-134. If the gross beta particle activity exceeds 50 pCi per liter, an analysis of the sample shall be performed to identify the major radioactive constituents present and the appropriate organ and total body doses shall be calculated to determine compliance with 310 CMR 22.09(2)(a). Quarterly monitoring for iodine-131 shall be based on a composite of five consecutive daily samples which shall be analyzed once each quarter. As ordered by the Department, more frequent monitoring shall be conducted when iodine-131 is identified in the finished water. Annual monitoring for strontium-90 and for tritium shall be conducted by analysis of four quarterly samples, or with the express written permission of the Department a composite of four consecutive quarterly samples. The Department may in its discretion allow the substitution of environmental surveillance data taken in conjunction with a nuclear facility for direct monitoring of man-made radioactivity by the supplier of water where the Department determines such data is applicable to a particular community water system.

d. If any maximum contaminant level set forth in 310 CMR 22.09(2)(a) is exceeded, the community water system shall give notice to the Department pursuant to 310 CMR 22.15 and shall notify the public pursuant to 310 CMR 22.16. Monitoring at monthly intervals shall be continued until the concentration does not exceed the maximum contaminant level or until a monitoring schedule as a condition to a variance, exemption, or enforcement action shall become effective.

22.10: Alternative Analytical Methods

With the express written permission of the Department, given after a public hearing and the approval of the Administrator or the Administrator's designee, an alternate analytical technique may be employed for any analytical technique prescribed in these regulations. The Department shall give such permission only if the alternative technique is substantially equivalent to the prescribed test in both precision and accuracy

22.10: continued

as it relates to the determination of compliance with any maximum contaminant level. The use of the alternative analytical technique shall not decrease the frequency of monitoring required by these regulations.

22.11: Laboratory Certification

(1) No laboratory shall conduct the analyses of drinking water required by these regulations and report them to the supplier of water or to the Department for the purpose of complying with these regulations unless the Department has certified the laboratory, pursuant to 310 CMR 22.11, as being capable of conducting uniform, professional and reliable analysis, and as being capable of documenting the validity of analytical data produced except that measurements of turbidity, free chloring residual, temperature, pH, and analyses for the control of treatment works for public water systems may be performed by any employee or agent of the public water system whom the Department designates as competent and authorized to perform such analyses. No sample shall be considered for the purpose of determining compliance with these regulations if the sample was analyzed by a laboratory not certified pursuant to 310 CMR 22.11, or whose certification expired or was revoked. All sample results submitted to the Department shall include the name and address of the laboratory analyzing the sample.

(2) For purposes of 310 CMR 22.11, all analyses shall be divided into the following disciplines:

(a) Chemical analyses. This discipline shall be subdivided into the following categories:

1. Mineral, such as calcium, magnesium, sodium, potassium, iron, manganese, chloride alkalinity, sulfate, silica, fluoride, pH, conductance, dissolved gases.
2. Physical, such as color, turbidity, odor, residue (solids).
3. Nutrient, such as organic nitrogen, ammonia, nitrate, nitrite, phosphorus.
4. Demand, such as COD, BOD, TOC, chlorine residual.
5. Trace Metals, such as silver, barium, cadmium, copper, nickel, mercury, lead, zinc, tin, chromium, arsenic, selenium.
6. Toxic Substances (other than trace metals), such as phenol, cyanide, sulfide.
7. Pesticides, Herbicides, and other Organics, such as hydrocarbons, chlorinated hydrocarbons, carbamates and organo-phosphorus compounds.

(b) Microbiological Analyses. This discipline shall be subdivided into the following categories:

1. Total Coliform by the Membrane Filter Method.
2. Fecal Coliform by the Membrane Filter Method.
3. Total Coliform by the Fermentation Tube Method.
4. Fecal Coliform by the Fermentation Tube Method.
5. Standard Plate Count.

(c) Radiological Analyses.

(3) A laboratory may be approved and certified in one or more disciplines, or in one or more categories within a discipline, but only if, for each category and discipline, the laboratory demonstrates it has adequate personnel, facilities, methodology and quality procedure to properly perform analyses on its own premises. The laboratory's certificate of approval shall clearly indicate all disciplines and/or categories in which the laboratory is certified.

(4) A laboratory that desires certification in one or more disciplines or categories shall submit an application on forms provided by the Department. No such application shall be accepted unless the laboratory filing the application agrees in writing to:

22.11: continued

(a) Authorize Department Personnel to enter their premises and conduct an on-site review of the laboratory;
(b) Participate in a proficiency testing program in environmental analyses administered by the Department;
(c) Promptly submit all reports and data required; and
(d) Notify the Department in writing within ten days of any change in address of the laboratory.

(5) A laboratory shall be certified only if, with respect to the discipline or category for which it is being certified, it meets all of the following requirements:

(a) Laboratory personnel shall meet the following requirements:

1. Analyst. - Microbiological.

a. Academic Training. Minimum of high school diploma or its equivalent.

b. Experience. One year of work experience in water bacteriology, plus a minimum of one month of on-the-job training under the direct supervision of a qualified analyst in methodologies being considered for approval or certification. Each year of college-level training in a related scientific field, or demonstrated equivalency, shall be considered equal to one year of work experience.

c. Supervision. Supervision by a supervisor/consultant who meets the qualifications prescribed in 310 CMR 22.11(5)(a)3. Department microbiologists may be available as consultants for those laboratories certified only for microbiological analyses, which employ no supervisor/consultant, which employ no more than two analysts and which do analyses only for suppliers of water that are agencies or political subdivisions of the Commonwealth.

2. Analyst. - Chemical and Radiological.

a. Academic Training. Minimum of high school diploma or its equivalent.

b. Experience. Analysts conducting radiological analyses and chemical analyses other than for organic chemicals shall possess:

(i) a minimum of two years of experience in radiological or inorganic analyses, including six months of on-the-job training, under the direct supervision of a qualified analyst, in measurements being considered for approval or certification; or

(ii) with no experience, two years of on-the-job training, under the direct supervision of a qualified analyst, in measurements being considered for approval or certification.

Analysts conducting analyses for organic chemicals shall possess a minimum of six months experience in the measurement of chlorinated hydrocarbons and chlorophenoxys and two years of experience in gas chromatography.

In each case, each year of college-level training in a related scientific field, or demonstrated equivalency shall be considered equal to one year of work experience.

c. Supervision. Analysts conducting chemical and radiological analyses shall be supervised by a supervisor/consultant who meets the qualifications prescribed in 310 CMR 22.11(5)(a)3.

3. Supervisor/Consultant.

a. Academic Training. Minimum of a bachelor's degree in microbiology, biology, chemistry, or closely related fields.

b. Experience. Minimum of two years of work experience in measurements being considered for approval or certification.

c. Exception: A person who has served as a supervisor/consultant in an environmental laboratory or its equivalent for not less than two consecutive years in the last five years

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prior to June 24, 1977, and who does not meet the academic training or the experience requirements defined above, may be qualified as a supervisor/consultant but only if said person applies for qualification by not later than June 24, 1979 and the Department approves the application.

4. Laboratory Director. The laboratory director shall have sufficient training and experience, and shall exercise sufficient personal supervision over the laboratory, so that he or she is in fact exercising administrative and legal responsibility for the operation of the laboratory.

5. A certified laboratory shall notify the Department in writing when a change of Laboratory Supervisor/Consultant or Laboratory Director occurs, and shall submit a curriculum vita. This notification shall be submitted within ten days of the change. This requirement shall not apply when the new Supervisor/Consultant is a microbiologist made available to the laboratory by the Department pursuant to 310 CMR 22.11(5)(a)1c.

6. Laboratories which analyse only for turbidity or chlorine residual shall be exempt from the provisions of this 310 CMR 22.11(5)(a).

(b) An environmental laboratory requesting certification shall employ sufficient personnel and shall possess sufficient space to process and examine the sampling workload undertaken by the facility. Work areas shall be clean, well-lighted and properly ventilated. Adequate temperature controlled incubators shall be available to meet the requirements for the tests performed by the laboratory and sufficient refrigerated storage facilities shall be available for samples and for reagents used in the testing. All certified laboratories shall establish a health and safety program to protect personnel from laboratory hazards as recommended and required by Federal and State agencies.

(c) All reagents, glassware and equipment essential for the satisfactory performance of all laboratory analyses for which certification is requested shall be on hand or readily available on the premises. Testing instrumentation shall be in proper working order. All precision equipment (e.g. analytical balances, spectrophotometers, etc.) shall be calibrated at regular intervals. Records shall be maintained on the calibration history of each piece of precision equipment.

(d) The laboratory shall strictly adhere to the methods prescribed in these regulations for the determination of biological chemical, physical, or radiological parameters in environmental samples.

(e) Certified laboratories must maintain a quality control program to establish the precision of each analytical procedure for which they are approved and the accuracy embodied in their analytical results. This program shall include all of the following:

1. Records of the operation and maintenance of all laboratory equipment;
2. Records on control samples, standard calibration curves, incubator and autoclave operation;
3. Participation in a proficiency testing program administered by the Department; and
4. Quality control activities shall be documented on a regular and continuing schedule. Records on the laboratory's quality control program shall be maintained on file for at least two (2) years.

(f) Sufficient information shall accompany each sample to permit absolute identification. The specific information provided on the sampling certificate shall include the sample source, the location of the sampling site, the date and time of collection and the name of the individual collecting the sample.

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(g) Maintain records in strict conformity with the requirements of 310 CMR 22.17.
(h) Certified laboratories shall provide collection containers of the recommended size, quality and construction for collection of environmental samples, as well as any required preservative.
(i) Analytical results generated by out-of-state environmental testing laboratories for Massachusetts industries, municipalities, individuals, or suppliers of water may be reported and accepted if the out-of-state laboratory is certified or licensed by a federal agency or State having equivalent or higher standards than those prescribed in 310 CMR 22.11, as determined by the Department. In addition, such out-of-state laboratories may be required to participate in written examinations and proficiency testing programs by the Department.
(j) Certified laboratories shall be required to have current knowledge of all Federal and State drinking water standards for all categories in which they have been approved or certified. Certified laboratories shall immediately report the results of all samples which exceed an established maximum contaminant level to the supplier of water. The supplier of water shall be responsible for initiating immediate and appropriate follow-up action.
(k) A laboratory shall not be certified if it has not satisfied all of the requirements which said laboratory agreed to satisfy pursuant to 310 CMR 22.11(4).

(6) Provisional certification may be granted by the Department for ninety (90) days when all certification requirements are satisfied except an adequate proficiency testing program. During the provisional certification period, the laboratory shall analyze proficiency testing samples provided by the Department and shall submit a report on the results obtained. After evaluating the results of the proficiency testing, the Department shall either grant or withhold certification.

(7) A laboratory's certification may be revoked at any time for any of the following reasons:
(a) Non-adherence to analytical methods prescribed in these regulations.
(b) Failure to perform at satisfactory levels, as indicated by proficiency testing results.
(c) Reporting, as official examinations, results for any test not covered on the laboratory's certificate of approval.
(d) Permitting persons other than qualified laboratory personnel to perform and report results of environmental analyses.
(e) Reporting, as its own, results actually provided by
 1. laboratories in Massachusetts that are not certified by the Department; or
 2. Out-of-State laboratories that do not meet the reciprocity requirements of these regulations.
(f) Failure to promptly submit all reports and data required.
(g) The laboratory obtained the certificate through fraud, deceit, or submission of inaccurate information concerning personnel qualifications.

(8) A laboratory whose certification has been revoked may have certification reinstated through the following procedures:
(a) The Laboratory Director shall submit a written report to the Department detailing the specific corrections that have been made, or that the Director intends to make, in regard to the deficiencies that resulted in revocation of the certificate. This statement of intent shall include a projected completion date on which all deficiencies shall be corrected.

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(b) The Laboratory Director shall, at the same time, submit a written request for reinstatement review by the Department. The action taken to correct deficiencies will be observed during this on-site review.

(9) Certificates shall be valid for a period of one (1) year unless sooner revoked for cause. Certificates shall be prominently displayed on the premises of the laboratories certified.

(10) The Department shall publish or cause to be published at least annually a list of certified laboratories. This list shall include the name and location of the laboratory, the names of the director and supervisor/consultant and the categories of analyses in which the laboratory has been granted certification. Deletions from and additions to the list shall be available at the designated offices of the Department.

22.12: Consecutive Public Water Systems

When a public water system supplies water to one or more other public water systems, the Department may, notwithstanding any provision of 310 CMR 22.05 to 310 CMR 22.09, inclusive, to the contrary, modify the monitoring requirements imposed by these regulations to the extent that the interconnection of the systems justifies treating them as a single system for monitoring purposes. Any modified monitoring shall be conducted pursuant to a schedule given express written approval by the Department and approved by the Administrator or the Administrator's designee.

22.13: Variances

The Department may grant variances from the requirements of 310 CMR 22.05 to 310 CMR 22.09, inclusive, but only subject to the following conditions:

(1) The Department may grant one or more variances to one or more public water systems

(a) which, because of characteristics of the raw water sources which are reasonably available to the system(s), cannot comply with a prescribed maximum contaminant level or levels despite application of the best technology, treatment techniques, or other means, which the Department finds are generally available, taking costs into consideration. The Department shall not grant a variance pursuant to 310 CMR 22.13(1)(a) unless the Department finds in consultation with the Massachusetts Department of Public Health that the variance will not result in an unreasonable risk to health. If the Department grants a public water system a variance pursuant to 310 CMR 22.13(1)(a) the Department shall prescribe within one year of the date the variance is granted, a schedule for:

1. Compliance, including increments of progress by the public water system with each maximum contaminant level requirement with respect to which the variance was granted, and

2. implementation by the public water system of such control measures as the Department may require for each contaminant, subject to the maximum contaminant level requirement, during the period ending on the date compliance with such requirement is required.

(b) from any provision of these regulations which requires the use of a specified treatment technique with respect to a contaminant if the public water system applying for the variance demonstrates to the satisfaction of the Department that such treatment technique is not necessary to protect the health of persons because of the

22.13: continued

nature of the raw water source of such system. A variance granted pursuant to 310 CMR 22.13(1)(b) shall be conditioned on such monitoring and other requirements as the Department may prescribe.

(2) Before the Department grants any variance, or prescribes any schedule pursuant to any variance, the Department shall give notice and opportunity for public hearing to the public, to the Massachusetts Department of Public Health, and to the Agency. A notice given pursuant to 310 CMR 22.13(2) may cover the granting of more than one variance or the prescribing of more than one schedule, and a hearing held pursuant to such notice shall include each of the variances and schedules covered by the notice.

(3) The Department shall not accept any application for a variance unless the public water system applying for the variance agrees in writing to all of the following:
(a) Pay in full the cost of all notices and hearings required by 310 CMR 22.13(2).
(b) Comply with any schedule prescribed pursuant to 310 CMR 22.13(1)(a) as expeditiously as possible;
(c) Comply with any monitoring or other requirement prescribed pursuant to 310 CMR 22.13(1)(b).
(d) Report to the Department, in the manner prescribed in 310 CMR 22.15, the results of all tests, measurements and analyses made in compliance with the variance, and with the schedule and/or monitoring requirements prescribed pursuant to the variance;
(e) Report to the Department, in the manner prescribed in 310 CMR 22.15, any failure to comply with the terms of the variance, or with the schedule and/or monitoring requirements prescribed pursuant to the variance;
(f) Notify the public, in the manner prescribed in 310 CMR 22.16 of the granting of the variance;
(g) Notify the public, in the manner prescribed in 310 CMR 22.16 of any failure to comply with the variance or with any requirement of any schedule or monitoring requirement prescribed pursuant to the variance; and
(h) Maintain all the records prescribed in 310 CMR 22.17 in the manner prescribed in said 310 CMR 22.17.

(4) Every variance issued by the Department shall be conditioned on compliance by the public water system with the requirements set forth in 310 CMR 22.13(3). Said requirements shall have the same force and effect they would have if specifically set forth in these regulations.

(5) The Department shall promptly report to the Administrator or to the Administrator's designee, every variance granted by the Department. Such notification shall contain all of the following:
(a) The reason for the variance;
(b) The basis for the Department's finding that the granting of the variance will not result in an unreasonable risk to health, in those cases where the Department must make such a finding before granting a variance; and
(c) Documentation of the need for the variance.

(6) All applications for variances shall be made on forms prescribed by the Department.

22.14: Exemptions

The Department may exempt any public water system from any maximum contaminant level prescribed in 310 CMR 22.05 to 310 CMR 22.09, inclusive, or from any prescribed treatment technique, or from both, but only subject to the following conditions:

22.14: continued

(1) The department shall not grant any exemption unless the Department finds all of the following:
 (a) Due to compelling factors, which may include economic factors, the public water system is unable to comply with the maximum contaminant level requirement or the treatment technique requirement;
 (b) The public water system was in operation on the effective date of such maximum contaminant level requirement or treatment technique requirement; and
 (c) The granting of the exemption will not result in an unreasonable risk to health. The Department shall make this finding in consultation with the Massachusetts Department of Public Health.

(2) If the Department grants a public water system an exemption, the Department shall prescribe within one year of the date the exemption is granted, a schedule for
 (a) Compliance, including increments of progress, by the public water system with each maximum contaminant level requirement and treatment technique requirement with respect to which the exemption was granted, and
 (b) Implementation by the public water system of such control measures as the Department may require for each contaminant, subject to the maximum contaminant level requirement or treatment technique requirement, during the period ending on the date compliance with such requirement is required.

(3) Before the Department grants any exemption, or prescribes any schedule pursuant to any exemption, the Department shall give notice and opportunity for public hearing to the public, to the Massachusetts Department of Public Health, and to the Agency. A notice given pursuant to 310 CMR 22.14(3) may cover the granting of more than one exemption or the prescribing of more than one schedule, and a hearing held pursuant to such notice shall include each of the exemptions and schedules covered by the notice.

(4) The Department shall not accept any application for an exemption unless the public water system applying for the exemption agrees in writing to all of the following:
 (a) Pay in full the cost of all notices and hearings required by 310 CMR 22.14(3);
 (b) Comply with any schedule prescribed pursuant to 310 CMR 22.14(2) as expeditiously as possible, and in no event by later than the deadlines prescribed in 310 CMR 22.14(5);
 (c) Report to the department, in the manner prescribed in 310 CMR 22.15, the results of all tests, measurements, and analyses made in compliance with the exemption, and with the schedule prescribed pursuant to the exemption;
 (d) Report to the Department, in the manner prescribed in 310 CMR 22.15, any failure to comply with the terms of the exemption, or with the schedule prescribed pursuant to the exemption;
 (e) Notify the public, in the manner prescribed in 310 CMR 22.16 of the granting of the exemption;
 (f) Notify the public, in the manner prescribed in 310 CMR 22.16, of any failure to comply with the exemption or with any requirement of any schedule prescribed pursuant to the exemption;
 (g) Maintain all the records prescribed in 310 CMR 22.17 in the manner prescribed in 310 CMR 22.17.

(5) Every exemption shall be conditioned on compliance by the public water system with the following requirements, all of which shall have the same force and effect they would have if specifically set forth in these regulations:

22.14: continued

(a) All of the requirements set forth in 310 CMR 22.14(4).
(b) Except as provided in 310 CMR 22.14(5)(c), every schedule prescribed pursuant to an exemption shall require compliance by the public water system with each maximum contaminant level and treatment technique requirement with respect to which the exemption was granted as expeditiously as practicable and in no event later than
  1. January 1, 1981 in the case of an exemption granted with respect to a maximum contaminant level requirement or treatment technique requirement in effect on June 24, 1977; or
  2. Not later than seven years after the effective date of the maximum contaminant level requirement or treatment technique requirement with respect to which the exemption was granted if such requirement took effect after June 24, 1977.
(c) If the exemption was granted to a public water system which, as determined by the Department, has entered into an enforceable agreement to become a part of a regional water system, the schedule prescribed pursuant to the exemption shall require compliance by said public water system with each contaminant level and treatment technique requirement with respect to which the exemption was granted as expeditiously as practicable and in no event later than
  1. January 1, 1983 in the case of an exemption granted with respect to a maximum contaminant level requirement or treatment technique requirement in effect on June 24, 1977; or
  2. Not later than nine years after the effective date of the maximum contaminant level requirement or treatment technique requirement with respect to which the exemption was granted if such requirement took effect after June 24, 1977.

(6) The Department shall promptly report to the Administrator or to the Administrator's designee every exemption granted by the Department. Such notification shall contain all of the following:
(a) The reason for the exemption;
(b) The basis for the Department's finding that the granting of the exemption will not result in an unreasonable risk to health; and
(c) Documentation of the need for the exemption.

(7) All applications for exemptions shall be made on forms prescribed by the Department.

22.15: Reporting Requirements

(1) Every supplier of water shall report to the Department within 48 hours every failure to comply with any of these regulations applicable to the supplier of water, including failure to comply with any monitoring requirement applicable to the supplier of water pursuant to any of these regulations.

(2) Unless a shorter reporting period is prescribed in 310 CMR 22.15(1) or in any other provision of these regulations, the supplier of water shall report to the Department the results of every test, measurement or analysis the supplier of water is required by these regulations to make within (a) the first ten days following the month in which the results are received or (b) the first ten days following the end of the required monitoring period as stipulated by the Department, whichever of these is shorter.

(3) The supplier of water is not required to report analytical results to the Department in cases where a Department laboratory performs the analysis.

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(4) Every supplier of water shall report to the Department at least once each month the use of chemicals added to the water supply. Such reports shall include, but not be limited to, the name of the chemical, the amount added, the resulting concentration of the chemical in the water, and the reason for adding the chemical to the water.

(5) Every supplier of water shall report to the Department in January of each year on a form prescribed by the Department the amount of water that passes through their distribution systems during the preceding calendar year. Such reports shall include, at a minimum, the following:
(a) a monthly breakdown of the amount of water
1. purchased from other public water systems,
2. sold to other public water systems, and
3. sold or otherwise supplied to other consumers.
(b) an annual breakdown, to the extent known to the supplier of water, of the amount of water furnished during the year to each of the following classes of users:
1. residential users.
2. agricultural users.
3. commercial users.
4. industrial users.
5. other public water systems.
6. unaccounted for.

22.16: Public Notification Requirements

(1) Every community water system which fails to comply with an applicable maximum contaminant level, an applicable testing procedure, is granted a variance or an exemption from an applicable maximum contaminant level, fails to comply with the requirements of any schedule prescribed pursuant to a variance or exemption, or fails to perform any monitoring required by those regulations, shall notify persons served by the system of the failure or grant by inclusion of a notice in the first set of water bills of the system issued after the failure or grant and in any event by written notice within three months. Such notice shall be repeated at least once every three months so long as the system's failure continues or the variance or exemption remains in effect. If the system issues water bills less frequently than quarterly, or does not issue water bills, the notice shall be supplemented by or made by another form of direct mail.

(2) If a community water system has failed to comply with an applicable maximum contaminant level, the owner of operator shall notify the public of such failure, in addition to the notification required by 310 CMR 22.16(1), by all of the following methods:
(a) By publication on not less than three consecutive days in a newspaper or newspapers of general circulation in the area served by the system. Such notice shall be completed within fourteen days after the supplier of water learns of the failure. If the area served by a community water system is not served by a daily newspaper of general circulation, the notification by newspaper required by 310 CMR 22.16(2) shall instead be given by publication on three consecutive weeks in a weekly newspaper of general circulation serving the area. If no weekly or daily newspaper of general circulation serves the area, notice shall be given by posting the notice in post offices within the area served by the system.
(b) By furnishing a copy of the notice to the principal radio and television stations serving the area served by the system. Such notice shall be furnished within seven days after the supplier of water learns of the failure.
(c) Except that the requirements of 310 CMR 22.16(2)(b) may be waived by the Department if it determines that the violation has been eliminated, and there is no longer a risk to public health.

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(3) If a non-community water system fails to comply with an applicable maximum contaminant level, fails to comply with an applicable testing procedure, is granted a variance or an exemption from an applicable maximum contaminant level, fails to comply with the requirement of any schedule prescribed pursuant to a variance or exemption, or fails to perform any monitoring required by these regulations, the owner or operator shall give notices by continuous posting of such failure or granting of a variance or exemption to persons served by the system as long as the failure or granting of the variance or exemption continues.

(4) Notice given pursuant to this section shall be written in a manner reasonably designed to inform fully the users of the system. The notice shall be conspicuous and shall not use unduly technical language, unduly small print, or other methods which would frustrate the purpose of the notice. The notice shall disclose all material facts regarding the subject including the nature of the problem, and, when appropriate, a clear statement that a primary drinking water regulation has been violated, and any preventive measures that should be taken by the public. Where appropriate or where designated by the Department, bilingual notice shall be given. Notice may include a balanced explanation of the significance or seriousness to the public health of the subject of the notice, a fair explanation of steps taken by the system to correct any problem and the results of any additional sampling.

(5) In any instance in which notification by mail is required by 310 CMR 22.16(1) but notification by newspaper or to radio or television stations is not required by 310 CMR 22.16(2), the Department may order the supplier of water to provide notification by newspaper or in post offices, and to radio and television stations when circumstances make more immediate or broader notice appropriate to protect the public health.

(6) The provisions of 310 CMR 22.16(1) to 22.16(5), inclusive, do not apply to sodium. Instead, when the level of sodium exceeds the maximum contaminant level, the supplier of water shall notify persons served by the supply of the recommended level and the actual concentration of the substance in question.

In the case of a community water supply, such notification, together with an explanation of the reasons for the presence of the substance and possible ways of correcting the situation, such as treatment, development of new sources, chemical injection, etc., shall be sent to all persons served by the system at least annually by inclusion with a water bill. If the supplier of water does not issue water bills, the notice shall be made or supplemented by another form of direct mail.

In the case of a non-community water system notification shall conform to the requirements of 310 CMR 22.16(3) and 22.16(4).

(7) A copy of all notifications sent, issued or posted by the supplier of water in compliance with the requirments of this section shall be furnished to the Department no later than the time it is given to the user of the system.

(8) Whenever the Department deems such action appropriate, the Department may, on behalf of the supplier of water, give any notice to the public required by 310 CMR 22.16. The provisions of 310 CMR 22.16(8) shall not excuse any supplier of water from itself giving any notice required by 310 CMR 22.16.

22.17: Record Maintenance

All suppliers of water or certified laboratories as appropriate shall retain on their premises or at a convenient location near their premises in a form admissible as evidence in Massachusetts Courts the following records:

(1) Records of bacteriological analyses made pursuant to these regulations shall be kept for not less than 5 years. Records of chemical analyses made pursuant to these regulations shall be kept for not less than 10 years. Actual laboratory reports may be kept, or data may be transferred to tabular summaries, provided that such summaries are in a form admissible as evidence in Massachusetts Courts and that all of the following information is included:

(a) The date, place and time of sampling, the full name of the person who collected the sample and the agency or organization for which that person works;
(b) Identification of the sample as to whether it was a routine distribution system sample, check sample, raw or process water sample or other special purpose sample;
(c) Date of analysis;
(d) Laboratory and person responsible for performing analysis;
(e) The analytical technique/method used; and
(f) The results of the analysis.

(2) Records of action taken by the system to correct violation of these regulations shall be kept for a period not less than 3 years after the last action taken with respect to the particular violation involved.

(3) Copies of any written reports, summaries, or communications relating to sanitary surveys of the system conducted by the system itself, by a private consultant, or by any local, State or Federal agency, shall be kept for a period not less than 10 years after completion of the sanitary survey involved.

(4) Records concerning a variance or exemption granted to the system shall be kept for a period ending not less than 5 years following the expiration of such variance or exemption.

(5) Records concerning the use of chemicals added to the water supply shall be kept for not less than 5 years. Said records shall include the information prescribed in 310 CMR 22.15(4).

(6) Records of the sizes and materials of construction of all water mains, records of materials used in joints of water mains, and records of the materials of construction of all services shall be maintained.

22.18: Right of Entry

All suppliers of water shall authorize agents and employees of the Commonwealth, upon presentation of their credentials, to enter their premises, excluding dwelling places, without a warrant for the purpose of inspecting, surveying and sampling public water systems, whether or not the Commonwealth has evidence that the system is in violation of an applicable legal requirement.

22.19: Distribution System Requirements

In order to protect the distribution system of a public water system from contamination the following requirements shall be applied:

(1) All service connections shall have a minimum residual water pressure at street level of at least 20 pounds per square inch under all design conditions of flow.

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(2) All water storage tanks connected to a distribution system of a public water system shall be constructed and located so as to adequately protect the water from contamination. Tanks and basins shall be covered and vents and overflow pipes screened. They shall not be directly connected to sanitary sewers or to storm drainage systems. Sewers, drains, standing water and similar sources of possible contamination must be kept at least 50 feet from the tank or basin. Water main pipe, pressure tested to 50 pounds per square inch without leakage, may be used for gravity sewers at distances greater than 20 feet and less than 50 feet.

(3) Existing uncovered distribution storage tanks or basins may be continued in use but only if all of the following requirements are met:

(a) A free chlorine residual of at least 0.25 milligrams per liter or more, as directed by the Department, after 10 minutes of contact time is maintained at all times in the water leaving the tank or basin.

(b) The water leaving the tank or basin meets the requirements prescribed in 310 CMR 22.05 and 310 CMR 22.08 for coliform bacteria and turbidity, respectively, as measured by at least daily samples, and the supplier of water has submitted a written schedule, approved in writing by the Department, indicating dates by which the tank or basin will be covered.

(4) The Department may grant variances from the provisions of 310 CMR 22.19, but only after giving notice and opportunity for hearing to the public and to the Massachusetts Department of Public Health.

(5) Suppliers of water for community public water systems shall collect samples from a representative entry point to the water distribution system for the purpose of analysis to determine the corrosivity characteristics of the water.

(a) The supplier shall collect two samples per plant for analysis for each plant using surface water sources wholly or in part; one during mid-winter and one during mid-sumer. The supplier of the water shall collect one sample per plant for analysis for each plant using ground water sources. The minimum number of samples required to be taken by the system shall be based on the number of treatment plants used by the system, except the multiple wells drawing raw water from a single aquifer may, with the approval of the Department, be considered one treatment plant for determining the minimum number of samples. The Department may, in specific instances, require more samples than authorized above.

(b) Determination of the corrosivity characteristics of the water shall include measurement of pH, calcium hardness, alkalinity, temperature, total dissolved solids (total filterable residue), and calculation of the Langelier Index in accordance with 310 CMR 22.19(7). The determination of corrosivity characteristics shall only include one round of sampling (two samples per plant for surface water and one sample per plant for ground water sources). However, in addition, the Department has the discretion to require monitoring for additional parameters which may indicate corrosivity characteristics, such as sulfates and chlorides. The Aggressive Index, as described in 310 CMR 22.19(7)(b) can be used instead of the Langelier Index with the approval of the Department.

(6) The supplier of water shall report to the Department the results of the analyses for the corrosivity characteristics within the first 10 days of the month following the month in which the sample results were received. If more frequent sampling is required by the Department, the supplies can accumulate the data and shall report each value within 10 days of the month following the month in which the analytical results of the last sample was received.

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(7) Analyses conducted to determine the corrosivity of the water shall be made in accordance to the following methods:
- (a) Langelier Index - "Standard Methods for the Examination of Water and Wastewater," 14th Edition, Method 203, pp. 61-63.
- (b) Agressive Index - "AWWA Standard for Asbestos-Cement Pipe, 4 in through 24 in for Water and Other Liquids," AWWA C400-77, Revision of C400-75, AWWA, Denver Colorado.
- (c) Total Filtrable Residue - "Standard Methods for the Examination of Water and Wastewater," 14th Edition, Method 208B, pp. 92-93; or "Methods for Chemical Analysis of Water and Wastes." Method 160.1.
- (d) Temperature - "Standard Methods for the Examination of Water and Wastewater," 14th Edition, Method 212, pp. 125-126.
- (e) Calcium Hardness - EDTA Titrimetric Method "Standard Methods for the Examination of Water and Wastewater," 14th Edition, Method 309B, pp. 202-206; or "Annual Book of ASTM Standards," Method D1126-67 (8).
- (f) Alkalinity - Methyl Orange End Point pH 4.5. "Standard Methods for the Examination of Water and Wastewater," 14th Edition, Method 403, pp. 278-281; or "Annual Book of ASTM Standards," Method D1067-70-B; or "Methods for Chemical Analysis of Water and Wastes," Method 310.1.
- (g) pH - "Standard Methods for the Examination of Water and Wastewater," 14th Edition, Method 424, pp. 460-465; or "Methods for Chemical Analysis of Water and Wastes," Method 150.1; or "Annual Book of ASTM Standards," Method D129378 A or B.
- (h) Chloride - Potentiometric Method, "Standard Methods for the Examination of water and Wastewater," 14 Edition, p. 306.
- (i) Sulfate - Turbidimetric Method, "Methods for Chemical Analysis of Water and Wastes," pp. 277-278, EPA. Office ofTechnology Transfer, Washington, D.C. 20460, 1974, or "Standard Methods for the Examination of Water and Wastewater," 13th Edition, pp. 334-335, 14th Edition, pp. 496-498.

22.20: Surface Water Supplies

(1) To protect surface waters used as sources of drinking water supply from contamination, the requirements of 310 CMR 22.20 shall apply to all land and watercourses used as or tributary to a public water system except:
- (a) Rivers and streams used as sources of supply when the rivers and streams are not impounded at some point by means of a dam or dike to create a reservoir at which the water supply intake is located.
- (b) Certain watercourses or bodies of water used as sources of public water supply where conditions are imposed by specific legislation.
- (c) Certain watercourses or bodies of water where in the express written opinion of the Department sufficient provisions have been made by means of treatment, storage, restrictions on the time of diversion, or other means to assure an acceptable quality of water.
- (d) Emergency sources approved by the Department under the provisions of General Laws, Chapter 40, Section 40.

(2) No cesspool, privy, septic tank, dry well, leaching field, filter or other place for the reception, deposit, or storage of human excrement; no device for the collection of house slops, sink waste, water which has been used for washing or cooking, or other polluted water; and no hitching or standing place for horses, cattle or other animals shall be located, constructed, or maintained within one hundred feet of the high water mark of such source of water supply or tributary thereto.

(3) No human excrement, or compost containing human excrement, or municipal, commercial or industrial refuse or waste product or polluting liquid or other substance which in the opinion of the Department is of

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a nature poisonous or injurious either to human beings or animals, or other putrescible organic matter whatsoever, shall be discharged directly into or at any place from which such liquid or substance may flow or be washed or carried into said source of water supply or tributary thereto.

(4) No burial shall be made, except by permission in writing by the Board of Water Commissioners or like body having jurisdiction over such source of supply, in any cemetery or other place within 100 feet of the high water mark of a source of public water supply or tributary thereto. No lands not under the control of cemetery authorities and used for cemetery purposes, from which lands the natural drainage flows into said source of water supply or tributary thereto, shall be taken or used for cemetery purposes until a plan and sufficient description of the lands is presented to the Department and until such taking or use is expressly approved in writing by the Department.

(5) No system of sewers or other works for the collection, conveyance, disposal, or purification of domestic, municipal, commercial or industrial sewage or drainage, or other hazardous or putrescible matter whatsoever shall be constructed or maintained at any place within the watershed of such source of water supply or tributary thereto unless such system is in accordance with the State Environmental Code (310 CMR 11.00 to 310 CMR 18.00, inclusive),and the State Plumbing Code (248 CMR 1.01 through 2.22). Where these codes are not applicable the plans and specifications shall be approved in writing by the Department prior to construction.

(6) No public or private hospital or other place intended for the treatment of persons afflicted with a contagious or infectious disease, and no manufacturing or processing plant producing wastes which are toxic or injurious either to human beings or animals, shall, until the location thereof has been expressly approved in writing by the Department, be located or constructed at any place within the watershed of a source of public water supply or tributary thereto. No such facility shall be maintained at any place within the watershed, unless the facility has complied with all the provisions required by the Department or orders issued by the Department, for the treatment or disposal of sewage, drainage, or other hazardous substances or matter, which may be discharged therefrom.

(7) No person shall wade or bathe in any source of drinking water supply, and no person shall, unless permitted by written permit by the Board of Water Commissioners or like body having jurisdiction over such source of supply, fish in; enter or go in any boat, seaplane, or other contrivance; enter upon the ice for any purpose, including the cutting or taking of ice; or cause any animal to go in or upon such source of water supply or tributary thereto.

(8) All reports which may be made to any board of health, or to any health officer of any town, of cases of contagious or infectious disease occuring within the watershed of such source of water supply or tributary thereto, shall be open to inspection at all reasonable times by the Board of Water Commissioners or like body having jurisdiction over such source of supply, by its officers or agents, and by the Department.

(9) The supplier of water shall cause regular and thorough inspections to be made of the water shed to ascertain compliance with 310 CMR 22.21. It shall be the duty of the aforesaid supplier of water to cause copies of any rules and regulations violated to be served upon the persons violating the same together with notices of such violations.

22.20: continued

If such persons do not immediately comply with the rules and regulations, it shall be the further duty of the aforesaid supplier of water to take appropriate action to enjoin such violations and to promptly notify the Department of such violations. The aforesaid supplier of water shall report to the Department in writing annually, prior to the 30th day of January, the results of the regular inspections made during the preceding calendar year. The report shall state the number of inspections which were made, the number of violations found, the number of notices served, the number of violations abated and the general condition of the watershed at the time of the last inspection.

22.21: Ground Water Supplies

To protect ground waters used as sources of drinking water supply from contamination the following requirements shall be applied:

(1) Where a community water system derives its water entirely from ground water sources, standby wells and pumping equipment, or their equivalent, shall be provided except where
- (a) An interconnection with another approved public water supply can be provided or
- (b) The standby requirement is exempted by the express written order of the Department.

(2) Suppliers of water shall acquire sufficient land around wells, infiltration galleries, springs, and similar sources of ground water used as sources for drinking water to protect the water from contamination. This requirement shall generally be deemed to have been met if all land within 400 feet of a gravel packed well or 250 feet of a tubular well with a diameter of 2 1/2 inches or less is under the ownership or control of the supplier of water. The Department may order greater distances or permit lesser distances than the distances required herein if the Department deems such order or permission necessary or sufficient to protect the public health.

(3) The supplier of water for a community water system shall cause regular and thorough inspections to be made of the area surrounding the well to ascertain whether 310 CMR 22.21 is being complied with. It shall be the duty of the aforesaid supplier of water to cause copies of any rules and regulations violated to be served upon the persons violating the same together with notices of such violations. If such persons served do not immediately comply with the rules and regulations it shall be the further duty of the aforesaid supplier of water to take appropriate action to enjoin such violations and to promptly notify the Department of such violations. The aforesaid supplier of water shall report to the Department in writing annually, prior to the 30th day of January, the results of the regular inspections which were made during the preceding calendar year. The report shall state the number of violations found, the number of notices served, the number of violations abated and the general condition of the area surrounding the well at the time of the last inspection.

22.22: Cross Connections

(1) Definitions. As used in 310 CMR 22.22, unless the context indicates otherwise, the following words shall have the following meanings:
- (a) "Air-Gap" shall mean the unobstructed vertical distance through the free atmosphere between the lowest opening from any pipe or faucet supplying water to a tank, plumbing fixture, or other device and the flood level rim of the receptacle.
- (b) "Backflow" shall mean the flow of water or other liquids, mixtures, or substances into the distribution pipes of a potable supply of water from any source or sources other than the intended source.

22.22: continued

(c) "Backflow Preventer with Intermediate Atmospheric Vent" shall mean a device having two independently operating check valves separated by an intermediate chamber with a means for automatically venting it to the atmosphere. The check valves are force loaded to a normally closed position; the venting means is force loaded to a normally open position.

(d) "Approved Backflow Preventer" shall mean a device or means approved by the Department to prevent backflow.

(e) "Back Pressure" shall mean pressure created by mechanical means or other means causing water, liquids, or other substances to flow or move in a direction opposite to what is intended.

(f) "Back Siphonage" shall means a form of backflow due to reduced or sub-atmospheric pressure within a public water system.

(g) "Barometric Loop" shall mean a loop of pipe rising at least 35 feet, at its topmost point, above the highest fixture it supplies.

(h) "Chack Valve" shall mean a self-closing device which is designed to permit the flow of fluids in one direction and to close if there is a reversal of flow.

(i) "Contaminant" shall mean any physical, chemical, biological or radiological substance or matter in water.

(j) "Cross Connection" shall mean any actual or potential connection between a public water system, any waste pipe, soil pipe, sewer, drain, or any unapproved source or system. Without limiting the generality of the foregoing, the term "cross connection" shall also include any by-pass arrangements, jumper connections, removal section, swivel or changeover devices, and other temporary section or permanent device through which or because of which backflow can or may occur.

(k) "Department" shall mean the Massachusetts Department of Environmental Quality Engineering.

(l) "Health Hazard" shall mean actual or potential threat of contamination of the public water syste, including the consumer's potable water system, to such a degree that there would be danger to health in the opinion of the Department.

(m) "Person" shall mean an individual, corporation, company, association, trust, partnership, the Commonwealth, a municipality, district, or other subdivision or body politic of the Commonwealth, or any department, agency, or instrumentality of the United States, except that nothing herein shall be construed to refer to or to include any American Indian tribe, or the United States Secretary of the Interior on his capacity as trustee of Indian lands.

(n) "Potable Water" shall mean water from any source which has been approved by the Department for human consumption.

(o) "Public Water System" shall mean a system for the provision to the public of piped water for human consumption, if such system has at least fifteen (15) service connections or regularly serves an average of at least twenty-five (25) individuals daily at least sixty (60) days of the year. Such term includes (1) any collection, treatment, storage, and distribution facilities under control of the operator of such a system and used primarily in connection with such system; and (2) any collection or pretreatment storage facilities not under cuh control which are used primarily in connection with such system. A public water system is either a "comunity water system" or a "non-community water system".

1. "Community water system" shall mean a public water system which serves at least fifteen (15) service connections used by year-round residents or regularly serves at least twenty-five (25) year-round residents.

2. "Non-community water system" shall mean a public water system that is not a community water system.

(p) "Reduced Pressure Backflow Preventer" shall mean a device incorporating (1) two or more check valves, (2) an automaticly operating differential relief valve located between the two checks, (3) two shutoff valves, and (4) necessary appurtenances for testing.

22.22: continued

The device shall operate to that the pressure in the zone between the two check valves is maintained at a value less than the pressure on the public water system side of the device. At cessation of normal flow, the pressure between the check valves shall be less than the supply pressure. In case of leakage of either check valve, the differential relief valve shall oeprate to maintain reduced pressure by discharging to the atmosphere.

(q) "Supplier of Water" shall mean any person who owns or operates a public water system.

(r) "Unapproved Water Supply" shall mean any water not approved by the Department as safe for human consumption.

(s) "Atmosphere Vacuum Breaker" shall mean a device used to prevent back siphonage and not to be used under static line pressure.

(2) Responsibility.

(a) The Department has the following responsibilities relative to cross connections:

1. Establishment and administration of regulations covering cross connections;
2. reviewing and approving plans for proposed new installation of air gaps with tank and pump arrangements, reduced pressure backflow preventers or double check valve assemblies before they may be lawfully installed or maintained;
3. Inspection of new installations for compliance with approved plans;
4. Issuing permits to maintain approved cross connections as indicated in 310 CMR 22.22(4);
5. Providing advice and assistance to others involved in program elements under 310 CMR 22.22;
6. Surveying commercial, industrial, and institutional buildings served by the public water system to determine if cross connections exist, whenever the Department deems such surveys necessary;
7. Annual inspection and testing of approved backflow preventers.

(b) The supplier of water is responsible for the safety of the public water system under its jurisdiction, and shall have the following specific responsibilities relative to cross connections:

1. Making semi-annual inspections of all approved backflow prevention devices installed on the distribution system:
2. Assisting Department personnel in annual inspections of approved backflow prevention devices;
3. Inspecting all commercial, industrial and institutional premises served by the public water system to determine if cross connections exist, whenever the supplier of water deems such inspections necessary;
4. Taking appropriate action to eliminate hazardous conditions;
5. Reporting to the Department any violations of these regulations found in surveys or otherwise;
6. Maintaining records of inspections of approved backflow preventers, and submitting copies of the records of the inspections to the Department.

(c) The owner of any permit for a cross connection has the following responsibilities relative to cross connections:

1. Applying annually for renewal of the permit;
2. Having suitable arrangments made so that inspections can be made during regular business hours;
3. Maintaining a spare parts kit and special tools as indicated in 310 CMR 22.22(8);
4. Providing necessary labor for inspection and testing by the Department or supplier of water as indicated in 310 CMR 22.22(8);
5. Testing double check valve installations monthly, testing reduced pressure backflow preventers quarterly, and maintaining records of the testing as required by 310 CMR 22.22(9)(c)

22.22: continued

(d) Local plumbing inspectors are required by the State Plumbing Code to be cognizant of cross connections and to have eliminated any violation coming to their attention.
(e) The Board of State Examiners of Plumbers and Gas Fitters approves types and models of atmospheric vacuum breakers and of backflow preventers with intermediate atmospheric vent which may be used in Massachusetts for certain low hazard applications referred to in the State Plumbing Code. Examples of such applications are shown in Table 22-1.
(f) The backflow devices described in 310 CMR 22.22(2)(e) shall be installed and inspected under a permit issued by the local Plumbing Inspector or by the Board of State Examiners of Plumbers and Gas Fitters.

(3) Cross Connections Prohibited; Exceptions
(a) In all cases, plumbing cross connections are prohibited by 310 CMR 22.22 and the supplier of water shall have the authority to prohibit and shall prohibit cross connections unless the following requirements are net:
1. The public water system is protected by a method meeting the requirements of 310 CMR 22.22, and
2. Approved backflow preventers or vacuum breakers are properly installed wherever the potable water outlet may be submerged, and
3. Plans, drawings, and specifications showing the method of protecting the public water system have been approved by the Department prior to construction and installation.
(b) No supplier of water shall supply water to any person maintaining a connection which does not meet the approval and permit requirements of the Department and the Requirements of the Board of State Examiners of Plumbers and Gas Fitters.

(4) Permit Required
(a) The person having jurisdiction over a cross connection meeting the requirements of 310 CMR 22.22(3) shall obtain a separate permit from the Department annually for each double check valve assembly and reduced pressure backflow preventer installed in accordance with approved plans. Permits shall expire on December 31 of each year.
(b) After notice and opportunity for a hearing, the Department may revoke any permit at any time whenever, in the opinion of the Department, the cross connection or the maintenance thereof no longer complies with 310 CMR 22.22. A request for a hearing shall not authorize any person to maintain the cross connection in question pending the outcome of the hearing, unless the Department by written order prescribes otherwise.
(c) No person shall maintain a cross connection without a permit or after revocation of the permit.

(5) Location of Protective Devices. The location of the backflow preventer with respect to the plumbing on the premises and the service connection will be determined by the degree of hazard existing or potentially existing and shall conform to the following requirements:
(a) Proper location of the approved backflow preventer(s) allows for simultaneous protection of the public water supply distribution system and the potable water system within the premises. This type of installation, referred to as "in-plant protection", is required whenever feasible in the opinion of the Department.
(b) Approved backflow preventers shall be located so as to achieve protection of all cross connections with a minimum number of devices.

22.22: continued

Table 22-1

310 CMR: DEPARTMENT OF ENVIRONMENTAL QUALITY ENGINEERING

TABLE 22-1

RPBD - REDUCED PRESSURE BACKFLOW DEVICE
DCVA - DOUBLE CHECK VALVE ASSEMBLY
AVB - ATMOSPHERIC VACUUM BREAKER
BFPAV - BACKFLOW PREVENTER WITH INTERMEDIATE ATMOSPERIC VENT

TYPE OF HAZARD ON PREMISES	ACCEPTABLE TYPES OF BACKFLOW PREVENTER					COMMENTS
	AG	RPBD	DCVA	AVB	BFPAV	
1. Sewage Treatment Plant	X	X				
2. Sewage Pumping Station	X	X				
3. Food Processing	X	X	X*			* If No Health Hazard Exists
4. Laboratories	X	X				
5. Sinks with hose threads on inlet	X	X		X		
6. Hospitals, Mortuaries, Clinics	X	X				
7. Plating Facilities	X	X				
8. Irrigation Systems	X	X		X*		Each Case Should Be Treated Individually * If No Back Pressure Exists
9. Radioactive Material Nuclear Reactors	X	X				
10. Submerged Inlets	X	X		X*		*If No Health Hazards Exists and No Back Pressure
11. Dockside Facilities	X	X				
12. Valved outlets or fixtures with hose attachments	X	X	X*	X**		Each Case Should be Treated Individually *If No Health Hazard Exists **If No Health Hazard Exists and No Back Pressure
13. Commercial Laundries	X	X				

22.22: continued

Table 22-1 continued

Table 22-1 Continued

RPBD - REDUCED PRESSURE BACKFLOW DEVICE
DCVA - DOUBLE CHECK VALVE ASSEMBLY
AVB - ATMOSPHERIC VACCUM BREAKER
BFPAV - BACKFLOW PREVENTER WITH INTERMEDIATE ATMOSPHERIC VENT

TYPE OF HAZARD ON PREMISES	ACCEPTABLE TYPES OF BACKFLOW PREVENTERS					COMMENTS
	AG	RPBD	DCVA	AVB	BFPAV	
14. Commercial Dishwashing Machines	X	X		X		
15. High and Low Pressure Boilers	X	X				If chemicals are added more frequently than once a year.
16. Low Pressure Heating Boilers					X	Residential and small commercial, having no chemical or chemicals added no more often than once a year.
17. Photo Processing Equipment	X	X				
18. Reservoirs-Cooling Tower Recirculating Systems	X	X	X*			*If No Health Hazards Exits
19. Fire Fighting Systems	X	X	X*			*If No Health Hazards Exits
20. Solar Energy Systmes	X	X			X*	*Residential and Small Commercial having no Chemicals or only USP Glycerine added to water.

22.22: continued

(c) When high or varying degrees of hazard exist, in-plant protection must be supplemented by additional protection at the meter or property line. The following list gives examples of type of facilities which must have additional protection at the meter or property line:

1. Nuclear reactors or other facilities where radioactive materials are used;
2. Sewage treatment plants and pumping stations;
3. Piers, docks, marinas, shipyards;
4. Chemical plants;
5. Metal plating industries;
6. Hospitals, mortuaries, clinics;
7. Laboratories, except when the Department determines no health hazard exists;
8. Others specified in writing by the Department.

(d) In premises where it would be impossible to locate all cross connections, or where the internal water piping system is frequently changed, or when economic reasons do not allow protection of all cross connections, the public water system's distribution system must be protected by means of an approved type backflow preventer or air gap separation at the meter or the building or property line and the owner of the premises must provide potable water for domestic purposes.

(6) Types of Backflow Preventer Required.

(a) Depending on the degree of hazard and type of backflow involved, the Department may deem acceptable air-gap separation, reduced pressure backflow preventers, double check valves, non-pressure type vacuum breakers, or barometric loops as backflor preventers. Table 22-1 is a guide for the protection required against certain types of hazards.

(b) Each distribution system has unique problems and cross connections found within premises occur in a variety of forms and vary in nature such that the protection of each installation must be considered in the light of conditions found to exist. Therefore, the Department shall make the final determination as to what type of backflow prevention shall be required.

(c) There shall be no by-pass around any approved backflow preventer unless an approved backflow preventer is installed on the by-pass.

(d) Reduced pressure backflow preventers, double check valve assemblies, and any manufactured air-gap items used pursuant to 310 CMR 22.22 must be types and models specifically approved by the Department.

(e) Atmospheric vacuum breakers and other backflow prevention devices must meet the requirements of the Board of State Examiners of Plumbers and Gas Fitters.

(7) Approval of Devices for Use In Massachusetts.

(a) The Department shall maintain a list of the approved or provisionally approved backflow preventers mentioned in 310 CMR 22.22(6)(d).

(b) The Department shall consider the suitability of a specific size and model of device for use in cross connection control in the Commonwealth after receipt of all of the following information:

1. A laboratory test report from an independent testing laboratory, based on American Society of Sanitary Engineering Standard No. 1013, No. 1015, or American Water Works Association Standard C-506-78 or University of Southern California Specifications.
2. A report of a field test conducted for one year under supervision of an independent laboratory in conformance with University of Southern California Specifications or American Water Works Association Standard C-506-78.

22.22: continued

3. A copy of ASSE Certification Seal of U.S.C. Certificate of Approval.
4. Current catalogs and specifications information installation instructions, service and maintenance manuals.

(c) A specific size and model of device may be classified as provisionally approved upon receipt of information indicating that the device has given satisfactory performance under the tests referred to in 310 CMR 22.22(7)(b) and upon receipt of the certificate of approval referred to therein, provided that the materials of construction meet the following requirements:

1. The bodies and internal parts of mechanical devices shall be of corrosion resistant material approved by the Department.
2. The clapper or poppet facing rings and the relief valve facing rings must be of a molded synthetic rubber.

(d) After a provisionally approved device gives trouble free operation for a period of one year in the Commonwealth in an approved installation, the device shall be classified as fully approved except that provisional approval may be extended at the discretion of the Department.

(8) Installation Practices.

(a) "Reduced Pressure Backflow Preventer". This device, effective against backflow caused by back pressure or back siphonage, is used to protect the public water system from substances which are hazardous to health.

1. For in-plant protection, the reduced pressure backflow preventer shall be installed on the customer's side of the water meter on the potable water supply line.
2. Drinking and domestic water lines, lines for safety showers, and lines for eye wash devices must be taken off the upstream side of the backflow preventer.
3. The backlfow preventer shall be located so as to permit easy access and provide adequate and convenient space for maintenance, inspection, and testing.
4. The backflow preventer and shut-off valves must be installed in a horizontal line between 3 and 4 feet from the floor and a minimum of 6 inches from any wall.
5. Tightly closing valves must be installed at each end of the device.
6. The device must be protected from freezing, flooding, and mechanical damage.
7. If the device is to be installed on a hot water line, a device approved for use at the elevated temperature must be used.
8. If a drain is to be provided for the relief valve port, there must be an approved air-gap separation between the port and drain line. To be approved, the air-gap must be at least twice the internal diameter of the discharge line.
9. Before installing a backflow preventer, pipelines shall be thoroughly flushed to remove foreign material.
10. The owner or owner's agent must maintain a spare parts kit and any special tools required for removal and re-assembly of devices.
11. The owner or owner's agent must provide necessary labor for inspection and testing performed by the Department or the supplier of water.
12. Pit installation is strongly discouraged and will be approved only in special unusual cases. See 310 CMR 22.22(8)(f).

(b) "Double Check Valves". A double check valve assembly is effective against backflow caused by back pressure or back siphonage and can be used to protect the public water system from substances which may be objectionable but not hazardous to health.

1. Drinking and domestic water lines, lines for safety showers, and lines for eye wash devices must be taken off the upstream side of the check valves.

22.22: continued

2. The double check valve assembly shall be installed with adequate speace to facilitate maintenance, insepction, and testing.
3. The top of the check valves must be a minimum of 30 inches and a maximum of 54 inches from the floor.
4. There must be at least 12 inches clearance between check valves and any wall.
5. If a water meter is not provided on the upstream side of the double check valve assembly, a 3 to 5 foot spacer must be installed between the check valves.
6. Tightly closing valves must be installed at each end of the assembly.
7. Check valves must be provided with suitable connections and appurtenances for testing.
8. The owner or owner's agent must maintain a spare parts kit and any special tools required for removal and reassembly of devices.
9. The owner or owner's agent must provide necessary labor for the inspection and testing performed by the Department or the supplier of water.
10. The check valves must be protected against flooding, freezing, and mechanical damage.
11. Pit installation is strongly discouraged. See 310 CMR 22.22(8)(f).

(c) "Atmospheric Vacuum Breaker". The atmospheric vacuum breaker, designed to prevent back siphonage, is not effective against backflow due to back pressure. See 310 CMR 22.22(6)(e).

1. Vacuum breakers must be installed at least six inches above the flood level rim of the fixture they serve.
2. The device must be installed downstream of the last shut off serving the fixture or equipment.
3. Vacuum breakers must not be installed in locations where the device is subject to corrosive fumes, dust or grit.
4. The device must be protected against freezing and mechanical abuse.
5. If vacuum breakers are used as protection on tanks containing liquids which are hazardous to health, further protection will be required on the main water line.
6. Atmospheric vacuum breakers must not be used under conditions of static line pressure.

(d) "Barometric Loop". A barometric loop is effective against back siphonage only and will be approved only when no health hazard exists and back pressure is not anticipated.

(e) "Fire Protection Systems". Private fire protection systems, because of their varying degrees of hazard, must be evaluated by the Department to determine the type of backflow prevention required. Therefore, no changes in either the equipment comprising a system or the source of water supply for the system shall be made without prior approval of the Department. Also, the approval of the Department shall be obtained before any chemicals are used in the system. Buildings having the following actual or potential cross connections shall be required to have backflow prevention:

1. Any system with a pumper connection into which chemical additives may be injected by fire department equipment.
2. Fire systems which may be subject to contamination with anti-freeze, "Foamite", or other chemicals used in fighting fires.
3. Fire systems subject to contamination from auxiliary or used water supplies or private storage tanks.
4. Fire systems and storage reservoirs which may be treated for prevention of scale formation, corrosion, algae, slime growths.
5. Fire systems with pumper connections within 1,500 feet of an auxiliary unapproved water supply.

Gate valves required for fire protection systems must be OS&Y type.

22.22: continued

(f) "Pit Construction". Installation within a pit shall not be permitted except under exceptional circumstances, and then only as follows:

1. The pit interior shall be a minimum of 10 feet long, 4½ feet wide, and must have a clear height of 6½ feet high.
2. The pit must be of watertight construction.
3. The pit opening and manhole cover must be at least 27 inches in diameter.
4. The foot-hold inserts must be of steel, aluminum, or other material approved by the Department, must be a maximum of 12 inches apart, and must be installed so that the top foot-hold is within 12" of the pit opening and the bottom foot-hold is within 12" of the pit floor.
5. An adequate drain must be installed. The drain line shall not be connected to a sewer.
6. The floor shall be pitched to drain.
7. If built in a roadway, the top of the pit must be adequately reinforced.

(9) Inspection, Testing and Overhauling of Devices.

(a) After approval of plans and installation of approved devices, the owner or installer shall notify the Department so that arrangements can be made for an inspection by the Department.

(b) Approved backflow preventers shall be tested annually by the Department. More frequent testing of any device subject to repeated failure on testing may be specified by the Department.

(c) Approved backflow preventers shall be tested semiannually by the supplier of water.

(d) The owner or owner's agent must test double check valve installations monthly and reduced pressure backflow preventers quarterly. A record of the date and results of the test must be kept and made available on request to the supplier of water or representatives of the Department.

(e) Devices failing the test or found defective shall be overhauled, repaired or replaced.

(f) Reduced pressure backflow preventers and double check valves shall be inspected internally and completely overhauled at least once every five years.

(g) Some iron bodied double check valves, installed before prohibited by pertinent rules and regulations, are still in use. Iron bodied double check valves must be overhauled and cleaned yearly.

(10) Penalties. Section 160A of Chapter 111 of the General Laws provides, in part, as follows: "Whoever maintains such a connection without a permit or after revocation of the permit to maintain such connection shall be punished by a fine of not more than five hundred dollars, to the use of the Commonwealth, or by imprisonment for not more than one year, or both."

REGULATORY AUTHORITY

310 CMR 22.00: M. G. L. c. 111, s. 160A.

NON-TEXT PAGE

C-2.8 June 1974 letter from Woburn City Engineer to Massachusetts Department of Public Health regarding reactivation of wells G and H for emergency supply.

E

City of Woburn
Massachusetts

DEPARTMENT OF PUBLIC WORKS
ENGINEERING DIVISION

THOMAS J. MERNIN, P.E.
CITY ENGINEER

June 17, 1974

Mr. George J. Coogan, Director
Bureau of Water Supply 727-2692
Dept. of Public Health
600 Washington Street
Boston, Mass.

Dear Sir:

This is to notify your office that the City is considering activating its East Woburn Well Field for emergency water supply purposes. Inclosed are copies of the Chemical Analysis for both Wells and I was informed by Mr. Kenneth Tarbell of your Tewksbury office that the Bacterial Analysis for both Wells was zero. If there are any questions concerning this matter please contact this office.

Yours truly,

Thomas J. Mernin, P.E.
City Engineer

TJM/js

cc: Mr. Albert Wall

[illegible]

WATER [illegible] per liter)

Collector: [illegible]

Source A [illegible] Well 1

Source B " " " " 2

Source C

Source D

Source E

Source F

	525731					
Sample No.	A	B	C	D	E	F
Date of Collection	6/5/74					
Date of Receipt	6/5/74					
TURBIDITY	0	0				
SEDIMENT	0	0				
COLOR	5	25				
ODOR	0	0				
pH	6.5	6.4				
ALKALINITY-Total ($CaCO_3$)	44	43				
HARDNESS ($CaCO_3$)	137.	149.				
CALCIUM (Ca)	40.	40.				
MAGNESIUM (Mg)	9.0	12.				
SODIUM (Na)	50.	50.	H.S.	37		
POTASSIUM (K)	3.5	3.5				
IRON (Fe)	.00	.00				
MANGANESE (Mn)	.35	.40	High	0.05		
SILICA (SiO_2)	16	17				
SULFATE (SO_4)	114	126	✓			
CHLORIDE (Cl)	90.	100.	✓			
SPEC.COND.(micromhos/cm)	485	550				
NITROGEN (AMMONIA)	1.4	2.4				
NITROGEN (NITRATE)	5.4	3.3				
NITROGEN (NITRITE)	.001	.020				
COPPER (Cu)	.00	.00				

C-2.9 June 1975 letter from Massachusetts Department of Health to Woburn Board of Water Commissioners regarding change of chemical treatment of wells G and H.

The Commonwealth of Massachusetts
Department of Public Health
600 Washington Street
Boston 02111
Room 320

WILLIAM J. BICKNELL, M.D.
COMMISSIONER

June 24, 1975

Board of Water Commissioners
City of Woburn
Massachusetts

RE: WOBURN - Public Water Supply
Change of Chemicals, Wells G and H

Gentlemen:

The Department of Public Health has received a letter of May 7, 1975, from Mr. William A. Nieman, Chief Pumping Station Operator. In his letter, Mr. Nieman has requested approval of the use of Calgon TG-10 as a replacement for Calgosil in treating Wells G and H.

The Department has no objection to the use of Calgon TG-10 provided that the dose rate must be limited to four parts per million computed as sodium hexamataphosphate on the basis of the analysis for the phosphate radical.

We feel it is necessary, however, to call your attention to the poor quality of the water obtained from Wells G and H. Analyses performed over the last few years show that the water from these sources contains elevated levels of nitrates, ammonia nitrogen, chlorides, sulfates, sodium, manganese and hardness and has poor physical characteristics in addition, as evidenced by the test results for color, odor, turbidity and sediment. The Department does not encourage continued reliance on these sources to meet warm weather demands. We strongly recommend that your Board initiate immediate action to develop more satisfactory sources of supply or treat these supplies completely to make them more acceptable.

Very truly yours,

George J. Coogan
Director
Bureau of Water Supply and Water Quality

C/E/PW/sk

3237 - 1975

C-2.10 November 1977 letter from Massachusetts DEQE to Woburn Board of Public Works regarding approval of a well site for further testing.

FACSIMILE

November 3, 1977

Board of Public Works
City Hall
Woburn, MA 01801

Re: Woburn - Public Water Supply Approval of Well Site between Wells G and H for Further Testing.

Gentlemen:

The Metropolitan Boston-Northeast Regional Office of the Department of Environmental Quality Engineering has received a letter, dated August 31, 1977, requesting a sanitary survey of a proposed well site located about halfway between wells G and H north of Salem Street, about 200 feet easterly of the Aberjona River and near the so-called Rifle Range. This request was submitted on your behalf by Dufresne-Henry Engineering Corporation.

Engineers from this office examined the proposed site on September 8, 1977.

Chemical analysis of raw water from wells G and H indicates high concentrations of hardness, sodium, manganese, sulfate, chloride, and ammonia. Preliminary chemical analysis from a test well, identified as 1-77, indicates high concentrations of hardness, sodium, iron, managanese, sulfate, chloride, ammonia, andd C.C.E., suggesting that it lies in that same aquifer as wells G and H.

Although this chemical analysis data is only preliminary, the Department feels that if the well site is used as a source of water supply it shall require treatment.

The Department approves of the proposed site for further testing using an eight inch test well, subject to the following:

1. That a prolonged pumping test, lasting a minimum of five (5) days, be conducted to evaluate the quantity and quality of water available.
2. That this office be notified at least five (5) days prior to start-up, so proper sampling and analysis can be performed.

FACSIMILE

In our letter to you, dated June 24, 1976, you were advised to investigate treatment of G and H wells or to look for additional sources. Please notify this office as to the status of our recommendations.

If you care to discuss this situation, please call this office at 851-7261. Thank you for your continued cooperation.

Very truly yours,
For the Commissioner,

Thomas F. McLoughlin
Regional Environmental Engineer
Metropolitan Boston-Northeast
Region

cc: Board of Health
City Hall
Woburn, Massachusetts 01801

Engineers Office
City Hall
Woburn, Massachusetts 01801
Attn: Mr. Mernin

Dufresne-Henry Engineering Corporation
89 Main Street
Concord, Massachusetts 01742
Attn: Mr. Allen

Water Department
City Hall
Woburn, Massachusetts 01801
Attn: Mr. Wall

J

November 3, 1977

Board of Public Works
City Hall
Woburn, Massachusetts 01801

Re: WOBURN – Public Water Supply
Approval of Well Site Between
Wells G and H for further Testing.

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Engineers from this office examined the proposed site on September 8, 1977.

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Although this chemical analysis data is only preliminary, the Department feels that if the well site is used as a source of water supply it shall require treatment.

The Department approves of the proposed site for further testing using an eight-inch test well subject to the following:

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2. That this office be notified at least five (5) days prior to start up so proper sampling and analysis can be performed.

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Very truly yours,

For the Commissioner,

Thomas F. McLoughlin
Regional Environmental Engineer
Metropolitan Boston-Northeast Region

TFM/EFb/amr

cc: Board of Health
City Hall
Woburn, Massachusetts 01801

Engineers Office
City Hall
Woburn, Massachusetts 01801
Attention: Mr. Mernin

Dufresne-Henry Engineering Corp.
89 Main Street
Concord, Massachusetts 01742
Attention: Mr. Allen

Water Department
City Hall
Woburn, Massachusetts 01801
Attention: Mr. Wall

C-2.11 January 1978 letter and report from Dufresne-Henry Engineering regarding water quality problems at wells G and H in East Woburn.

Engineering Corporation

NORTH SPRINGFIELD, VERMONT
MANCHESTER CENTER, VERMONT
MONTPELIER, VERMONT
ST. JOHNSBURY, VERMONT

CONCORD, MASSACHUSETTS
KEENE, NEW HAMPSHIRE
NEW LONDON, NEW HAMPSHIRE
YARMOUTH, MAINE

CONSULTING ENGINEERS AND PLANNERS

PLEASE ADDRESS REPLY TO:
PRECISION PARK
NORTH SPRINGFIELD, VERMONT 05150
802 886-2261

January 26, 1978

LETTER OF TRANSMITTAL

City of Woburn
Woburn
Massachusetts 01801

Attention: Mr. Albert J. Wall
Superintendent of Public Works

Re: Final Report in Relation to
East Side Wells

Gentlemen:

We submit herewith in accordance with our agreements dated March 1 and September 30, 1976, final report of the investigation in relation to the water quality problems at Wells G and H in East Woburn.

The investigation included the expenditure of nearly $37,000 in actual services performed by others, such as well work and pumping tests. The work performed by these services enabled us to evaluate the hydrology of the area and determine that the area would support additional withdrawal of ground water.

About 150 samples of water were collected and analyzed in our laboratory and some in the State Lab, during our investigation.

The problem with the East Side Well Water, to which we were directed to address ourselves at the start of this investigation, was the complaints of objectionable tastes and odors. We determined that the complaints were attributable to the action of chlorine on the organic matter residing in the distribution system. This was proven by the fact that the raw water itself, taken directly from the wells, had no objectionable taste or odor.

As a result of our investigation, the State Department of Environmental Quality Engineering (DEQE) has lifted the chlorination requirement providing that twice weekly samples tested for coliform are all negative showing no contamination. It is also reported that the water has improved in quality and there have been no complaints from the water users on the East Side.

Manganese is present in the ground water at Wells G and H in the amount of about 0.6 milligrams per liter (mg/l) and the DEQE would like to have it removed to a more acceptable level of 0.05 mg/l.

It will therefore be necessary to treat the water and the estimated cost of a treatment plant is about $1,500,000, based on 1979 construction. The only alternative to this is to go to the MDC. The MDC can supply water to Woburn only on an emergency basis until such time as a 48-inch diameter pipe is laid by them around Spot Pond and a 6,000,000 gallon reservoir is constructed on Bear Hill. It is estimated that such a project would not be completed for nearly 10 years. In the meanwhile, Woburn must provide ample potable water for its customers so some action must be taken immediately.

To do this we recommend that steps be taken to begin the planning stage of a treatment plant on the East Side water supply and the construction of an additional gravel packed well between G and H so that the full capacity of the ground water resource which exists in the Aberjona River Valley can be utilized. Such a project will forestall the need for complete reliance on MDC water for many years and will be more cost-effective and economical in the long run.

The following report outlines the basis of our recommendations which are to continue the use of the City's most treasured resource - ground water.

We appreciate the assistance of personnel in your department and we shall be pleased to work with you in developing this project.

Very truly yours,

DUFRESNE-HENRY ENGINEERING CORP.

L. M. Pittendreigh

L. M. Pittendreigh, P.E. [illegible]
Associate

Geo.: Allen
617-369-5390

LMP/ran

LORRIN
M.
PITTENDREIGH

REPORT

1. History

Gravel Packed Wells G and H are located in the Rifle Range Area of East Woburn and are shown on the locus plan, Plate No. 1, included in the Appendix. The Aberjona River provides recharge of the ground water reservoir from which the wells derive their water.

The wells were constructed in 1965 and the pump in Well G has a capacity of 800 gpm at 265 ft. total dynamic head (TDH). The pump in Well H has a capacity of 400 gpm at the same TDH.

When the wells were first started there was evidence of contamination and the State Health Department required that the water be chlorinated. Manganese was also present in the ground water and the reaction of the addition of chlorine caused precipitation to occur in the distribution system, resulting in numerous complaints of laundry stains by the water users and chlorinous odors throughout East Woburn. ✓

The coliform contamination was corrected by excavating all of the organic soil or peat for 30 feet around the wells and replacing it with clean bank-run sand and gravel. The order to chlorinate was not rescinded so consequently the wells were not used except in emergencies because of the taste and odor problems. ✓

In later years the increased water demands of the City made it necessary to use these wells despite the complaints.

On March 1, 1976 we were employed to investigate the well water quality problem and recommend corrective measures, if feasible, and weigh the advantages of either constructing a manganese removal plant or purchasing water from the MDC.

2. Ground Water Reservoir

Gravel Packed Well G was constructed in the overburden of a preglacial bedrock valley (Aberjona) and the formation encountered was as follows:

0 - 5 feet peat (static water level @ 1 foot)
5 - 20 medium sand and gravel
20 - 30 brown sand
30 - 60 grey fine sand and clay
60 - 64 brown sand and gravel
64 - 68 medium brown sand
68 - 79 brown sand and gravel

The log of gravel packed well H is as follows:

0 - 17 feet peat (static water level @ 2 feet)
17 - 26 fine brown silty sand
26 - 28 fine brown sand
28 - 34 medium to coarse brown sand and gravel
34 - 39 fine to coarse brown sand and gravel
39 - 45 medium to coarse brown sand and gravel
45 - 51 fine to medium brown sand and gravel with some coarse sand and gravel
51 - 58 fine to medium brown sand
58 - 78 medium to coarse brown sand and gravel
78 - 88 medium to coarse brown sand and gravel with some black sand.

This formation was deposited during the last glacial recession period and it consists of good water bearing material. The elevation of the ground in the vicinity of these wells is approximately 40 feet above mean sea level. Consequently the bottom of these wells are about 40 feet below mean sea level. Thus we have a deep reservoir of ground water stored between the interstices or spaces between the sand and gravel.

The bottom water of all deep reservoirs is deficient in oxygen and this often promotes the growth of filamentous bacteria, one of which is called Crenothrix. These are anaerobic (not requiring oxygen) and have the ability of converting iron and manganese from an insoluble to a soluble state. This explains the presence of manganese in the ground water at Wells G and H which pump water from the bottom of a deep ground water reservoir whose bottom water is immobile, i.e., probably never flows or moves because it is below sea level.

The bottom water in many surface reservoirs containing manganese has been improved by aeration systems which bubble air from the bottom. The bubbling air causes circulation and results in movement of the water which greatly improves the water quality.

3. Aeration

An innovative method of causing this bottom water to circulate is shown on Plate No. 2 (A5765). This was discussed early in March of 1976 and verbal approval was obtained to conduct the necessary preliminary tests shortly thereafter.

Drawing No. D5600 entitled "Hydrological Diagram Showing Proposed Method of Investigating the Ground Water Aquifer, Gravel Packed Wells G and H" included in the Appendix, shows the preliminary steps recommended in order to monitor the results of air injection.

This consisted of installing an air injection well about 30 feet from the gravel packed well terminating at the same depth. Located in a line extending toward the gravel packed well from the air injection well are four (4) observation wells each two (2) feet apart and consisting of 1-1/4" PVC screens having the same depth as the gravel packed wells.

The cone of influence around a gravel packed well when pumping 800 gpm (Well G), shown on Drawing D 5600 is the result of hydraulic friction of water passing through the aquifer or water bearing formation. In other words the withdrawal of water from a gravel packed well causes radial flow towards the well. If air was injected in the injection well it would not only travel vertically through the water but would also move slowly toward the gravel packed well.

These wells were installed during April 1976 and are shown on the photo - Plate No. 3 in the Appendix. The observation wells are designated A, B, C, and D beginning 2 feet from the air injection well leading toward the gravel packed well.

The continual injection of air under the preliminary test began on May 12, 1976 and water analyses attached in the Appendix, were made of samples collected at various depths in the observation wells and from Well "G". The results indicated that the introduction of air improves the quality of the ground water.

Table No. 3 shows the results of samples taken from observation well A at a depth of 20 feet. Before air was introduced the manganese content was 0.80 mg/l and on June 1 the manganese was down to 0.02 mg/l. The nitrates dropped from 3.1 to 1.84 mg/l. At 40 feet the manganese dropped from 0.80 to 0.20 mg/l and nitrates from 3.4 to 1.45 mg/l as shown on Table No. 4. Table No. 5 shows that the manganese in samples taken in Well "A" at 55 feet deep decreased from 0.95 on May 11 to 0.04 mg/l on June 1. Table No. 6 indicates what happens at 83± ft. depth. Here the reduction was not so great due to the fact that the air is not in contact with the water at that depth.

The water at the shallow depths of the other observation wells shows considerable improvement. Take for instance, the water in observation Well "D" at 25 ft. (Table No. 9). It had a manganese content of only 0.05 mg/l, which showed a reduction of 0.9 mg/l and the iron went from 6.55 mg/l initially to 0.21 mg/l. At about 83 ft. depth in Well "D" as shown on Table No. 10, the manganese and iron were 0.02 and 0.01 mg/l.

The beneficial effects on water being pumped from Gravel Packed Well "G" as shown on Table No. 11 was not noticeable because the treated water comprised a very small percent of the water being pumped.

This preliminary test gave distinct indications that bubbling air in the ground water improved the quality of the water. We therefore recommended the installation of nine (9) additional air diffusers to "circle" Well G.

Further indications that the diffusion of air in ground water provides beneficial treatment was revealed when the City received notification from International Licensing Network, Ltd. of New York, claiming that our recommended process was an "infringement" of a patent held by Layne-New England Company.

The situation became serious when bids were solicited on December 10, 1976 for installation of air diffuser wells at Well G. Layne-New England received a notification and informed us that they were not interested.

On January 7, 1977 we received a communication from Mr. Robert Goldscheider of the International Licensing Network Ltd. which included:

> "According to Mr. Erickson (Layne-N.E.), this request for a quotation reflects an attempt by you to simulate the results of the Vyredox Method. I am therefore constrained to inform you that my client is the holder of a valid U.S. patent in this specific area and that your initiative, if physically implemented, could constitute an infringement. I am therefore hereby putting you on notice that your actions in this case will be closely monitored and that I intend to advise my client to take immediate and vigorous action to defend and preserve its rights if they are violated in any way."

We immediately employed an attorney and on January 21, 1977 he informed us that there is no infringement and Mr. Goldscheider concurred and the matter was dropped.

On February 23, 1977 the American Pile Driving Equipment Corp. completed the nine (9) additional air diffuser wells making ten (10) in all as shown on Drawing D6243 in the Appendix.

On March 1, 1977 the manifold piping connecting the air diffuser wells was completed and air injection commenced March 2, 1977.

An average of 17.5 cubic feet of air per minute (cfm) was injected into the water bearing formation around Well G continuously while the well was pumping into the distribution system in a normal manner. This was determined by a rotameter on the air line to the air diffuser wells. Due to the varied porosity or character of the water bearing formation in the circle of 30 feet radius from Well G the division of air injection was not uniform. The formation encountered varied from fine sand to coarse gravel. Naturally the air diffuser wells in the coarse gravel deliver more air than in the finer material. This phenomenon did not cause concern and had to be accepted.

There was no radical change in the water quality being pumped from Well G even after two months operation despite the continuous introduction of air. Water analyses taken are shown in the Appendix. Any change in water quality would be a very slow reaction in view of the magnitude of the ground water reservoir. A slight increase in dissolved oxygen was detected and the amount of chlorine required to carry the proper residual was noticeably reduced. These signs indicated satisfactory results.

We made a written request to the DEQE on May 3, 1977 to eliminate the addition of chlorine to Well G for a period of time in order to observe whether this would improve the quality of the water in East Woburn. This request was based on the fact that the raw water bacteria samples taken directly from the pump at Well G at two week intervals for a period of several months were negative showing that chlorine was not necessary.

On May 19, 1977 we received verbal approval from Mr. Fred Barker of the Tewksbury Office of the DEQE to eliminate chlorine from Well G for a four week trial period. Mr. Barker indicated that approval was the result of our call to Mr. George Coogan, the Director of Water Supply in Boston on that day.

The program established by the DEQE is as follows:

1. The trial to begin May 23, 1977 and shall terminate June 20, 1977.
2. The air injection at Well G shall not be used during this trial period and Well H shall not be used.
3. Bacteria samples shall be collected each Monday and Thursday and delivered to the Lawrence Lab.

The trial period with "no chlorine" began June 7, 1977 and on June 29, 1977 Mr. Fred Barker issued a 30 day extension based on the good results. This procedure has continued to date and there have been no complaints of taste and odors in the East Woburn area - in fact there have been many favorable comments on the water quality.

During the developments at Well G we conducted similar tests at Well H as shown on Drawing D5600. The results of analyses taken from the observation wells are shown on Tables 17 through 21 in the Appendix and they show high concentration of iron whereas the water being pumped from Well H was very low in iron. The manganese in Well H is comparable to Well G.

The only logical explanation for the high iron in the four (4) observation wells at Well H is that they are actually out in the swamp area (30 feet from H) where the water could have an entirely different quality.

4. Test Well Work

Drawing D6357 shows the relative location of Well G to H and the site of test wells driven to explore the water bearing material between the two wells.

Test Well No. 1-76 driven December 8, 1976 had the following log of material:

0 - 63 ft. fine brown sand and clay
63 - 76 ft. fine brown sand some gravel and clay
The well pumped 15 gpm

Test Well No 2-76 driven December 10, 1976 had the following log of material:

7

R (1-77)

0 - 37 feet fine sand and clay
37 - 50 ft. brown sand and gravel
50 - 67 ft. sharp gray gravel and clay
67 - 84 ft. dark gray sand and gravel
The Well was pulled back to 50 ft. - set double screen.
Well pumped 60 gpm with 14" vac.

Test Well No. 2 indicated the presence of excellent water bearing material so an 8-inch well was installed and an extended pumping test conducted from November 14, 1977 to November 23, 1977 pumping 250 gpm. ✓

Drawing D6357 includes a hydraulic profile running between G and H. Also shown is the curve (section through cone of influence) of influence around the wells observed during the pumping test. You will note that the drawdown was not severe - in fact it shows that additional water can be pumped from this site in the Aberjona Valley. The water levels observed in surrounding observation wells and the 8-inch pumping well are included in Appendix. Plate No. 4 is a Time Drawdown and Time Recovery Graph which shows that another 48" x 24" gravel packed well in the location of the 8-inch well would supply an additional 600 gpm. This will make a combined ground water yield from the East Woburn Area of about 2.5 MGD. ←

5. Treatment of Water Supply

The letter containing approval to conduct the extended pumping test from the DEQE stated that:

> "Preliminary chemical analysis from a test well identified as 1-77 indicates high concentrations of hardness, sodium, iron, manganese, sulfate, chloride, ammonia and C.C.E...."

> "Although this chemical analysis data is only preliminary, the Department feels that if the well site is used as a source of water supply it shall require treatment."

In comparing the chemical analyses of samples collected from the pumping test with regular samples which are routinely collected from Wells G and H, it is apparent that the 8-inch well on which the pumping test was conducted derives its water from the same aquifer. The analyses of samples (shown on Table 31 in the Appendix) taken during the test were performed at the DEQE Lawrence Laboratory and **one sample showed 2.79 mg/l of carbon-chloroform extract (C.C.E.)**. C.C.E. is a mixture of organic compounds that can be absorbed on activated carbon under prescribed conditions and then desorbed with the solvent chloroform.

These organic contaminants - natural substances, insecticides, herbicides and other agricultural chemicals are present in the ground water of the Aberjona River Valley. Both natural and man-made contaminants can have undesirable effects on health and can cause tastes and odors. **C.C.E. in well water should not exceed 0.1 mg/l.** To remove the C.C.E. will require filtration through carbon and this may be one of the steps referred to in the DEQE letter under "treatment".

"Treatment" can also mean the removal of iron and manganese to acceptable limits. This will include filtration using a special sand media. The iron and manganese are oxidized by chemicals just prior to filtration, usually by potassium permanganate, and then removed by attraction to the media grains. This attraction is similar to "magnetic" attraction but more complex. In some cases, the potassium permanganate is used only to regenerate the special sand between filter runs but to adequately treat this water the permanganate will be fed continuously into the water prior to filtration. Chemical costs will amount to $40 per million gallons. We, therefore, estimate the total cost of treatment including maintenance and operation not to exceed $180 per million gallons. This is much less than the cost of MDC water.

Following the removal of iron and manganese the water will pass through activated carbon "polishing" filters. These will absorb the organic contaminants that might be present in the water. Carbon filtration alone would not constitute complete treatment. This was shown by the test conducted at Well H. ✓

In the Well H pumping station is a carbon column consisting of a 12-inch flanged pipe with dome ends about 12 feet long. It stands vertically adjacent to the deep well turbine pump and was purchased as a pilot plant about 15 years ago when Well H had a taste and odor problem.

As part of our investigation we asked the water department personnel to reactivate the carbon column to filter the raw water from Well H through four (4) feet of granular activated carbon (Filtasorb 200). The test was initiated on August 22, 1977 with a flow of 8 gpm. The hydraulics of the carbon column included a water meter to measure the rate of flow and a pressure gauge on the influent pipe. The filtered water was discharged to atmosphere outside the station.

Analyses of the raw and filtered water are shown on Table Nos. 27 through 30. Through the experiment the carbon removed some of the iron but the manganese was not noticeably reduced. The removal of iron by the carbon media was also shown by the clogging of the filter media thus reducing the flow and creating increased back-pressure. Plate No. 5 is a graph showing the gradual decrease in the rate of filtration shown by a plot of the daily meter readings. This diminishing filter rate was coupled with the rise of pressure on the inlet side of the filter showing the clogging action of iron-buildup.

6. Conclusions and Recommendations

From our investigation we conclude that the problem with objectionable water quality in East Woburn was caused by the action of chlorine on the organic matter residing on the interior of the distribution pipes. The major benefit derived from our investigation was the elimination of chlorination resulting in a substantial reduction in taste and odor complaints. It is reported that there have been no complaints since termination of chlorination.

The water from Wells G and H contains a small amount of iron but the manganese exceeds the Drinking Water Standards of the U.S. Public Health Service.

	Average at "G" (mg/l)	Average at "H" (mg/l)	Drinking Water Standards (mg/l)
Iron	0.01	0.16	0.3
Manganese	0.57	0.88	0.05

Iron and manganese are not classified under the Safe Drinking Water Act but the limits were established for aesthetic and economic reasons only, rather than because of adverse health effects, and their presence above this recommended limit represents an unusual treatment problem for a water supply. Today the water from G and H is complexed by the addition of an approved hexametaphosphate. This forms a complex that keeps the iron and/or manganese in solution and prevents its troublesome precipitation. They are not removed - they are still present in the water. But even though they exceed the total of 0.35 mg/l limit, they cause no aesthetic objections.

There is no criteria that requires treatment other than what is now being carried at Wells G and H, but if an additional well is constructed, the development must be approved by the DEQE. They will not approve construction of a new well without including treatment.

Therefore, we recommend the construction of another gravel packed well and a treatment plant with a total capacity of 2.5 MGD. The plant will include six (6) pressure filters ten (10) feet in diameter containing special sand for the removal of iron and manganese. These will be followed by similar filters containing granular activated carbon. Drawing D6859 in the Appendix shows the general layout of the plant.

7. Estimate of Cost

Based on constructing another gravel packed well together with an iron and manganese removal plant during 1979, we estimate the cost to be as follows:

1.	Gravel Packed Well, 50 ft. @ $600	$ 30,000
2.	Pumping Station and pumping equipment (low head pump)	100,000
3.	Alterations to existing pumping equipment in "G" and "H" wells	50,000
4.	Piping changes and discharge pipe	50,000
5.	Building for treatment plant	300,000
6.	Treatment Plant equipment, pumps, generator, electric work, and piping	670,000
		$1,200,000
	Allowance for construction contingencies, engineering and supervision	300,000
		$1,500,000

8. Financing

The following calculations pertain to the financing of the project:

Borrow $1,500,000 for 20 years (pay back in 18 yrs)

Principal Payments	$ 85,000
Interest	128,000
	$213,000 per year in first years.

Woburn Assessed Valuation = $120,000,000.

$\frac{213,000}{120,000}$ = $1.78 on tax rate

From the above it would appear that if Federal or State Aid is not available the project would amount to less than $2 on the tax rate.

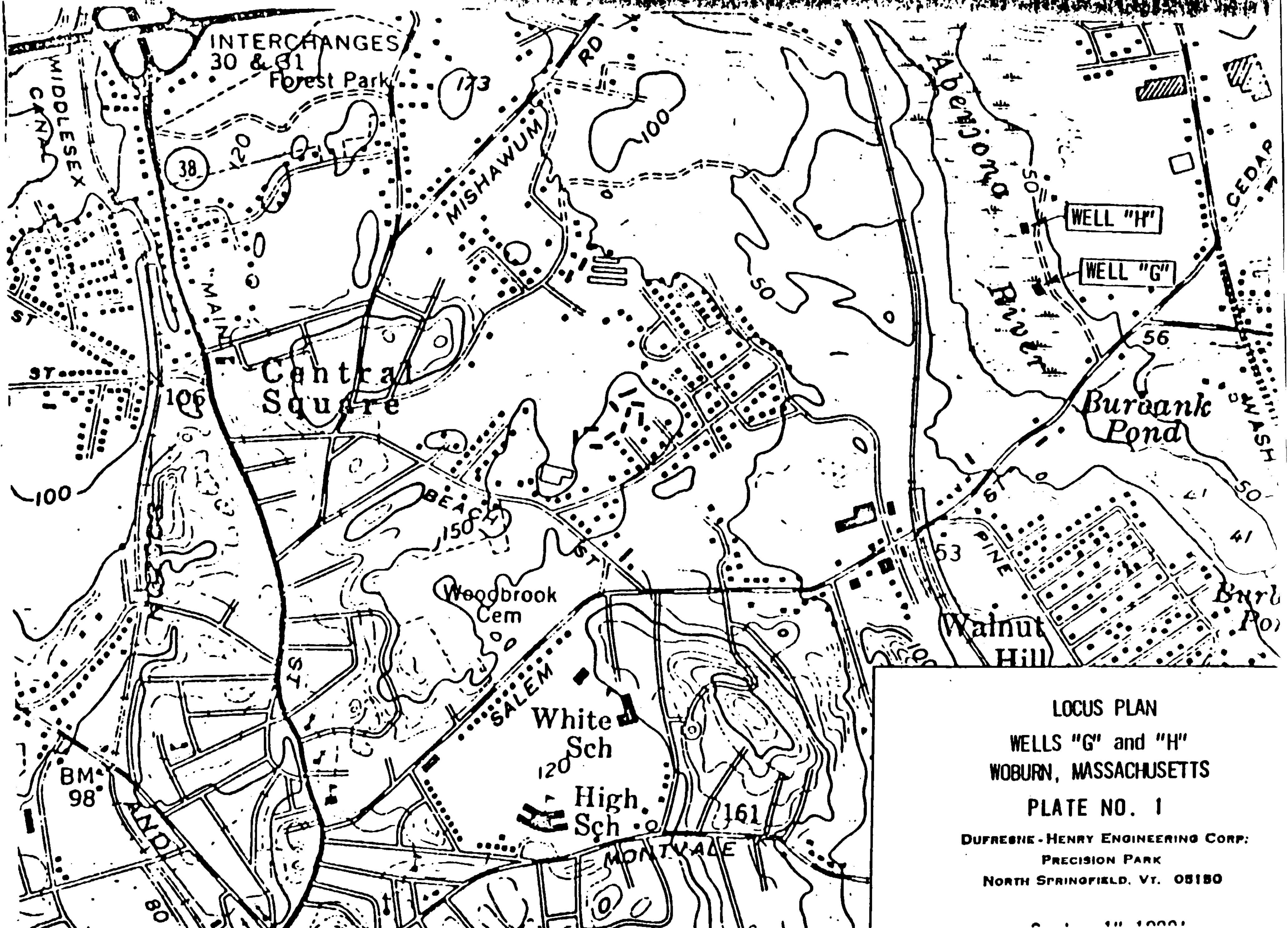
END

LIST OF APPENDICES

CHRONOLOGY
WOBURN - EAST SIDE WELL PROBLEM

Dec. 2, 1975	Met with DPW and discussed the problem.
Feb. 2, 1976	Met with Aldermen & DPW to discuss what the study would include.
Mar. 17, 1976	Received signed contract.
May 4, 1976	Air (test) well at "G" and PVC sample wells completed.
May 11, 1976	First samples taken from PVC sample wells with GPW "G" off and no air injection.
May 21, 1976	First sample taken from "G" well with air injection in the air (test) well.
June 10, 1976	Pumping "G" well into distribution system.
June 29, 1976	Met with Aldermen & DPW and discussed our recommendation to "circle" Well "G" with air diffusion wells.
Sept. 30, 1976	Received Engineering Agreement for service involving "circle" of air diffusion wells at Well G.
Oct. 1, 1976	Began injecting air for the preliminary test at Well H.
Dec. 8, 1976	2-1/2" test well driven between Well "G" & "H" - 50 feet deep pumps 60 gpm.
Dec. 10, 1976	Sent out request for bids for installing nine (9) air diffuser wells around Well G.
Jan. 17, 1977	Meeting with Special Water Committee and Layne N.E. Re: Patent Infringement.
Jan. 21, 1977	Letter from Attorney stating no infringement on Layne's patent.
Jan. 22, 1977	American Pile Driving Equipment was low bidder on air diffusor wells at Well G.
Feb. 2, 1977	Well contractor (American Pile Driving) started air diffuser wells around "G" well.

Feb. 23, 1977	Air diffuser at "G" wells completed.
Mar. 1, 1977	Piping manifold between compressors and air diffuser wells completed.
Mar. 2, 1977	Started injecting air in the "ring" of diffuser wells.
Mar. 21-23, 1977	Installed larger compressor. Total air now being injected at Well G equals 26 cfm.
May 3, 1977	Letter to DEQE requesting permission to eliminate chlorine.
May 10, 1977	Initiated steps to conduct study of water quality of "H" well filtering through four feet of carbon in a 12-inch carbon column.
May 19, 1977	Received approval from Mr. Fred Barker of the DEQE to eliminate the chlorine at "G" well on a trial basis. The directive requested that air injection also be terminated - reason unexplained.
June 7, 1977	Began the trial period with the elimination of chlorine from "G" Well.
June 22, 1977	Samples are collected weekly and they show no coliform contamination.
June 29, 1977	Mr. Fred Barker issued an extension of time for another 30 days of no chlorine at "G" well.
Aug. 22, 1977	Began filtering some of well water from H through 4 feet of carbon in the carbon column.
Nov. 11, 1977	The head loss on the carbon filter reached 100 psi so test was terminated.



LOCUS PLAN

WELLS "G" and "H"

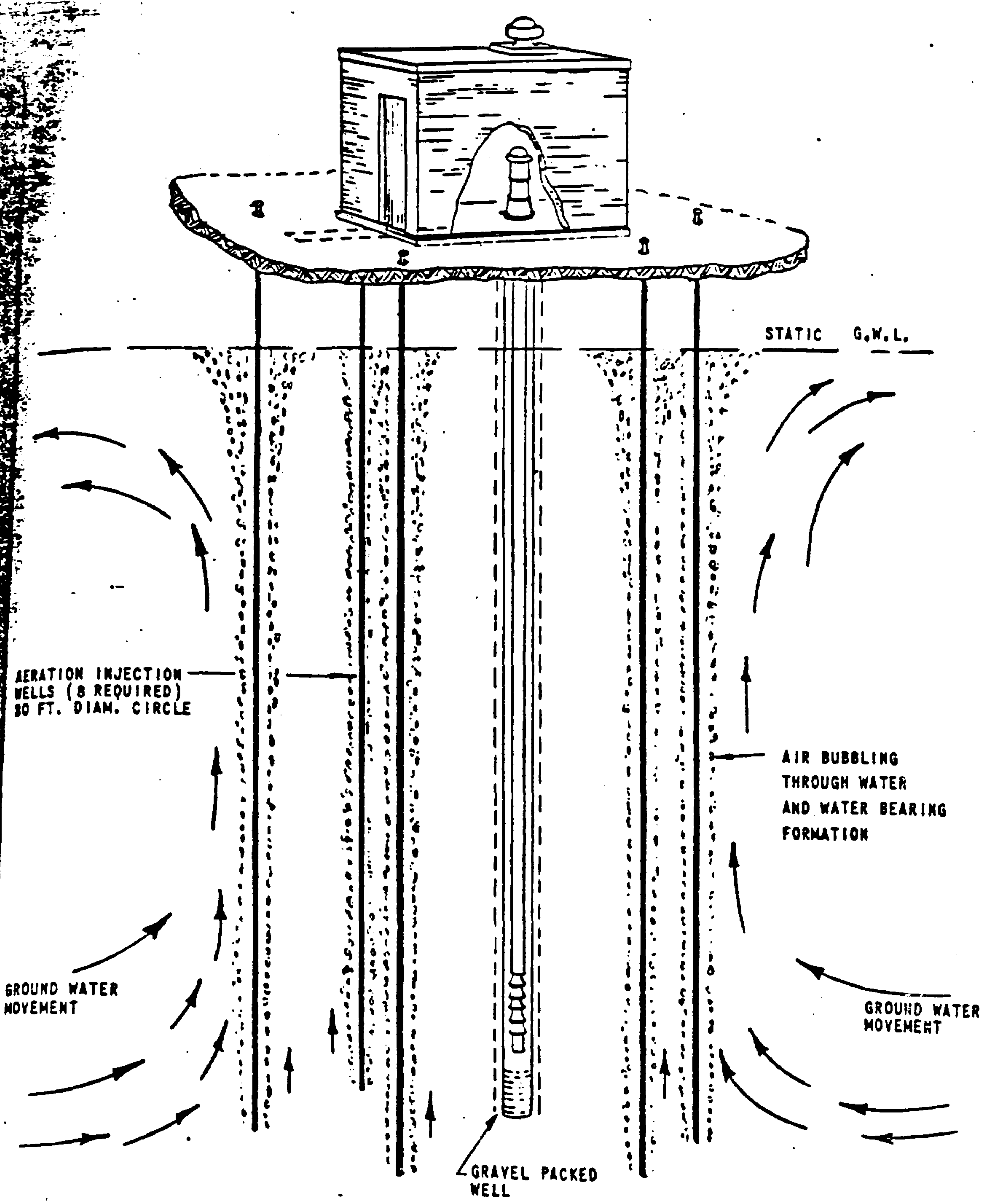
WOBURN, MASSACHUSETTS

PLATE NO. 1

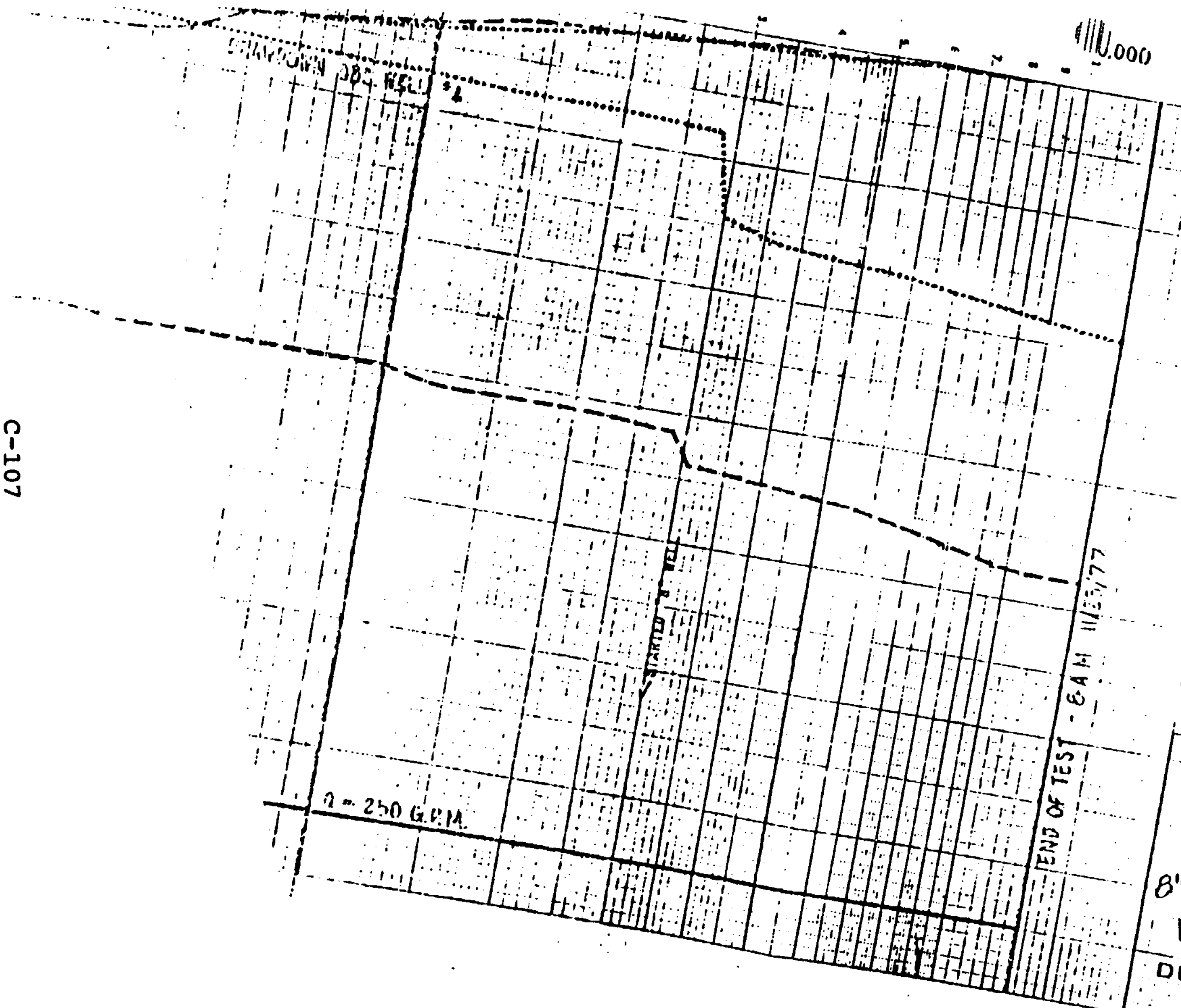
DUFRESNE-HENRY ENGINEERING CORP:

PRECISION PARK

NORTH SPRINGFIELD, VT. 05150



CLIENT NO	12-0037	DUFRESNE-HENRY ENGINEERING CORP., NO. SPRINGFIELD, VT. PROPOSED AERATION FOR GROUND WATER RESERVOIR TURNOVER	PLATE NO. 2
ENGINEER	L.H.P.		
DRAWN BY	O.R.P.		
DATE	10-1-75	WOBURN MASS.	A 5765

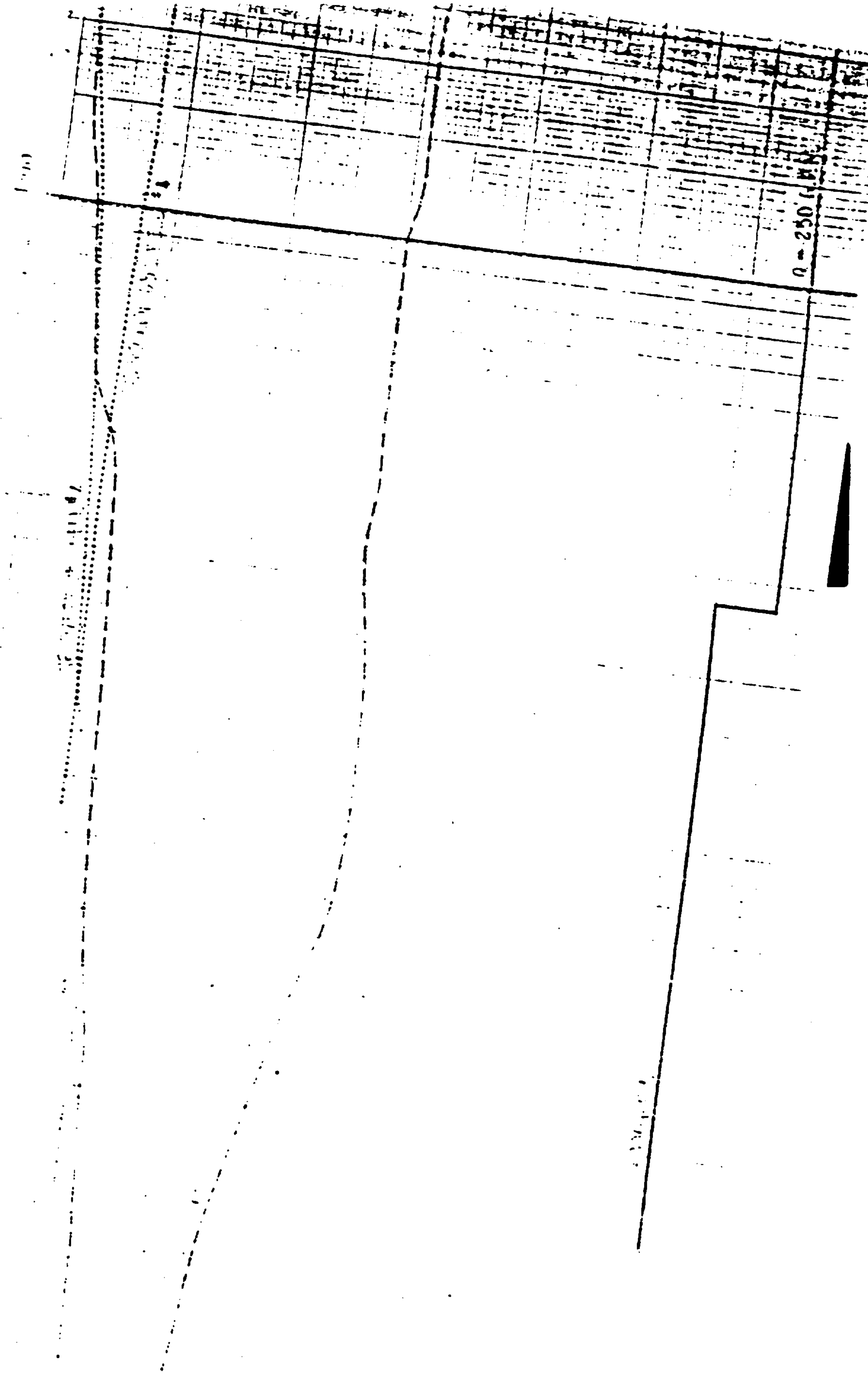


TIME - DRAWDOWN &
TIME - RECOVERY GRAPH
for
8" PUMPING TEST at RIFLE RANGE
WOBURN, MASSACHUSETTS

DUFRESNE-HENRY
Engineering Corporation

C-M 12-0037

PLATE NO. 4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Special

Precision Park
North Springfield, VT 05150

8- "G" Well

Table No. 12

Collector: Bill Nieman

WATER SUPPLY ANALYSIS (mg. per liter)
(made at D-H Lab)

Source A - Discharge of G.P. Well "G" w/Calgon TG-10 injected into pump intake
Source B - Tap at 24 Felton Street
Source C - Tap at 11 George Avenue
Source D - Tap at Wood Street
Source E -
Source F -

	A	B	C	D	E	F
Sample No. or Work Order	12-0037	12-0037	12-0037	12-0037		
Date of Collection 1976	9AM 6/18	9AM 6/18	7AM 6/18	9AM 6/18		
Date of Receipt						
TURBIDITY						
SEDIMENT						
COLOR						
ODOR						
pH						
ALKALINITY-Total($CaCO_3$)						
HARDNESS ($CaCO_3$)						
CALCIUM(Ca)						
MAGNESIUM(Mg)						
SODIUM(Na)						
POTASSIUM(K)						
IRON(Fe)	0.00	0.02	0.03	0.03		
MANGANESE(Mn)	0.58	0.65	0.55	0.65		
SILICA(SiO_2)						
SULFATE(SO4)						
CHLORIDE(Cl)						
SPEC.COND.(micromhos/cm)						
NITROGEN(AMMONIA)						
NITROGEN(NITRATE)						
NITROGEN(NITRITE)						
COPPER(Cu)						
Total Phosphate	0.29	0.39	0.40	0.40		
Ortho Phosphate	0.02	0.23	0.12	0.05		
Metaphosphate	0.27	0.16	0.28	0.35		

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Precision Park
North Springfield, VT 05150

2+ G Well

Table No. 13

Collector: George Allan

WATER SUPPLY ANALYSIS (mg. per liter)
(made at D-H Lab)

Source A - Obs. Well "A" 20' deep
Source B - Obs. Well "A" 55' deep
Source C - Obs. Well "A" 81' deep
Source D - Obs. Well "C" 70' deep (sample had iron precipitate)
Source E - Obs. Well "D" 25' deep
Source F - Obs. Well "D" 83' deep

All samples collected while G.P. Well "G" was pumping into the system and air being injected in the air well

For continuation see Table No. 14

	A	B	C	D	E	F
Sample No. or Work Order	12-0037	ditto	ditto	ditto	ditto	ditto
Date of Collection	6/28/76	6/28	6/28	6/28	6/28	6/28
Date of Receipt						
TURBIDITY						
SEDIMENT						
COLOR						
ODOR						
pH						
ALKALINITY-Total($CaCO_3$)						
HARDNESS ($CaCO_3$)						
CALCIUM(Ca)						
MAGNESIUM(Mg)						
SODIUM(Na)						
POTASSIUM(K)						
IRON(Fe)	0.22	0.11	0.10	16.4	0.24	0.12
MANGANESE(Mn)	0.23	0.16	0.18	0.18	0.16	0.73
SILICA(SiO_2)						
SULFATE(SO4)						
CHLORIDE(Cl)						
SPEC.COND.(micromhos/cm)						
NITROGEN(AMMONIA)						
NITROGEN(NITRATE)						
NITROGEN(NITRITE)						
COPPER(Cu)						

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North Springfield, VT 05150

Table No. 14

Collector: George Allan

WATER SUPPLY ANALYSIS (mg. per liter)
(made at D-H Lab)

Source A - Discharge of G.P. Well "G" (No Cl_2)*
Source B - " " " " "G" (With Cl_2)**
Source C -
Source D -
Source E -
Source F -

This is a continuation of Table No. 1

* This sample contains TG-10 (no Cl_2)
** " " " Cl_2 and TG-10

	A	B	C	D	E	F
Sample No. or Work Order	12-0037	12-0037				
Date of Collection	6/8/76	6/8/76				
Date of Receipt						
TURBIDITY						
SEDIMENT						
COLOR						
ODOR						
pH						
ALKALINITY-Total($CaCO_3$)						
HARDNESS ($CaCO_3$)						
CALCIUM(Ca)						
MAGNESIUM(Mg)						
SODIUM(Na)						
POTASSIUM(K)						
IRON(Fe)	0.08	0.10				
MANGANESE(Mn)	0.54	0.56				
SILICA(SiO_2)						
SULFATE(SO4)						
CHLORIDE(Cl)						
SPEC.COND.(micromhos/cm)						
NITROGEN(AMMONIA)						
NITROGEN(NITRATE)						
NITROGEN(NITRITE)						
COPPER(Cu)						

Table No. 15

North Springfield, VT 05150

Collector: George Allan

WATER SUPPLY ANALYSIS (mg. per liter)
(made at D-H Lab)

Source A - Discharge of G.P. Well "G" (1:30 PM)

Source B - Obs. Well "D" (25' deep)

Source C - Discharge of G.P. Well "G" Tap in p.s.

Source D - " " " " "G" Tap outside P.S.

Source E - " " " " "H" " " P.S.

Source F -

	A	B	C	D	E	F
Sample No. or Work Order	12-0037	12-0037	ditto	ditto	ditto	
Date of Collection	7/9/76	7/9/76	8/2/76	8/2/76	8/2/76	
Date of Receipt						
TURBIDITY						
SEDIMENT						
COLOR						
ODOR						
pH						
ALKALINITY-Total($CaCO_3$)						
HARDNESS ($CaCO_3$)						
CALCIUM(Ca)						
MAGNESIUM(Mg)						
SODIUM(Na)						
POTASSIUM(K)						
IRON(Fe)	0.08	0.03	0.01	0.01	0.04	
MANGANESE(Mn)	0.25	0.15	0.59	0.59	0.82	
SILICA(SiO_2)						
SULFATE(SO4)						
CHLORIDE(Cl)						
SPEC.COND.(micromhos/cm)						
NITROGEN(AMMONIA)						
NITROGEN(NITRATE)			1.60	2.20	3.00	
NITROGEN(NITRITE)						
COPPER(Cu)						
TOTAL PHOSPHATE (as PO)	-----	-----	1.25	2.50	1.56	

, Mass.

Table No. 22 North Springfield, VT 05150

Collector: D. L. Maher
C. Kelley

WATER SUPPLY ANALYSIS (mg. per liter)
(made at D-H Lab)

Source A - 2 1/2" test well, 76 ft. deep, 2 ft. from old obs.well and 200' north of "G" Well
Source B - 2 1/2" test well, 84 ft. deep (pulled to 50 ft.) about 350 ft. north of "G" Well
Source C -
Source D -
Source E -
Source F -

Source A is D. L. Maher Well No. 1-76
Source B is D. L. Maher Well No. 2-76

	A	B	C	D	E	F
Sample No. or Work Order	12-0038-1	12-0038-2				
Date of Collection	12-8-76	12-10-76				
Date of Receipt						
TURBIDITY						
SEDIMENT						
COLOR						
ODOR						
pH	7.6	7.9				
ALKALINITY-Total ($CaCO_3$)						
HARDNESS ($CaCO_3$)						
CALCIUM(Ca)						
MAGNESIUM(Mg)						
SODIUM(Na)						
POTASSIUM(K)						
IRON(Fe)	0.18	0.24				
MANGANESE(Mn)	0.11	0.25				
SILICA(SiO_2)						
SULFATE(SO4)						
CHLORIDE(Cl)						
SPEC.COND.(micromhos/cm)						
NITROGEN(AMMONIA)						
NITROGEN(NITRATE)	0.22	0.04				
NITROGEN(NITRITE)						
COPPER(Cu)						

North Springfield, VT 05156

Collector: George Allan

WATER SUPPLY ANALYSIS (mg. per liter)
(made at D-H Lab)

Source A - Discharge from "G" Well - Raw water (no chlorine) before air injection

Source B - Discharge from "G" Well - Raw water (no chlorine) after 3 days of air injection (3 small air compressors)

Source C - " " " " 8:30 AM Raw Water

Source D - " " " " Raw Water

Source E - " " " " " "

Source F - " " " " " "

	A	B	C	D	E	F
Sample No. or Work Order	12-0053	ditto	ditto	ditto	ditto	ditto
Date of Collection	3/2/77	3/7/77	3/11/77	3/14/77	3/24/77	3/28/77
Date of Receipt	3/9/77	3/9/77	3/11/77	3/14/77		
TURBIDITY						
SEDIMENT						
COLOR						
ODOR						
pH	6.7	6.3	6.45	6.40	6.80	6.65
ALKALINITY-Total($CaCO_3$)						
HARDNESS ($CaCO_3$)					150	148
CALCIUM(Ca)						
MAGNESIUM(Mg)						
SODIUM(Na)						
POTASSIUM(K)						
IRON(Fe)	0.10	0.13	0.01	0.01	0.02	0.00
MANGANESE(Mn)	0.52	0.57	1.26	1.30	0.54	0.59
SILICA(SiO_2)						
SULFATE(SO4)						
CHLORIDE(Cl)					80.0	81.5
SPEC.COND.(micromhos/cm)						
NITROGEN(AMMONIA)					6.8	3.2
NITROGEN(NITRATE)	1.50	1.33	2.84	2.06	2.50	0.85
NITROGEN(NITRITE)						
COPPER(Cu)						

North Springfield, VT 05150

Collector: George Allan

WATER SUPPLY ANALYSIS (mg. per liter)
(made at D-H Lab)

Source A - Discharge from "G" Well - Raw Water
Source B -
Source C -
Source D -
Source E -
Source F -

	A	B	C	D	E	F
Sample No. or Work Order	12-0053					
Date of Collection	3/31/77					
Date of Receipt						
TURBIDITY						
SEDIMENT						
COLOR						
ODOR						
pH	6.85					
ALKALINITY-Total ($CaCO_3$)						
HARDNESS ($CaCO_3$)						
CALCIUM(Ca)						
MAGNESIUM(Mg)						
SODIUM(Na)						
POTASSIUM(K)						
IRON(Fe)	0.01					
MANGANESE(Mn)	0.57					
SILICA(SiO_2)						
SULFATE(SO4)						
CHLORIDE(Cl)						
SPEC.COND.(micromhos/cm)						
NITROGEN(AMMONIA)	2.8					
NITROGEN(NITRATE)	2.20					
NITROGEN(NITRITE)						
COPPER(Cu)						

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North Springfield, VT 05150

Collector: Nieman

Table No. 25 **WATER SUPPLY ANALYSIS** (mg. per liter)
(made at D-H Lab)

Source A - 11 George Ave. 7:30 AM
Source B - 22 Monroe St. 10:00 PM
Source C - 39 Wood St. 10:00 PM
Source D - 77 Central St. 7:00 PM
Source E - 14 Hill St. 7:00 PM
Source F -

Samples collected at random in East Woburn 4/1/77

	A	B	C	D	E	F
Sample No. or Work Order	12-0053	12-0053	12-0053	12-0053	12-0053	
Date of Collection	4/1/77	4/1/77	4/1/77	4/1/77	4/1/77	
Date of Receipt						
TURBIDITY						
SEDIMENT						
COLOR						
ODOR						
pH	6.80	6.80	7.10	6.85	6.90	
ALKALINITY-Total($CaCO_3$)						
HARDNESS ($CaCO_3$)						
CALCIUM(Ca)						
MAGNESIUM(Mg)						
SODIUM(Na)						
POTASSIUM(K)						
IRON(Fe)	0.03	0.05	0.03	0.02	0.01	
MANGANESE(Mn)	0.45	0.57	0.44	0.58	0.52	
SILICA(SiO_2)						
SULFATE(SO4)						
CHLORIDE(Cl)						
SPEC.COND.(micromhos/cm)						
NITROGEN(AMMONIA)						
NITROGEN(NITRATE)						
NITROGEN(NITRITE)						
COPPER(Cu)						
Total Phosphate	1.04	1.01	1.29	1.22	0.43	
Ortho Phosphate	0.43	0.46	0.37	0.40	0.21	

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North Springfield, VT 05150

Collector: Nieman & Flaher

Table No. 25a WATER SUPPLY ANALYSIS (mg. per liter)

Source A - Gravel Packed Well "G"
Source B - " " " "
Source C - " " " "
Source D -
Source E -
Source F -

- These samples were analized at the State Lab at different times and are shown for comparison only.

	A	B	C	D	E	F
Sample No. or Work Order	53449	537281	542003			
Date of Collection	12/2/75	4/13/76	3/29/77			
Date of Receipt	12/3/75	4/14/76	3/30/77			
TURBIDITY	1	1	0			
SEDIMENT	0	0	0			
COLOR	10	7	3			
ODOR	20c	0	20			
pH	6.6	6.5	6.5			
ALKALINITY-Total($CaCO_3$)	58	53	50			
HARDNESS ($CaCO_3$)	128	110	133			
CALCIUM(Ca)	37	33	40			
MAGNESIUM(Mg)	8.7	6.7	8.0			
SODIUM(Na)	45	40	60			
POTASSIUM(K)	5.0	3.5	4.3			
IRON(Fe)	.02	.15	.00			
MANGANESE(Mn)	.60	.30	.57			
SILICA(SiO_2)	11	10	13			
SULFATE(SO4)	89	76	--			
CHLORIDE(Cl)	120	76	85			
SPEC.COND.(micromhos/cm)	700	500	540			
NITROGEN(AMMONIA)	3.4	1.3	3.8			
NITROGEN(NITRATE)	2.5	1.7	2.2			
NITROGEN(NITRITE)	.001	.035	.001			
COPPER(Cu)	.05	.00	.01			

Table No. 26

North Springfield, VT 05150

Collector: Nieman

WATER SUPPLY ANALYSIS (mg. per liter)
(made at D-H Lab)

Source A - 11 George Street
Source B - 57 Central Street
Source C - 22 Monroe Street - 2:00 PM
Source D - 39 Wood Street - 12:30 PM
Source E - 4 High Street
Source F -

Samples collected at random in East Woburn 5/7/77

	A	B	C	D	E	F
Sample No. or Work Order	12-0053	12-0053	12-0053	12-0053	12-0053	
Date of Collection	5/7/77	5/7/77	5/7/77	5/7/77	5/7/77	
Date of Receipt						
TURBIDITY						
SEDIMENT						
COLOR						
ODOR						
pH	6.90	6.75	6.95	7.00	7.35	
ALKALINITY-Total ($CaCO_3$)						
HARDNESS ($CaCO_3$)						
CALCIUM(Ca)						
MAGNESIUM(Mg)						
SODIUM(Na)						
POTASSIUM(K)						
IRON(Fe)	0.02	0.02	0.01	0.01	0.02	
MANGANESE(Mn)	0.47	0.30	0.57	0.14	0.37	
SILICA(SiO_2)						
SULFATE(SO4)						
CHLORIDE(Cl)						
SPEC.COND.(micromhos/cm)						
NITROGEN(AMMONIA)						
NITROGEN(NITRATE)						
NITROGEN(NITRITE)						
COPPER(Cu)						
Total Phosphate	1.26	0.39	1.22	0.44	0.84	
Ortho Phosphate	0.50	0.56	0.85	0.34	0.59	

North Springfield, [illegible]

Table No. [illegible] Collector: [illegible]

WATER SUPPLY ANALYSIS (mg. per liter)

(made at D-H Lab)

Source A -	Gravel Packed Well "G"	
Source B -	Gravel Packed Well "H"	
Source C -	Gravel Packed Well "G"	
Source D -	Gravel Packed Well "H"	- Raw Water
Source E -	Gravel Packed Well "H"	- After passing through carbon filter
Source F -	Gravel Packed Well "G"	

	A	B	C	D	E	F
Sample No. or Work Order	12-0053	12-0053	12-0053	12-0053	12-0053	12-0053
Date of Collection	5/5/77	5/5/77	5/18/77	6/17/77	6/17/77	6/17/77
Date of Receipt						
TURBIDITY						
SEDIMENT						
COLOR				70	10	
ODOR						
pH	7.25	6.45	6.55			6.8
ALKALINITY-Total ($CaCO_3$)						
HARDNESS ($CaCO_3$)						
CALCIUM(Ca)						
MAGNESIUM(Mg)						
SODIUM(Na)						
POTASSIUM(K)						
IRON(Fe)	0.00	0.08	0.02	2.4	0.21	
MANGANESE(Mn)	0.58	1.27	1.17	1.88	0.05	0.47
SILICA(SiO_2)						
SULFATE(SO4)						
CHLORIDE(Cl)						
SPEC.COND.(micromhos/cm)						
NITROGEN(AMMONIA)	2.3	0.4	2.8			
NITROGEN(NITRATE)	0.12	0.01	1.75			
NITROGEN(NITRITE)						
COPPER(Cu)						
Total Phosphate	0.99	1.07	1.62			
Ortho Phosphate	0.54	0.72	0.21			

Table No. 25 Collector: George Allan

WATER SUPPLY ANALYSIS (mg. per liter)
(made at D-H Lab)

Source A - Gravel Packed Well "G"
Source B - Gravel Packed Well "H" Raw Water (hydrogen sulfide odor)*
Source C - Gravel Packed Well "H" 7.5 gpm effluent of carbon column
Source D - Gravel Packed Well "H" Raw Water
Source E - Gravel Packed Well "H" 7.5 gpm effluent of carbon column
Source F -

* First day of carbon column operation

	A	B	C	D	E	F
Sample No. or Work Order	12-0053	12-0053	12-0053	12-0053	12-0053	
Date of Collection	7/14/77	8/23/77	8/23/77	8/24/77	8/24/77	
Date of Receipt						
TURBIDITY						
SEDIMENT						
COLOR						
ODOR						
pH	6.75	6.65	7.55	6.60	6.50	
ALKALINITY-Total ($CaCO_3$)						
HARDNESS ($CaCO_3$)						
CALCIUM(Ca)						
MAGNESIUM(Mg)						
SODIUM(Na)						
POTASSIUM(K)						
IRON(Fe)	0.03	2.26	0.38	0.33	0.16	
MANGANESE(Mn)	0.49	2.16	2.99	1.27	1.25	
SILICA(SiO_2)						
SULFATE(SO4)						
CHLORIDE(Cl)						
SPEC.COND.(micromhos/cm)						
NITROGEN(AMMONIA)						
NITROGEN(NITRATE)	0.68					
NITROGEN(NITRITE)						
COPPER(Cu)						
Total Phosphate	0.64					
Ortho phosphate	0.05					

North Springfield, VT 05150

Table No. 29

Collector: George Allan

WATER SUPPLY ANALYSIS (mg. per liter)
(made at D-H Lab)

Source A - Gravel Packed Well "H" Raw Water
Source B - Gravel Packed Well "H" Effluent of Carbon Column Filter
Source C - Gravel Packed Well "H" Raw Water
Source D - Gravel Packed Well "H" Effluent of Carbon Column Filter
Source E -
Source F -

	A	B	C	D	E	F
Sample No. or Work Order	12-0053	12-0053	12-0053	12-0053		
Date of Collection	8/24/77	8/24/77	9/2/77	9/2/77		
Date of Receipt						
TURBIDITY						
SEDIMENT						
COLOR						
ODOR						
pH	6.60	6.50	6.30	6.55		
ALKALINITY-Total ($CaCO_3$)						
HARDNESS ($CaCO_3$)						
CALCIUM(Ca)						
MAGNESIUM(Mg)						
SODIUM(Na)						
POTASSIUM(K)						
IRON(Fe)	0.33	0.16	0.67	0.06		
MANGANESE(Mn)	1.27	1.25	1.02	0.23		
SILICA(SiO_2)						
SULFATE(SO4)						
CHLORIDE(Cl)						
SPEC.COND.(micromhos/cm)						
NITROGEN(AMMONIA)						
NITROGEN(NITRATE)						
NITROGEN(NITRITE)						
COPPER(Cu)						

North Springfield VT 05150

Table No. 30

Collector: L. Pittendreigh

WATER SUPPLY ANALYSIS (mg. per liter)

(made at D-H Lab)

Source A - Gravel Packed Well "H" Raw Water

Source B - Gravel Packed Well "H" Effluent of Carbon Column Filter

Source C - Gravel Packed Well "H" Raw Water

Source D - Gravel Packed Well "H" Effluent of Carbon Column Filter

Source E - Test Well 1-77

Source F -

	A	B	C	D	E	F
Sample No. or Work Order	12-0053	12-0053	12-0053	12-0053	12-0053	
Date of Collection	9/12/77	9/12/77	9/16/77	9/16/77	9/14/77	
Date of Receipt	9/14/77	9/14/77	9/27/77	9/27/77	9/27/77	
TURBIDITY						
SEDIMENT						
COLOR						
ODOR						
pH	6.35	6.45				
ALKALINITY-Total($CaCO_3$)						
HARDNESS ($CaCO_3$)						
CALCIUM(Ca)						
MAGNESIUM(Mg)						
SODIUM(Na)						
POTASSIUM(K)						
IRON(Fe)	0.24	0.10	0.10	0.02	0.06	
MANGANESE(Mn)	0.89	0.89	0.95	0.95	0.36	
SILICA(SiO_2)						
SULFATE(SO4)						
CHLORIDE(Cl)						
SPEC.COND.(micromhos/cm)						
NITROGEN(AMMONIA)						
NITROGEN(NITRATE)	0.30	0.30	0.03	0.08	0.00	
NITROGEN(NITRITE)						
COPPER(Cu)						

Special

[illegible]

North Springfield, [illegible] 05150

Collector: B. Jones

TABLE NO. 31

WATER SUPPLY ANALYSIS (mg. per liter)

(made at D-H Lab)

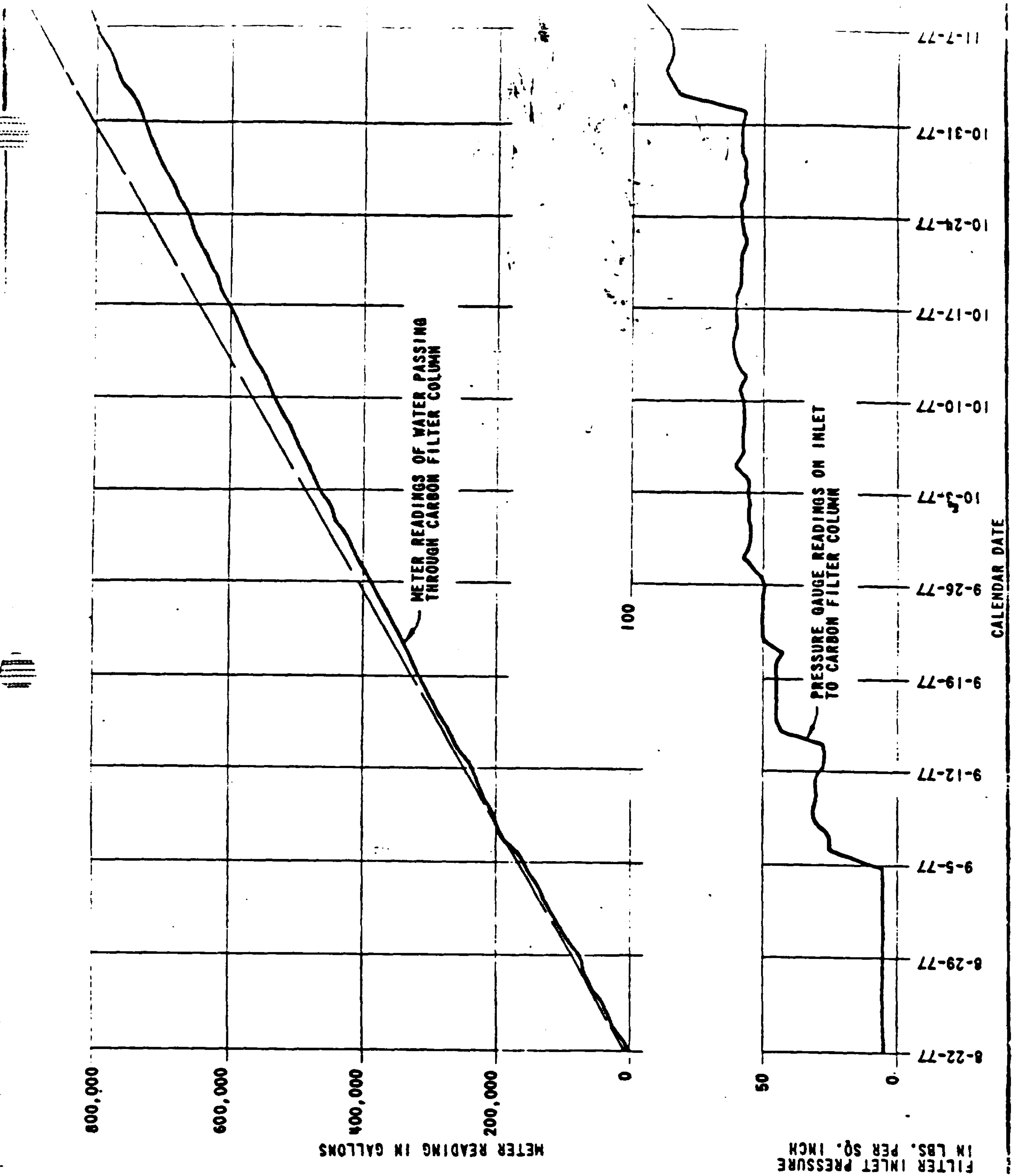
(Made by Lawrence Lab)

W. 16

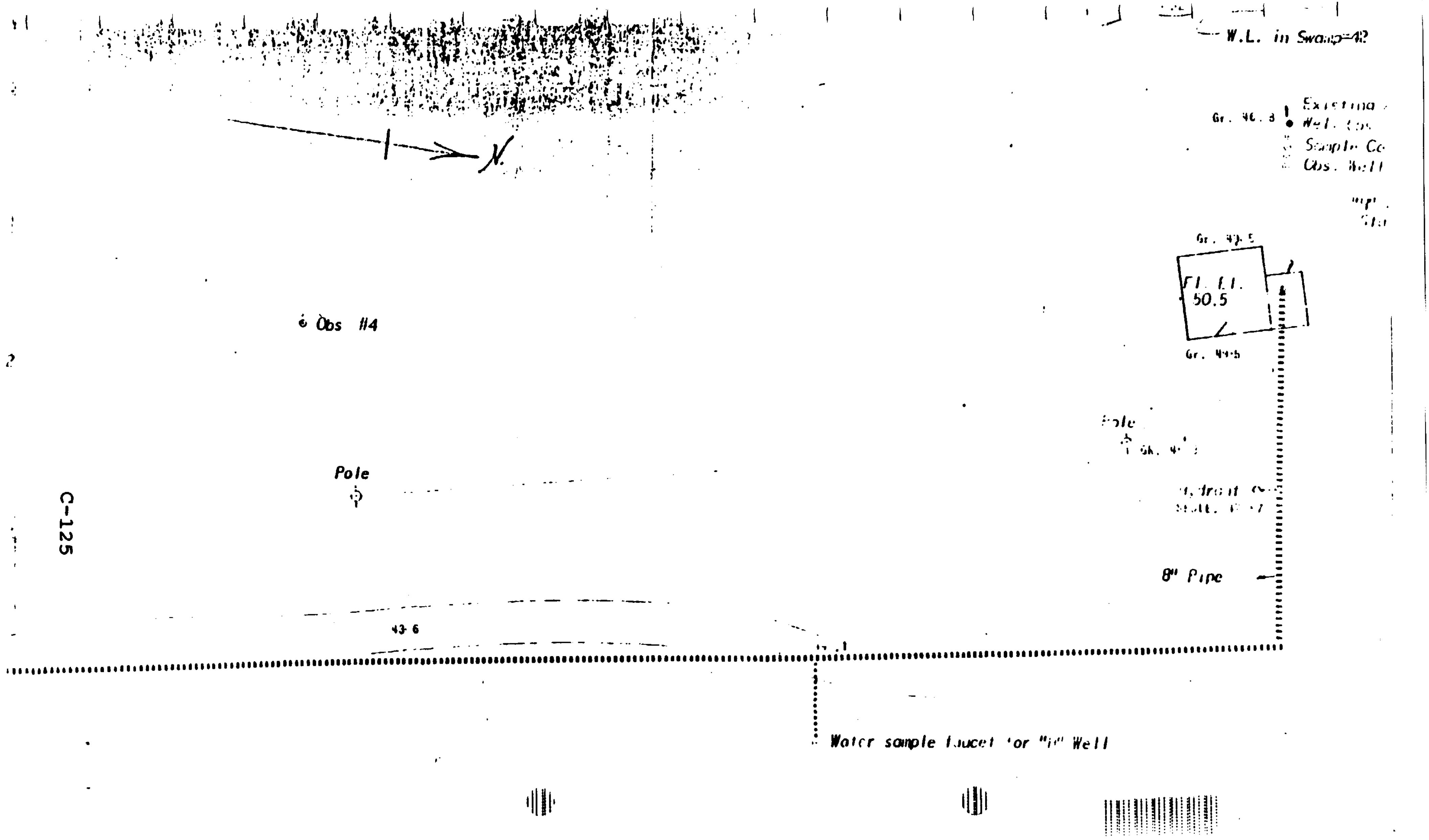
Source A - 8" Test Well 1st day of pumping test
Source B - 8" Test Well 3rd day of pumping test
Source C - 8" Test Well 4th day of pumping test
Source D - 8" Test Well 7th day of pumping test
Source E - 8" Test Well last day of pumping test -
Source F -

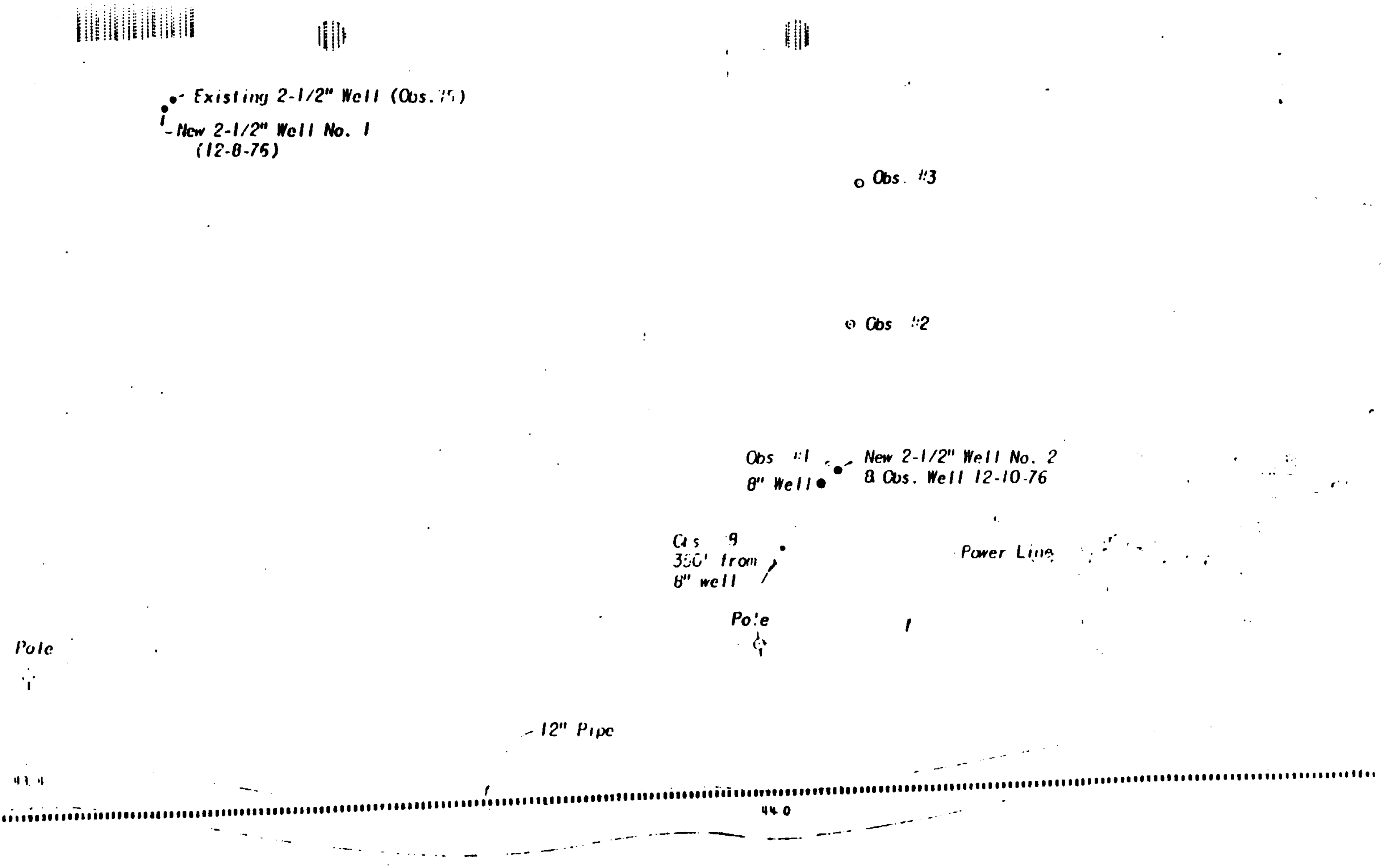
8" well located
between G and H
pumping 250 GPM

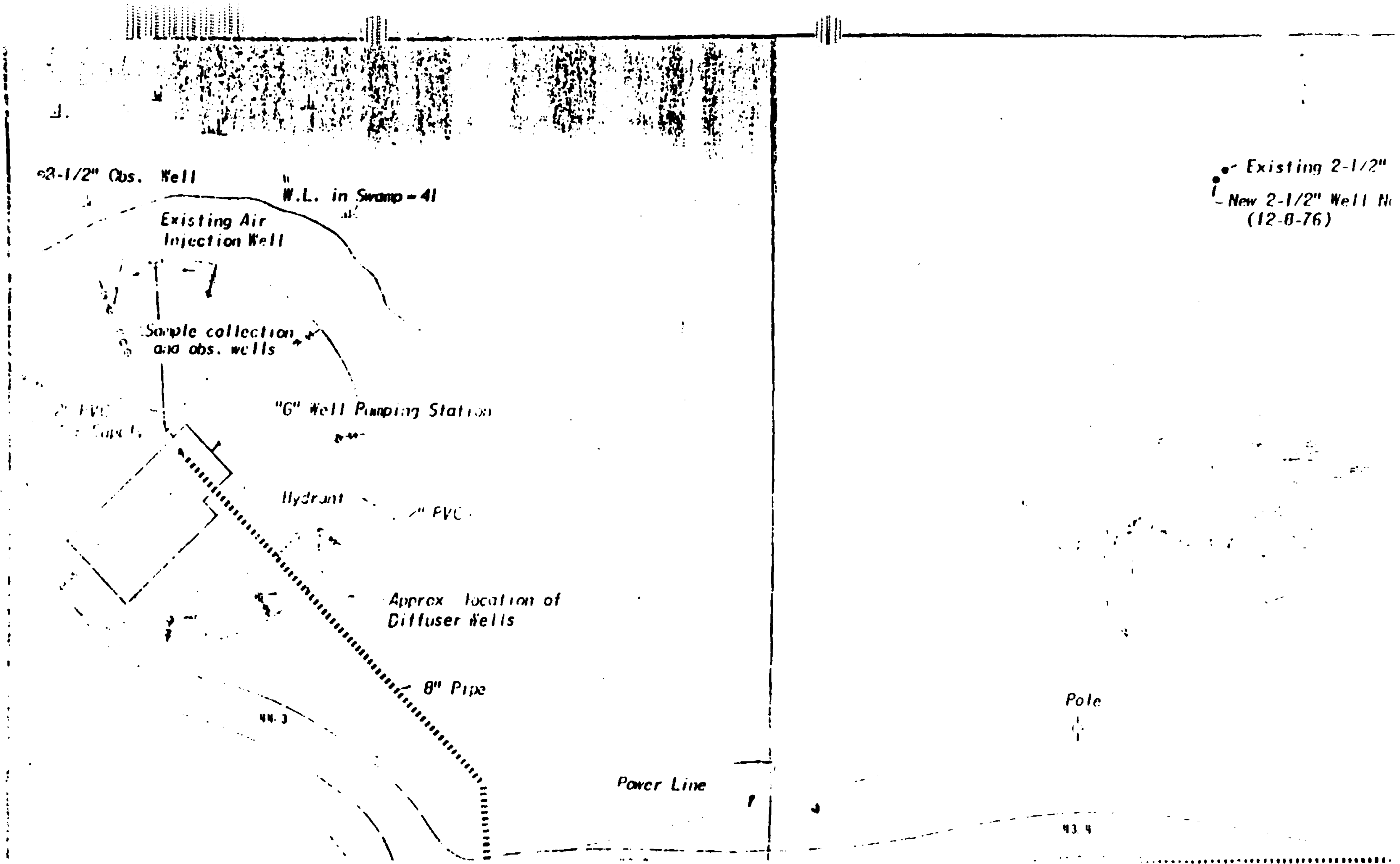
	A	B	C	D	E	F
Sample No. or Work Order	543933	543946	947	543977	543970	
Date of Collection	11/14/77	11/16/77	11/17/77	11/20/77	11/23/77	
Date of Receipt	11/15/77	11/17/77		11/23/77	11/23/77	
TURBIDITY	1.1	0.4		0.2	0.1	
SEDIMENT	0	0		0	0	
COLOR	4	3		0	3	
ODOR	0	0		0	0	
pH	6.6	6.4		6.7	6.8	
ALKALINITY-Total($CaCO_3$)	74	59		54	53	
CCE			2.79			
HARDNESS ($CaCO_3$)	141	94		98	83	
CALCIUM(Ca)	40	18		26	20.	
MAGNESIUM(Mg)	10	7.9		8.0	7.9	
SODIUM(Na)	43	78		72.	57.	
POTASSIUM(K)	4.6	5.0		4.8	4.5	
IRON(Fe)	0.12	0.1		0.06	.08	
MANGANESE(Mn)	0.58	0.61		.64	.63	
SILICA(SiO_2)	13	13		17	17	
SULFATE(SO4)	160	135		120	125	
CHLORIDE(Cl)	110	100		100	105	
SPEC.COND.(micromhos/cm)	640	620		520	540	
NITROGEN(AMMONIA)	3.2	4.6		3.7	3.7	
NITROGEN(NITRATE)	0.0	0.7		0.9	1.0	
NITROGEN(NITRITE)	.001	.001		.001	.002	
COPPER(Cu)	.00	.18		.07	.00	

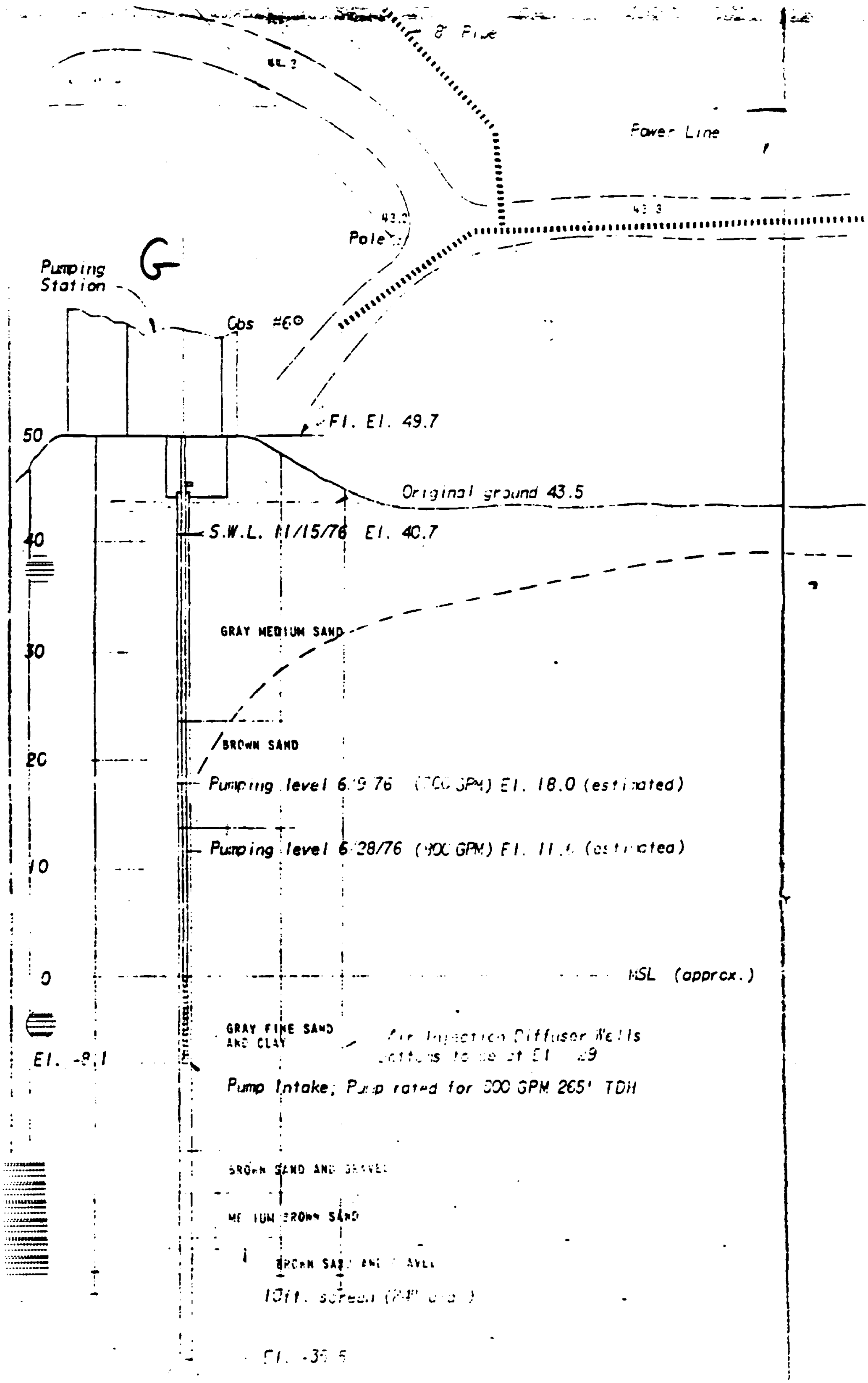


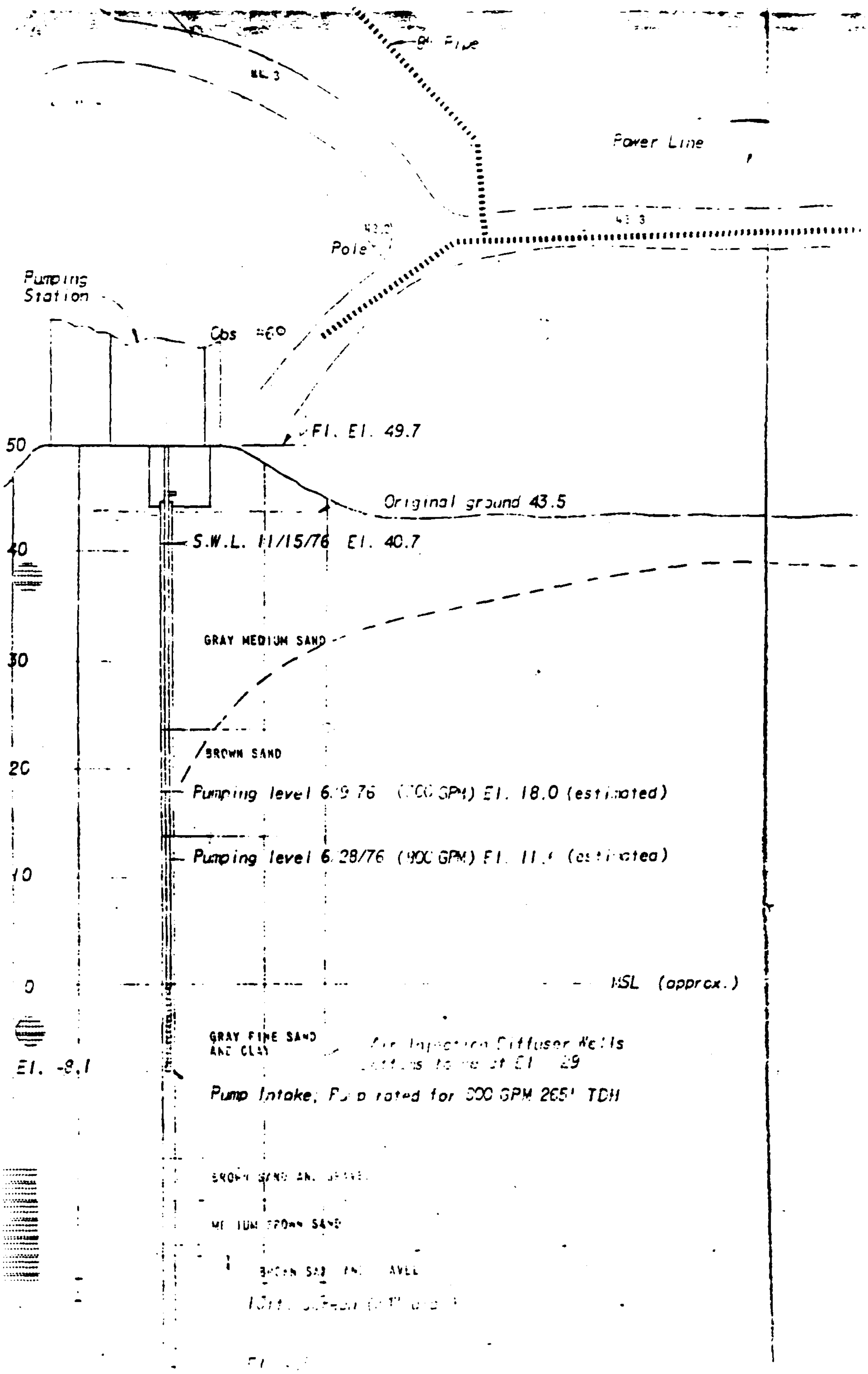
NT NO	12-0053	DUFRESNE-HENRY ENGINEERING CORP. *Precision Park, North Springfield, Vermont 05150*	PLATE NO. . 5
NGINEER	LMP	CARBON COLUMN PILOT PLANT STUDY	
RAWN BY	EHP	GRAVEL PACKED WELL "H"	
ATE	1-11-78	WOBURN. MASSACHUSETTS	A 5964

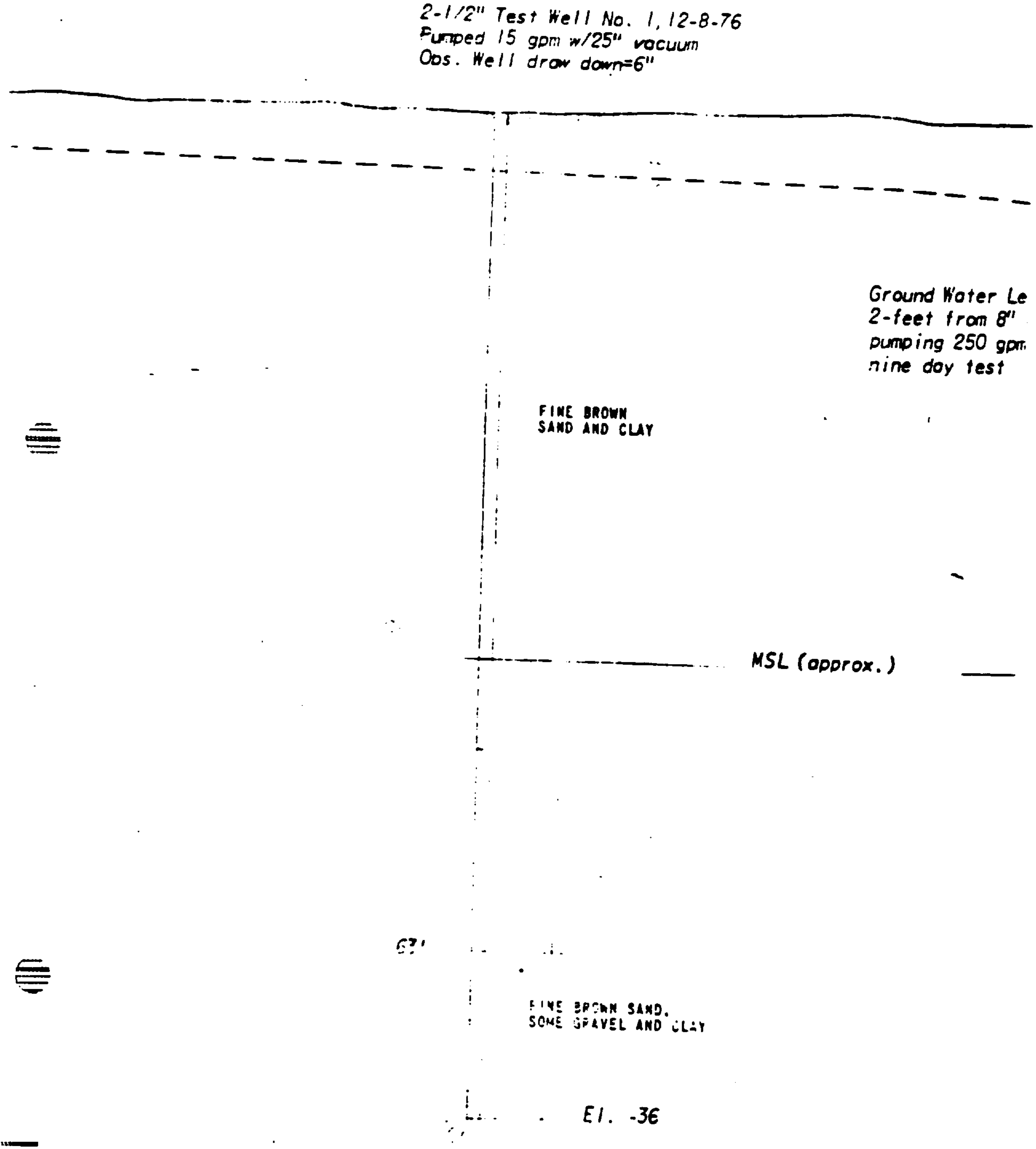

W.L. in Swamp=42
Gr. 46.3
Existing
Wel. Co.
Sample Co
Obs. Well
Gr. 49.5
Fl. El.
50.5
Gr. 49.5
Pole
Hydrant
8" Pipe
N.
Obs #4
Pole
43.6
Water sample faucet for "i" Well


Existing 2-1/2" Well (Obs. #5)
New 2-1/2" Well No. 1
(12-8-76)
Obs. #3
Obs #2
Obs #1
8" Well
New 2-1/2" Well No. 2
& Obs. Well 12-10-76
Obs #9
350' from
8" well
Power Line
Pole
Pole
12" Pipe
43.4
44.0


3-1/2" Obs. Well
W.L. in Swamp = 41
Existing Air Injection Well
Sample collection and obs. wells
"G" Well Pumping Station
2" PVC
Hydrant
2" PVC
Approx location of Diffuser Wells
8" Pipe
44.3
Power Line
Pole
43.4
Existing 2-1/2"
New 2-1/2" Well N
(12-8-76)

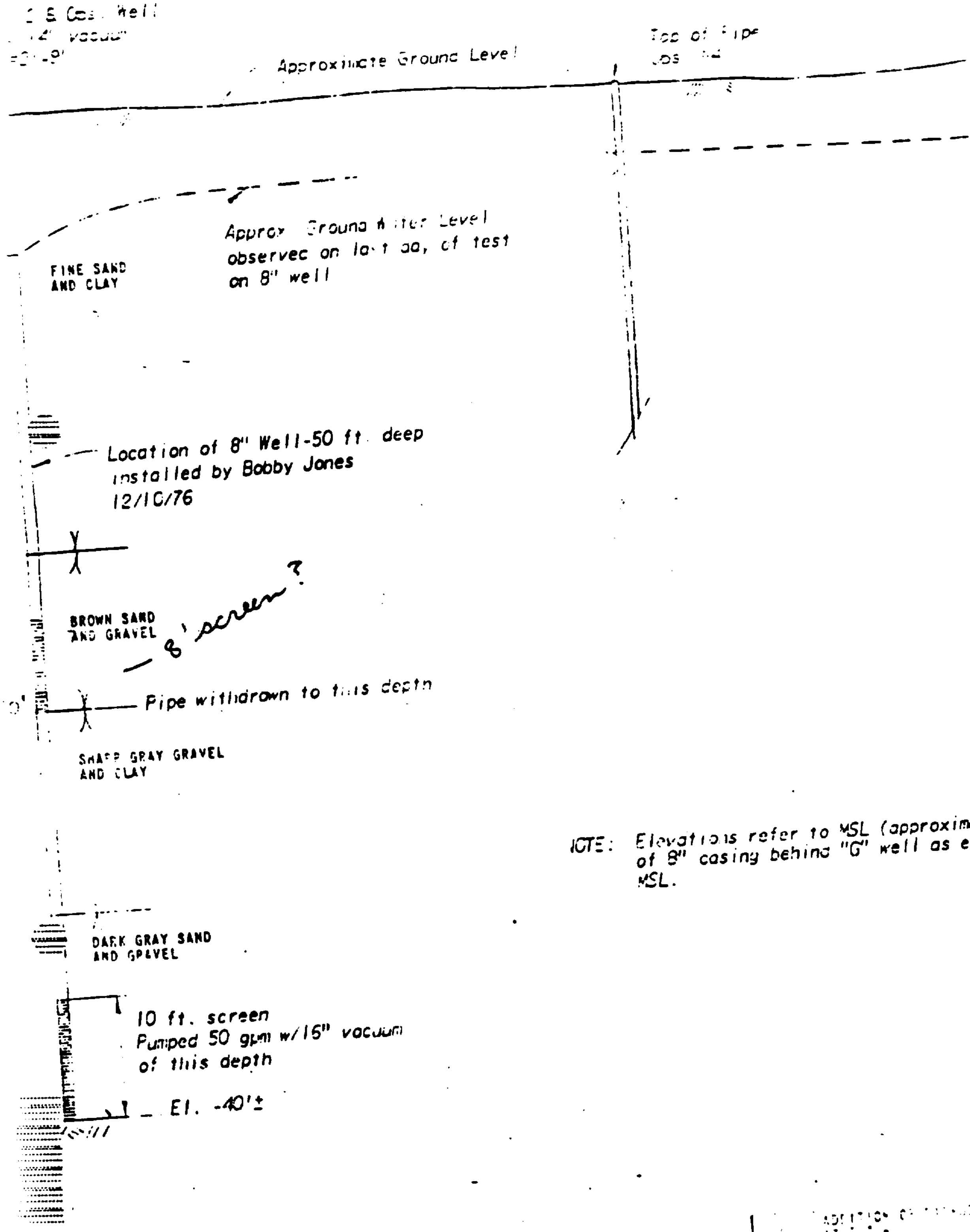

8" Pipe
Power Line
43.2
43.3
Pole
G
Pumping Station
Obs #6
Fl. El. 49.7
50
Original ground 43.5
40
S.W.L. 11/15/76 El. 40.7
GRAY MEDIUM SAND
30
BROWN SAND
20
Pumping level 6/9/76 (700 GPM) El. 18.0 (estimated)
Pumping level 6/28/76 (900 GPM) El. 11.6 (estimated)
10
0
MSL (approx.)
GRAY FINE SAND AND CLAY
Air Injection Diffuser Wells bottoms to be at El. -29
El. -8.1
Pump Intake; Pump rated for 300 GPM 265' TDH
BROWN SAND AND GRAVEL
MEDIUM BROWN SAND
BROWN SAND AND GRAVEL
10 ft. screen
El. -39.5


8" Pipe
Power Line
43.3
Pole
Pumping Station
Obs #6
Fl. El. 49.7
50
Original ground 43.5
S.W.L. 11/15/76 El. 40.7
40
GRAY MEDIUM SAND
30
BROWN SAND
20
Pumping level 6/9/76 (GPM) El. 18.0 (estimated)
Pumping level 6/28/76 (900 GPM) El. 11. (estimated)
10
0
MSL (approx.)
GRAY FINE SAND AND CLAY
Air Injection Diffuser Wells
El. 29
El. -8.1
Pump Intake; Pump rated for GPM 265' TDH
BROWN SAND AND GRAVEL
MEDIUM BROWN SAND
BROWN SAND AND GRAVEL

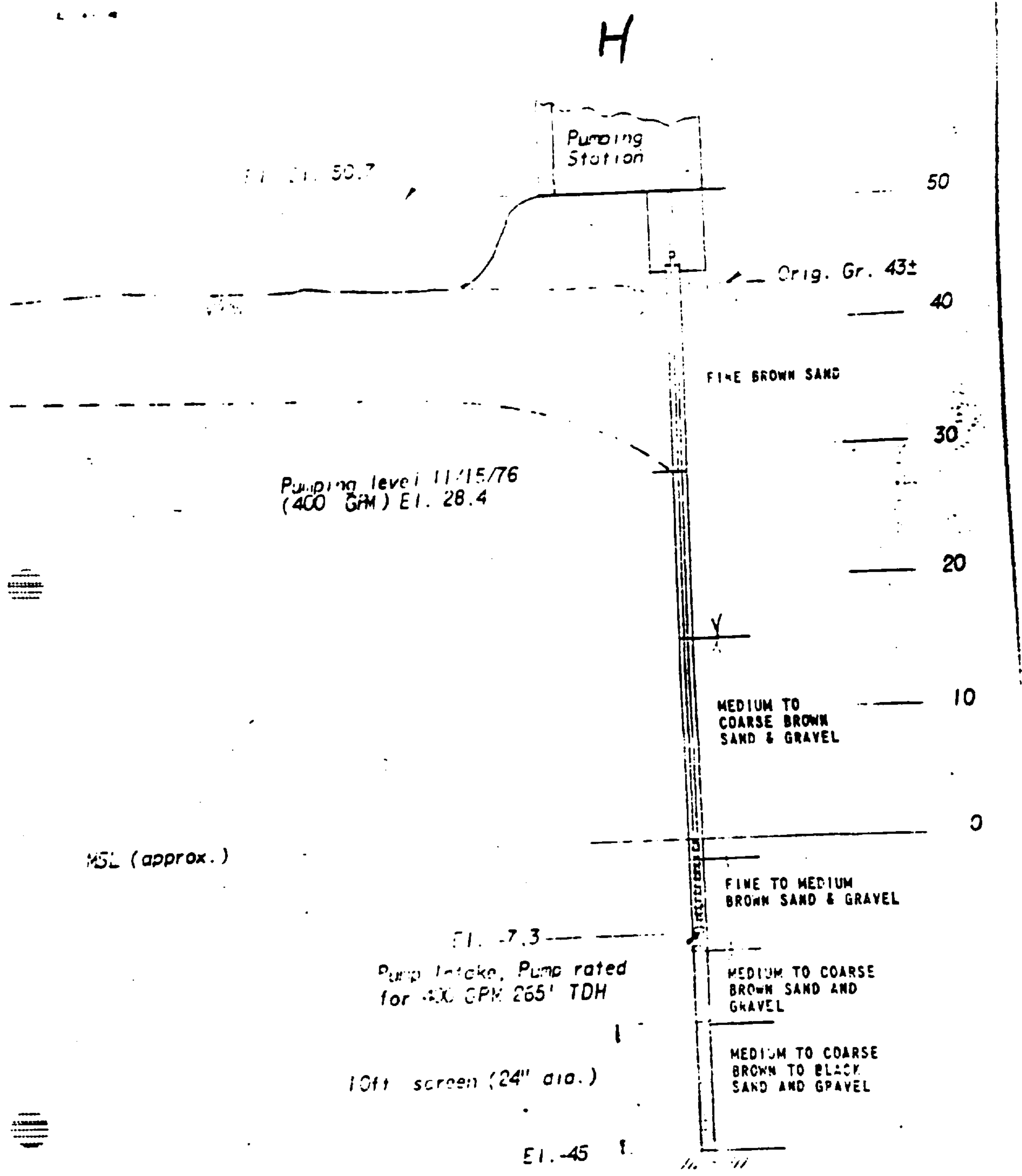


HYDRAULIC PROFILE

Scale: 1"=20' Hor
1"=10' Ver



NOTE: Elevations refer to MSL (approxim
of 8" casing behind "G" well as e
MSL.



WELLS "G" & "H"
HYDRAULIC STUDY

WOBURN MASSACHUSETTS

DUFRESNE-HENRY
Engineering Corporation

C-2.12 April 1979 letter from Massachusetts DEQE to Woburn Board of Water Commissioners regarding a proposed public supply well off Salem Street.

The Commonwealth of Massachusetts
Department of Environmental Quality Engineering
Metropolitan Boston - Northeast Regional Office
Tewksbury State Hospital
Tewksbury, Massachusetts 01876

Tel. 617-851-7261

April 4, 1979

Board of Water Commissioners
City Hall
Woburn, Massachusetts 01801

RE: WOBURN-Public Water Supply
Proposed Well Site off
Salem Street

Gentlemen:

The Department has considered the proposal of the City of Woburn to develop a wellsite for public water suuply approximately 210 feet southwest of Consolidated Freightways off Salem Street (Cranberry Bog Site).

After careful review of the proposal, the Department is still of the opinion that the proposed site should not be used for development of a source of public water supply because of the presence of the following sources and potential sources of pollution.

1. A sewer line within a 400 ft. of the proposed well site.
2. An Industrial building complex and parking area within a 400 ft. of the proposed well site.
3. An auto junk yard adjacent to the Aberjona River approximately 1200 ft. upstream of the proposed well site.

If you have any further questions concerning this matter please call me at 851-7261.

Thank you for your continued cooperation.

Very truly yours,

For the Commissioner,

Gerald W. McCall

Gerald W. McCall
Acting Regional Environmental Engineer
Metropolitan Boston-Northeast Region

EGM/Efb/jb

CC: Mr. Wall, Supt.
Department of Public Works
10 Common St. City Hall
Woburn, MA 01801

Board of Health
13 Rear Church Ave
Woburn, MA

Tom Mernin
City Engineer
City Hall
Woburn, MA

Dufresne-Henry Eng. Corp.

C-2.13 November 1957 Water quality analysis data sheet for Consolidated Chemical, Inc. test well on western shore of Mishawum Lake.

FACSIMILE

SKINNER & SHERMAN, INC.

Chemists and Engineers
246 Stuart Street
Boston, Massachusetts

Report on: Water (3)
(New Stauffer Chemical Company)

Date: November 29, 1957

To: Consolidated Chemical Industries, Inc., Box 318
Woburn, MA
Attn: Mr. R.M. Banwell

Our Case No: 54891 Sample No.(s)

Date Rec'd: November 26, 1957

How Received: Brought to the laboratory.

Instructions: Analysis.

Sample(s) Marked: SS#-15395 Sample #1 - Well water discharging into storage tanks.
SS#-15396 Sample #2 - Test Well #3.
SS#-15397 Sample #3 - Woburn City Water
Purchase Order #39216

RESULTS:

	Parts per Million		
	#1	#2	#3
Total Solids	239.00	6920.00	146.00
Lost on Ignition	45.00	1180.00	25.00
Fixed Solids	194.00	5740.00	121.00
Silica - SiO_2	18.60	40.8	4.40
Iron Oxide - Fe_2O_3	2.14	1072.5	0.21
Aluminum Oxide - Al_2O_3	4.26	97.5	3.19
Calcium - Ca	34.40	384.0	20.80
Magnesium - Mg	9.69	271.0	6.63
Sodium and Potassium - Na & K	5.64	838.9	6.28
Chlorides - Cl	31.00	375.0	20.00
Bicarbonates - HCO_3	24.40	7.80	19.03
Sulfates - SO_4	62.82	3640.00	37.60
Hardness as $CaCO_3$	119.6	2200.00	90.00
Hydrogen Ion Concentration	pH=6.7	pH=4.65	pH=6.48
Iron - Fe	1.50	750.0	0.13

These radicles were probably combined as follows:

	#1	#2	#3
Silica - SiO_2	18.80		4.40
Iron Oxide - Fe_2O_3	2.14		0.21
Aluminum Oxide - Al_2O_3	4.26		3.19
Calcium Sulfate - $CaSO_4$	89.58		49.36

SKINNER & SHERMAN INC.

CHEMISTS AND ENGINEERS
246 STUART STREET,
BOSTON 16 · MASSACHUSETTS

Now Stauffer Chemical Co

Report on Water (3)

Date November 29, 1957

To Consolidated Chemical Industries, Inc., Box 318,
Woburn, Mass., Attn: Mr. R. M. Banwell

Our Case No. 54891 Sample No (s)

Date Rec'd. November 26, 1957

How Received Brought to the laboratory.

Instructions Analysis.

Sample (s) Marked SS #-15395 Sample #1-Well water discharging into storage tanks
SS #-15396 Sample #2-Test Well #5
SS #-15397 Sample #3-Woburn City Water
Purchase Order #59216

[illegible]

	[illegible] #1	307 Parts Per Million #2	City water #3
Total Solids	239.00	6920.00	146.00
Loss On Ignition	45.00	1180.00	25.00
Fixed Solids	194.00	5740.00	121.00
Silica - SiO_2	18.60 /19	40.8	4.40
~~Iron Oxide - Fe_2O_3~~ x .155423	~~2.14~~	1072.5	0.21
Aluminum Oxide - Al_2O_3 ✓.529130	4.26 2.25	97.5	3.19
Calcium - Ca	34.40 35	884.0	20.80
Magnesium - Mg	9.69 9.7	271.0	6.63
Sodium & Potassium - NaK	5.64 5.6	558.9	6.28
Chlorides - Cl	31.00 31	375.0	20.00
Bicarbonates - HCO_3	24.40 24	7.80	19.03
Sulfates - SO_4	62.52 63	3640.00	37.60
Hardness as $CaCO_3$	119.6 120	2800	90.00
Hydrogen Ion Concentration	pH-6.7 ✓	pH-4.65	pH-6.48
Iron - Fe	1.50 ✓	750	0.15

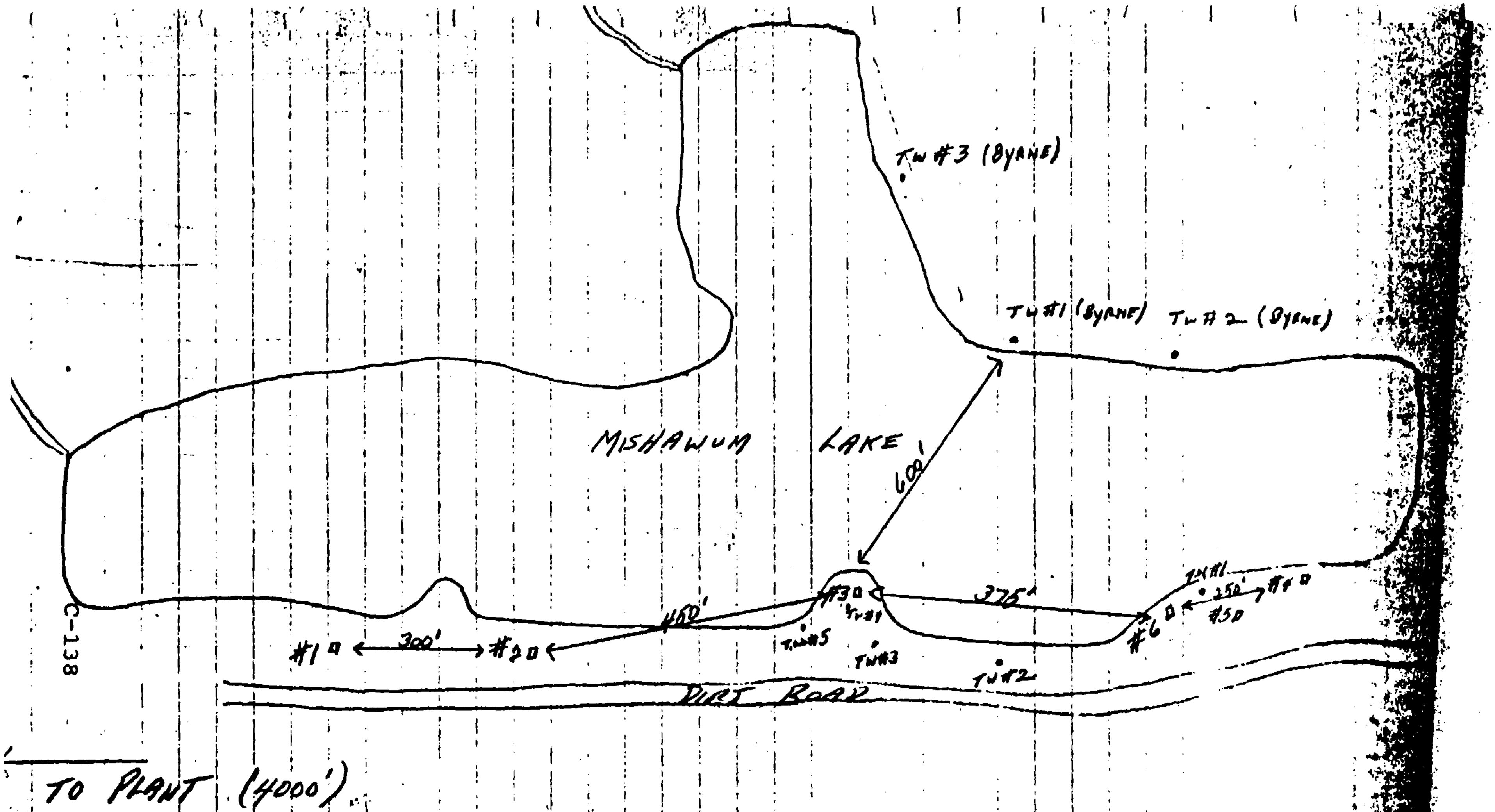
These radicles were probably combined as follows:

	#1	#2	#3
Silica - SiO_2	18.60		4.40
Iron Oxide - Fe_2O_3	2.14		0.21
Aluminum Oxide - Al_2O_3	4.26		3.19
Calcium sulfate - $CaSO_4$	89.58		40.36

Continued on attached sheet

C-137

[illegible]



CONSOLIDATED CHEMICAL INDUSTRIES
SKETCH OF WELL FIELD
WOBURN, MASS.

□ OLD G.P. WELLS 1-5 L+B
6 L.NY.

TW = TEST WELLS 2½"

C-2.14 March 1964 notes of Mr. Herbert D. Nickerson regarding discharge of polluted material onto land owned by Stauffer Chemical Company.

FACSIMILE

Notes relative to: Woburn Stauffer Chemical Company - Discharge of Pollutional Material onto Land

BY: Herbert D. Nickerson

DATE: March 18, 1964

On Saturday, March 14, 1964, the writer received a telephone call from Mr. Walter Howard, Plant Manager, Stauffer Chemical Company, Woburn. Mr. Howard asked the writer to visit the chemical company on Monday, as sludge and drainage were discharging onto the company's property from the operation of a privately owned dump in North Woburn.

Accordingly, the writer, accompanied by Mr. Pottle of this office, met with Mr. Howard and Mr. Edward App, Health Inspector, Woburn, at the Stauffer Chemical Company, North Woburn. Mr. Howard stated that sludge material, collected from the Atlantic Gelatine Company, Woburn, was discharged into a low area of the dump operated by All-State Sand and Gravel, Inc. (Mr. Robert Corea), and thence discharged to a small brook which flows easterly under the Boston and Maine Railroad tracks and onto property owned by the Stauffer Chemical Company, immediately northerly of Mishawum Lake. Mr. App stated that George Trucking Company had a contract with Atlantic Gelatine Company, Inc. to discharge such sludge at the dump. The latter contract apparently was approved by the Woburn Board of Health, and it was agreed that such sludge would be discharged into a deep pit, covered with lime, and backfilled daily. Atlantic Gelatine had apparently said there would only be a couple of trucks a week. Mr. App informed the writer that at the present time approximately 14 trucks discharge sludge daily over a 7-day weekly period. During the examination, two dump trucks discharged sludge over the banking of the dump. Each truck contained approximately 20 cubic yards of sludge. Two small bags of lime were added for each truckload.

It was determined that a small brook, un-named, emanates from the general dump area and receives drainage from the dump, discharging through the same culvert as the sludge material. The sludge is purportedly washed down with a hose from time to time. However, the end result is that highly polluted liquid, mixed with sludge, discharges onto property owned by Stauffer Chemical Company. The writer estimates that approximately 3 to 5 acres of swamp land have been affected by this discharge. At the time of the examination, several fires were burning at the dump, causing heavy dense smoke resulting in obnoxious odors. The wind was from the west to northwest, and caused the smoke to blow in an easterly direction toward the swamp. It was, therefore, impossible to determine whether or not the sludge exhibited any severe odor. It is the writer's opinion that, during the warmer seasons of the year, there will be a definite odor problem resulting from this sludge material. Somewhat more northerly of Mishawum Lake, Halls Brook discharges through a culvert to the same general swampy area. Halls Brook flows by a piggery and receives drainage from the manure pile.

A second piggery, located southerly and adjacent to the dump, discharges surface drainage indirectly to Mishawum Lake. The Wilmington trunk sewer line and the Woburn sewer run parallel along the easterly side of the Boston and Maine Railroad tracks. A manhole on the Woburn sewer, immediately east of the dump, had its manhole cover ajar and there was evidence of overflowing conditions. At the time of the examination, the manhole was almost surcharged.

The writer and group made a survey around Mishawum Lake, and found no other readily detectable sources of pollution. An examination of the lagoon and settling system at the Stauffer Chemical Company determined that there were prominent odors resulting from the stock piling of sludge material from the settling unit. Mr. Howard then showed the writer where the sludge material was discharged into a deep pit, covered with lime and HTH, and allowed to drain. Some sulfide odors were noted at this area.

It is quite obvious that there are severe problems in the North Woburn area which result from many isolated and specific causes. Air pollution problems do exist: from the operation of the Stauffer Chemical Company; the two piggeries; the burning dump; the putrefied sludge; and sewage surcharges flow from the trunk sewer lines. From the Atlantic Gelatine Company standpoint and the operation of the All-State Sand and Gravel Inc. Dump, there are two immediate problems:

1. The immediate stopping of drainage from the dump into the brook and onto private land, and

2. Potential litigation between the Stauffer Chemical Company and All-State Sand and Gravel, Inc.

Notes Relative to: **Woburn Stauffer Chemical Company-**
Discharge of Pollutional Material Onto Land

BY: Herbert D. Nickerson

DATE: March 18, 1964

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DEFENDANT'S EXHIBIT G-437

ALL-STATE LEGAL SUPPLY CO.

The writer and group made a survey around Mishawum Lake and found no other readily detectable sources of pollution. An examination of the lagoon and settling system at the Stauffer Chemical Company determined that there were prominent odors resulting from the stock piling of sludge material from the settling unit. Mr. Howard then showed the writer where the sludge material was discharged into a deep pit covered with lime and HTH and allowed to drain. Some sulphide odors were noted at this time.

It is quite obvious that there are severe problems in the North Woburn area which result from many isolated and specific causes. Air pollution problems do exist: from the operation of the Stauffer Chemical Company; the 2 piggeries; the burning dump; the putrified sludge; and sewage surcharges flow from the trunk sewer lines. From the Atlantic Gelatin Company standpoint and the operation of the All-State Sand and Gravel Inc. Dump, there are 2 immediate problems: (1.) The immediate stopping of drainage from the dump into the brook and onto private land and (2.) Potential litigation between the Stauffer Chemical Company and the All-State Sand and Gravel Inc.

se

C-2.15 October 1970 report titled, "Aberjona River Sanitary Survey at Wilmington, Woburn, Stoneham, and Winchester," prepared by Robert M. Cady, Massachusetts Department of Public Health.

ABERJONA RIVER SANITARY SURVEY
AT WILMINGTON, WOBURN, STONEHAM AND WINCHESTER

October, 1970

by

Robert M. Cady

DEFENDANT'S
EXHIBIT
6-257
ALL-STATE LEGAL SUPPLY CO.

a catch basin, which was located in an area where engine parts are cleaned. There was no M.D.C. Oil Trap to prevent the oil pollution. The flow and likewise the usage is highly variable. On August 11, 1970, Mr. Roy B. Craft, the General Manager of the above firm submitted plans of an oil trap. The City of Woburn Plumbing Inspector, Mr. Charles McGondel, did not approve the plans because the trap was exposed to excess runoff. In this condition the trap might surcharge, thus releasing the trapped oil and grease into the sewer.

The writer contacted Mr. Crafts on October 9, 1970. He told the writer that he is revising his plans to protect the oil trap from any runoff. The area will be enclosed by a roof and walls. The writer feels that progress is being made and will follow this progress to ensure eventual pollution abatement.

G. Roketenetz Piggery

This pig farm was mentioned in the Camp, Dresser & McKee 1967 report as being a probable pollution source. In order to substantiate this allegation, the writer and N.R.O. Bartolomeo visited the farm on September 16, 1970. During the inspection, the owner was not present. The farm buildings and fences were old and dilapidated and there were pigs freely roaming about. We observed piles of garbage in numerous locations and attempted to discern the drainage direction from the farm. A perimeter examination revealed that the drainage goes downgrade to the south then east toward Michawum Lake. The drainage ditch was dry, yet filled with lush vegetation. Therefore, no dye or flow studies were made and no sample was taken.

It is the writer's opinion that the pig farm is not an active pollution source but that organic and coliform pollutants can originate from the farm, intermittently, i.e., during vigorous runoff or thaws. Also the location of the piggery pictured by the CDM 1967 plan is incorrect because Hall's Brook doesn't pass through the farm but one quarter mile northwest of that piggery.

A source of ammonia was noted in the Woburn Survey about Michawam Lake conducted by Peter G. Moleux on February 29, 1968. This writer tested the brook upstream and before the brook flows beneath New Boston Road. The results show that the brook water was not polluted. However, the brook crosses beneath the road and dissipates into a swampy area. This swampy area eventually joins the drainage from the Woburn Dump and National Polychemicals, which are upstream (see Figures 3 and 4).

On September 16, 1970 the writer spoke to the contractor who is developing this swampy area. He told the writer that he intended to direct the brook inside corrugated steel pipe up to the Boston & Maine Railroad tracks. During the preparation of the site, the contractor unearthed pig carcasses and pig excrement which was still quite odorous. It can be thus assumed that these former piggeries have contributed pollutants to the Aberjona Watershed and that this drainage will cease when the site is graded and filled. The site will be titled the Woburn Industrial Park.

H. Stauffer Chemicals (now abandoned and presently owned by Mark Phillip Trust)

This plant used to process unwanted, chrome-tanned animal hides and hoofs for glue. The abandoned plant still has settling basins and lagoons filled with industrial wastes. The wastewater in the lagoons is black and contains 54 mg/l of hexavalent chromium (see laboratory results, 9-22-70). No flow was observed by the writer nor were there any plumbing plans available to the writer. The overflow from the lagoons allegedly entered the M.D.C. Trunk sewer after passage through a bar screen.

In June 1970, the writer surveyed the lagoons and noticed that a drainage ditch into Michawum Lake contained the same black wastewater as was observed in the settling lagoons. A sample was taken and the results show that the water had a B.O.D. of 90 mg/l and a C.O.D. of 525 mg/l. This ditch also receives drainage from the abandoned dump that contains animal hides and residue. How the wastewater entered the ditch remains a mystery but the ultimate disposal of the waste should involve the Division and the Bureau of Environmental Health. At this sampling, the writer did not suspect the presence of hexavalent chrome. The Stauffer plant will be razed as part of a development project in the area. The project will proceed in phases, including a phase which involves the cleaning and/or filling of the settling basins and lagoons. The writer determined that the wastewater contains hexavalent chromium and will advise the owners as to the best method of wastewater disposal and solids burial so as to prevent the intermittent pollution of the drainage waters from the area near the pits and lagoons.

I. Woburn Municipal Dump

The dump is operated as a sanitary landfill and it is located west of New Boston Road near Stauffer Chemicals. The dump is situated in a swampy area which drains into a ditch, which is tributary to Michawum Lake. The writer sampled the drainage from the dump and found that it contains pollutants. The B.O.D. was 29 mg/l along with a high fecal and total coliform bacteria count. The swamp is continually being filled to expand the dump, however the natural drainage will prevail. This drainage will be a constant source of pollution until abated or at least lessened. A letter will be sent to the City of Woburn relative to this source of pollution.

J. Woburn Barrel Company - New Boston Road

This firm has been dumping fly ash and chemical residue onto the ground adjacent to a drainage ditch, which drains into Lake Richawum. On September 25, 1970 the writer told the owner, Mr. Stephen Dagata to stop this dumping. The writer gave the owner three weeks to comply. The writer shall ascertain whether the pollution has stopped in a future visit. Meanwhile, a letter will be sent to the owner outlining the possible action which could be taken to abate the pollution.

K. International Minerals - New Boston Road

This firm is a warehouse for the storage of solid and liquid fertilizers. There is a small pond on the property and piles of what appears to be fertilizer are located along its shoreline. The pond has a small, intermittent outlet to the Aberjona drainage, but the writer saw no flow out of the pond. The pond is warm and shallow with waters pea soup green in color (eutrophic?).

It is the writer's opinion that no action is needed at this site. The owner denies that the observed piles are fertilizer and the writer detected no odor from the piles.

L. Lipton Foods - Tabby Cat Food - Woburn Street, Woburn

This firm intermittently discharges a heated effluent into an unnamed pond on their property. The writer observed abundant, normal flora and fauna in the pond. The outlet of the pond is a spillway at the southern end. The water quality leaving the pond is excellent. The pond receives drainage from E.C. Whitney Barrel Company via a ditch on the northwest shore. Also, a ditch enters the pond at the northern shoreline. Therefore, the pond receives street runoff and railbed drainage yet the effects of this water haven't, as yet, caused any serious problems in the pond.

It is the writer's opinion that this firm is not a pollution source in the Aberjona watershed.

M. Metal Processing Company - 26 Newshaw Street

This firm receives work through sub-contracts for the sealing of glass and metal electronic components. The writer noticed an asbestos cement pipe (4" diameter) discharging water to the river from this firm during June 1970. An inspection of the plant was conducted by the writer. The co-owner, Mr. Donald Atkins, told the writer that the discharge is untreated well-water, which is used for cooling purposes. The water is used and discharged without any water treatment.

The writer feels that this discharge is not a pollution source into the Aberjona River and may be beneficial through augmentation of stream flow.

IV. Wilmington

A. E. C. Whitney Barrel Company - Woburn Street

This firm receives used 55 gallon drums from various surrounding industries. They steam-clean the barrels for re-use. The industrial and sanitary wastewaters are discharged into a public sewer. The writer noticed a great deal of spillage, into the railroad drainage ditches, originating from this firm's yard. Further study revealed that the pollution results from poor housekeeping on the part of the owner. The writer told Mr. Edward Whitney that he must protect the receiving waters from possible pollution, which he agreed to do. A future visit by the writer was made to check the progress being made to prevent the runoff from entering the drainage network of the Aberjona River. The owner is awaiting the construction of a spur track, which will cause great disruption of drainage and land. No significant steps had been taken to provide protection for the ditches. Therefore, a letter should be sent by the Division outlining the penalties for pollution and asking the owner to provide better runoff protection. The writer will make a future inspection to determine if extended action by the Division is required to obtain pollution abatement.

B. National Polychemicals, Inc.

This firm is actively polluting the waters of the Commonwealth with very acid (pH 1.8) industrial wastes. The firm is now on an implementation schedule to abate this discharge. This drainage, undoubtedly, causes the corrosion of any metal or metal-bearing minerals in the stream bed. The water is carried downstream into Michawum Lake. This discharge contains salts, formaldehyde, mineral acids, organic nitrogen compounds (amides, urea) and oil. The laboratory analysis (9-22-70) is presented in the report.

C. Raffi & Swanson, Inc. - James Street

This firm has been the source of pollution in the past but has removed all offending discharges into the waters of the Commonwealth. The writer visited the plant and found that the firm is not at present a pollution source. The railroad drainage ditch beside the firm was devoid of wastewater from past or present discharges.

D. International Salt Company - 245 Woburn Street

This firm is a distribution center and warehouse. They have maintained four foot high piles of salt in their parking lot. The salt is used for snow melting purposes and the runoff thereof enters the drainage into Lake Michawum. The superintendent, Mr. Joseph Bardillo, told the writer that he will remove the salt to an interior location and terminate all dumping near the parking lot.

On October 5, 1970 the writer re-visited the firm and the salt piles were still present. The superintendent told the writer that he was expecting a buyer shortly, who would remove the piles. The writer shall re-inspect the firm to determine if legal action is necessary. Meanwhile, a letter should be sent to Mr. Bardillo informing him of the penalties resulting from water pollution.

V. Summary and Results

Table I shows the list of sources examined in this report. The results of an analysis of Lake Michawum waters are shown in Table II.

Figures 1, 2 and 3 show the sources examined along the Aberjona River from Winchester to Wilmington.

Figure 4 shows the drainage into Michawum Lake from Wilmington, Reading and North Woburn. The sketch shows the path of Hall's Brook through the Woburn Industrial Park, now being constructed. The brook meets the drainage from Wilmington, i.e., National Polychemicals, J.J. Whitney Barrel Company and the Woburn dump. This water flows beneath the Boston & Maine Railroad where it joins the drainage from the Stauffer Chemical property. The stream then enters the lake. Only during massive runoff would the Roketenetz Piggery drainage enter the lake. The east lobe of the lake had a normal population of flora and fauna, whereas the main body of the lake and the river contained only snakes and snapping turtles. Sampling points are shown as A, B, C, D, E, F and the results are appended.

TABLE I. SOURCES OF POLLUTION ALONG THE ABERJONA RIVER [illegible] DURING SUMMER 1970

No.	Source	Pollutants	Flow	Pollution Data	Comments
1	Walter and Bills Inc. Winchester	Caustic Rinse Water	Nil	No	Firm awaiting permission to tie into sewerage
2	General Foods - Atlantic Gelatin - Woburn	Thermal	Variable	Yes	Sweetwater Brook is monitored 24 hours by T.V.
3	Anderson Foreign Motors Building # 5 - Woburn	Soap, oil and grease	Variable	Yes	Operation moved to main shops
4	Brodie Industrial Trucks, Inc. - Woburn	Soaps and oil	Variable	No	Firm awaiting city approval of oil trap
5	Stauffer Chemicals - Mark Phillip Trust - Owner (abandoned chemical pits and lagoons)	Abandoned filled chemical pits intermittent leaching into drainage some Cr^{+6}	Intermittent	No	Method of disposal of pit contents to be determined and approved by Division and M.D.H.
6	Woburn Dump - Woburn	Dump drainage containing assimilative organics and fecal bacteria	Variable	No	Landfill needs attention to lessen pollution to drainage into Mishawum Lake
7	Whitney Barrel Company - Wilmington	Spillage and drainage	Nil	Yes	Owner will provide better storage procedures
8	National Polychemicals - Wilmington	Salts, acids, amines, oil, grease	Considerable	No	Discharge will terminate during spring 1971

TABLE I (CONTINUED)

No.	Source	Pollutants	Flow	Pollution Abated	Comments
10	International Minerals - Woburn	Fertilizer piles and bags - drainage is intermittent	Nil	No	Owner will remove piles from near small pond
11	International Salt Co. - Wilmington	Salt Piles	Runoff	No	Future surveillance will determine action
12	J. O. Whitin Co. - Winchester	Thermal condensate	168 gpm	NO	Writer will meet with plant engineers to reduce temperature of effluent

TABLE II. RESULTS OF WATER ANALYSIS OF [illegible] LAKE ON NOVEMBER 17, 1969*

Test	Concentrations (mg/liter)	
Total Solids	553	
5-day B.O.D. (20 C)	14	
Ammonia nitrogen	19.2	
Nitrite nitrogen	0.24	
Nitrate nitrogen	0.3	
pH	6.1	
Coli/100 ml/M.F.	30	(at Dam)
"	30	(½ way left)
"	110	(½ way right)
"	50	(end of pond)

* Lapuck Laboratories - 520 Main Street - Waltham, Mass. (obtained at Dana F. Perkins & Sons, Inc. - Reading)

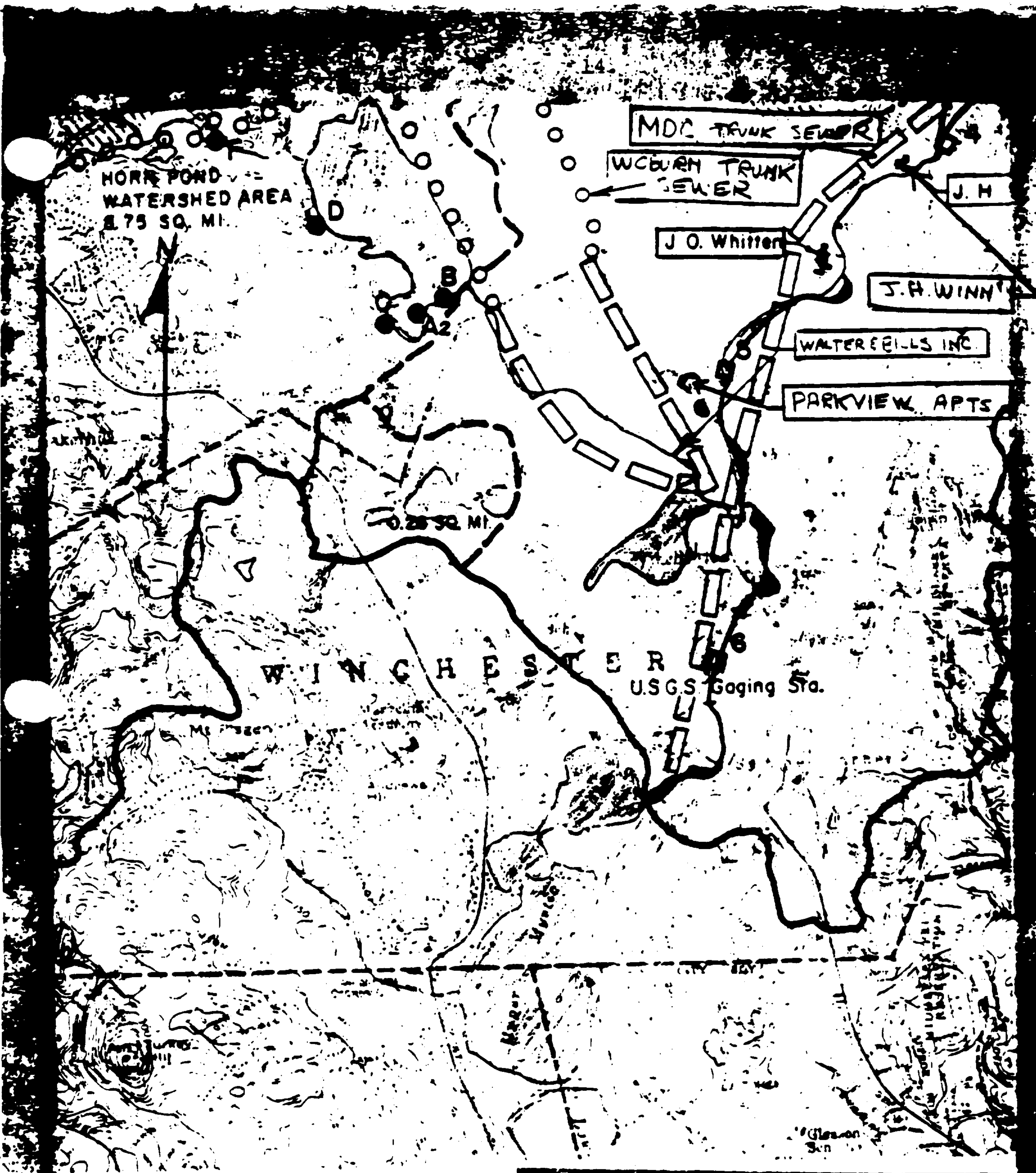
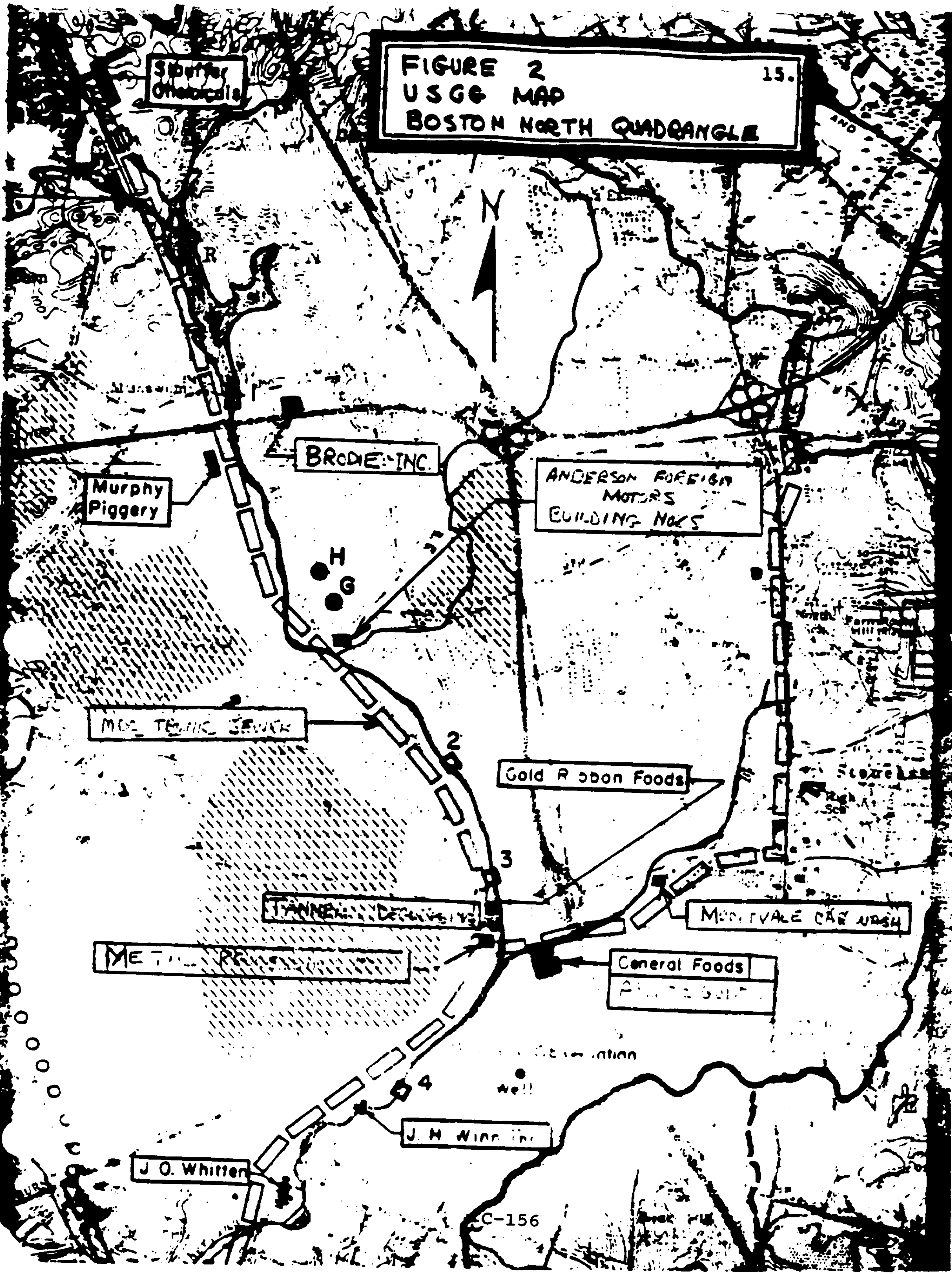


FIGURE 1 -
USGG MAP
LEXINGTON QUADRANGLE

FIGURE 2
USGS MAP
BOSTON NORTH QUADRANGLE



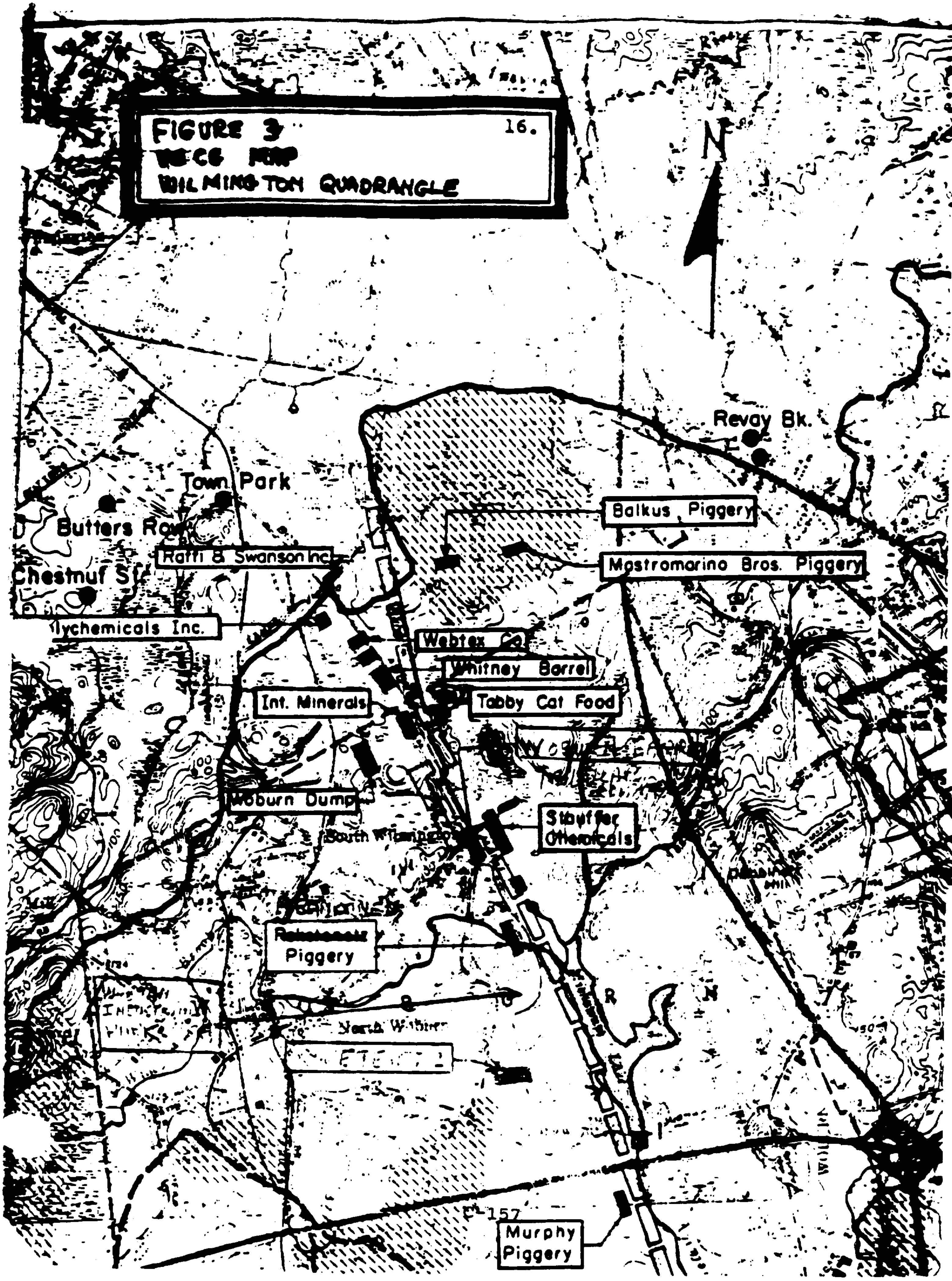
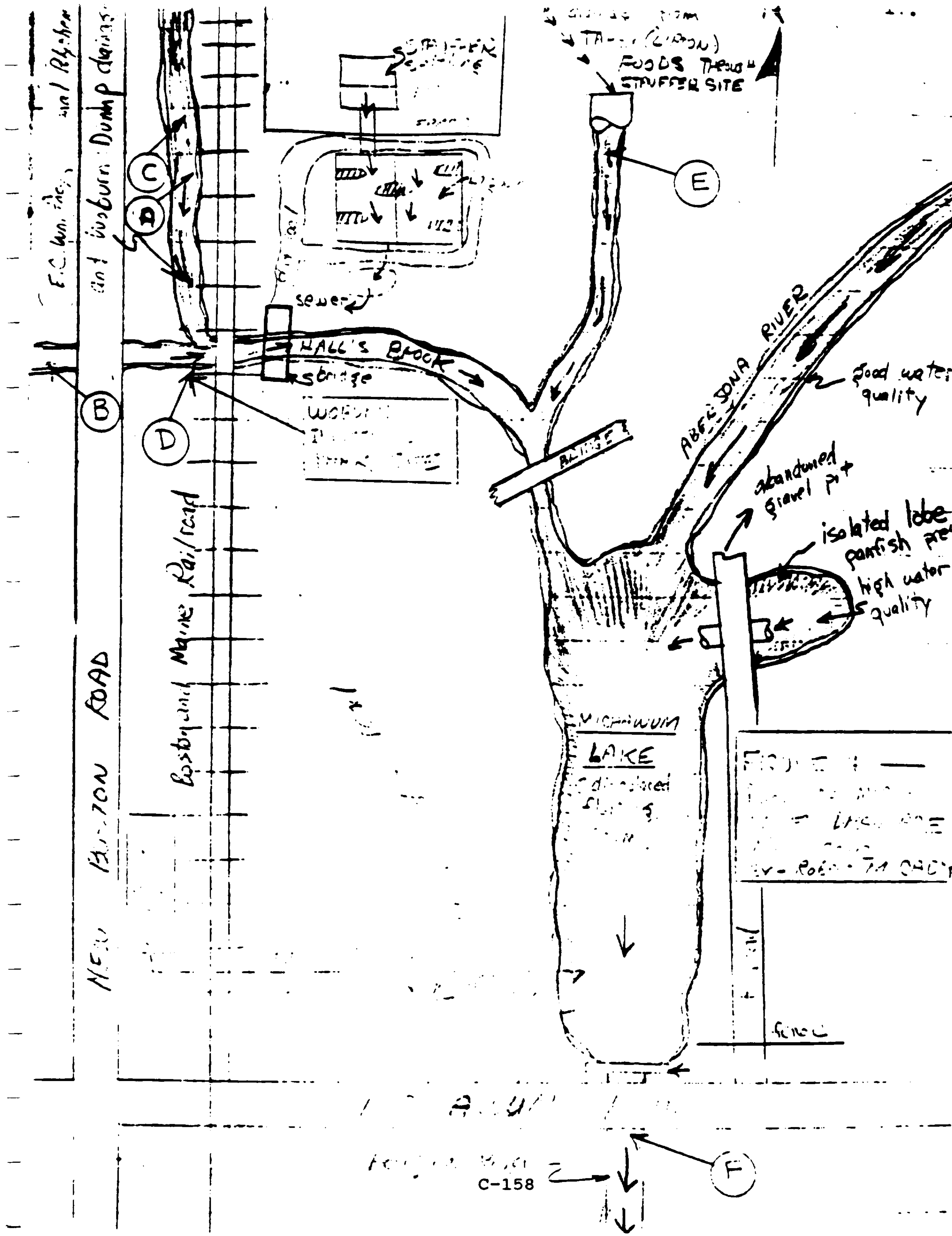


FIGURE 3
WECE MAP
WILMINGTON QUADRANGLE

FOODS THROUGH
STOUFFER SITE
STOUFFER
E
C
D
B
D
F
and Washburn Dump drains
NEW BOSTON ROAD
Boston and Maine Railroad
sewer
HALL'S BROOK
storage
WOBURN
BRIDGE
ABERJONA RIVER
good water quality
abandoned gravel pit
isolated lobe panfish pre
high water quality
MISHAWUM LAKE
fence
Aberjona River

VI. Conclusions and Recommendations

In order to obtain a better understanding of the Aberjona River a more complete water sampling program is needed. For example, the Division conducted a sampling program in 1967 and found high ammonia nitrogen at Station 2 (Salem Street, Woburn). Station 1 (Rt. 129 - Reading) could be considered a clean water station. Therefore, Station 2 reflects the water quality draining from the abandoned piggeries and Michawum Lake. There is no evidence to substantiate public sewerage overflows above Station 2.

The writer was unable to test river water samples because of the workload in the laboratory. Recent data on the river will substantiate the 1967 findings of the Division and more sampling stations will further assess the quantity of pollutants and their exact source. A dissolved metal analysis of the water sample should be included in the program.

The development projects at the abandoned Murphy and New Boston Road piggeries and Stauffer Chemicals will undoubtedly effect water quality because of runoff. The present discharge of untreated industrial wastewater from National Polychemical pollutes the water in the Aberjona River. The effluent contains salts, acid and some organic amino compounds. This effluent could be the source of the high ammonia content in the river at Station 2 (see laboratory results, 9-22-1970).

The writer recommends the following river stations as a tentative sampling program:

1. Hall's Brook at B & M railroad tracks - Woburn
2. Drainage Ditch at Merrimack Street - Woburn
3. Drainage Ditch East of Stauffer - Woburn
4. Aberjona River - Rt. 129 - Reading
5. Michawum Lake outlet at Michawum Road - Woburn
6. Aberjona River at Cedar and Salem Streets - Woburn
7. Aberjona River at Montvale Avenue - Woburn
8. Aberjona River at Washington Street - Winchester
9. Aberjona River at Swanton Street - Winchester
10. Aberjona River at USGS Survey Weir - Winchester.

The writer also recommends that the Division become involved with plans for the disposal of wastewater and sludge at the abandoned Stauffer Chemicals - Woburn. The consultant for the property owner is Dana F. Perkins and Sons, Inc. of Reading. The Woburn dump is a source of pollutants through drainage into Michawum Lake. The City of Woburn should be directed by the Division to minimize this drainage into the watercourse.

The J.C. Whitney Barrel Company indirectly is adding pollution to the drainage into Michawum Lake. The writer directed the owner of the firm to take steps to rectify this pollution. Future visits by Division Personnel will be made to ensure proper cleanup. Also, visits to the Woburn Barrel Company, International Minerals and International Salt Company will be made to prevent and correct indiscriminate dumpings of potentially offensive materials near the ditches draining into the Aberjona River.

Finally, the water quality in the Aberjona River should improve immensely when the National Polychemical waste water stream is removed (Spring 1971). No sampling should be initiated prior to the discontinuance of this discharge. The constituents of this wastewater are exactly those cations and anions found to be offensive in the Upper Mystic Lakes (nitrite, sulfates, sodium chloride and dissolved metals). Slow improvement in water quality should be experienced after the National Polychemicals effluent is removed, but development on the watershed will produce occasional slugs of turbid water, originating from the proposed filling of Mishawum Lake and the Woburn Industrial Park.

Lawrence MASSACHUSETTS DEPARTMENT OF PUBLIC HEALTH Woburn

WASTE ANALYSIS (mg. per liter) (City or Town)

Division of Water Pollution Control

Source A Woburn Ditch - Dump Road

Source B Halls Brock North - New Boston Street

Source C R.R. Ditch - Confluence

Source D Hall's Brook - R.R. Bridge

Source E Ditch Modular East

Source F Mishawum Pond

	A	B	C	D	E	F
Sample No.	219 306	307	308	309	310	311
Date of Collection	6-17-70					
Type Sample	Catch					
Time of Collection	10:00	10:00	10:30	11:00	11:30	12:00
Collector	R. Cady					
Date Received	6-17-70					
Temperature						
COD	115	60	510	266	525	331
BOD	29	1.2	197	64	90	10
Suspended Total Solids - Loss						
pH	7.3	5.6	2.5	3.2	6.8	5.2
Alkalinity - phth Total	230	41	Acidity 396	Acidity 69	85	7
Coliform MPN						
Total Solids Loss on Ignition						
Dissolved Oxygen						
Relative Stability						
Nitrite - Nitrogen						
Nitrate - Nitrogen						
Calcium *						64
Zinc *						1
Sodium *						500

Remarks: * Use Atomic Absorption Method

Lab. **Lawrence** MASSACHUSETTS DEPARTMENT OF PUBLIC HEALTH **Woburn**
WASTE ANALYSIS (mg. per liter) (City or Town)
Division of Water Pollution Control

Source A **Woburn Ditch - Dump Road**
Source B **Hall's Brook North - New Boston Street**
Source C **R.R. Ditch - Confluence**
Source D **Hall's Brook - R.R. Bridge**
Source E **Ditch Modular East**
Source F

	A	B	C	D	E	F
Sample No.	249 312	313	314	315	316	
Date of Collection	6-17-70					
Type Sample	Catch					
Time of Collection	10:00 am	10:00 am	10:30 am	11:00 am	11:30 am	
Collector	R. Cady					
Date Received	6-17-70					
Temperature						
COD						
BOD						
Suspended Total Solids - Loss						
pH						
Alkalinity - phth Total						
Coliform MPN						
Total Solids Loss on Ignition						
Dissolved Oxygen						
Relative Stability						
Nitrite - Nitrogen						
Nitrate - Nitrogen						
Coliform MPN	24,000	4600	< 36	< 36	930	
Fecal Coliform	2400	750	< 36	< 36	91	

Remarks:

31/21

Lab. LAWRENCE MASSACHUSETTS DEPARTMENT OF PUBLIC HEALTH WOBURN
WASTE ANALYSIS (mg. per liter) (City or Town)
Division of Water Pollution Control

Source A Building #5 - Pit Leakage - ANDERSON FOREIGN MOTORS - WOBURN
Source B
Source C
Source D
Source E
Source F

	A	B	C	D	E	F
Sample No.	R50009					
Date of Collection	7-20-79					
Type Sample	Grab					
Time of Collection	9:30am					
Collector	Cody					
Date Received	7-20-79					
Temperature						
COD						
BOD						
Suspended Total Solids - Loss						
pH						
Alkalinity - phth Total						
Coliform MPN						
Total Solids Loss on Ignition						
MBAS	0.1					
Hexane Soluble	2060					
Dissolved Oxygen						
Relative Stability						
Nitrite - Nitrogen						
Nitrate - Nitrogen						

Remarks:

JUL 31

Lab. Lawrence MASSACHUSETTS DEPARTMENT OF PUBLIC HEALTH [illegible]

WASTE ANALYSIS (mg. per liter) (City or Town)

Division of Water Pollution Control

Source A Sweetwater Brook - Atlantic Gelatin
Source B
Source C
Source D
Source E
Source F

	A	B	C	D	E	F
Sample No.	R50010					
Date of Collection	7-18-70					
Type Sample	Grab					
Time of Collection	9:00am					
Collector	Cady and Denson					
Date Received	7-20-70					
Temperature						
COD						
BOD						
Suspended Total Solids - Loss						
pH						
Alkalinity - phth Total						
Coliform MPN						
Total Solids Loss on Ignition						
MBAS	<1					
Dissolved Oxygen						
Relative Stability						
Nitrite - Nitrogen						
Nitrate - Nitrogen						

Remarks:

Lab. Lawrence JUL 2 1970 MASSACHUSETTS DEPARTMENT OF PUBLIC HEALTH Wilmington
(City or Town)

WASTE ANALYSIS (mg. per liter)
Division of Water Pollution Control

Source A R.R. Ditch (East) - Upstream
Source B R.R. Ditch - Downstream
Source C
Source D
Source E
Source F

] E.C. WITNEY BARREL
Woburn Street - Wilmington

	A	B	C	D	E	F
Sample No.	R50 011	012				
Date of Collection	7-20-70	-				
Type Sample	Grab					
Time of Collection	9:00am	9:45am				
Collector	Cady					
Date Received	7-20-70					
Temperature						
COD	52	600				
BOD	5.2	320				
Suspended Total	20	72				
Solids - Loss	16	65				
pH	6.5	6.2				
Alkalinity - phth						
Total	40	135				
Coliform MPN						
Total Solids						
Loss on Ignition						
Dissolved Oxygen						
Relative Stability						
Nitrite - Nitrogen						
Nitrate - Nitrogen						

Remarks:

Lab. Lawrence MASSACHUSETTS DEPARTMENT OF PUBLIC HEALTH Woburn (City or Town)

WASTE ANALYSIS (mg. per liter)

Division of Water Pollution Control

Source A Culvert to Sweetwater Brook (At Gal)

Source B " " " " " "

Source C

Source D

Source E

Source F

	A	B	C	D	E	F
Sample No.	R50371	372				
Date of Collection	8-5-70	8-5-70				
Type Sample	Grab	Grab				
Time of Collection	12:45 PM	1:20 PM				
Collector	Cady and	Chisholm				
Date Received	8-11-70					
Temperature						
COD						
BOD		1.0				
Suspended Total		80				
Solids - Loss		26				
pH		7.0				
Alkalinity - phth						
Total		30				
Coliform MPN						
Total Solids						
Loss on Ignition						
MBAS	0.3 *					
Dissolved Oxygen						
Relative Stability						
Nitrite - Nitrogen						
Nitrate - Nitrogen						

Remarks:

* Excessive Foam

Rec'y

Lab. [illegible] MASSACHUSETTS DEPARTMENT OF PUBLIC HEALTH [illegible]

Att 3 News

WASTE ANALYSIS (mg. per liter) (City or Town)

Div. of Water Pollution Control

Source A National Polychemical R. R. Ditch
Source B
Source C
Source D
Source E
Source F

	A	B	C	D	E	F
Sample No.	850 945					
Date of Collection	9-22-70					
Type Sample	Catch					
Time of Collection	10:00					
Collector	R. Cody					
Date Received	9-22-70					
Temperature						
COD	835					
BOD	118					
Suspended Total Solids - Loss						
pH	1.5					
Alkalinity - phth						
Acidity Total	1700					
Coliform MPN						
Total Solids						
Loss on Ignition						
Chlorides	2100					
Sulfates	8750					
Dissolved Oxygen						
Relative Stability						
NH 3-N	850					
Nitrite - Nitrogen	0.000					
Nitrate - Nitrogen	5.					

Remarks:

OCT 7 1970

Lab. Lawrence MASSACHUSETTS DEPARTMENT OF PUBLIC HEALTH Woburn

WASTE ANALYSIS (mg. per liter) (City or Town)

Div. of Water Pollution Control

Source A Stauffer Chemical-Lagoon Outlet

Source B

Source C

Source D

Source E

Source F

	A	B	C	D	E	F
Sample No.	[illegible]					
Date of Collection	9-22-70					
Type Sample	Grab					
Time of Collection	10:00					
Collector	[illegible]					
Date Received	9-22-70					
Temperature						
COD	[illegible]					
BOD	>10,000					
Suspended Total Solids - Loss						
pH	6.4					
Alkalinity - phth Total	 1900					
Coliform MPN						
Total Solids Loss on Ignition						
Hex. Chromium	9					
Dissolved Oxygen						
Relative Stability						
Nitrite - Nitrogen						
Nitrate - Nitrogen						

Remarks:

JUN 9 1970

ALLIED BIOLOGICAL CONTROL CORPORATION

P. Bland

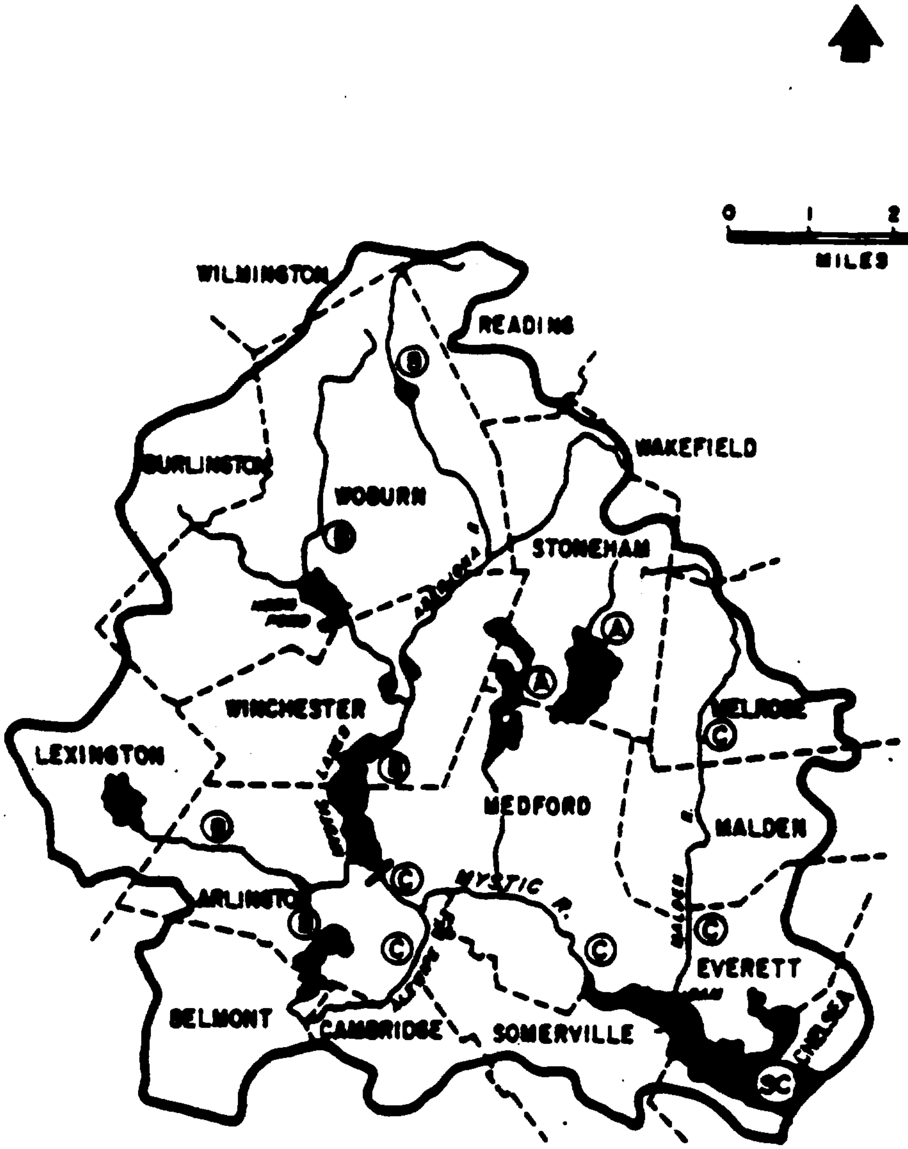
WATER QUALITY LABORATORY

Source A	UPPER MYSTIC LAKE SURFACE
Source B	ABERJONA RIVER, U.S. GEOL. STATION
Source C	WEDGE POND OUTLET
Source D	ABERJONA RIVER, MISHAWAUM LAKE OUTLET
Source E	CULVERT BEHIND WOBURN BARREL CO.
Source F	OUTLET FROM WOBURN TOWN DUMP

	A	B	C	D	E	
Analysis Number	700070	700071	700072	700073	700074	700
Date of Testing	6/2/70	6/2/70	6/2/70	6/2/70	6/2/70	6/2
Temperature - °C	21.2	21.1	25.5	26.7	24.5	25.
Turbidity - JTU			↑			
Solids* - Total						
- Suspended						
Color - Apparent						
- True						
Alkalinity* - phth	0	0	0	0		
- Total	41.0	32.0	41.0	14.0		
Aluminum*						
Biochemical Oyxgen Demand*						
Chemical Oxygen Demand*						
~~Dissolved~~ Copper	.06	.13	.01	.14	.16	.21
Chloride*	120.0	212.0	103.0	256.0	1670.0	155
Dissolved Oxygen*	8.0	6.5	7.0	4.0		0.6
Hardness*						
Hydrogen Sulfide*						
[illegible]						
Zinc	.030	.16	.005	1.00	0.65	0.3
Nitrogen* - Ammonium						
- Nitrite						
- Nitrate	2.0		4.0			12.
[illegible]	8.35	6.79	8.40	4.70	4.40	4.1
Phosphate* - Ortho						
- Poly						
- Total						
[illegible]						
[illegible]						
Detergents* - ABS & LAS						
Bacteria** - Coliform						
- E. coli						
- Fecal Streptococci						
- Total Bacteria						
- Iron						
- Sulfur						

* Parts Per Million

**Count Per 100 ml of Sample (MF)



COMMONWEALTH OF MASSACHUSETTS
WATER RESOURCES COMMISSION

MYSTIC RIVER BASIN
CLASSIFICATION

WATER USE CLASSES - Ⓐ Ⓑ Ⓒ Ⓓ (SC)
— CHANGE CLASSIFICATION

C-2.16 November 1970 Robert Cady field memorandum describing waste water discharge from Hubert Steel Drum.

FACSIMILE

Field Memorandum (70-11-157)

Woburn-Mystic River-SUR-Discharge of Wastewaters from Hubert Steel Drum.

DATE: November 16, 1970

BY: Robert M. Cady

On the above date, the author and N.R.O. Bartolomeo were in Woburn inspecting water pollution abatement along the Aberjona watershed. Upon inspecting the property owned by Roger __. Brown (International Minerals) on 316 New Boston Road, we observed a wastewater stream coming from a building on the property.

A site sketch is included, along with the laboratory results obtained from a sample of the wastewater. No flow was coming from the building, and it seems that the operation had shut down for the day.

The wastewater originated from the Hubert Steel Drum Company. The property has subsurface sanitary waste disposal but has no access to the public sewer. The firm obtains used 55-gallon drums containing a variety of chemicals. The firm steam-cleans the barrels and discharges the wastewater through a pipe on the floor.

The waste water was very odorous (even in the cold air) and the laboratory results show that it contains material which, even in a diluted state, would seriously degrade the receiving waters. The wastewater contained large quantities of hexavalent chromium, oil-grease, Biochemical Oxygen Demand and Chemical Oxygen Demand.

The writer recommends that the Division write the owner a letter stating that the discharge is unlawful and must stop. The firm's address is as follows:

A.L. Hubert Steel Drum Company
316 New Boston Road
Woburn, Massachusetts.

Appended: (1) LEE results R 51514 (2 layers)
(2) Site sketch

File

Field Memorandum (70-11-157)

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Date: November 16, 1970

By: Robert M. Cady Robert M. Cady

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[illegible]. L. Hubert Steel Drum Company
316 New Boston Road
Woburn, Massachusetts.

RMC/rew

Appended: (1) Lab results R 51514 (2 layers)
(2) Site sketch

RECEIVED
NOV 30 1970
DIVISION OF
WATER POLLUTION CONTROL

C-173

DEFENDANT'S
EXHIBIT
G-603

~~NOV 23 1970~~ NOV 24 1970

MASSACHUSETTS DEPARTMENT OF PUBLIC HEALTH WOBURN
(City or Town)

b. / Lawrence

WASTE ANALYSIS (mg. per liter)

Div. of Water Pollution Control

Source A Hubert Steel Drum Co. Bottom Layer (6% of volume)

Source B Hubert Steel Drum Co. Top Layer

Source C

Source D

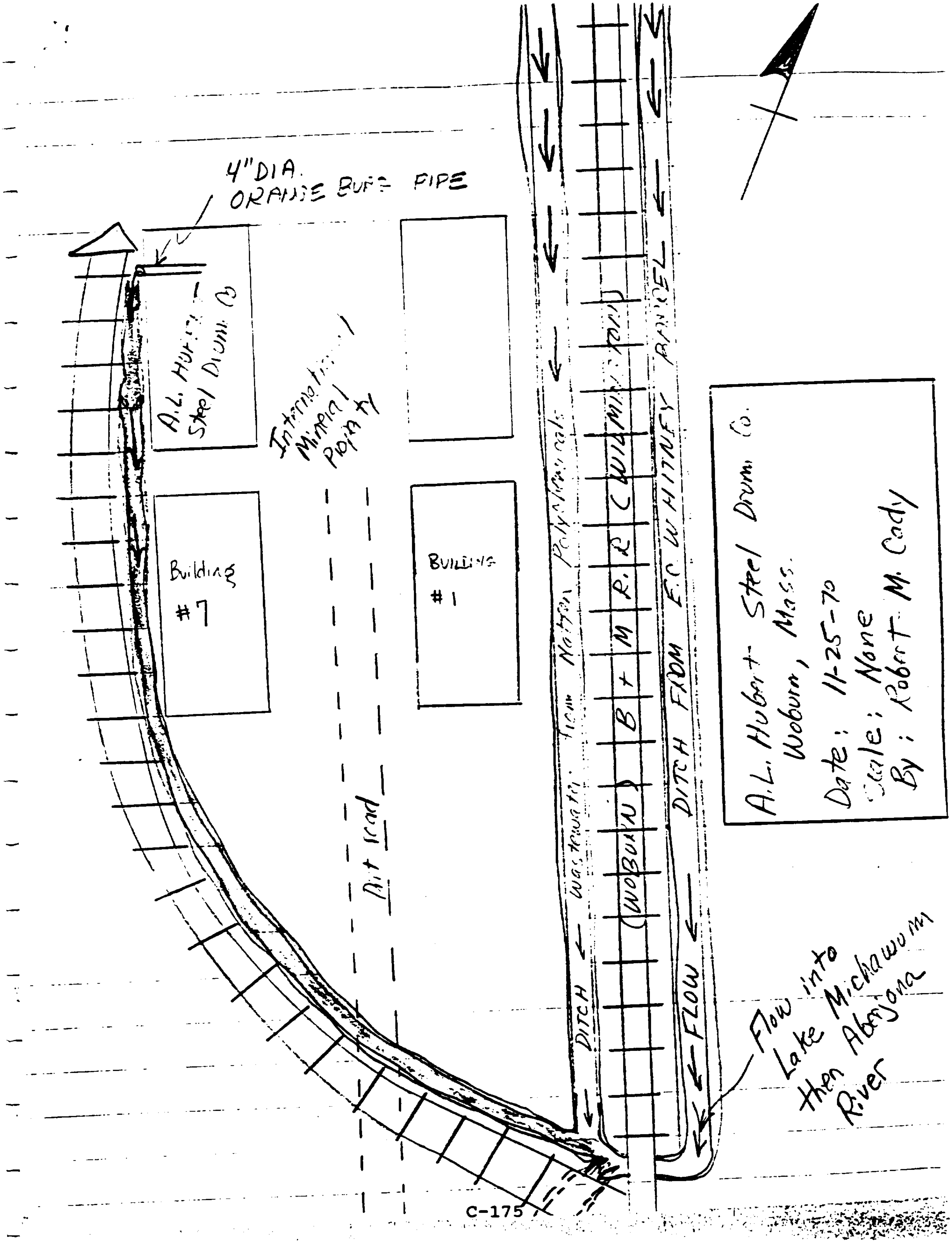
Source E

Source F

	A	B	C	D	E	F
Sample No.	R51514	* 514				
Date of Collection	11-16-70					
Type Sample	Catch					
Time of Collection	3:00 P M					
Collector	Robert Cady					
Date Received	11-16-70					
Temperature						
COD	8500	> 700,000				
BOD	2050					
Suspended Solids Total - Loss						
	11.2					
pH						
Alkalinity - phth Total	1140					
Coliform MPN						
Total Solids	6530	583,000				
Loss on Ignition	3360	575,000				
Hexane Soluble	5600	28,600				
Dissolved Oxygen						
Relative Stability						
Nitrite - Nitrogen						
Nitrate - Nitrogen						
Copper	0.0 **					
Total Chromium	4.0					

Remarks: * Top Layer occupied 6 percent by volume.

* * The blue color in the ashed portion of the bottom sample did not result from a copper salt.



A.L. Hubert Steel Drum Co.
Woburn, Mass.
Date: 11-25-70
Scale: None
By: Robert M. Cody

C-2.17 May 1973 Robert Cady memorandum describing an inspection of National Polychemicals, Inc.

Memorandum

Wilmington-MTC-SUR-Inspection of National Polychemicals, Inc. Property

By: Robert M. Cady

Date: May 23, 1973

The writer was asked to make a progress report for the Aberjona
River Commission. This report would include present and completed
implementation schedules. The writer visited the above location
to observe the operation, maintenance, and control of the recently
completed industrial wastewater treatment plant. This facility
discharges treated effluent to the new Silver Lake interceptor near
Eames Street, Wilmington. The writer observed a large volume of
① industrial sludge which was dumped beside the PVC lined lagoons.
The sludge was eroded by rainfall which subsequently washed the
material into the surrounding swamp. The treatment plant has a
belt oil skimmer which removes oil to 30 gallon steel drums.
② These drums were filled and spillage was being washed into the
yard drainage. The PVC lined lagoons were broken through in 2
③ locations. The breakthrough discharged to the surrounding swamp.
The firm recently sank 2 wells near the lagoons. Discharges from
these wells were traced to the railroad drainage ditches. The
water was highly contaminated in that the vegetation surrounding
the discharge was killed. The outlet from the swamp to the railroad
drainage ditch is covered with oil. It is the writer's impression
that this area was to be cleaned by the company after the abatement
equipment was operational.

The writer observed oil seepage into the railroad drainage ditch. Further investigation revealed that the oil originated from an oil storage area which contains 4 large above ground tanks.

The writer recommends that the Division send a letter to the above firm outlining the above pollution sources and requiring an abatement program to eliminate each of the aforementioned sources of water pollution. It will be noted that the firm has retained the consultant firm of Dana Perkins. The consultant is studying the sludge problem. A report thereof is due soon. The other sources of pollution, however, are not being studied by the consultant.

RMC/rew

DEFENDANT'S
EXHIBIT
G-649
ALL-STATE LEGAL SUPPLY CO.

C-2.18 June 1973 letter from Town of Wilmington to Stepan Chemical Company regarding sewer discharge variance.

S. Ford
Sup.

TOWN OF WILMINGTON
MASSACHUSETTS

OFFICE OF THE WATER & SEWER BOARD
TOWN HALL

June 15, 1973

Mr. Charles P. Riley, Gen'l Mgr.
Stepan Chemical Company
National Polychemical Division
51 Eames Street
Wilmington, Massachusetts 01887

Dear Mr. Riley:

In view of the extension granted by the MDC accepting the current waste concentration for your plant until December 1, 1973, the Board of Water & Sewer Commissioners has voted to grant a like variance from the Town of Wilmington Rules and Regulations of Sewer Use until that date.

Very truly yours

Arnold C. Blake, Chairman
Board of Water & Sewer Commissioners
Town of Wilmington

ACB:sb

cc: Sterling Morris, Town Manager
A. C. Hayes, Director of Sewerage Division, MDC
T. McMahon, Director of Water Pollution Control
C. W. Moores, Badger Consultants, Inc.
R. Caruso, Environmental Protection Agency

RECEIVED
[illegible] 19 1973
CONTROL

DIVISION OF WATER POLLUTION CONTROL

LAWRENCE EXPERIMENT STATION

WASTE WATER ANALYSIS (mg. per liter)

WILMINGTON

Collector: Cady

Source A R.R. Ditch at Eames St., No. A
Source B " " " " No. B
Source C " " cut, No. C
Source D " " below cut, No. D
Source E
Source F

	A	B	C	D	E	F
Sample No.	R60689	R60690	R60691	R60692		
Date of Collection	9/24/74	9/24	9/24	9/24		
Time of Collection	11:45	11:30	11:15	11:15		
Date Received	9/24/74	9/24	9/24	9/24		
COD	19	258	304	236		
BOD	2.0	120	60	63		
pH	6.9	6.6	4.9	6.8		
Alkalinity, Total	74	68	7.0	27		
Suspended Solids	5.0	35	148	83		
Total Solids	164	198	1576	1004		
Total Kjeldahl - N						
Ammonia - N	0.85	0.63	100	65		
Nitrate - N	1.3	0.5	18	9.0		
Total P						
Chloride	27	47				
Total Coliform	430			2400		
Fecal Coliform	430			36		

DIVISION OF WATER POLLUTION CONTROL
LAWRENCE EXPERIMENT STATION
WASTE WATER ANALYSIS (mg. per liter)

WILMINGTON - WOBURN

Collector: Cady

Source A Wilmington, R.R. Ditch above Eames St. MTC-A
Source B " " " below " " MTC-B
Source C " " " @ cut MTC-C
Source D " " " below cut MTC-D
Source E Woburn 24" CSP MTC-E
Source F " Dump Ditch upstream MTC-F

	A	B	C	D	E	F
Sample No.	R60780	R60781	R60782	R60783	R60784	R60785
Date of Collection	10/7/74	10/7	10/7	10/7	10/7	10/7
Time of Collection	11:00	11:00	10:45	10:45	10:30	10:15
Date Received	10/7/74	10/7	10/7	10/7	10/7	10/7
COD	18	155	547	304	228	23
BOD	2.1	35	47	39	64	4.2
pH	6.8	6.5	5.4	6.2	6.4	7.4
Alkalinity, Total	36	47	14	29	30	181
Suspended Solids	26	6.5	252	68	22	3.0
Total Solids	~~XX~~ 190	212	1668	920	1081	394
CHLORIDE		45	470	270		
Total Kjeldahl - N						
Ammonia - N	0.45	0.50	105	60	95	28
Nitrate - N	1.1	0.5	50	22	13	1.0
Total P	0.01	0.01	1.75	0.45	0.42	0.03
Total Coliform	230					2400
Fecal Coliform	91					930
Iron					9.0	2.0
Copper					0.00	0.00
Chromium					0.15	0.00
Nickel					0.05	0.00
Zinc					0.15	0.05
Lead					0.10	0.10
Cadmium					0.00	0.00

Cady

DIVISION OF WATER POLLUTION CONTROL
LAWRENCE EXPERIMENT STATION
WASTE WATER ANALYSIS (mg. per liter)

WILMINGTON - WOBURN

Collector: Cady

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[illegible]

Source A Woburn, dump ditch downstream MTC - G
Source B
Source C
Source D
Source E
Source F

	A	B	C	D		F
Sample No.	R60786					
Date of Collection	10/7/74					
Time of Collection	10:00					
Date Received	10/7/74					
COD	41					
BOD	3.8					
pH	7.0					
Alkalinity, Total	240					
Suspended Solids	14					
Total Solids	548					
Total Kjeldahl - N						
Ammonia - N	35					
Nitrate - N	0.8					
Total P	0.04					
Total Coliform	4600					
Fecal Coliform	930					
Iron	3.5					
Copper	0.00					
Chromium	0.00					
Nickel	0.00					
Zinc	0.10					
Lead	0.10					
Cadmium	0.00					

C-2.19 July 1973 letter from Stepan Chemical Company to the Commonwealth of Massachusetts.

STEPAN
National Polychemicals Division
Eames St., Wilmington, Massachusetts 01

July 18, 1973.

RECEIVED

JUL 26 1973

MASS DIVISION O
WATER POLLUTION C

Mr. Thomas C. McMahon, Director
The Commonwealth of Massachusetts
Water Resources Commission
Leverett Saltonstall Building
Government Center
100 Cambridge Street
Boston, Massachusetts 02202.

Dear Mr. McMahon:

The following is an item by item response to your letter of July 13, 1973.

(1) The large volume of "industrial sludge" is pure calcium sulfate (gypsum) which had been lifted out of the secondary clarifier. This material has no odor and has not been eroded since being placed in its present position. It became necessary to remove this material from the pond because overflow conditions were being reached as the pond had filled at a much faster rate than had been anticipated due to a lower rate of compaction as the solids level increased. I am sure that your Division is aware of the fact that Dana Perkins has been engaged to engineer a second secondary clarifying pond and also a sanitary landfill for the gypsum on our property adjacent to the Woburn City dump. The engineering work on both of these projects has been progressing and Mr. Tarbell of Public Health and Mr. Romano, Wilmington Health Officer, have made a preliminary inspection of the proposed landfill area and of the secondary clarifier. It was pointed out at this time that erosion had not taken place even with very heavy rains. The general plans as developed by our consultant, Dana Perkins, entail the use of two secondary clarifier ponds with one area cleaned each year by removal of the gypsum to the approved landfill area. These plans will be submitted to your Division for review as soon as preliminary approval is obtained from Public Health.

(2) The PVC liner in the lagoon has not been broken in two places. I can only assume that this comment refers to several channels from the lagoon that were created by the pond overflowing for a short period before the calcium sulfate was removed.

(3) The wells referred to were experimental borings, placed under pumping tests by the D. L. Maher Company of North Reading. We were assured by Mr. Maher that he had the right to conduct flow tests on these wells without obtaining permits. This flow was discontinued on February 5, 1973 and will not be restarted.

(4) The oil drums that receive the flow from the skimmer have been removed, the area cleaned and tight housekeeping will be maintained in the future.

telephone (617) 933-4240 cable NAP

The oil seepage which was directed to our attention by your inspectors was at the railroad ditch level about 10 - 15 feet below grade and behind our chemical storage tank farm. All tanks and lines were examined and found to be free from leakage. The soil behind the tankfarm at grade level is sandy and clean with no indications of chemical runoff. Our water pollution consultants from the Badger Corporation examined this site and have theorized that the seepage could be due to natural occuring hydrocarbons being leached from the soil at the extremely high water table that was experienced in May of this year.

We have recently examined the railroad ditch under the prevaling conditions of a much lower water table and there are now only very slight traces of oil films in the ditch. I am sure that your Division is aware that this ditch is loaded with raw sewerage emanating from above our plant site and that the bottom of the ditch exhibits concentrations of black sludge which appears to be raw sewerage derived.

At the present time, we are cooperating very closely with the Town of Wilmington, the MDC, and Public Health to eliminate all of our problem areas through approved long-term solutions. The Badger Corporation are consulting with us on the mechanics of the treatment plant with particular concentration in the area of finding more efficient sump pumps to handle our effluent streams. We have attempted to cooperate fully with your Division as evidenced by our conducting engineering personnel from other companies through our facility at Mr. Bonne's request and offering our engineering designs free of charge. However, on the inspection level, we feel that cooperation has been less than desirable. During the last inspection, your people refused my invitation to enter the office building and discuss with me their findings. They indicated to the plant people that they were "too busy" to do this. On another occasion one of your inspectors drove an automobile directly into our plant and through several hazardous operating areas to the treatment plant. I am sure that you are aware under the OSHA regulations that we are responsible for the safety of all persons who enter our plant areas and that all visitors must be equipped with the proper safety equipment at the front office.

The key personnel in this Division are ready to discuss our entire program and the individual points raised in your letter of July 13 at any time convenient to your personnel.

Very truly yours,

NATIONAL POLYCHEMICALS
A Division of Stepan Chemical Company

Charles P. Riley, Jr.
General Manager

CPR/jlp

C-2.20 September 1974 Robert Cady memorandum describing a waste water sewer break at Stepan Chemical Company.

MEMORANDUM FOR THE RECORD

BY: Robert Cady

DATE: September 19, 1974

SUBJECT: Wilmington - MTC - SUR - STEPAN Chemical Co. meeting former National Polychemicals Inc.

On the above date the writer and John Lynch from the EPA's Permits Branch met with Messers Ronald McBrien & Richard Cantwell of STEPAN. The meeting was intended to be an information/updating encounter in preparation for the Annual Meeting of the Mystic Watershed Association on October 17, 1974. This Association, in its newsletter, cited continuous water pollution from STEPAN and intended to seek methods of eliminating the discharges.

The meeting revealed that STEPAN had an industrial waste sewer break recently and there was an untreated discharge into the surface water drainage. It appeared that a 15" VCP broke from excessive overburden and it took four days to repair. Meanwhile, all untreated wastes were pumped to a storm drain, which eventually discharged into the nearby brooks. STEPEN took no efforts to seek outside advice during this incident nor did they notify this Division. Mr. McBrien pleaded ignorance of DWPC's regulations, however, he will submit a belated report and pledged to report all future incidents..

A tour of the plant's grounds was made. The headwall which was discharging untreated wastewaters was inspected and the area was covered with a yellow precipitate. The industrial waste treatment facility, including the sludge lagoons were operating well. The original liner was filled with drying sludge while the new "liner" had about four feet of freeboard. A decision by the local Board of Appeals is awaited concerning the approved dump site for the dried sludge. The decision is expected by the end of October.

The inspection produced the following results:

1) STEPAN will report immediately all spills and pipeline breaks.

2) STEPAN will receive a NPDES permit for the discharge of contaminated run-off. EPA will require extensive diking of product-packaging areas and sampling.

3) STEPAN will sample, weekly, the stations in the affected watershed in

DEFENDANT'S EXHIBIT G-658
ALL-STATE LEGAL SUPPLY CO.

order to develop trends of residual pollution by chlorides, ammonia, chemical oxygen demanding pollutants, oils and greases along with pH.

4) DWPC and EPA will sample four surface water stations duplicating the above work with the addition of a "clean" water station. The data, hopefully, will be available compilation prior to the October 17, 1974 meeting.

RMC/mef

C-2.21 November 1974 Robert Cady memorandum describing discharges of waste water from Stepan Chemical Company to the railroad ditch and the Aberjona River.

FACSIMILE

MEMORANDUM FOR THE RECORD

BY: Robert Cady

DATE: November 15, 1974

SUBJECT: WILMINGTON-MTC-SUR-WATER POLLUTION FROM STEPAN CHEMICAL CORPORATION (FORMER NATIONAL POLYCHEMICAL, INC.)

As mentioned in a previous memorandum about the above firm, a sampling program was instituted during October 1974. Figure I depicts the sampling stations. Samples were collected:

1. Above Eames Street and the plant property.
2. At the "cut" where the storm water enters the railroad ditch.
3. About 150 feet downstream in the railroad ditch.
4. At the storm water headwall.

Table I presents the data collected 9/24/74, 10/7/74. On 10/16/74, the storm water headwall was sampled during a heavy downpour. The location was re-sampled a week later, and a bright yellow chemical was in the ditch at this time. Table II presents these two sets of sampling results.

As presented in Tables I and II, it is obvious that the firm is still polluting the waters of the Commonwealth. Samples collected at the "cut" (Station C) were low in pH, and contained large amounts of ammonia and chloride. The samples collected at the storm water headwall show that the storm sewers carry excessive pollutants during run-off. These same storm sewers also carry spilled "product" during dry weather as shown by the results collected on 10/23/74.

The writer recommends that the following steps be taken as a result of the September/October sampling of surface waters at Stepan Chemical Company in Wilmington:

1. The discharge from the storm water headwall should be monitored for flow and chemical constituents (pH, alkalinity, BOD, COD, T.S.S., NH_3-N, chlorides, and sulfates) under the NPDES program. A permit for this discharge should be granted and, through an orderly engineering study/monitoring process, the pollutants should be reduced.

FACSIMILE

2. The "cut" should also receive a permit, written to provide a gradual elimination of ammonia, chloride, low pH, and sulfates.

The draft permits, written by EPA, were reviewed by the writer. The permits covered the storm run-off and the "cut". The writer feels that additional weekly analysis on the two (composites?) should be performed. The reports should also include: alkalinity, BOD, and COD, along with the other required analyses. The NPDES appears to be a good mechanism for eliminating recurrent discharges of pollutants to the railroad ditch and the Aberjona River.

MEMORANDUM FOR THE RECORD

BY: Robert Cady

DATE: November 15, 1974

SUBJECT: WILMINGTON -MTC -SUR -WATER POLLUTION FROM STEPAN CHEMICAL CORP.
(FORMER NATIONAL POLYCHEMICAL, INC.)

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RC/em

DEFENDANT'S
EXHIBIT
G-662
ALL-STATE LEGAL SUPPLY CO.

C-2.22 October 1976 Robert Cady memorandum describing sampling and analysis on the Stepan Chemical Company property.

FACSIMILE

MEMORANDUM FOR THE RECORD

BY: Robert Cady

DATE: October 15, 1976

SUBJECT: Wilmington - MTC - SUR - Stepan Chemical Company Sampling

On September 15, 1976, the writer sampled various stream locations and process discharges in or around the property of Stepan Chemical Company (former National Poly Chemicals). The sampling locations are presented in figure 1. Laboratory data from these stations is appended, and all samples were analyzed at the Lawrence Experiment Station (LES).

The sampling was conducted with a Stepan employee, Mr. Don Knight, and notice was given to a company official, Mr. Ron McBrien. The sampling was initiated by request from Commissioner David Standley to Director McMahon, dated July 27, 1976. It appears that EPA was hesitant to issue a permit to Stepan, after its Surveillance and Analysis (S/A) Section (Don Porteous report) determined that there was significant surface water pollution upstream of the Stepan property, as presented in the EPA's December 10-11, 1975 and February 6-12, 1976 data.

The writer was disturbed by the absence of cooperation with this sampling because the data introduced a new location hitherto thought to be "clean". Also, in discussions with EPA and Stepan, it was agreed that DWPC would team up with every sampling effort. Sampling and intentions towards NPDES permit issuance began for this firm in 1974. The reader's attention is called to the writer's September - October 1974 sampling, which showed that the railroad drainage upstream of Stepan was acceptable and contained little water pollution (figure 1 - Station STPCO-7).

Six water samples were collected on September 15, 1976 by the writer, and brought to LES for analysis of: BOD, COD, pH, alkalinity, T.S.S., chloride, sulfate, hardness, TKN, ammonia, and nitrates. As determined by EPA-SA, the STPCO-3 location (west and upstream) was grossly polluted with sulfate, chlorides, and ammonia. This station is off Stepan's property. Water enters the property (at STPCO-3) and exits the area at the "cut" (STPCO-1). A very slight movement of water was noticed at this location and it appeared to be practically stagnant. STPCO-4, the separator (septic tank), was flowing (5GPM) at the time of sampling. This discharge, which is alleged to be "cooling water", in fact contained ammonia, sulfate, and chloride, indicating gross contamination. Location STPCO-2 was not flowing, however, a swamp area west of the stream bed was traversed, and puddles of a "red dichromate-like" substance were noticed and sampled. A rivulet behind the three outside warehouses was walked, and it was determined that the ditch dead-ended behind the building and no flow from Eames Street entered this drainage way. During the sampling, a black material (possibly a petroleum distillate) was noticed oozing out of the ground into the flowing discharge from STPCO-4. LES personnel could not qualitatively identify this material, which is immiscible in water, floats, and is black in color.

With the assumption that STPCO-3 might be contaminated, as determined by EPA-SA, the writer went further upstream to a wet area (see figure 1). This area was created by a developer while he was draining his property for commercial development. The area STPCO-6 contained a series of small ponds which would overflow into STPCO-3 during a wet period. The sampling data for STPCO-6 showed relatively "clean" water. Also, the location STPCO-3 was traversed for other stream inflows west of the railroad bed and no other flows into STPCO-3 were noticed. Also, no industrial, commercial, or public inflows of wastewater were noticed above STPCO-3 or STPCO-6. The above study leads the writer to the thesis that STPCO-3 is grossly contaminated by polluted groundwater as it flows through contaminated Stepan subsoil.

Hardness was determined in most of the sampling locations because the writer noticed that Stepan dewaters their sludge lagoon dredgings near the surface stream, thereby exposing the gypsum sludge to erosion and run-off as the material dewaters.

A summary of the inspection and sampling inside and around the Stepan property on September 15, 1976 is as follows:

1) LES data shows severe water pollution leaving the area near Stepan Chemical in Wilmington. STPCO-1 has high ammonia, hardness, sulfates, chlorides, COD, and acidic (pH 3.6) water.

2) Data from Station STPCO-2 indicates "puddles" of strong waste waters which could be washed into surface streams and/or groundwaters during a rainfall and subsequent run-off.

3) Data from Station STPCO-3 indicates heavy groundwater pollution because an adjoining station, STPCO-6, was relatively "clean".

4) Data from Station STPCO-4 indicates that the alleged "cooling water" is contaminated with chemicals. This situation is openly verified by Stepan's own monitoring data given to the writer.

5) Data from Station STPCO-5 again demonstrates an "upstream" pollution source, however, the writer's 1974 (September-October) sampling proved the contrary. Therefore, this station must also be contaminated by polluted groundwater, as indicated by the acres of dead trees nearby, i.e the area east of the buildings.

6) Data from Station STPCO-6 indicates that there is "clean" surface run-off upstream of the contaminated STPCO-3 station, which supports the thesis that contaminated groundwater has contributed to the pollution found in surface stations far-removed from the legal Stepan property.

FACSIMILE

7) The U.S.G.S. Wilmington "quad sheet" suggests that Stepan is located in a marsh area (shallow groundwater levels), and possibly any indiscriminate waste water/chemical discharge to the ground would quickly reach the drainage ditches. The flow of the groundwater and its influence on the above stations remains to be determined.

Recommendations based on the writer's September 1976 observations would include:

1) Issue immediately a NPDES permit for the alleged cooling water discharge STPCO-4 (approximately 5GPM @ sampling). The permit should require Stepan to remove all pollutants from this stream, including: chloride (124 mg/l), sulfates (64 mg/l), ammonia (70 mg/l).

2) DWPC should order Stepan to cease the "dewatering" of gypsum sludge near the drainage ditches.

3) Institute a groundwater study in and around Stepan to show:

   (a) depth of groundwater
   (b) soil transmissibility
   (c) level of contamination
   (d) groundwater volume and flow direction with relation to the surface water channels.

Appended: (1) Figure 1 - Locus and sampling stations.

(2) LES data - R67123-4-5-6-7-8 (dated 9/15/76).

MEMORANDUM FOR THE RECORD

Robert M. Cady

BY: Robert Cady

DATE: October 15, 1976

SUBJECT: Wilmington - NTC - SUA - Stepan Chemical Company Sampling

On September 15, 1976, the writer sampled various stream locations and process discharges in or around the property of Stepan Chemical Company (former National Poly Chemicals). The sampling locations are presented in Figure 1. Laboratory data from these stations is appended and all samples were analyzed at the Lawrence Experiment Station (LES).

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DEFENDANT'S EXHIBIT
G-671

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2) DNPC should order Stepan to cease the "dewatering" of gypsum sludge near the drainage ditches.

3) Institute a groundwater study in and around Stepan to show (a) depth of groundwater (b) soil transmissibility (c) level of contamination (d) groundwater volume and flow-direction with relation to the surface water channels.

Appended: (1) Figure 1 - Locus and sampling stations

(2) LES Data - R67123-4-5-6-7-8 (dated 9/15/76)

C/adh

W-Res

DIVISION OF WATER POLLUTION CONTROL
LAWRENCE EXPERIMENT STATION
WASTE WATER ANALYSIS (mg. per liter)

WILMINGTON

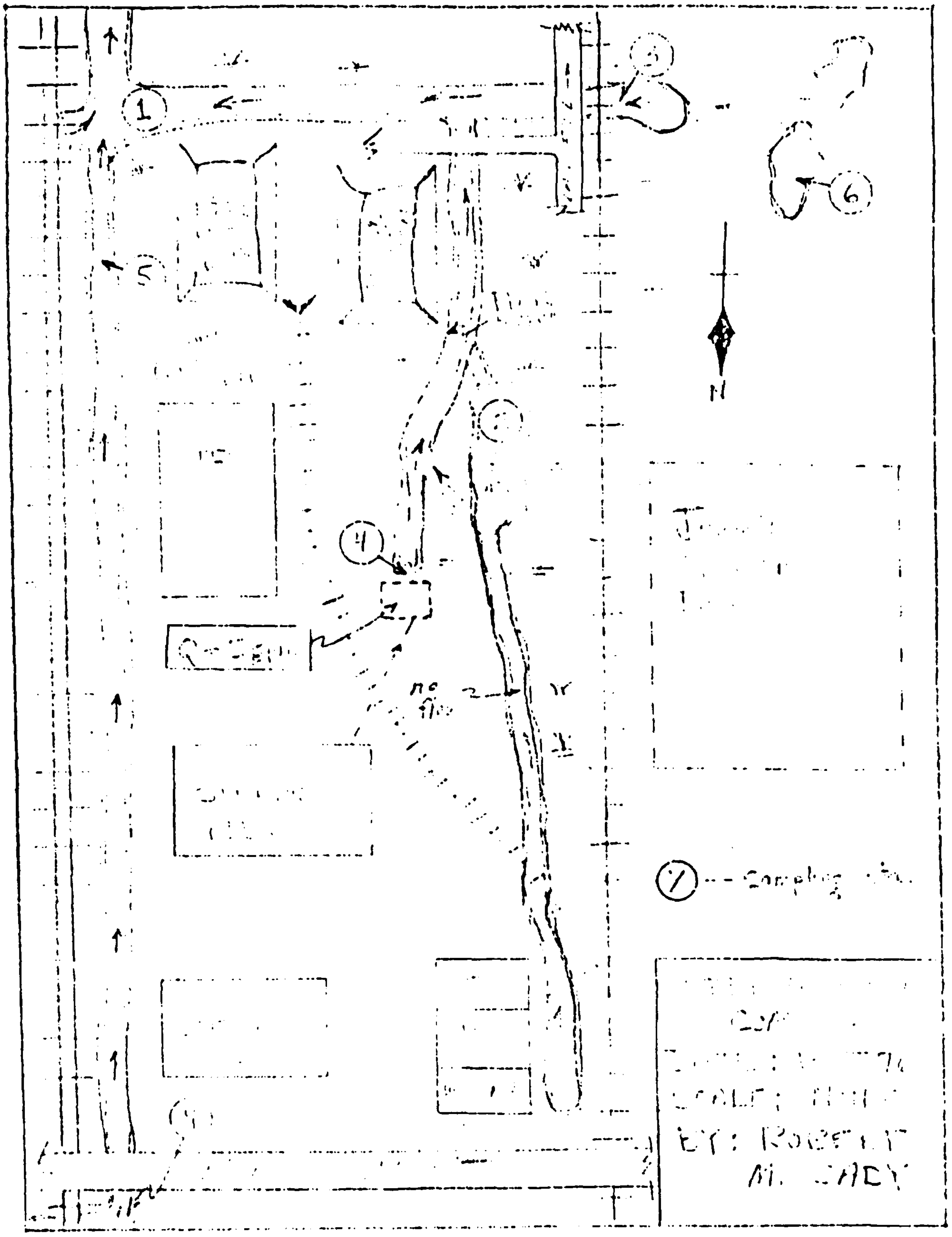
Collector: Cady

SOURCE A Stepan Drainage, STP C01
SOURCE B " STP C02
SOURCE C " Drainage, STP C03
SOURCE D " Separator, STP C04
SOURCE E " STP C05
SOURCE F " Drainage, STP C06

RECEIVED
OCT 1 [illegible] 1976
WATER POLL[illegible]

	A	B	C	D	E	F
Sample No.	R67123	R67124	R67125	R67126	R67127	R67128
Date of Collection	9/15/76	9/15	9/15	9/15	9/15	9/15
Time of Collection	1530	1500	1500	1500	1500	0930
Date Received	9/16/76	9/16	9/16	9/16	9/16	9/16
COD	380	2,900	220	62	130	
BOD	18	70	63	0.4	66	
pH	3.6	4.9	4.1	9.0	6.7	5.9
Alkalinity, Total	25	23	12	230	98	3.0
PHTH				76		
Suspended Solids	75	432	3.0	10	11	
Total Solids						
CHLORIDE	500	*	510	124	129	10
SULFATE	305	150	1,950	64	59	19
HARDNESS	156	16	248	64	112	
Total Kjeldahl - N	190	76	440	77	18	
Ammonia - N	150	30	220	70	17	0.05
Nitrate - N	0.0	0.0	0.0	1.0	0.3	0.1
Total P						
Total Coliform						
Fecal Coliform						
*COLOR INTERFERENCE						

FIGURE 1 - SAMPLING LOCATIONS & LOCUS OF STREAM



DIVISION OF WATER POLLUTION CONTROL

LAWRENCE EXPERIMENT STATION

WASTE WATER ANALYSIS (mg. per liter)

WILMINGTON

Collector: Cady

Source A R.R. Ditch at Eames St., No. A
Source B " " " " No. B
Source C " " cut, No. C
Source D " " below cut, No. D
Source E
Source F

	A	B	C	D	E	F
Sample No.	R60689	R60690	R60691	R60692		
Date of Collection	9/24/74	9/24	9/24	9/24		
Time of Collection	11:45	11:30	~~XX~~11:15	11:15		
Date Received	9/24/74	9/24	9/24	9/24		
COD	19	258	304	236		
BOD	2.0	120	60	63		
pH	6.9	6.6	4.9	6.8		
Alkalinity, Total	74	68	7.0	27		
Suspended Solids	5.0	35	148	83		
Total Solids	164	198	1576	1004		
Total Kjeldahl - N						
Ammonia - N	0.85	0.63	100	65		
Nitrate - N	1.3	0.5	18	9.0		
Total P						
Chloride	27	47				
Total Coliform	430			2400		
Fecal Coliform	430			36		

DIVISION OF WATER POLLUTION CONTROL
LAWRENCE EXPERIMENT STATION
WASTE WATER ANALYSIS (mg. per liter)

WILMINGTON - WOBURN

Collector: Cady

Source A Wilmington, R.R. Ditch above Eames St. MTC-A
Source B " " " below " " MTC-B
Source C " " " @ cut MTC-C
Source D " " " below cut MTC-D
Source E Woburn 24" CSP MTC-#
Source F " Dump Ditch upstream MTC-F

	A	B	C	D	E	F
Sample No.	R60780	R60781	R60782	R60783	R60784	R60785
Date of Collection	10/7/74	10/7	10/7	10/7	10/7	10/7
Time of Collection	11:00	11:00	10:45	10:45	10:30	10:15
Date Received	10/7/74	10/7	10/7	10/7	10/7	10/7
COD	18	155	547	304	228	23
BOD	2.1	35	47	39	64	4.2
pH	6.8	6.5	5.4	6.2	6.4	7.4
Alkalinity, Total	36	47	14	29	30	181
Suspended Solids	26	6.5	252	68	22	3.0
Total Solids	~~IF~~ 190	212	1668	920	1081	394
CHLORIDE		45	470	270		
Total Kjeldahl - N						
Ammonia - N	0.45	0.50	105	60	95	28
Nitrate - N	1.1	0.5	50	22	13	1.0
Total P	0.01	0.01	1.75	0.45	0.42	0.03
Total Coliform	230					2400
Fecal Coliform	91					930
Iron					9.0	2.0
Copper					0.00	0.00
Chromium					0.15	0.00
Nickel					0.05	0.00
Zinc					0.15	0.05
Lead					0.10	0.10
Cadmium					0.00	0.00

Cady

DIVISION OF WATER POLLUTION CONTROL
LAWRENCE EXPERIMENT STATION
WASTE WATER ANALYSIS (mg. per liter)

WILMINGTON - WOBURN

Collector: Cady

RECEIVED
[illegible] 1974
MA[illegible] WATER [illegible] CONTROL

Source A Woburn, dump ditch downstream MTC - G
Source B
Source C
Source D
Source E
Source F

	A	B	C	D		F
Sample No.	R60786					
Date of Collection	10/7/74					
Time of Collection	10:00					
Date Received	10/7/74					
COD	41					
BOD	3.8					
pH	7.0					
Alkalinity, Total	240					
Suspended Solids	14					
Total Solids	548					
Total Kjeldahl - N						
Ammonia - N	35					
Nitrate - N	0.8					
Total P	0.04					
Total Coliform	4600					
Fecal Coliform	930					
Iron	3.5					
Copper	0.00					
Chromium	0.00					
Nickel	0.00					
Zinc	0.10					
Lead	0.10					
Cadmium	0.00					

C-2.23 January 1977 Thomas McMahon memorandum regarding groundwater and surface water contamination by industrial waste water discharges from Stepan Chemical Company.

68M-10.74-109109

THE COMMONWEALTH OF MASSACHUSETTS
WATER RESOURCES COMMISSION

LEVERETT SALTONSTALL BUILDING GOVERNMENT CENTER
100 CAMBRIDGE STREET, BOSTON 02202

OFFICE OF THE DIRECTOR
DIVISION OF WATER
POLLUTION CONTROL

MEMORANDUM January 17, 1977

Wilmington

TO: David Standley, Commissioner
Department of Environmental Quality Engineering

FROM: Thomas C. McMahon, Director
Division of Water Pollution Control

SUBJECT: Stepan Chemical Company - Polychemical Department

In response to your July 27, 1976 memorandum, an engineer from this Division reviewed all the past information concerning the Stepan Chemical Company. Also, a comprehensive surface water sampling was conducted and a report was written. There appears to be a strong possibility of contaminated groundwater reaching a nearby stream, thereby polluting the stream and evenutally the upper Mystic Lake with acid pH, chlorides, sulfates, hardness and ammonia. It is further alleged that the past untreated discharge of industrial wastewater, prior to the present waste treatment plant, extensively polluted the subsurface waters beneath and near STEPAN.

A contaminated cooling water discharge was discovered and will be handled through the NPDES program for eventual cleanup.

Having confirmed an extensive water pollution problem, a committee was formed under the auspices of MAPC's 208 - water quality project. The committee was composed of representatives of DWPC, Mystic River Watershed Association, MDC and EPA. A few meetings were held along with many informal meetings between the Division engineer and MAPC staff hydrologist. It was determined through this committee, that an engineering consultant should be commissioned to conduct a geo-hydrological study at and around Stepan. The data produced by this study would serve as an enforcement tool in the formulation of an implementation schedule for the eventual abatement of groundwater and surface water pollution. Preliminary and rough estimates of the costs of the required study vary between $14,300 and $30,000. After the study, provided positive proof is obtained, Stepan will be required to submit their own report on nitrogen removal and neutralization of the contaminated groundwater with a method of treatment and time schedule needed to effect a cleanup.

DEFENDANT'S
EXHIBIT
G-675
ALL-STATE LEGAL SUPPLY CO.

The funding of the geohydrological study by the MAPC 208 program is all but impossible. Therefore other sources of funding must be sought so that this Division can obtain the necessary technical information for an enforcement action under Chapter 21, the Massachusetts Clean Waters Act.

Discussions, concerning the above situation between the water quality section, the enforcement section and the industrial waste section have suggested that a Research and Demonstration Grant be utilized to obtain the necessary geo-hydrological data for the formulation of an enforcement order. Perhaps this study, would serve as a model to investigate and eventually control other polluted groundwater sources affecting surface waters in the Commonwealth. It will be noted that an R & D grant was utilized as an enforcement tool in the Nyanza, Ashland (mercury) incident.

The Division will soon contact consultant engineering firms with a list of tasks and requests for proposal to study the extensive groundwater-surface water pollution of the Stepan Chemical Company.

TCM/KC/adb

C-2.24 December 1978 GeoTechnical Engineers, Inc. report regarding investigation of the Stepan Chemical Company property.

Report

on

Groundwater and Surface Water Study

Stepan Chemical Company
Wilmington, Massachusetts

Φ GEOTECHNICAL ENGINEERS INC.

C-209

Report

on

Groundwater and Surface Water Study

Stepan Chemical Company
Wilmington, Massachusetts

Presented to

Commonwealth of Massachusetts
Water Resources Commission
Division of Water Pollution Control

Submitted by

Geotechnical Engineers Inc.
1017 Main Street
Winchester, Massachusetts 01890

(617) 729-1625

Project 77348

December 6, 1978

Thomas O. Keller

Thomas O. Keller
Engineer

Daniel P. LaGatta
President

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7. CONCLUSIONS AND RECOMMENDATIONS

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1. INTRODUCTION

1.1 Purpose

Stepan Chemical Company, located in Wilmington, Massachusetts is a producer of organic chemicals used in the plastics industry. In the process of production, chemical waste slurry is deposited in lined lagoons for drying and subsequent removal to a landfill storage area. Prior to construction of the first lagoon in 1972, some liquid wastes were deposited in unlined pits in the area presently occupied by the lagoons. The purpose of this report is to present the results of an investigation into suspected groundwater and surface water contamination by past and present operations of Stepan Chemical Company.

1.2 Project Site

Stepan Chemical Company is located in Wilmington, Massachusetts. The site is shown in Fig. 1 which is a portion of the USGS Wilmington Quadrangle map. The site is bound on the north by Eames Street, on the east and west by the Boston and Maine Railroad, and on the south by the town line of Wilmington and Woburn. The site consists of approximately 53 acres with the production facilities located in the northern one half of the site, as shown in Fig. 2. The southern one half of the site is wooded.

A drainage ditch on the B&M property (referred to as the "East Drainage Ditch" in this report) borders Stepan's east property line and the B&M tracks and carries water from north to south along the project site boundary. This drainage ditch continues adjacent to the B&M tracks until its confluence with Hall's Brook about 0.9 mi south of the Stepan property. The majority of surface water on the Stepan property is routed to a single channel (referred to as the "Outlet Channel" in this report) which flows into the East Drainage Ditch, as shown in Fig. 2.

1.3 Scope

Twelve soil and rock borings were made on the Stepan property to determine subsurface conditions. Groundwater wells were installed in 11 of these borings to determine elevation contours of the groundwater surface on Stepan's property and to obtain water samples for analytical measurements. One existing groundwater well was discovered on the project site on May 31, 1978 and was sampled in the same manner as wells installed by GEI. Samples of surface waters were taken from a total of 17 locations for analytical measurements.

Groundwater and/or surface water samples were taken on November 11 and December 8-9, 1977 and February 21-22, March 15, April 10, and May 31, 1978. Fifty-eight groundwater samples and 57 surface water samples were obtained in the above period and analyzed for pH, acidity, sulfate, chloride, ammonia, and dissolved solids by ECO, Inc. in Cambridge, Massachusetts. In addition, analyses were made of three samples obtained from lined lagoons on the site used to store solid and liquid wastes of the plant.

An investigation of the lagoon liners was also made.

Flow measurements of water in drainage ditches were made on February 21, March 15, and April 11, 1978.

1.4 Authorization

This project was authorized by the Commonwealth of Massachusetts Water Resources Commission, Division of Water Pollution Control, Contract No. 9708-11-100-5-77-CR, dated August 15, 1977.

2. EXECUTIVE SUMMARY

Stepan Chemical Company, located in Wilmington, Massachusetts is a producer of organic chemicals used in the plastics industry. In the process of production, chemical waste slurry is deposited in lined lagoons for drying and subsequent removal to a landfill storage area. Prior to construction of the first lagoon in 1972, some liquid wastes were deposited in unlined pits in the area presently occupied by the lagoons. This report presents results of an investigation into suspected groundwater and surface water contamination by past and present operations of Stepan Chemical Company.

The location of the Stepan Site is shown in Fig. 1. Most of the site is drained by a ditch which borders the east property line and parallels the B&M railroad tracks. The water in this "East Drainage Ditch" flows to Hall's Brook which flows into the Aberjona River.

The Massachusetts Division of Water Pollution Control has established that the East Drainage Ditch is a Class B waterway.

The primary source of contamination of water i~~s~~n the East Drainage Ditch are discharges of water from an "Outlet Channel" located near the southern end of the Stepan property which drains much of the Stepan property. The secondary source of contamination to the East Drainage Ditch is infiltration of groundwater into the drainage ditch from the Stepan property.

The primary cause of contamination of surface water upstream of the Outlet Channel is believed to be the infiltration of contaminated groundwater into the drainage ditches. It is believed that contaminated groundwater results from leakage of the present treatment lagoons and remnant effects of the former "acid pits." In addition, spillage of chemicals on the ground surface of Stepan's property probably contribute to groundwater and surface water contamination.

If necessary, water in the East Drainage Ditch could be treated to achieve Class B water quality. This solution would require building a treatment facility to handle large volumes of water and would not eliminate the major sources of the pollution which are believed to be leakage from the existing lagoons and remnant contamination from the former "acid pits."

The lagoons could be eliminated as a source of pollution by either 1) redesigning the lagoons with a high factor of safety against leakage or 2) developing a waste treatment system which did not require use of lagoons. Remnant contamination from the former "acid pits" could be partially controlled by surrounding the contaminated area with an impervious cutoff wall at an estimated cost of $225,000.

3. SURFACE CONDITIONS

3.1 Plant Layout and Operation

The chemical plant operations began in 1953 under the ownership of National Polychemicals, Inc. (NPI). In June 1971, NPI merged with Stepan Chemical Company and the chemical plant name was changed to Stepan Chemical Company.

The plant structures occupy the northern portion of the project site, as shown in Fig. 2. According to Stepan personnel, untreated effluent from the plant operation was discharged into "acid pits" (see Fig. 2) from sometime prior to 1965 up until July 1971. From July 1971 to February 1972, treated effluent was discharged into the "acid pits." The location of the "acid pits" was taken from a design drawing entitled "Layout Lined Disposal Area, National Polychemicals, Inc., Wilmington, Mass." by Dana F. Perkins and Sons, Inc. dated September 2, 1971.

The chemical composition of discharges into the "acid pits" could not be determined, but it is believed that the liquids had low pH. The "acid pits" were not lined, and therefore, discharges were free to enter the groundwater. According to an aerial photograph taken April 24, 1971 (by Col-East, Inc. for Dana F. Perkins and Sons, Inc.), a drainage ditch connected the "acid pits" to a small pond in the center of Stepan's property (see Fig. 2 and Section 3.2), which in turn discharges into a drainage ditch labeled the North Drainage Ditch on Fig. 2. During periods of high waste discharge or heavy rainfall, it is believed that contaminated water in the "acid pits" flowed into drainage ditches which eventually discharge into the East Drainage Ditch running between Stepan's east property line and the B&M railroad (see Fig. 2). In addition, during periods of very high flow, it is believed that contaminated water could overflow drainage ditches leading to the East Drainage Ditch. It is believed that the presently observed dead trees in the area southeast of the "acid pits" are the result of contaminated overflows from the "acid pits" and/or contaminated groundwater flow due to discharges from the acid pits.

The Massachusetts Water Resources Commission Division of Water Pollution Control was established in 1967. This Commission required Stepan to implement a waste treatment program to eliminate discharges of effluent into the acid pits.

In September of 1971, the operation for disposing of effluent was changed to that presently in use. According to Stepan personnel, effluent is presently divided into two groups, 1) sulfate bearing and 2) non-sulfate bearing. The latter is treated by Stepan and discharged into an underground sewer line which connects to a sewer line owned by the Town of Wilmington. The Town of Wilmington sewer line connects to a Metropolitan District Commission sewer line. Liquid containing sulfates is mixed with a calcium hydroxide slurry to form calcium sulfate sludge which is pumped into either of two polyvinyl chloride (PVC) lined lagoons located as shown in Fig. 2. Lagoon 1 and Lagoon 2 were constructed in 1972 and 1973, respectively. The lagoons are discussed further in Chapter 6. The amount of calcium hydroxide slurry added to effluent containing sulfate is such that the resulting sludge may have a pH as high as 11. The lower limit of pH for material pumped into the lagoons from the present operations could not be determined.

Sludge remains in the lagoons until it has air dried sufficiently to be removed. Periodically (on the order of once every one or two years) the "dried" sludge is removed from the lagoons and placed in a landfill area in the southwest corner of the project site (see Fig. 2). According to Stepan personnel, sludge is removed from the lagoons with a clamshell and put into trucks for transport to the landfill. Stepan personnel have noted that sludge in the lower portion of the lagoons remains in a wet state and that the clamshell cannot lift this wet material because of its tendency to flow out of the clamshell bucket.

3.2 Surface Drainage

The locations of the existing major drainage-ways at the site are shown in Fig. 2. The majority of surface water flow on Stepan's property is discharged into the East Drainage Ditch through the Outlet Channel.

Water enters the Outlet Channel from the North and South Drainage Ditches as shown in Fig. 2; flow of water in the South Drainage Ditch is intermittent. The Center Pond is connected to the North Drainage Ditch by a short channel as shown in Fig. 2.

A pipe which discharges water into the West Drainage Ditch is located at the Headwall shown in Fig. 2. During periods of heavy rain or high snow melt, the area northwest of the Headwall becomes inundated and surface water flows directly into the West Drainage Ditch. Water in the West Drainage Ditch passes through a culvert under a roadway and enters the North Drainage Ditch.

Water flows onto Stepan's property from the West Pond shown in Fig. 2 via a drainage ditch and culvert under the west B&M tracks. Water flowing from the culvert enters a swampy area and can flow into either the North or South Drainage Ditches. During periods of low flow, it is believed that water enters the North Drainage Ditch only.

The East Drainage Ditch is about 10 to 20 ft from Stepan's east property line and parallels the B&M tracks. The ditch carries water from north to south and eventually flows into Hall's Brook about 0.9 mi downstream of the Stepan property. Hall's Brook flows into the Aberjona River 0.2 miles downstream from its confluence with the East Drainage Ditch. The Aberjona River, in turn, flows into the Upper Mystic Lake in Winchester, Massachusetts. The stream distance along the Aberjona River from its point of confluence with Hall's Brook to the Upper Mystic Lake is about 5.7 miles.

Table 16 contains a listing of the sampling stations established by GEI to monitor water in drainage ditches on and adjacent to Stepan's property.

3.3 Surface Water Flow

Table 17 summarizes flow data obtained for drainage ditches at the project site. Flow was determined by multiplying the velocity of water in the ditch by the cross sectional area of the ditch at the measuring location. Velocity was determined with a Pygmy Current Meter manufactured by Teledyne Gurley, Troy, New York. The cross sectional area of the ditch was estimated with the aid of a six-ft folding rule. The accuracy of the flow measurements is estimated to be on the order of ± 0.1 cfs.

Flow measurements taken March 15, 1978 are indicative of a "high flow" condition. The "high flow" condition corresponds to the end of snow melting as shown by Climatological Data in Fig. 3. A "low flow" condition is expected to occur during the summer months.

Based on the stream flow measurements, it is estimated that the increase in flow in the East Drainage Ditch from SS-1 to SS-16 due to groundwater infiltration is within the accuracy of the flow measurements or between zero and 0.1 cfs.

4. SUBSURFACE CONDITIONS

4.1 Subsoils

Twelve borings were made at the project site to determine subsoil conditions. Groundwater wells were installed in 11 of these borings at locations shown in Fig. 2. Appendix A contains the groundwater-well installation report for each boring. A well was not installed in Boring 9 at the northwest corner of Stepan's property because of shallow bedrock at this location. An existing groundwater well, designated W-101, was discovered near Lagoon 1 on May 31, 1978. This well was used for both groundwater sampling and groundwater elevation measurements.

The borings indicate that the general soil profile at the site is 3 to 15 ft of layered fine to coarse sands, occasionally mixed with gravel and/or silt, over a layer of predominantly sandy gravel and gravelly sand, occasionally containing silt. An estimate of horizontal soil permeability was made by conducting an in situ falling head permeability test in each groundwater well installed by GEI. Values of horizontal soil permeability are given in the groundwater installation reports in Appendix A. Horizontal soil permeabilities range from 0.01 cm/sec to 0.0001 cm/sec, the average for the 11 wells being 0.007 cm/sec.

The boring in the northwest corner of Stepan's property (Boring 9) indicated rock at a depth of 5 ft. Boring refusal was met in eight borings at depths ranging from 10.2 to 21.2 ft. Since rock was not cored, boring refusal may indicate the presence of a boulder. Boring refusal was not met in Boring Nos. 5, 10, and 11, which were made to depths ranging from 12.0 ft to 24.0 ft.

4.2 Groundwater

Groundwater elevations in each groundwater well are given in Table 18. Fig. 4 is a plot of groundwater elevation vs. time for each well. The average groundwater elevation for each well from November 2, 1977 to May 31, 1978 was obtained from the curves of Fig. 4 and is given in the last column of Table 18. The maximum groundwater elevation occurred between late February and early April of 1978 which corresponds to the period of snow melting as shown by the Climatological Data in Fig. 3. Groundwater elevations fluctuated on the order of about one foot during the sampling period. Generally, the fluctuation in the wells paralleled each other (Fig. 4) which indicates that the pattern of groundwater elevation contours is similar for high and low groundwater levels at the site.

A groundwater-elevation contour map was made from the average groundwater elevations for each well and is shown in Fig. 5. Groundwater elevations between two wells were determined by linear interpolation of the groundwater elevations in each well. The actual groundwater elevations between wells may vary from those shown in Fig. 5. It was assumed that the groundwater elevations adjacent to the East Drainage Ditch were the same as the water elevations in the ditch. Direction of groundwater flow is from higher to lower elevation and is perpendicular to groundwater contour lines.

Sufficient data are not available to draw contours in the northwest portion of the site, and the contour lines have been extrapolated as dotted lines in this area as shown in Fig. 5.

At GW-10, GW-11 and GW-12, the groundwater elevations are similar, and it is not possible on the basis of existing groundwater elevation data to accurately determine the direction of flow in this area.

Cross sections through the site are shown in Fig. 6 and 7. Fig. 2 shows the location of each cross section. Average groundwater elevations in wells have been plotted and elevations of water in drainage-ways are plotted as measured on April 14, 1978. The groundwater level in the wells for this date are reasonably close to the average levels. The bottom elevations of the lagoon liners were taken from design drawings of the liners referenced in Chapter 6.

On May 31, 1978, water was standing in Lagoon 2 and water was not seen at the surface of Lagoon 1. Both lagoons appeared filled with sludge throughout the groundwater sampling period. The cross sections show that (1) the groundwater surface outside the lagoons is above the design elevation of the bottom of both lagoon liners and (2) water in Lagoon 2 is at a higher elevation than the surrounding groundwater.

It was not possible on the basis of the existing groundwater elevation data to determine if waters in the lagoons are creating localized increases in the groundwater surface elevation near the lagoons.

4.3 Groundwater Flow into Drainage Ditches

4.3.1 Flow into the East Drainage Ditch

The average groundwater elevations in Wells GW-2 through GW-5, which are located within 15 to 90 ft of the East Drainage Ditch, are higher than the elevation of the water surface in the East Drainage Ditch measured on May 31,

1978. Therefore, it is concluded that groundwater flows into the ditch; GEI personnel have observed seepage of groundwater out of the slope on the west side of the East Drainage Ditch near GW-2.

The available data on groundwater elevations, surface elevations, depth to refusal, and permeability were used to estimate the groundwater flow into the East Drainage Ditch from Stepan's property. The upper and lower bounds for this groundwater flow are estimated to be from 0.2 cfs to 0.002 cfs.

4.3.2 Flow into Ditches on Stepan Property

Surface water elevations were measured at SS-5, SS-11, and SS-12 on April 14, 1978 and at SS-9 on June 8, 1978. A comparison between the surface water elevation at these locations with average groundwater elevations for the nearest well were made. This comparison showed that the groundwater elevation was higher than the surface water elevation in the ditches in all cases, the difference in elevation being between 0.4 and 1.3 ft. Therefore, it is concluded that groundwater infiltrates into the North Drainage Ditch, West Drainage Ditch, Outlet Channel, and the ditch connecting the West Pond to Stepan's property.

5. ANALYTICAL RESULTS

5.1 General

All water quality tests were performed by ECO, Inc. of Cambridge, Massachusetts. Water samples were analyzed for pH, acidity, sulfate, chloride, ammonia, and dissolved solids. All samples were delivered to ECO, Inc. on the same day that they were taken and analyzed for pH and acidity within two hours after delivery. Samples of sludge from the lagoons were also analyzed by ECO, Inc.

5.2 Lagoon Samples

On May 31, 1978, a sample of water from Lagoon 2 was obtained by Stepan personnel under the supervision of GEI; analytical results for this sample are presented in Table 14 which shows that the lagoon water has a pH of 1.4 and has high concentrations of all other parameters tested. The low pH of water in Lagoon 2 is unusual in that normal operations of the waste treatment facility should create a sludge with a pH >7.

On May 31, 1978, sludge was taken for analysis from Lagoon 1 and from a small lined basin north of Lagoon 2 by GEI with the aid of Stepan personnel. The small basin was constructed between April 14, 1978 and May 31, 1978. Details of the design of this basin are not known to GEI. According to Stepan personnel, sludge in the basin was taken from Lagoon 2, and it will be referred to in this report as sludge from Lagoon 2. The analytical results for the sludge samples are presented in Table 15 which shows that sludge from Lagoon 1 has a pH of about 10 and the sludge from Lagoon 2 has a pH of about 5.

As stated in Section 3.1, sludge remains in the lagoons until it has air dried sufficiently to be removed. Stepan personnel have observed that the sludge in the lower portion of the lagoons remains in a wet state and have attributed this wetness to insufficient evaporation of water from the sludge. Another possible explanation for this wetness is that there are leaks near the bottom of the liners, and since the groundwater surface is above the bottom of the liners, these leaks allow groundwater to enter the lagoon. If this were the case, the sludge would remain in a wet state higher than the groundwater surface elevation because of capillary tension.

A grain-size analysis of the sludge from Lagoon 2 was made to obtain an estimate of the height of capillary rise in the sludge material. The grain-size curve of the sludge is shown in Fig. 20. The sludge is predominantly silt-sized. The height of the capillary rise in a silt having the grain-size characteristics shown in Fig. 20 is approximately 3.0 to 3.5 ft. If groundwater were in direct communication with the sludge in a lagoon and the sludge behaved similarly to a silt with respect to capillary rise, then the sludge would probably be wet in the lower 3 to 6 ft of the lagoon because of capillary rise of the groundwater.

5.3 Groundwater

The analytical results of groundwater samples taken from November 11, 1977 to May 31, 1978 are shown in Tables 1 through 6. Average analytical results for each well are shown in Table 13. The data summarized in Table 13 indicates that a wide range of groundwater quality exists on the project site. To establish if isolated zones of high chemical concentration are present on the site, the areal distributions of each groundwater quality parameter were plotted. These distribution plots are shown Figs. 8 through 13.

The areal distribution of pH was plotted by assigning to each well the average measured pH for the sampling period (average values are given in Table 13 and Fig. 8). The pH of water between two wells was assumed to vary linerly between wells. Lines of equal pH were then drawn. Distribution lines were not drawn around GW-1 and GW-2 because they are relatively isolated from the other wells.

The areal distribution of the remaining five water quality parameters were determined similarly except that values of the distribution lines represent the logarithm (base 10) of the concentration. The logarithm method was used so that transitions from high to low concentration would be smooth.

The following sections consider the areal distribution plots of each parameter in more detail.

5.3.1 pH

The areal distribution of pH, Fig. 8, indicates that pH changes from above 7 to below 4 within about 200 ft in the vicinity of the lagoons. The average pH for wells GW-6 and GW-11 was 8.0 and 7.9, respectively. All other wells had an average pH below 7, the lowest pH being 3.4 in Well W-101.

On May 31, 1978 the water in Lagoon 2 had a pH of 1.4 and the sludge in Lagoon 1 had a pH of about 10.1.

The variable pH of the groundwater could be due in part to the following:

1) Discharge of wastes into Lagoon 2 if the PVC liner of Lagoon 2 was leaking. Presently, there is water with pH = 1.4 in Lagoon 2; we have no record of past water quality in Lagoon 2.
2) Discharge of wastes into Lagoon 1 if the PVC liner of Lagoon 1 was leaking. Presently, the material in Lagoon 1 has a high pH.
3) Discharges of effluent into the "acid pits" prior to 1971; this effluent may still be affecting the pH of the groundwater. It is believed that acids were discharged into the pits (hence "acid pits") and that this effluent had low pH.

5.3.2 Acidity

The areal distribution of acidity is shown in Fig. 9. Average acidity of groundwater varies from 32 (acidity is expressed in mg/ℓ as $CaCO_3$) in GW-12 to 6,928 in W-101.

The highest acidity is in the vicinity of the lagoons. The acidity of water in Lagoon 2 on May 31, 1978 was 7,217. The acidity tends to decrease from the lagoons towards the drainage ditches.

A possible explanation for the highly acidic groundwater near the lagoons is that the water inside Lagoon 2 is leaking through the PVC liner. If Lagoon 1 contained acidic water in the past and the liner was leaking, it too could be a possible source of the present high acidity in the groundwater. Another possible explanation is that discharge of effluent into the "acid pits" prior to 1971 created a load of highly acidic material beneath the present lagoons; this load may still be contaminating the groundwater.

5.3.3 Sulfate

The areal distribution of sulfate is shown in Fig. 10. Average concentration of sulfate varies from 7 (sulfate concentration is expressed in mg/ℓ as SO_4^{-2}) in GW-10 to 15,000 in W-101. The zone of highest concentration is in the vicinity of the lagoons. The sulfate concentration of water in Lagoon 2 on May 31, 1978 was 15,600.

A possible explanation for the high sulfate concentration in the groundwater near the lagoons is that either or both of the lagoons are leaking. Another possibility is that dischage of an acid, for example H_2SO_4 into the "acid pits" prior to 1971 is still affecting the groundwater quality in the area.

5.3.4 Chloride

The areal distribution of chloride is shown in Fig. 11. Average concentration of chloride varies from 33 (chloride concentration is expressed in mg/ℓ as Cl^-) in GW-10 to 5,100 in GW-7. The zone of highest concentration includes the lagoon area and areas southeast and southwest of the lagoons. The chloride concentration of water in Lagoon 2 on May 31, 1978 was 4,750.

A possible explanation for the high chloride concentration in the groundwater near the lagoons is that either or both of the lagoons are leaking. It is possible that discharge of an acid, for example HCl, into the "acid pits" prior to 1971 is still affecting the groundwater quality in the area.

5.3.5 Ammonia

The areal distribution of ammonia is shown in Fig. 12. Average concentration of ammonia varies from 1 (ammonia concentration is expressed in mg/ℓ as NH_4Cl) in GW-10 and GW-12 to about 17,200 in GW-6 and GW-11. The latter average concentrations are affected by an unusually high ammonia measurement of about 60,000 in each well on December 8, 1977. If the unusually high ammonia measurement is not included in the average, then the average ammonia concentration in GW-6 and GW-11 is about 5,300. The zone of highest concentration is between GW-6 and GW-11 and extends over the location of the lagoons. The ammonia concentration of water in Lagoon 2 on May 31, 1978 was 4,700.

A possible explanation for the high ammonia concentration in the groundwater near the lagoons is that either or both of the lagoons is leaking. It is not known if ammonia was ever discharged into the "acid pits."

5.3.6 Dissolved Solids

The areal distribution of dissolved solids concentration is shown in Fig. 13. Average concentration of dissolved solids varies from about 42 (dissolved solids concentration is expressed in mg/ℓ as $CaCO_3$) in GW-10 and GW-12 to about 7,500 in GW-7 and W-101. The zone of highest concentration covers the lagoon area and portions southeast and southwest of the lagoons. This distribution is similar to that shown by the chloride concentration (see Section 5.2.4). The dissolved solids concentration in water in Lagoon 2 on May 31, 1978 was 11,000.

A possible explanation for the high dissolved solids concentration in the groundwater near the lagoons is that either or both of lagoons are leaking. Another possiblity is that discharge of effluent into the "acid pits" prior to 1971 caused an increase in the dissolved solids concentration near the lagoons which is still contaminating the groundwater.

5.3.7 Summary

The areal distributions of each groundwater quality parameter were plotted and are shown in Figs. 8 through 13. This section is intended to present a summary of these figures so that consistent trends can be shown.

A trend which is evident in the distribution plots is that a zone of high chemical concentration exists in the vicinity of the lagoons which is also the location of the former "acid pits." The pH distribution is an exception in that the pH of the groundwater varies from about 4 to 7 in the vicinity of the lagoons, apparently independent of the lagoon locations. The quality of water inside Lagoon 2 on May 31, 1978 was similar to the quality of surrounding groundwater except for pH as noted above. The groundwater quality can be attributed to leakage of the lagoons. However, remnant loads of contaminants from discharges into the "acid pits" prior to 1971 may still be affecting the groundwater quality in the area.

GW-10 and GW-12 have relatively low concentrations of chemicals while GW-11 has high concentrations. The groundwater flow in this area is difficult to define explicitly because the variation of groundwater elevation in this area is so small that several interpretations of the flow pattern are possible. If Lagoon 2 were leaking, then local variations of groundwater flow might exist such that GW-11 received contaminated groundwater, while GW-10 and GW-12 received relatively uncontaminated groundwater.

5.4 Surface Water

The analytical results of surface water samples taken from December 8, 1977 to April 10, 1978 are shown in Tables 7 through 12. These tables indicate that a wide range of surface water quality exists on the project site.

5.4.1 East Drainage Ditch

In order to establish the cause(s) of contaminated water in the East Drainage Ditch, each surface water quality parameter was plotted as a function of its location on the East Drainage Ditch. The appropriate groundwater quality parameter was put on the same plot at locations of wells along Stepan's east boundary. These plots were made for each sampling time during this investigation and are shown on Figs. 14 through 19; each figure represents a different water quality parameter. The following sections consider these figures in more detail.

5.4.1.1 pH

A plot of pH of water along the east boundary of Stepan's property is shown on Fig. 14.

Figure 14 shows that pH varied between 5.5 and 6.5 at SS-1 and varied between 5.6 and 6.4 at SS-7 for all of the sampling times. Therefore, the pH of water in the East Drainage Ditch did not change appreciably as it flowed from the northern end to the southern end of Stepan's property, and in some cases, the pH improved, i.e., it moved toward neutrality. The pH of water in the ditch changed sharply where discharges from the Outlet Channel entered the ditch flow. However, the change varied between an increase and a decrease in pH and the change was never more than about 0.8.

The pH of the groundwater along Stepan's east boundary shows a change between GW-1 and GW-5. Wells GW-1, GW-2, and GW-5 consistently show a pH of about 6, while Wells GW-3 and GW-4 consistently show a pH of about 4.3. However, the lower pH of the groundwater near GW-3 and GW-4 does not cause the pH of the East Drainage Ditch water to decrease significantly (see Fig. 14) even though groundwater infiltrates into the ditch. Groundwater flow into the East Drainage Ditch is probably a small percentage of the total flow in the ditch, except during dry periods.

5.4.1.2 Acidity

A plot of acidity along the east boundary of Stepan's property is shown in Fig. 15. All acidity measurements are expressed in mg/ℓ as $CaCO_3$.

Figure 15 shows that acidity of the East Drainage Ditch water varied between 30 and 59 at SS-1 and varied between 80 and 177 at SS-7 for all of the sampling times. Therefore, there was a consistent increase in acidity of water in the East Drainage Ditch as it flowed from the northern end to the southern end of Stepan's property. A large portion of this increase was due to discharges from the Outlet Channel, the largest increase in acidity from these discharges being 94 on March 15, 1978.

The acidity of groundwater in the wells along Stepan's east boundary shows a general trend from GW-1 to GW-5. Acidity of the groundwater taken from the wells is many times greater than the acidity of the drainage ditch water and tends to be highest near the center of the site, from GW-2 to GW-4. Infiltration of contaminated groundwater into the East Drainage Ditch is probably responsible for the measured increases in acidity of between 5 and 25 in the drainage ditch water as it flows from SS-1 to SS-16.

5.4.1.3 Sulfate

A plot of sulfate concentration in the water along the east boundary of Stepan's property is shown in Fig. 16. All sulfate concentrations are expressed in mg/ℓ as SO_4^{-2}.

Figure 16 shows that sulfate concentration in the East Drainage Ditch water varied between 12 and 37 at SS-1 and varied between 240 and 700 at SS-7 for all of the sampling times. Therefore, there was a consistent increase in the concentration of sulfate in the East Drainage Ditch water as it flowed from the northern end to the southern end of Stepan's property. A large portion of this increase was due to discharges from the Outlet Channel, the largest increase in sulfate concentration from these discharges being 420 on March 15, 1978.

Figure 16 shows that sulfate concentration in the groundwater taken from wells along Stepan's east boundary is much greater than the sulfate concentration in water of the East Drainage Ditch. Groundwater concentrations are lowest for GW-1 and GW-2 and tend to be high for GW-3, GW-4 and GW-5. Infiltration of contaminated groundwater into the East Drainage Ditch is most likely responsible for measured increases in sulfate concentration of between 42 and 133 in the drainage ditch water as it flows from SS-1 to SS-16.

5.4.1.4 Chloride

A plot of chloride concentration in the water along the east boundary of Stepan's property is shown in Fig. 17. All chloride concentrations are expressed in mg/ℓ as Cl^-.

Figure 17 shows that chloride concentration in the East Drainage Ditch water varied between 37 and 200 at SS-1 and varied between 185 and 400 at SS-7 for all of the sampling times. On the average, for each sampling time, there was a five-fold increase in chloride concentration in the ditch water as it flowed from SS-1 to SS-7. The largest portion of this increase was due to discharges from the Outlet Channel, the largest increase in chloride concentration from these discharges being 180 on March 15, 1978.

Figure 17 shows that the chloride concentration in the groundwater taken from wells along Stepan's east boundary is always greater than the chloride concentration in water of the East Drainage Ditch. However, there has been a trend from November 11, 1977 to April 10, 1978 for the chloride concentration in the groundwater to decrease; on April 10 the chloride concentration in the groundwater and surface water were similar. Infiltration of contaminated groundwater into the East Drainage Ditch is probably responsible for the measured increases in chloride concentration of between 33 and 100 in the drainage ditch water as it flows from SS-1 to SS-16.

5.4.1.5 Ammonia

A plot of ammonia concentration in the water along the east boundary of Stepan's property is shown in Fig. 18. All ammonia concentrations are expressed in mg/ℓ as NH_4Cl.

Figure 18 shows that ammonia concentration in the East Drainage Ditch water varied between 0.5 and 7 at SS-1 and varied between 270 and 780 at SS-7 for all of the sampling times. Therefore, there was a consistent increase in the concentration of ammonia in the East Drainage Ditch water as it flowed from the northern end to the southern end of Stepan's property. The most significant cause of this increase was the discharge from the Outlet Channel which increased the ammonia concentration of the ditch water by at least 245 each sampling time.

Figure 18 shows that the ammonia concentration in the groundwater taken from wells along Stepan's east boundary is consistently greater than the ammonia concentration in water of the East Drainage Ditch. GW-1 consistently has the lowest ammonia concentration of the wells along the east property boundary. The ammonia concentration tends to increase from GW-2 to GW-4 and then drops at GW-5. Infiltration of contaminated groundwater into the East Drainage Ditch is probably responsible for the measured increases in ammonia concentration of between 24 and 61 in the drainage ditch water as it flows from SS-1 to SS-16.

5.4.1.6 <u>Dissolved Solids</u>

A plot of dissolved solids concentration in the water along the east boundary of Stepan's property is shown in Fig. 19. All dissolved solids concentrations are expressed in mg/ℓ as $CaCO_3$.

Figure 19 shows that dissolved solids concentration in the East Drainage Ditch water varied between 81 and 130 at SS-1 and varied between 405 and 775 at SS-7 for all of the sampling times. Therefore, there was a consistent increase in the concentration of dissolved solids in the East Drainage Ditch water as it flowed from the northern end to the southern end of Stepan's property. This increase was partly due to the discharges from the Outlet Channel which caused increases in concentration as high as about 650.

Figure 19 shows that the dissolved solids concentration in the groundwater taken from wells along Stepan's east boundary is consistently greater than the dissolved solids concentration in water of the East Drainage Ditch. Dissolved solids concentration in the groundwater is generally lowest at GW-1 and GW-2 and tends to increase in GW-3, GW-4, and GW-5. Infiltration of contaminated groundwater into the East Drainage Ditch is probably responsible for the measured increases in dissolved solids concentration of between 55 and 104 in the drainage ditch water as it flows from SS-1 to SS-16.

5.4.1.7 Summary

This section summarizes the trends observed from analytical results of surface water and groundwater samples along the east boundary of Stepan's property, i.e., the East Drainage Ditch samples and groundwater samples from GW-1 to GW-5. These analytical results have been plotted for each water quality parameter in Figs. 14 through 19.

These figures show that water in the East Drainage Ditch becomes more contaminated as it passes from Stepan's north property line to Stepan's south property line. The major cause for this contamination is the discharge into the East Drainage Ditch from the Outlet Channel. In addition, Figs. 15 through 19 show that water in the East Drainage Ditch gradually becomes more contaminated as it flows from Stepan's north property line to the Outlet Channel (SS-1 to SS-16). Figure 14 shows that pH of water in the East Drainage Ditch remains either unchanged or becomes slightly more neutral from SS-1 to SS-16.

The gradual change in water quality from SS-1 to SS-16 can be attributed to groundwater infiltration into the East Drainage Ditch. Concentrations of all parameters, except pH, in the groundwater are considerably higher than concentrations in the East Drainage Ditch water as shown by Figs. 14 through 19. Therefore, a small amount of groundwater flow into the ditch can noticeably raise the chemical concentrations in the ditch water.

On the basis of groundwater elevation measurements and surface water elevation measurements, it has been concluded that groundwater from the Stepan property flows into the East Drainage Ditch (see Section 4.3.1). An attempt was made to determine the quantity of flow in the East Drainage Ditch caused by groundwater flow into the ditch. An accurate determination of this quantity could not be determined for the following reasons:

1) Based on in situ permeability measurements and the assumed hydraulic gradient, the quantity of groundwater flow is small.

2) The flow of water in the East Drainage Ditch was too small to measure accurately; hence the difference in flow at the north and south boundaries could not be used to estimate the groundwater flow.

5.4.2 Outlet Channel

The increase in contamination of water in the East Drainage Ditch from Stepan's north property line to Stepan's south property line (SS-1 to SS-7) is mainly due to discharges into the ditch from the Outlet Channel.

Figure 21 shows the major drainage-ways upstream of the Outlet Channel and the surface sampling stations on these drainage ways. To trace sources of pollution upstream of the Outlet Channel, the ammonia concentrations of water upstream of the Outlet Channel on April 10, 1978 were considered (these ammonia concentrations are given in Table 11). The ammonia concentrations, expressed in mg/ℓ as NH_4Cl, are shown on Fig. 21 next to the appropriate surface sampling stations.

The sampling locations farthest upstream of the Outlet Channel are the Headwall on the West Drainage Ditch (SS-10) and the West Pond (SS-15) which is west of the Stepan property line. These two locations show relatively low concentrations of ammonia.

Water flows from the West Pond to SS-12 on Stepan's property. Sampling Station SS-12 is just inside the Stepan property line about 300 ft downstream of the West Pond. In this distance, the ammonia concentration increases from 3 at SS-15 near the West Pond to 550 at SS-12, which is believed to be caused by contaminated groundwater infiltrating into the drainage ditch downstream of SS-15. In Section 4.3.2, it was established that the elevation of the groundwater in the area of SS-12 was higher than the elevation of the drainage ditch water, and hence groundwater infiltration into the ditch near SS-12 does occur. The groundwater well in this area (GW-11) typically has very high concentrations of ammonia.

Water flows from SS-12 to the junction of the North and South Drainage Ditches. At this junction, part of the water flows into the North Drainage Ditch and part flows into the South Drainage Ditch. As water flows from SS-12 to a point 200 ft downstream on the South Drainage Ditch (SS-14), the ammonia concentration increases from 556 to 630. This increase is probably due to infiltration of contaminated groundwater into the drainage ditch. As water flows from SS-14 to SS-13 in the South Drainage Ditch, it decreases in ammonia concentration from 630 to 100. This decrease in ammonia concentration is unexplained but may be due to dilution from relatively uncontaminated water entering the South Drainage Ditch from (1) small surface drainage-ways not shown on Fig. 2 and/or (2) less contaminated groundwater.

Water flows in the West Drainage Ditch from the Headwall (SS-10) to a culvert (SS-11). In this distance, the ammonia concentration increases from 10 to 180. This increase is believed to be caused by infiltration of contaminated groundwater into the drainage ditch.

Water flows from the West Drainage Ditch into the North Drainage Ditch. The water flowing into the North Drainage Ditch is a combination of water originating at the Headwall (SS-10) and the West Pond (SS-15) plus any groundwater which infiltrated into the drainage ditches leading up to North Drainage Ditch.

As water flows in the North Drainage Ditch, contaminated groundwater infiltrates into it and causes the ammonia concentration of the water to increase. Discharges from the Center Pond into the North Drainage Ditch have very high concentrations of ammonia (about 1,050). These discharges probably increase the ammonia concentration in the North Drainage Ditch water substantially. At the downstream end of the North Drainage Ditch (SS-8), the ammonia concentration of the water is 490.

Finally, the North and South Drainage Ditches merge to form the Outlet Channel which has an ammonia concentration of 425.

In summary, it is believed that high chemical concentrations in the Outlet Channel water are primarily due to infiltration of contaminated groundwater into the surface drainageways leading to the Outlet Channel.

6. LAGOONS

Information on the design and construction of the lined lagoons at Stepan Chemical Company has been difficult to obtain because of the lack of documentation. This chapter is intended to (1) provide information on the lagoons made available to GEI, (2) document observations made by GEI of the lagoon performance, and (3) arrive at conclusions of the liner integrity.

Construction of Lagoon 1 was completed in January 1972, and construction of Lagoon 2 was completed sometime in 1973. Information on the lagoon design was obtained from two drawings, both entitled "Layout Lined Disposal Area, National Polychemicals, Inc., Wilmington, Mass.," by Dana F. Perkins and Sons, Inc., dated September 2, 1971 and June 28, 1973. These drawings show that the lagoons were to be constructed at the location of the former "acid pits" (see Fig. 2). The bottoms of the liners were to be placed on natural ground and the sides of the liners were to be placed on either natural ground or a fill layer. The drawings show that a polyvinyl chloride (PVC) liner was to be used for Lagoon 1; no mention of liner type was given for Lagoon 2. The liner type was determined to be PVC for both lagoons through discussions with Stepan Chemical Company personnel. The thickness of the liners was measured in the field by GEI (at an exposed portion) and found to be 0.020 in. (20 mil) thick. The design drawings indicate that the liners were to be exposed at the ground surface and that no protective layer was to be placed on top of the liner sides or bottom. Field observations by GEI confirm that the lagoon liners are exposed at the surface and that exposed portions are in varying degrees of deterioration. Tears and holes in portions of the liners exposed at the ground surface have been observed.

The manufacturer of the PVC liners was determined from Stepan personnel to be Firestone Coated Fabric Co. Firestone personnel indicated that they no longer sell liners of the type used at Stepan Chemical Company. Firestone could not provide GEI with specific information on the PVC liners installed at Stepan. Stepan personnel indicated that construction of Lagoon 1 was inspected by a representative of Firestone but that no construction records for the lagoon could be found. According to Stepan personnel, the liners were placed on natural ground which had been cleared of large stones. According to Dana F. Perkins and Sons, Inc. personnel, the groundwater table was lowered to allow construction of the lagoons in a dry excavation. The details of the dewatering system and groundwater elevation records during construction could not be found.

It is believed that the capability of the lagoon liners to act as a barrier between stored wastes and the groundwater has greatly diminished since the time the liners were installed. This conclusion was made on the basis of the following:

1. Presently, PVC liners are not recommended for use on critical facilities. Rather, they are recommended for temporary installations, farm ponds, shallow lakes and related facilities. The performance of PVC liners for retaining heavily polluted liquids has been poor.

2. PVC liners should be covered with a soil layer or roof to prevent damage due to weathering. In particular, exposure of a PVC liner to the sun will cause serious degradation of the liner. The liners at Stepan do not have covers and are exposed at the surface. Tears and holes have been observed in the exposed liners.

3. PVC liners should be placed on a prepared sand bed to prevent large particles in the natural soil from puncturing the liner. According to design drawings, the PVC liners at Stepan were not placed on a prepared sand bed.

4. PVC liners are not recommended for storing liquids having a high pH. Exposure of a PVC liner to high pH will cause the chemical reactions which created the PVC to reverse and the liner will eventually disintegrate. The sludge stored in Lagoon 1 was sampled for this study, and it had a pH greater than 10. Because the liners have been in operation for 5 to 7 years, it is possible that serious disintegration of the liner has occurred due to storage of highly basic material.

5. The clamshell used to remove sludge from the liners may have inadvertently punctured the liners.

7. CONCLUSIONS AND RECOMMENDATIONS

7.1 Conclusions

The primary source of contamination of water in the East Drainage Ditch as it flows adjacent to the Stepan property and the B&M railroad tracks is water from the Outlet Channel which drains much of the Stepan property. The secondary source of contamination to the East Drainage Ditch is infiltration of groundwater into the East Drainage Ditch from the Stepan property.

The relative contribution of each of these sources may be seen in the following table which summarizes the water quality measured in the East Drainage Ditch at SS-1 "upstream" of the Stepan property, SS-16 just upstream of its confluence with the Outlet Channel, SS-6 just downstream of the Outlet Channel, and SS-7 which represents the quality of water leaving the site.

Parameter	SS-1	SS-16	SS-6	SS-7
pH	5.5 - 6.5	5.7 - 5.8	5.4 - 6.4	5.6 - 6.3
Acidity (mg/ℓ as $CaCO_3$)	30 - 59	35 - 50	70 - 214	80 - 177
Sulfate (mg/ℓ as SO_4^{-2})	12 - 37	55 - 100	240 - 650	240 - 700
Chloride (mg/ℓ as Cl^-)	37 - 200	70 - 115	185 - 450	185 - 425
Ammonia (mg/ℓ as NH_4Cl)	0.5 - 7	30 - 40	285 - 800	270 - 780
Dissolved Solids (mg/ℓ as $CaCO_3$)	81 - 130	136 - 218	450 - 775	405 - 775

The primary cause of contaminated water in drainage ditches upstream of the Outlet Channel is believed to be the infiltration of contaminated groundwater into the drainage ditches. It is believed that contaminated groundwater results from leakage of the present treatment lagoons and remnant effects of the former "acid pits." In addition, spillage of chemicals on the ground surface of Stepan's property probably contribute to groundwater and surface water contamination.

The Massachusetts Division of Water Pollution Control (MDWPC) has established that the East Drainage Ditch is a Class B waterway. According to the "Massachusetts Water Quality Standards" effective September 21, 1978, Class B waters shall have a pH "in the range of 6.5-8.0 standard units and not more than 0.2 units outside of the naturally occurring range."

The measured pH of water in the East Drainage Ditch near Stepan's northern boundary (SS-1) has ranged from 5.5 to 6.5 and the pH of water in the East Drainage Ditch near Stepan's southern boundary (SS-7) has ranged from 5.6 to 6.3. The range of the pH of the water leaving the southern boundary of the Stepan property is nearly the same as the range of the pH of the water entering the northern boundary of the Stepan property.

The Class B water quality for waters in the East Drainage Ditch with respect to acidity, sulfate, chloride, ammonia, and dissolved solids were not available at the time of publication.

7.2 Recommendations

Recommendations are based on the requirement of the Massachusetts Division of Water Pollution Control to achieve Class B water quality in the East Drainage Ditch. The Division has not established standards for groundwater quality.

If necessary, water in the East Drainage Ditch could be treated to achieve Class B water quality. This solution would be very costly because of the requirement to build a treatment facility to handle large volumes of water and would not eliminate the source of the pollution.

Determination of the source of the low pH measurements in the ditch water at SS-1 was not included in the scope of this investigation. It is recommended that a study be made to determine the cause of low pH in the ditch water at SS-1.

The major sources of the acidity, sulfate, chloride, ammonia, and dissolved solids concentrations in the East Drainage Ditch water downstream of SS-1 are believed to be leakage from the existing lagoons and remnant contamination from the former "acid pits." The lagoons could be eliminated as a source of pollution by either (1) redesigning the lagoons with a high factor of safety against leakage or (2) developing a waste treatment system which does not require the use of lagoons.

Remnant contamination from the former "acid pits" is a difficult pollution source to eliminate. It may be possible by overexcavation in the area of the former "acid pits" to remove the most highly contaminated soils. However, this solution would be very costly because of the large excavation volumes required and necessity to decontaminate the excavated material.

Remnant contamination from the former "acid pits" could be partially controlled by surrounding the contaminated area with an impervious cutoff wall. The most economical cutoff wall would probably consist of a bentonite-soil mixture and would require the use of a bentonite resistant to the chemical attack of contaminated groundwater. The cost of this type of cutoff wall is estimated to be $5 per sq ft of wall. Assuming an average depth of wall of 25 ft (to bedrock surface) and a total wall length of 1800 ft, the total cost of installation is estimated at $225,000. The actual cost may vary from the above due to uncertainties in the estimate of the average depth to bedrock.

TABLE 1 - ANALYTICAL RESULTS OF GROUNDWATER SAMPLES
STEPAN CHEMICAL COMPANY
WILMINGTON, MASSACHUSETTS

pH(1)

	1977		1978			
Groundwater Well No.	Nov 11	Dec 8 Dec 9	Feb 22	Mar 15	Apr 10	May 31
GW-1	6.9	6.0	6.1	5.9	5.8	-
GW-2	6.4	6.2	6.1	5.6	5.8	-
GW-3	4.6	4.5	4.7	4.1	4.1	-
GW-4	4.5	4.4	4.4	4.1	4.1	4.1
GW-5	6.2	6.1	(2)	(2)	5.7	-
GW-6	8.0	8.3	8.2	7.8	7.6	7.4
GW-7	4.2	4.0	4.0	3.8	3.8	3.7
GW-8	5.5	5.8	6.1	5.7	5.8	-
GW-10	4.7	4.4	4.4	4.0	4.2	-
GW-11	6.3	7.8	8.6	8.1	8.6	8.5
GW-12	6.3	5.3	5.9	5.3	5.0	-
W-101	-	-	-	-	-	3.4

Notes:

(1) This analysis was carried out using the method described in *Standard Methods for the Examination of Water and Wastewater*, 13 ed., Am. Public Health Assoc., Washington, DC, 1971. Specific reference is as follows: 144A pH, p. 276.

(2) Frozen - no sample obtained.

TABLE 2 - ANALYTICAL RESULTS OF GROUNDWATER SAMPLES
STEPAN CHEMICAL COMPANY
WILMINGTON, MASSACHUSETTS

Acidity(1)

mg/ℓ as $CaCO_3$

	1977		1978			
Groundwater Well No.	Nov 11	Dec 8 Dec 9	Feb 22	Mar 15	Apr 10	May 31
GW-1	144	89	104	94	100	-
GW-2	450	340	373	408	200	-
GW-3	405	450	345	269	190	-
GW-4	580	603	290	159	438	385
GW-5	248	183	(3)	(3)	238	-
GW-6	90(2)	790	472	508	520	520
GW-7	1737	2100	1873	1990	1910	2117
GW-8	468	504	391	279	205	-
GW-10	86	69	63	70	60	-
GW-11	2700	1330	909	1230	90	924
GW-12	45	30	25	30	32	-
W-101	-	-	-	-	-	7217

Notes

(1) This analysis was carried out using the method described in *Standard Methods for the Examination of Water and Wastewater*, 13 ed., Am. Public Health Assoc., Washington, DC, 1971. Specific reference is as follows: 101 Acidity, p. 50; phenolphthalein indicator-titration performed at room temperature.

(2) Frozen - no sample obtained.

(3) Alkalinity measurement to phenolphthalein end point using method described in manual specified in note (1). Specific reference is as follows: 102 Alkalinity, p. 52.

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TABLE 3 - ANALYTICAL RESULTS OF GROUNDWATER SAMPLES
STEPAN CHEMICAL COMPANY
WILMINGTON, MASSACHUSETTS

Sulfate$^{(1)}$

mg/ℓ as SO_4^{-2}

	1977		1978			
Groundwater Well No.	Nov 11	Dec 8 Dec 9	Feb 22	Mar 15	Apr 10	May 31
GW-1	73	69	42	62	300	-
GW-2	20	18	8	12	14	-
GW-3	815	550	600	650	465	-
GW-4	755	550	320	200	750	300
GW-5	390	659	(2)	(2)	1000	-
GW-6	5750	6250	4500	4500	4000	3600
GW-7	7500	6250	9000	6500	6500	8200
GW-8	1500	2100	1850	1525	1650	-
GW-10	8	6	12	3	7	-
GW-11	5750	5000	4750	4250	3900	3300
GW-12	23	18	12	10	9	-
W-101	-	-	-	-	-	15000

Notes:

(1) This analysis was carried out using the method described in *Standard Methods for the Examination of Water and Wastewater*, 13 ed., Am. Public Health Assoc., Washington, DC, 1971. Specific reference is as follows: 156C Turbidimetric Method, p. 334.

(2) Frozen - no sample obtained.

TABLE 4 - ANALYTICAL RESULTS OF GROUNDWATER SAMPLES
STEPAN CHEMICAL COMPANY
WILMINGTON, MASSACHUSETTS

Chloride(1)

mg/ℓ as Cl^-

	1977		1978			
Groundwater Well No.	Nov 11	Dec 8 Dec 9	Feb 22	Mar 15	Apr 10	May 31
GW-1	525	600	375	300	130	-
GW-2	300	230	250	200	200	-
GW-3	2500	600	225	200	80	-
GW-4	2500	1600	750	165	160	450
GW-5	1000	600	(2)	(2)	500	-
GW-6	6500	5250	2500	2000	2125	2250
GW-7	5750	8000	4250	3500	4000	4500
GW-8	1500	1150	850	500	400	-
GW-10	100	30	10	10	13	-
GW-11	5500	7000	4500	3750	4125	5000
GW-12	300	25	22	20	20	-
W-101	-	-	-	-	-	3500

Notes:

(1) This analysis was carried out using the method described in *Standard Methods for the Examination of Water and Wastewater*, 13 ed., Am. Public Health Assoc., Washington, DC, 1971. Specific reference is as follows: 112B Mercuric Nitrate Method, p. 97.

(2) Frozen - no sample obtained.

TABLE 5 - ANALYTICAL RESULTS OF GROUNDWATER SAMPLES
STEPAN CHEMICAL COMPANY
WILMINGTON, MASSACHUSETTS

Ammonia(1)

mg/ℓ as NH_4Cl

	1977		1978			
Groundwater Well No.	Nov 11	Dec 8 Dec 9	Feb 22	Mar 15	Apr 10	May 31
GW-1	6.6	5.6	15	10	46.5	-
GW-2	180	230	190	180	115	-
GW-3	85	350	230	340	195	-
GW-4	720	1250	280	170	490	210
GW-5	67	430	(2)	(2)	200	-
GW-6	6000	67000(3)	6000	2800	4000	3200
GW-7	7000	1050	7200	4700	5100	4300
GW-8	850	2300	1300	1100	1000	-
GW-10	1.7	1.6	0.5	0.8	0.3	-
GW-11	7000	60000(3)	8600	5400	5850	4400
GW-12	0.2	0.2	0.8	0.5	0.7	-
W-101	-	-	-	-	-	3700

Notes:

(1) This analysis was carried out using the method described in *Standard Methods for the Examination of Water and Wastewater*, 13 ed., Am. Public Health Assoc., Washington, DC, 1971. Specific reference is as follows: 132C Phenate Method, p. 232.

(2) Frozen - no sample obtained.

(3) This measurement was checked by repeating the analysis.

TABLE 6 - ANALYTICAL RESULTS OF GROUNDWATER SAMPLES
STEPAN CHEMICAL COMPANY
WILMINGTON, MASSACHUSETTS

Dissolved Solids(1)

mg/ℓ as $CaCO_3$

	1977			1978			
Groundwater Well No.	Nov 11 A(2)	Nov 11 B(2)	Dec 8 Dec 9	Feb 22	Mar 15	Apr 10	May 31
GW-1	810	-	378	328	328	389	-
GW-2	660	-	306	307	343	240	-
GW-3	3940	658	638	549	556	425	-
GW-4	6320	1440	1409	618	328	1303	790
GW-5	1940	502	749	(3)	(3)	1300	-
GW-6	26470	6850	6971	5217	4887	4533	4900
GW-7	31100	-	7986	7987	6764	6764	8560
GW-8	7860	-	2479	1571	1481	1696	-
GW-10	820	-	79	13.5	46	38	-
GW-11	25600	-	7032	7336	6076	6971	7400
GW-12	3900	39	45	33.8	40	40	-
W-101	-	-	-	-	-	-	7700

Notes:

(1) This analysis was carried out using the method described in *Standard Methods for the Examination of Water and Wastewater* 13 ed., Am. Public Health Assoc., Washington, DC, 1971. Specific reference is as follows: 226 Specific Conductance, p. 550. Specific conductance was converted to mg/ℓ as $CaCO_3$ using a conversion table in *Hach Methods Manual*, 8 ed., Hach Chemical Company, Ames, Iowa, 1972.

(2) Results in Column A were obtained using a method described in *Standard Methods for the Examination of Water and Wastewater* Specific reference is as follows: 224E Dissolved Matter, p. 539. Results in Column B were obtained using the method referred to in note (1).

(3) Frozen - no sample obtained.

TABLE 7 - ANALYTICAL RESULTS OF SURFACE WATER SAMPLES
STEPAN CHEMICAL COMPANY
WILMINGTON, MASSACHUSETTS

pH(1)

	1977	1978			
Surface Sampling Station No.	Dec 8	Jan 19	Feb 21	Mar 15	Apr 10
SS-1	6.3	6.5	6.2	5.7	5.5
SS-2	6.3	6.4	6.3	-	-
SS-3	6.1	6.4	6.2	5.7	5.8
SS-4	6.3	6.5	(2)	5.7	5.9
SS-5	4.9	5.1	(2)	4.9	6.7
SS-6	5.7	5.6	6.4	5.4	6.1
SS-7	5.8	5.8	6.3	5.6	6.1
SS-8	4.9	(2)	(2)	5.5	6.8
SS-9	(2)	(2)	(2)	(2)	5.2
SS-10	6.2	7.1	9.8	8.1	8.4
SS-11	6.2	7.3	9.4	6.5	7.7
SS-12	4.4	4.7	4.6	4.2	4.1
SS-13	-	(2)	(2)	(2)	4.0
SS-14	-	(2)	(2)	(2)	4.2
SS-15	-	(2)	(2)	5.3	4.4
SS-16	-	-	-	5.7	5.8
SS-17	-	-	-	6.1	-

Notes:

(1) This analysis was carried out using the method described in *Standard Methods for the Examination of Water and Wastewater*, 13 ed., Am. Public Health Assoc., Washington, DC, 1971. Specific reference is as follows: 144A pH, p. 276.

(2) Frozen - no sample obtained.

TABLE 8 - ANALYTICAL RESULTS OF SURFACE WATER SAMPLES
STEPAN CHEMICAL COMPANY
WILMINGTON, MASSACHUSETTS

Acidity (1)

mg/ℓ as $CaCO_3$

	1977	1978			
Surface Sampling Station No.	Dec 8	Jan 19	Feb 21	Mar 15	Apr 10
SS-1	44.5	37.5	59.0	29.8	42.5
SS-2	44.5	40.0	54.5	-	-
SS-3	64.2	55.0	59.0	37.3	45.0
SS-4	69.2	42.5	(2)	39.8	62.5
SS-5	222	230	(2)	194	100
SS-6	143	110	214	129	70.0
SS-7	103	105	177	104	80.0
SS-8	321	(2)	(2)	124	120
SS-9	(2)	(2)	(2)	(2)	143
SS-10	14.8	10.0	100 (3)	9.9	5.0
SS-11	54.3	60.0	175 (3)	39.8	30.0
SS-12	19.5	400	909	388	200
SS-13	-	(2)	(2)	(2)	80.0
SS-14	-	(2)	(2)	(2)	30.0
SS-15	-	(2)	(2)	39.8	17.5
SS-16	-	-	-	34.8	50.0
SS-17	-	-	-	24.9	-

Notes

(1) This analysis was carried out using the method described in *Standard Methods for the Examination of Water and Wastewater*, 13 ed., Am. Public Health Assoc., Washington, DC, 1971. Specific reference is as follows: 101 Acidity, p. 50; phenolphthalein indicator-titration performed at room temperature.

(2) Alkalinity measurement to phenolphthalein end point using method described in manual specified in note (1). Specific reference is as follows: 102 Alkalinity, p. 52.

(3) Frozen - no sample obtained.

TABLE 9 - ANALYTICAL RESULTS OF SURFACE WATER SAMPLES
STEPAN CHEMICAL COMPANY
WILMINGTON, MASSACHUSETTS

Sulfate(1)

mg/ℓ as SO_4^{-2}

	1977	1978			
Surface Sampling Station No.	Dec 8	Jan 19	Feb 21	Mar 15	Apr 10
SS-1	37	33	15	12	18
SS-2	43	27	22	-	-
SS-3	64	30	32	14	28
SS-4	170	75	(2)	42	80
SS-5	675	725	(2)	800	500
SS-6	475	450	650	475	240
SS-7	470	440	700	425	240
SS-8	750	(2)	(2)	900	600
SS-9	(2)	(2)	(2)	(2)	1200
SS-10	25	32	17	48	28
SS-11	260	110	60	165	155
SS-12	2050	1000	3250	800	700
SS-13	-	(2)	(2)	(2)	360
SS-14	-	(2)	(2)	(2)	900
SS-15	-	(2)	(2)	5	11
SS-16	-	-	-	55	100
SS-17	-	-	-	10	-

Notes:

(1) This analysis was carried out using the method described in *Standard Methods for the Examination of Water and Wastewater*, 13 ed., Am. Public Health Assoc., Washington, DC, 1971. Specific reference is as follows: 156C Turbidimetric Method, p. 334.

(2) Frozen - no sample obtained.

TABLE 10 - ANALYTICAL RESULTS OF SURFACE WATER SAMPLES
STEPAN CHEMICAL COMPANY
WILMINGTON, MASSACHUSETTS

Chloride(1)

mg/ℓ as Cl^-

	1977	1978			
Surface Sampling Station No.	Dec 8	Jan 19	Feb 21	Mar 15	Apr 10
SS-1	200	50	50	37	60
SS-2	220	62	75	-	-
SS-3	250	75	100	52	80
SS-4	300	87	(2)	55	110
SS-5	750	350	(2)	325	300
SS-6	450	225	450	250	185
SS-7	400	220	425	200	185
SS-8	825	(2)	(2)	350	300
SS-9	(2)	(2)	(2)	(2)	700
SS-10	150	110	100	138	75
SS-11	330	175	150	125	140
SS-12	800	400	975	400	400
SS-13	-	(2)	(2)	(2)	140
SS-14	-	(2)	(2)	(2)	350
SS-15	-	(2)	(2)	15	37
SS-16	-	-	-	70	115
SS-17	-	-	-	50	-

Notes:

(1) This analysis was carried out using the method described in *Standard Methods for the Examination of Water and Wastewater*, 13 ed., Am. Public Health Assoc., Washington, DC, 1971. Specific reference is as follows: 112B Mercuric Nitrate Method, p. 97.

(2) Frozen - no sample obtained.

TABLE 11 - ANALYTICAL RESULTS OF SURFACE WATER SAMPLES
STEPAN CHEMICAL COMPANY
WILMINGTON, MASSACHUSETTS

Ammonia(1)

mg/ℓ as NH_4Cl

	1977	1978			
Surface Sampling Station No.	Dec 8	Jan 19	Feb 19	Mar 15	Apr 10
SS-1	1.8	1.5	1.8	0.5	7
SS-2	3.0	1.5	2.8	-	-
SS-3	27	16	18	95	9
SS-4	63	25	(2)	25	36
SS-5	560	1040	(2)	520	425
SS-6	430	440	800	350	285
SS-7	340	380	780	380	270
SS-8	600	(2)	(2)	520	490
SS-9	(2)	(2)	(2)	(2)	1050
SS-10	6.0	34	110	150	10
SS-11	460	160	380	290	180
SS-12	800	1200	1700	900	550
SS-13	-	(2)	(2)	(2)	100
SS-14	-	(2)	(2)	(2)	630
SS-15	-	(2)	(2)	3	3
SS-16	-	-	-	30	40
SS-17	-	-	-	43	-

Notes:

(1) This analysis was carried out using the method described in *Standard Methods for the Examination of Water and Wastewater*, 13 ed., Am. Public Health Assoc., Washington, DC, 1971. Specific reference is as follows: 132C Phenate Method, p. 232.

(2) Frozen - no sample obtained.

TABLE 12 - ANALYTICAL RESULTS OF SURFACE WATER SAMPLES
STEPAN CHEMICAL COMPANY
WILMINGTON, MASSACHUSETTS

Dissolved Solids(1)

mg/ℓ as $CaCO_3$

	1977	1978			
Surface Sampling Station No.	Dec 8	Jan 19	Feb 21	Mar 15	Apr 10
SS-1	114	106	94	81	130
SS-2	120	101	81	-	-
SS-3	150	125	112	82	144
SS-4	218	165	(2)	116	231
SS-5	999	945	(2)	770	775
SS-6	563	538	775	597	450
SS-7	512	515	775	605	405
SS-8	1178	(2)	(2)	927	892
SS-9	(2)	(2)	(2)	(2)	1581
SS-10	124	152	122	238	141
SS-11	240	302	285	328	310
SS-12	1922	1160	2327	1035	749
SS-13	-	(2)	(2)	(2)	481
SS-14	-	(2)	(2)	(2)	1106
SS-15	-	(2)	(2)	47	41
SS-16	-	-	-	136	218
SS-17	-	-	-	86	-

Notes:

(1) This analysis was carried out using the method described in *Standard Methods for the Examination of Water and Wastewater,* 13 ed., Am. Public Health Assoc., Washington, DC, 1971. Specific reference is as follows: 226 Specific Conductance, p. 550. Specific conductance was converted to mg/ℓ as $CaCO_3$ using a conversion table in *Hach Methods Manual,* 8 ed., Hach Chemical Company, Ames, Iowa, 1972.

(2) Frozen - no sample obtained.

TABLE 13 - AVERAGE ANALYTICAL RESULTS OF GROUNDWATER SAMPLES FOR SAMPLING PERIOD NOV. 11, 1977 TO APRIL 10, 1978(1) STEPAN CHEMICAL COMPANY WILMINGTON, MASSACHUSETTS

Groundwater Well No.	pH	Acidity mg/ℓ as $CaCO_3$	Sulfate mg/ℓ as SO_4^{-2}	Chloride mg/ℓ as Cl^-	Ammonia mg/ℓ as NH_4Cl	Dissolved Solids mg/ℓ as $CaCO_3$
GW-1	6.1	106	109	386	17	356
GW-2	6.0	354	14	236	179	299
GW-3	4.4	332	616	721	240	565
GW-4	4.3	414	515	1035	582	1020
GW-5	6.0	223	683	700	232	850
GW-6	8.0	572	5000	3675	17160	5692
GW-7	4.0	1922	7150	5100	5010	7375
GW-8	5.8	369	1725	880	1310	1807
GW-10	4.3	70	7	33	1	44
GW-11	7.9	1252	4730	4975	17370	6854
GW-12	5.5	32	14	77	1	40
W-101(2)	3.4	6928	15000	3500	3700	7700

Notes: (1) Refer to Note (1) of Tables 1 through 6 for methods of analysis.

(2) W-101 sampled on May 31, 1978 only.

TABLE 14 - ANALYTICAL RESULTS OF LAGOON WATER

Sample	pH	Acidity mg/ℓ as $CaCO_3$	Sulfate mg/ℓ as SO_4^{-2}	Chloride mg/ℓ as Cl^-	Ammonia mg/ℓ as NH_4Cl	Dissolved Solids mg/ℓ as $CaCO^3$
Water from Lagoon 2- Taken May 31, 1978	1.4	7217	15600	4750	4700	11000

Note: Refer to Note (1) of Tables 1 through 6 for methods of analysis.

TABLE 15 - ANALYTICAL RESULTS OF LAGOON SLUDGE

Sample	$pH^{(1)}$	Carbonate $^{(1)}$ Alkalinity mg/ℓ	Bicarbonate $^{(1)}$ Alkalinity mg/ℓ
Sludge from Lagoon 1 May 31, 1978	10.1	10.2	6.3
Sludge from Lagoon 2 $^{(2)}$ May 31, 1978	5.1	-	1.5

Notes: (1) A washed filtered sample of sludge was dried and a 100 mg aliquot was resuspended in 300 ml deionized water. The results presented in this table were obtained by titration of the resuspended material vs. 0.01 N HCℓ.

(2) This sample was taken from lined basin immediately north of Lagoon 2 which contained sludge previously stored in Lagoon 2.

TABLE 16 - LOCATIONS OF SURFACE SAMPLING STATIONS
STEPAN CHEMICAL COMPANY
WILMINGTON, MASSACHUSETTS

SS-1 - Entrance of East Drainage Ditch to project site; near intersection of Stepan's north and east property lines.

SS-2 - East Drainage Ditch, north of storage tanks on Stepan's property.

SS-3 - East Drainage Ditch, south of storage tanks on Stepan's property.

SS-4 - East Drainage Ditch, across from GW-4.

SS-5 - Outlet Channel, a few feet from entrance of water into East Drainage Ditch.

SS-6 - East Drainage Ditch, a few feet south (downstream) of confluence with Outlet Channel.

SS-7 - Exit of East Drainage Ditch from project site; near intersection of Stepan's south and east property lines.

SS-8 - North Drainage Ditch, prior to entrance to Outlet Channel.

SS-9 - Short channel which connects the Center Pond to the North Drainage Ditch.

SS-10 - Pipe at Headwall (West Drainage Ditch).

SS-11 - West Drainage Ditch, north (upstream) of culvert under roadway.

SS-12 - East (downstream) of culvert which is beneath the B&M tracks along Stepan's west property line.

SS-13 - South Drainage Ditch, prior to entrance to Outlet Channel.

SS-14 - South Drainage Ditch, in swampy area downstream of SS-12.

SS-15 - Discharge of West Pond.

SS-16 - East Drainage Ditch, a few feet north (upstream) of confluence with Outlet Channel.

SS-17 - Occasional flow into West Drainage Ditch.

Note: See Fig. 2 for locations of Surface Sampling Stations.

TABLE 17 - FLOW MEASUREMENTS
STEPAN CHEMICAL COMPANY
WILMINGTON, MASSACHUSETTS

Location of Flow Measurement with Reference to Surface Sampling Station	F L O W (cfs)		
	Feb. 21, 1978	Mar. 15, 1978	April 11, 1978
Near SS-1	0.3	0.4	0.3
Near SS-5	-	-	0.3
Near SS-6	0.2	-	1.0
∿150' South of SS-6	-	0.7	-
∿150' North of SS-7	-	0.6	-
Near SS-11	-	-	0.1
Near SS-12	-	0.1	0.2
Near SS-16	0.3	0.8	0.4

Note: See Fig. 1 for locations of surface sampling stations. All flow measurements made with Pygmy Current Meter manufactured by Teledyne Gurley, Troy, New York.

Because of the shallow water depth (3 to 12 in.) in drainage ditches, it was difficult to obtain accurate flow measurements with the Pygmy Current Meter. The apparent decrease in flow from some upstream to downstream stations may be due to inaccuracies in the flow measurement.

TABLE 18 - GROUNDWATER ELEVATIONS(1) STEPAN CHEMICAL COMPANY WILMINGTON, MASSACHUSETTS

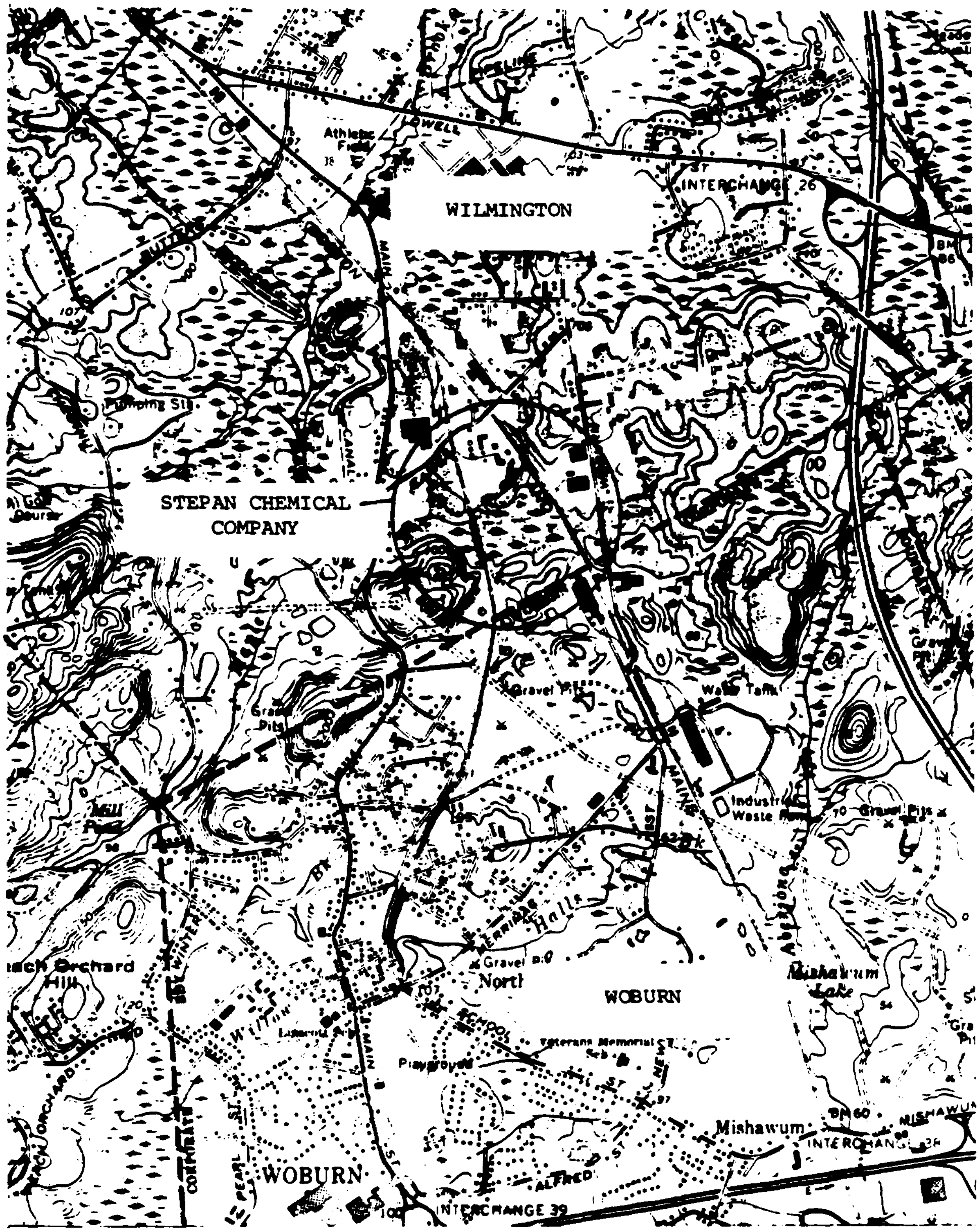
Groundwater Well No.	Elevation of Top of Protective Casing (ft)	Elevation of Ground Surface (ft)	Groundwater Elevation, (ft)							
			1 9 7 7		1 9 7 8					Average of All Readings
			Nov 2	Dec 8, 9	Feb 22	Mar 15	Apr 5	Apr 10	May 31	
GW-1	89.4	87.8	79.9	78.0	79.1	78.5	82.0(4)	78.7	78.5	78.8
GW-2	89.7	87.6	79.7	79.7	80.6	79.9	80.2	80.5	79.9	80.1
GW-3	88.1	85.4	80.5	81.1	81.2	81.1	82.0	81.5	81.9	81.3
GW-4	82.3	79.8	76.8	77.1	77.8	77.8	77.3	77.2	77.0	77.3
GW-5	79.4(2)	76.3	76.4	76.9	Frozen	Frozen	77.3	77.1	76.7	76.9
GW-6	88.9	87.2	82.6	83.1	83.5	83.0	83.8	83.5	83.0	83.2
GW-7	84.8	82.7	79.5	79.8	80.5	80.5	80.2	79.9	79.5	80.0
GW-8	80.4	77.8	75.9	76.2	76.7	76.4	76.3	76.2	75.6	76.2
GW-10	89.6	87.1	81.1	81.3	82.1	81.6	82.1	81.8	81.4	81.6
GW-11	87.4	85.6	81.1	81.3	82.1	81.6	81.5	82.4	81.3	81.6
GW-12	85.6(3)	82.0	80.9	81.9	82.7	82.2	82.0	82.0	81.9	82.0
W-101	89.7	89.3	-	-	-	-	-	-	82.0	82.0

Notes:
1) Elevation datum is USGS Mean Sea Level.
2) Prior to May 31, 1978, the top of casing was at El 79.7 ft. The casing was removed to perform a permeability test and replaced to El 79.4 ft.
3) Prior to May 31, 1978, the top of casing was at El 85.3 ft. The casing was removed to perform a permeability test and replaced to El 85.6 ft.
4) This reading is unusally high because of repairs to a nearby sewer line. This reading was not used to compute the average groundwater elevation in GW-1.

Geotechnical Engineers Inc.

Project 77348
June, 1978

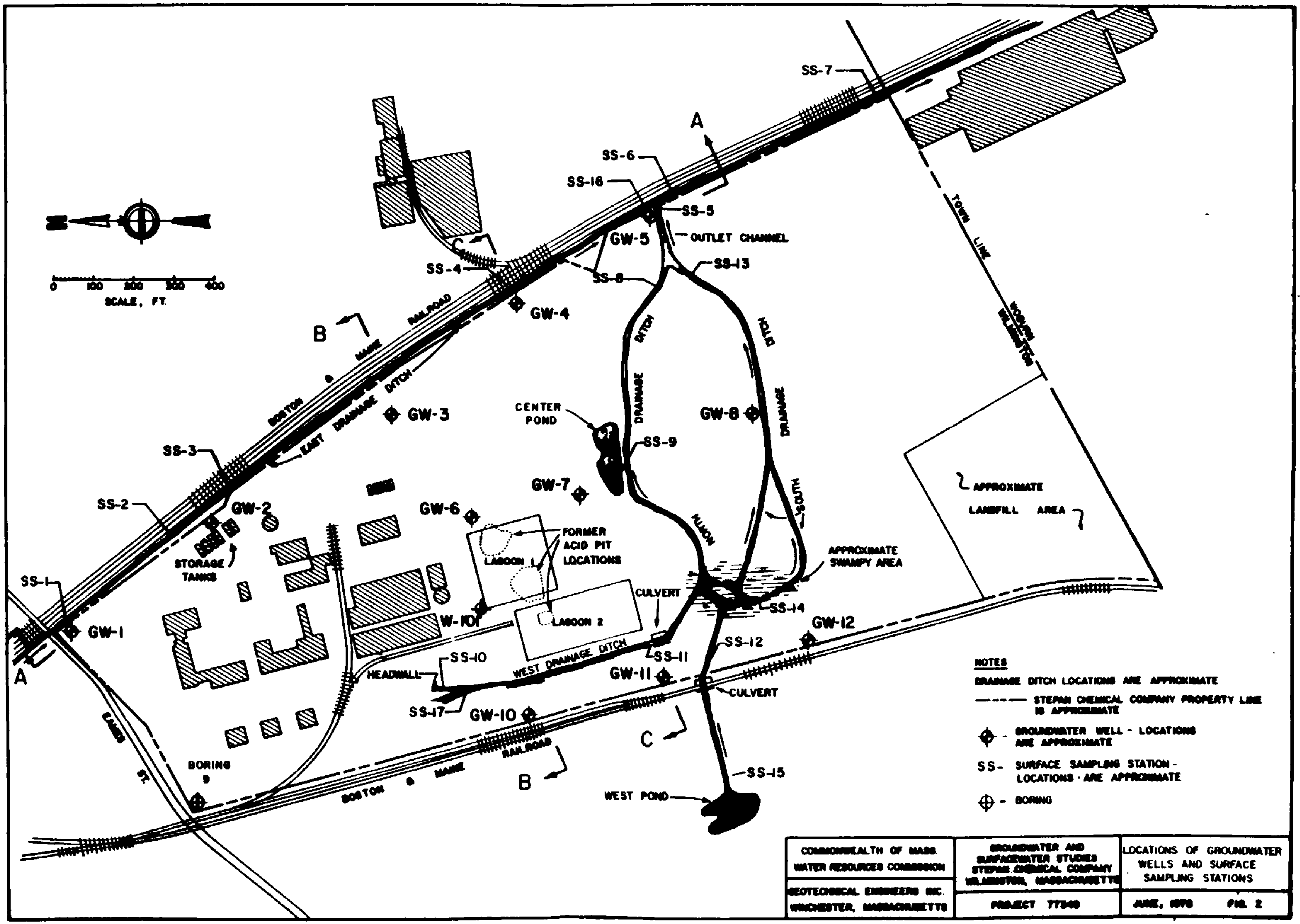
FIGURES



From USGS Quadrangle Map - Wilmington Quadrangle.

Scale: 1" = 2000'

Commonwealth of Massachusetts Water Resources Commission	Groundwater and Surface Water Studies Stepan Chemical Company Wilmington, Massachusetts	LOCATION PLAN STEPAN CHEMICAL COMPANY
Geotechnical Engineers Inc. Winchester, Massachusetts	Project 77348	June, 1978 Fig. 1



NOTES

DRAINAGE DITCH LOCATIONS ARE APPROXIMATE

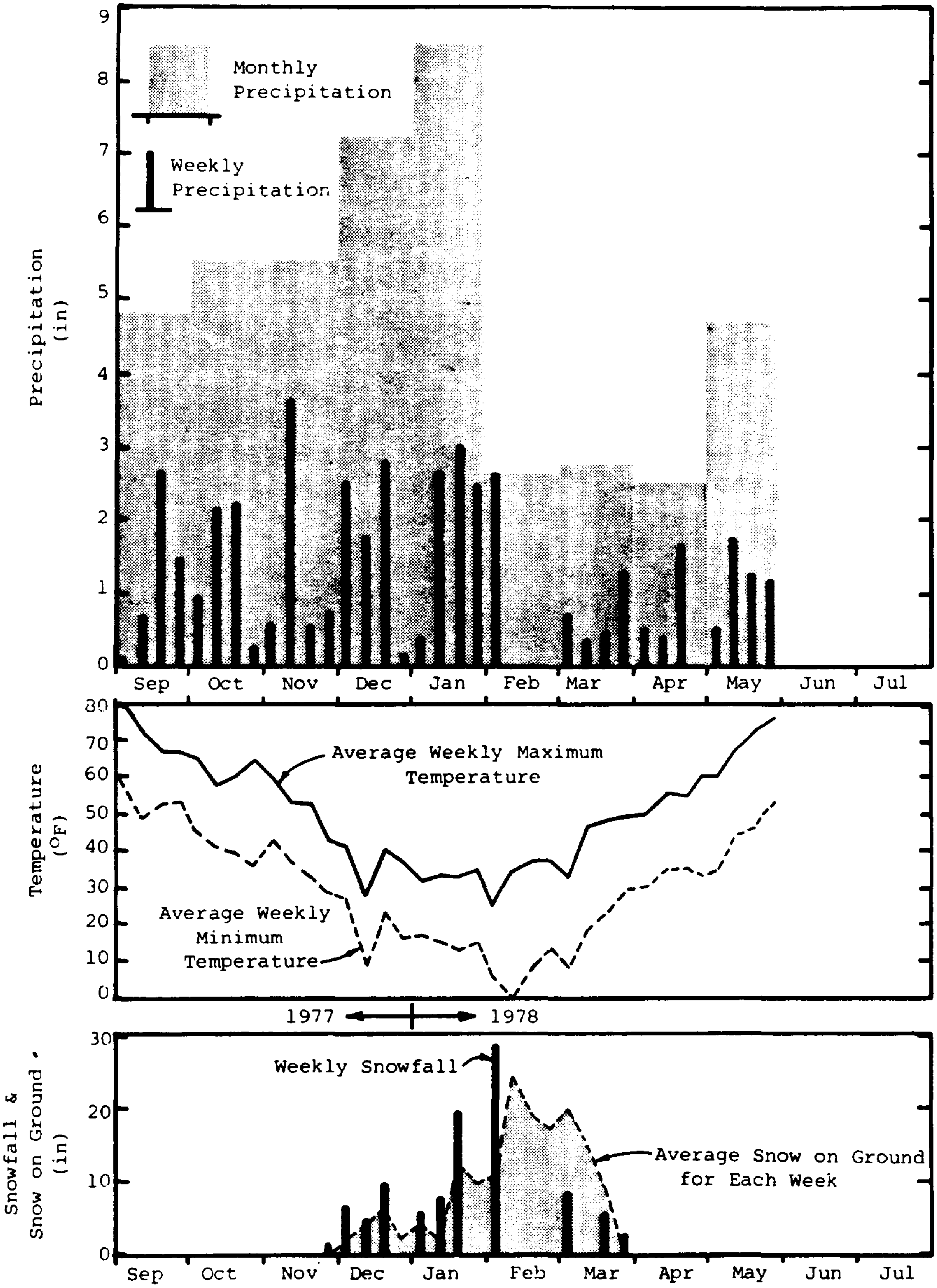
—·—·— STEPAN CHEMICAL COMPANY PROPERTY LINE IS APPROXIMATE

⊕ - GROUNDWATER WELL - LOCATIONS ARE APPROXIMATE

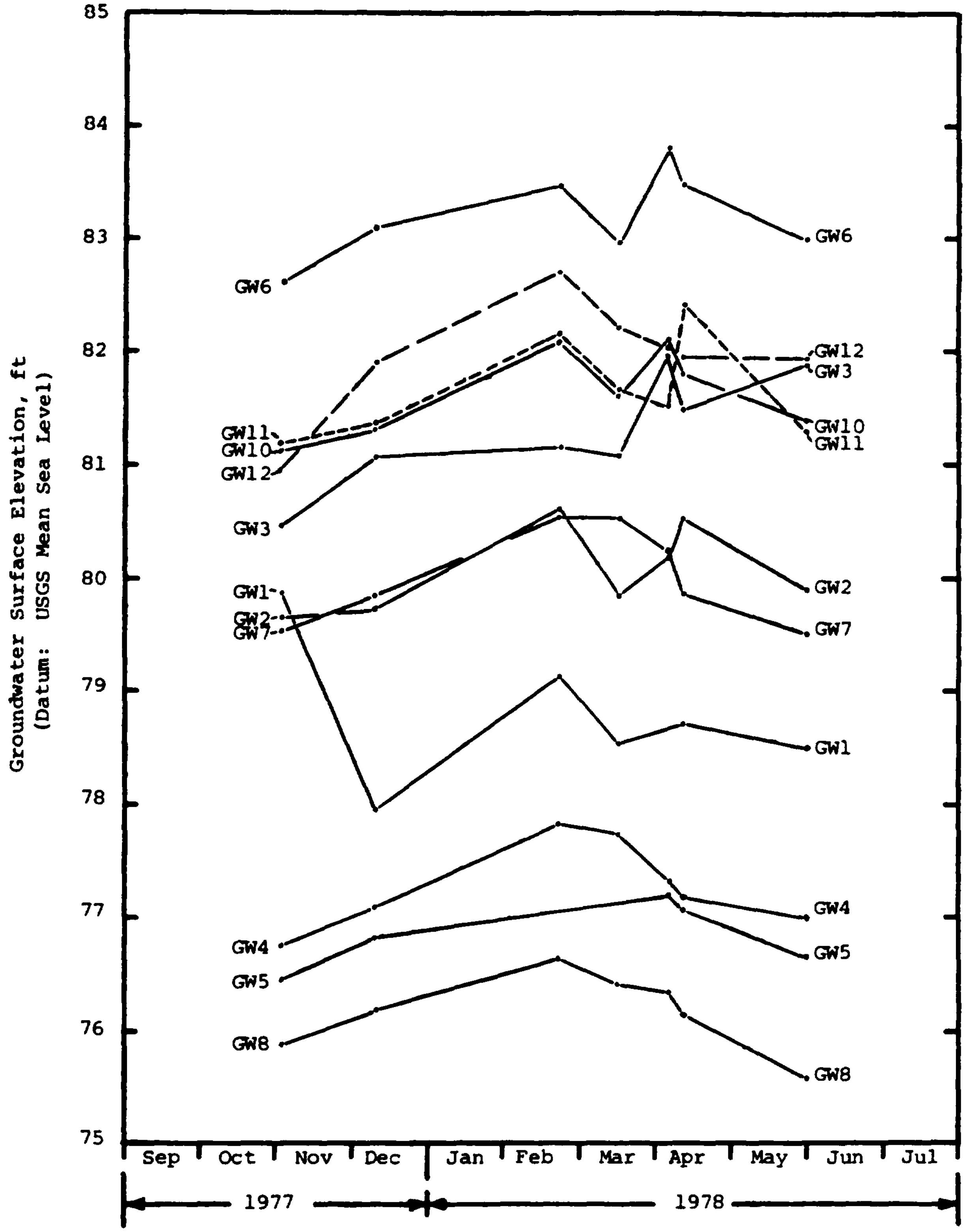
SS- SURFACE SAMPLING STATION - LOCATIONS ARE APPROXIMATE

⊕ - BORING

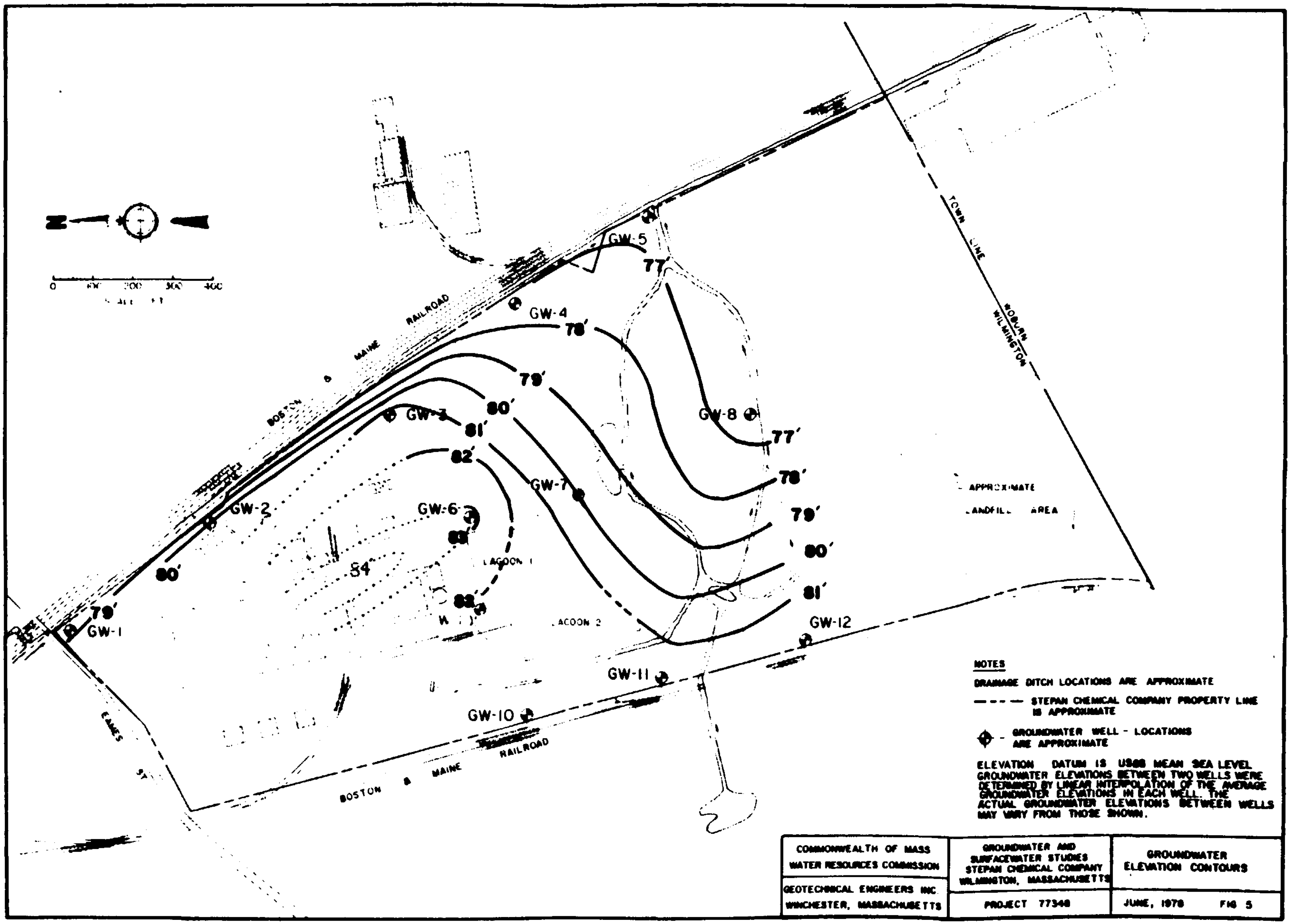
COMMONWEALTH OF MASS. WATER RESOURCES COMMISSION	GROUNDWATER AND SURFACEWATER STUDIES STEPAN CHEMICAL COMPANY WILMINGTON, MASSACHUSETTS	LOCATIONS OF GROUNDWATER WELLS AND SURFACE SAMPLING STATIONS
GEOTECHNICAL ENGINEERS INC. WINCHESTER, MASSACHUSETTS	PROJECT 77340	JUNE, 1978 FIG. 2



Commonwealth of Massachusetts Water Resources Commission	Groundwater and Surface Water Studies Stepan Chemical Company Wilmington, Massachusetts	CLIMATOLOGICAL DATA FROM READING STATION - USCOMM-NOAA
Geotechnical Engineers Inc. Winchester, Massachusetts	Project 77348	June, 1978 Fig. 3



Commonwealth of Massachusetts Water Resources Commission	Groundwater & Surface Water Studies Stepan Chemical Company Wilmington, Massachusetts	GROUNDWATER SURFACE ELEVATIONS
Geotechnical Engineers Inc. Winchester, Massachusetts	Project 77348	June, 1978 Fig. 4



NOTES

DRAINAGE DITCH LOCATIONS ARE APPROXIMATE

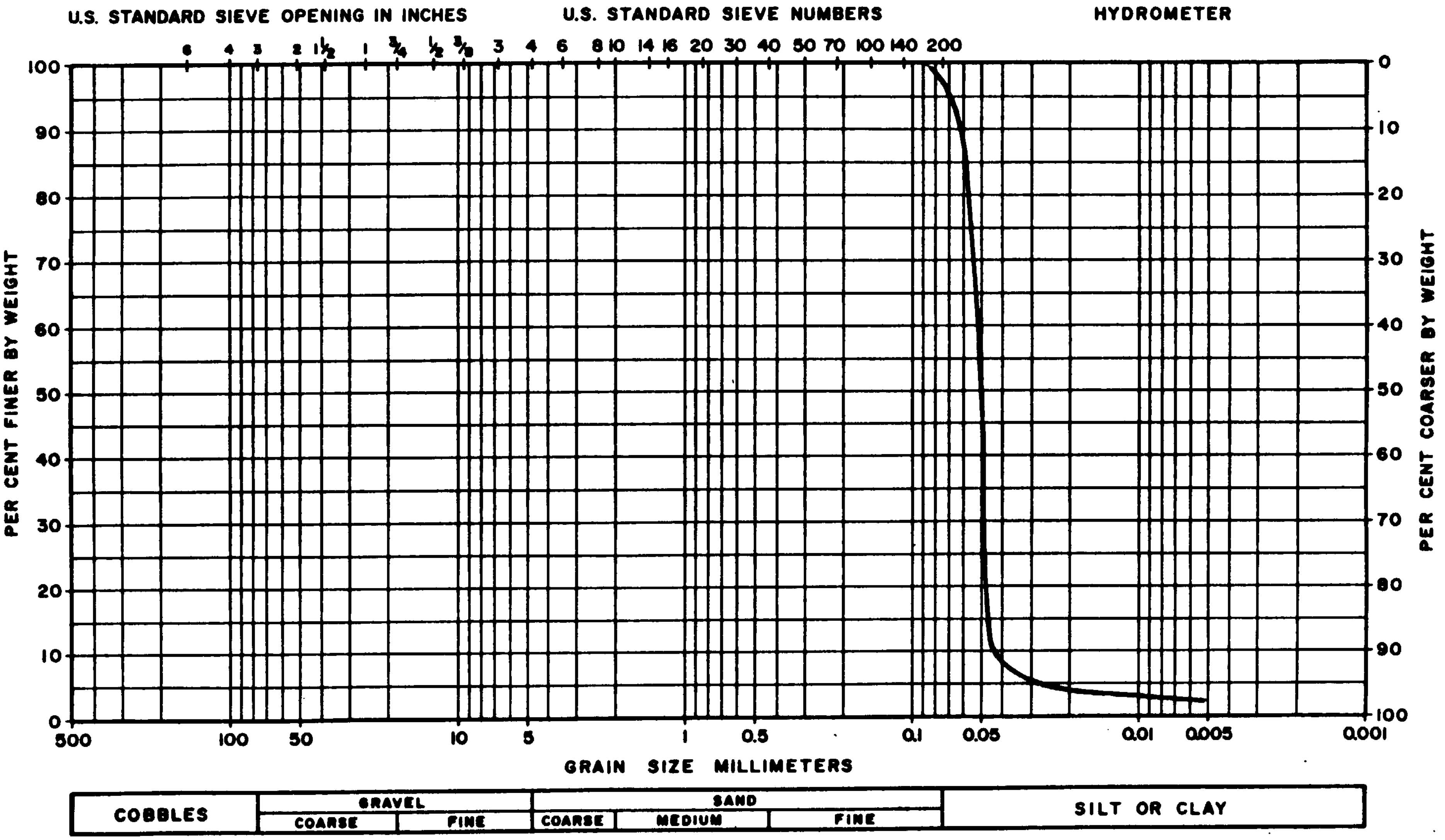
— — — — STEPAN CHEMICAL COMPANY PROPERTY LINE IS APPROXIMATE

⊕ - GROUNDWATER WELL - LOCATIONS ARE APPROXIMATE

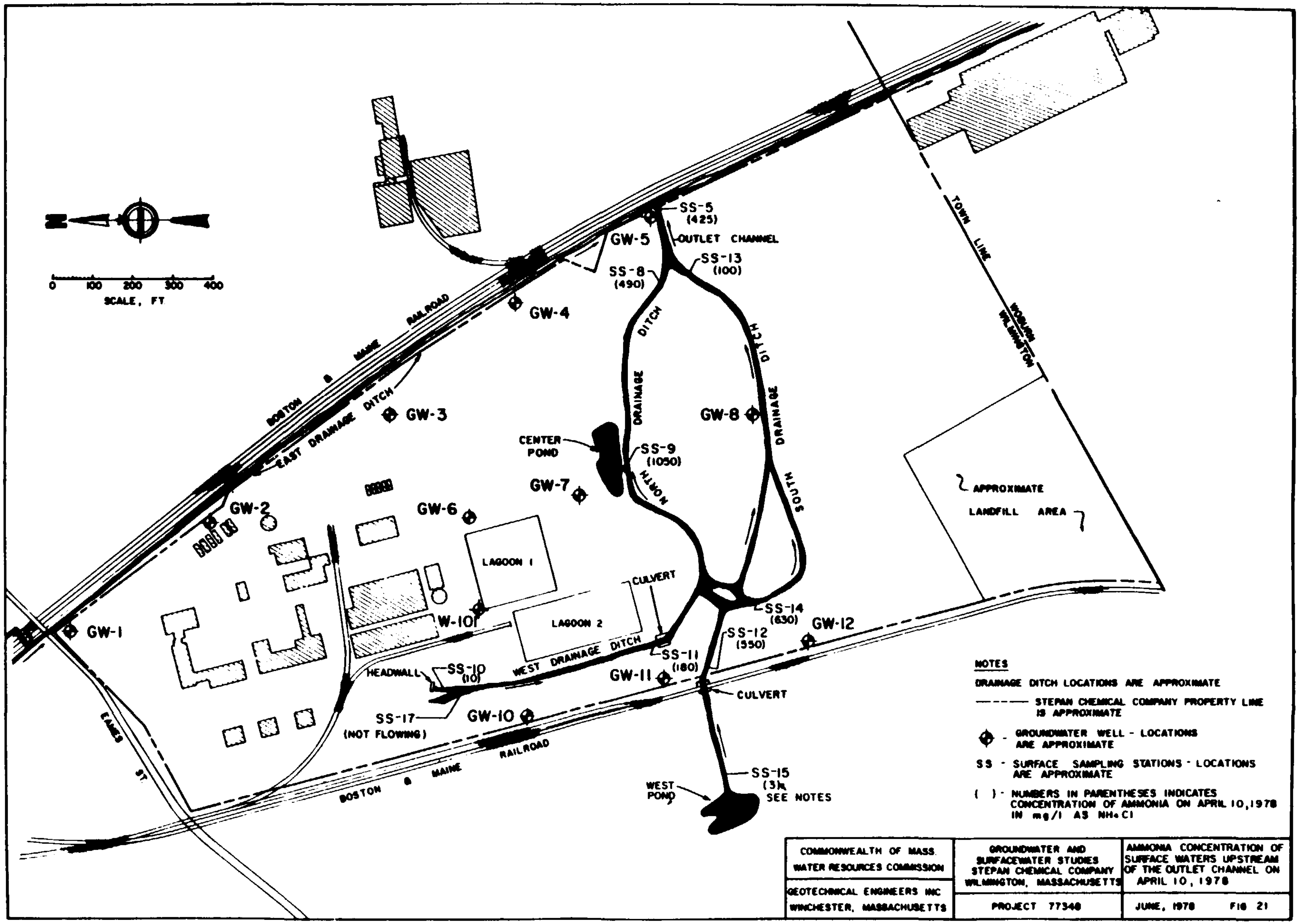
ELEVATION DATUM IS USGS MEAN SEA LEVEL GROUNDWATER ELEVATIONS BETWEEN TWO WELLS WERE DETERMINED BY LINEAR INTERPOLATION OF THE AVERAGE GROUNDWATER ELEVATIONS IN EACH WELL. THE ACTUAL GROUNDWATER ELEVATIONS BETWEEN WELLS MAY VARY FROM THOSE SHOWN.

COMMONWEALTH OF MASS WATER RESOURCES COMMISSION	GROUNDWATER AND SURFACEWATER STUDIES STEPAN CHEMICAL COMPANY WILMINGTON, MASSACHUSETTS	GROUNDWATER ELEVATION CONTOURS
GEOTECHNICAL ENGINEERS INC. WINCHESTER, MASSACHUSETTS	PROJECT 77348	JUNE, 1978 FIG 5

Lab. 4-3 rev. 0 28 May 74



Commonwealth of Massachusetts Water Resources Commission	Groundwater and Surface Water Studies Stepan Chemical Company Wilmington, Massachusetts	GRAIN SIZE CURVE OF SLUDGE FROM LAGOON 2
Geotechnical Engineers Inc. Winchester, Massachusetts	Project 77348	June, 1978 Fig. 20



NOTES

DRAINAGE DITCH LOCATIONS ARE APPROXIMATE

------ STEPAN CHEMICAL COMPANY PROPERTY LINE IS APPROXIMATE

⊕ - GROUNDWATER WELL - LOCATIONS ARE APPROXIMATE

SS - SURFACE SAMPLING STATIONS - LOCATIONS ARE APPROXIMATE

( ) - NUMBERS IN PARENTHESES INDICATES CONCENTRATION OF AMMONIA ON APRIL 10,1978 IN mg/l AS NH_4Cl

COMMONWEALTH OF MASS. WATER RESOURCES COMMISSION	GROUNDWATER AND SURFACEWATER STUDIES STEPAN CHEMICAL COMPANY WILMINGTON, MASSACHUSETTS	AMMONIA CONCENTRATION OF SURFACE WATERS UPSTREAM OF THE OUTLET CHANNEL ON APRIL 10, 1978
GEOTECHNICAL ENGINEERS INC WINCHESTER, MASSACHUSETTS	PROJECT 77340	JUNE, 1978 FIG 21

APPENDIX A

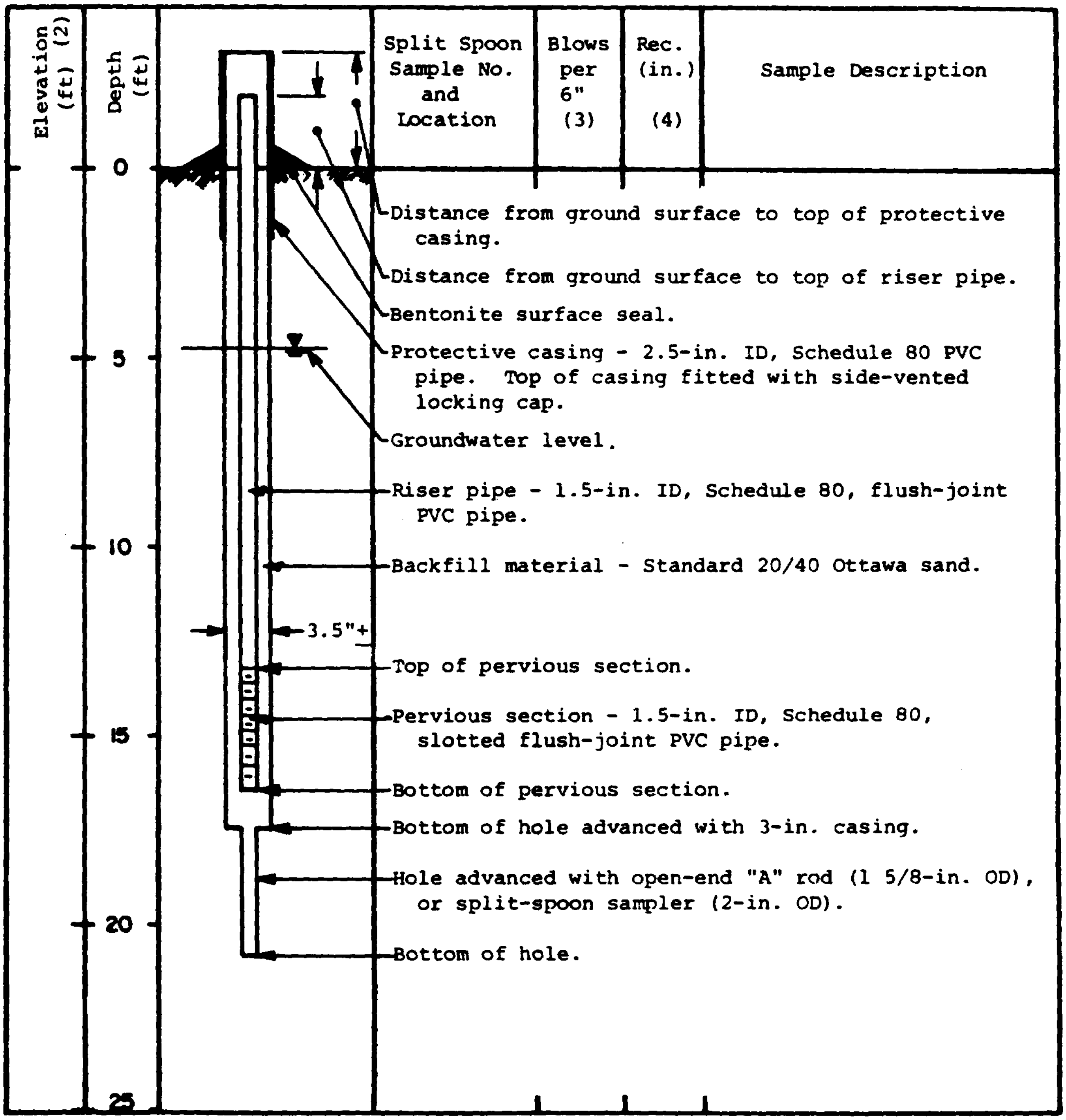
GROUNDWATER WELL INSTALLATION REPORT

Groundwater Well No.:

Date Installed:

Permeability[(1)] :

Project No. : 77348



(1) Approximate horizontal soil permeability at level of pervious section as determined from in situ falling head permeability test.

(2) Survey Datum - USGS Mean Sea Level = 0 ft.

(3) Blows on split-spoon sampler were from 140-lb hammer falling 30-in. Standard 24-in. split-spoon sampler was used (ASTM D-1586).

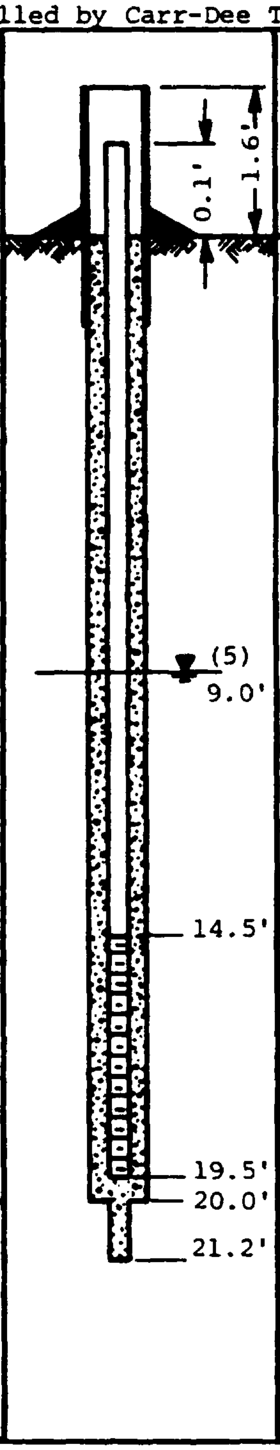
(4) Length of sample recovered.

Geotechnical Engineers Inc.

GROUNDWATER WELL INSTALLATION REPORT

Groundwater Well No.:	1	Date Installed:	Oct. 26, 1977
Permeability(1) :	2×10^{-2} cm/sec	Project No. :	77348

Well Installed by Carr-Dee Test Boring Corp. Soils Described by R. Gardner, GEI



Elevation (ft) (2)	Depth (ft)	Split Spoon Sample No. and Location	Blows per 6" (3)	Rec. (in.) (4)	Sample Description
87.8	0				
		SS-1	2-6-7-7	17	SS-1 ~8" Brown sandy loam. ~2" Light brown gravelly sand. ~1" Black medium sand ~6" Light brown gravelly sand.
82.8	5				
		SS-2	5-1-1-1	5	SS-2 Top 5" - light brown fine to coarse sand. Lost bottom 18".
		SS-3 (overdrove 12")	1/12" 1/12" 1/12"	6	SS-3 ~2" Black organic fine sand ~4" Light brown fine to coarse sand.
77.8	10				
		SS-4	2-1-1-4	9	SS-4 ~7" Gray-brown fine sand. ~2" Black fibrous, organic medium sand.
72.8	15				
		SS-5	15-12-22-65	9	SS-5 Tan-brown sandy gravel. Gravel is angular to sub-angular and up to ~1 3/8" in size.
67.8	20				
		SS-6	48-44-100/2"	6	SS-6 Coarse sand and gravel. Gravel is angular and up to ~1 3/8" in size.
62.8	25				

Notes: (1), (2), (3), (4) See first page of Appendix A for additional information.
(5) Groundwater level is the average of six measurements taken from November 2, 1977 to May 31, 1978.

Geotechnical Engineers Inc.

GROUNDWATER WELL INSTALLATION REPORT

Groundwater Well No.: 2

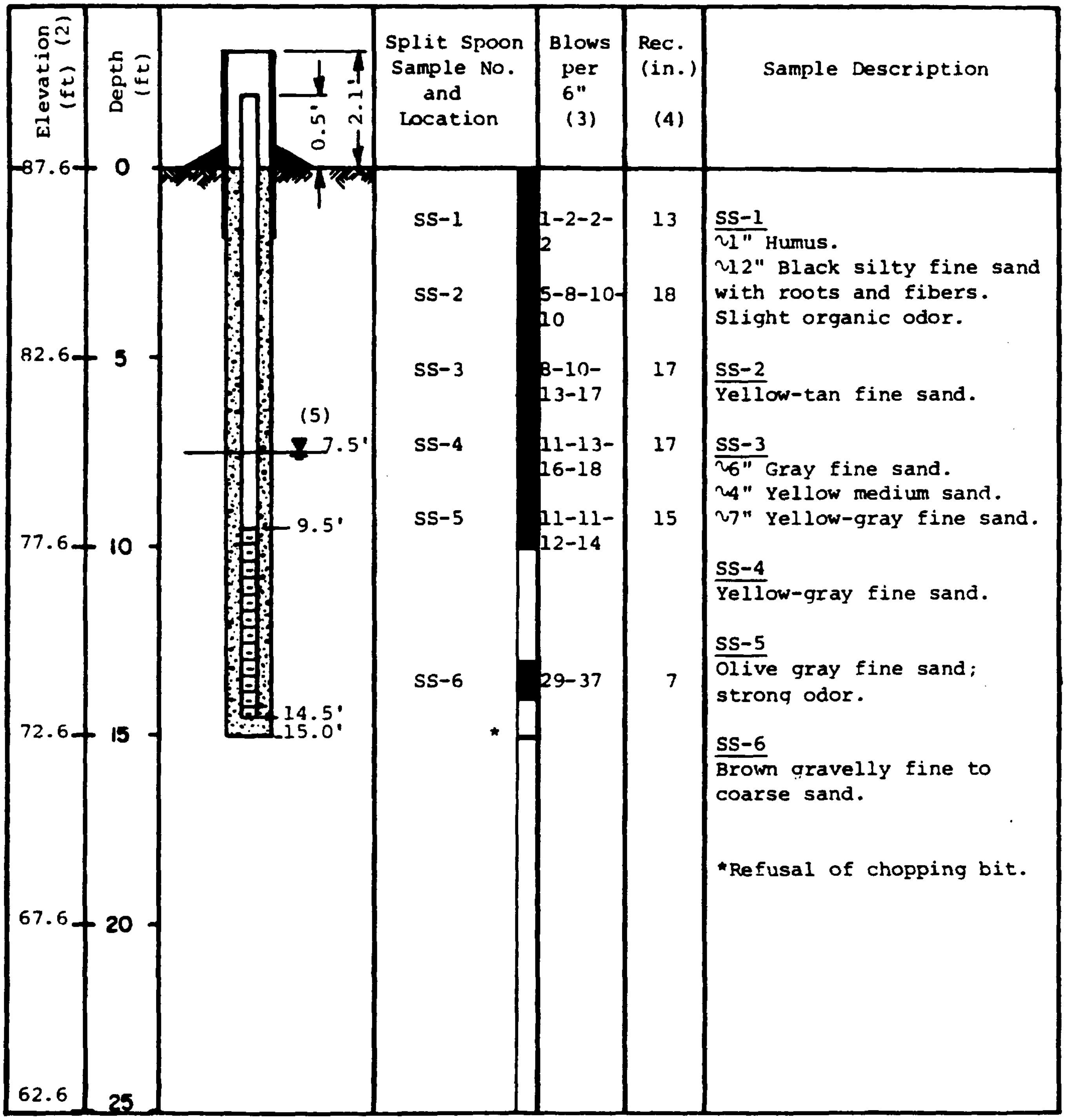
Date Installed: Nov. 1, 1977

Permeability(1) : 9×10^{-3} cm/sec

Project No. : 77348

Well Installed by Carr-Dee Test Boring Corp.

Soils Described by R. Gardner, GEI



Split Spoon Sample No. and Location	Blows per 6" (3)	Rec. (in.) (4)	Sample Description
SS-1	1-2-2-2	13	**SS-1** ~1" Humus. ~12" Black silty fine sand with roots and fibers. Slight organic odor.
SS-2	5-8-10-10	18	**SS-2** Yellow-tan fine sand.
SS-3	8-10-13-17	17	**SS-3** ~6" Gray fine sand. ~4" Yellow medium sand. ~7" Yellow-gray fine sand.
SS-4	11-13-16-18	17	**SS-4** Yellow-gray fine sand.
SS-5	11-11-12-14	15	**SS-5** Olive gray fine sand; strong odor.
SS-6	29-37	7	**SS-6** Brown gravelly fine to coarse sand.
*			*Refusal of chopping bit.

Notes: (1), (2), (3), (4) See first page of Appendix A for additional information.
(5) Groundwater level is the average of seven measurements taken from November 2, 1977 to May 31, 1978.

Geotechnical Engineers Inc.

GROUNDWATER WELL INSTALLATION REPORT

Groundwater Well No.: 3

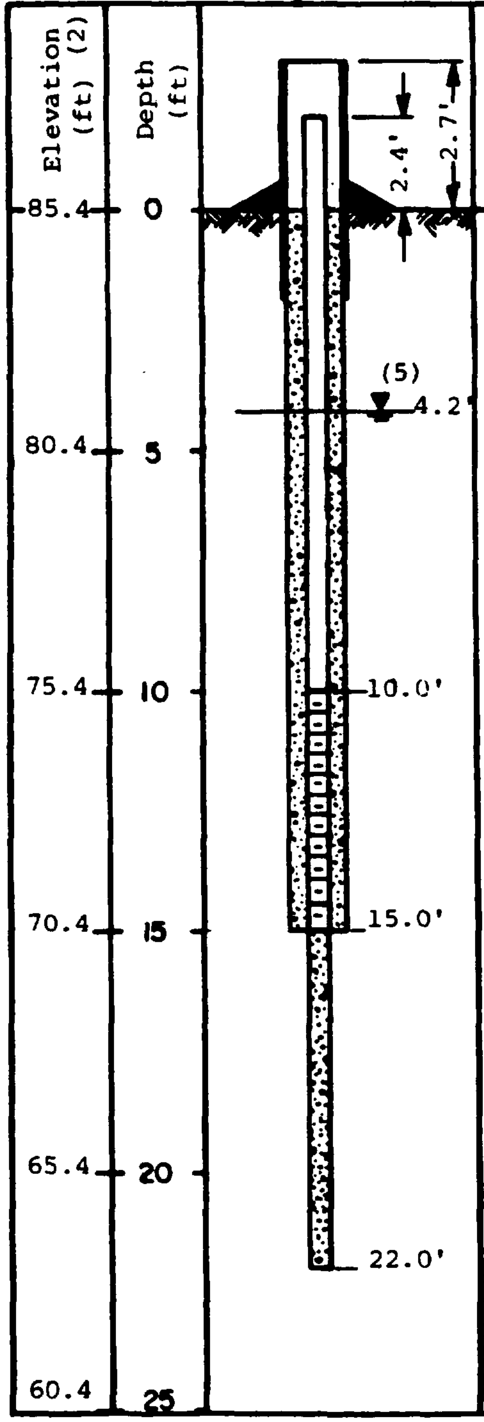
Date Installed: Nov. 1, 1977

Permeability(1) : 2×10^{-4} cm/sec

Project No. : 77348

Well Installed by Carr-Dee Test Boring Corp.

Soils Described by R. Gardner, GEI



Split Spoon Sample No. and Location	Blows per 6" (3)	Rec. (in.) (4)	Sample Description
SS-1A SS-1B	2-2-6-10	16	SS-1A ∿6" Dark gray fine sand and humus. SS-1B ∿10" Gray fine sand; slight odor similar to that of lagoons.
SS-2	26-37-43	15	SS-2 Yellow-brown fine sand; slight chemical odor.
SS-3	26-38-31-32	21	SS-3 Olive-brown silty fine sand
SS-4A SS-4B	7-8-13-27	16	SS-4A ∿10" Yellow-brown fine sand; slight chemical odor. SS-4B ∿6" Gray and black micaceous sand and gravel. Gravel is angular to subrounded.
SS-5	50-40-42-41	15	SS-5 Olive gray silty fine sandy gravel. Gravel is black and angular up to ∿1/2" in size. Trace of mica flakes.
*			*Drove open-ended "A" rod with 200 lb weight. Refusal at 22'; 120 blows/0.5"

Notes: (1), (2), (3), (4) See first page of Appendix A for additional information.
(5) Groundwater level is the average of seven measurements taken from November 2, 1977 to May 31, 1978.

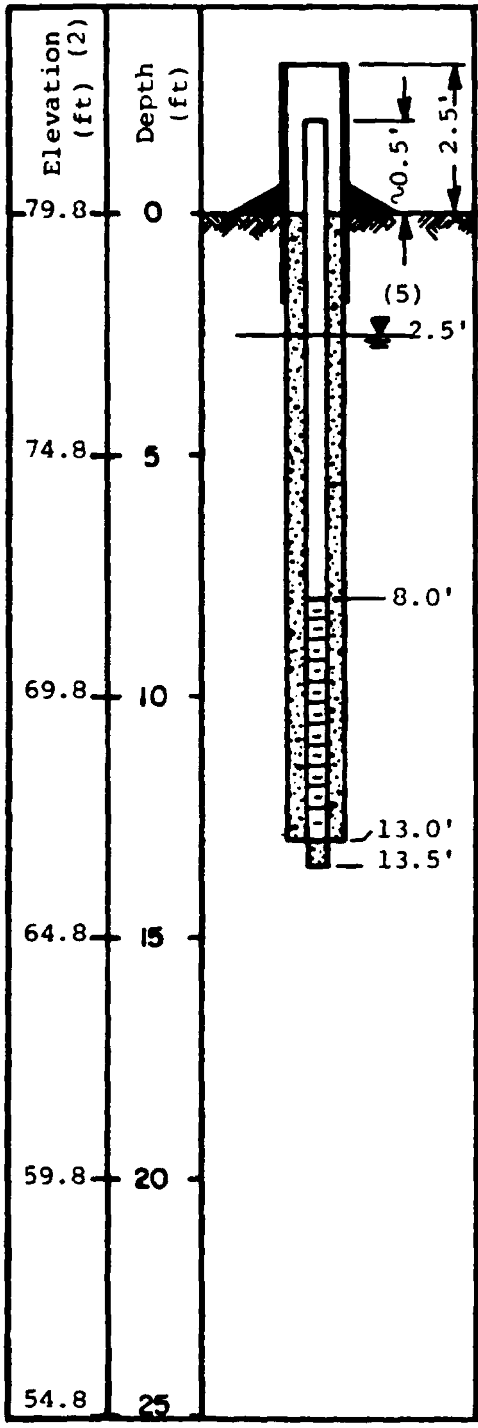
Geotechnical Engineers Inc.

GROUNDWATER WELL INSTALLATION REPORT

Groundwater Well No.: 4 — Date Installed: Oct. 31, 1977

Permeability(1) : 5 x 10^{-4} cm/sec — Project No. : 77348

Well Installed by Carr-Dee Test Boring Corp. — Soils Described by R. Gardner, GEI

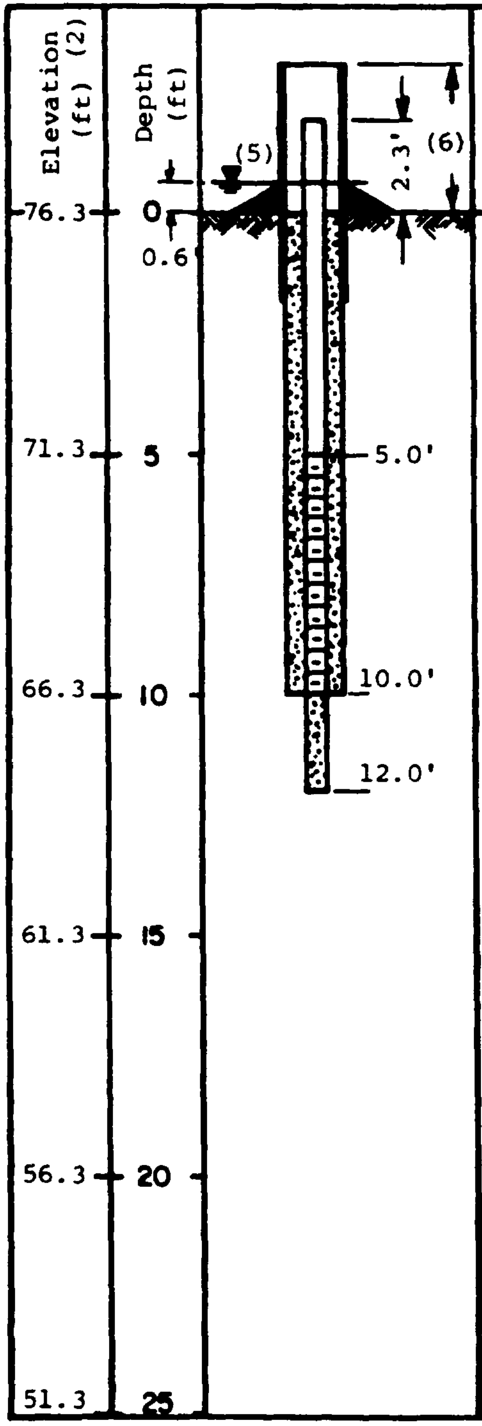


Split Spoon Sample No. and Location	Blows per 6" (3)	Rec. (in.) (4)	Sample Description
SS-1	1-1-1-1	24	SS-1 ~3" Humus. ~21" Olive-brown fine sand.
SS-2	1-5-7-8	15	SS-2 ~6" Slightly sandy humus. ~9" Olive-brown slightly silty fine sand.
SS-3	9-12-16-17	15	SS-3 Light olive-brown slightly silty fine to very fine sand.
SS-4	6-29-57-29	11	SS-4 Tan silty very fine sand.
SS-5	160/6"	3	SS-5 Black angular rock fragments up to ~3/4" in size.

Notes: (1), (2), (3), (4) See first page of Appendix A for additional information.
(5) Groundwater level is the average of seven measurements taken from November 2, 1977 to May 31, 1978.

GROUNDWATER WELL INSTALLATION REPORT

Groundwater Well No.: 5
Date Installed: Oct. 31, 1977
Permeability(1) : 6. x 10^{-3} cm/sec
Project No. : 77348
Well Installed by Carr-Dee Test Boring Corp.
Soils Described by R. Gardner, GEI



Split Spoon Sample No. and Location	Blows per 6" (3)	Rec. (in.) (4)	Sample Description
SS-1	1-1-1-1	12	SS-1 Black sandy humus.
SS-2A	1-1-2-4	15	SS-2A ∿7" Dark gray silty fine sand; organic odor.
SS-2B			SS-2B ∿8" Dark gray silty fine sand; no odor.
SS-3	7-8-11-12	14	SS-3 Gray-brown slightly silty fine sand.
SS-4	31-26-23-49	13	SS-4 Gray slightly silty sand and gravel. Gravel is angular to subangular up to ∿3/4" in size.
			No refusal

Notes: (1), (2), (3), (4) See first page of Appendix A for additional information.

(5) Groundwater level is the average of five measurements taken from November 2, 1977 to May 31, 1978. Water was not ponded around surface casing at time of measurements.

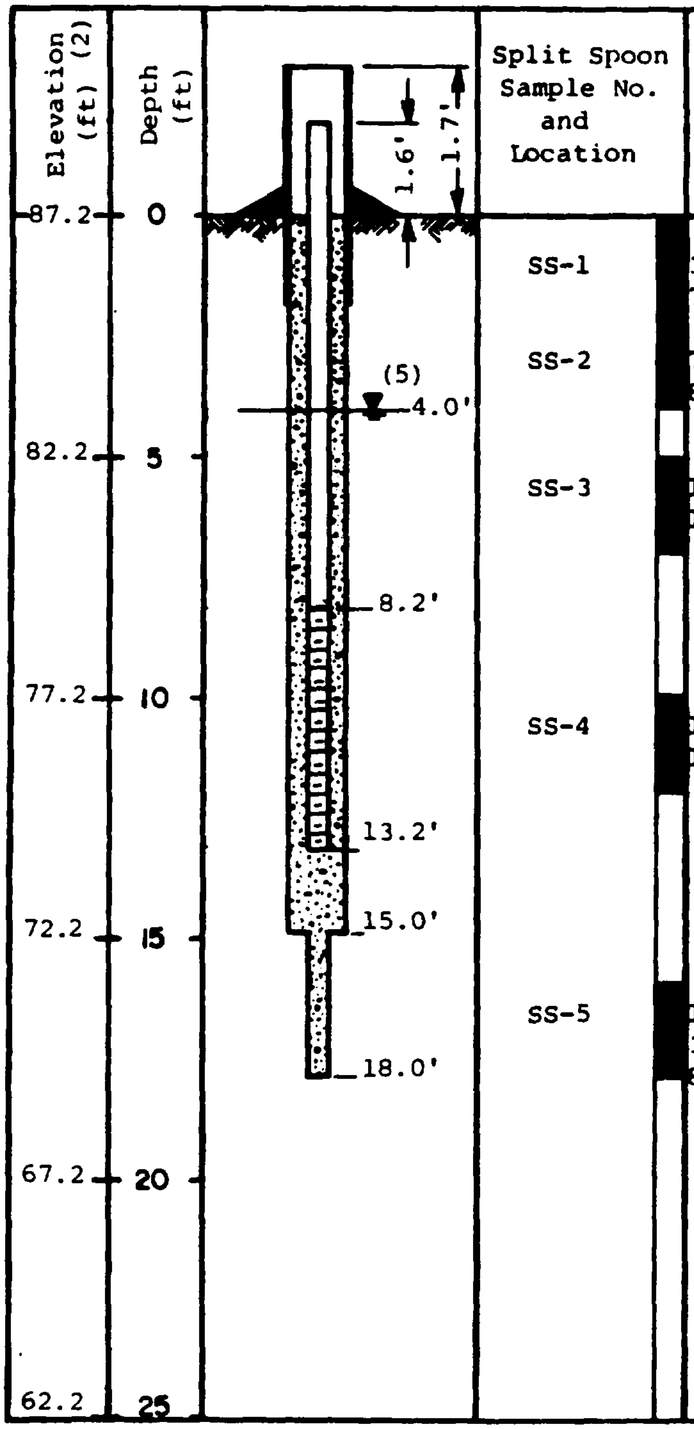
(6) Prior to May 31, 1978, distance from ground surface to top of casing was 3.4'. Casing was removed to perform permeability test and replaced to present "stickup" of 3.1'.

GROUNDWATER WELL INSTALLATION REPORT

Groundwater Well No.: 6 — Date Installed: Oct. 28, 1977

Permeability (1) : 1 x 10^{-4} cm/sec — Project No. : 77348

Well Installed by Carr-Dee Test Boring Corp. — Soils Described by R. Gardner, GEI



Split Spoon Sample No. and Location	Blows per 6" (3)	Rec. (in.) (4)	Sample Description
SS-1	3-4-7-7	15	**SS-1** ∿10" Dark brown loamy fine sand. ∿5" White fine material in layers. Similar to that in adjacent lagoon; strong ammonia odor.
SS-2	7-6-9-8	12	**SS-2** Dark brown loamy sand grading into black fine sand; strong odor.
SS-3	11-14-15-16	12	**SS-3** Yellow-brown slightly silty fine sand; strong ammonia odor.
SS-4	12-14-16-15	11	**SS-4** Similar to SS-3 with slight amount of gravel up to ∿½" in size. Odor similar to that of lagoons, less ammonia odor.
SS-5	10-45-39-89/5"	7	**SS-5** Top - Silty fine sand. Bottom - Dark brown micaceous fine sand. Tip of spoon plugged with silty fine sand and piece of gravel ∿1 3/8" in size.

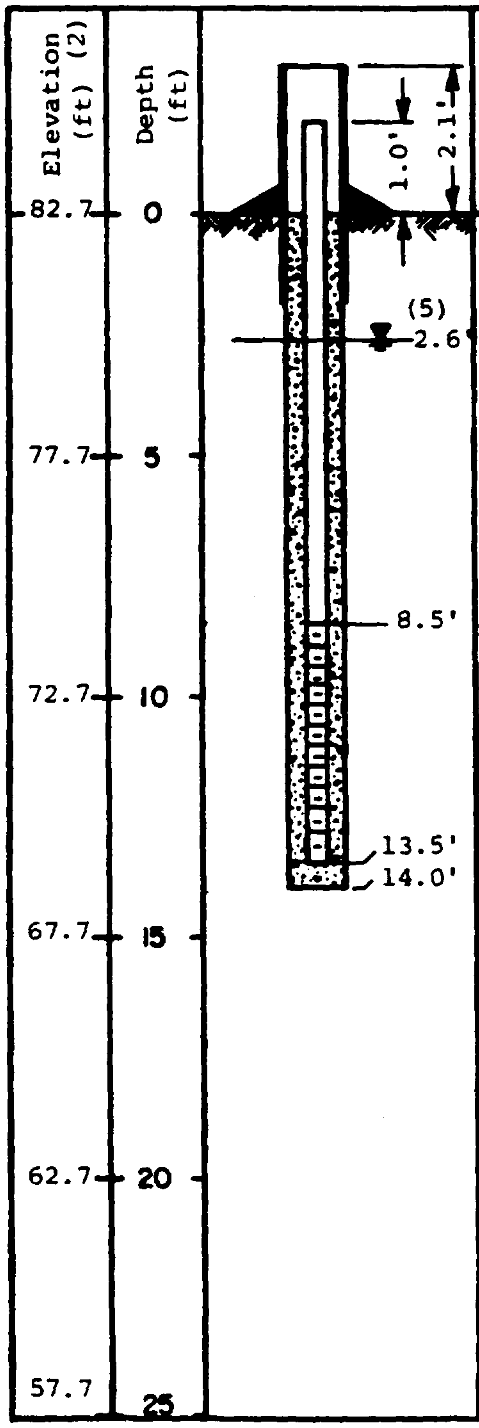
Notes: (1), (2), (3), (4) See first page of Appendix A for additional information.
(5) Groundwater level is the average of seven measurements taken from November 2, 1977 to May 31, 1978.

GROUNDWATER WELL INSTALLATION REPORT

Groundwater Well No.: 7 — Date Installed: Oct. 27, 1977

Permeability(1) : 2×10^{-4} cm/sec — Project No. : 77348

Well Installed by Carr-Dee Test Boring Corp. — Soils Described by R. Gardner, GEI



Split Spoon Sample No. and Location	Blows per 6" (3)	Rec. (in.) (4)	Sample Description
SS-1	1-1-1-1	12	SS-1 Sandy peat.
SS-2	67-47-33-37	15	SS-2 Sand and gravel mixed with fines similar to material in lagoons. Odor similar to odor of material in lagoons.
SS-3	35-21-47-60/3"	14	SS-3 Similar to SS-2 except more natural fine material; strong odor.
*			*120 blows on split spoon with 140 lb weight; no penetration.

Notes: (1), (2), (3), (4) See first page of Appendix A for additional information.
(5) Groundwater level is the average of seven measurements taken from November 2, 1977 to May 31, 1978.

GROUNDWATER WELL INSTALLATION REPORT

Groundwater Well No.: 8

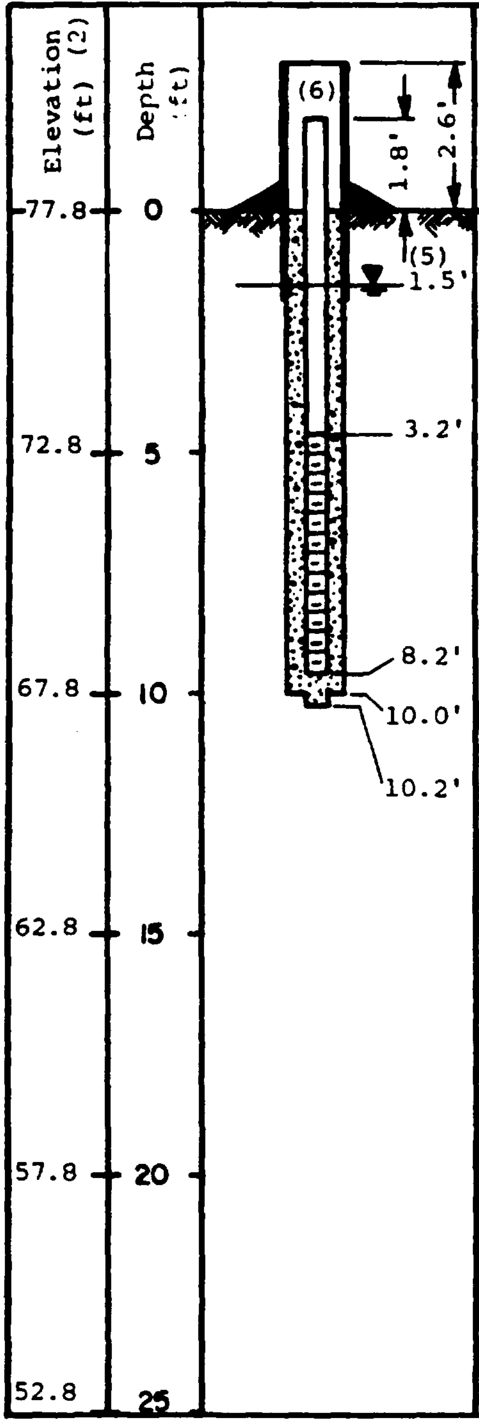
Date Installed: Oct. 28, 1977

Permeability(1) : 2×10^{-2} cm/sec

Project No. : 77348

Well Installed by Carr-Dee Test Boring Corp.

Soils Described by R. Gardner, GEI



Split Spoon Sample No. and Location	Blows per 6" (3)	Rec. (in.) (4)	Sample Description
SS-1A SS-1B	1-2-7-18	12	SS-1A ∿8" Fibrous peat. SS-1B ∿4" Dark brown silty fine sand. Organic material and fibrous material present.
SS-2	25-20-20-21	11	SS-2 Slightly silty sandy gravel Particles are angular to subrounded up to 1 3/8" in size.
*			*Drove open-ended "A" rod with 200 lb weight. Refusal at 10.2'; 120 blows/no penetration

Notes: (1), (2), (3), (4) See first page of Appendix A for additional information.

(5) Groundwater level is the average of seven measurements taken from November 2, 1977 to May 31, 1978.

(6) On May 31, 1978 the riser pipe and slotted pervious section were lifted approximately 1.4' while removing standpipe used to conduct permeability test. The existing dimensions for the riser pipe and slotted section are given.

GROUNDWATER WELL INSTALLATION REPORT

Groundwater Well No.: 9

Permeability$^{(1)}$:

Date Installed: -

Project No. : 77348

Soils Described by R. Gardner, GEI

Elevation (ft) (2)	Depth (ft)		Split Spoon Sample No. and Location	Blows per 6" (3)	Rec. (in.) (4)	Sample Description
	0	Well Not Installed	SS-1A SS-1B	5-7-6-17	10	<u>SS-1A</u> ∿5" Brown loamy fine to coarse sand. Trace of gravel. <u>SS-1B</u> ∿5" Tan silty fine sand. Trace of medium to coarse sand, gravel and mica flakes.
	5		*			
	10					*Drilled rock - BX core. 100% recovery RQD = 0% Upper 12" is massive Lower 18" is very broken. Some high angle joints.
	15					
	20					
	25					

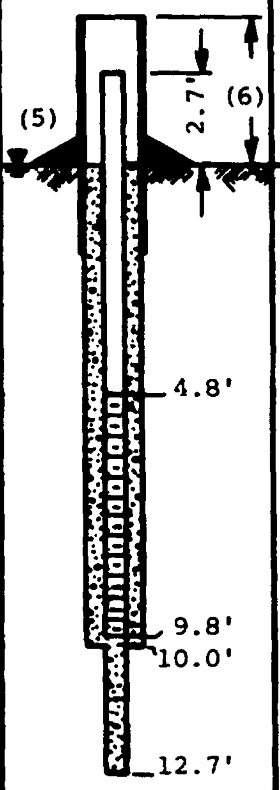
<u>Notes</u>: (1) Not applicable.
(2) Not surveyed.
(3), (4) See first page of Appendix A for additional information.

Geotechnical Engineers Inc.

GROUNDWATER WELL INSTALLATION REPORT

Groundwater Well No.: 12
Permeability(1) : 4 x 10^{-3} cm/sec
Well Installed by Carr-Dee Test Boring Corp.

Date Installed: Nov. 2, 1977
Project No. : 77348
Soils Described by R. Gardner, GEI



Elevation (ft) (2)	Depth (ft)	Split Spoon Sample No. and Location	Blows per 6" (3)	Rec. (in.) (4)	Sample Description
82.0	0	SS-1A SS-1B	1-1-2-3	17	SS-1A ∿8" Black sandy humus SS-1B ∿9" Brown organic silty fine sand.
77.0	5	SS-2	19-30-40-34	13	SS-2 Light brown slightly silty, gravelly fine to coarse sand.
72.0	10	SS-3 *	33-34-29-21	9	SS-3 Gray slightly silty sandy gravel. Gravel is angular to subrounded and up to ∿1 3/8" in size.
67.0	15				*Drove open-ended "A" rod with 200-lb weight. 120 blows for last 2" of penetration.
62.0	20				Recovered brownish-gray clayey, gravelly sand.
57.0	25				

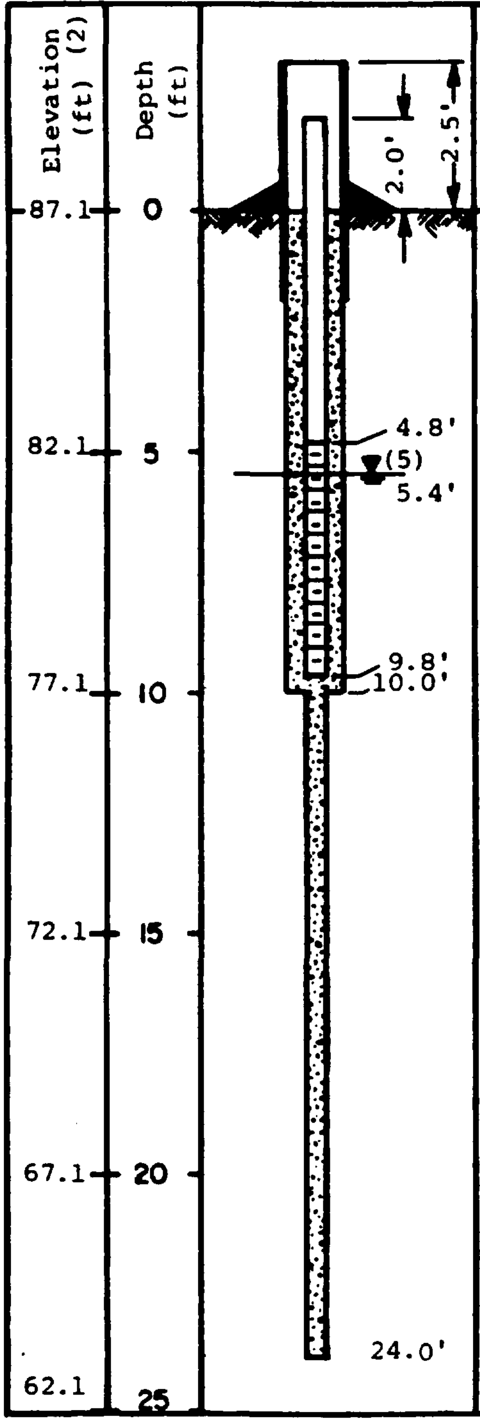
Notes: (1), (2), (3), (4) See first page of Appendix A for additional information.
(5) Groundwater level is the average of seven measurements taken from November 2, 1978 to May 31, 1978.
(6) Prior to May 31, 1978, distance from ground surface to top of casing was 3.3'. Casing was removed to perform permeability test and replaced to present "stickup" of 3.6'.

GROUNDWATER WELL INSTALLATION REPORT

Groundwater Well No.: 10 — Date Installed: Nov. 2, 1977

Permeability(1) : 1. x 10^{-2} cm/sec — Project No. : 77348

Well Installed by Carr-Dee Test Boring Corp. — Soils Described by R. Gardner, GEI



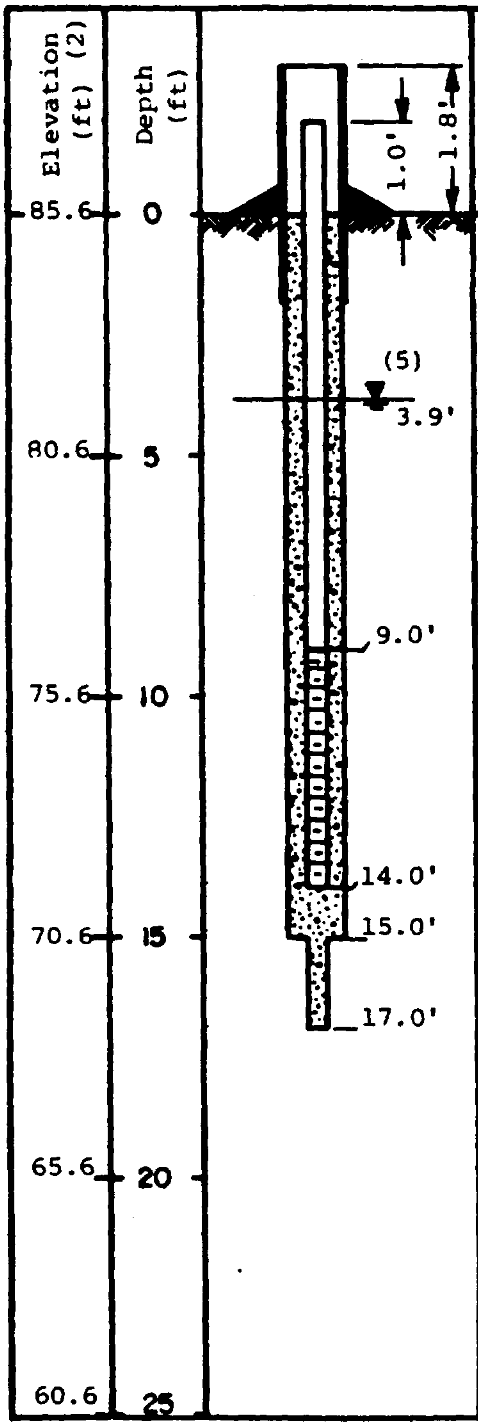
Split Spoon Sample No. and Location	Blows per 6" (3)	Rec. (in.) (4)	Sample Description
SS-1A SS-1B	1-1-1-2	14	SS-1A ∿4" Black sandy humus. SS-1B ∿10" Orange-brown fine sand; slight organic odor.
SS-2A SS-2B	4-6-12-20	13	SS-2A ∿6" Similar to SS-1B SS-2B ∿7" Similar to SS-1B except for presence of subangular gravel up to 1/2" in size.
SS-3	40-85	8	SS-3 Yellow-tan silty fine sand.
*			*Drove open-ended "A" rod with 200-lb weight. Recovered slightly silty sand and gravel.
**			**Drove open-ended "A" rod with 200-lb weight. No refusal. Recovered silty medium to coarse sand with material similar to that in nearby lagoon.

Notes: (1), (2), (3), (4) See first page of Appendix A for additional information.
(5) Groundwater level is the average of seven measurements taken from November 2, 1977 to May 31, 1978.

Geotechnical Engineers Inc.

GROUNDWATER WELL INSTALLATION REPORT

Groundwater Well No.: 11
Date Installed: Oct. 31, 1977
Permeability(1) : 5×10^{-4} cm/sec
Project No. : 77348
Well Installed by Carr-Dee Test Boring Corp.
Soils Described by R. Gardner, GEI

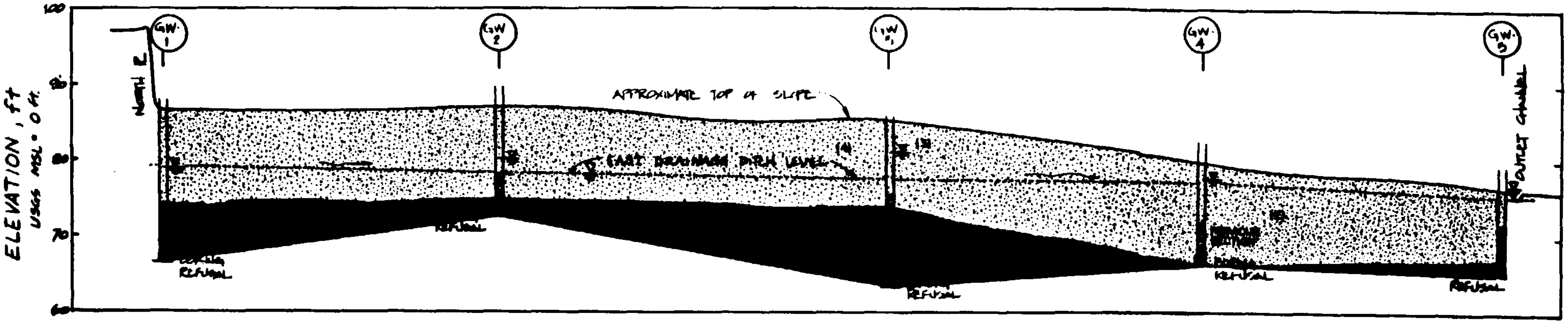


Split Spoon Sample No. and Location	Blows per 6" (3)	Rec. (in.) (4)	Sample Description
SS-1	1-2-3-3	11	Gray-brown sand and gravel mixed with material similar to that in lagoons.
SS-2	1/12"-1-1	4	Dark brown slightly sandy forest mulch.
SS-3	1-1	11	Similar to SS-2.
SS-4	3-4-4-4	11	Gray to olive-brown slightly silty fine sand.
SS-5	6-8-8-10	13	Gray-brown slightly silty fine sand; odor similar to that in lagoons.
SS-6	36-45-28-34	16	Brown silty sand and gravel. Gravel up to ~1" in size.

No refusal.

Notes: (1), (2), (3), (4) See first page of Appendix A for additional information.
(5) Groundwater level is the average of seven measurements taken from November 2, 1977 to May 31, 1978.

Geotechnical Engineers Inc.



CROSS SECTION A-A

General Description of Soil Layers(1)

▨ Layers of fine to coarse sand occasionally mixed with gravel and/or silt.

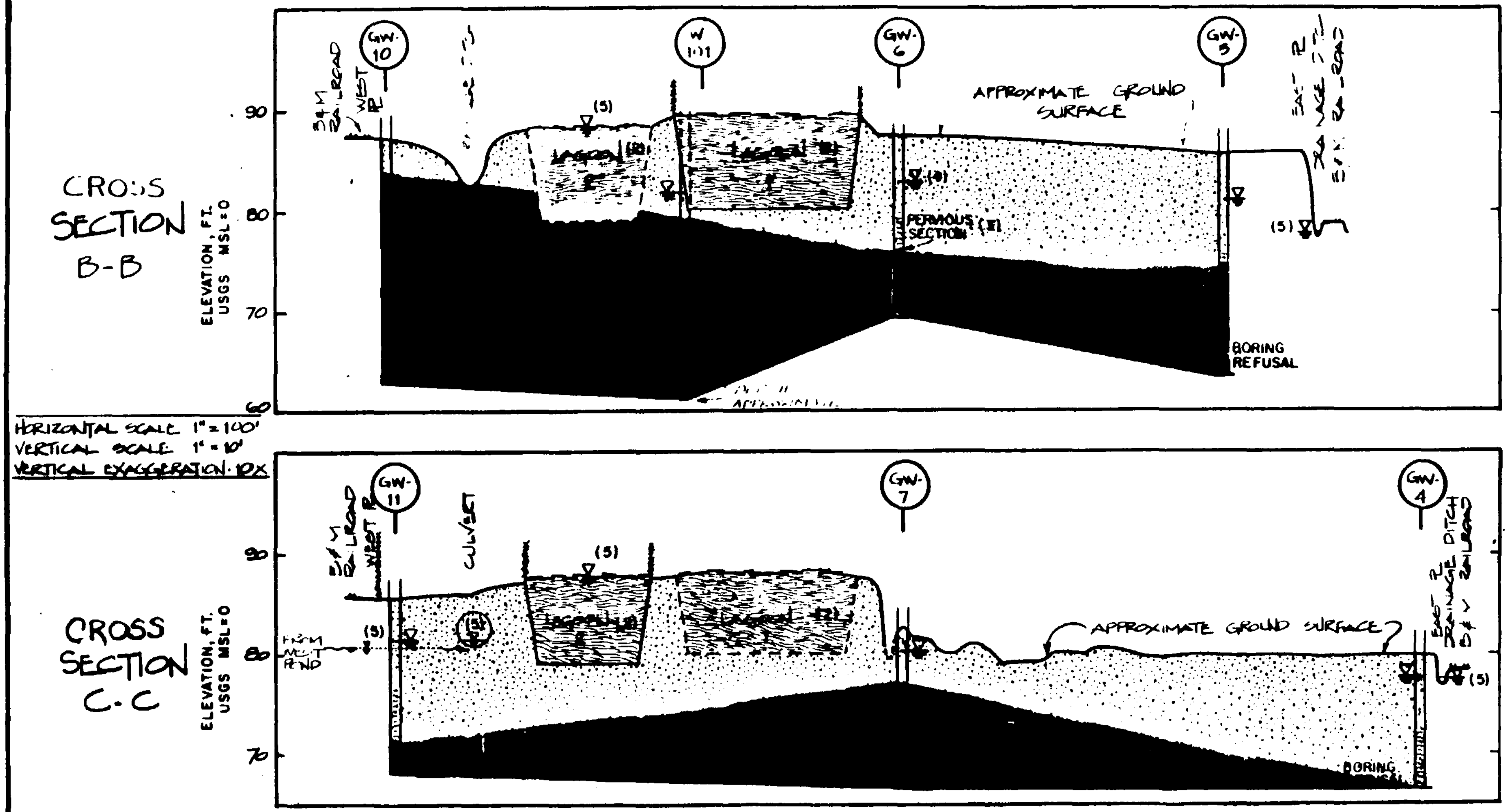
■ Predominantly sandy gravel and gravelly sand occasionally mixed with silt.

Notes:

1) Detailed descriptions of individual samples from the borings are contained in Appendix A. The soil conditions, including stratum boundaries, are known only at the boring locations and may vary significantly from the straight line interpolations shown between boring locations.
2) Pervious section of the groundwater wells are indicated by horizontal dashes.
3) Groundwater elevations are average values taken from Table 18.
4) Surface water elevations were measured on April 14, 1978.

HORIZONTAL SCALE 1" = 100'
VERTICAL SCALE 1" = 10'
VERTICAL EXAGGERATION 10X

Commonwealth of Massachusetts Water Resources Commission	Groundwater and Surface Water Studies Stepan Chemical Company Wilmington, Massachusetts	CROSS SECTION A-
Geotechnical Engineers Inc. Winchester, Massachusetts	Project 77340	June, 1978 Fig



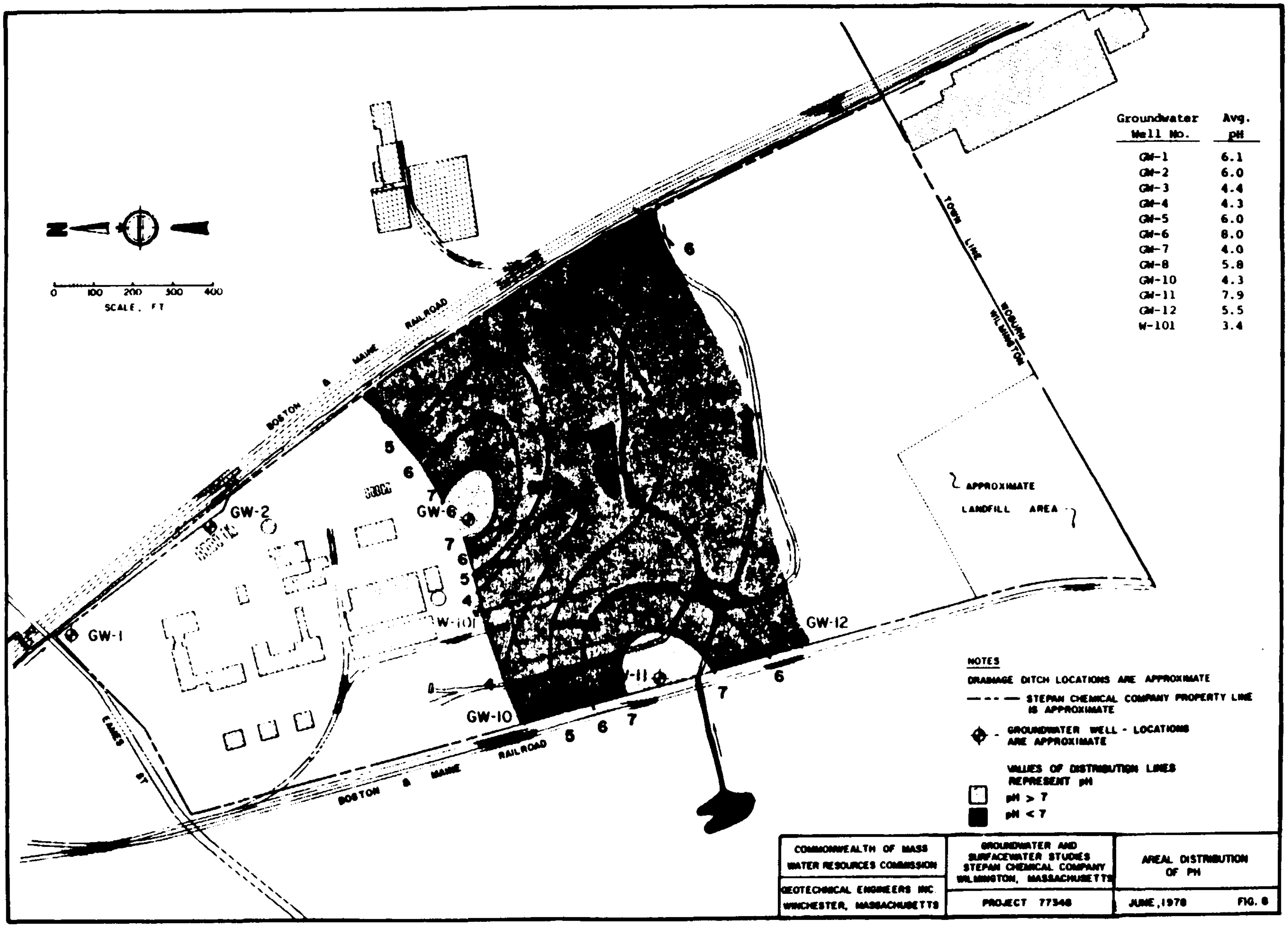
General Description of Soil Layers[1]

Layers of fine to coarse sand occasionally mixed with gravel and/or silt.

▇ Predominantly sandy gravel and gravelly sand occasionally mixed with silt.

Notes:
1) Detailed descriptions of individual samples from the borings are contained in Appendix A. The soil conditions, including strata boundaries, are known only at the boring locations and may vary significantly from the straight line interpolations shown between boring locations.
2) Illustrated positions of the lagoons are based on design drawings.
3) Pervious section of the groundwater wells are indicated by horizontal dashes.
4) Groundwater elevations are average values taken from Table 10.
5) Surface water elevations were measured on April 14, 1978.

Commonwealth of Massachusetts Water Resources Commission	Groundwater and Surface Water Studies Stepan Chemical Company Wilmington, Massachusetts	CROSS SECTION B-B AND CROSS SECTION C-C
Geotechnical Engineers Inc. Winchester, Massachusetts	Project 77348	June, 1978 Fig. 7



Groundwater Well No.	Avg. pH
GW-1	6.1
GW-2	6.0
GW-3	4.4
GW-4	4.3
GW-5	6.0
GW-6	8.0
GW-7	4.0
GW-8	5.8
GW-10	4.3
GW-11	7.9
GW-12	5.5
W-101	3.4

NOTES

DRAINAGE DITCH LOCATIONS ARE APPROXIMATE

— - - — STEPAN CHEMICAL COMPANY PROPERTY LINE IS APPROXIMATE

⌖ - GROUNDWATER WELL - LOCATIONS ARE APPROXIMATE

VALUES OF DISTRIBUTION LINES REPRESENT pH

☐ pH > 7

■ pH < 7

COMMONWEALTH OF MASS
WATER RESOURCES COMMISSION

GEOTECHNICAL ENGINEERS INC.
WINCHESTER, MASSACHUSETTS

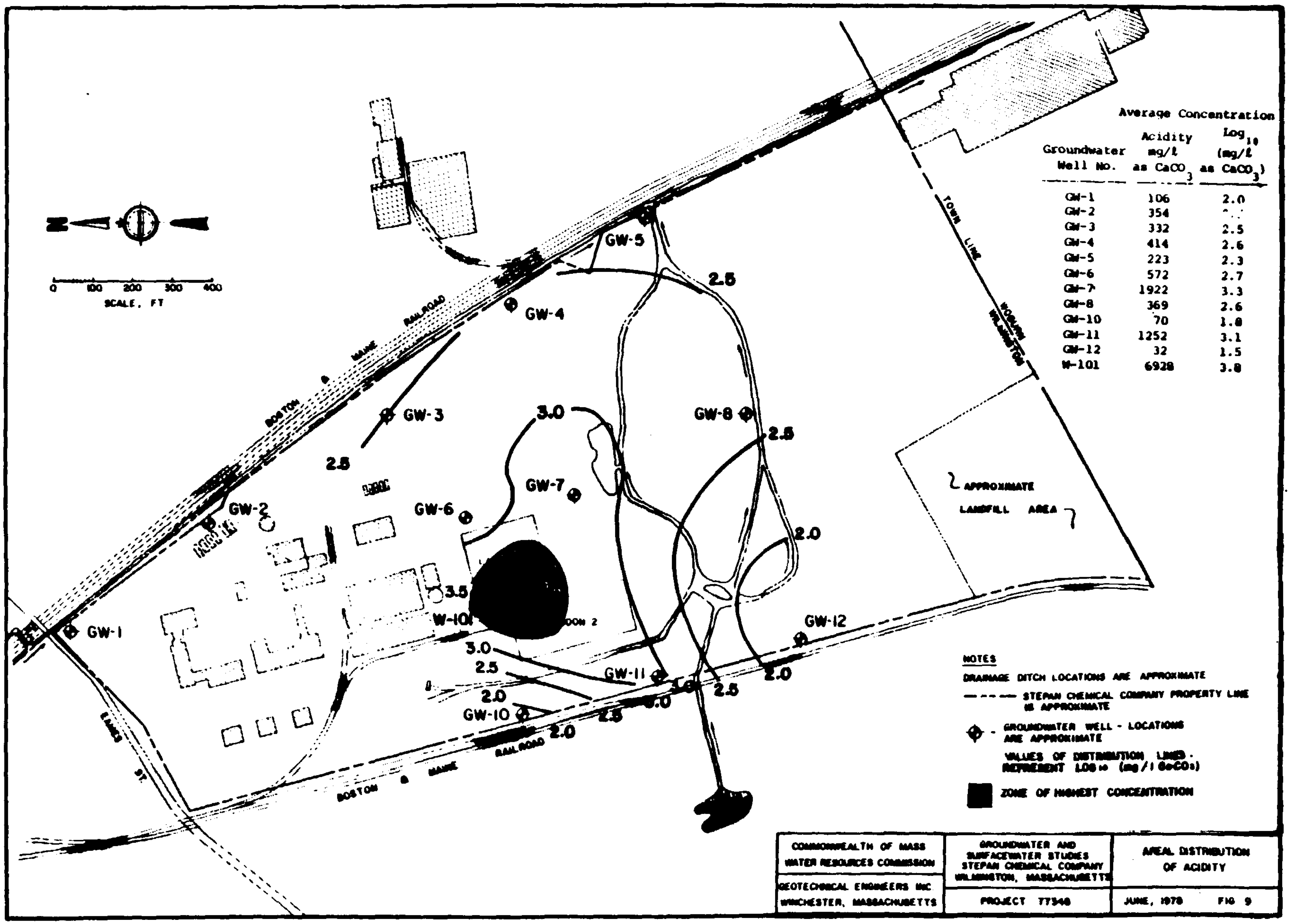
GROUNDWATER AND
SURFACEWATER STUDIES
STEPAN CHEMICAL COMPANY
WILMINGTON, MASSACHUSETTS

PROJECT 77348

AREAL DISTRIBUTION
OF PH

JUNE, 1978

FIG. 8



Average Concentration

Groundwater Well No.	Acidity mg/ℓ as $CaCO_3$	Log_{10} (mg/ℓ as $CaCO_3$)
GW-1	106	2.0
GW-2	354	[illegible]
GW-3	332	2.5
GW-4	414	2.6
GW-5	223	2.3
GW-6	572	2.7
GW-7	1922	3.3
GW-8	369	2.6
GW-10	70	1.8
GW-11	1252	3.1
GW-12	32	1.5
W-101	6928	3.8

NOTES

DRAINAGE DITCH LOCATIONS ARE APPROXIMATE

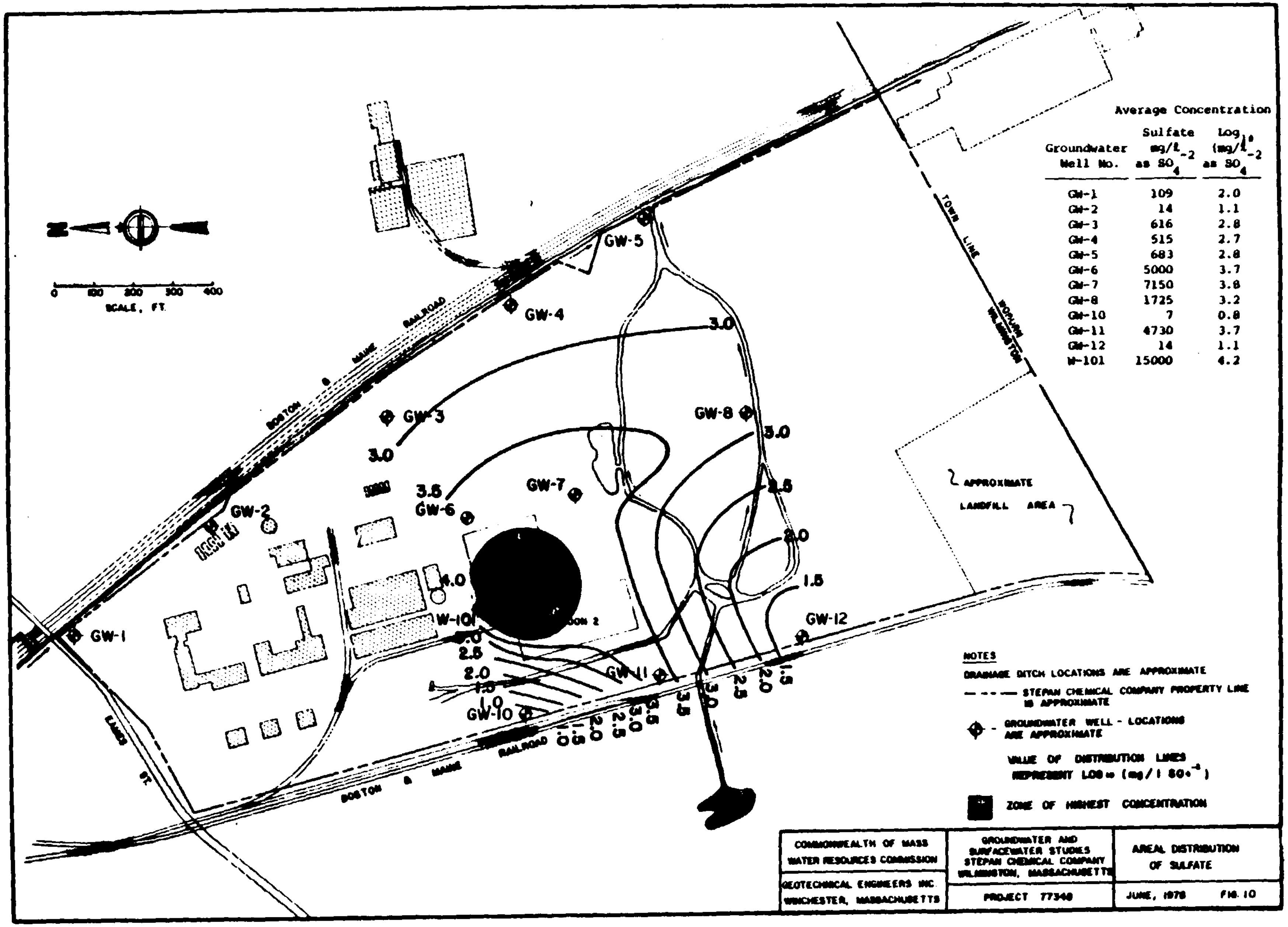
— — — STEPAN CHEMICAL COMPANY PROPERTY LINE IS APPROXIMATE

⊕ - GROUNDWATER WELL - LOCATIONS ARE APPROXIMATE

VALUES OF DISTRIBUTION LINES REPRESENT LOG_{10} (mg/l $CaCO_3$)

■ ZONE OF HIGHEST CONCENTRATION

COMMONWEALTH OF MASS WATER RESOURCES COMMISSION	GROUNDWATER AND SURFACEWATER STUDIES STEPAN CHEMICAL COMPANY WILMINGTON, MASSACHUSETTS	AREAL DISTRIBUTION OF ACIDITY
GEOTECHNICAL ENGINEERS INC WINCHESTER, MASSACHUSETTS	PROJECT 77346	JUNE, 1978 FIG 9



Average Concentration

Groundwater Well No.	Sulfate mg/ℓ as SO_4^{-2}	Log_{10} (mg/ℓ as SO_4^{-2})
GW-1	109	2.0
GW-2	14	1.1
GW-3	616	2.8
GW-4	515	2.7
GW-5	683	2.8
GW-6	5000	3.7
GW-7	7150	3.8
GW-8	1725	3.2
GW-10	7	0.8
GW-11	4730	3.7
GW-12	14	1.1
W-101	15000	4.2

NOTES

DRAINAGE DITCH LOCATIONS ARE APPROXIMATE

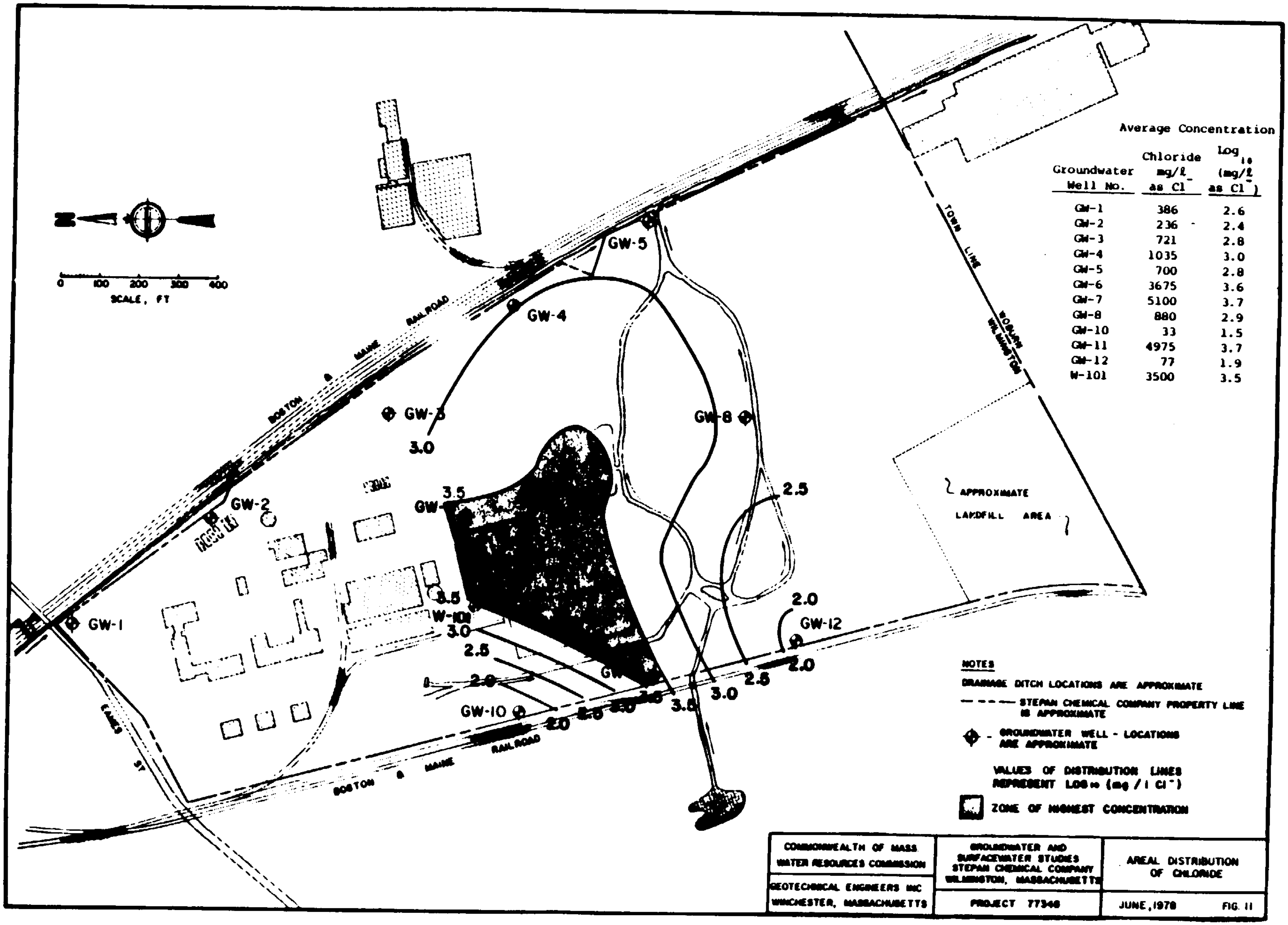
— - - — STEPAN CHEMICAL COMPANY PROPERTY LINE IS APPROXIMATE

⊕ - GROUNDWATER WELL - LOCATIONS ARE APPROXIMATE

VALUE OF DISTRIBUTION LINES REPRESENT LOG_{10} (mg / l SO_4^{-2})

■ ZONE OF HIGHEST CONCENTRATION

COMMONWEALTH OF MASS WATER RESOURCES COMMISSION	GROUNDWATER AND SURFACEWATER STUDIES STEPAN CHEMICAL COMPANY WILMINGTON, MASSACHUSETTS	AREAL DISTRIBUTION OF SULFATE
GEOTECHNICAL ENGINEERS INC. WINCHESTER, MASSACHUSETTS	PROJECT 77340	JUNE, 1978 FIG. 10



Average Concentration

Groundwater Well No.	Chloride mg/ℓ as Cl⁻	Log₁₀ (mg/ℓ as Cl⁻)
GW-1	386	2.6
GW-2	236	2.4
GW-3	721	2.8
GW-4	1035	3.0
GW-5	700	2.8
GW-6	3675	3.6
GW-7	5100	3.7
GW-8	880	2.9
GW-10	33	1.5
GW-11	4975	3.7
GW-12	77	1.9
W-101	3500	3.5

NOTES

DRAINAGE DITCH LOCATIONS ARE APPROXIMATE

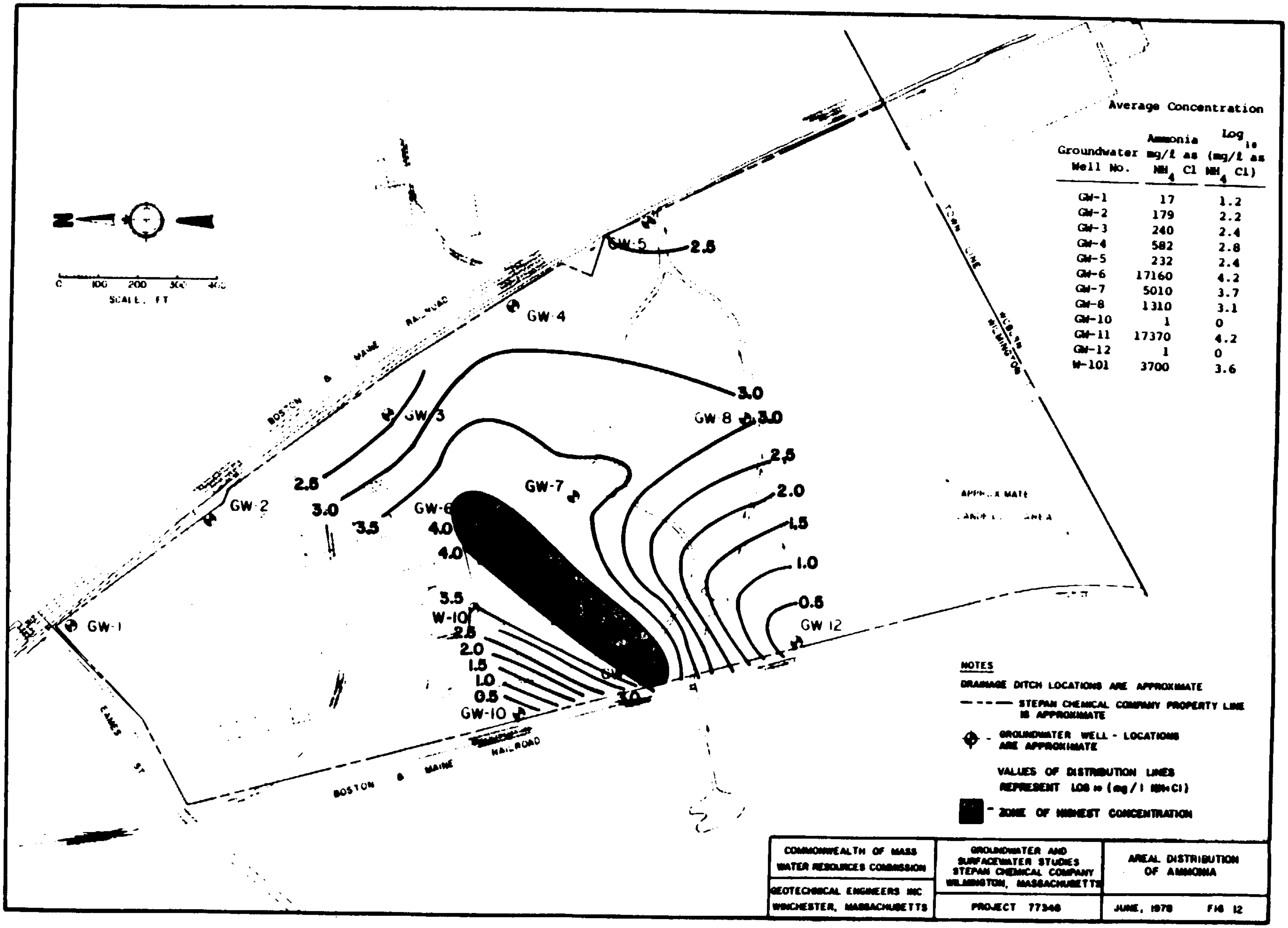
– – – – STEPAN CHEMICAL COMPANY PROPERTY LINE IS APPROXIMATE

⊕ - GROUNDWATER WELL - LOCATIONS ARE APPROXIMATE

VALUES OF DISTRIBUTION LINES REPRESENT LOG₁₀ (mg / l Cl⁻)

■ ZONE OF HIGHEST CONCENTRATION

COMMONWEALTH OF MASS. WATER RESOURCES COMMISSION	GROUNDWATER AND SURFACEWATER STUDIES STEPAN CHEMICAL COMPANY WILMINGTON, MASSACHUSETTS	AREAL DISTRIBUTION OF CHLORIDE
GEOTECHNICAL ENGINEERS INC WINCHESTER, MASSACHUSETTS	PROJECT 77348	JUNE, 1978 FIG. 11



Average Concentration

Groundwater Well No.	Ammonia mg/ℓ as NH_4Cl	Log_{10} (mg/ℓ as NH_4Cl)
GW-1	17	1.2
GW-2	179	2.2
GW-3	240	2.4
GW-4	582	2.8
GW-5	232	2.4
GW-6	17160	4.2
GW-7	5010	3.7
GW-8	1310	3.1
GW-10	1	0
GW-11	17370	4.2
GW-12	1	0
W-101	3700	3.6

NOTES

DRAINAGE DITCH LOCATIONS ARE APPROXIMATE

STEPAN CHEMICAL COMPANY PROPERTY LINE IS APPROXIMATE

GROUNDWATER WELL - LOCATIONS ARE APPROXIMATE

VALUES OF DISTRIBUTION LINES REPRESENT LOG_{10} (mg/l NH_4Cl)

■ - ZONE OF HIGHEST CONCENTRATION

COMMONWEALTH OF MASS
WATER RESOURCES COMMISSION

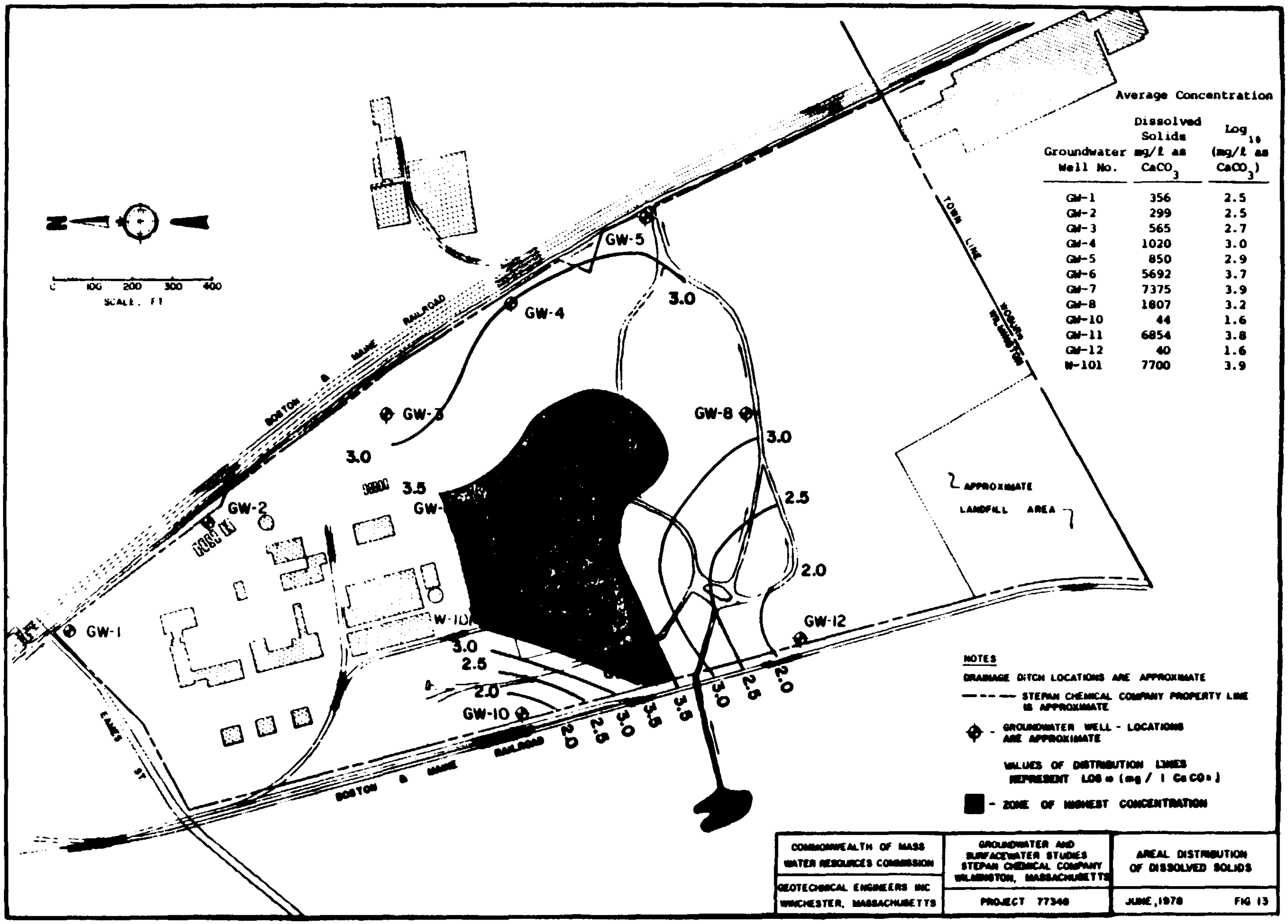
GEOTECHNICAL ENGINEERS INC
WINCHESTER, MASSACHUSETTS

GROUNDWATER AND
SURFACEWATER STUDIES
STEPAN CHEMICAL COMPANY
WILMINGTON, MASSACHUSETTS

PROJECT 77340

AREAL DISTRIBUTION
OF AMMONIA

JUNE, 1978 FIG 12



Average Concentration

Groundwater Well No.	Dissolved Solids mg/ℓ as $CaCO_3$	Log_{10} (mg/ℓ as $CaCO_3$)
GW-1	356	2.5
GW-2	299	2.5
GW-3	565	2.7
GW-4	1020	3.0
GW-5	850	2.9
GW-6	5692	3.7
GW-7	7375	3.9
GW-8	1807	3.2
GW-10	44	1.6
GW-11	6854	3.8
GW-12	40	1.6
W-101	7700	3.9

NOTES

DRAINAGE DITCH LOCATIONS ARE APPROXIMATE

— — — STEPAN CHEMICAL COMPANY PROPERTY LINE IS APPROXIMATE

⊕ - GROUNDWATER WELL - LOCATIONS ARE APPROXIMATE

VALUES OF DISTRIBUTION LINES REPRESENT LOG_{10} (mg / l $CaCO_3$)

■ - ZONE OF HIGHEST CONCENTRATION

COMMONWEALTH OF MASS
WATER RESOURCES COMMISSION

GEOTECHNICAL ENGINEERS INC
WINCHESTER, MASSACHUSETTS

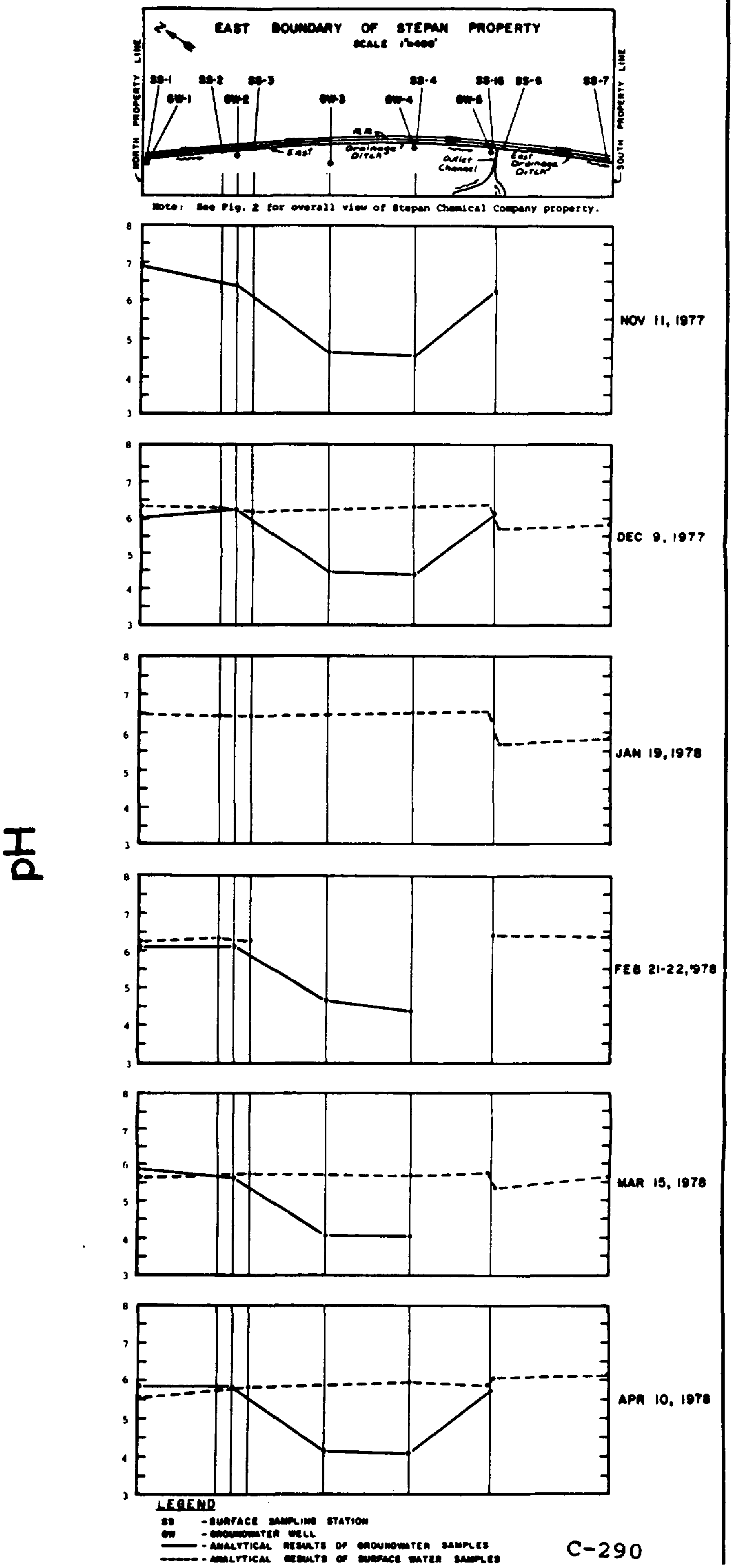
GROUNDWATER AND
SURFACEWATER STUDIES
STEPAN CHEMICAL COMPANY
WILMINGTON, MASSACHUSETTS

PROJECT 77348

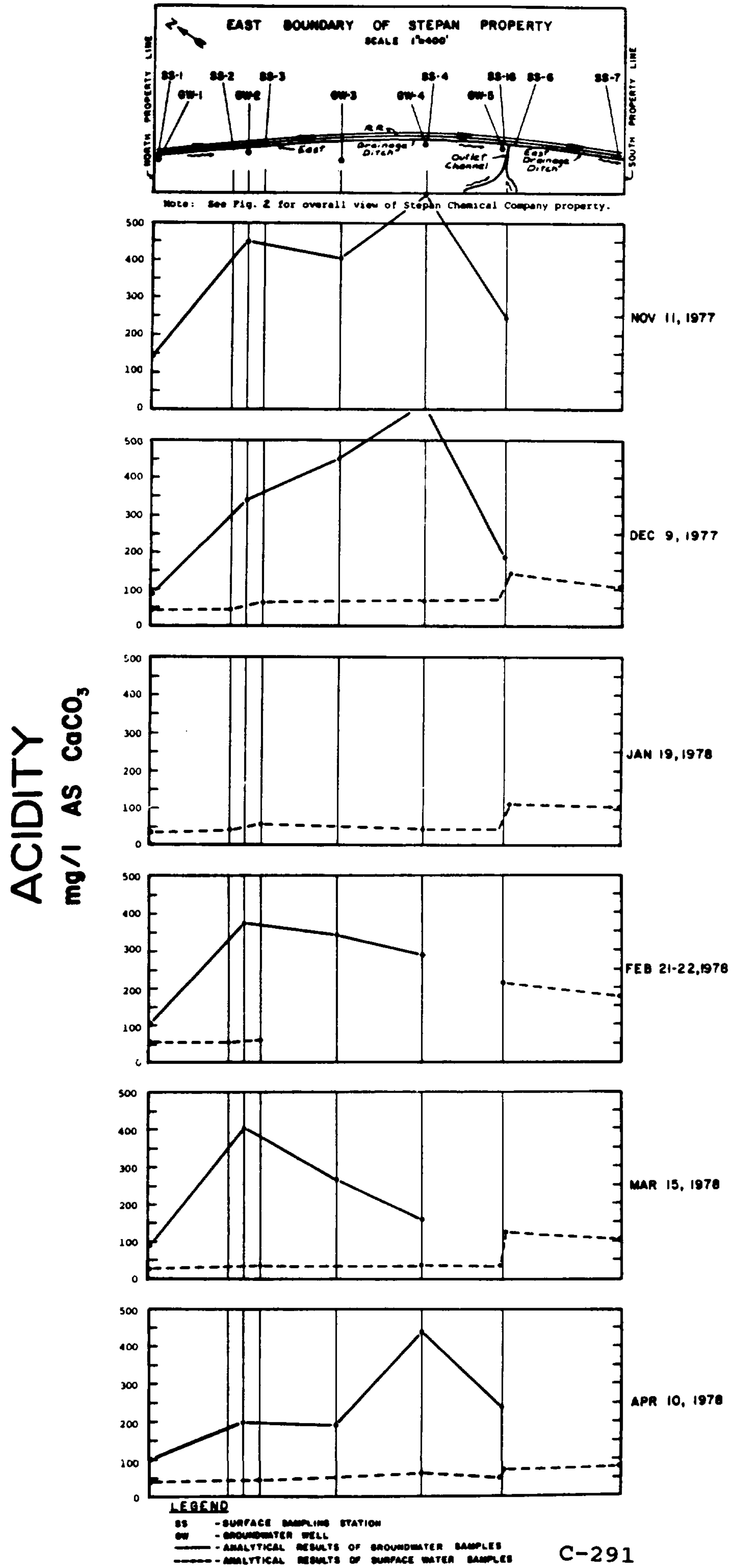
AREAL DISTRIBUTION
OF DISSOLVED SOLIDS

JUNE, 1978

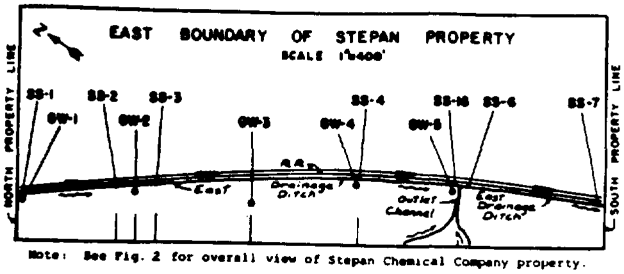
FIG 13



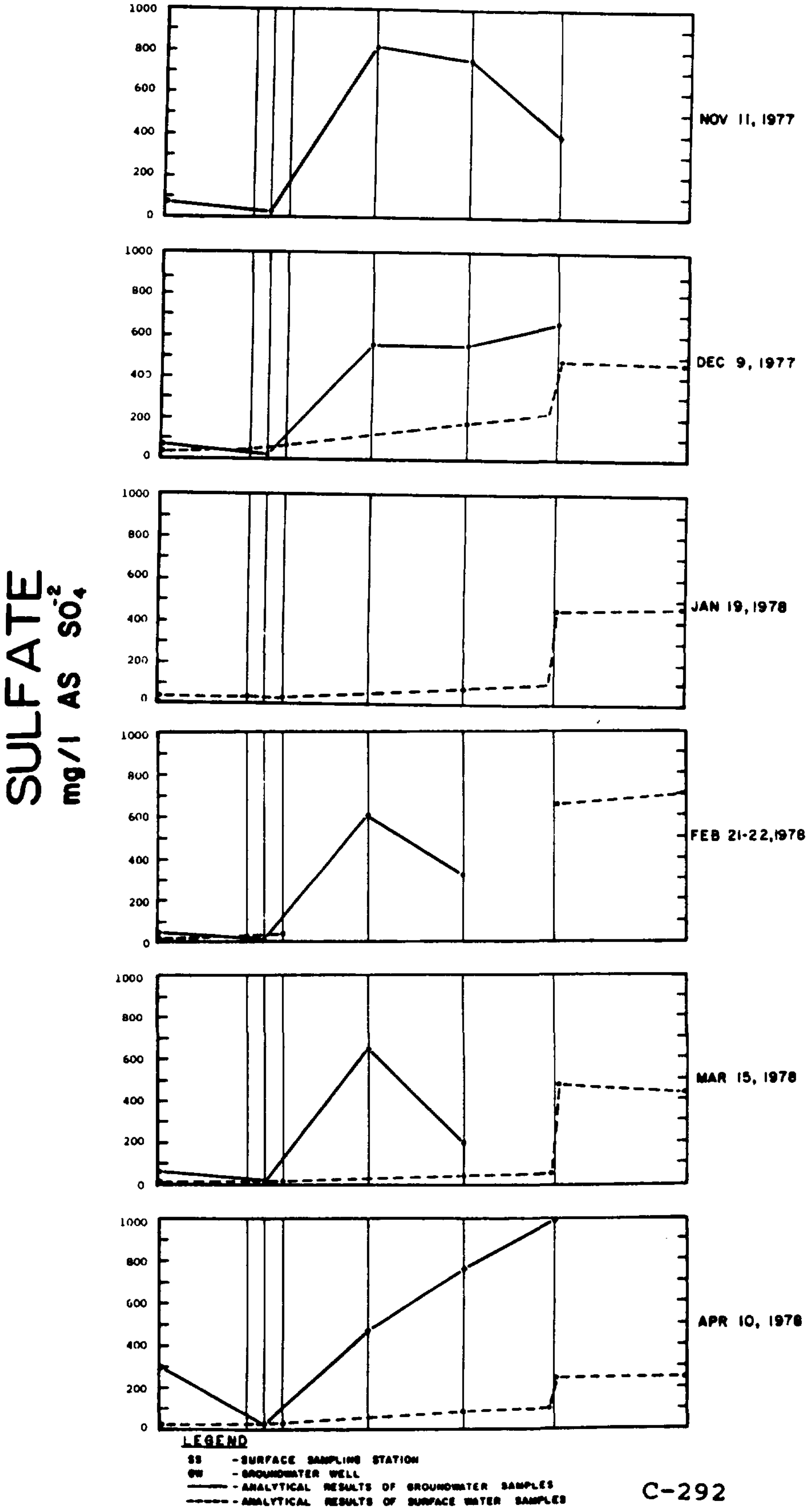
Note: See Fig. 2 for overall view of Stepan Chemical Company property.



Note: See Fig. 2 for overall view of Stepan Chemical Company property.

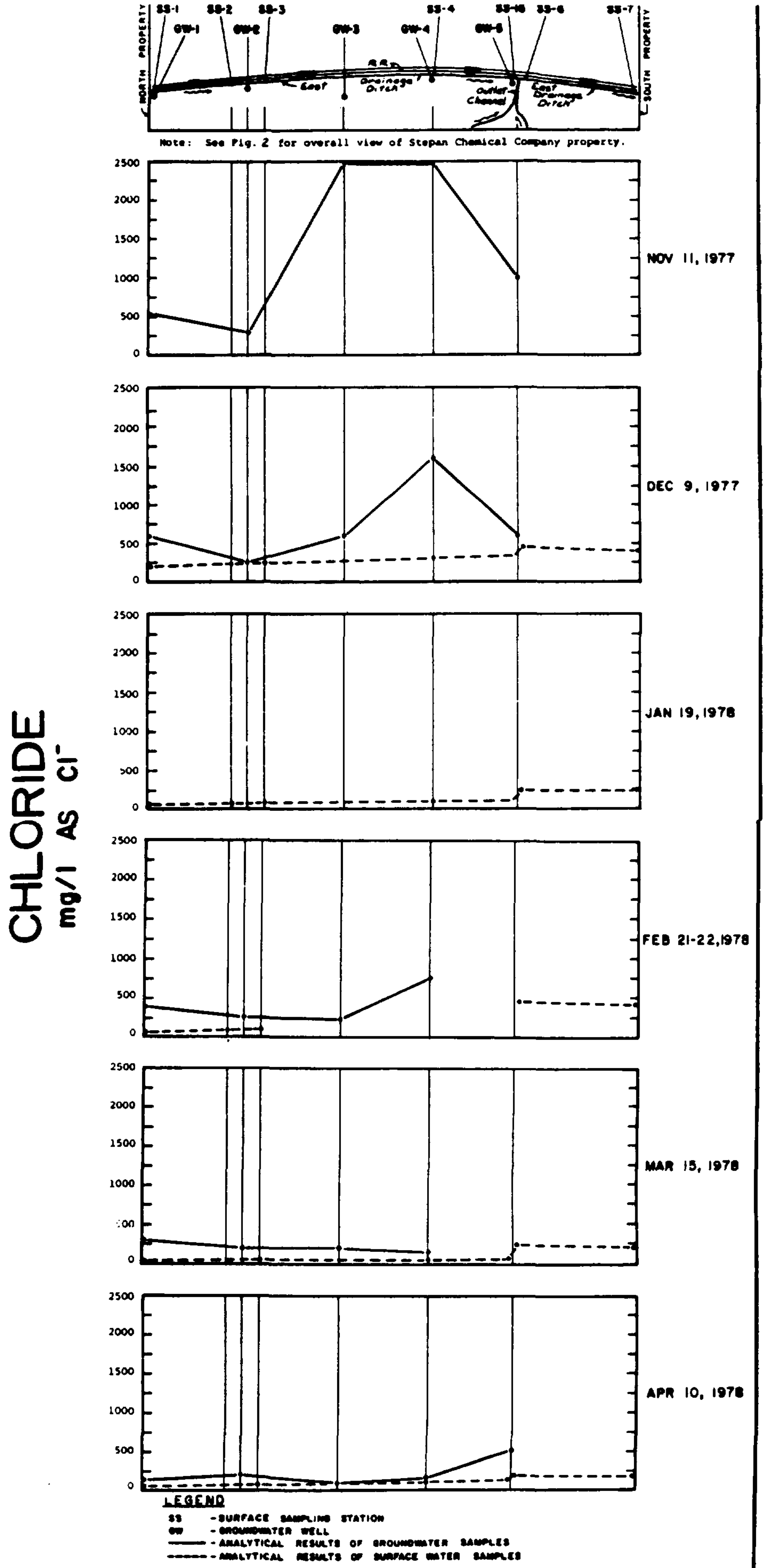


Note: See Fig. 2 for overall view of Stepan Chemical Company property.



C-292

Commonwealth of Massachusetts	Groundwater & Surface Water Studies	ANALYTICAL RESULTS ALONG EAST BOUNDARY OF



Note: See Fig. 2 for overall view of Stepan Chemical Company property.

Commonwealth of Massachusetts
Water Resources Commission

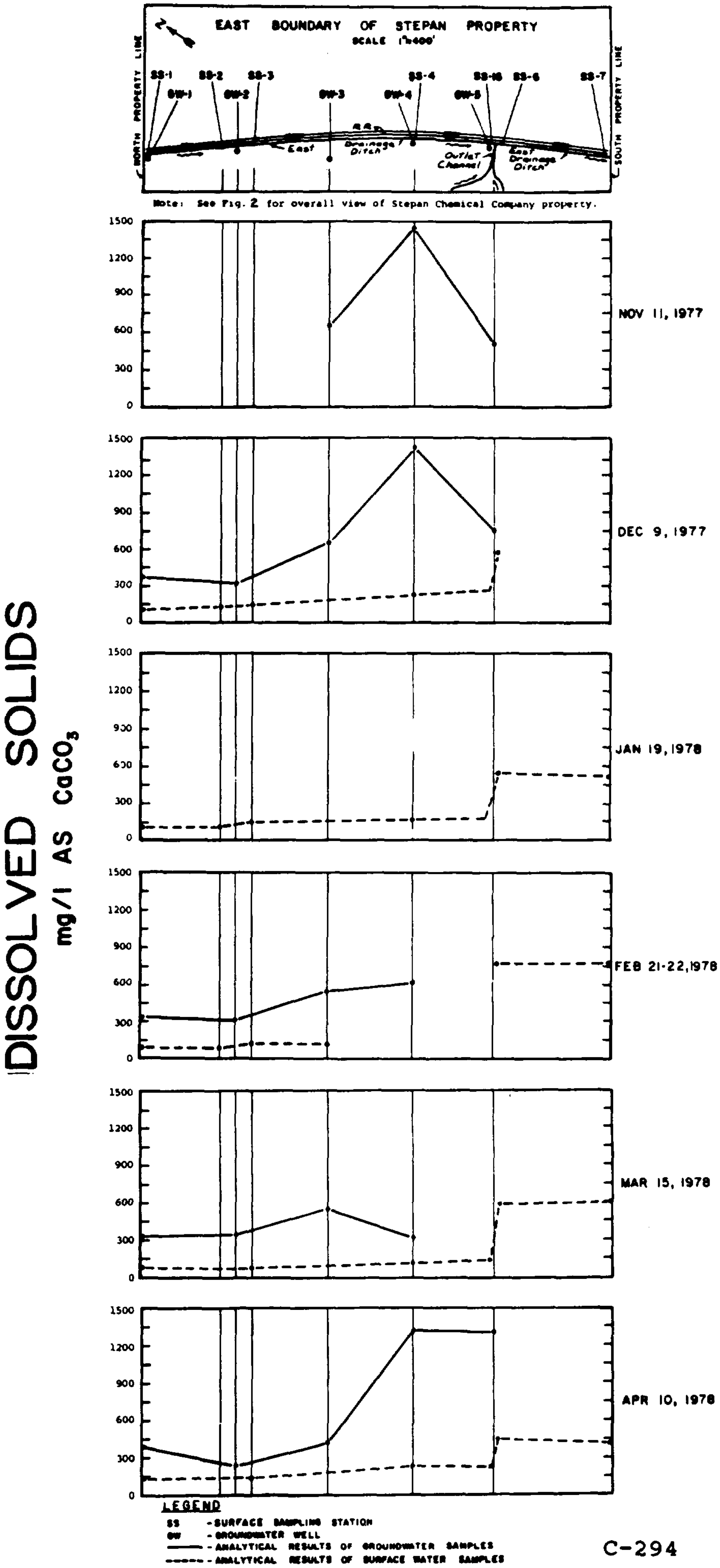
Geotechnical Engineers Inc.
Winchester, Massachusetts

Groundwater & Surface
Water Studies
Stepan Chemical Company
Wilmington, Massachusetts

Project 77348

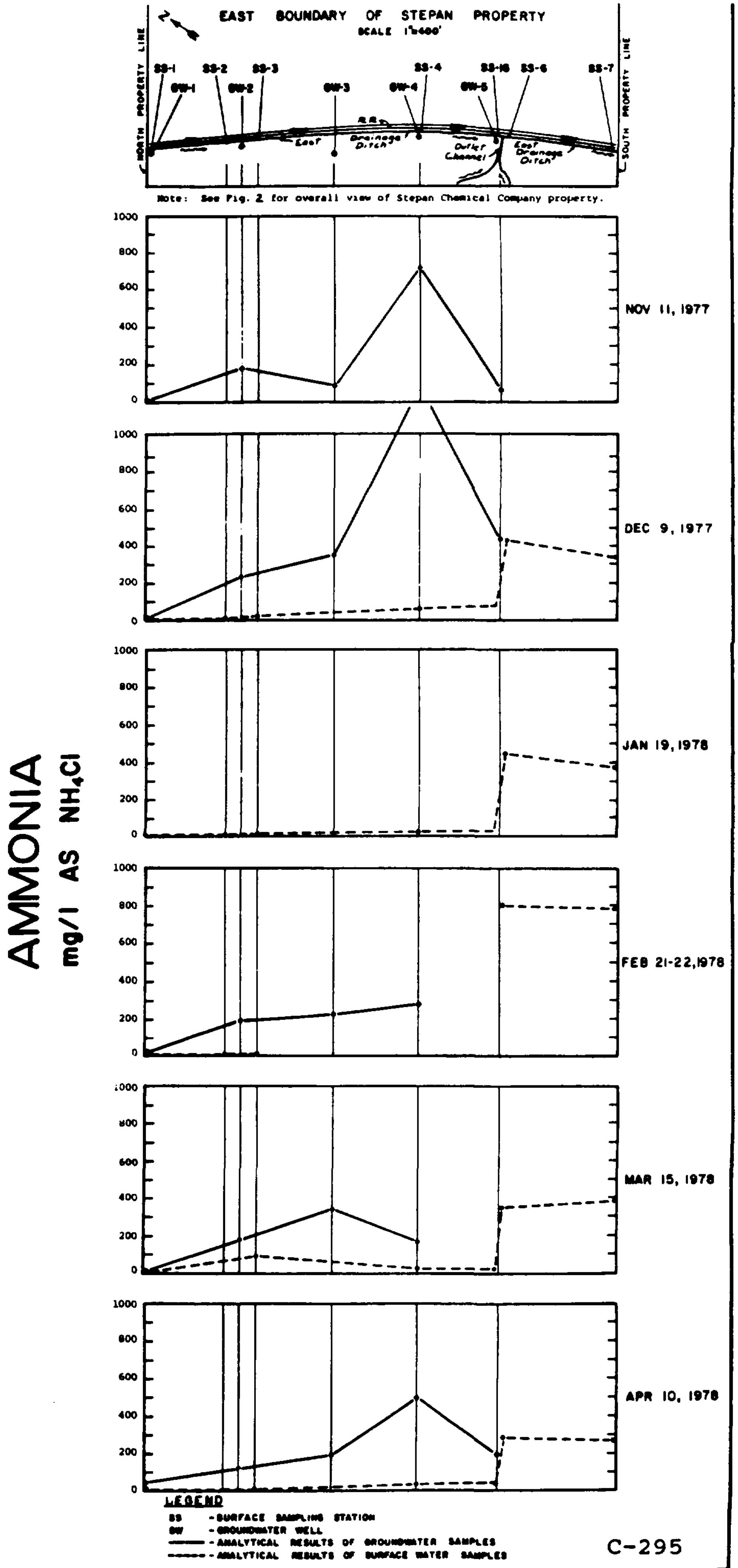
ANALYTICAL RESULTS ALONG
EAST BOUNDARY OF
STEPAN PROPERTY
Chloride

June, 1978 Fig. 17



C-294

Commonwealth of Massachusetts	Groundwater & Surface Water Studies	ANALYTICAL RESULTS ALON EAST BOUNDARY OF



Commonwealth of Massachusetts Water Resources Commission	Groundwater & Surface Water Studies Stepan Chemical Company Wilmington, Massachusetts	ANALYTICAL RESULTS ALONG EAST BOUNDARY OF PROPERTY AMMONIA
Geotechnical Engineers Inc.		

C-2.25 July 1979 chemical analysis summary sheet for samples collected from the Aberjona River and its tributaries.

[illegible]
Consulting Engineers
Reading, Massachusetts 01867

WATER TESTS RESULTS

MARK PHILLIP TRUST
WOBURN, MASSACHUSETTS
Samples Dated June 26, 1979

Sample No.	Location	Time	Temp.* (°C.)	Dissolved* Oxygen (mg/l)	pH	Specific Conductivity [illegible]	Total Coliform ([illegible] 100 ml)
79-A-1 ✓	Outlet of Weir Lipton Pet Foods Pond	2:45 PM	22.5	6.4	6.8	1400	0 Heavy Background
79-A-2 ✓	Drainage ditch from Lipton Pet Foods at Commerce Way (Sta 63+0 Lt.)	3:00 PM	21.0	4.6	6.8	900	0 Heavy Background
79-A-3 ✓	Outlet of 60"Ø Pipe at Route 93 (Aberjona River)	4:05 PM	15.2	9.1	7.0	1800	800 Heavy Background
79-A-4 ✓	Downstream of 2 - 36"Ø at Marshalls	3:15 PM	21.2	9.0	7.3	2200	300 Heavy Background
79-A-5 ✓	Aberjona River Channel at Mishawum Road	3:30 PM	20.1	7.8	7.1	1900	200 Heavy Background
79-A-6 ✓	Inlet of 24" Culvert at New Boston Street (Willow Brook)	3:50 PM	21.5	5.1	8.4	2800	200 Heavy Background
79-A-7 ✓	Outlet of Twin Arch Culverts at New Boston St. (Halls Brook)	3:40 PM	19.2	7.3	7.0	1400	173 Heavy Background
79-A-8 ✓	Halls Brook Outlet into Project at RR Tracks	4:20 PM	20.5	9.0	6.8	900	0 Heavy Background
79-A-9 ✓	Halls Brook Storage Area 60"Ø Outlet at Mishawum Road	3:30 PM	21.0	8.3	7.2	1500	100 Heavy Background

*Tests Conducted In Field.

ARNOLD GREENE TESTING LABORATORIES, INC.
Nondestructive - Chemical - Pollution - Metallurgical/Inspection - Evaluation - Analysis
EAST NATICK INDUSTRIAL PARK · 6 HURON DRIVE · NATICK, MASS. 01760
(617) 235-7330, 653-5950 · TELEX 948459 (GREENE LAB NTIK)
BRANCH LABORATORIES
HATO REY, PUERTO RICO 00917 (809) [illegible]
EVERETT, MASS. 02149 (617) 387-3770
SPRINGFIELD, MASS. 01104 (413) 734-6546
AUBURN, MASS. 01501 (617) 832-5600

TEST REPORT

TO: Mark Phillip TR.	DATE 7/2/79	MATERIAL Water
Industriplex, Rt. 128	JOB NO. B 18617	HEAT NO.
Woburn, MA 01801	LAB. NO. 5888	SPECIFICATIONS:
ATT: Mr. D'Annolfo	ORDER NO. 1909	

	79-A-1	79-A-2	79-A-3	79-A-4	79-A-5	79-A-6
BOD_5(mg/L)	6.8	4.6	0.5	3.0	0.6	5.0
Ammonia(mg/L(N))	0.2	37.0	0.30	12.0	11.0	90.0
Total Phosphorus(mg/L)	0.14	0.12	0.04	0.11	0.09	0.15
Oil and Grease(mg/L)	0.4	0.1	0.1	<0.1	<0.1	<0.1
Total Cynnide(mg/L)				<0.01		<0.01
Total Chromium(mg/L)				<0.02		<0.02
Hexavalent Chromium(mg/L)				<0.01		<0.01
Trivalent Chromium(mg/L)				<0.02		<0.02

	79-A-7	79-A-8	79-A-9
BOD_5(mg/L)	1.2	2.6	5.6
Ammonia(mg/L(N))	0.64	42.0	21.0
Oil and Grease(mg/L)	<0.1	<0.1	<0.1
Total Phosphorus(mg/L)	0.12	0.11	0.06

SUBSCRIBED TO AND SWORN TO BEFORE ME THIS
DAY OF 19

NOTARY PUBLIC

IN WITNESS WHEREOF, I HAVE HEREUNTO SET MY HAND THIS
DAY OF 19
ARNOLD GREENE TESTING LABORATORIES, INC.

Robert T. Legere

12-[illegible] 38A