



RECRA ENVIRONMENTAL, INC.

Chemical Waste Analysis, Prevention and Control

EXPANDED PHASE I INVESTIGATION
Genesee River Gorge (Lower Falls)
Site I.D. #828044
Prepared For:

New York State Department of
Environmental Conservation

Appendix B
Appendix C

RECEIVED

JAN 13 1988

BUREAU OF
WATERWAYS AND SHIP CONTROL
DEPT. OF ENVIRONMENTAL CONSERVATION
ALBANY, N.Y.

APPENDIX B

CHEMICAL/ANALYTICAL DATA

Itemization of information presented in this Appendix can be found in the Reference Section for Section 4.3. The material contained within the contents of the associated reference number preceded by an asterisk (*) is presented in this Appendix.

SAMPLING REPORT

Monroe County Sites :

Brighton - Brighton (T)
Lower Falls - Rochester (C)
Sigismundi/7-Up - Pittsford (T)
Perinton Landfill - Perinton (T)
Churchville Well - Riga (T)

Sampling Date: September 12, 1983

Sampling Time: 10:00 a.m. - 3:30 p.m.

By: Deborah Jackson
Senior Engineering Technician
Division of Solid and Hazardous Waste
Region 8

September 23, 1983

Site Information

General site information may be found on the Waste Disposal Site Information Sheet - submitted by the Monroe County Environmental Management Council.

Sampling Information

The following sites were sampled on September 12, 1983 by Deborah Jackson-DEC and Louise Hartshorn-EMC.

Brighton #23

Sample 83-255-01 was a downgradient liquid sample from a drainage ditch on the north side of the dump area, to be analyzed for priority pollutant organics and heavy metals. The pH = 7.1

Sample 83-255-01a was a sediment sample to be analyzed for heavy metals.

Sample 83-255-02 was an upgradient liquid sample from the drainage ditch, to be analyzed for priority pollutant organics and heavy metals. The pH = 7.3

Sample 83-255-02a was a sediment sample to be analyzed for heavy metals.

The upgradient sample had orangish red leachate with an oilish sheen leaching out of several areas in the ditch. This sampling point may be adjacent (on the north side) to another dump site, Brighton #22.

Lower Falls

Sample 83-255-03 was a liquid sample from a groundwater seep from the rockface adjacent to the Lower Falls. This sample is to be analyzed for priority pollutant organics, volatile organics and heavy metals. The pH = 6.8

The rock face was stained white and there was an organic odor.

Sigismundi/7-Up

Sample 83-255-04 was a creek sample, on the back side of the plant's property, to be analyzed for priority pollutant organics, volatile organics and heavy metals. The pH = 6.9

The creek was a black color with orange stains on the drier areas. There was an oilish film on top of the water in several areas.

Sample 83-255-05 was a creek sample, on the back side of the plant farther uphill, to be analyzed for priority pollutant organics and heavy metals. The pH = 5.9. There was an orange residue on the sides of the creek. This creek flowed to a ponded area, which contained dead trees and an orange residue floating along the edges. There was a strong organic odor and methane gas production in the pond.

Lower Falls - Genesee River

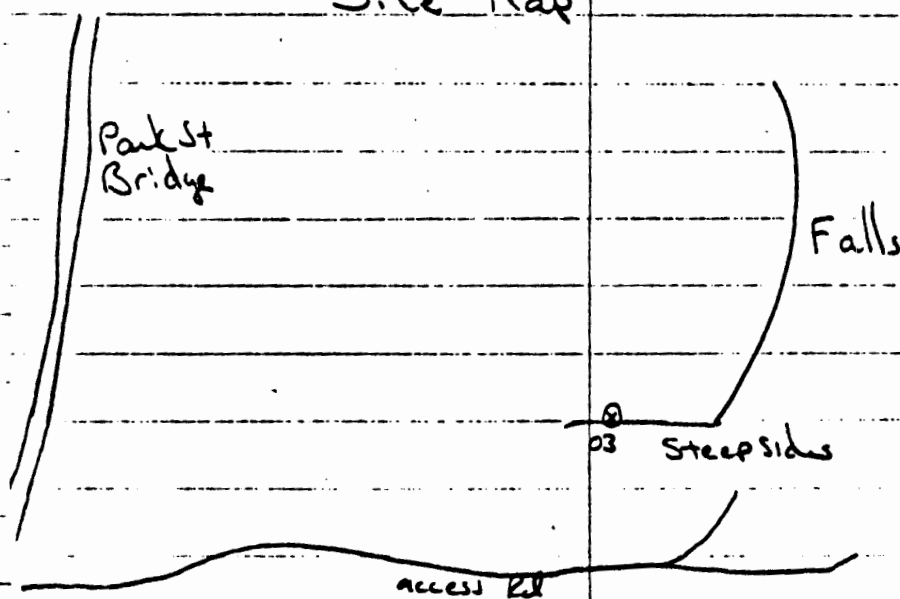
83-255-03 - groundwater seep

The sample is to be analyzed for
p.p. organics, metals and volatile organics
pH = 6.8

Sampling point is a ground water seep,
the rock face is stained white and
there was a strong organic odor about.

There were several seeps nearby one of
which was also white with an oilish sheen
on the top

Site Map



SECTION 4.3
REF. 3

Mobile Laboratory

Sample Type: Aqueous

[illegible]



RECRA ENVIRONMENTAL LABORATORIES

Division of Recra Research, Inc.

October 1, 1984

Mr. Richard Burton
Monroe County Environmental
Health Laboratory
435 East Henrietta Road
Rochester, NY 14620

Re: Analytical Results

Dear Mr. Burton:

Please find enclosed results of the analyses of the sample received at our laboratories on September 27, 1984.

If you have any questions concerning these data, do not hesitate to contact our Customer Service Representative at (716) 692-7620.

Sincerely,

RECRA ENVIRONMENTAL LABORATORIES

James A. Ploscyca
Laboratory Manager

DJT/JAP/mdc
Enclosure

I.D. #84-974

SECTION 4.3
REF5

ANALYTICAL RESULTS

MONROE COUNTY ENVIRONMENTAL HEALTH LABORATORY
GAS CHROMATOGRAPHY

Report Date: 10/1/84

PARAMETER	UNITS OF MEASURE	SAMPLE IDENTIFICATION (DATE)
		GENESEE RIVER LOWER FALLS UPPER SEEP WEST BANK (9/21/84)
Benzene	ug/l	6,000
Toluene	ug/l	6,500
meta-xylene	ug/l	1,500
ortho-xylene	ug/l	1,200
para-xylene	ug/l	680

COMMENTS:

Analyses were performed according to U.S. Environmental Protection Agency methodologies.

Results of the analyses of specific organic compounds are based upon the matching of retention times, between samples and standards, on a single gas chromatographic column.

FOR RECRA ENVIRONMENTAL LABORATORIES

DATE

Heborah J. Prario

10/1/84



RECRA ENVIRONMENTAL LABORATORIES

I.D. #84-974

ANALYTICAL RESULTS

MONROE COUNTY ENVIRONMENTAL HEALTH LABORATORY
GAS CHROMATOGRAPHY
QUALITY CONTROL

Report Date: 10/1/84

REPLICATE ANALYSIS OF
SAMPLE GENESEE RIVER LOWER FALLS UPPER SEEP WEST BLANK

COMPOUND IDENTIFICATION	UNITS OF MEASURE	VALUE 1	VALUE 2	MEAN	STANDARD DEVIATION	PERCENT COEFFICIENT OF VARIATION
Benzene	ug/l	5,600	6,400	6,000	570	9.4
Toluene	ug/l	6,400	6,600	6,500	140	2.2
meta-xylene	ug/l	1,500	1,400	1,500	71	4.9
ortho-xylene	ug/l	1,200	1,200	1,200	0	0
para-xylene	ug/l	680	680	680	0	0

RECOVERY ANALYSIS OF
SAMPLE GENESEE RIVER LOWER FALLS UPPER SEEP WEST BLANK

COMPOUND IDENTIFICATION	ng OF SPIKE	ng RECOVERED	% RECOVERY
Benzene	14	17	121
Toluene	14	19	136
meta-xylene	12	12	100
ortho-xylene	13	13	100
para-xylene	13	13	100

FOR RECRA ENVIRONMENTAL LABORATORIES

DATE

Reborah J. Praries
10/1/84

RECRA ENVIRONMENTAL LABORATORIES

I.D. #84-974



RECRA ENVIRONMENTAL LABORATORIES

Division of Recra Research, Inc.

October 30, 1984

Mr. Richard Burton
Monroe County Environmental
Health Laboratory
435 East Henrietta Road
Rochester, NY 14620

Re: Analytical Results

Dear Mr. Burton:

Please find enclosed results of the analyses of the samples received at our laboratories on October 16, 1984.

If you have any questions concerning these data, do not hesitate to contact our Customer Service Representative at (716) 692-7620.

Sincerely,

RECRA ENVIRONMENTAL LABORATORIES

James A. Ploscyca
Laboratory Manager

DJT/JAP/mdc
Enclosure

I.D. #84-1038

ANALYTICAL RESULTS

MONROE COUNTY ENVIRONMENTAL HEALTH LABORATORY
GAS CHROMATOGRAPHYReport Date: 10/30/84
Date Received: 10/16/84

PARAMETER	UNITS OF MEASURE	SAMPLE IDENTIFICATION (DATE)			
		#1 (10/11/84)	#2 (10/11/84)	#3 (10/11/84)	#4 (10/11/84)
Benzene	ug/l	5,800	6,000	5,600	770
Toluene	ug/l	4,800	5,000	5,500	680
meta-Xylene	ug/l	1,700	870	1,600	300
ortho-Xylene	ug/l	1,700	1,400	1,500	280
para-Xylene	ug/l	730	750	790	140

COMMENTS:

Analyses were performed according to U.S. Environmental Protection Agency methodologies where applicable.

Results of the analyses for specific organic compounds are based upon the matching of retention times, between samples and standards, on a single gas chromatographic column.

Sample #4 contained an oily material that was not included in this analysis. Only the aqueous portion of the sample was analyzed.

FOR RECRA ENVIRONMENTAL LABORATORIES

DATE

Robert J. Macius
10/30/84

ANALYTICAL RESULTS

MONROE COUNTY ENVIRONMENTAL HEALTH LABORATORY
GAS CHROMATOGRAPHY
QUALITY CONTROLReport Date: 10/30/84
Date Received: 10/16/84REPLICATE ANALYSIS OF
SAMPLE #1

COMPOUND IDENTIFICATION	UNITS OF MEASURE	VALUE 1	VALUE 2	MEAN	STANDARD DEVIATION	PERCENT COEFFICIENT OF VARIATION
Benzene	ug/l	6,000	5,600	5,800	280	4.9
Toluene	ug/l	4,900	4,700	4,800	140	2.9
meta-Xylene	ug/l	1,400	2,000	1,700	420	25
ortho-Xylene	ug/l	1,400	1,900	1,700	350	21
para-Xylene	ug/l	760	700	730	42	5.8

RECOVERY ANALYSIS OF
SAMPLE #1

COMPOUND IDENTIFICATION	ng OF SPIKE	ng RECOVERED	% RECOVERY
Benzene	22	18	82
Toluene	23	20	87
meta-Xylene	19	13	68
ortho-Xylene	20	14	70
para-Xylene	20	14	70

FOR RECRA ENVIRONMENTAL LABORATORIES

DATE

Reborah G. Prall
10/30/84

Sample from the pool at
the base of the lower falls

ANALYTICAL RESULTS

MONROE COUNTY ENVIRONMENTAL HEALTH LABORATORY

Report Date: 11/14/84

INTRODUCTION:

On October 16, 1984 a sample was received at Recra Environmental Laboratories. A request was made by Monroe County Environmental Health Laboratory to have the sample analyzed under conditions for the Environmental Protection Agency decreed priority pollutants. The sample chromatograms were then to be compared to the chromatograms of sample RG&E Tunnel which was analyzed on an earlier date.

METHODS:

Priority pollutant analyses were conducted according to Environmental Protection Agency (EPA) methodologies.

The sample was analyzed by Gas Chromatography/Mass Spectrometry (GC/MS).

RESULTS AND DISCUSSION:

Enclosed are the sample chromatograms.

A similarity is seen between the extractable fractions of each sample. It must be noted that the chromatogram of sample RG&E Tunnel represents a dilution of 100 times of the extract.

The three main volatile constituents of the RG&E Tunnel sample- benzene, toluene & ethylbenzene- are not seen in the 6&7 sample volatile fraction.

Respectfully Submitted,

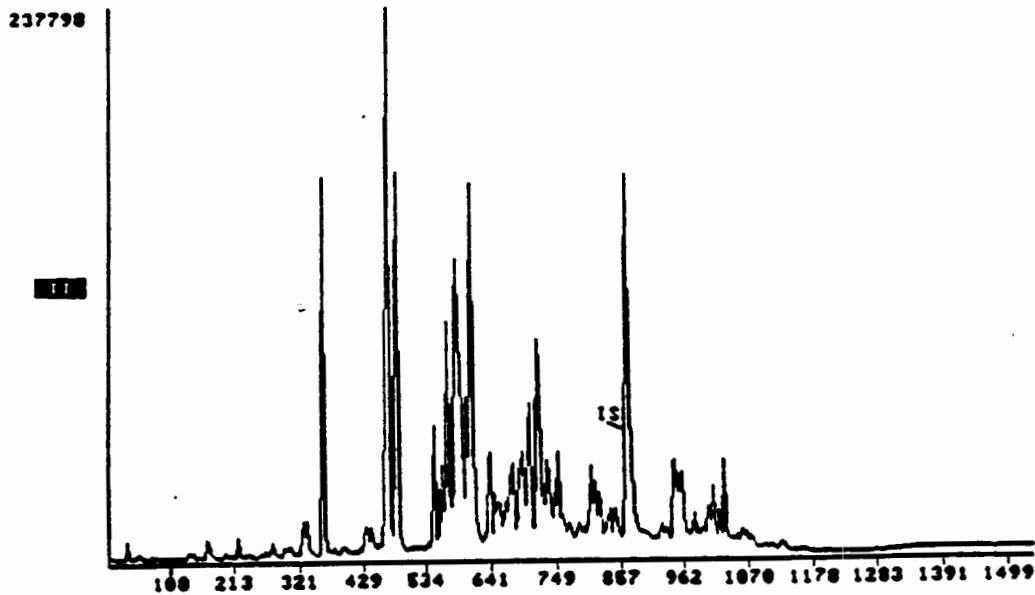
RECRA ENVIRONMENTAL LABORATORIES



Barbara J. Krajewski
GC/MS Supervisor

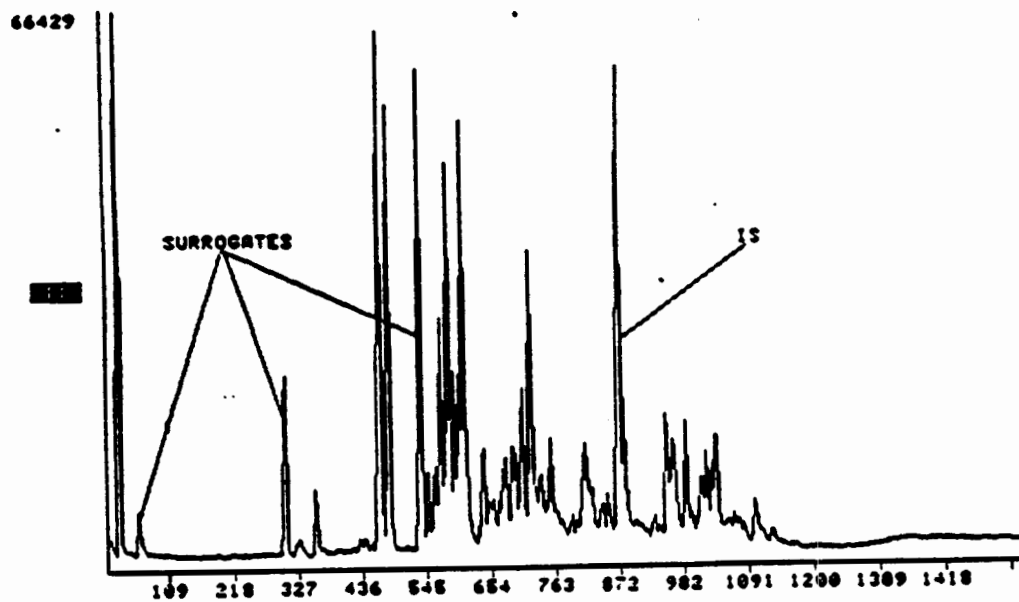
NUM: R6JE TUNNEL JOB 962
PINT: DF100 PP12912/13 BN/AP

EXP: 30381



NUM: 6647 JOB 1038A
PINT: PP13079/80 BN/AP

EXP: 30520



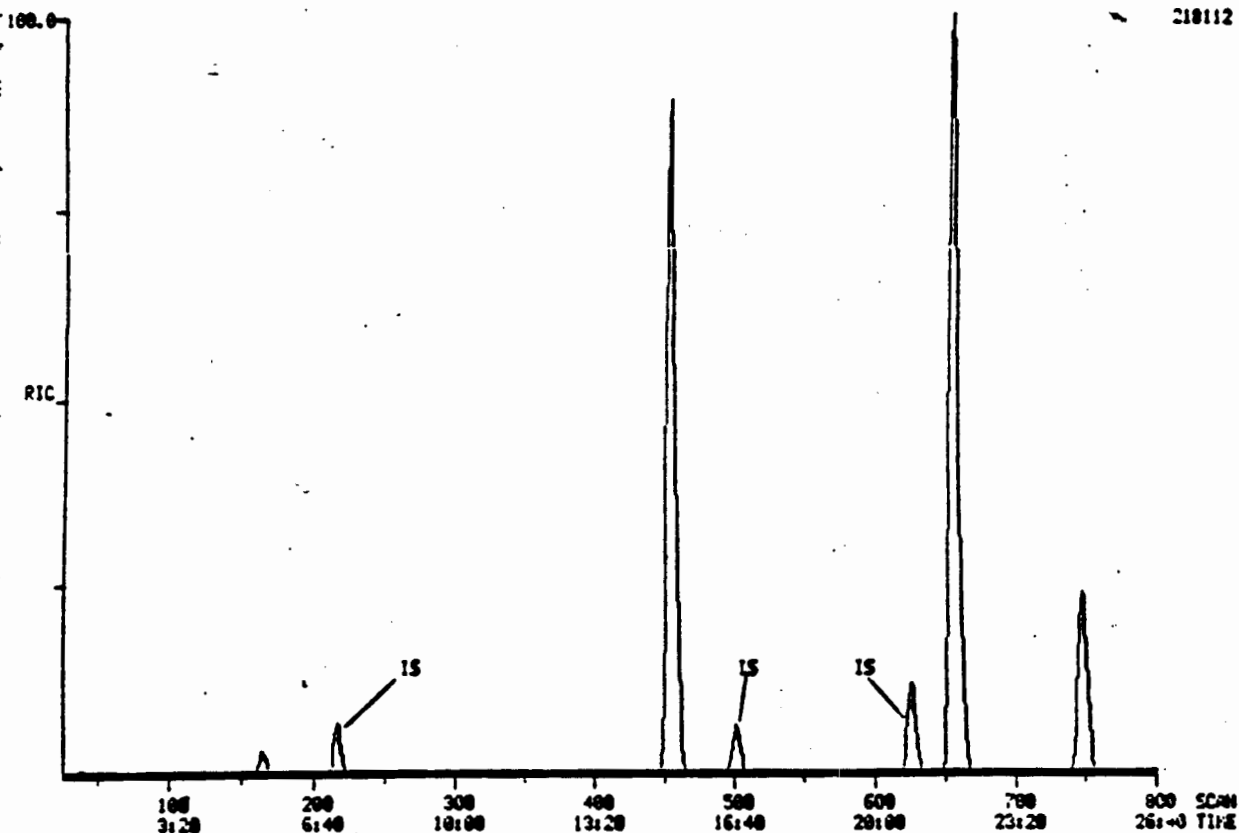
RIC
 10/25/04 17:23:00
 SAMPLE: RCLE TUNNEL JOB 962 UOA
 RANGE: G 1, 4 LABEL: N -4.12.0 QUANT: A 0, 1.0 BASE: U 20, 3

DATA: 5337 0454
 CALI: CAL1005 04

SCANS 25 TO 800

SECTION 4 3
REF 7

218112

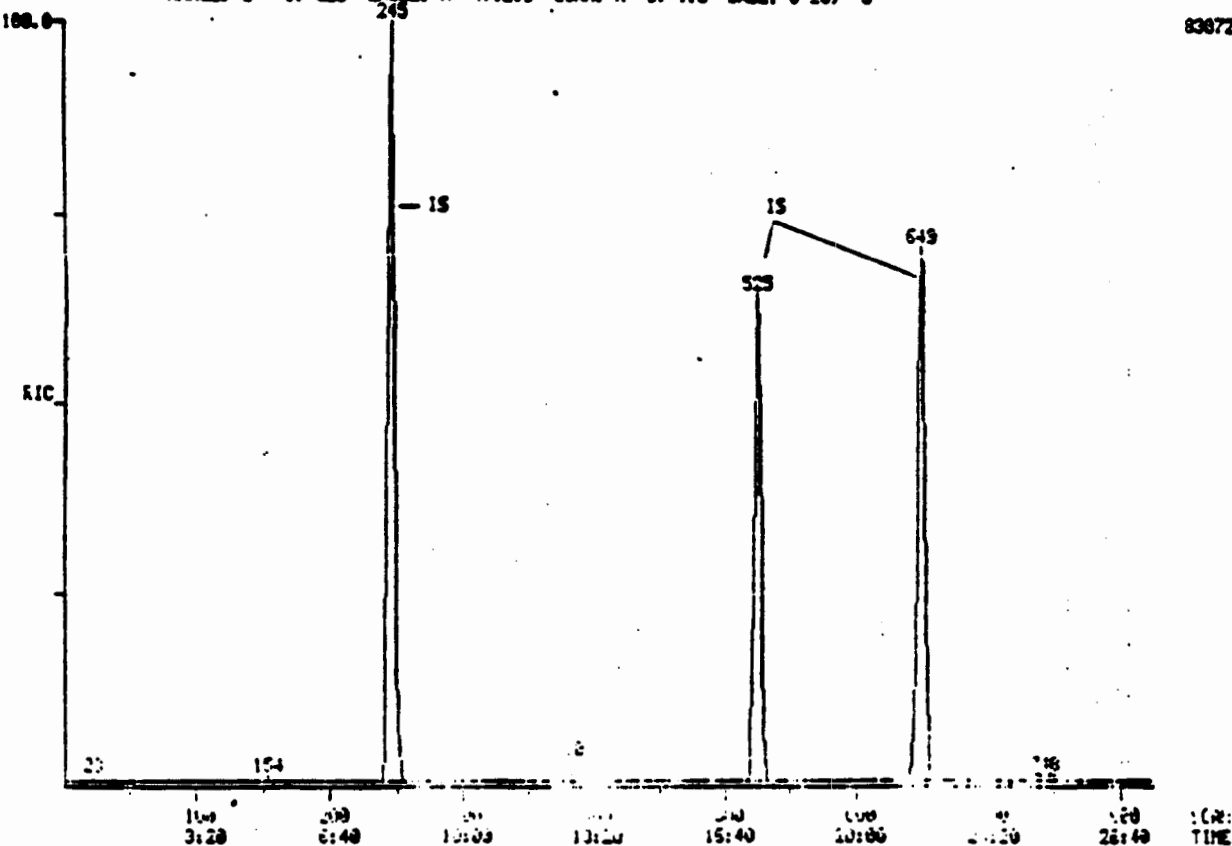


RIC
 10/26/04 22:52:00
 SAMPLE: 9803 647 JOB 1038A UOA WATER
 RANGE: G 1, 825 LABEL: N -4.12.0 QUANT: A 0, 1.0 BASE: U 20, 3

DATA: 9803 01
 CALI: CAL1025 05

SCANS 1 TO 825

83872



ANALYTICAL RESULTS

Prepared For

New York State
Department of Environmental Conservation
Division of Solid and Hazardous Waste
Bureau of Hazardous Site Control
50 Wolf Road
Albany, New York 12233

Prepared By

Recra Environmental, Inc.
10 Hazelwood Drive, Suite 106
Amherst, New York 14150

METHODOLOGIES

The specific methodologies employed in obtaining the enclosed analytical results are indicated on the specific data table. The method numbers presented refer to the following U.S. Environmental Protection Agency reference.

- o 40 CFR Part 136 "Guidelines Establishing Test Procedures for the Analysis of Pollutants Under the Clean Water Act" October 26, 1984 (Federal Register) U.S. Environmental Protection Agency.

COMMENTS

Comments pertain to data on one or all pages of this report.

The values reported as "less than" (<) indicate the working detection limit for the particular sample and/or parameter.

The estimated concentration for the tentatively identified components is quantified by the internal standard method. Raw area counts are used for both the compound to be measured and the internal standard. A response factor of 1 is assumed. This value is a rough estimation, since instrumental responses have been known to vary as much as three orders of magnitude.

Computer identification for the library comparison search was derived by a comparison of the sample peak mass spectra to those in the computer's library of mass spectra. None of the compounds listed under the library comparison search could be confirmed in the absence of specific standards.



AQUEOUS MATRIX
METHOD 625 - BASE/NEUTRAL/ACID EXTRACTABLES

COMPOUND (Units of Measure = µg/l)	SAMPLE IDENTIFICATION
	#6 & 7
Acenaphthene	190
Acenaphthylene	1,300
Anthracene	680
Benzo(a)anthracene	1,600*
Benzo(b)fluoranthene	730**
Benzo(k)fluoranthene	<62
Benzo(a)pyrene	1,000
Benzo(g,h,i)perylene	<100
Bis(2-chloroethyl)ether	<140
Bis(2-chloroethoxy)methane	<130
Bis(2-chloroisopropyl)ether	<140
Bis(2-ethylhexyl)phthalate	<62
4-Bromophenylphenylether	<48
Butyl benzyl phthalate	<62
2-Chloronaphthalene	<48
4-Chlorophenylphenylether	<100
Chrysene	<62
Dibenzo(a,h)anthracene	<62
Di-n-butyl phthalate	780
1,2-Dichlorobenzene	<48
1,3-Dichlorobenzene	<48
1,4-Dichlorobenzene	<110
3,3'-Dichlorobenzidine	<420
Diethyl phthalate	<550
Dimethyl phthalate	<40
2,4-Dinitrotoluene	<140
2,6-Dinitrotoluene	<48
Di-n-octylphthalate	<62
Fluoranthene	980
Fluorene	770
Hexachlorobenzene	<48
Hexachlorobutadiene	<23
Hexachlorocyclopentadiene	<620
Hexachloroethane	<40
Indeno(1,2,3-cd)pyrene	<92
Isophorone	<55
Naphthalene	200
Nitrobenzene	<48
N-nitrosodi-n-propylamine	<620
Phenanthrene	2,300
Pyrene	1,700

*Chromatographically, Benzo(a)anthracene and Chrysene coelute. The reported value is therefore an "and/or" value.

**Chromatographically Benzo(b)fluoranthene and Benzo(k)fluoranthene coelute. The reported value is therefore an "and/or" value.

(Continued)

1/5185

SECTION 4.3
REF. 8AQUEOUS MATRIX
METHOD 625 - BASE/NEUTRAL/ACID EXTRACTABLES

COMPOUND (Units of Measure = $\mu\text{g/l}$)	SAMPLE IDENTIFICATION
	#6 & 7
1,2,4-Trichlorobenzene	<48
4-Chloro-3-methylphenol	<75
2-Chlorophenol	<82
2,4-Dichlorophenol	<68
2,4-Dimethylphenol	<68
2,4-Dinitrophenol	<1,000
2-Methyl-4,6-dinitrophenol	<600
2-Nitrophenol	<90
4-Nitrophenol	<60
Pentachlorophenol	<90
Phenol	<38
2,4,6-Trichlorophenol	<68
Analysis Date	10/29/84
Internal Standards	
Level Added = 20 $\mu\text{g/l}$	
Phenanthrene-d10	78
(% Recovery)	
Surrogates	
Level Added = 100 $\mu\text{g/l}$	
(% Recovery)	
Decafluorobiphenyl	91
2-Fluorobiphenyl	83
2-Fluorophenol	32
Pentafluorophenol	0.45



I.D. #84-1038A

HECRA ENVIRONMENTAL, INC.

EXTRACTABLE LIBRARY COMPARISON SEARCH

SAMPLE I.D.: #6 & 7
JOB #: 84-1038A

SCAN #	COMPOUND	ESTIMATED CONCENTRATION (µg/l)
25	Unknown	1,600
328	Unknown ² (Possibly substituted aromatic)	140
431	Unknown (Possibly substituted aromatic)	70
467	Methyl-naphthalene isomer	1,900
482	Methyl-naphthalene isomer	1,500
548	1,1'-Biphenyl	180
560	2-Ethyl-naphthalene	260
570	Dimethyl-naphthalene isomer	770
583	Dimethyl-naphthalene isomer	1,600
592	2-Ethenyl-naphthalene	510
600	Dimethyl-naphthalene isomer	700
641	3-Methyl-1,1'-Biphenyl	440
649	4-Methyl-1,1'-Biphenyl	100
657	(Methylethyl)-naphthalene isomer	200
667	Unknown (Possibly dibenzofuran)	88
675	Trimethyl-naphthalene isomer	310
679	Trimethyl-naphthalene isomer	190
689	Unknown (Possibly substituted aromatic)	550
706	Unknown	510
716	Unknown (Possibly 9H-fluorene)	230



EXTRACTABLE LIBRARY COMPARISON SEARCH

SAMPLE I.D.: #6 & 7
JOB #: 84-1038A

SCAN #	COMPOUND	ESTIMATED CONCENTRATION (µg/l)
738	Unknown	340
754	9H-Fluorene	330
764	Unknown (Possibly substituted aromatic)	51
773	Unknown	73
791	Unknown	87
812	Unknown (Possibly 2-Methyl-9H-fluorene)	380
817	9-Methyl-9H-fluorene	190
825	4-Methyl-9H-fluorene	140
843	2-Methyl-9H-fluorene	120
851	Dibenzothiophene	150
931	Unknown (Possibly substituted aromatic)	100
951	4-Methyl-phenanthrene	500
964	9-Methyl-phenanthrene	590
988	Unknown (Possibly substituted aromatic)	110
1010	Unknown (Possibly substituted aromatic)	170
1059	Unknown (Possibly substituted aromatic)	97
1066	11H-Benzo-fluorene isomer	70
1072	Unknown (Possibly substituted aromatic)	68
1080	Methyl-pyrene isomer	67



VINCE - FYI - make it coming
Din Money

SECTION 4.3
VINCE REF 10

DICK

Do this please
in FYI

CHESTER GAS AND ELECTRIC CORPORATION

CHEMICAL/ENVIRONMENTAL LABORATORY

Inter-Office Correspondence

September 19, 1985

SUBJECT: Station 5 Tunnel - Seep Locations
Sampled by: C.R. McKay and P.C. Camel
1000-1130 hours, 7/31/85

TO: D.J. Money

The first indication of organic residue entering the tunnel was at about the 750-foot mark. There were two or three locations where water was coming into the tunnel before this, but there was no indication of organic matter. A sample was taken off the wall at 750 feet and at 780 feet. The organic matter was very thick in consistency. It was necessary to get a lot of silt along with these samples. At 800 and 875 feet there was material of about the same consistency on the walls. At 875 feet it was down both sides of the tunnel wall. Water was flowing down the wall at all of these locations.

Between 1000 and 1075 feet there was a lot of water flowing directly to the tunnel floor. The surface of the water on the tunnel floor was coated with a film of the brown organic liquid. From 1250 feet to the south end of the tunnel there were several seeps with a considerable amount of water flowing directly to the floor. There was a heavy film of brown organic liquid on the surface of the water flowing back to the sump pump. A sample of this water and film was taken at about 1250 feet. At one location near the south end of the tunnel the brown organic liquid was dripping directly to the tunnel floor (about one drop every second). A sample of this material was collected by allowing it to drip directly into the sample container.

C. Robert McKay
C. Robert McKay
Supervisor
Chemical Laboratory

CLIENT ROCHESTER GAS & ELECTRIC CORPORATIONJOB NO. 2246.006.517DESCRIPTION Semi Solid SampleSAMPLE NO. 44893 DATE COLLECTED 7-31-84 DATE REC'D. 8-6-84 DATE ANALYZED 8-23-84

ppm	ppm
1,3-Dichlorobenzene	Diethylphthalate
1,4-Dichlorobenzene	N-nitrosodiphenylamine
1,2-Dichlorobenzene	Hexachlorobenzene
Hexachloroethane	4-Bromophenyl phenyl ether
Bis (2-chloroethyl) ether	Phenanthrene 56000.
Bis (2-chloroisopropyl) ether	Anthracene 44000.
N-Nitrosodi-n-propylamine	Di-n-butyl phthalate
Nitrobenzene	Fluoranthene 23000.
Hexachlorobutadiene	Pyrene
1,2,4-Trichlorobenzene	Benzidine
Isophorone	Butyl benzyl phthalate
Naphthalene 3100.	Bis(2-ethylhexyl)phthalate
Bis (2-chloroethoxy) methane	Chrysene 9800.
Hexachlorocyclopentadiene	Benzo(a)anthracene
2-Chloronaphthalene	3,3-Dichlorobenzidine
Acenaphthylene 14600.	Di-n-octylphthalate
Acenaphthene 8600.	Benzo(b)fluoranthene
Dimethyl phthalate	Benzo(k)fluoranthene 3200.
2,6-Dinitrotoluene	Benzo(a)pyrene 4600.
Fluorene 17500.	Indeno(1,2,3-cd)pyrene
4-Chlorophenyl phenyl ether	Dibenzo(a,h)anthracene
2,4-Dinitrotoluene	Benzo(g,h,i)perylene
1,2-Diphenylhydrazine	N-Nitrosodimethyl Amine

Methodology: Federal Register — 40 CFR, Part 136, December 3, 1979

Comments:

Same as previous sample



SECTION 4.3
REF. 11

O'BRIEN & GERE

September 26, 1984

Mr. C. Robert McKay
Supervisor, Chemical Laboratory
ROCHESTER GAS AND ELECTRIC CORPORATION
89 East Avenue
Rochester, NY 14649

File: 2246.006.517

Dear Mr. McKay:

Enclosed please find the results of analytical testing performed on samples received August, 1984. The samples included three charcoal tubes and a container of black substance.

The tubes were analyzed for hydrocarbon and the report sheet reveals the predominant peaks. There were several unidentified peaks at less than 10% of the major components. The black material was identified as a coal tar base. The mass spectral scan revealed the presence of polynuclear aromatic compounds which are characteristic of coal tar. We did not see straight chain hydrocarbons which would have indicated a petroleum based material.

Should you have further questions, please feel free to contact us.

Very truly yours,

O'BRIEN & GERE ENGINEERS, INC.

David R. Hill
Manager of Analytical Services

DRH/bpp

Enclosure



O'BRIEN & GERE

SECTION 4.3
REF. 11Base/Neutral
Priority PollutantsCLIENT ROCHESTER GAS & ELECTRIC CORPORATIONJOB NO. 2246.006.517DESCRIPTION Semi Solid SampleSAMPLE NO. 44893 DATE COLLECTED 7-31-84 DATE REC'D. 8-6-84 DATE ANALYZED 8-23-84

ppm

ppm

1,3-Dichlorobenzene		Diethylphthalate	
1,4-Dichlorobenzene		N-Nitrosodiphenylamine	
1,2-Dichlorobenzene		Hexachlorobenzene	
Hexachloroethane		4-Bromophenyl phenyl ether	
Bis (2-chloroethyl) ether		Phenanthrene	56000.
Bis (2-chloroisopropyl) ether		Anthracene	44000.
N-Nitrosodi-n-propylamine		Di-n-butyl phthalate	
Nitrobenzene		Fluoranthene	23000.
Hexachlorobutadiene		Pyrene	
1,2,4-Trichlorobenzene		Benzdine	
Isophorone		Butyl benzyl phthalate	
Naphthalene	3100.	Bis(2-ethylhexyl)phthalate	
Bis (2-chloroethoxy) methane		Chrysene	9800.
Hexachlorocyclopentadiene		Benzo(a)anthracene	
2-Chloronaphthalene		3,3-Dichlorobenzidine	
Acenaphthylene	14600.	Di-n-octylphthalate	
Acenaphthene	8600.	Benzo(b)fluoranthene	
Dimethyl phthalate		Benzo(k)fluoranthene	3200.
2,6-Dinitrotoluene		Benzo(a)pyrene	4600.
Fluorene	17500.	Indeno(1,2,3-cd)pyrene	
4-Chlorophenyl phenyl ether		Dibenzo(a,h)anthracene	
2,4-Dinitrotoluene		Benzo(g,h,i)perylene	
1,2-Diphenylhydrazine		N-Nitrosodimethyl Amine	

Methodology: Federal Register -- 40 CFR, Part 136, December 3, 1979

Comments:

Authorized: [Signature]Date: 9-26-84



SECTION 4.3
REF. 11

Laboratory Report

CLIENT: ROCHESTER GAS & ELECTRIC CORPORATION

JOB NO. 2246.006.517

caption Analysis of Charcoal Tubes for Volatile Organics

DATE COLLECTED

DATE REC'D.

DATE ANALYZED 8-24-84

[illegible]

Methodology: Federal Register — 40 CFR, Part 136, December 3, 1979

Units: mg/L (ppm) unless otherwise noted

RESEARCH

ND = None Detected

O'Brien & Gere Engineers, Inc.

x 4873 / 1304 Buckley Rd. / Syracuse, NY / 13221 / (315) 451-4700

Author's note

Date: 9-26-84



RECRA ENVIRONMENTAL LABORATORIES

Division of Recra Research, Inc.

ANALYTICAL RESULTS

MONROE COUNTY ENVIRONMENTAL HEALTH LABORATORY PRIORITY POLLUTANT ANALYSES

Prepared For:

Monroe County Environmental
Health Laboratory
435 East Henrietta Rd.
Rochester, NY 14620

Prepared By:

Recra Environmental Laboratories
4248 Ridge Lea Rd.
Amherst, NY 14226

Report Date: October 29, 1984



RECRA ENVIRONMENTAL LABORATORIES

Division of Recra Research, Inc.

SECTION 4.3
REF-12

October 29, 1984

Mr. Richard Burton
Monroe County Environmental
Health Laboratory
435 East Henrietta Rd.
Rochester, NY 14620

Re: Analytical Results

Dear Mr. Burton:

Please find enclosed results of the analyses of the sample received at our laboratories on September 20, 1984.

If you have any questions concerning these data, do not hesitate to contact our Customer Service Representative at (716) 692-7620.

Sincerely,

RECRA ENVIRONMENTAL LABORATORIES

James A. Ploscyca
Laboratory Manager

BJK/JAP/dmf
Enclosure

I.D. #84-962

ANALYTICAL RESULTS

MONROE COUNTY ENVIRONMENTAL HEALTH LABORATORY PRIORITY POLLUTANT ANALYSES

Report Date: 10/29/84

INTRODUCTION:

On September 20, 1984 a sample was received at Recra Environmental Laboratories. A request was made by the Monroe County Environmental Health Laboratory to have the sample analyzed for selected fractions of the Environmental Protection Agency decreed priority pollutants and to qualify and quantify any significant non-priority pollutant peaks identified in the fractions.

This report will address the results of those analyses.

METHODS:

Priority pollutant analyses were conducted according to Environmental Protection Agency (EPA) methodologies.

Organic priority pollutants were analyzed by Gas Chromatography/Mass Spectrometry (GC/MS).

RESULTS AND DISCUSSION:

No volatile field blank was received.

The sample was received in one volatile vial. Analysis for the volatile compounds was performed first and the remaining volume was then used for the acid/base neutral fraction. Since material was adhering to the sides of the vial, the concentration for the acid/base neutral fraction is not considered valid.

The detection limits for the acid/base neutral fraction reflect the limited sample volume available and the high concentrations of compounds found which necessitated sample extract dilution.



RESULTS AND DISCUSSION: (Cont'd.)

Benzo(a)anthracene/chrysene and benzo(b)fluoranthene/benzo(k)fluoranthene coelute and have similar mass spectra. Positive values should be interpreted as the presence of either or both isomers and are reported only once to avoid confusion.

Computer identification for the library comparison search is derived by a comparison of the sample peak mass spectra to those in the computer's library of mass spectra. None of the compounds listed under the library comparison search could be confirmed due to the absence of specific standards. The estimated concentration of these tentatively identified compounds is quantified by the internal standard method. A response factor of 1 is assumed. This value is a rough estimation since instrumental responses have been known to vary as much as three orders of magnitude.

Compounds reported as ND are "not detected".

Respectfully Submitted,

RECRA ENVIRONMENTAL LABORATORIES



Barbara J. Krajewski
GC/MS Supervisor

BJK/dmf



ANALYTICAL RESULTS

MONROE COUNTY ENVIRONMENTAL HEALTH LABORATORY GAS CHROMATOGRAPHY/MASS SPECTROMETRY PRIORITY POLLUTANT ANALYSES

Report Date: 10/29/84

ACID/PHENOLICS

COMPOUND	DETECTION LIMIT (ug/l)	SAMPLE IDENTIFICATION
		RG&E TUNNEL
2-chlorophenol	870	ND
2,4-dichlorophenol	710	ND
2,4-dimethylphenol	710	ND
4,6-dinitro-o-cresol	6,300	ND
2,4-dinitrophenol	110,000	ND
2-nitrophenol	950	ND
4-nitrophenol	630	ND
p-chloro-m-cresol	790	ND
pentachlorophenol	950	ND
phenol	390	ND
2,4,6-trichlorophenol	710	ND

ADDITIONAL SAMPLE INFORMATION

Sample Date	-
Extraction Date	10/11/84
Analysis Date	10/24/84
Internal Standard (IS) - Level	20 ug/l
deuterated phenanthrene - Recovery	51%
Surrogate Standard (SS1) - Level	100 ug/l
2-fluorophenol - Recovery	**
Surrogate Standard (SS2) - Level	100 ug/l
pentafluorophenol - Recovery	**

**Surrogate recoveries could not be determined due to the high concentration of compounds present which necessitated sample extract dilutions.

FOR RECRA ENVIRONMENTAL LABORATORIES

DATE

Edward J. Kazianka
10/29/84



ANALYTICAL RESULTS

MONROE COUNTY ENVIRONMENTAL HEALTH LABORATORY
 GAS CHROMATOGRAPHY/MASS SPECTROMETRY
 PRIORITY POLLUTANT ANALYSES

Report Date: 10/29/84

BASE/NEUTRALS

COMPOUND	DETECTION LIMIT (ug/l)	SAMPLE IDENTIFICATION
		RG&E TUNNEL
benaphthene	500	8,400 ug/l
benaphthylene	920	57,000 ug/l
anthracene	500	29,000 ug/l
benzidine	115,000	ND
benzo(a)anthracene	2,000	11,000 ug/l
benzo(a)pyrene	660	6,300 ug/l
benzo(b)fluoranthene	1,300	5,000 ug/l
benzo(g,h,i)perylene	1,100	1,300 ug/l
benzo(k)fluoranthene	660	-
bis(2-chloroethoxy)methane	1,400	ND
bis(2-chloroethyl)ether	1,500	ND
bis(2-chloroisopropyl)ether	1,500	ND
bis(2-ethylhexyl)phthalate	660	ND
2-bromophenylphenylether	500	ND
butylbenzylphthalate	660	ND
2-chloronaphthalene	500	ND
2-chlorophenylphenylether	1,100	ND
chrysene	660	-
dibenzo(a,h)anthracene	660	ND
1,2-dichlorobenzene	500	ND
1,3-dichlorobenzene	500	ND
1,4-dichlorobenzene	1,200	ND
3,3'-dichlorobenzidine	4,300	ND
diethylphthalate	5,800	ND
dimethylphthalate	420	ND
di-n-butylphthalate	660	ND

(Continued)



ANALYTICAL RESULTS

MONROE COUNTY ENVIRONMENTAL HEALTH LABORATORY
GAS CHROMATOGRAPHY/MASS SPECTROMETRY
PRIORITY POLLUTANT ANALYSES

Report Date: 10/29/84

BASE/NEUTRALS

COMPOUND	DETECTION LIMIT (ug/l)	SAMPLE IDENTIFICATION
		RG&E TUNNEL
2,6-dinitrotoluene	500	ND
2,4-dinitrotoluene	1,500	ND
di-n-octylphthalate	660	ND
1,2-diphenylhydrazine	6,600	ND
fluoranthene	580	6,500 ug/l
fluorene	500	38,000 ug/l
hexachlorobenzene	500	ND
hexachlorobutadiene	240	830 ug/l
hexachlorocyclopentadiene	6,600	ND
hexachloroethane	420	ND
indeno(1,2,3-cd)pyrene	970	ND
isophorone	580	ND
naphthalene	420	42,000 ug/l
nitrobenzene	500	ND
N-nitrosodimethylamine	6,600	ND
N-nitrosodi-n-propylamine	6,600	ND
N-nitrosodiphenylamine	500	ND
phenanthrene	1,400	55,000 ug/l
pyrene	500	18,000 ug/l
1,2,4-trichlorobenzene	500	ND

ADDITIONAL SAMPLE INFORMATION

Sample Date	-
Extraction Date	10/11/84
Analysis Date	10/24/84
Internal Standard - Level	20 ug/l
deuterated phenanthrene - Recovery	51%
Surrogate Standard (SS3) - Level	100 ug/l
decafluorobiphenyl - Recovery	120%
Surrogate Standard (SS4) - Level	100 ug/l
2-fluorobiphenyl - Recovery	82%

FOR RECRA ENVIRONMENTAL LABORATORIES

DATE

Barbara J. Krajendic
10/29/84

RECRA ENVIRONMENTAL LABORATORIES

T. D. 431-062

ANALYTICAL RESULTS

MONROE COUNTY ENVIRONMENTAL HEALTH LABORATORY
GAS CHROMATOGRAPHY/MASS SPECTROMETRY
PRIORITY POLLUTANT ANALYSES

Report Date: 10/29/84

VOLATILES

COMPOUND	DETECTION LIMIT (ug/l)	SAMPLE IDENTIFICATION
		RG&E TUNNEL
acrolein	400	ND
acrylonitrile	400	ND
benzene	4.4	180 ug/l
bromodichloromethane	2.2	ND
bromoform	4.7	ND
bromomethane	10	ND
carbon tetrachloride	2.8	ND
chlorobenzene	6.0	ND
chloroethane	10	ND
1-chloroethylvinyl ether	10	ND
chloroform	1.6	ND
chloromethane	10	ND
dibromochloromethane	3.1	ND
1,1-dichloroethane	4.7	ND
1,2-dichloroethane	2.8	ND
1,1-dichloroethylene	2.8	ND
trans-1,2-dichloroethylene	1.6	ND
1,2-dichloropropane	6.0	ND
1,3-dichloropropene	5.0	ND
ethylbenzene	7.2	34 ug/l
ethylene chloride	2.8	ND
1,1,2,2-tetrachloroethane	6.9	ND
tetrachloroethylene	4.1	ND

(Continued)



ANALYTICAL RESULTS

MONROE COUNTY ENVIRONMENTAL HEALTH LABORATORY
GAS CHROMATOGRAPHY/MASS SPECTROMETRY
PRIORITY POLLUTANT ANALYSES

Report Date: 10/29/84

VOLATILES

COMPOUND	DETECTION LIMIT (ug/l)	SAMPLE IDENTIFICATION
		RG&E TUNNEL
toluene	6.0	160 ug/l
1,1,1-trichloroethane	3.8	ND
1,1,2-trichloroethane	5.0	ND
trichloroethylene	1.9	ND
vinyl chloride	10	ND

ADDITIONAL SAMPLE INFORMATION

Sample Date	-
Analysis Date	10/5/84
Internal Standard - Level	40 ug/l
1-bromochloromethane - Recovery	120%
Internal Standard - Level	40 ug/l
1,2-bromo-1-chloropropane - Recovery	98%
Internal Standard - Level	40 ug/l
1,4-dichlorobutane - Recovery	130%

FOR RECRA ENVIRONMENTAL LABORATORIES

DATE

Barbara J. Krajewski
10/29/84

ANALYTICAL RESULTS

MONROE COUNTY ENVIRONMENTAL HEALTH LABORATORY
GAS CHROMATOGRAPHY/MASS SPECTROMETRY
LIBRARY COMPARISON SEARCH

Report Date: 10/29/84

SAMPLE I.D.: RG&E TUNNEL
EXTRACTABLE FRACTION

SCAN #	COMPUTER LIBRARY IDENTIFICATION	CAS #	ESTIMATED CONCENTRATION (ug/l)
326	1,2,3,4-tetrahydro-1,4-methanonaphthalen-9-one	6165884	7,000
433	1,2-dihydro-6-methylnaphthalene	2717477	6,000
472	1-methylnaphthalene	90120	80,000
487	2-methylnaphthalene	91576	50,000
548	1,1'-biphenyl	92524	10,000
560	2-ethylnaphthalene	939275	6,000
571	1,5-dimethylnaphthalene	571619	30,000
585	3,3'-bipyridine	581464	50,000
594	2,2'-bipyridine	366187	10,000
640	1,1'-methylenebisbenzene	101815	10,000
678	2-(1-methylethyl)naphthalene	2027170	6,000
691	2,3,6-trimethylnaphthalene	829265	20,000
705	1H-phenalene	203805	20,000
735	1,1'-(diazomethylene)bisbenzene	883409	8,000
808	9-methyl-9H-fluorene	2523377	7,000
821	4-methyl-9H-fluorene	1556996	4,000
946	4-methylphenanthrene	832644	10,000

FOR RECRA ENVIRONMENTAL LABORATORIES

DATE

Brian J. Kuzewski
10/29/84



ANALYTICAL RESULTS

MONROE COUNTY ENVIRONMENTAL HEALTH LABORATORY
GAS CHROMATOGRAPHY/MASS SPECTROMETRY
LIBRARY COMPARISON SEARCH

Report Date: 10/29/84

SAMPLE I.D.: RG&G TUNNEL
VOLATILE FRACTION

<u>SCAN #</u>	<u>COMPUTER LIBRARY IDENTIFICATION</u>	<u>CAS #</u>	<u>ESTIMATED CONCENTRATION (ug/l)</u>
165	carbon disulfide	75-15-0	20

FOR RECRA ENVIRONMENTAL LABORATORIES

DATE

Bobana J. Kujewski
10/29/84

RIC

10/05/84 17:23:00

SAMPLE: ROSE TUNNEL JOB 962 UOA

RANGE: G 1 4 LABEL: H -4.12.0 CURVE: A 0, 1.0 BASE: U 20. 3

DATA: 9357 1154

CH1: CAL1005 14

SUM15

25

218112

100.0

RIC

15

15

15

#165

100
3:20

200
6:40

300
10:00

400
13:20

500
16:40

600
20:00

700
23:20

800
26:40

SECTION 4.5
REF 12

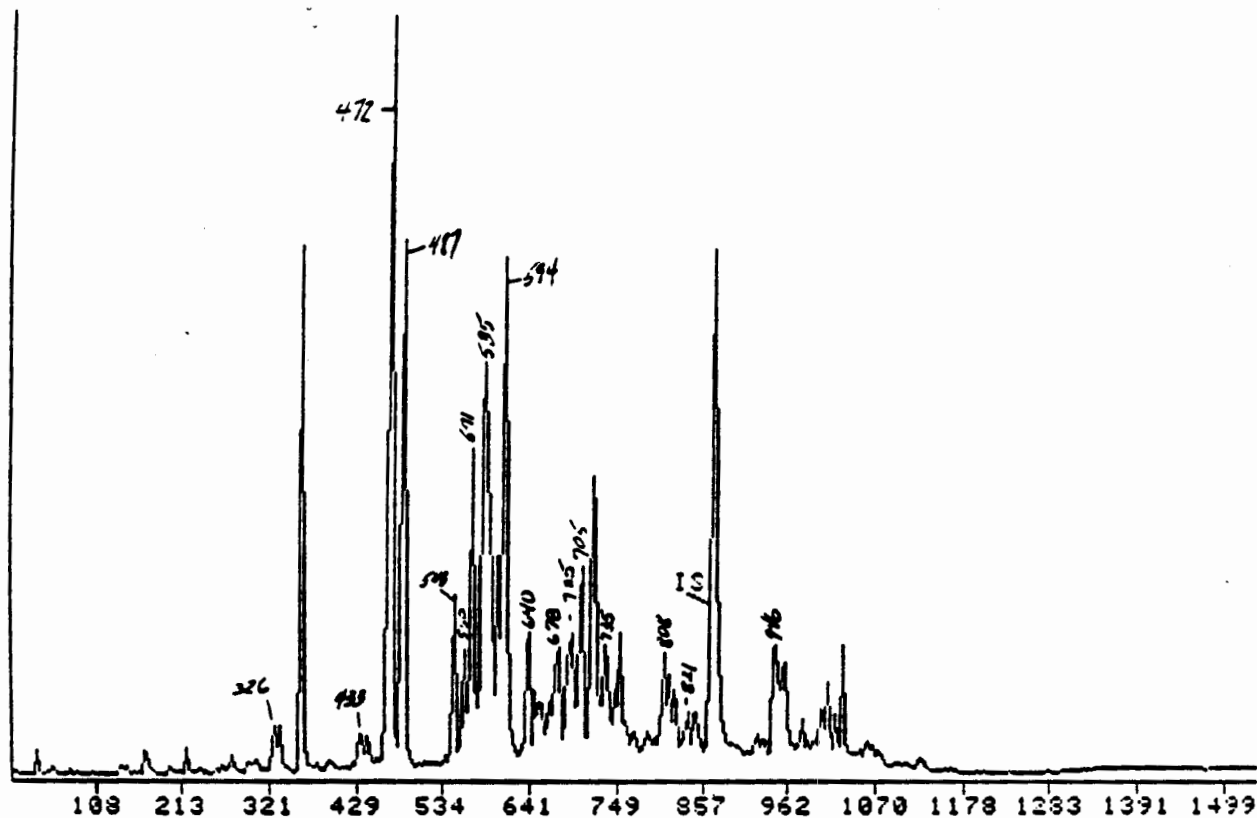
SECTION 4.0
REF. 12

NAME RGJE TUNNEL JOB 962
MISC DF100 PP12912/13 BN/AP

FRN 30381

237798

TI



SECTION 4.3
REF 13

APPENDIX CC

Laboratory Analyses of Samples -
RG&E Tunnel and Station 5

TABLE T

SAMPLE COMPARISONS OF R.G. & E. AND ST. PAUL INTERCEPTOR TUNNELS

Ground	Concentration (ppm)	
	R.G. & E. ¹	St. Paul Interceptor ²
phthalene	42*	19,000
Methylnaphthalene	50	12,000
naphthylene	57	4,700
naphthene	8.4	56
benzofuran	NA	39
fluorene	38	2,000
benanthrene	55	4,800
anthracene	29	1,600
fluoranthene	6.5	1,100
ene	18	1,800
azo(a)anthracene	11	160
ysene	NA	830
azo(b)fluoranthene	5	40
azo(k)fluoranthene	NA	69
azo(a)pyrene	6.3	130
beno(1,2,3-cd)pyrene	ND	55
azo(g,h,i)perylene	1.3	52
ene	<1	57
luene	<1	25

estimated by library comparison search

- not analyzed

- not detected

taken from Recra report on River (Green Hill)
(#3)

Sample was collected from a pool at the base of the Lower Falls for comparison with the R.G. & E. tunnel sample. Results showed a similarity between the extractable fractions of each sample but the pool sample lacked the volatile constituents found in the tunnel sample.

Sample analysis by Recra Research, Inc.

Sample analysis by Versar, Inc.

SOURCE: Genesee River Sediment Toxics Survey, May 1985.

STATION 5 TUNNEL REPAIR

Water Treatment Tank

Inlet		Outlet												
Date	Oil & Grease	pH	Benzene	Toluene	m-Xylene	p-Xylene	o-Xylene	Oil & Grease	pH	Benzene	Toluene	m-Xylene	p-Xylene	o-Xylene
								ppb						
7/25/85								1	6.4	540	830	680	580	*
								3	7.3	170	38	40	9	35
								1	8.2	240	240	220	75	160
								1	8.3	16	8	43	12	31
8/08/85	33							2	7.4	32	36	53	16	39
8/12/85	40							1	7.7	40	4	76	15	58
8/15/85	18	560	950	350	130	250		2	7.8	38	<1	110	20	85
8/19/85	14							1	8.0	210	45	74	17	74
8/22/85	12							1	7.9	220	60	120	36	95
8/26/85	26							1	7.8	330	220	140	26	98
8/29/85	16							<1	9.9	480	620	220	88	170
9/03/85	1							1	11.0	220	270	130	50	87
9/05/85	24							1	11.8	142	180	94	35	74
9/09/85	7							<1	10.4	120	150	69	25	52
9/12/85	<1							10	10.8	120	130	70	27	54
9/16/85	12							1	11.1	260	260	150	62	120
9/19/85	6							1	10.7	Sample broken at testing laboratory				
9/23/85	1							<1	8.2	250	260	99	35	78
9/26/85	7							4	8.0	140	170	98	*	84
9/30/85	12							<1	7.8	21	100	74	*	45
10/03/85	1							1	7.6	<1	3	33	*	21
10/07/85	1							1	7.7	18	94	100	*	59
10/10/85	8							3	7.7	88	41	36	10	29
10/14/85	2							1	7.5	170	130	67	23	54
10/17/85	50							1	7.5	180	160	100	37	79
10/21/85	3							1	7.6	150	130	82	29	63
10/24/85	9							3	7.8	120	110	73	25	55
10/28/85	2							3	8.2	<1	<1	<1	<1	<1
10/31/85	2							1	9.1	170	200	110	42	83
11/04/85	3							1	9.0	150	120	57	26	46
11/07/85	1							1	7.9	45	27	11	5	8
11/11/85	1							<1	8.3	25	4	10	5	9
11/14/85	4							1	8.3	85	42	76	33	56
11/18/85	4							<1	8.0					

SECTION 443
REF 13



SECTION 4
REF. 13

O'BRIEN & GERE

September 26, 1984

Mr. C. Robert McKay
Supervisor, Chemical Laboratory
ROCHESTER GAS AND ELECTRIC CORPORATION
89 East Avenue
Rochester, NY 14649

File: 2246.006.517

Dear Mr. McKay:

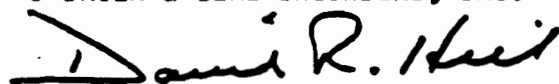
Enclosed please find the results of analytical testing performed on samples received August, 1984. The samples included three charcoal tubes and a container of black substance.

The tubes were analyzed for hydrocarbon and the report sheet reveals the predominant peaks. There were several unidentified peaks at less than 10% of the major components. The black material was identified as a coal tar base. The mass spectral scan revealed the presence of polynuclear aromatic compounds which are characteristic of coal tar. We did not see straight chain hydrocarbons which would have indicated a petroleum based material. 

Should you have further questions, please feel free to contact us.

Very truly yours,

O'BRIEN & GERE ENGINEERS, INC.



David R. Hill
Manager of Analytical Services

DRH/bpp

Enclosure

CLIENT ROCHESTER GAS & ELECTRIC CORPORATION

JOB NO. 2246.006.517

DESCRIPTION Semi Solid Sample

SAMPLE NO. 44893 DATE COLLECTED 7-31-84 DATE RECD. 8-6-84 DATE ANALYZED 8-23-84

ppm	ppm
1,3-Dichlorobenzene	Diethylphthalate
1,4-Dichlorobenzene	N-nitrosodiphenylamine
1,2-Dichlorobenzene	Hexachlorobenzene
Hexachloroethane	4-Bromophenyl phenyl ether
Bis (2-chloroethyl) ether	Phenanthrene 56000.
Bis (2-chloroisopropyl) ether	Anthracene 44000.
N-Nitrosodi-n-propylamine	Di-n-butyl phthalate
Nitrobenzene	Fluoranthene 23000.
Hexachlorobutadiene	Pyrene
1,2,4-Trichlorobenzene	Benzidine
Isophorone	Butyl benzyl phthalate
Naphthalene 3100.	Bis(2-ethylhexyl)phthalate
Bis (2-chloroethoxy) methane	Chrysene 9800.
Hexachlorocyclopentadiene	Benzo(a)anthracene
2-Chloronaphthalene	3,3-Dichlorobenzidine
Acenaphthylene 14600.	Di-n-octylphthalate
Acenaphthene 8600.	Benzo(b)fluoranthene
Dimethyl phthalate	Benzo(k)fluoranthene 3200.
2,6-Dinitrotoluene	Benzo(a)pyrene 4600.
Fluorene 17500.	Indeno(1,2,3-cd)pyrene
4-Chlorophenyl phenyl ether	Dibenzo(a,h)anthracene
2,4-Dinitrotoluene	Benzo(g,h,i)perylene
1,2-Diphenylhydrazine	N-Nitrosodimethyl Amine

Methodology: Federal Register — 40 CFR, Part 136, December 3, 1979

Comments:

*see have this
in duplicate*

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Appendix B
JV-290 D183 Section 4.3
Ref 15

CONFIDENTIAL
Copy 3 of 7

LABORATORY REPORT ON THE ANALYSIS
OF SOIL AND WATER SAMPLES FOR THE
COMBINED SEWER OVERFLOW
ABATEMENT PROGRAM,
ROCHESTER PURE WATERS DISTRICT

*Ambrose Smith
Coast Guard*

September 1981

Prepared for:

LOZIER-SEELYE-TONIAS
65 West Broad Street
Rochester, New York 14614



ecology and environment, inc.

195 SUGG ROAD, P.O. BOX D, BUFFALO, NEW YORK 14225, TEL. 716-632-4491

International Specialists in the Environmental Sciences

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Appendix
B
Section 4.3
Ref. 15

1. INTRODUCTION

This is a laboratory report on the analysis of a series of soil and water samples collected by the hazardous materials group of Ecology and Environment, Inc., (E & E) for the Combined Sewer Overflow Abatement Program, Rochester Pure Waters District.

The samples were received by E & E's Analytical Services Center (ASC) from August 3 through August 13, 1981. They were analyzed to determine whether hazardous substances were present. The tests selected to make this determination and the samples to be analyzed were in part chosen on the basis of field observations and monitoring and included the following:

Inorganics: Cyanide, phenols, arsenic, barium, cadmium, chromium, lead, mercury, and selenium;

Organics: Priority pollutants, base/neutral extractables, and volatiles.

The chemicals included in these analyses are listed in Table 1-1.

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Appendix B
Section 4.3
Ref. 15

Table 1-1

PRIORITY POLLUTANT ANALYSES

Base Neutral Extractables

Acenaphthene
Acenaphthylene
Anthracene
Benzo(a)anthracene
Benzo(b)fluoranthene
Benzo(k)fluoranthene
Benzo(a)pyrene
Benzo(g,h,i)perylene
Benzidine
Bis(2-chloroethyl)ether
Bis(2-chloroethoxy)methane
Bis(2-ethylhexy)phthalate
Bis(2-chloroisopropyl)ether
4-Bromophenyl phenyl ether
Butyl benzyl phthalate
2-Chloronaphthalene
4-Chlorophenyl phenyl ether
Chrysene
Dibenz(a,h)anthracene
Di-n-butylphthalate
1,3-Dichlorobenzene
1,4-Dichlorobenzene
1,2-Dichlorobenzene
3,3'-Dichlorobenzidine
Diethylphthalate
Dimethylphthalate
2,4-Dinitrotoluene
2,6-Dinitrotoluene
Diethylphthalate
1,2-Diphenylhydrazine
Fluoranthene
Fluorene
Hexachlorobenzene
Hexachlorobutadiene
Hexachloroethane
Hexachlorocyclopentadiene
Indeno(1,2,3-cd)pyrene
Isophorone
Naphthalene
Nitrobenzene
N-Nitrosodimethylamine
N-Nitrosodi-n-propylamine
N-Nitrosodiphenylamine
Phenanthrene
Pyrene
2,3,7,8-Tetrachlorodibenzo-p-dioxin
1,2,4-Trichlorobenzene

Acid Extractables

4-Chloro-3-methylphenol
2-Chlorophenol
2,4-Dichlorophenol
2,4-Dimethylphenol
2-Methyl-4,6-dinitrophenol
2-Nitrophenol
4-Nitrophenol
Pentachlorophenol
Phenol
2,4,6-Trichlorophenol

Volatile Organics

Acrolein
Acrylonitrile
Benzene
Bromomethane
Bromodichloromethane
Bromoform
Carbon tetrachloride
Chlorobenzene
Chloroethane
2-Chloroethyl vinyl ether
Chloroform
Chloromethane
Dibromochloromethane
1,1-Dichloroethane
1,2-Dichloroethane
1,1-Dichloroethene
trans-1,2-Dichloroethene
1,2-Dichloropropane
cis-1,3-Dichloropropene
trans-1,3-Dichloropropene
Ethyl benzene
Methylene chloride
1,1,2,2-Tetrachloroethane
Tetrachloroethene
1,1,1-Trichloroethane
1,1,2-Trichloroethane
Trichloroethene
Trichlorofluoromethane
Toluene
Vinyl chloride

Appendix B
Section 4.3
Ref. 15

state or promulgated by the Environmental Protection Agency (EPA) under Section 303 of the Clean Water Act. They are presented merely to provide guidelines against which on-site conditions may be compared, as well as to provide a measure by which relative degrees of potential hazards may be determined.

It must be kept in mind that the following interpretation of the sample analysis applies only to the current proposed location of the tunnels and structures as indicated on Figure 1-1. In the event that they are relocated, additional investigations may be required.

3. METHODS OF ANALYSIS

Before inorganic analysis was performed, the samples were dried to a constant weight. The percent solids obtained for all samples are given in Table 3-1.

3.1 INORGANICS

The analyses for inorganic parameters were performed according to the procedures described in the EPA manual, "Methods for Chemical Analysis of Water and Wastes (EPA 600/4-79-020, March 1979)." Given below are the parameters tested for and the identification of the method used. The results are presented in Section 5.

Parameter	Method Number
Arsenic	206.2
Barium	208.1
Cadmium	213.2
Chromium	218.2
Cyanide	335.2
Lead	239.1
Mercury	245.5
Phenols	420.1
Selenium	270.2

The metals analyses (except for mercury) were performed after hot-acid digestion of 1 gram of sample in an acidic aqueous solution consisting of 2.5% hydrochloric acid and 2.5% nitric acid. The digest was filtered through Whatman #40 filter paper prior to analysis. For mercury, 0.5 grams of sample were digested.

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Table 3-1
PERCENT SOLIDS OF SOIL SAMPLES

Lab No.	Identification	Percent Solids
1163	Leachate, Seep #1	76.0
1237	S-I-2, S-15, 70-71.5'	78.2
1238	S-I-2, S-16, 75-76.5'	80.7
1333	S-I-6, S-3, 10-11.5'	86.1
1334	S-I-6, S-17, 75-76.5'	79.7
1335	S-I-6, S-18, 84-84.5'	78.0
1230	S-I-7, S-10, 44.5-46.0'	83.8
1231	S-I-7, S-12, 54.5-56.0'	80.6
1232	S-I-7, S-14, 66-67.5'	82.6
1157	S-I-8, S-1, 0-1.5'	82.7
1158	S-I-8, S-5, 20-21.5'	81.4
1159	S-I-9, S-2, 5-6.5'	80.5
1210	S-I-9, S-5, 20-21.5'	73.3
1211	S-I-9, S-9, 40-41.5'	85.3
1212	S-I-9B, S-4, 15-16.5'	84.5
1213	S-I-9B, S-6B, Auger Flight 30'	77.9
1233	S-I-10, S-3, 9.5-11.0'	83.8
1234	S-I-10, S-9, 39.5-41.0'	80.5
1214	S-I-11, S-3, 10-11.5'	84.9
1157	S-I-12, S-1, 0-1.5'	93.5
1158	S-I-12, S-4, 15-16.5'	85.9
1159	S-I-12, S-8, 35-36.5'	80.3
1160	S-I-12, S-10, 45-46.5'	84.9
1161	S-I-12, S-13, 60-61.5'	71.0

All soil samples to be analyzed for metals were first dried to a constant weight. Given here is the percent of the dried samples compared to the original moist sample.

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Lead and mercury levels were determined by the extraction procedure (EP Toxicity Test), using 100 g. of sample, as described in the Federal Register, 43 FR 58956, December 18, 1978.

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3.2 VOLATILE ORGANICS

Aqueous samples, which were collected in 40 mL glass vials with Teflon-lined seals, were analyzed by the gas chromatography/mass spectrometry (GC/MS) purge and trap method described in 40 CFR Part 136, "Guidelines Establishing Test Procedures for the Analysis of Pollutants," Method 624, 44 FR 69464, December 3, 1979.

The soil samples were analyzed for volatile organics by GC/MS, using the headspace methods (8.82 and 8.24) described in "Test Methods for Evaluating Solid Waste (USEPA, SW-846, 1980)."

The results are presented in Section 5.

3.3 EXTRACTABLE ORGANICS

The aqueous samples were extracted and analyzed according to Method 625, 44 FR 69464. The soil samples (25 g) were Soxhlet extracted using 1:1 acetone/hexane, Method 8.86, and analyzed according to Method 8.24, of "Test Methods for Evaluating Solid Waste."

The results are shown in Section 5.

GC/MS operating conditions are described and chromatograms for all analyses are included as Appendix B.

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Agate Lake
Agate Lake
Agate Lake

5. RESULTS

The results of the laboratory analysis of soil and water samples are presented, by bore hole and depth, in this section in tables 5-1 through 5-10. Results of the analysis of aqueous samples are given in ug/L. Those from the soil samples are in mg/kg dry-weight basis for metals analyses.

Results of organics analyses are reported in mg/kg. These samples were tested in their original (moist) condition.

Not all samples were analyzed for all parameters. This is indicated by "NA" (not analyzed).

All results are reported to three significant figures.

Sect (5)

Table S-1

RESULTS OF ANALYSIS OF
LEACHATE SPRING #1 AND LEACHATE SEEP #1

(Spring given in ug/L; Seep given in mg/kg on a Dry-Weight Basis)

	E & E Lab No. 81-	Sample Description	Be	Cd	Cr	Pb	As	Se	Hg	Compounds	Detection Limit (ug/L)
1. Metals	1182	Leachate Spring #1	908	6.26	5.5	40.2	22.9	<2	0.47	--	--
	1183	Leachate Seep #1	142	0.92	16.7	150	25.5	0.227	5.83	--	--
2. EP Toxicity (ug/L)	1183	Leachate Seep #1	--	--	--	<10	--	--	10.8	--	--
3. Volatile Organics	1211	Leachate Spring #1	--	--	--	--	--	--	--	ND*	10
4. Base/Neutrals	1211	Leachate Spring #1	--	--	--	--	--	--	--	ND	10
5. Acids Extractable	1211	Leachate Spring #1	--	--	--	--	--	--	--	ND	50

*ND - None detected

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Table 5-2
RESULTS OF ANALYSIS OF BORE HOLE 5-1-2

	E & E Lab No. 81-	Sample Ident./Depth	Ba	Cd	Cr	Pb	As	Se	Hg	Compounds	Detection Limit (mg/kg)
1. Metals (Dry- Weight Basis (mg/kg))	1237	S-15, 70- 71.5'	121	1.21	7.61	186	13.6	<0.2	1.10	--	--
	1238	S-16, 75- 76.5'	128	1.32	21.0	612	18.1	<0.2	3.17	--	--
2. Volatile Organics	1237	S-15, 70- 71.5'	--	--	--	--	--	--	--	ND*	5
	1238	S-16, 75- 76.5'	--	--	--	--	--	--	--	ND	5
3. Base/Neutrals	1237	S-15, 70- 71.5'	--	--	--	--	--	--	--	Naphthalene Anthracene/ Phenanthrene† Fluorene Fluoranthene Pyrene	80 186 66 111 109
	1238	S-16, 75- 76.5'	--	--	--	--	--	--	--	Naphthalene Anthracene/ Phenanthrene† Fluorene Fluoranthene Pyrene	16 37 8.6 24 38

Priority
Pollutant
Concentra-
tion**
(mg/kg)

*ND - None detected

**Detection limit 5 mg/kg

†Anthracene and Phenanthrene are an isomeric pair which cannot be separated by GC/MS. The resulting concentration is based on Anthracene standard values.

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Table 5-3

RESULTS OF ANALYSIS OF TOWN HOLE 5-1-6

	E & E Lab No. 01-	Sample Ident./Depth	Ba	Cd	Cr	Pb	As	Se	Hg	Compounds	Detection Limit (mg/kg)
1. Metals (Dry- Weight Basis (mg/kg))	1333	S-3, 10- 11.5'	127	0.299	11.4	119	12.3	<0.2	<1.0	--	--
	1334	S-17, 75- 76.5'	165	0.393	10.6	249	23.6	<0.2	6.49	--	--
	1335	S-18, 84- 84.5'	157	0.295	11.7	187	21.7	<0.2	15.3	--	--
2. EP Toxicity (ug/L)	1334	S-17, 75- 76.5'	--	--	--	<10	--	--	<1.0	--	--
	1335	S-18, 84- 84.5'	--	--	--	<10	--	--	<1.0	--	--
3. Volatile Organics	1333	S-3, 10- 11.5'	--	--	--	--	--	--	--	ND*	5
	1334	S-17, 75- 76.5'	--	--	--	--	--	--	--	ND	5
	1335	S-18, 84- 84.5'	--	--	--	--	--	--	--	ND	5
4. Base/Neutrals	NA**	--	--	--	--	--	--	--	--	--	--

*ND - None detected

**NA - Not analyzed

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Table S-4
RESULTS OF ANALYSIS OF BORE HOLE S-1-7

	E & E Lab No. 81-	Sample Ident./Depth	Ba	Cd	Cr	Pb	As	Se	Hg	Compounds	Priority Pollutant Concentra- tion* (mq/kg)
1. Metals (Dry- Weight Basis (mq/kg))	1230	S-10, 44.5- 46.0'	91.0	1.19	11.2	349	19.1	<0.2	2.81	--	--
	1231	S-12, 54.5- 56.0'	NA**	NA	NA	NA	NA	<0.2	NA	--	--
	1232	S-14, 66- 67.5'	536	5.17	10.3	596	10.9	<0.2	3.05	--	--
2. Volatile Organics	NA	--	--	--	--	--	--	--	--	--	--
3. Dams/Neutrals	1230	S-10, 44.5- 46'	--	--	--	--	--	--	--	Anthracene/ Phenanthrene Fluoranthene Pyrene	<5 <5 <5

*Detection limit 5 mq/kg
**NA - Not analyzed

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Table S-5
RESULTS OF ANALYSIS OF BORE HOLE S-1-B

	E & E Lab No. 01-	Sample Ident./Depth	Ba	Cd	Cr	Pb	As	Se	Hg	Compounds	Priority Pollutant Concentra- tion* (mg/kg)
1. Metals (Dry- Weight Basis (mg/kg))	1197	S-1, 0-1.5'	60.0	0.218	10.1	64.0	19.8	<0.2	17.6	--	--
	1198	S-5, 20- 21.5'	87.0	0.102	18.4	61.0	7.14	<0.2	2.96	--	--
2. Volatile Organics	NA**	--	--	--	--	--	--	--	--	--	--
3. Base/Neutrals	1197	S-1, 0-1.5'	--	--	--	--	--	--	--	Anthracene/ Phenanthrene	<5
	1198	S-5, 20- 21.5'	--	--	--	--	--	--	--	Anthracene/ Phenanthrene Fluoranthene Pyrene	<5 <5 <5

*Detection limit 5 mg/kg

**NA - Not analyzed

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Table 5-6
RESULTS OF ANALYSIS OF BORE HOLES S-1-9 and S-1-9B

	E & E Lab No. 81-	Sample Ident./Depth	Ba	Cd	Cr	Pb	As	Se	Hg	Compounds	Priority Pollutant Concentration* (mg/kg)
1. Metals (Dry- Weight Basis [mg/kg])	1199	S-2, 5-6.5'	143	0.737	18.3	1101	36.6	<0.2	5.28	--	--
	1200	S-5, 20- 21.5'	136	6.36	18.2	530	13.1	<0.2	12.2	--	--
	1201	S-9, 40- 41.5'	88.0	1.05	14.1	148	6.19	<0.2	3.04	--	--
	1212	S-4B, 15- 16.5'	93.0	1.62	31.6	3627	17.0	<0.2	2.33	--	--
	1213	S-6B, Grab from Auger Flight 30'	213	1.90	42.9	1080	17.9	<0.2	4.76	--	--
2. EP Toxicity (ug/L)	1199	S-2, 5-6.5'	--	--	--	<10	--	--	<1.0	--	--
	1200	S-5, 20- 21.5'	--	--	--	<10	--	--	<1.0	--	--
	1212	S-4B, 15- 16.5'	--	--	--	17.4	--	--	--	--	--
	1213	S-6B, Grab from Auger Flight 30'	--	--	--	<10	--	--	<1.0	--	--

*Detection limit 5 mg/kg

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Table 5-6 (Cont.)

	C & E Lab No. 81-	Sample Ident./Depth	Ba	Cd	Cr	Pb	As	Se	Hg	Compounds	Priority Pollutant Concentration* (mg/kg)
3. Volatile Organics	NA**	--	--	--	--	--	--	--	--	--	--
4. Base/Neutrals	1199	S-2, 5-6.5'	--	--	--	--	--	--	--	Anthracene/ Phenanthrene	<5
	1200	S-5, 20- 21.5'	--	--	--	--	--	--	--	Anthracene/ Phenanthrene Fluoranthene Pyrene Chrysene	6.28 6.96 6.13 10.46
	1201	S-9, 40- 41.5'	--	--	--	--	--	--	--	Anthracene/ Phenanthrene Fluoranthene Pyrene	<5 <5 <5
	1212	S-4B, 15- 16.5'	--	--	--	--	--	--	--	Anthracene/ Phenanthrene Fluoranthene Pyrene Chrysene	11.43 7.22 6.42 8.40
	1213	S-6B, Grab from Auger Flight 30'	--	--	--	--	--	--	--	Anthracene/ Phenanthrene Fluoranthene Pyrene	<5 <5 <5

*Detection limit 5 mg/kg
 **NA - Not analyzed

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Table S-7
RESULTS OF ANALYSIS OF DORE INHLE S-1-10

	E & E Lab No. 01-	Sample Ident./Depth	Ba	Cd	Cr	Pb	As	Se	Hg
1. Metals (Dry- Weight Basis (mg/kg))	1233	S-3, 9.5- 11.0'	NA*	NA	NA	NA	NA	<0.2	NA
	1234	S-9, 39.5- 41.0'	98.0	0.305	9.55	79.0	10.3	<0.2	1.30
2. Volatile Organics	NA	--	--	--	--	--	--	--	--
3. Base/Neutrals	NA	--	--	--	--	--	--	--	--

*NA - Not analyzed

Table S-8
RESULTS OF ANALYSIS OF BORE HOLE S-1-11

	E & E Lab No. 81-	Sample Ident./Depth	Ba	Cd	Cr	Pb	As	Se	Hg	Compounds	Priority Pollutant Concentra- tion* (mg/kg)
1. Metals (Dry- Weight Basis (mg/kg))	1214	S-3, 10-11.5'	93.0	0.452	1.10	81.0	2.86	<0.2	3.26	--	--
2. Volatile Organics	NA**	--	--	--	--	--	--	--	--	--	--
3. Base/Neutrals	1214	S-3, 10-11.5'	--	--	--	--	--	--	--	Anthracene/ Phenanthrene Fluoranthene Pyrene	<5 <5 <5

*Detection limit 5 mg/kg

**NA - Not analyzed

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Table 5-9
RESULTS OF ANALYSIS OF BORE HOLE S-1-12

	E & E Lab No. 01-	Sample Ident./Depth	Ba	Cd	Cr	Pb	As	Se	Hg	Compounds	Priority Pollutant Concentration ^a (mg/kg)
1. Metals (Dry- Weight Basis (mg/kg))	1187	S-1, 0-1.5'	111	0.576	4.73	72.0	14.1	<0.2	<1.0	--	--
	1188	S-4, 15- 16.5'	133	5.17	20.1	371	14.7	<0.2	3.92	--	--
	1189	S-8, 35- 36.5'	191	1.51	22.5	6571	30.7	<0.2	14.1	--	--
	1190	S-10, 45- 46.5'	163	1.37	6.37	119	6.32	0.252	1.71	--	--
	1191	S-13, 60- 61.5'	128	0.563	10.3	234	10.4	<0.2	6.53	--	--
2. EP Toxicity (ug/L)	1189	S-8, 35- 36.5'	--	--	--	14.9	--	--	1.8	--	--
	1191	S-13, 60- 61.5'	--	--	--	<10	--	--	2.8	--	--
3. Volatile Organics	NA**	--	--	--	--	--	--	--	--	--	--

^aDetection limit 5 mg/kg
^{**}NA - Not analyzed

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Table S-9 (Cont.)

	E & E Lab No. 01-	Sample Ident./Depth	Ba	Cd	Cr	Pb	As	Se	Hg	Compounds	Priority Pollutant Concentra- tion* (mg/kg)
A. None/Neutral	1187	S-1, 0-1.5'	--	--	--	--	--	--	--	Naphthalene	<5
										Methyl naphthalene	--
										Anthracene/ Phenanthrene	<5
										Fluoranthene	<5
										Pyrene	<5
	1188	S-4, 15- 16.5'	--	--	--	--	--	--	--	Methyl naphthalene	--
										Heptadecane	--
										Anthracene/ Phenanthrene	<5
										Fluoranthene	<5
										Pyrene	<5
	1189	S-8, 35- 36.5'	--	--	--	--	--	--	--	Long chain hydrocarbons such as Heptadecane	--
										Octadecane	--
										Eicosane	--
										Anthracene/ Phenanthrene	<5
	1190	S-10, 45- 46.5'	--	--	--	--	--	--	--	None	
	1191	S-13, 60- 61.5'	--	--	--	--	--	--	--	Anthracene/ Phenanthrene	<5
										Fluoranthene	<5
										Pyrene	<5

* Detection limit 5 mg/kg

**NA=Not analyzed

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SECTION 4.3
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INTERPRETATION OF SAMPLE ANALYSIS
COMBINED SEWER OVERFLOW ABATEMENT
PROGRAM, ROCHESTER PURE WATERS DISTRICT

September 1981

*Embrose 2/1/82
and 1/1/82*

Prepared for:

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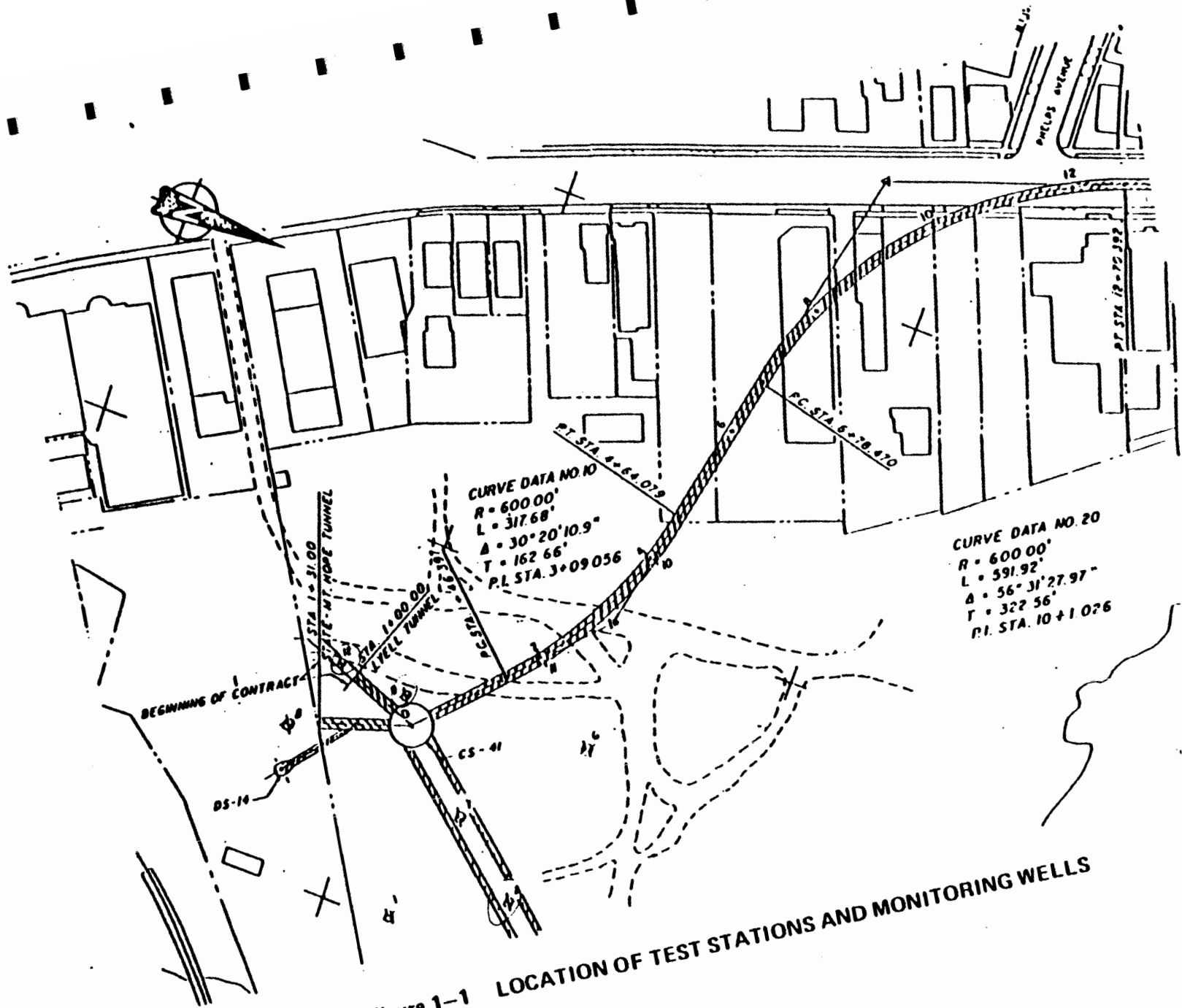
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1. INTRODUCTION

From August 4 to 13, 1981, field investigators from Ecology and Environment, Inc., (E & E) collected soil and water samples during the drilling of eight test holes and the installation of monitoring wells at the Rochester Gas and Electric Corporation's (RG&E) Lake Avenue site in Rochester, New York. Figure 1-1 illustrates the location of the test stations and monitoring wells. The samples were collected at the surface and at subsequent five-foot intervals in each hole, and were divided with RG&E for analysis at their discretion. Only one monitoring well, number 12, had enough water for analysis. Water samples were also collected at the edge of the property along the Genesee River gorge. E & E monitored the site using the Century 128 Organic Vapor Analyzer (OVA) and the H-NU PI-101 Photoionizer (H-NU) to determine levels of protection for on-site personnel and to identify samples for laboratory analysis.

E & E's Analytical Services Center analyzed the samples and prepared a report entitled, Laboratory Report on the Analysis of Soil and Water Samples for the Combined Sewer Overflow Abatement Program, Rochester Pure Waters District. A summary of pertinent findings and comparisons with existing criteria may be found in the various tables in the accompanying document. The criteria cited in the tables are tools that can be used to provide relevant comparisons of the laboratory analysis to conditions on-site. However, it is important to note that, with the exception of the Extraction Procedure (EP) Toxicity Test, the criteria have no regulatory effect unless adopted by the



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2. RECOMMENDATIONS AND CONCLUSIONS

The recommendations included in this report are based on data gathered during drilling activities at eight specific locations. Because of the nature and location of the landfill content, the gathered data and the recommendations may not necessarily be applicable to construction activities at significant distances from the locations sampled. Similarly, recommendations for construction at other sites cannot be made without appropriate monitoring, sampling, and analysis.

The following recommendations and conclusions are based on the laboratory analysis and field monitoring, as well as on a review of existing toxicological data and federal regulations:

- Protective clothing, including coveralls, rubber gloves, and boots, should be worn during excavation and construction;
- Monitoring should be conducted for vapors and particulates;
- A site-specific contingency plan should be developed prior to construction to provide definite safety procedures to be followed in the event that significant quantities of organic vapors are encountered;
- Dust should be controlled on-site;
- Runoff from the site, especially in the vicinity of station 12, should be controlled;

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- Disposal of excavated material in a secure landfill may not be necessary; however, dust should be controlled while handling the muck, which should not be taken off-site, if possible;
- Geotechnical investigations can be conducted without the use of personnel protection.

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A discussion of these recommendations follows.

Direct monitoring of the test drilling at the site with the OVA and H·NU indicated varying degrees of organic contamination in the soil, but not in the ambient air. In addition, no significant levels of explosive gases were detected at the drilling locations. For these reasons, there does not appear to be conditions which would preclude further drilling for geotechnical investigations at the site. However, protective measures against the contaminants detected during laboratory and field analysis, as well as the use of air monitoring devices, are warranted during construction.

The results of the investigation, which are discussed further in Sections 3 and 4, indicate that hazardous contaminants are present on the site and, although the sample analyses do not indicate organic contaminant levels in sufficient quantities to characterize the site as extremely dangerous to human health and safety, a contingency plan is still recommended. A contingency plan provides measures to be taken in the event that significant quantities of organic or toxic vapor materials are detected on-site that could create situations potentially threatening to workers, the general public, or the environment. The elements of a contingency plan include emergency response plans and procedures, a safety authority and communication system, a site-specific safety plan, and monitoring procedures.

The contaminants of major concern found at the site are lead, chromium, arsenic, mercury, and, to a lesser extent, the polynuclear aromatic hydrocarbons (PNAs). A detailed discussion of the potential chronic health hazards of these substances is included in Appendix A of this report. The primary risks of exposure are through inhalation and skin contact with contaminated particulate matter. Adequate protection for on-site personnel against such exposure is recommended.

Skin absorption is an unlikely route of exposure to the metals because of their tendency to bind tightly to organic material in the soil, as demonstrated by the EP Toxicity analysis for lead and mercury (see Section 3). However, direct contact with the PNAs found at station 2 may represent a potential risk to workers on-site. Although the levels of PNAs detected in the samples were fairly low, the demonstrated characteristics of PNAs as irritants and as potential carcinogens, as well as the possibility that higher levels could be encountered during excavation, indicate the need for protective clothing. Such clothing should include coveralls (to be disposed of or laundered daily), rubber gloves, and boots, which should be washed prior to departure from the work site. In addition, the possible presence of highly volatile, short-chain, low-boiling-point compounds represents a potential respiratory exposure hazard during excavation in confined spaces or tunneling, and suggests that a vapor monitoring program would be advisable during such activities. The hazard potential of constituents found in the samples are discussed in Appendix A.

Inhalation of metal-contaminated dusts may represent a more difficult control problem, particularly during the major excavation. Because of numerous influencing variables (e.g., wind conditions, soil moisture, etc.), levels of dust generated cannot be accurately predicted. However, the use of engineering controls, such as dust-suppressing wetting agents, may be sufficient to maintain particulate levels within established industrial hygiene standards. A suggested practice is to monitor work site particulate counts of the metals in order to determine whether dust levels are within their respective Time Weighted Averages (TWA).

Table 2-1 lists TWAs recommended by the American Conference of Governmental Industrial Hygienists (ACGIH). These values, which are based on industrial experience and experimental studies, refer to concentrations of airborne contaminants that may be safely tolerated in the work place eight hours per day, five days per week. Although they may serve as the basis for Occupational Safety and Health Administration (OSHA) standards, they are revised more frequently, and consequently, may be more conservative than current standards. However,

Table 2-1
RECOMMENDED MAXIMUM EXPOSURE LEVELS OF AIRBORNE METAL DUSTS

Substance	TWA* (mg/m ³)
Barium	0.50
Cadmium	0.05
Chromium	0.05
Lead	0.15
Arsenic	0.20
Selenium	0.20
Mercury	0.05

*TWA = Time Weighted Average work place exposure levels recommended by American Conference of Governmental Industrial Hygienists.

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adherence to the TWAs will insure compliance with current regulations and provide the best known levels of worker health protection.

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If dust levels of the toxic metals are found to be unacceptable, it will be necessary to institute a respiratory protection program that will afford high efficiency filtration of the particles. Such a program may necessitate quantitative fit-testing of respirators and a medical surveillance program to monitor blood levels of the toxic metals encountered. Because of the results of the field sampling analysis, it is further suggested that the work site be monitored for organic and explosive vapors when workers are working near the soil or in confined spaces, such as tunnels.

The contaminants found in well number 12 do not appear to pose a health threat to people working on-site. However, because contaminants in excess of New York State water quality standards may be released from the site, a National Pollutant Discharge Elimination System (NPDES) permit may be required from the state. Options for control of water from the well include surface impoundment, discharge into the sewer system (if acceptable to Monroe County and the City of Rochester), or engineering controls, such as entrenchment or grout curtains.

Although contaminants in the soil represent a potential worker exposure problem, the concentrations do not appear to be high enough to require disposal in a secure landfill under the Resource and Recovery Act (RCRA). However, special handling of the excavated soil is recommended. A verbal opinion expressed by Mr. Myles Morse of the EPA (see attached contact report) indicates that RCRA hazardous waste regulations relevant to the disposal of specific polynuclear aromatic hydrocarbons (PNAs) are not applicable to soil excavated during construction of the sewers. It must be emphasized, however, that this was a verbal opinion only. An effort should be made to obtain a formal, written confirmation of that opinion. It must also be emphasized that construction activity should include measures to prevent contaminated soil from leaving the site. It is recommended that the contaminated soil be put back in the construction areas where possible. Precautions should be taken to control erosion of the soil during construction to reduce worker exposure problems. Topsoil should be placed over the contaminated soil before revegetation.

CONFIDENTIAL

SECTION 4.3
REF. 16

Of the seven metals found in the soil samples and analyzed, only lead and mercury were present in dry-weight concentrations potentially in excess of EP Toxicity standards. As shown in Table 2-2, however, the concentrations of lead and mercury in the extracts of each sample proved to be below EP Toxicity standards, indicating that the metals are tightly bound to the soil under field conditions and would not require special disposal procedures under RCRA.

Direct field monitoring of the soil samples with the OVA and H·NU indicated the presence of varying levels of gaseous compounds. Although such measurements were generally found to be 20 parts per million (ppm) or less above ambient air conditions, readings in excess of 500 ppm were detected by the OVA in two samples from station 6 at depths of 75 to 76.5 feet and 84 to 84.5 feet. However, subsequent laboratory analysis of the soil samples did not detect significant levels of volatile organic compounds. This suggests that the soil may be contaminated with highly volatile, short-chain, low-boiling-point compounds (such as methane), which are quickly released from the soil when aerated.

Analysis of the base/neutral fraction of the soil samples, as shown in Table 2-3, revealed the presence of low levels of PNAs in samples from station 9 at depths of 15 to 21.5 feet and in samples from station 2 at depths of 70 to 76.5 feet. Although these compounds, particularly naphthalene, are indicative of coal tar, the concentrations are too low to state conclusively that coal tar may be found in the vicinity of either station 2 or station 9.

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REF. 116

Table 2-2

EP TOXICITY ANALYSIS OF SELECTED SOIL SAMPLES
RG&E LAKE AVENUE SITE, ROCHESTER, NEW YORK

Sample Location*	Extract Analysis Results (mg/L) (rounded to nearest .001 mg)	
	Lead (5.0 mg/L)**	Mercury (0.2 mg/L)**
Leachate Seep #1	<.010	.001
Station #12, 35-36.5 ft	.015	.002
Station #12, 60-61.5 ft	<.010	.003
Station #9, 5-6.5 ft	<.010	<.001
Station #9, 20-21.5 ft	<.010	<.001
Station #9, 15-16.5 ft	.017	NA†
Station #9, Grab from auger flight, 30 ft	<.010	<.001
Station #6, 75-76.5 ft	<.010	<.001
Station #6, 84-84.5 ft	<.010	<.001

*Figures indicate depth from which sample core was taken.

**Figures refer to EPA standards for maximum allowable concentrations
of contaminants as determined by Extraction Procedure.

†NA = not analyzed

Table 2-3

BASE/NEUTRAL ANALYSIS OF SOIL SAMPLES
RG&E LAKE AVENUE SITE, ROCHESTER, NEW YORK

Substance	MATE* (ppm)	Analysis Range (ppm)	Stations with Highest Concentrations
Anthracene/ Phenanthrene	1,700.0/48.0	5 - 186.0	2
Fluoranthene	2,800.0	5 - 111.0	2
Pyrene	6,900.0	5 - 109.0	2
Chrysene	66.0	5 - 12.1	9
Naphthalene	1,500.0	16 - 80.0	2
Fluorene	--	8.6 - 66.0	2

*MATE = Minimum Acute Toxicity Effluent levels of contaminants in
soil that are acceptable to human health.

3. SOIL SAMPLE ANALYSIS

Table 3-1 compares the range of results from the metals analysis (dry-weight basis) of the soil samples with the Minimum Acute Toxicity Effluent (MATE) values specific to soil contamination levels acceptable to human health. The MATE levels were developed by the EPA as part of its Multimedia Environmental Goals for Environmental Assessment. They represent contaminant concentrations in source emissions to air, water, and land that will not evoke significant toxic responses when the exposures are of short duration (i.e., fewer than eight hours per day); therefore, they may be used to define action levels for personnel protection.

Virtually all samples listed in Table 3-1 exceeded the MATE levels. The highest levels of all metals were generally found in the vicinity of stations 9 and 12. The recommendations for dust control and personnel protection are based on the comparison of MATE levels and the sample analysis.

In order to determine classification of wastes as hazardous under RCRA, and because of varying tendencies of metals to leach from soil, it was necessary to determine the EP Toxicity of the soil samples. The EP Toxicity refers to the maximum allowable concentrations of contaminants in the soil extract. The samples were chosen for the EP Toxicity Test based on the dry-weight laboratory analysis results and the assumption that 100% of the contaminants in the soil would leach out. Thus, only two out of the seven heavy metals were present in sufficient quantity to perform the EP Toxicity Test for nine soil samples.

CONFIDENTIAL

SECTION 4.3
REF 16

Table 3-1

DRY WEIGHT METALS ANALYSIS OF SOIL SAMPLES
RG&E LAKE AVENUE SITE, ROCHESTER, NEW YORK

Substance	MATE* (ppm)	Sample Analysis Range (ppm)	Stations with Largest Concentrations
Barium	10.0	60.0 - 536.0	7, 9
Cadmium	0.1	0.102 - 6.36	7, 9, 12
Chromium	0.5	1.10 - 42.9	2, 9, 12
Lead	0.5	40.2 - 6,571.0	9, 12
Arsenic	0.5	2.86 - 36.6	6, 9, 12
Selenium	0.1	<0.2 - 0.252	12
Mercury	0.02	<1.0 - 17.6	8, 9, 12

*MATE = Minimum Acute Toxicity Effluent levels of contaminants in
soils that are acceptable to human health.

4. WATER SAMPLE ANALYSIS

In addition to the analysis of soils from the hole borings, two water samples were analyzed. The results of this analysis are compared in Table 4-1 to MATE levels specific to water contamination levels and to EPA Proposed Allowable Limits. The Proposed Allowable Limits refer to EPA water quality criteria recommending the best estimate of the concentration of specific contaminants in water which may exist and still not pose an undue risk to the health of those people who either eat fish or drink from that water. The results are also compared to New York State water quality standards for non-community drinking water supplies.

Leachate spring number 1, located at the base of the site at the Genesee River, exceeded the EPA Proposed Allowable Limits for chromium, arsenic, and mercury, but did not exceed MATE or New York State levels. Water from well number 12 was found to have lead in excess of MATE levels, as well as cadmium, chromium, lead, arsenic, and mercury in excess of the Proposed Allowable Limits. All metals analyzed in well number 12 were in excess of New York State water quality standards. This suggests that water from the site may represent a potential surface water pollution problem if not contained. However, only one of the eight installed wells produced water in sufficient quantity to sample at the time the investigation was conducted. There are limited data with respect to seasonal flow rates and direction to determine the quantities which should be controlled and the extent of the problem.

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SECTION 4.3
REF 16.

Table 4-1

WATER SAMPLE ANALYSIS FOR METALS
RG&E LAKE AVENUE SITE, ROCHESTER, NEW YORK

Sample	Substance	MATE* (ug/L)	PAL** (ug/L)	NYS Standards*** (ug/L)	Sample (ug/L)
Leachate Spring #1	Barium	5,000	---	1,000	908
	Cadmium	50	10	10	6.26
	Chromium	2,500	0.008	50	5.5
	Lead	2,500	50	50	40.2
	Arsenic	2,500	0.02	50	22.9
	Selenium	50	10	10	2.0
	Mercury	10	0.2	2.0	0.47
Well #12	Barium	5,000	---	1,000	1,230
	Cadmium	50	10	10	26.5
	Chromium	2,500	0.008	50	149
	Lead	2,500	50	50	3,750
	Arsenic	2,500	0.02	50	252
	Selenium	50	10	10	5.2
	Mercury	10	0.2	2.0	4.12

*MATE = Minimum Acute Toxicity Effluent levels of contaminants in water that are acceptable to human health.

**PAL = Proposed Allowable Limits for contaminants in water that are acceptable to human health.

***NYS = New York State maximum contaminant levels for non-community water systems

MEMO TO THE FILES

FROM: DA MacArthur *ARM*
RE: Siphon Tunnel
Hazardous Wastes
FILE: 888.058 SPBI
DATE: 3/8/85
CC: CB Murphy, Jr.
RL Elander
DE Kenney
JP Terwilliger
DJ Carleo
S Kaczmar

*This was 1st letter
drafted results - included in flow
section to explain when samples changed
from: 7-00*

The following summarizes the air and water quality field and analytical data gathered to date during and subsequent to the identification of a significant inflow of chemical compounds into the siphon tunnel beginning Monday, February 25, 1985 as detailed in a memo from J.P. Terwilliger dated March 1, 1985. Figure 1 shows a schematic of the sampling locations.

Liquid Phase Samples

Three sets of samples have been collected of the contaminated materials from the siphon tunnel to date:

1. Samples were collected of the liquid phase "oil/water" mixture at the source of the seep in the tunnel on 2/26/85. These samples were delivered to the OBG lab late on 2/26/85; however, no analyses have been done on this sample to date due to scheduling conflicts.
2. On Friday, 3/1/85, John P. Terwilliger ordered a sample to be taken at the dewatering pump discharge to the settling tank and sent to General Testing Corporation in Rochester for analysis. Analysis included purgeable aromatics (GC Method 602), volatile organic halogens (GC Method 601), petroleum hydrocarbons, pH, and PCBs. The results of the analyses are shown in Attachment 1.
3. On Monday, 3/4/85, two samples were collected by Mike Gerber of OBG during a site visit to do some air quality monitoring in the tunnel. The first sample (3A) was obtained from inside the tunnel near the TBM. This sample contained a large black glob of the coal tar material. This sample was analyzed as follows:
 - a. The liquid (clear) portion was analyzed for purgeable organic compounds using the GC test method 602. Results are shown on Attachment 2.

Copies given to: Bruce Finster - DC
D. L. R. - MCHD

- b. A portion of the large black glob was extracted and analyzed for base neutrals using the GC/MS. Results are shown on Attachment 3.

The second sample (3B) was taken at the discharge of the tunnel dewatering pump prior to discharge to the settling basins. This sample was analyzed for purgeable organics using GC test method 602. The results are shown on Attachment 4.

4. On Wednesday, 3/6/85, two samples were collected from the settling tank lagoons and delivered to the OBG lab by RL Elander. These samples were collected at the following locations:
 - a. Effluent from the first metal settling tank (4A). The sample was reddish/ brown in color and seemed to have a lot of material in it. Material clung to the sides of the glass and had to be thoroughly rinsed off.
 - b. Effluent from the second earthen lagoon (4B). This sample was much clearer than the first lagoon effluent and the sample bottle did not have significant material adhering to the glass. (Note: when this sample was obtained, no discharge from the lagoon to the river was occurring as some reworking of the lagoon was being done.)

Both the settling basin effluent samples were analyzed for purgeable aromatics (GC Method 602). In addition, the sample from the second settling basin was analyzed for the base neutrals. The results of the analyses are shown in Attachment 5.

Air Quality Analyses

The following generally describes the air quality testing and test results obtained from approximately the time the coal tar/gasoline problems first began:

2/22/85 Drager pump tests performed by Pike's safety engineer at the front of the TBM:

Oxygen	21%
H ₂ S	0
CH ₄	0
nitrous fumes	0

Explosimeter mounted on machine (calibrated for CH₄), no explosive atmosphere detected.
Safety engineer did not have an organic vapor analyzer (OVA) for use.

Page -3-

- 2/27/85 Drager tube tests using NMS MX-241 device by Pike's safety engineer
benzene - 40 ppm total hydrocarbons
toluene - 50 ppm total hydrocarbons
- 3/4/85 Mike Gerber of OBG performed air quality tests inside tunnel. Using OVA, readings ranged from 20-69 ppm in various locations in the tunnel. See notes and data in Attachment 6 for more details. The HNU meter did not work.
- 3/5/85 Chyun Associates began air quality sampling at 0930. Oxygen levels were measured at 21%, lower explosion level was 0%, H₂S was 0%. OVA readings in the morning ranged from 26-31 ppm from station 13+95 to 19+45. In the afternoon, OVA readings ranged from 26-42 ppm. Over 1000 ppm were recorded in the effluent going from the tunnel to the shaft. See Chyun's inspection report number 001T (Attachment 7) for further details.
- 3/6/85 Additional OVA readings taken by Chyun, which ranged from 12-25 ppm. At the tunnel heading readings ranged from 206-400 ppm. No explosive conditions, nor H₂S detected, oxygen at 21%. Air samples were taken for further analyses at Chyun's lab. See Chyun's inspection report number 002T (Attachment 8) for further details.

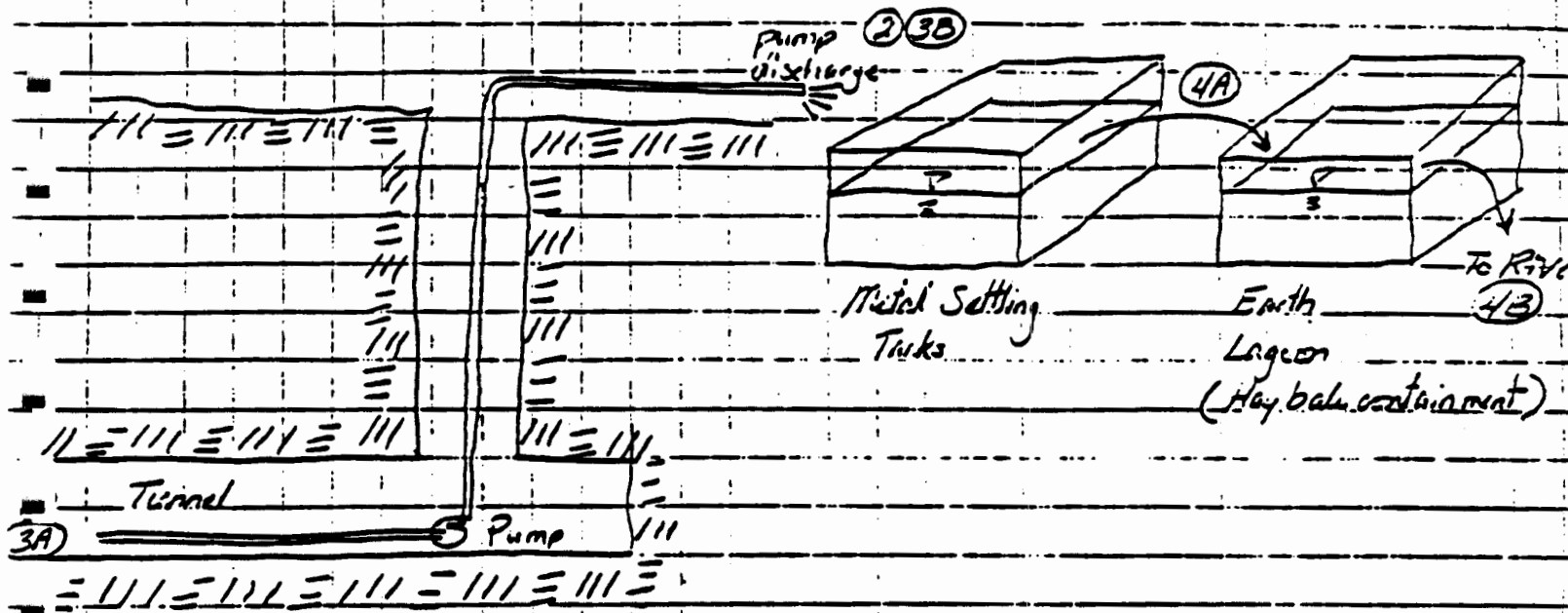
Also available are previous data reports on the chemical compounds seeping from the face of the gorge as obtained by the Monroe County Environmental Health Laboratory. This previously gathered data was attached to a memo by RL Elander dated March 7, 1985.

:jd

SUBJECT	SHEET	BY	DATE	JOB NO.

Figure 1

Samples which have been collected for analysis



① Sample collected 2-26-85 inside tunnel near source (no analysis yet done)

② Sample collected 3-1-85 from pump discharge and sent to Central Testing Corporation for analysis

3A Sample collected 3-4-85 inside tunnel near source. This sample contained large glob

3B Sample collected 3-4-85 from pump discharge

4A Effluent from the first settling tank collected 3-6-85

4B Effluent from the earth lagoon collected 3-6-85



O'BRIEN & GERE

April 16, 1985

Mr. Irwin Brodell, P.E.
Deputy Director
MONROE COUNTY DEPARTMENT
OF ENGINEERING
350 East Henrietta Road
Rochester, New York 14620

Re: Rochester Pure Waters District
St. Paul Boulevard
Interceptor Improvements
Contract 13 (C-36-745-05)
Chemical Contaminants

File: 888.058

Dear Mr. Brodell:

Please find attached copies of all analytical data obtained to date on the siphon tunnel chemical contamination on the above-referenced project. The analytical data has been divided into two general categories:

- 1) air quality monitoring and sampling data in the tunnel
- 2) water and sediment sampling data. A summary of samples collected is provided with this segment of the data.

Most of this data has been previously communicated to NYSDEC and/or the Health Department either verbally or as preliminary copies. As further data becomes available, we will forward it to you.

If you have any questions or require further explanation of the enclosed, please contact us.

Very truly yours,

O'BRIEN & GERE ENGINEERS, INC.

Dwight A. MacArthur
Dwight A. MacArthur, P.E.
Managing Engineer

DAM:djb
Enclosures:

cc: Mr. H. Bilow, MCDOE
Mr. J. Terwilliger, OBG Resident Engineer
Ms. D. Jackson, NYSDEC-Avon
Mr. C. Asprinio, AES
Dr. M. Merkens, MCDOH

RECEIVED

JUL 10 1985

SOLID WASTE
D.E.C. REG. #8

ROCHESTER PURE WATERS DISTRICT
ST. PAUL BOULEVARD INTERCEPTOR IMPROVEMENTS
CONTRACT 13 C-36-745-05
SIPHON TUNNEL CONTAMINATION

Water Phase and Sediment Samples
Analytical Data

April 16, 1985
O'Brien & Gere Engineers, Inc.

DECISION
REF 19

ROCHESTER PURE WATERS DISTRICT
CONTRACT 13 C-36-745-05
Water Phase & Sediment Phase

Sample Summary

	<u>Sample Date</u>	<u>Number</u>	<u>Location</u>	<u>Analyses</u>
	2-26-85	45849	Water in Tunnel	PCB
	3- 1-85	General Testing	Effluent from Old Settling Basin	See Attached
2,3	3- 4-85	54765	From Tunnel: Water Phase Solid Phase (glob)	Purgeables Base Neutrals
4	3- 4-85	54744	Tunnel Pump Out	Purgeables
5	3- 6-85	51769	Effluent from Old Settling Pond	Purgeables, Base Neutrals
	3- 6-85	56627	Effluent from 1st Settling Tank	Purgeables
	3-13-85	58989	Settled Material in Tanks: Coal Tar	Flashpoint, EP Toxicity, pH
	3-13-85	59390	Settled Material in Tanks: Well-Mixed	Flashpoint, pH, BTX
	3-13-85	51774	Skimmings in Tanker: Well-Mixed : Surface Only	Flashpoint, pH, BTX Flashpoint
	3-26-85	71266	Sample of Skimmings on New Pond	Flashpoint, pH, BTX
	3-26-85	71211	Sediment Sample from Peter B Pond	Flashpoint, pH, BTX EP Toxicity
	3-22-85	67894	Effluent from New Settling Pond	Items 1-35 per DEC
	3-28-85	69937	Effluent from New Settling Pond	Items 1-35 per DEC
	4- 5-85	72951	Effluent from New Settling Pond	Items 1-35 per DEC

general testing corporation

710 Exchange Street
Rochester, NY 14608
(716) 434-3780

85 Trinity Place
Hackensack, NJ 07601
(201) 486-5242

SECTION 4
REC 12

LABORATORY REPORT

Job No. 50300 Date 3/6/85

Sample(s) Reference

John Terwillger
O'Brien & Gere
104 Buckley Road
Syracuse, NY 13221

Priority Pollutant Data
29 Purgeable Halocarbons
(Volatile Organic Halogens)
Outfall from Tunnel Project
3/1/85

Site Samples (x) received () collected by General Testing

ATTACHMENT 1 (123)

O. # _____

ANALYTICAL RESULTS, $\mu\text{g/l}$ (ppb)

Sample Description

Analysis * by GC Method 601
(in order of elution)

Sample(s) Collected 3/1/85

Time(s) Collected _____

Sample Analyzed 3/5/85

Chloromethane <20

Bromomethane <20

Dichlorodifluoromethane &

Vinyl Chloride <20

Chloroethane <20

Methylene Chloride <10

Trichlorofluoromethane <10

1,1-Dichloroethane <10

1,2-Dichloroethane (Trans) <10

Chloroform <10

1,2-Dichloroethane <10

1,1,1-Trichloroethane <10

Carbon Tetrachloride <10

Bromodichloromethane <10

1,2-Dichloropropane <10

1,3-Dichloropropene (Trans) <10

Trichloroethene <10

1,3-Dichloropropene (Cis) &

Dibromochloromethane &

1,1,2-Trichloroethane ** <20

2-Chloroethylvinyl Ether <20

Bromoform <20

1,1,2,2-Tetrachloroethane <20

Tetrachloroethene <20

Chlorobenzene <20

1,3-Dichlorobenzene (m) <20

1,2-Dichlorobenzene (o) <20

1,4-Dichlorobenzene (p) <20

* elute Together

Analysis procedures in accordance with Standard Methods
for the Examination of Water and Wastewater, 15th Edition and
Methods for Chemical Analysis of Water and Wastes, EPA
44-1/8-1-1, lowest detected concentration with procedure
used. Quality control performed with above samples
as requested.

EPA 44-1/8-1-1, 1273

Laboratory Director

general testing corporation

710 Exchange Street
Rochester, NY 14608
(716) 454-3780

65 Tenny Place
Hicksville, NY 07801
(201) 433-5242

SECTION 43
REF 19

LABORATORY REPORT

Job No. 50300 Date 3/6/85

Sample(s) Reference
Outfall from Tunnel Project

Mr. John Terwillger
O'Brien & Gere
104 Buckley Road
Syracuse, NY 13221

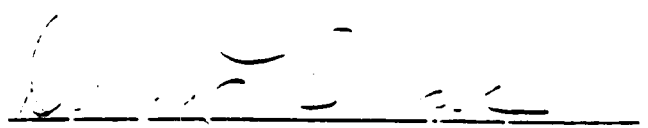
1st Samples (x) received () collected by General Testing 3/1/85

ATTACHMENT 1 (2 of 3)

ANALYTICAL RESULTS (mg/l unless stated otherwise)

Sample Description	
Settling Basin	
Time(s) Collected	3/1/85
Time(s)	-
Petroleum Hydrocarbon	10,000
Gravimetric (Silica Gel)	
pH	7.5 (10% suspension in DI Water)

Analyses performed in accordance with Standard Methods
for the Examination of Water and Wastewater, 16th Edition and
Methods for Chemical Analysis of Water and Wastes, EPA
821/9-81-010, latest detectable concentration with procedure
and determination of results performed with above samples
on the above request.



Analyst, Director

general testing corporation

710 Exchange Street
Rochester, NY 14608
(716) 454-3780

25 Trinity Place
Hackensack, NJ 07601
(201) 466-3242

SECTION 13
REF 19

LABORATORY REPORT

Job No. 50300 Date 3/6/85

Sample(s) Reference

Priority Pollutant Data
7 Purgeable Aromatics

Outfall from Tunnel Project

John Terwilliger
O'Brien & Gere
1704 Buckley Road
Syracuse, NY 13221

Re Samples (x) received () collected by General Testing 3/1/85

ATTACHMENT 1 (3 of 3)

ANALYTICAL RESULTS, $\mu\text{g/l (ppb)}$

Sample Description

Analysis * by GC Method 602

Settling
Basin

Sample(s) Collected 3/1/85

Time(s) Collected -

Date Analyzed 3/5/85

Benzene 5100

Toluene 3500

Ethylbenzene 300

Chlorobenzene <20

1,4-Dichlorobenzene <20

1,3-Dichlorobenzene <20

1,2-Dichlorobenzene <20

Additional Compounds eluting but

not on 602 list

m-Xylene 2700

p-Xylene * 860

o-Xylene *

Styrene

Propylbenzene

* Elute together

Analytical procedures in accordance with Standard Methods

for the Examination of Water and Wastewater, 16th Edition and

Standard Chemical Analysis of Water and Wastes, EPA

440/5-89-0101, lowest detected concentration with procedure

used. Subsequent to confirmation with above sample, no

detectable concentration.

PA 01 088 85-100 1000

SECTION 4.3
REF 19

O'BRIEN & GERE

Laboratory Report

CLIENT Monroe County Department of Engineering 888.075

DESCRIPTION Cliff St. Siphon Tunnel - Sample of Water in Tunnel

DATE COLLECTED 2-26-85 DATE RECEIVED 2-27-85

SAMPLE NO. 45849

PCBs (Total) $\mu\text{g/l}$ <1

OBSERVE

Methodology: Federal Register — 40 CFR, Part 136, December 3, 1979

Units: mg/l (ppm) unless otherwise noted

Comments:

Authorized: [Signature]

O'Brien & Gere Engineers, Inc.
Box 4070, 1004 Buckle Rd., Syracuse, NY 13221 315-481-4700

Date: 4-11-85

O'BRIEN & GERE

Purgeable
Priority PollutantsCliff Street Siphon Tunnel - Contract 13
MONROE COUNTY DEPARTMENT OF ENGINEERING

888.058.146

Sample from tunnel near TBM (Water Phase)
(oily surface layer)

54765	3-4-85	3-5-85	3-7-85
	ppb		ppb
Chloromethane	< 1000	1,2-Dichloropropane	< 1000
Bromomethane	< 1000	t-1,3-Dichloropropene	< 1000
Dichlorodifluoromethane	< 1000	Trichloroethene	< 1000
Vinyl chloride	< 1000	Benzene	29,000
Chloroethane	< 1000	Dibromochloromethane	< 1000
Methylene chloride	< 1000	1,1,2-Trichloroethane	< 1000
Trichlorofluoromethane	< 1000	c-1,3-Dichloropropene	< 1000
1,1-Dichloroethene	< 1000	2-Chloroethylvinyl ether	< 10,000
1,1-Dichloroethane	< 1000	Bromoform	< 10,000
t-1,2-Dichloroethene	< 1000	1,1,2,2-Tetrachloroethane	< 1000
Chloroform	< 1000	Tetrachloroethene	< 1000
1,2-Dichloroethane	< 1000	Toluene	15,000
1,1,1-Trichloroethane	< 1000	Chlorobenzene	< 1000
Carbon tetrachloride	< 1000	Ethylbenzene	< 1000
Bromodichloromethane	< 1000		

Methodology: Federal Register — 40 CFR, Part 136, December 3, 1979

Comments: Note: Total Xylene - 1700 ppb (1.7 ppm)

(see attach 2)

A. K. M. M.

4-11-85

O'BRIEN & GERE

Base/Neutral Priority Pollutants

Cliff Street Siphon Tunnel - Contract 13

CLIENT MONROE COUNTY DEPARTMENT OF ENGINEERING

888.058.146

DESCRIPTION Sample from tunnel near TBM - Liquid portion that settled, Black in color

SAMPLE NO. 54765 DATE COLLECTED 3-4-85 DATE RECEIVED 3-5-85 DATE ANALYZED 3-7-85

ppm

ppm

1,3-Dichlorobenzene

Diethylphthalate

1,4-Dichlorobenzene

N-nitrosodiphenylamine

1,2-Dichlorobenzene

Hexachlorobenzene

Hexachloroethane

4-Bromophenyl phenyl ether

Bis (2-chloroethyl) ether

Phenanthrene

5700

Bis (2-chloroisopropyl) ether

Anthracene

6400

N-Nitrosodi-n-propylamine

Di-n-butyl phthalate

Nitrobenzene

Fluoranthene

3500

Hexachlorobutadiene

Pyrene

3100

1,2,4-Trichlorobenzene

Benzidine

Isophorone

Butyl benzyl phthalate

Naphthalene-

7900

Bis(2-ethylhexyl)phthalate

Bis (2-chloroethoxy) methane

Chrysene

1700

Hexachlorocyclopentadiene

Benzo(a)anthracene

2-Chloronaphthalene

3,3-Dichlorobenzidine

Acenaphthylene

2200

Di-n-octylphthalate

Acenaphthene

Benzo(b)fluoranthene

2800

Dimethyl phthalate

Benzo(k)fluoranthene

2,6-Dinitrotoluene

Benzo(a)pyrene

5900

Fluorene

3700

Indeno(1,2,3-cd)pyrene

4-Chlorophenyl phenyl ether

Dibenzo(a,h)anthracene

2,4-Dinitrotoluene

Benzo(g,h,i)perylene

540

1,2-Diphenylhydrazine

N-Nitrosodimethyl Amine

Methodology: Federal Register — 40 CFR, Part 136, December 3, 1979

Comments:

old Attach 3

[Signature]

4-11-85

O'BRIEN & GERE

Purgeable
Priority PollutantsCliff Street Siphon Tunnel - Contract 13
MONROE COUNTY DEPARTMENT OF ENGINEERING

888.058.146

Tunnel Pump Out - Water Phase
(oily surface layer)

54744

3-4-85

3-5-85

3-7-85

	ppb		ppb
Chloromethane	< 1000	1,2-Dichloropropane	< 1000
Bromomethane	< 1000	t-1,3-Dichloropropene	< 1000
Dichlorodifluoromethane	< 1000	Trichloroethene	< 1000
Vinyl chloride	< 1000	Benzene	5700 (5.7 ppm)
Chloroethane	< 1000	Dibromochloromethane	< 1000
Methylene chloride	< 1000	1,1,2-Trichloroethane	< 1000
Trichlorofluoromethane	< 1000	c-1,3-Dichloropropene	< 1000
1,1-Dichloroethene	< 1000	2-Chloroethylvinyl ether	< 10,000
1,1-Dichloroethane	< 1000	Bromoform	< 10,000
t-1,2-Dichloroethene	< 1000	1,1,2,2-Tetrachloroethane	< 1000
Chloroform	< 1000	Tetrachloroethene	< 1000
1,2-Dichloroethane	< 1000	Toluene	4000 (4.0 ppm)
1,1,1-Trichloroethane	< 1000	Chlorobenzene	< 1000
Carbon tetrachloride	< 1000	Ethylbenzene	< 1000
Bromodichloromethane	< 1000		

Methodology: Federal Register — 40 CFR, Part 136, December 3, 1979

Comments: Note: M - Xylene < 2000

old Att # 4

A. K. J. J.
4-11-85

O'BRIEN & GERE

Base/Neutral
Priority PollutantsCliff Street Siphon Tunnel - Contract 13
MONROE COUNTY DEPARTMENT OF ENGINEERING

888.058.146

DESCRIPTION Effluent from Settling Lagoon

SAMPLE NO. 51769 DATE COLLECTED 3-6-85 DATE TESTED 3-6-85 DATE RECEIVED 3-7-85

	ppb		ppb
1,3-Dichlorobenzene		Diethylphthalate	
1,4-Dichlorobenzene		N-nitrosodiphenylamine	
1,2-Dichlorobenzene		Hexachlorobenzene	
Hexachloroethane		4-Bromophenyl phenyl ether	
Bis (2-chloroethyl) ether		Phenanthrene	280 (.28 ppm)
Bis (2-chloroisopropyl) ether		Anthracene	280 (.28 ppm)
N-Nitrosodi-n-propylamine		Di-n-butyl phthalate	
Nitrobenzene		Fluoranthene	92
Hexachlorobutadiene		Pyrene	110
1,2,4-Trichlorobenzene		Benzidine	
Isophorone		Butyl benzyl phthalate	
Naphthalene	1300 (1.3ppm)	Bis(2-ethylhexyl)phthalate	
Bis (2-chloroethoxy) methane		Chrysene	34
Hexachlorocyclopentadiene		Benzo(a)anthracene	
2-Chloronaphthalene		3,3-Dichlorobenzidine	
Acenaphthylene	71	Di-n-octylphthalate	
Acenaphthene	32	Benzo(b)fluoranthene	32
Dimethyl phthalate		Benzo(k)fluoranthene	
2,6-Dinitrotoluene		Benzo(a)pyrene	42
Fluorene	92	Indeno(1,2,3-cd)pyrene	
4-Chlorophenyl phenyl ether		Dibenzo(a,h)anthracene	
2,4-Dinitrotoluene		Benzo(g,h,i)perylene	
1,2-Diphenylhydrazine		N-Nitrosodimethyl Amine	

Methodology: Federal Register — 40 CFR, Part 136, December 3, 1979

Comments:

Sample 4B - Old Attachment #5

A. M. Pitt

O'BRIEN & GERE

Purgeable
Priority PollutantsCliff Street Siphon Tunnel - Contract 13
MONROE COUNTY DEPARTMENT OF ENGINEERING

888.058.146

Effluent from First Settling Tank

(Dewatering Basin)

56627

3-6-85

3-6-85

3-7-85

	ppb		ppb
Chloromethane	<1000	1,2-Dichloropropane	<1000
Bromomethane	<1000	t-1,3-Dichloropropene	<1000
Dichlorodifluoromethane	<1000	Trichloroethene	<1000
Vinyl chloride	<1000	Benzene	4400 (4.4 ppm)
Chloroethane	<1000	Dibromochloromethane	<1000
Methylene chloride	<1000	1,1,2-Trichloroethane	<1000
Trichlorofluoromethane	<1000	c-1,3-Dichloropropene	<1000
1,1-Dichloroethene	<1000	2-Chloroethylvinyl ether	<10,000
1,1-Dichloroethane	<1000	Bromoform	<10,000
t-1,2-Dichloroethene	<1000	1,1,2,2-Tetrachloroethane	<1000
Chloroform	<1000	Tetrachloroethene	<1000
1,2-Dichloroethane	<1000	Toluene	3600 (3.6 ppm)
1,1,1-Trichloroethane	<1000	Chlorobenzene	<1000
Carbon tetrachloride	<1000	Ethylbenzene	<1000
Bromodichloromethane	<1000		

Methodology: Federal Register — 40 CFR, Part 136, December 3, 1979

Comments: Note: Duplicate run - 4700 ppb Benzene

Sample 417 Not Attached

A. H. H. H.
4-11-85

O'BRIEN & GERE

Purgeable
Priority PollutantsCliff Street Siphon Tunnel - Contract 13
MONROE COUNTY DEPARTMENT OF ENGINEERING

888.058.146

Effluent from Settling Lagoon

(Tunnel Seepage)

51769

3-6-85

3-6-85

3-7-85

ppb

ppb

Chloromethane	<1000	1,2-Dichloropropane	<1000
Bromomethane	<1000	t-1,3-Dichloropropene	<1000
Dichlorodifluoromethane	<1000	Trichloroethene	<1000
Vinyl chloride	<1000	Benzene	1300 (1.3 ppm)
Chloroethane	<1000	Dibromochloromethane	<1000
Methylene chloride	<1000	1,1,2-Trichloroethane	<1000
Trichlorofluoromethane	<1000	c-1,3-Dichloropropene	<1000
1,1-Dichloroethene	<1000	2-Chloroethylvinyl ether	<10,000
1,1-Dichloroethane	<1000	Bromoform	<10,000
t-1,2-Dichloroethene	<1000	1,1,2,2-Tetrachloroethane	<1000
Chloroform	<1000	Tetrachloroethene	<1000
1,2-Dichloroethane	<1000	Toluene	1200 (1.2 ppm)
1,1,1-Trichloroethane	<1000	Chlorobenzene	<1000
Carbon tetrachloride	<1000	Ethylbenzene	<1000
Bromodichloromethane	<1000		

Methodology: Federal Register — 40 CFR, Part 136, December 3, 1979

Comments:

Sample 4B did attach 5

A. M. M.

4-11-85

O'BRIEN & GERE

Laboratory
Report

CLIENT Monroe County Department of Engineering 03.888.058.146
DESCRIPTION Settled Material in Original Settling Tanks
Coal Tar Compound (Sample No. 58989) Silt-Coal Tar Mix (Sample No. 59390)
DATE COLLECTED 3-13-85 DATE RECD 3-14-85

	SAMPLE NO. 58989	SAMPLE NO. 59390
pH	7.7	7.9
Closed Cup Flashpoint °C	48.	> 70.
EP Toxicity, mg/l		
As	0.01	
Ba	0.3	
Cd	< 0.01	
Cr	< 0.01	
Pb	< 0.01	
Hg	< 0.01	
Se	< 0.01	
Ag	< 0.01	

Note: The coal tar residue (58989) was segregated from the other soil materials in as pure a sample as reasonably possible.
The silt-coal tar mix sample (59390) was well-blended prior to analysis.

Benzene	50
Toluene	150
Ethylbenzene	33
Xylene	380

Methodology: Federal Register — 40 CFR, Part 136, December 3, 1979

Units: mg/l (ppm) unless otherwise noted

Comments:

Authorized: *O'Brien & Gere*

Laboratory
Report

O'BRIEN & GERE

CLIENT Monroe County Department of Engineering : 888.075
DESCRIPTION Cliff St. Siphon Tunnel - Sample of Floatables Skimmed from Settling Ponds,
sample taken from storage tanker at site
DATE COLLECTED 3-22-85 DATE RECD 3-22-85 DATE 3-28-85

SAMPLE NO. 51774

Flashpoint, °C

- sample shaken > 70°
- surface material decant > 70°

Benzene	2.6
Toluene	10.0
Ethylbenzene	1.0
Xylenes	3.7

Methodology: Federal Register — 40 CFR, Part 136, December 3, 1979

Units: mg/l (ppm) unless otherwise noted

Comments:

Authorized: *A. J. [Signature]*Date: 4-11-85

O'BRIEN & GERE

Laboratory Report

CLIENT Monroe County Department of Engineering 888.075
DESCRIPTION Cliff St. Siphon Tunnel- Sample of Floatables Skimmed from
New Settling Ponds
DATE COLLECTED 3-26-85 DATE RECD 3-26-85

SAMPLE NO. 71266

Flashpoint, °C
pH

46
69

Benzene

86

Toluene

180

Ethylbenzene

18

Xylenes

140

Methodology: Federal Register — 40 CFR, Part 136, December 3, 1979

Units: mg/l (ppm) unless otherwise noted

Comments: Testing to date has not indicated the presence of organic halogens in the contaminated material (ref. General Testing results dated 3-6-85). Therefore GC12 testing has not been conducted. **Authorized:** [Signature]

Authorized: [Signature]

O'Brien & Gere Engineers Inc.

Doc. 1072-1073, 1074, 1075, 1076, 1077, 1078, 1079, 1080, 1081, 1082, 1083, 1084, 1085, 1086, 1087, 1088, 1089, 1090, 1091, 1092, 1093, 1094, 1095, 1096, 1097, 1098, 1099, 1100, 1101, 1102, 1103, 1104, 1105, 1106, 1107, 1108, 1109, 1110, 1111, 1112, 1113, 1114, 1115, 1116, 1117, 1118, 1119, 1120, 1121, 1122, 1123, 1124, 1125, 1126, 1127, 1128, 1129, 1130, 1131, 1132, 1133, 1134, 1135, 1136, 1137, 1138, 1139, 1140, 1141, 1142, 1143, 1144, 1145, 1146, 1147, 1148, 1149, 1150, 1151, 1152, 1153, 1154, 1155, 1156, 1157, 1158, 1159, 1160, 1161, 1162, 1163, 1164, 1165, 1166, 1167, 1168, 1169, 1170, 1171, 1172, 1173, 1174, 1175, 1176, 1177, 1178, 1179, 1180, 1181, 1182, 1183, 1184, 1185, 1186, 1187, 1188, 1189, 1190, 1191, 1192, 1193, 1194, 1195, 1196, 1197, 1198, 1199, 1200, 1201, 1202, 1203, 1204, 1205, 1206, 1207, 1208, 1209, 1210, 1211, 1212, 1213, 1214, 1215, 1216, 1217, 1218, 1219, 1220, 1221, 1222, 1223, 1224, 1225, 1226, 1227, 1228, 1229, 1230, 1231, 1232, 1233, 1234, 1235, 1236, 1237, 1238, 1239, 1240, 1241, 1242, 1243, 1244, 1245, 1246, 1247, 1248, 1249, 1250, 1251, 1252, 1253, 1254, 1255, 1256, 1257, 1258, 1259, 1260, 1261, 1262, 1263, 1264, 1265, 1266, 1267, 1268, 1269, 1270, 1271, 1272, 1273, 1274, 1275, 1276, 1277, 1278, 1279, 1280, 1281, 1282, 1283, 1284, 1285, 1286, 1287, 1288, 1289, 1290, 1291, 1292, 1293, 1294, 1295, 1296, 1297, 1298, 1299, 1300, 1301, 1302, 1303, 1304, 1305, 1306, 1307, 1308, 1309, 1310, 1311, 1312, 1313, 1314, 1315, 1316, 1317, 1318, 1319, 1320, 1321, 1322, 1323, 1324, 1325, 1326, 1327, 1328, 1329, 1330, 1331, 1332, 1333, 1334, 1335, 1336, 1337, 1338, 1339, 1340, 1341, 1342, 1343, 1344, 1345, 1346, 1347, 1348, 1349, 1350, 1351, 1352, 1353, 1354, 1355, 1356, 1357, 1358, 1359, 1360, 1361, 1362, 1363, 1364, 1365, 1366, 1367, 1368, 1369, 1370, 1371, 1372, 1373, 1374, 1375, 1376, 1377, 1378, 1379, 1380, 1381, 1382, 1383, 1384, 1385, 1386, 1387, 1388, 1389, 1390, 1391, 1392, 1393, 1394, 1395, 1396, 1397, 1398, 1399, 1400, 1401, 1402, 1403, 1404, 1405, 1406, 1407, 1408, 1409, 1410, 1411, 1412, 1413, 1414, 1415, 1416, 1417, 1418, 1419, 1420, 1421, 1422, 1423, 1424, 1425, 1426, 1427, 1428, 1429, 1430, 1431, 1432, 1433, 1434, 1435, 1436, 1437, 1438, 1439, 1440, 1441, 1442, 1443, 1444, 1445, 1446, 1447, 1448, 1449, 1450, 1451, 1452, 1453, 1454, 1455, 1456, 1457, 1458, 1459, 1460, 1461, 1462, 1463, 1464, 1465, 1466, 1467, 1468, 1469, 1470, 1471, 1472, 1473, 1474, 1475, 1476, 1477, 1478, 1479, 1480, 1481, 1482, 1483, 1484, 1485, 1486, 1487, 1488, 1489, 1490, 1491, 1492, 1493, 1494, 1495, 1496, 1497, 1498, 1499, 1500, 1501, 1502, 1503, 1504, 1505, 1506, 1507, 1508, 1509, 1510, 1511, 1512, 1513, 1514, 1515, 1516, 1517, 1518, 1519, 1520, 1521, 1522, 1523, 1524, 1525, 1526, 1527, 1528, 1529, 1530, 1531, 1532, 1533, 1534, 1535, 1536, 1537, 1538, 1539, 1540, 1541, 1542, 1543, 1544, 1545, 1546, 1547, 1548, 1549, 1550, 1551, 1552, 1553, 1554, 1555, 1556, 1557, 1558, 1559, 1560, 1561, 1562, 1563, 1564, 1565, 1566, 1567, 1568, 1569, 1570, 1571, 1572, 1573, 1574, 1575, 1576, 1577, 1578, 1579, 1580, 1581, 1582, 1583, 1584, 1585, 1586, 1587, 1588, 1589, 1590, 1591, 1592, 1593, 1594, 1595, 1596, 1597, 1598, 1599, 1600, 1601, 1602, 1603, 1604, 1605, 1606, 1607, 1608, 1609, 1610, 1611, 1612, 1613, 1614, 1615, 1616, 1617, 1618, 1619, 1620, 1621, 1622, 1623, 1624, 1625, 1626, 1627, 1628, 1629, 1630, 1631, 1632, 1633, 1634, 1635, 1636, 1637, 1638, 1639, 1640, 1641, 1642, 1643, 1644, 1645, 1646, 1647, 1648, 1649, 1650, 1651, 1652, 1653, 1654, 1655, 1656, 1657, 1658, 1659, 1660, 1661, 1662, 1663, 1664, 1665, 1666, 1667, 1668, 1669, 1670, 1671, 1672, 1673, 1674, 1675, 1676, 1677, 1678, 1679, 1680, 1681, 1682, 1683, 1684, 1685, 1686, 1687, 1688, 1689, 1690, 1691, 1692, 1693, 1694, 1695, 1696, 1697, 1698, 1699, 1700, 1701, 1702, 1703, 1704, 1705, 1706, 1707, 1708, 1709, 1710, 1711, 1712, 1713, 1714, 1715, 1716, 1717, 1718, 1719, 1720, 1721, 1722, 1723, 1724, 1725, 1726, 1727, 1728, 1729, 1730, 1731, 1732, 1733, 1734, 1735, 1736, 1737, 1738, 1739, 1740, 1741, 1742, 1743, 1744, 1745, 1746, 1747, 1748, 1749, 1750, 1751, 1752, 1753,

• • •

SECTION 43
REF 19

Laboratory Report

O'BRIEN & GERE

CLIENT Monroe County Department of Engineering 888.075
DESCRIPTION Cliff St. Siphon Tunnel - Sample of Settled Material in
Original Earth Settling Pond
DATE COLLECTED 3-26-85 DATE RECD 3-26-85 DATE ANALYZED

SAMPLE NO. 71211

Flashpoint, °C 38
pH 9.0

Benzene 110
Toluene 280
Ethylbenzene 76
Xylenes 310

EP Toxicity:

As
Ba
Cd <.01 ms/l
Cr
Pb <.01 ms/l
Hg <.0005 ms/l
Se <.01
Ag <.01 ms/l

Methodology: Federal Register — 40 CFR, Part 136, December 3, 1979 Units: mg/l (ppm) unless otherwise noted
Comments: Testing to Date has not indicated the presence of organic halogens
in the contaminated material (ref. General Testing results dated 3-6-85)
Therefore %Cl₂ testing has not been conducted. Authorized: [Signature]
O'Brien & Gere Engineers, Inc.
Box 4373 • 1304 Buckley Rd • Syracuse, NY 13221 • 315-451-4700 Date: 7-11-85

O'BRIEN & GERE

SECTION 4.3
REF. 19
**Laboratory
Report**

CLIENT Monroe County Department of Engineering

888.075

DESCRIPTION Cliff St. Siphon Tunnel - Effluent from Small Settling Pond

DATE COLLECTED _____ DATE RECD. _____ DATE ANALYZED _____

Date Collected	3-22-85	3-28-85	4-5-85	4-12-85	4-19-85
Lab Sample No.	67894	69937	72951	75913	75334
pH	7.6	7.4	7.6	-	7.7
Oil & Grease, mg/l	21	4.0	29	45	25
Benzene, mg/l	17.0	6.9	13.0	11.0	19.0
Toluene, mg/l	9.4	5.2	12.0	10.0	16.0
Ethylbenzene, mg/l	0.8	0.49	0.68	0.70	0.7
Xylenes, mg/l	9.0	2.1	4.2	3.6	3.0
Polynuclear Aromatics (PNA)*	25	14	38		

Methodology: Federal Register — 40 CFR, Part 136, December 3, 1979

Units: mg/l (ppm) unless otherwise noted

Comments: *Maximum value derived from the summation of
all compounds eluting after naphthalene

Authorized: [Signature]

O'Brien & Gere Engineers, Inc.
Box 4973 1304 Buckley Rd., Syracuse, NY 13221 (315) 451-4700

Date: 4-12-85

Lower Falls File -

SECTION 43
REF 20

St. Paul Inceptor Tunnel Leachate Sample

Date Sampled: 2/28/85

Versar

INC.

Location: Inside tunnel, at leachate seep along a
Fault Line.

Note: See Photo's.

April 8, 1985
857-C-12

Jack Ryan
Room 317
Bureau of Water Research
NYS Dept. Environmental Conserv.
50 Wolf Road
Albany, New York 12233-0001

Lower Falls

Reference: Versar-Report Number 857-88

Dear Mr. Ryan:

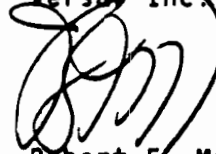
Please find enclosed our report for sample numbers:

RHO-84019-01

Received from Jackson on 3/04/85

Should you have any questions concerning these data, please contact me at your earliest convenience and refer to the above report number.

Sincerely,
Versar Inc.



Robert E. Maxfield, Manager
Inorganic Chemistry Branch
Laboratory Operations

REM:nan
Enclosure

Frank Ricotta is sending samples to:

Monroe County
Commissioner Grants - Albany
O'Brien & Gere

Copies of analytical results only sent to:

Bruce Finster / Frank Keller

Richard Elliot - MCHD

Dick Burton - MCHD

Louise Hartshorn - MCENC

By DJS 4/23/85

METALS DATA



Sample #:

RHO 84019 01

METALS RESULTS

(Conc. in: mg/l)

Date: 4-2-85Project #: 857-88Lab #: 8929

Parameter	Sample Concentration	Parameter	Sample Concentration
Ag	< 0.01	As	< 0.02
Be	< 0.002	Hg	< 0.002
Cd	< 0.02		
Cr	< 0.008	Se	< 0.01
Cu	< 0.006	Tl	< 0.02
Ni	< 0.03		
Pb	0.128		
Zn	< 0.006		
Sb*	< 0.05		

Comments: * Run by ICP due to limited sample volume

Procedures in accordance with:
Test Methods for Evaluating
Solid Wastes, SW-846, 2nd Edition,
USEPA, Washington, D.C., 1982


Robert Maxfield, Lab Manager

Versar
INC

METALS QUALITY ASSURANCE

AA

(Conc. in: mg/l)

Date: 4-2-85Batch: 857-88

		As	Hg	Se	Tl		
Reference Standard Source: EPA	Found	0.054	0.0035		0.048	0.052	
	True	0.0534	0.0036		0.050	0.0504	
	Rel. % Err.	1.	-2.8		-4.0	3.2	
Calb. Blank	Results	<0.01	<0.0002		<0.005	<0.01	
Reg. Blank 1	Results	<0.01	<0.0002		<0.005	<0.01	
Reg. Blank 2	Results						
Inst. Calb. (Verification) Source: EPA	Found	0.102	0.002		0.048	0.071	
	True	0.100 ⁺	0.002 ⁺		0.050	0.07 ⁺	
	Rel. % Err.	2.	0.		-4.0	1.4	
Duplicate 1 * Sample #: RNo 84019 01	Sample Result	<0.02			<0.01	<0.02	
	Dup. Result	<0.02			<0.01	<0.02	
	RPD	-			-	-	
Duplicate 2 Sample #:	Sample Result						
	Dup. Result						
	RPD						
Spike 1 * Sample #: RNo 84019 01	Sample Result	<0.02			<0.01	<0.02	
	Spike Result	0.183			0.172	<0.02	
	Spike Added	0.20			0.2	0.2	
	% Recovery	92.			86.	0.	
Spike 2 Sample #:	Sample Result						
	Spike Result						
	Spike Added						

Versar_{INC}METALS QUALITY ASSURANCEICP
(Conc. in: mg/l)Date: 4-2-85Batch: 857-88

		Ag	Be	Cd	Cr	Cu	Ni	Pb
Reference Standard Source: EPA	Found	0.068	0.232	0.238	0.304	0.344	0.200	0.490
	True	0.068	0.235	0.244	0.311	0.339	0.207	0.480
	Rel. % Err.	0.	-1.3	-2.4	-2.2	1.5	-3.4	2.1
Calb. Blank	Results	<0.005	<0.001	<0.01	<0.004	<0.003	<0.015	<0.05
Reg. Blank 1	Results	<0.005	<0.001	<0.01	<0.004	0.019	<0.015	0.058
Reg. Blank 2	Results							
Inst. Calb. (Verification) Source: EPA	Found	0.070	0.234	0.244	0.307	0.348	0.209	0.470
	True	0.068	0.235	0.244	0.311	0.339	0.207	0.480
	Rel. % Err.	2.9	-0.42	0.	-1.3	2.6	0.97	-2.1
Duplicate 1 Sample #: RNo 84019 01	Sample Result	<0.01	<0.002	<0.02	<0.008	<0.006	<0.03	0.128
	Dup. Result	<0.01	<0.002	<0.02	<0.008	<0.006	0.037	0.127
	RPD	-	-	-	-	-	-	0.78
Duplicate 2 Sample #:	Sample Result							
	Dup. Result							
	RPD							
Spike 1 Sample #: RNo 84019 01	Sample Result	<0.01	<0.002	<0.02	<0.008	<0.006	<0.03	0.128
	Spike Result	0.304	0.326	0.310	0.302	0.333	0.309	0.673
	Spike Added	0.4	0.4	0.4	0.4	0.4	0.4	0.8
	% Recovery	76.	82.	78.	76.	83.	77.	68.
Spike 2 Sample #:	Sample Result							
	Spike Result							
	Spike Added							

METALS QUALITY ASSURANCEICP
(Conc. in: mg/l)Date: 4-2-85Batch: 857-88

		Zn	Sb					
Reference Standard Source: EPA	Found	0.411	0.186					
	True	0.418	0.203					
	Rel. % Err.	-1.7	-8.4					
Calb. Blank	Results	<0.003	<0.025					
Reg. Blank 1	Results	0.044	<0.025					
Reg. Blank 2	Results							
Inst. Calb. (Verification) Source: EPA	Found	0.415	0.179					
	True	0.418	0.203					
	Rel. % Err.	-0.72	-12.					
Duplicate 1 Sample #: RHO 84019 01	Sample Result	<0.006	<0.05					
	Dup. Result	<0.006	<0.05					
	RPD	-	-					
Duplicate 2 Sample #:	Sample Result							
	Dup. Result							
	RPD							
Spike 1 Sample #: RHO 84019 01	Sample Result	<0.006	<0.05					
	Spike Result	0.334	0.325					
	Spike Added	0.4	0.4					
	% Recovery	84.	81.					
Spike 2 Sample #:	Sample Result							
	Spike Result							
	Spike Added							

GC/MS DATA

ORGANICS DATA SUMMARY
PROJECT 857.002 BATCH 88
NYS CONTRACT NO. C000661

NYS SAMPLE NO.	COMPOUNDS DETECTED	CONCENTRATION (ppm)
RHO-84019-01	Naphthalene	19,000.
	2-Methylnaphthalene	12,000.
	Acenaphthylene	4700.
	Acenaphthene	56.
	Dibenzofuran	39.
	Fluorene	2000.
	Phenanthrene	4800.
	Anthracene	1600.
	Fluoranthene	1100.
	Pyrene	1800.
	Benzo(a)anthracene	160.
	Chrysene	830.
	Benzo(b)fluoranthene	40.
	Benzo(k)fluoranthene	69.
	Benzo(a)pyrene	130.
	Indeno(1,2,3-cd)pyrene	55.
	Benzo(g,h,i)perylene	52.
	BENZENE	57.
	Toluene	25.

A-5



APRIL 4, 1985

NYS ORGANICS DATA SUMMARY REPORT
VERSAR PROJECT 857.002 BATCH 88
NYS CLIENT: JACKSON

Batch 88, received on March 4, 1985, consisted of one leachate sample for volatile and semivolatile organics analysis. EPA Method 624/sw-846 Method 8240 was employed for the volatiles analysis. Two Method 624 volatile compounds were detected and quantified in the leachate sample. EPA Method 625/SW-846 Method 8270 was used for the semivolatiles analysis. Seventeen semivolatile organics from EPA method 625 were detected and quantified in the sample. The semivolatile sample extract was analyzed at three different dilutions in order to quantify as many compounds as possible.

Due to the dilution factors required for appropriate analysis of the sample, the results of the surrogate spikes and the matrix spikes cannot be reported for the semivolatiles fraction. The spikes were diluted below the instrument detection limits.

SCOTT E. POWERS

A handwritten signature in cursive script, appearing to read "Scott E. Powers", written over a horizontal line.

MASS SPECTROMETRY SECTION CHIEF
LABORATORY OPERATIONS

GC/MS DATA INDEX

NYS CONTRACT C000661

VERSAR PROJECT 857.002

NYS BATCH ID#: 88

The following GC/MS information is provided in this report:

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DATA SUMMARY

Q.C. SUMMARY

Versar INC.

SURROGATE PERCENT RECOVERY SUMMARY VOLATILES

PROJECT-BATCH 857.002 B# 88

CONTRACT NO. C000661

[illegible]

Versar INC.

DUPLICATE DATA FORM

Sample Number

RH-054-019-002

Lab Sample ID No: 3211

PROJECT-BATCH 857.002 B#

Sample Matrix: Low Level Aqueous

Data Release Authorized By: MB

Volatile Compounds

ug/l

ug/l

		ug/l or ug/Kg (Circle One)	Sample Result	Duplicate Result	RPD
74-87-3	Chloromethane	10u			
74-83-9	Bromomethane	10u			
75-01-4	Vinyl Chloride	10u			
75-00-3	Chloroethane	10u			
75-09-2	Methylene Chloride	5u			
67-64-1	Acetone	5u			
75-15-0	Carbon Disulfide	1u			
75-35-4	1, 1-Dichloroethene	5u			
75-34-3	1, 1-Dichloroethane	5u			
156-80-5	Trans-1, 2-Dichloroethene	5u			
67-66-3	Chloroform	5u			
107-06-2	1, 2-Dichloroethane	1u			
78-93-3	2-Butanone	5u			
71-55-6	1, 1, 1-Trichloroethene	5u			
58-23-5	Carbon Tetrachloride	5u			
108-05-4	Vinyl Acetate	5u			
75-27-4	Bromodichloromethane	5u			
79-34-5	1, 1, 2, 2-Tetrachloroethane	10u			
78-87-5	1, 2-Dichloropropane	10u			
10061-02-6	Trans-1, 3-Dichloropropene	5u			
79-01-6	Trichloroethene		120.	120.	0.
124-48-1	Dibromochloromethane	5u			
79-00-5	1, 1, 2-Trichloroethane	5u			
71-43-2	Benzene	5u			
10061-01-5	cis-1, 3-Dichloropropene	5u			
110-75-8	2-Chloroethylvinyl ether	10u			
75-25-2	Bromoform	10u			
591-78-6	2-Hexanone	5u			
108-10-1	4-Methyl-2-Pentanone	5u			
127-18-4	Tetrachloroethene	5u			
108-88-3	Toluene	5u			
108-90-7	Chlorobenzene	5u			
100-41-4	Ethylbenzene	5u			
100-42-5	Styrene	5u			
	Total Xylenes				

Versar INC.

VOA MATRIX SPIKE RECOVERY

PROJECT-BATCH 857.002 B#CONTRACT NO. C000661VOA SAMPLE NO. RH-084-08-001

COMPOUND	Conc. Spike Added (ug)	Sample Result (ug)	Conc. MS (ug)	Percent Recovery
1,1-Dichloroethene	50	0.	56.	112.
Trichloroethene	50	0.	54.	108.
Chlorobenzene	50	0.	50.	100.
Toluene	50	0.	54.	108.
Benzene	50	0.	52.	104.

Versar INC.

**SURROGATE PERCENT RECOVERY SUMMARY
SEMIVOLATILES**

PROJECT-BATCH 857.002 B# 88

CONTRACT NO. C000661

[illegible]

Versar INC.

SEMI VOLATILE MATRIX SPIKE RECOVERY

PROJECT-BATCH 857.002 B#88CONTRACT NO. C000661BNA SAMPLE NO. RHO-8409-01

COMPOUND	Conc. Spike Added (ug)	Sample Result (ug)	Conc. MS (ug)	Percent Recovery
1,2,4-Trichlorobenzene	100	*	*	*
Acenaphthene	100			
2,4 Dinitrotoluene	100			
Di-n-Butylphthalate	100			
Pyrene	100			
N-Nitrosodi-n-Propylamine	100			
1,4-Dichlorobenzene	100			
Pentachlorophenol	100			
Phenol	100			
2-Chlorophenol	100			
4-Chloro-3-Methylphenol	100			
4-Nitrophenol	100	↓	↓	↓

* - No matrix spike values reported, due to extremely large dilutions required prior to GC/MS analysis.

Versar INC.

DUPLICATE DATA FORM

Sample Number

RHO-84019-01

Lab Sample ID No: 8929PROJECT-BATCH 857.002 B# 88Sample Matrix Low Level AqueousData Release Authorized By: MB

Semivolatile Compounds

		<u>ug/L</u> or <u>ug/Kg</u> (Circle One)	Sample Result	Duplicate Result	RPD
62-75-9	N-Nitrosodimethylamine	10u			
108-95-2	Phenol	10u			
62-63-3	Aniline	5u			
111-44-4	bis(2-Chloroethyl)Ether	10u			
95-57-8	2-Chlorophenol	10u			
541-73-1	1, 3-Dichlorobenzene	10u			
106-46-7	1, 4-Dichlorobenzene	10u			
100-51-6	Benzyl Alcohol	20u			
95-50-1	1, 2-Dichlorobenzene	10u			
95-48-7	2-Methylphenol	5u			
39638-32-9	bis(2-chloroisopropyl)Ether	20u			
106-44-5	4-Methylphenol	5u			
621-64-7	N-Nitroso-Di-n-Propylamine	10u			
67-72-1	Hexachloroethane	10u			
96-95-3	Nitrobenzene	10u			
78-68-1	Isophorone	10u			
88-75-5	2-Nitrophenol	20u			
105-67-9	2, 4-Dimethylphenol	10u			
65-85-0	Benzoic Acid	100u			
111-91-1	bis(2-Chloroethoxy)Methane	20u			
120-83-2	2, 4-Dichlorophenol	10u			
120-82-1	1, 2, 4-Trichlorobenzene	10u			
91-20-3	Naphthalene	10u	19,000. ppm	14,000 ppm	30 %
106-47-8	4-Chloroaniline	50u			
87-68-3	Hexachlorobutadiene	10u			
59-50-7	4-Chloro-3-Methylphenol	10u			
91-57-8	2-Methylnaphthalene	20u	12,000. ppm	5000 ppm	82 %
77-47-4	Hexachlorocyclopentadiene	10u			
88-06-2	2, 4, 6-Trichlorophenol	10u			
95-95-4	2, 4, 5-Trichlorophenol	100u			
91-58-7	2-Chloronaphthalene	10u			
88-74-4	2-Nitroaniline	100u			
131-11-3	Dimethyl Phthalate	10u			
208-96-8	Acenaphthylene	10u	4700. ppm	2100 ppm	76 %
99-09-2	3-Nitroaniline	100u			

Versar INC.

DUPLICATE DATA FORM

Sample Number

RHO-84019-01

Lab Sample ID No: 8929PROJECT-BATCH 857.002 B# 89Sample Matrix Low Level AqueousData Release Authorized By: MB

Semivolatile Compounds

		<u>ug/L or ug/Kg</u> (Circle One)	Sample Results	Duplicate Results	RPD
83-32-8	Acenaphthene	10u	56 ppm	30 ppm	60%
81-28-5	2, 4-Dinitrophenol	50u			
100-02-7	4-Nitrophenol	50u			
132-64-9	Dibenzofuran	10u	39 ppm	20 ppm	64%
121-14-2	2, 4-Dinitrotoluene	20u			
808-20-2	2, 6-Dinitrotoluene	20u			
84-66-2	Diethylphthalate	10u			
7005-72-3	4-Chlorophenyl-phenylether	10u			
86-73-7	Fluorene	10u	2000 ppm	940 ppm	72%
100-01-6	4-Nitroaniline	100u			
534-62-1	4, 6-Dinitro-2-Methylphenol	20u			
86-30-6	N-Nitrosodiphenylamine (1)	10u			
101-85-3	4-Bromophenyl-phenylether	10u			
118-74-1	Hexachlorobenzene	10u			
87-86-5	Pentachlorophenol	10u			
85-01-8	Phenanthrene	10u	4800 ppm	2300 ppm	70%
120-12-7	Anthracene	10u	11000 ppm	760 ppm	71%
84-74-2	Di-n-Butylphthalate	10u			
208-44-0	Fluoranthene	10u	1100 ppm	530 ppm	70%
82-87-5	Benzidine	40u			
129-00-0	Pyrene	10u	1800 ppm	940 ppm	63%
86-68-7	Butylbenzylphthalate	10u			
91-84-1	3, 3'-Dichlorobenzidine	20u			
86-68-3	Benzol(a)Anthracene	10u	1100 ppm	71 ppm	77%
117-81-7	bis(2-Ethylhexyl)Phthalate	10u			
218-01-8	Chrysene	20u	830 ppm	440 ppm	61%
117-84-0	Di-n-Octyl Phthalate	10u			
208-88-2	Benzol(b)Fluoranthene	20u	40 ppm	19 ppm	71%
207-08-9	Benzol(k)Fluoranthene	20u	69 ppm	173 ppm	86%
50-32-8	Benzol(a)Pyrene	20u	130 ppm	57 ppm	78%
193-39-6	Indeno(1, 2, 3-cd)Pyrene	20u	55 ppm	34 ppm	47%
83-70-3	Dibenz(a, h)Anthracene	20u			
191-24-2	Benzol(g, h, i)Perylene	20u	52 ppm	31 ppm	51%

SAMPLE DATA



Organics Analysis Data Sheet

Sample Number

RHO-840-19-01

Laboratory Name: VERSAR, INC.Case No: 857.002-88Lab Sample ID No: 8929CQC Report No: 857.002-88Sample Matrix: Mid Level AqueousContract No: C000661Data Release Authorized By: MSVolatile Compounds *ATD New*

Concentration: Low Medium (Circle One)

Date Extracted/Prepared: 3/13/85Date Analyzed: 3/13/85Conc/Dil Factor: 1000Percent Moisture: 100%

CAS Number		ug/L or ug/Kg (Circle One)
74-87-3	Chloromethane	1,000u
74-83-9	Bromomethane	1,000u
75-01-4	Vinyl Chloride	1,000u
75-00-3	Chloroethane	1,000u
75-09-2	Methylene Chloride	1,000u
67-64-1	Acetone	1,000u
75-15-0	Carbon Disulfide	1,000u
75-35-4	1, 1-Dichloroethene	1,000u
75-34-3	1, 1-Dichloroethane	1,000u
156-60-5	Trans-1, 2-Dichloroethene	1,000u
67-66-3	Chloroform	1,000u
107-06-2	1, 2-Dichloroethane	1,000u
78-93-3	2-Butanone	1,000u
71-55-6	1, 1, 1-Trichloroethane	1,000u
56-23-5	Carbon Tetrachloride	1,000u
108-05-4	Vinyl Acetate	1,000u
75-27-4	Bromodichloromethane	1,000u

CAS Number		ug/L or ug/Kg (Circle One)
79-34-5	1, 1, 2, 2-Tetrachloroethane	1,000u
78-87-5	1, 2-Dichloropropane	1,000u
10061-02-6	Trans-1, 3-Dichloropropene	1,000u
79-01-6	Trichloroethene	1,000u
124-48-1	Dibromochloromethane	1,000u
79-00-5	1, 1, 2-Trichloroethane	1,000u
71-43-2	Benzene	57,000.
10061-01-5	cis-1, 3-Dichloropropene	1,000u
110-75-8	2-Chloroethylvinylether	1,000u
75-25-2	Bromoform	1,000u
591-78-6	2-Hexanone	1,000u
108-10-1	4-Methyl-2-Pentanone	1,000u
127-18-4	Tetrachloroethene	1,000u
108-88-3	Toluene	25,000.
108-90-7	Chlorobenzene	1,000u
100-41-4	Ethylbenzene	1,000u
100-42-5	Styrene	1,000u
	Total Xylenes	

u = None detected. The number to the left of "u" is the detection limit.

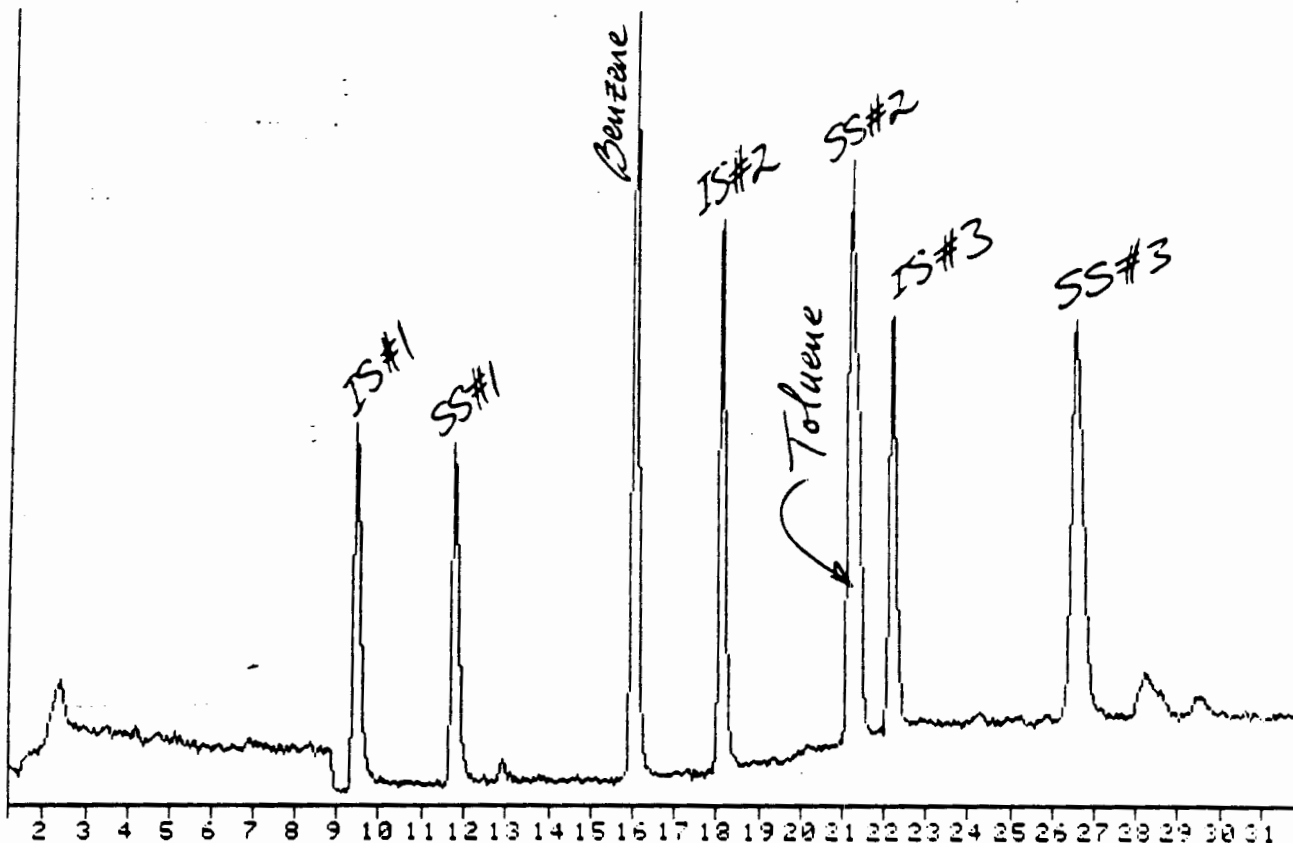
SECTION 4.3
REF. 20

NAME HP VOA WATER#8929C 1/1000 SML NYC#PHO-340-19-01.
MISC 29254 157 10023 857.2/88 2130 3/13/85 WT

FRN 29254

39133

TI



AREA TABLE ENTRIES: FRN 29254

Entry	Time	Mass	Area	%
1	9.5	127.7	7470.	100.0
2	11.8	64.7	17064.	228.4

CALCULATE % ON ENTRY #:

AREA TABLE ENTRIES: FRN 29254

Entry	Time	Mass	Area	%
1	18.2	113.7	32623.	100.0

CALCULATE % ON ENTRY #:

AREA TABLE ENTRIES: FRN 29254

Entry	Time	Mass	Area	%
1	22.2	116.7	19465.	100.0
2	21.2	97.7	29074.	149.4
3	26.6	94.7	26879.	138.1

CALCULATE % ON ENTRY #:

89%

107%
93%

AREA TABLE ENTRIES: FRN 29254

Entry	Time	Mass	Area	%	Response Factor	Dilution Factor	Conc. (ug/l)	Compound
1	18.2	113.7	34384.	100.0				
2	16.1	77.7	53700.	156.2	1.37	1000	57,000.	Benzene

CALCULATE % ON ENTRY #1

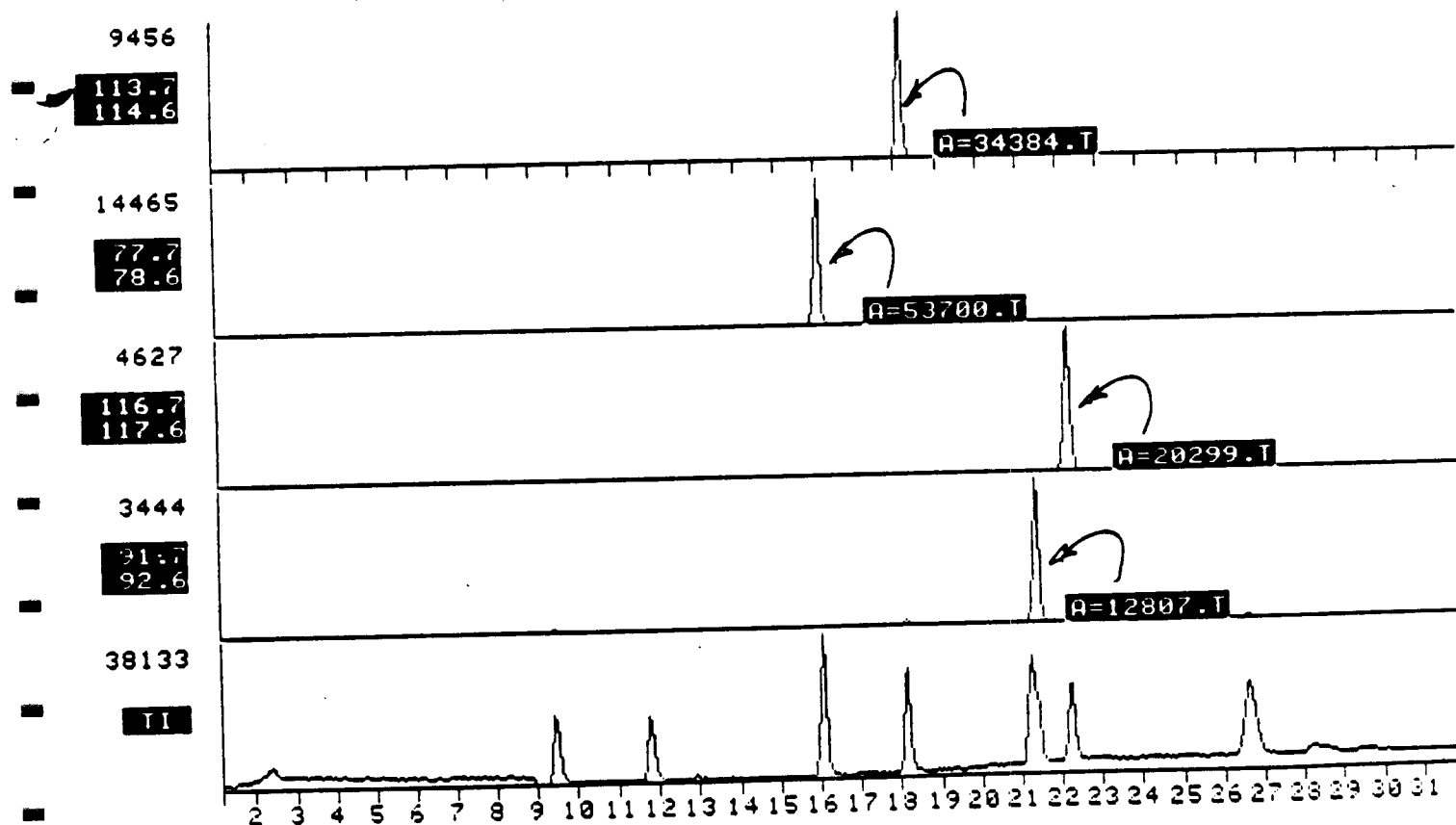
AREA TABLE ENTRIES: FRN 29254

Entry	Time	Mass	Area	%	Response Factor	Dilution Factor	Conc. (ug/l)	Compound
1	22.2	116.7	20299.	100.0				
2	21.4	91.7	12807.	63.1	1.24	1000	25,000.	Toluene

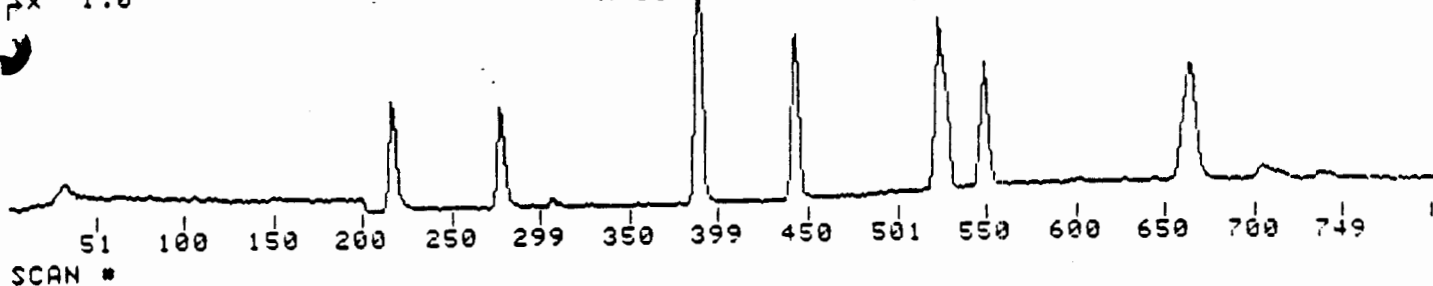
CALCULATE % ON ENTRY #1

NAME HP VOA WATER*8929C 1/1000 SML NYS*RHO-840-19-01.
MISC 29254 157 10023 857.2/88 2130 3/13/85 WT

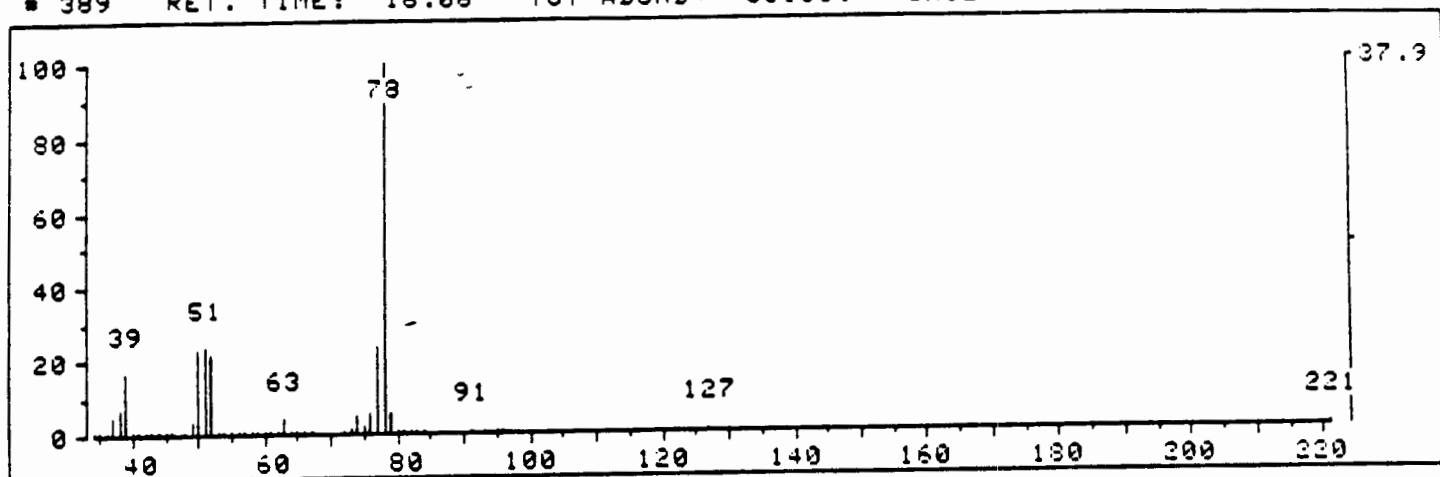
FRN 29254



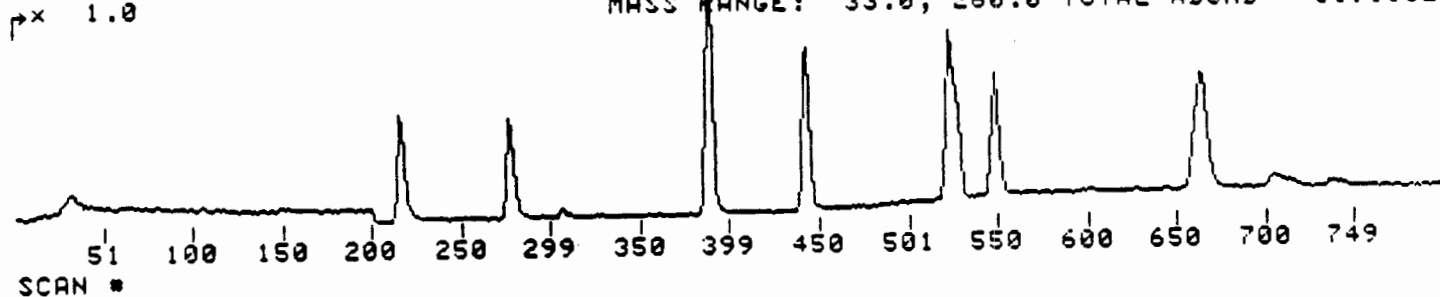
HP VOA WATER#8929C 1/1000 5ML NYS#RHO-840-19-01. **FRN** 29254, **CRN** 157
29254 157 10023 857.2/88 2130 3/13/85 WT 803 SCANS (803 SCANS, 30.88 MIN)
p x 1.0 MASS RANGE: 33.0, 260.0 TOTAL ABUND= 3198032.



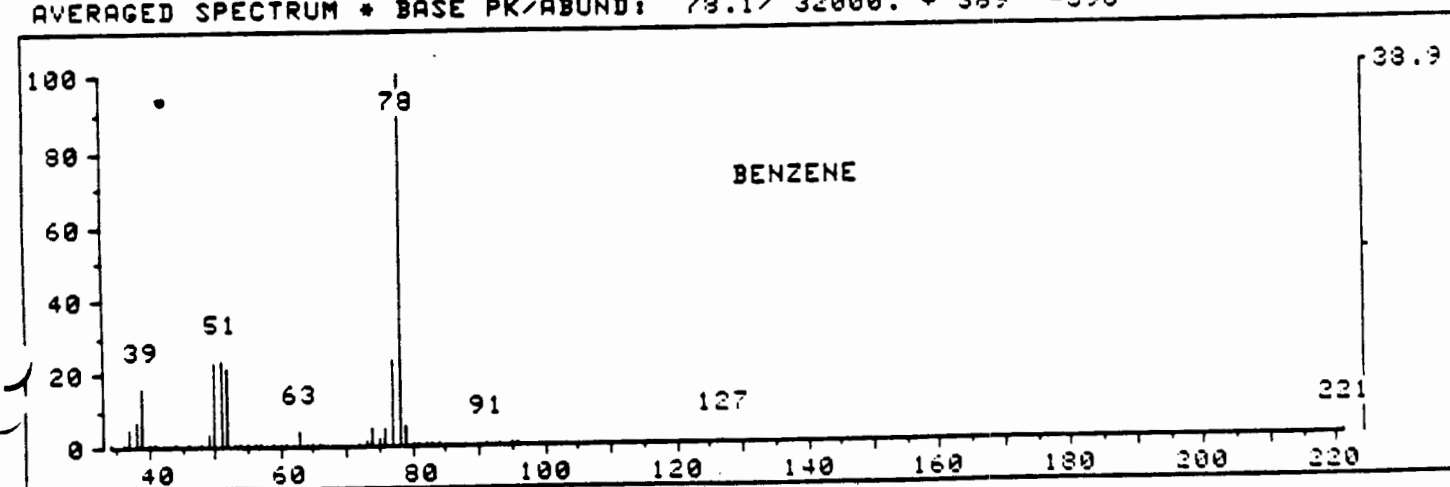
* 389 RET. TIME: 16.08 TOT ABUND= 38133. BASE PK/ABUND: 73.1/ 14465.



HP VOA WATER#8929C 1/1000 5ML NYS#RHO-840-19-01. **FRN** 29254, **CRN** 157
29254 157 10023 857.2/88 2130 3/13/85 WT 803 SCANS (803 SCANS, 30.88 MIN)
p x 1.0 MASS RANGE: 33.0, 260.0 TOTAL ABUND= 3198032.

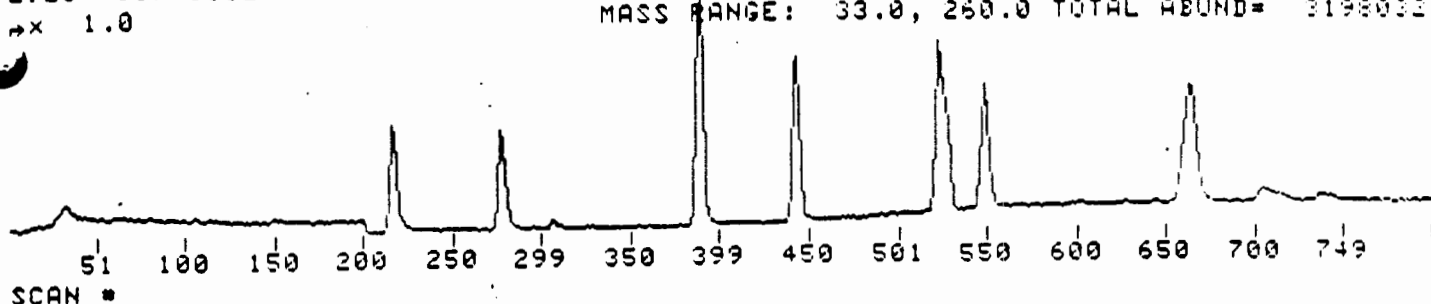


AVERAGED SPECTRUM * BASE PK/ABUND: 73.1/ 32000. + 389 -399

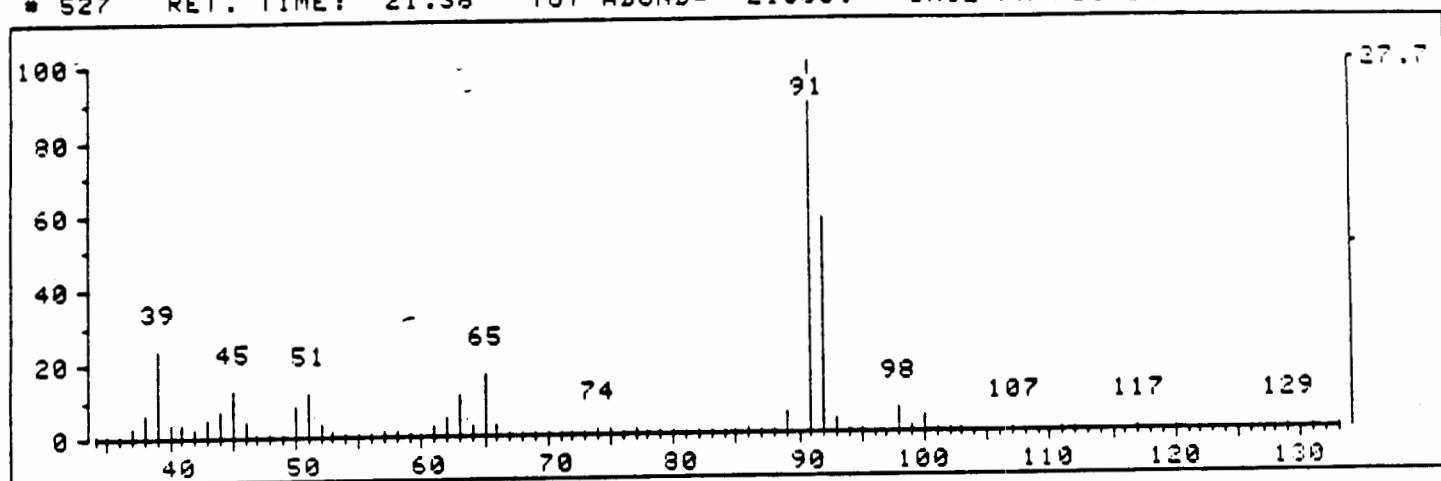


SECTION 4.3
REF. 20

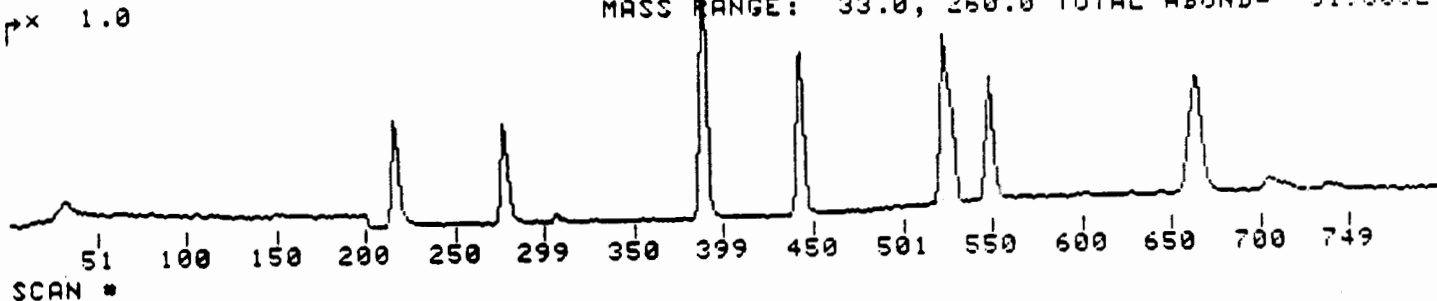
HP VOA WATER#8929C 1/1000 5ML NYS#RHO-840-19-01. FRN 29254, CRN 157
29254 157 10023 857.2/88 2130 3/13/85 WT 803 SCANS (803 SCANS, 30.88 MIN)
x 1.0 MASS RANGE: 33.0, 260.0 TOTAL ABUND= 3198032.



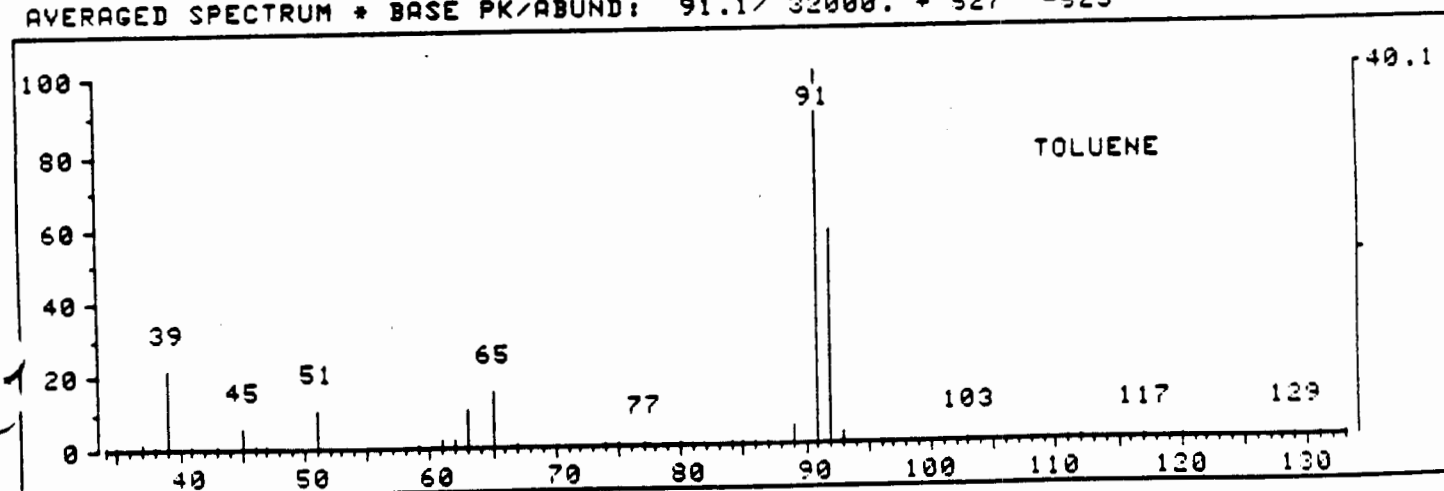
* 527 RET. TIME: 21.38 TOT ABUND= 21363. BASE PK/ABUND: 91.1/ 5919.



HP VOA WATER#8929C 1/1000 5ML NYS#RHO-840-19-01. FRN 29254, CRN 157
29254 157 10023 857.2/88 2130 3/13/85 WT 803 SCANS (803 SCANS, 30.88 MIN)
x 1.0 MASS RANGE: 33.0, 260.0 TOTAL ABUND= 3198032.



AVERAGED SPECTRUM * BASE PK/ABUND: 91.1/ 32000. + 527 -523



Versar INC.

Sample Number

RHO-84019-01

Organics Analysis Data Sheet

Low Level Aqueous

Semivolatile Compounds

Concentration: Low Medium (Circle One)Date Extracted/Prepared: 3-7-85Date Analyzed: 3/22/85 3/30/85 3/30/85Conc/Dil Factor: 1/25 1/125 1/625

CAS Number		ug/L or ug/Kg (Circle One)
62-75-9	N-Nitrosodimethylamine	10u
108-96-2	Phenol	10u
62-53-3	Aniline	5u
111-44-4	bis(2-Chloroethyl)Ether	10u
95-57-8	2-Chlorophenol	10u
541-73-1	1, 3-Dichlorobenzene	10u
106-46-7	1, 4-Dichlorobenzene	10u
100-51-8	Benzyl Alcohol	20u
95-50-1	1, 2-Dichlorobenzene	10u
95-48-7	2-Methylphenol	5u
39638-32-9	bis(2-chloroisopropyl)Ether	20u
106-44-5	4-Methylphenol	5u
621-64-7	N-Nitroso-Di-n-Propylamine	10u
67-72-1	Hexachloroethane	10u
98-95-3	Nitrobenzene	10u
78-59-1	Isophorone	10u
88-75-8	2-Nitrophenol	20u
106-67-9	2, 4-Dimethylphenol	10u
65-85-0	Benzoic Acid	100u
111-91-1	bis(2-Chloroethoxy)Methane	20u
120-83-2	2, 4-Dichlorophenol	10u
120-82-1	1, 2, 4-Trichlorobenzene	10u
91-20-3	Naphthalene	19,000 ppm
106-47-8	4-Chloroaniline	50u
87-68-3	Hexachlorobutadiene	10u
59-50-7	4-Chloro-3-Methylphenol	10u
91-57-8	2-Methylnaphthalene	12,000 ppm
77-47-4	Hexachlorocyclopentadiene	10u
88-06-2	2, 4, 6-Trichlorophenol	10u
95-95-4	2, 4, 5-Trichlorophenol	100u
91-58-7	2-Chloronaphthalene	10u
88-74-4	2-Nitroaniline	100u
131-11-3	Dimethyl Phthalate	10u
206-96-8	Acenaphthylene	4700 ppm
99-09-2	3-Nitroaniline	100u

CAS Number		ug/L or ug/Kg (Circle One)
83-32-9	Acenaphthene	56 ppm
51-28-6	2, 4-Dinitrophenol	50u
100-02-7	4-Nitrophenol	50u
132-84-9	Dibenzofuran	39 ppm
121-14-2	2, 4-Dinitrotoluene	20u
606-20-2	2, 6-Dinitrotoluene	20u
84-66-2	Diethylphthalate	10u
7005-72-3	4-Chlorophenyl-phenylether	10u
86-73-7	Fluorene	2000 ppm
100-01-8	4-Nitroaniline	100u
534-82-1	4, 6-Dinitro-2-Methylphenol	20u
86-30-6	N-Nitrosodiphenylamine (1)	10u
101-85-3	4-Bromophenyl-phenylether	10u
118-74-1	Hexachlorobenzene	10u
87-86-5	Pentachlorophenol	10u
85-01-8	Phenanthrene	4800 ppm
120-12-7	Anthracene	1600 ppm
84-74-2	Di-n-Butylphthalate	10u
206-44-0	Fluoranthene	1100 ppm
92-87-5	Benzidine	40u
129-00-0	Pyrene	1800 ppm
85-68-7	Butylbenzylphthalate	10u
91-94-1	3, 3'-Dichlorobenzidine	20u
86-55-3	Benz(a)Anthracene	160 ppm
117-81-7	bis(2-Ethylhexyl)Phthalate	10u
218-01-9	Chrysene	830 ppm
117-84-0	Di-n-Octyl Phthalate	10u
205-99-2	Benz(b)Fluoranthene	40 ppm
207-08-9	Benz(k)Fluoranthene	69 ppm
50-32-8	Benz(a)Pyrene	130 ppm
193-39-5	Indeno(1, 2, 3-cd)Pyrene	55 ppm
53-70-3	Dibenz(a, h)Anthracene	20u
191-24-2	Benz(g, h, i)Perylene	52 ppm

(1)-Cannot be separated from diphenylamine

ERCO

205 Alewife Brook Parkway, Cambridge, Massachusetts 02138 (617) 661-3111 Telex 650-256-7697 (MCI)

SECTION 4.3.15
REF 21

A DIVISION OF
ENSECO
INCORPORATED

May 23, 1985

Mr. Jack Ryan
New York State DEC
Bureau of Water Research
50 Wolf Road
Albany, NY 12233-0001

Dear Jack:

Enclosed is a set of data for Martin Brand. Sample numbers include RR-884-016-01 through -04 (ERCO Invoice No. 5635-383).

If you have any questions about the data, please do not hesitate to contact me.

Sincerely,

Dallas Wait

A. Dallas Wait, Ph.D.
Director of Analytical
Services

ADW/abs
cc: Martin Brand

RECEIVED

MAY 28 1985

BUREAU OF EMERGENCY REMEDIAL ACTION
DIVISION OF SOLID AND
HAZARDOUS WASTE

Regional and international offices:

- Suite 115, Statesman Insurance Building, 3815 Montrose, Houston, Texas 77006 (713) 523-7311
- 525 Central Avenue, Cedarhurst, New York 11516 (516) 295-1162
- c/o Bectech Trading Co., Ltd., P.O. Box 101-41, Taipei, Taiwan (R.O.C.) Tel. 5013908

(6)

Cliff Street Tunnel

Rochester, NY

Region 8

NYSDEC Inspection
April 10, 1985Martin Brand-Frank Ricotta, Central Office
Vince Dick, Region 8

Samples taken from seeps in tunnel:

<u>Analysis</u>	<u>DEC I.D. No.</u>	<u>Sample Location</u>
VOA	RR8-84-016-01	R1 8+55 west sidewall R2 8+55 west sidewall (red seeps/liquid sample)
PP exc. VOA	RR8-84-016-02	R3 9+25 east sidewall (red seep/rock sample)
VOA	RR8-84-016-03	B1 11+15 west sidewall B2 11+15 west sidewall (black seeps/liquid sample)
PP exc. VOA	RR8-84-016-04	B3 11+15 west sidewall (black seeps/rock sample)

* PP - priority pollutant

Submitted to: ERCO
205 Alewife Brook Pkwy.
Cambridge, MA 02138
Attention: Dallas Wait

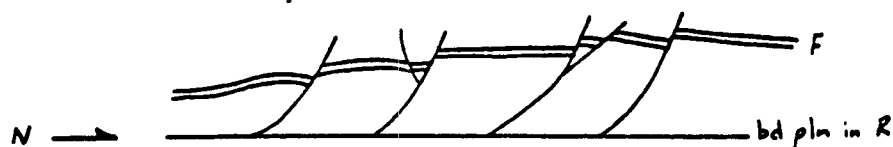
Results returned: May 28, 1985

D

62+70	MW	end of major seeps in MW
61+30	MW	major joint transects tunnel at low angle, seeping
60+35	MW	large joint, dry - MW/TH contact below tunnel floor
60+10	MW	small, dried seeps on east sidewall
59+45	MW	major seeping joint
57+40	MW	major joint system, ceiling failure - no seeps
56+85	MW	west sidewall - low angle small faults, north dipping, cut across tunnel



39+75	R/F	small faults within Reynales/Furnaceville, south dipping, total displacement of 1.5-2.0 feet to the south, no seeps



Grimsby/Thorold formations highly competent, unfractured, no seeps

Maplewood Shale highly fractured/jointed, small faults, many seeps

Reynales/Furnaceville generally competent with some large joints/small faults, isolated small seeps

Lower Sodus highly fractured/jointed, no visible seeps

Copy for [unclear]

SECTION 4.3
REF. 2.1

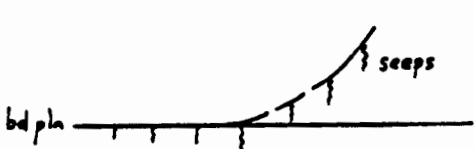
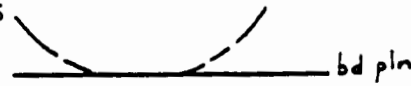
(b)

Field Notes
April 19, 1985

Lake Avenue Tunnel

Rochester, NY
Region 8

Martin Brand NYSDEC
Vince Dick NYSDEC

<u>Station</u>	<u>Formation</u>	<u>Comments</u>
71+00	MW/TH	1st appearance of seeps from the Maplewood Shale/Thorold Sandstone contact - seeps are predominantly black with red/rust-brown fractions oily, film-like appearance - rock surface stained
67+80	MW/TH	red, rust-brown, and black seeps emanating from MW/TH contact - appears along bedding plane and joints and intersection of joints/fractures with bedding plane - seeps move up into MW along joints
65+95	MW	joint set - mineralized deposits on fracture planes, healing of joint
65+45	MW	extensive joint system - seeping along joint/bedding plane approximately 8 feet above MW/TH contact on east sidewall - west sidewall has mineralized deposits on joint surfaces (dry)
64+80	MW	west sidewall - seeps along joint planes and at intersection of joints with prominent bedding plane within MW shale
64+30	MW	low angle joints, dying out along bedding planes
		
		seeps not actively flowing, film/skin on surface - large, low angle joints intersect tunnel tangentially in this area - seeps continue along low angle joints and bedding planes for short distance then die out

Sample Received: 4/12/85
Analysis Completed: 4/17/85
All Results in: ug/l (ppb)
Reported by: JFM
Checked by: NS
Client: New York State DEC

ERCO / A Division of ENSECO
VOLATILE ORGANICS ANALYSIS

BY EPA METHOD 624

- Data Report -

Page 1 of 2

Compounds	Minimum Reporting Limit	Client ID: ERCO ID:	Trip Blank 15424	ERCO Procedural Blank 7657
Chloromethane	5		ND	ND
Bromomethane	5		ND	ND
Vinyl chloride	5		ND	ND
Chloroethane	5		ND	ND
Methylene chloride	5		ND	ND
Acetone	25		ND	ND
Carbon disulfide	2		ND	ND
1,1-dichloroethene	2		ND	ND
1,1-dichloroethane	2		ND	ND
Trans-1,2-dichloroethene	2		ND	ND
Chloroform	2		ND	ND
1,2-dichloroethane	2		ND	ND
2-Butanone	10		ND	ND
1,1,1-trichloroethane	2		ND	ND
Carbon tetrachloride	2		ND	ND
Vinyl acetate	2		ND	ND
Bromodichloromethane	2		ND	ND
1,2-dichloropropane	2		ND	ND
Trans-1,3-dichloropropene	2		ND	ND
Trichloroethene	2		ND	ND
Dibromochloromethane	2		ND	ND
1,1,2-trichloroethane	2		ND	ND
Benzene	2		ND	ND
Cis-1,3-dichloropropene	2		ND	ND
2-Chloroethylvinylether	2		ND	ND
Bromoform	2		ND	ND
2-Hexanone	10		ND	ND
4-Methyl-2-pentanone	10		ND	ND
Tetrachloroethene	2		ND	ND
1,1,2,2-Tetrachloroethane	2		ND	ND
Toluene	2		ND	ND
Chlorobenzene	2		ND	ND
Ethylbenzene	2		ND	ND
Styrene	2		ND	ND
Total xylenes	2		ND	ND

ND = Not detected.

ERCO / A Division of ENSECO
VOLATILE ORGANICS ANALYSISBY EPA METHOD 624

- Data Report -

Page 2 of 2

Client: New York State DEC

COMPOUNDS	Minimum Reporting Limit	Client ID: ERCO ID:	Trip Blank 15424	ERCO Procedural Blank 7657

Additional
Compounds

None detected

Dilution factor:

1

1

Multiply minimum reporting limit by dilution factor to obtain true minimum limit.

Surrogate
Recoveries

% recovery D ₄ -1,2-dichloroethane	100%	100%
% recovery D ₈ -toluene	110%	100%

Sample Received: 4/12/85
Analysis Completed: 4/17/85
All Results in: ug/l. (ppb)
Reported by: JFM
Checked by: NS
Client: New York State DEC

ERCO / A Division of ENSECO
VOLATILE ORGANICS ANALYSIS

BY EPA METHOD 624

- Data Report -

Page 1 of 2

Compounds	Minimum Reporting Limit	Client ID: ERCO ID:	RR-884-016-01 15420	RR-884-016-03 15422
Chloromethane	5		ND	ND
Bromomethane	5		ND	ND
Vinyl chloride	5		ND	ND
Chloroethane	5		ND	ND
Methylene chloride	5		ND	ND
Acetone	25		ND	ND
Carbon disulfide	2		ND	ND
1,1-dichloroethene	2		ND	ND
1,1-dichloroethane	2		ND	ND
Trans-1,2-dichloroethene	2		ND	ND
Chloroform	2		ND	ND
1,2-dichloroethane	2		ND	ND
2-Butanone	10		ND	ND
1,1,1-trichloroethane	2		ND	ND
Carbon tetrachloride	2		ND	ND
Vinyl acetate	2		ND	ND
Bromodichloromethane	2		ND	ND
1,2-dichloropropane	2		ND	ND
Trans-1,3-dichloropropene	2		ND	ND
Trichloroethene	2		ND	ND
Dibromochloromethane	2		ND	ND
1,1,2-trichloroethane	2		ND	ND
Benzene	2		4,900	53,000
Cis-1,3-dichloropropene	2		ND	ND
2-Chloroethylvinylether	2		ND	ND
Bromoform	2		ND	ND
2-Hexanone	10		ND	ND
4-Methyl-2-pentanone	10		ND	ND
Tetrachloroethene	2		37	540
1,1,2,2-Tetrachloroethane	2		ND	ND
Toluene	2		2,000	20,000
Chlorobenzene	2		ND	ND
Ethylbenzene	2		410	1,300
Styrene	2		300	8,500
Total xylenes	2		920	15,000

ND = Not detected.

ERCO / A Division of ENSECO
VOLATILE ORGANICS ANALYSIS

BY EPA METHOD 624

- Data Report -

Page 2 of 2

Client: New York State DEC

COMPOUNDS	Minimum Reporting Limit	Client ID: ERCO ID:	RR-884-016-01 15420	RR-884-016-03 15422

Additional
Compounds

None detected

Dilution factor:	5	250

Multiply minimum reporting limit by dilution factor to obtain true minimum limit.

Surrogate
Recoveries

% recovery D ₄ -1,2-dichloroethane	88%	93%
% recovery D ₈ -toluene	100%	100%

Sample Received: 4/12/85
Analysis Completed: 5/12/85
All Results in: ug/l (ppb)
Reported by: EK
Checked by: AM

ERCO / A DIVISION OF ENSECO, INC.

PESTICIDE ANALYSIS

- Data Report -

Client: New York State DEC

----- RR-884-016 -----						ERCO
Client ID:	02	04	02	04		Blank
ERCO ID:	15421	15423a	15443D	15444Sa		15445B
89P aldrin	ND	ND	ND	2.0 (100%)		ND
90P dieldrin	ND	ND	ND	4.9 (98%)		ND
91P chlordane	ND	ND	ND	ND		ND
92P 4,4'-DDT	ND	ND	ND	ND		ND
93P 4,4'-DDE	ND	ND	ND	ND		ND
94P 4,4'-DDD	ND	ND	ND	ND		ND
95P alpha-endosulfan	ND	ND	ND	ND		ND
96P beta-endosulfan	ND	ND	ND	ND		ND
97P endosulfan sulfate	ND	ND	ND	ND		ND
98P endrin	ND	ND	ND	6.7 (134%)		ND
99P endrin aldehyde	ND	ND	ND	ND		ND
100P heptachlor	ND	ND	ND	3.7 (185%)		ND
101P heptachlor epoxide	ND	ND	ND	ND		ND
102P alpha-BHC	ND	ND	ND	ND		ND
103P beta-BHC	ND	ND	ND	ND		ND
104P gamma-BHC	ND	ND	ND	2.1 (105%)		ND
105P delta-BHC	ND	ND	ND	ND		ND
106P PCB-1242	ND	ND	ND	ND		ND
107P PCB-1254	ND	ND	ND	ND		ND
108P PCB-1221	ND	ND	ND	ND		ND
109P PCB-1232	ND	ND	ND	ND		ND
110P PCB-1248	ND	ND	ND	ND		ND
111P PCB-1260	ND	ND	ND	ND		ND
112P PCB-1016	ND	ND	ND	ND		ND
113P toxaphene	ND	ND	ND	ND		ND

ND = Not detected at or above reporting limit of 0.1 ppb.

^aDetection limit = 1.0 ppb.

SECTION 4.3
REF. 2.1

CLIENT New York State DEC
CLIENT ID ERCO BLANK
ERCO ID 2215445B
SAMPLE RECEIVED 4/12/85
ANALYSIS COMPLETED 4/26/85
RESULTS IN ug/kg (ppb) dry weight

ERCO / A Division of ENSECO

SUMMARY OF
ORGANIC PRIORITY POLLUTANT ANALYSIS

ACID COMPOUNDS

21A	2,4,6-trichlorophenol	ND
22A	p-chloro-m-cresol	ND
24A	2-chlorophenol	ND
31A	2,4-dichlorophenol	ND
34A	2,4-dimethylphenol	ND
57A	2-nitrophenol	ND
58A	4-nitrophenol	ND
59A	2,4-dinitrophenol	ND
60A	4,6-dinitro-o-cresol	ND
64A	pentachlorophenol	ND
65A	phenol	ND

BASE/NEUTRAL COMPOUNDS

1B	acenaphthene	ND
5B	benzidine	ND
8B	1,2,4-trichlorobenzene	ND
9B	hexachlorobenzene	ND
12B	hexachloroethane	ND
18B	bis(2-chloroethyl)ether	ND
20B	2-chloronaphthalene	ND
25B	1,2-dichlorobenzene	ND
26B	1,3-dichlorobenzene	ND
27B	1,4-dichlorobenzene	ND
28B	3,3-dichlorobenzidine	ND
35B	2,4-dinitrotoluene	ND
36B	2,6-dinitrotoluene	ND
37B	1,2-diphenylhydrazine	ND
39B	fluoranthene	ND
40B	4-chlorophenyl phenyl ether	ND
41B	4-bromophenyl phenyl ether	ND

BASE/NEUTRAL COMPOUNDS

42B	bis(2-chloroisopropyl)ether	ND
43B	bis(2-chloroethoxy)methane	ND
52B	hexachlorobutadiene	ND
53B	hexachlorocyclopentadiene	ND
54B	isophorone	ND
55B	naphthalene	ND
56B	nitrobenzene	ND
61B	N-nitrosodimethylamine	ND
62B	N-nitrosodiphenylamine	ND
63B	N-nitrosodi-n-propylamine	ND
66B	bis(2-ethylhexyl)phthalate	ND
67B	butyl benzyl phthalate	ND
68B	di-n-butyl phthalate	ND
69B	di-n-octyl phthalate	ND
70B	diethyl phthalate	ND
71B	dimethyl phthalate	ND
72B	benzo(a)anthracene	ND
73B	benzo(a)pyrene	ND
74B	3,4-benzofluoranthene	ND
75B	benzo(k)fluoranthene	ND
76B	chrysene	ND
77B	acenaphthylene	ND
78B	anthracene	ND
79B	benzo(ghi)perylene	ND
80B	fluorene	ND
81B	phenanthrene	ND
82B	dibenzo(a,h)anthracene	ND
83B	indeno(1,2,3-cd)pyrene	ND
84B	pyrene	ND
129B	2,3,7,8-tetrachlorodibenzo-p-dioxin	ND

ND = None detected above the average
reporting limit of 530 ppb for acids
and 530 ppb for B/N.

Reported by: PD
Checked by: LG

*Trace concentrations detected below the average reporting limit.

SURROGATE RECOVERIES (%):

<u>ACID</u>		<u>BASE/NEUTRAL</u>	
d ₆ -phenol	46	d ₅ -nitrobenzene	89
2-fluorophenol	72	fluorobiphenyl	97

CLIENT New York State DEC
CLIENT ID RR-884-016-04
ERCO ID 2215444 Matrix Spike
SAMPLE RECEIVED 4/12/85
ANALYSIS COMPLETED 4/26/85
RESULTS IN ug/kg (ppb) dry weight

ERCO / A Division of ENSECO

SUMMARY OF
ORGANIC PRIORITY POLLUTANT ANALYSISACID COMPOUNDS

21A 2,4,6-trichlorophenol ND
22A p-chloro-m-cresol----- (97%) 5,400
24A 2-chlorophenol----- (95%) 5,300
31A 2,4-dichlorophenol ND
34A 2,4-dimethylphenol ND
57A 2-nitrophenol ND
58A 4-nitrophenol----- (31%) 1,700
59A 2,4-dinitrophenol ND
60A 4,6-dinitro-o-cresol ND
64A pentachlorophenol----- (33%) 1,800
65A phenol----- (44%) 2,500

BASE/NEUTRAL COMPOUNDS

1B acenaphthene *
5B benzidine ND
8B 1,2,4-trichlorobenzene *
9B hexachlorobenzene ND
12B hexachloroethane ND
18B bis(2-chloroethyl)ether ND
20B 2-chloronaphthalene ND
25B 1,2-dichlorobenzene ND
26B 1,3-dichlorobenzene ND
27B 1,4-dichlorobenzene *
28B 3,3-dichlorobenzidine ND
35B 2,4-dinitrotoluene *
36B 2,6-dinitrotoluene ND
37B 1,2-diphenylhydrazine ND
39B fluoranthene----- 48,000
40B 4-chlorophenyl phenyl ether ND
41B 4-bromophenyl phenyl ether ND

BASE/NEUTRAL COMPOUNDS

42B bis(2-chloroisopropyl)ether ND
43B bis(2-chloroethoxy)methane ND
52B hexachlorobutadiene ND
53B hexachlorocyclopentadiene ND
54B isophorone ND
55B naphthalene----- 63,000
56B nitrobenzene ND
61B N-nitrosodimethylamine ND
62B N-nitrosodiphenylamine ND
63B N-nitrosodi-n-propylamine ND
66B bis(2-ethylhexyl)phthalate ND
67B butyl benzyl phthalate ND
68B di-n-butyl phthalate *
69B di-n-octyl phthalate ND
70B diethyl phthalate ND
71B dimethyl phthalate ND
72B benzo(a)anthracene----- 24,000
73B benzo(a)pyrene *
74B 3,4-benzofluoranthene
75B benzo(k)fluoranthene ----- *a
76B chrysene----- 26,000
77B acenaphthylene----- 76,000
78B anthracene----- 47,000
79B benzo(ghi)perylene *
80B fluorene----- 53,000
81B phenanthrene----- 160,000
82B dibenzo(a,h)anthracene *
83B indeno(1,2,3-cd)pyrene *
84B pyrene----- 80,000
129B 2,3,7,8-tetrachlorodibenzo-
p-dioxin ND

ND = None detected above the average
reporting limit of 560 ppb for acids
and 22,000 ppb for B/N.

Reported by: LD
Checked by: LD

*Trace concentrations detected below the average reporting limit.

*a = Coelute

SURROGATE RECOVERIES (%): ACID

d6-phenol 43
2-fluorophenol 66

BASE/NEUTRAL

d5-nitrobenzene 56
fluorobiphenyl 84

(unable to accurately determine matrix spike recoveries of the B/N compounds
due to high dilution factor)

CLIENT	New York State DEC
CLIENT ID	RR-884-016-02
ERCO IQ	2215443 Duplicate
SAMPLE RECEIVED	4/12/85
ANALYSIS COMPLETED	4/26/85
RESULTS IN	ug/kg (ppb) dry weight

ERCO / A Division of ENSECO

SUMMARY OF
ORGANIC PRIORITY POLLUTANT ANALYSISACID COMPOUNDS

21A	2,4,6-trichlorophenol	ND
22A	p-chloro-m-cresol	ND
24A	2-chlorophenol	ND
31A	2,4-dichlorophenol	ND
34A	2,4-dimethylphenol	ND
57A	2-nitrophenol	ND
58A	4-nitrophenol	ND
59A	2,4-dinitrophenol	ND
60A	4,6-dinitro-o-cresol	ND
64A	pentachlorophenol	ND
65A	phenol	ND

BASE/NEUTRAL COMPOUNDS

1B	acenaphthene	*
5B	benzidine	ND
8B	1,2,4-trichlorobenzene	ND
9B	hexachlorobenzene	ND
12B	hexachloroethane	ND
18B	bis(2-chloroethyl)ether	ND
20B	2-chloronaphthalene	ND
25B	1,2-dichlorobenzene	ND
26B	1,3-dichlorobenzene	ND
27B	1,4-dichlorobenzene	ND
28B	3,3-dichlorobenzidine	ND
35B	2,4-dinitrotoluene	ND
36B	2,6-dinitrotoluene	ND
37B	1,2-diphenylhydrazine	ND
39B	fluoranthene	*
40B	4-chlorophenyl phenyl ether	ND
41B	4-bromophenyl phenyl ether	ND

BASE/NEUTRAL COMPOUNDS

42B	bis(2-chloroisopropyl)ether	ND
43B	bis(2-chloroethoxy)methane	ND
52B	hexachlorobutadiene	ND
53B	hexachlorocyclopentadiene	ND
54B	isophorone	ND
55B	naphthalene-----	2,500
56B	nitrobenzene	ND
61B	N-nitrosodimethylamine	ND
62B	N-nitrosodiphenylamine	ND
63B	N-nitrosodi-n-propylamine	ND
66B	bis(2-ethylhexyl)phthalate-----	4,800
67B	butyl benzyl phthalate	ND
68B	di-n-butyl phthalate	ND
69B	di-n-octyl phthalate	*
70B	diethyl phthalate	ND
71B	dimethyl phthalate	ND
72B	benzo(a)anthracene	*
73B	benzo(a)pyrene	*
74B	3,4-benzofluoranthene	ND
75B	benzo(k)fluoranthene	ND
76B	chrysene	*
77B	acenaphthylene	*
78B	anthracene	*
79B	benzo(ghi)perylene	ND
80B	fluorene	*
81B	phenanthrene	*
82B	dibenzo(a,h)anthracene	ND
83B	indeno(1,2,3-cd)pyrene	ND
84B	pyrene	*
129B	2,3,7,8-tetrachlorodibenzo-p-dioxin	ND

ND = None detected above the average
reporting limit of 500 ppb for acids
and 500 ppb for B/N.Reported by: PD
Checked by: LG
ADW*Trace concentrations detected below
the average reporting limit.

SURROGATE RECOVERIES (%):	<u>ACID</u>		<u>BASE/NEUTRAL</u>	
	d ₆ -phenol	<u>50</u>	d ₅ -nitrobenzene	<u>75</u>
	2-fluorophenol	<u>74</u>	fluorobiphenyl	<u>86</u>

CLIENT New York State DEC
 CLIENT ID RR-884-016-04
 ERCO ID 2215423
 SAMPLE RECEIVED 4/12/85
 ANALYSIS COMPLETED 4/26/85
 RESULTS IN ug/kg (ppb) dry weight

ERCO / A Division of ENSECO

SUMMARY OF
ORGANIC PRIORITY POLLUTANT ANALYSISACID COMPOUNDS

21A 2,4,6-trichlorophenol ND
 22A p-chloro-m-cresol ND
 24A 2-chlorophenol ND
 31A 2,4-dichlorophenol ND
 34A 2,4-dimethylphenol ND
 57A 2-nitrophenol ND
 58A 4-nitrophenol ND
 59A 2,4-dinitrophenol ND
 60A 4,6-dinitro-o-cresol ND
 64A pentachlorophenol ND
 65A phenol ND

BASE/NEUTRAL COMPOUNDS

1B acenaphthene *
 5B benzidine ND
 8B 1,2,4-trichlorobenzene ND
 9B hexachlorobenzene ND
 12B hexachloroethane ND
 18B bis(2-chloroethyl)ether ND
 20B 2-chloronaphthalene ND
 25B 1,2-dichlorobenzene ND
 26B 1,3-dichlorobenzene ND
 27B 1,4-dichlorobenzene ND
 28B 3,3-dichlorobenzidine ND
 35B 2,4-dinitrotoluene ND
 36B 2,6-dinitrotoluene ND
 37B 1,2-diphenylhydrazine ND
 39B fluoranthene-----49,000
 40B 4-chlorophenyl phenyl ether ND
 41B 4-bromophenyl phenyl ether ND

BASE/NEUTRAL COMPOUNDS

42B bis(2-chloroisopropyl)ether ND
 43B bis(2-chloroethoxy)methane ND
 52B hexachlorobutadiene ND
 53B hexachlorocyclopentadiene ND
 54B isophorone ND
 55B naphthalene-----68,000
 56B nitrobenzene ND
 61B N-nitrosodimethylamine ND
 62B N-nitrosodiphenylamine ND
 63B N-nitrosodi-n-propylamine ND
 66B bis(2-ethylhexyl)phthalate ND
 67B butyl benzyl phthalate ND
 68B di-n-butyl phthalate ND
 69B di-n-octyl phthalate ND
 70B diethyl phthalate ND
 71B dimethyl phthalate ND
 72B benzo(a)anthracene-----25,000
 73B benzo(a)pyrene *
 74B 3,4-benzofluoranthene
 75B benzo(k)fluoranthene-----*a
 76B chrysene-----25,000
 77B acenaphthylene-----77,000
 78B anthracene-----46,000
 79B benzo(ghi)perylene *
 80B fluorene-----49,000
 81B phenanthrene-----170,000
 82B dibenzo(a,h)anthracene *
 83B indeno(1,2,3-cd)pyrene *
 84B pyrene-----59,000
 129B 2,3,7,8-tetrachlorodibenzo-
 p-dioxin ND

ND = None detected above the average
 reporting limit of 530 ppb for acids
 and 21,000 ppb for B/N.

Reported by: PD
 Checked by: LG

ADW

*Trace concentrations detected below
 the average reporting limit.

*a = Coelute

SURROGATE RECOVERIES (%):

ACID

d6-phenol 49
 2-fluorophenol 68

BASE/NEUTRAL

d5-nitrobenzene **
 fluorobiphenyl **

**

CLIENT New York State DEC
CLIENT ID RR-884-016-02
ERCO ID 2215421
SAMPLE RECEIVED 4/12/85
ANALYSIS COMPLETED 4/26/85
RESULTS IN ug/kg (ppb) dry weight

ERCO / A Division of ENSECO

SUMMARY OF
ORGANIC PRIORITY POLLUTANT ANALYSIS

ACID COMPOUNDS

21A	2,4,6-trichlorophenol	ND
22A	p-chloro-m-cresol	ND
24A	2-chlorophenol	ND
31A	2,4-dichlorophenol	ND
34A	2,4-dimethylphenol	ND
57A	2-nitrophenol	ND
58A	4-nitrophenol	ND
59A	2,4-dinitrophenol	ND
60A	4,6-dinitro-o-cresol	ND
64A	pentachlorophenol	ND
65A	phenol	ND

BASE/NEUTRAL COMPOUNDS

42B	bis(2-chloroisopropyl)ether	ND
43B	bis(2-chloroethoxy)methane	ND
52B	hexachlorobutadiene	ND
53B	hexachlorocyclopentadiene	ND
54B	isophorone	ND
55B	naphthalene-----	2,900
56B	nitrobenzene	ND
61B	N-nitrosodimethylamine	ND
62B	N-nitrosodiphenylamine	ND
63B	N-nitrosodi-n-propylamine	ND
66B	bis(2-ethylhexyl)phthalate-----	7,600
67B	butyl benzyl phthalate	ND
68B	di-n-butyl phthalate	ND
69B	di-n-octyl phthalate	*
70B	diethyl phthalate	ND
71B	dimethyl phthalate	ND
72B	benzo(a)anthracene	*
73B	benzo(a)pyrene	*
74B	3,4-benzofluoranthene	*
75B	benzo(k)fluoranthene-----	*a
76B	chrysene	*
77B	acenaphthylene-----	570
78B	anthracene	*
79B	benzo(ghi)perylene	ND
80B	fluorene	*
81B	phenanthrene-----	590
82B	dibenzo(a,h)anthracene	ND
83B	indeno(1,2,3-cd)pyrene	ND
84B	pyrene	*
129B	2,3,7,8-tetrachlorodibenzo-p-dioxin	ND

ND = None detected above the average reporting limit of 520 ppb for acids and 520 ppb for B/N.

*Trace concentrations detected below the average reporting limit.

*a = Coelute

Reported by: PD
Checked by: LG

SURROGATE RECOVERIES (%): ACID

d6-phenol	<u>46</u>
2-fluorophenol	<u>63</u>

BASE/NEUTRAL

d5-nitrobenzene	<u>78</u>
fluorobiphenyl	<u>90</u>

Sample Received: 4/12/85
Analysis Completed: 4/26/85
All Results in: µg/g (ppm) dry wt.
Reported by: JEM
Checked by: LAS ADW

ERCO / A DIVISION OF ENSECO, INC.

INORGANIC ANALYSIS

- Data Report -

Client: New York State DEC

ERCO ID	CLIENT ID	Ag	As	Be	Cd	Cr	Cu	Hg	Ni
15421	RR-884-016-02	<0.24	7.4	0.74	<0.25	14	66	0.0065	26
15423	RR-884-016-04	<0.22	4.6	0.65	<0.22	13	84	0.0058	28

If customer has any questions regarding analysis, refer to sample in question by its
ERCO ID#.

SECTION 43
REF. 21



O'BRIEN & GERE

November 6, 1985

Mr. Frank Keller, P.E.
NEW YORK STATE DEPARTMENT OF
ENVIRONMENTAL CONSERVATION
Region 8
6274 East Avon-Lima Road
Avon, New York 14414

Re: Rochester Pure Waters District
St. Paul Boulevard Improvements
Contract 13 (C-36-745-05)
Closure Plan-Cliff St. Siphon Tunnel
Contaminants

File: 888.075

Dear Mr. Keller:

Enclosed please find three copies of the final draft of the above-referenced Closure Plan, for your review. As it is most important that the Closure Plan be implemented during the present construction season, we would appreciate your prompt review of the document. We would like to meet with you next week to discuss any comments you may have on the Closure Plan, and will be contacting you to arrange for such a meeting.

Thank you for your cooperation. If you have any questions regarding this matter, please contact us.

Very truly yours,

O'BRIEN & GERE ENGINEERS, INC.

Dwight A. MacArthur
Dwight A. MacArthur, P.E.
Managing Engineer

DC:jd

Enclosure:

cc: Mr. Irwin Brodell, P.E. - MCDOE

RECEIVED

NOV - 8 1985

WVA
D.E.C. REG. #1

RECEIVED

NOV 12 1985

SOLID WASTE
D.E.C. REG. #2

REPORT

*includes
only part
of report*

CLIFF STREET SIPHON TUNNEL
BREWER STREET CONSTRUCTION SITE

CLOSURE PLAN

MONROE COUNTY DEPARTMENT
OF ENGINEERING

ROCHESTER, NEW YORK

NOVEMBER, 1985

O'BRIEN & CERE ENGINEERS, INC.
1304 BUCKLEY ROAD
SYRACUSE, NEW YORK 13221

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1. Miscellaneous Analytical Results
2. Analytical Summary - Settling Pond Effluent
3. Analytical Summary - VanLare Treatment Plant Samples
4. Analytical Summary - Clear Water Samples

FIGURES

1. Location Map
2. Site Map
3. Active Settling Basins
4. Active Settling Basins - Core Sampling Locations
5. Analytical Summary - Benzene, Toluene, Ethylbenzene, Xylene
6. Analytical Summary - Oil and Grease
7. VanLare Treatment Plant Samples - Influent Levels
8. VanLare Treatment Plant Samples - Oil and Grease Level
9. Clear Water Tunnel Pumpout Samples - Oil and Grease Level

EXHIBITS

- A. Permits for Absorbent Materials
- B. Permits for Skimmed Materials
- C. Permits for Original Settling Basin Materials
- D. Disposal Cost Estimates

SECTION 1 - INTRODUCTION1.01 Background

During excavation of a siphon tunnel, constructed as part of the Combined Sewage Overflow Abatement Program (CSOAP) currently in progress for the Rochester Pure Waters District, Rochester, New York, a seep of coal tar compounds was encountered. The 2000-foot long tunnel is located under the Genesee River (see Figure 1), has a diameter of 12 feet, and runs from Brewer Street on the river's east side to Cliff Street on the western bank of the river. Remedial action became necessary to protect the health and safety of personnel involved in the tunnel construction as well as to protect water quality in the Genesee River, to which tunnel water was discharged after settling. Laboratory testing was performed to identify the chemical characteristics of the coal-tar material. It was identified as hazardous to personnel health and safety under long-term exposure or short-term, high concentrations. Efforts were also directed to comply with New York State Department of Environmental Conservation (NYSDEC) requirements concerning discharge to the River and to develop strategies for the safe disposal of settled and skimmed materials containing the contaminant.

Based on analyses performed, the material was determined to be similar to substances found in a nearby Rochester Gas and Electric (RG&E) tunnel and also similar to substances which have been emanating from the face of the Lower Falls located about a half-mile downstream from the siphon tunnel. County health officials have previously sampled this discharge from the face of the Falls for years. Solvents and a coal tar substance are contained in this material. It is not

unreasonable to assume that the source of the material discovered in the siphon tunnel is the same source of the material from the Falls. This indicates that a significant amount of this material may be contained within various geologic discontinuities in the rock strata in this localized area. A possible source of the coal tar substance is a group of coke and gas plants that were once located on the river's western side. These plants produced coal tar as a byproduct of the gasification process which they employed. The plants operated before the turn of the century and discontinued operation many years ago.

1.02 Chronology of Events

a. Initial Events

On the morning of February 25, 1985, upon entering the tunnel which was under construction, a strong odor was detected by workers. Upon further investigation, an oily substance was observed floating on the tunnel water at the invert. At Station 12 + 30, which was in the general area of the excavating work at this time, the substance was found to be seeping into the tunnel. Station 12 + 30 is located approximately halfway across the Genesee River along the tunnel's alignment. The infiltration appeared to be entering the tunnel from points extending from the invert and progressing up the left hand or southern side of the tunnel wall. As work progressed, this substance was characterized by an increasingly stronger odor as more areas of infiltration were observed. The Contractor's Safety Engineer continued to obtain air samples normally taken and wicks used to soak up the oil were placed in the shaft. Workers in the tunnel were issued half-face

respirators. The Safety Engineer again took air samples continually through the day and also obtained samples at the oil/water mixture from the tunnel. On Wednesday, February 26, 1985, crews were assigned tasks other than excavating the tunnel. Additional ventilation fans were installed and a 6-inch steel discharge line and pump were installed to pump out the oil/water mixture from the immediate contaminated area and out the Brewer Street access shaft. This discharge line was installed to prevent the oil/water mixture from flowing down the invert for the length of the tunnel and also to minimize the vapors coming from the liquid. The pump was installed in a sump at Station 12 + 68. In addition, attempts were made to stop the infiltration by grouting. Four 6 foot holes were drilled in the area of Station 11 + 55 to Station 11 + 70. Grout pressures up to 100 psi failed to inject any grout material into the rock and as a result grouting attempts were abandoned.

The seepage into the tunnel continued and on Friday, February 28, the Contractor's work crews were issued full face organic vapor respirators, rubber gloves and silicone cream by the Contractor's safety representative and instructed in the proper use of the equipment. At this point, the work crews declined to enter the tunnel. After additional clarifications of the composition of the contaminants and the protective equipment to be used was provided to the work crews, excavation of the tunnel was resumed on March 15, 1985. A blood and urine testing program was arranged so as to detect any abnormalities due to worker exposure.

b. Waste Handling

During this initial period, the oil/water mix was pumped out of the tunnel, through two settling tanks and into a small settling pond originally used for siltation purposes. This settling system was located at the Brewer Street work area (see Figure 2). The effluent from this pond was then discharged to the Genesee River. This system was deemed insufficient for treatment of the tunnel seepage, and a directive was issued to construct a system which would provide a greater degree of treatment. A 2-pond settling system (see Figure 3) was constructed in March. The tunnel effluent was pumped into a rectangular settling pond with a volume of nearly 250,000 gallons, providing a retention time of approximately 2 days depending on the tunnel pumpout rate. The pumping rates of the oil/water mix were typically on the order of 80-100 gallons per minute (gpm). After treatment in the large pond, flow entered a smaller polishing pond to provide additional treatment. The small pond's volume was approximately 30,000 gallons. Following treatment in this small pond, the effluent was discharged to a marsh area adjacent to the Genesee River. Effluent cascaded onto a stack of absorbent materials prior to passing into the marsh. Both ponds were equipped with oil booms to help capture and contain the oily film floating on the water surface.

The floating materials were removed from the pond surface by a Vactor truck at a frequency of once or twice per day. These skimmings were transferred from the Vactor truck to a 6000-gallon fully enclosed tank truck for storage on-site. Periodic decanting of the relatively clear water from the tanker after oil/water phase

separation was performed to reduce the volume of contaminated materials in the tanker. Absorbent materials used at the site were stored in small containers (luggers) at the site and covered with tarpaulins while arrangements were made for disposal. This procedure continued until late July, when the Contractor was instructed to install a system that would route the effluent from the small polishing pond into the Monroe County sewer system at Carthage Drive for treatment at the VanLare wastewater treatment plant.

During April, unquantified amounts of the coal tar material were observed in an area by the northwest corner of the pond which subsequently traveled down the bank to the nearby Genesee River. The apparent cause of this was a breach in the soil liner of the large settling basin. The ponds were constructed on a site which contained very coarse fill consisting of construction debris. This poor subbase material is the probable cause for the leakage problems encountered. To remedy the situation, a sump was dug in the leakage area and a pump was installed. The pump directed the contaminants collected in the sump back into the settling pond.

1.03 Waste Inventory

An inventory of the pollutants present was necessary in order to properly assess the situation and to determine necessary short-term and long-term remedial action. Regular air sampling performed by Chyun Associates provided information on air quality within the tunnel. Based on these test results, health and safety decisions were made to assure

adequate protection against adverse exposure levels in the tunnel. This air monitoring has continued throughout the entire period of contamination.

Various other tests were performed to better characterize the coal tar material. Preliminary analyses indicated that major components of the contaminant were polynuclear aromatic hydrocarbons and lower molecular weight aromatics including benzene, toluene, and xylene. This contaminant was tentatively identified as a light fraction coal tar and consequentially deemed a hazardous material. Additional tests were performed to address the issue of flammability of the substance.

On March 22, 1985, a regular weekly settling pond effluent sampling program was instituted. The collection and analyses were performed by O'Brien and Gere personnel. These samples provide a consistent database for which pollutant levels can be monitored over time. Sampling of the clear water volumes pumped from the tunnel, and the VanLare treatment plant influent and effluent was initiated when the pond effluent was discharged to the sewer system at Carthage Drive beginning in late July.

1.04 Analytical Data

To characterize the seepage contaminant, various analytical tests were performed. Several laboratories conducted the tests. Analyses included purgeable aromatics (GC Method 602), volatile organic halogens (GC Method 601), petroleum hydrocarbons, pH, and PCBs. Other chemical constituents that regularly appeared in the analytical results included the purgeable organic compounds such as benzene, toluene, ethylbenzene, and xylenes. Subsequent to full characterization of the

waste, the testing schedule was modified to include analysis for the presence of BTX as well as for oil and grease, cyanide, and pH as indicators of contaminant levels. See Table 1 for a summary of the various analyses performed. As previously outlined, O'Brien and Gere instituted a weekly analytical program in late March. Results of the settling pond effluent samples are presented in Table 2 and Figures 5 and 6. Table 3 summarizes the results of the analyses performed on influent and effluent samples of the VanLare treatment plant. Figures 7 and 8 provide a pictorial representation of the contaminant levels contained in the various samples from the treatment plant. Contaminant levels were generally very low in the samples taken of the plant effluent. The only significant concentrations detected in the plant effluent were of the oil and grease levels (see Figure 8), however, this is not an indication of the presence of the coal-tar compounds since the corresponding BTX values are so low. In addition, review of the plant effluent data indicates that the high oil and grease levels is a result of the procedure for collecting this effluent sample. Initially, the sample was collected by dropping a bucket into the effluent channel and obtaining a surface sample. Later, a weighted bucket was used to collect the sample from nearer mid-depth. Table 4 and Figure 9 outline the levels of oil and grease contained in the clear water tunnel pumpout samples. Oil and grease was the only experimental parameter that measured any detectable levels in these samples. BTX test results were all below detection limits.

Table 1. Miscellaneous Analytical Results

SECTION 4.3
REF 22

:St. Paul Blvd. Interceptor Improvements - Siphon Tunnel Contaminants							
:Miscellaneous Analytical Results			File No. 898.075				
:Note: All results expressed in parts per billion (ppb) unless otherwise noted							
: LABORATORY	: SAMPLE	: DATE	: BENZENE	: TOLUENE	: XYLENE	: ETHYL-	: OIL &
:	: LOCATION	:	:	:	:	: BENZENE	: GREASE
:Recre. Env. Lab	:Genesee River	:10/20/84	: 5800	: 4800	: 4130	:	:
:(for MCDOM)	:Gorge Seeps	:	: 6000	: 5000	: 3020	:	:
:	:(3 samples)	:	: 5600	: 5500	: 3890	:	:
:	:	:	:	:	:	:	:
:	:RG&E Tunnel	:10/20/84	: 180	: 160	:	: 34	:
:	:	:	:	:	:	:	:
:	:	:	:	:	:	:	:
:Chyun (for DBG)	:Siphon Tunnel	: 3/5/85	: 21000	: 21000	: 51000	: 23000	:
:	:Effluent	:	:	:	:	:	:
:	:	:	:	:	:	:	:
:	:	:	:	:	:	:	:
:Gen. Testing	:Siphon Tunnel	: 3/1/85	: 5100	: 3500	: 2700	: 300	: 21 ug/l
:(for DBG)	:Effluent	:	:	:	:	:	:
:	:	:	:	:	:	:	:
:	:	:	:	:	:	:	:
:Verser	:	: 3/4/85	: 57000	: 25000	:	: (1000	:
:(for NYSDOC)	:	:	:	:	:	:	:
:	:	:	:	:	:	:	:
:	:	:	:	:	:	:	:
:ERCO	:Genesee River	: 4/12/85	: 4900	: 2000	: 920	: 410	:
:(for NYSDOC)	:Gorge Seeps	:	: 53000	: 20000	: 15000	: 1300	:
:	:(2 samples)	:	:	:	:	:	:
:	:	:	:	:	:	:	:
:	:	:	:	:	:	:	:
:O'Brien & Gere	:Tunnel, near	: 3/4/85	: 29000	: 15000	: 1700	: (1000	:
:	:source (#54765):	:	:	:	:	:	:
:	:	:	:	:	:	:	:
:	:Pump discharge	:	:	:	:	:	:
:	:(#54744)	: 3/4/85	: 5700	: 4000	:	: (1000	:
:	:	:	:	:	:	:	:
:	:Earthen lagoon	:	:	:	:	:	:
:	:eff. (#51769)	: 3/6/85	: 1300	: 1200	:	: (1000	:
:	:	:	:	:	:	:	:
:	:Metal tank	:	:	:	:	:	:
:	:eff. (#56627)	: 3/6/85	: 4400	: 3600	:	: (1000	:
:	:	:	:	:	:	:	:
:	:Settled water'l:	:	:	:	:	:	:
:	:in tanks- Silt	:	:	:	:	:	:
:	:Coal Tar Mix	:	:	:	:	:	:
:	:(#59290)	: 3/13/85	: 50000	: 150000	: 380000	: 33000	:
:	:	:	:	:	:	:	:
:	:Sett. Tanker	:	:	:	:	:	:
:	:Floatables	:	:	:	:	:	:
:	:(#51774)	: 3/13/85	: 2500	: 10000	: 37	: 1000	:
:	:	:	:	:	:	:	:
:	:Sett. Pond	:	:	:	:	:	:
:	:Floatables	:	:	:	:	:	:
:	:(#71266)	: 3/28/85	: 66000	: 180000	: 140000	: 18000	:

Table 1 (cont'd)

:St. Paul Blvd. Interceptor Improvements - Siphon Tunnel Contaminants								:
:Miscellaneous Analytical Results				File No. 888.075				:
:Note: All results expressed in parts per billion (ppb) unless otherwise noted								:
								:
: LABORATORY	: SAMPLE	: DATE	: BENZENE	: TOLUENE	: XYLENE	: ETHYL-	: OIL &	:
:	: LOCATION	:	:	:	:	: BENZENE	: GREASE	:
								:
:	:	:	:	:	:	:	:	:
:	:Sediment from	:	:	:	:	:	:	:
:	:Peter B. Pond	:	:	:	:	:	:	:
:	:(#71211)	: 3/26/85	: 110000	: 280000	: 310000	: 76000	:	:
:	:	:	:	:	:	:	:	:
:	:Muck Pile -	:	:	:	:	:	:	:
:	:Exposed Face -	:	:	:	:	:	:	:
:	:Middle (#66161)	: 7/10/85	: (100	: 56	: 190	: 21	: (100	:
:	:	:	:	:	:	:	:	:
:	:Muck Pile -	:	:	:	:	:	:	:
:	:Exposed Face -	:	:	:	:	:	:	:
:	:Left (#66160)	: 7/10/85	: (100	: 41	: 75	: 14	: (100	:
:	:	:	:	:	:	:	:	:
:	:Muck Pile -	:	:	:	:	:	:	:
:	:Exposed Face -	:	:	:	:	:	:	:
:	:Right (#66159)	: 7/10/85	: (100	: 12	: 68	: 110	: (100	:
:	:	:	:	:	:	:	:	:
:	:	:	:	:	:	:	:	:
:	:	:	:	:	:	:	:	:



SECTION 4.3
REF. 23

O'BRIEN & GERE

August 7, 1985

14a
[Handwritten signature]

Mr. Irwin Brodell, P.E.
Director
MONROE COUNTY
DEPARTMENT OF ENGINEERING
350 E. Henrietta Road
Rochester, NY 14620

Re: Rochester Pure Waters District
St. Paul Boulevard Improvements
Contract 13 (C-36-745-05)
Chemical Contaminants

File: 888.075

Dear Mr. Brodell:

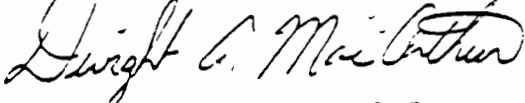
Please find attached a copy of the analytical results obtained on samples of the settling pond effluent at the Brewer Street construction site. For ease of reference all data obtained on the effluent samples from 3/22/85 through 7/25/85 is included for the prime parameters measured (pH, oil & grease, cyanide, BTX). As you know, pumping of the pond effluent to the sewer system began on 7/22/85. As indicated by the oil & grease data for 7/19/85, 7/22/85 and 7/25/85, pond performance has improved recently with respect to retention of the heavier coal-tar compounds. The levels of BTX are similar to those measured in the past.

Mr. Irwin Brodell, P.E.
August 7, 1985
Page -2-

If you have any questions regarding this data, please contact me.

Very truly yours,

O'BRIEN & GERE ENGINEERS, INC.



Dwight A. MacArthur, P.E.
Managing Engineer

DAM:jld

Attachment:

cc: Mr. H. Bilow, MCDOW
Mr. J. Terwilliger, OBG Resident Engineer
Mr. B. Butler, NYSDEC - Avon
Mr. T. Pearson, NYSDEC - Avon
Mr. C. Asprinio, AES
Dr. M. Merkens, MCDOH
Mr. G. Hansen, John B. Pike

NT Monroe County Department of Engineering JOB NO. 888.075DESCRIPTION Cliff St. Siphon Tunnel - Effluent from Small Settling Pond

DATE COLLECTED _____ DATE REC'D. _____ DATE ANALYZED _____

Date Collected	3-22-85	3-28-85	4-5-85	4-12-85	4-19-85
Lab Sample No.	67894	69907	72951	76913	78334
pH	7.6	7.4	7.6	--	7.7
Oil & Grease, mg/l	21	4.0	29	45	25
Benzene, mg/l	17.0	5.9	13.0	11.0	19.0
Toluene, mg/l	9.4	5.2	12.0	10.0	16.0
Ethylbenzene, mg/l	0.8	0.49	0.68	0.7	0.7
Xylenes, mg/l	9.0	2.1	4.2	3.6	3.0
Polynuclear Aromatics (PNA)*	25	14	36	--	--

Client: Nonroe County Dept. of Engineering Job No: 888.075
 Description: Cliff Street Siphon Tunnel - Effluent from Settling Ponds

Date Collected: _____ Date Recd: _____ Date Analyzed: _____

Date Collected	5-3-85	5-10-85	5-16-85	5-28-85	6-4-85	6-7-85					
Sample No.	77907	79080	79996	81487	65178	65296					
pH	9.9	8.2	7.9	7.2	7.0	7.5					
Oil & Grease, mg/l	60	26	23	55	65	110					
Cyanide, mg/l	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05					
Benzene, mg/l	18.0	26.0	19.0	21.0	17.0	25.0					
Toluene, mg/l	16.0	18.0	14.0	16.0	13.0	18.0					
Ethylbenzene, mg/l	0.81	1.0	0.7	0.9	0.7	0.3					
Xylenes, mg/l	2.2	2.5	2.7	2.1	2.4	2.1					

Methodology: Federal Register — 40 CFR, Part 136, December 3, 1979

Comments: October 26, 1984

O'Brien & Gere Engineers, Inc.
 Box 40737 / 1304 Buckley Rd. / Syracuse, NY 13221 / (315) 451-4700

Authorized: [Signature]
 Date: 6-14-85

SECTION 4.
 REF 23

CLIENT Monroe County Dept. of Engineering JOB NO. 888.075.150
 DESCRIPTION Cliff St. Siphon Tunnel - Effluent from Settling Ponds
 DATE COLLECTED 5-28-85 DATE REC'D _____ DATE ANALYZED 6-14-85

Date Collected Sample No.	6-14-85 65540	6-21-85 65651	7-1-85 65981	7-8-85 66066	7-15-85 2367	7-18-85 22120	7-19-85 22138	7-22-85 22170	7-25-85 22266	8-2-85 85344
pH	—	7.4	6.9	6.8	7.6	7.8	7.5	7.6	7.5	
Oil & Grease	97	110	59	110	61	10	46	38	28	
Cyanide, mg/l	<0.05	<0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	
Benzene, mg/l	19.0	24.0	21.0	19.0	16.0	*	10.0	13.0	20.0	
Toluene, mg/l	12.0	18.0	16.0	16.0	14.0	*	10.0	12.0	16.0	
Ethylbenzene, mg/l	0.1	0.9	0.7	0.5	0.7	*	0.7	0.6	2.1	
Xylenes, mg/l	2.0	3.0	2.1	2.2	2.3	*	2.1	2.4	9.8	

* Analytical results being confirmed.

Methodology: Federal Register — 40 CFR, Part 136 December 3, 1979

October 26, 1984

Comments:

O'Brien & Gere Engineers, Inc.
 Box 4873 / 1304 Buckley Rd / Syracuse, NY / 13221 / (315) 451-4700

Authorized: [Signature]

Date: 8/12/85

SECTION 4.3
 REF. 23



O'BRIEN & GERE

June 3, 1985

Mr. Manmohan Mehta
Solid Waste Engineer
NEW YORK STATE DEPARTMENT OF
ENVIRONMENTAL CONSERVATION
6274 East Avon-Lima Road
Avon, New York 14414

Re: Tunnel Spoil Testing & Disposal
St. Paul Boulevard Interceptor
Improvements (Contract 13)
C-36-745-05
File: 888.075.100

Dear Mr. Mehta:

During our site meeting with you and Mr. Frank Keller, we collected three (3) samples of the tunnel spoil material for analysis of chemical contaminants. These samples were collected on the top of the spoil pile, on the east face and on the west face. We have completed the analyses for those initial parameters agreed upon (BTX, pH, CN, Oil & Grease) and the results are attached. These results were communicated to you via telephone on Friday, May 31, 1985.

Based on these analytical results, we request your earliest decision regarding disposal of this identified portion of the tunnel spoil at Monroe County Airport.

If you have further questions regarding this matter, please contact me.

Very truly yours,

O'BRIEN & GERE ENGINEERS, INC.

Dwight A. MacArthur, P.E.
Managing Engineer

DAM/md

Att.

cc: Irwin Brodell, MCDOE
Harold Bilow, MCDOE
Frank Keller/Chuck Wilcox, NYSDEC - Avon
John Terwilliger, OBG Resident Engineer
Larry Ambeau, American Environmental
Greg Hauser, John B. Pike & Son, Inc.

RECEIVED

JUN 04 1985

**SOLID WASTE
D.E.C. REG. #8**



Laboratory Report

CLIENT Monroe County Dept. of Engrg. JOB NO. 888.075
DESCRIPTION Samples of Stockpiled Materials Excavated
from Siphon Tunnel at Brewer St. (Muck Pile)
DATE COLLECTED 5-28-85 DATE RECD. 5-29-85 DATE ANALYZED 5-31-85

	Benzene	Toluene	Ethylbenzene	Xylenes	pH	Cyanide	Oil & Grease
	ppm	ppm	ppm	ppm	-	ppm	mg/kg
Sample No. 81620 Top of Muck Pile	<0.010	0.044	0.018	0.031	7.6	<5	200
Sample No. 81621 West Face of Muck Pile	0.018	<0.010	0.130	0.049	7.7	<5	2040
Sample No. 81622 East Face of Muck Pile	0.033	0.120	0.012	0.056	7.4	<5	2120

Methodology: Federal Register -- 40 CFR, Part 136, December 3, 1979

Comments:

O'Brien & Gere Engineers, Inc.
Box 4873 / 1304 Buckley Rd / Syracuse, NY / 13221 / (315) 451-4700

Authorized:

Date:

RECEIVED



CC: VINCE DICK

FRANK ~~FRANK~~ FBI

File 100-111111
Chill St. 100-111111
SECTION 4.3
REF. 35

O'BRIEN & GERE

April 7, 1986

Mr. Irwin Brodell, P.E.
Director
MONROE COUNTY
DEPARTMENT OF ENGINEERING
350 East Henrietta Road
Rochester, NY 14620

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APR 9 1986

SOLID WASTE
D.E.C. REG. #8

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APR 8 1986

SOLID WASTE DIVISION
D.E.C. REG. #8

Re: Rochester Pure Waters District
Contract 13 (C-36-745-05)
Disposal of Siphon Tunnel
Spoil Material

File: 888.075.210

Dear Mr. Brodell:

On February 21, 1986, we collected four (4) additional samples of the tunnel spoil material for analysis of chemical contaminants. These samples were collected midway up on the east side of the exposed spoil pile face. We have completed the analyses for those parameters agreed upon (BTX, pH, CN, Oil & Grease, and GC scan) and the results are attached. These results were communicated to Mr. Vince Dick of NYSDEC on Friday, March 28, 1986.

On Tuesday, April 1, 1986 Mr. Dick directed that the remaining tunnel spoil materials at the site be disposed of at a sanitary landfill with a leachate collection system, rather than at the airport. He indicated that the level of xylenes was of specific concern. However, it appears to us that the level of xylenes is no different in the recent samples than existed in the previous samples which were allowed to be disposed of at the airport disposal site. In fact, the concentrations of BTX are all less for the recent samples than for the second set of samples collected on July 10, 1985. Mr. Dick reaffirmed the DEC position that the tunnel spoil material must go to a sanitary landfill with a leachate collection system in a telephone discussion on April 2, 1986. He indicated a letter would be transmitted shortly to that effect.

Mr. Irwin Brodell, P.E.
April 7, 1986
Page -2-

Three possible locations in the relative vicinity for disposal of these materials are:

- a. Monroe-Livingston in Henrietta, NY
- b. Seneca Meadows in Seneca Falls, NY
- c. High Acres Landfill in Perinton, NY

We are pursuing discussions with Monroe-Livingston and High Acres regarding the potential of disposing of the tunnel spoil materials at their sanitary landfill sites. However, it is likely that substantial laboratory testing will be required by the landfill operators prior to their acceptance of the spoil material. In addition, transportation and disposal costs will likely be significant.

It must be noted that all these costs for disposal of the tunnel spoil materials would be in addition to the transportation and disposal costs for the closure plan as estimated in our letter dated 1/23/86 and updated on 3/19/86. No previous indication has been made that the siphon tunnel spoil materials would require disposal at a location other than the airport. A very gross estimate of transportation and disposal costs is as follows (further analysis of costs are being pursued):

Transportation: $5000 \text{ CY} \times \frac{1 \text{ load}}{20 \text{ CY}} \times \$400/\text{load} = \$100,000$

Disposal: $5000 \text{ CY} \times \frac{27 \text{ ft}^3}{\text{CY}} \times \frac{120 \text{ \#}}{\text{ft}^3} \times \frac{1 \text{ ton}}{2000 \text{ \#}} \times \frac{\$17.64}{\text{ton}} = \$142,884$

TOTAL \$242,884

Obviously, the effect of the NYSDEC requirement for disposal of this material at a sanitary landfill is to greatly increase the cost of the overall closure plan. This stance appears to be inconsistent with previous comments made by DEC on the initial closure plan, wherein revisions to the plan were suggested to reduce the overall cost, and a measure of reasonableness was to be applied to determine the actual quantities of materials to be removed from the site.

Mr. Irwin Brodell, P.E.
April 7, 1986
Page 3

Please advise as to whether we should immediately pursue discussions with the local landfill operators regarding this disposal issue. Contact us if you should have any questions regarding the enclosed.

Very truly yours,

O'BRIEN & GERE ENGINEERS, INC.



For Dwight A. MacArthur, P.E.
Managing Engineer

DAM:jd:8:36

Attachment

cc: Mr. Harold Bilow, MCDOE
Mr. Frank Keller/Chuck Wilcox, NYSDEC - Avon
Mr. John Terwilliger, OBG Resident Engineer
Mr. Larry Ambeau, American Environmental
Mr. Greg Hauser, John B. Pike & Son, Inc.
Mr. Michael Schifano, MCDPW
Dr. Richard Burton, MCDOH

Vince Dick
Chuck Wilcox



O'BRIEN & GERE

Laboratory
Report

CLIENT Monroe County Dept of Engrg JOB NO. 888.075
DESCRIPTION Samples of Stockpiled Materials Excavated
From Siphon Tunnel at Brewer St (Muck Pile) 3rd set of samples
DATE COLLECTED 2-26-86 DATE REC'D 2-26-86 DATE ANALYZED _____

		Benzene	Toluene	Ethylbenzene	Xylenes	pH	Cyanide	Oil & Grease	GC (FID) Scan			
		ppm	ppm	ppm	ppm		ppm	mg/Kg	ppm			
#1	Sample No. 79554 5' from shaft along east face	<0.010	<0.010	<0.010	0.044	7.7	<5	<10	<10			
#2	Sample No. 79555 20' from shaft along east face	<0.010	<0.010	<0.010	0.068	7.7	<5	170	<10			
#3	Sample No. 79556 35' from shaft along east face	<0.010	<0.010	<0.010	0.045	7.7	<5	230	<10			
#4	Sample No. 79557 50' from shaft along east face	<0.010	<0.010	<0.010	0.061	7.7	<5	180	<10			

Methodology: Federal Register — 40 CFR, Part 136, December 3, 1979

Comments: mg/Kg wet weight for BTK

Authorized: _____

O'Brien & Gere Engineers, Inc.
Box 4873 / 1304 Buckley Rd / Syracuse, NY / 13221 / (315) 451-4700

Date: _____

SECTION 4.3
REF. 25



O'BRIEN & GERE

SECTION 4.3
REF. 26

May 9, 1986

Mr. Irwin Brodell, P.E.
Director
MONROE COUNTY
DEPARTMENT OF ENGINEERING
350 East Henrietta Road
Rochester, NY 14620

Re: Rochester Pure Waters District
Contract 13 (C-36-745-05)
Disposal of Siphon Tunnel
Spoil Material

File: 888.075.210

Dear Mr. Brodell:

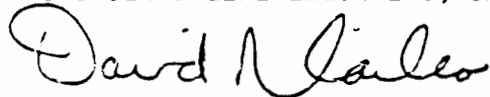
On April 24, 1986, we collected four (4) additional samples of the tunnel spoil material for analysis of chemical contaminants. These samples were collected midway up on the east side of the exposed spoil pile face. We have completed the analyses and the results are attached for those parameters agreed upon (BTX, pH, and those parameters outlined in the March 19, 1985 authorization to discharge from NYSDEC), with the exception of oil and grease, for which results will be forwarded as soon as possible. The requirement for these analyses was stated in a NYSDEC letter of April 9, 1986.

Mr. Irwin Brodell, P.E.
May 9, 1986
Page -2

We would propose a meeting the week of beginning May 12, 1986 to further discuss these results. I will be in contact with you regarding a specific date for such a meeting. In the meantime, if you have any questions, please call me.

Very truly yours,

O'BRIEN & GERE ENGINEERS, INC.



For Dwight A. MacArthur, P.E.
Managing Engineer

DAM:jld

Attachment:

cc: Mr. Harold Bilow, MCDOE
Mr. Frank Keller/Chuck Wilcox, NYSDEC - Avon
Mr. John Terwilliger, OBG Resident Engineer
Mr. Larry Ambeau, American Environmental
Mr. Greg Hauser, John B. Pike & Son, Inc.
Mr. Michael Schifano, MCDPW
Dr. Richard Burton, MCDOH

Laboratory
Report

CLIENT Monroe County Department of Engineering JOB NO. 888.075.510
 DESCRIPTION Samples of Stockpiled Materials Excavated From Siphon
Tunnel at Brewee Street (Mock Pile) 4th Set of Samples
 DATE COLLECTED 4-24-86 DATE REC'D. 4-25-86 DATE ANALYZED _____

		10,000 ppm 50,000 ppm 200,000 ppm 500,000 ppm 1,000,000 ppm Benzene	10,000 ppm 50,000 ppm 200,000 ppm 500,000 ppm 1,000,000 ppm Toluene	10,000 ppm 50,000 ppm 200,000 ppm 500,000 ppm 1,000,000 ppm Ethylbenzene	10,000 ppm 50,000 ppm 200,000 ppm 500,000 ppm 1,000,000 ppm Xylenes	10,000 ppm 50,000 ppm 200,000 ppm 500,000 ppm 1,000,000 ppm Oil & Grease	pH												
		ppm	ppm	ppm	ppm	mg/kg													
#1	Sample No. 67512 12' from shaft along east face	<0.010	<0.010	<0.010	0.065		9.9												
#2	Sample No. 67513 26' from shaft along east face	<0.010	0.019	0.037	0.200		9.9												
#3	Sample No. 67514 35' from shaft along east face	<0.010	0.020	0.042	0.430		11.1												
#4	Sample No. 67515 50' from shaft along east face	<0.010	0.010	<0.010	0.068		9.5												

Methodology: Federal Register — 40 CFR, Part 136, December 3, 1979

Comments: mg/kg wt weight for BTX

Authorized: _____

O'Brien & Gere Engineers, Inc.
Box 4073 / 1304 Buckley Rd / Syracuse, NY / 13221 / (315) 451-4700

Date: _____

SECTION 11.3
REF. 210



O'BRIEN & GERE

SECTION 14.3
REF 27

May 20, 1986

Mr. Frank Shattuck, P.E.
Regional Solid & Hazardous
Waste Engineer
NEW YORK STATE DEPARTMENT OF
ENVIRONMENTAL CONSERVATION
6274 East Avon-Lima Road
Avon, New York 14414

Re: Rochester Pure Waters District
Contract 13 - (C-36-745-05)
Disposal of Tunnel Muck Stockpiled
at Brewer Street

File: 888.075.210

Dear Mr. Shattuck:

On May 14, 1986 a meeting was held at Monroe County department of Engineering to discuss the disposal of remaining tunnel muck stockpiled at the Brewer Street construction site. The focus of the meeting was to review the results of recent laboratory analyses on samples taken from the muck stockpiles. A copy of these analytical results were transmitted to Mr. Frank Keller in a letter dated May 9, 1986.

On each of the four samples, only minor quantities of benzene, toluene and ethylbenzene (<0.020 mg/l) were detected, and xylenes ranged from concentrations of 0.065 to 0.430 ppm. These results were similar to levels measured on previous muck samples, which served as the basis for previous disposal of muck at the airport location.

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MAY 21 1986

**SOLID WASTE
D.E.C. REG. #8**

Mr. Frank Shattuck, P.E.
May 20, 1986
Page -2-

Complete testing for the list of parameters specified in NYSDEC's letter of March 19, 1985 was also completed for the four samples collected on April 24, 1986. Based on the analytical results, the total quantities of base neutrals (sum of individual constituents) expressed as a percentage of total material in the sample is as follows:

Sample No.	% of Sample	mg/kg
67512	0.000066	6.6
67513	0.003200	31.7
67514	0.000132	1.3
67515	0.000237	2.4

The quantities of coal tar contamination in the muck pile are very small and should pose no threat to the environment at the proposed disposal location - Monroe County Airport. Additional testing on Sample No. 67513 was conducted to assess the potential for coal tar contaminants to be leached from the soil. (See Attachment 1 for specific procedures followed.) From this additional testing, two new samples were created: a) a 24-hr leachate sample, and b) a 48-hour leachate sample. GC/MS analyses of these two samples indicate that:

- 1) less than 1% of the contaminants initially present in the soil leached from the soil over the 24-hr period of agitation
- 2) less than 0.3% of the contaminants leached from the soil over the next 24-hr exposure period, or a total of less than 1.3% over the full 48-hr period.

Based on these analyses, we feel that the greatest portion of tunnel muck remaining at the Brewer Street site can continue to be disposed of at the Monroe County Airport, as has been the past practice. We do not feel that there will be any threat to the environment from the trace contaminant levels of the muck. As indicated in the 24-hr and 48-hr leach tests conducted on the more contaminated sample, less than 1.3% of the base neutrals leached from the soil. The actual conditions at the Airport are such that it is unlikely this soil will be fully saturated nor will it be subject to the highly agitated conditions the sample was exposed to. In other words, leaching of contaminants from the soil should be at substantially lower rates than the laboratory tests indicated.

Mr. Frank Shattuck, P.E.
May 20, 1986
Page -3-

We also feel that the level of contaminants present in the tunnel muck at Brewer Street are in fact less than those which would be expected to be present in pavement or macadam debris, which is a part of disposal material from many roads, airport runway, or other surface construction projects.

Finally, the proposed disposal area is adjacent to the existing Monroe County Airport. Although no specific data is available, it seems logical that the airport area is currently exposed to trace quantities of similar types of compounds as a result of aviation fuels and deicing solutions.

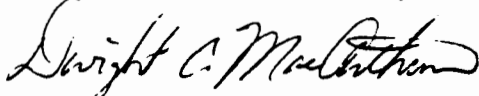
The above comments express our opinion that no significant environmental threat will result from disposal of the Brewer Street tunnel muck at the Monroe County Airport, as has been past practice. In addition to technical aspects, the financial consequences of disposing of the material at a sanitary landfill with a leachate collection system would be very large. It has been previously estimated that disposal of the 5000 yards of material would cost between \$250,000 and \$300,000 for disposal at a sanitary landfill, compared to present disposal costs of \$15,000 to \$28,000 for disposal at Monroe County Airport.

We therefore request that NYSDEC approve that tunnel muck remaining at Brewer Street may be disposed of at the Monroe County Airport.

We request your prompt review and response to the above issue.

Very truly yours, .

O'BRIEN & GERE ENGINEERS, INC.



Dwight A. MacArthur, P.E.
Managing Engineer

DAM:jld:D12:20

Enclosure:

cc: Mr. Irwin Brodell, MCDOE
Mr. Harold Bilow, MCDOE
Mr. Frank Keller/Chuck Wilcox, NYSDEC - Avon
Mr. John Terwilliger, OBG Resident Engineer
Mr. Larry Ambeau, American Environmental
Mr. Greg Hauser, John B. Pike & Son, Inc.
Mr. Michael Schifano, MCDPW
Dr. Richard Burton, MCDOH

Attachment

Procedure for Analyzing Tunnel Muck Leachability
Sample No. 67513

1. Fifty (50) grams of dry soil was placed in each of two glass containers for a total weight of 100g of soil. The procedure basically followed sample preparation requirements for EP Toxicity Method 1310 (SW-846).
2. Eight hundred milliliters (800 ml) of distilled water was added to each container for a total of 1600 ml and distilled water. (Note: No acid was added.)
3. The soil and water mixture in the containers was agitated in a 360° tumbler for 24 hours.
4. Equal aliquots of liquid from the two containers were composited to provide a one liter sample.
5. The resulting 1 liter sample was extracted per protocol of EPA Method 625 for injection into the GC/MS. This sample is referred to as the 24-hour leachate sample.
6. The remaining liquid in the two glass containers was decanted leaving only the original soil.
7. Steps 2 thru 5 were repeated. The resulting sample is referred to as the 48-hr leachate sample.

D12:21

Organics Analysis Data Sheet
(Page 2)

Sample Number

64492 MB

75X541 --

SECTION 4.3
REF 27

Semivolatile Compounds

Concentration: Low Medium (Circle One)

Date Extracted/Prepared: _____

Date Analyzed: 5/3/86

Conc/Dil Factor: _____

SURROGATES

%Recover

Phenol-5	34
2-Fluorophenol	15
2,4,6-Tribromophenol	1
d-5 Nitrobenzene	58
2-Fluorobiphenyl	71
Terphenyl	74

DL ug/l or ug/Kg
(Circle One)CAS
NumberDL ug/l or ug/Kg
(Circle One)

Methosulfamethyamine	330
Phenol	
Aniline	
4-2-Chloroethyl Ether	
Chlorophenol	
1,3-Dichlorobenzene	
4-Dichlorobenzene	
Tertiary Alcohol	
2-Dichlorobenzene	
Methylphenol	
2-chloroisopropyl Ether	
Methylphenol	
Nitroso-Di-n-Propylamine	
Hexachloroethane	
Trobenzene	
ochorone	
2-Nitrophenol	
4-Dimethylphenol	✓
benzoic Acid	1600
bis(2-Chloroethoxy)Methane	330
4-Dichlorophenol	
1,2,4-Trichlorobenzene	
Naphthalene	
-Chloroaniline	
Hexachlorobutadiene	
4-Chloro-3-Methylphenol	
Methylnaphthalene	
Hexachlorocyclopentadiene	
2,4,6-Trichlorophenol	✓
2,4,5-Trichlorophenol	1600
2-Chloronaphthalene	330
2-Nitroaniline	1600
Dimethyl Phthalate	330
Acenaphthylene	330

83-32-9	Acenaphthene	330
51-28-5	2,4-Dinitrophenol	1600
100-02-7	4-Nitrophenol	1600
132-64-9	Dibenzofuran	330
121-14-2	2,4-Dinitrotoluene	
605-20-2	2,6-Dinitrotoluene	
84-66-2	Diethylphthalate	
7005-72-3	4-Chlorophenyl-phenylether	
85-73-7	Fluorene	✓
100-01-6	4-Nitroaniline	1600
534-52-1	4,6-Dinitro-2-Methylphenol	1600
86-30-6	N-Nitrosodiphenylamine (1)	330
101-55-3	4-Bromophenyl-phenylether	
118-74-1	Hexachlorobenzene	✓
87-86-5	Pentachlorophenol	1600
85-01-6	Phenanthrene	330
120-12-7	Anthracene	
84-74-2	Di-n-Butylphthalate	0.3
206-44-0	Fluoranthene	✓
92-87-5	Benzidine	1600
129-00-0	Pyrene	330
95-68-7	Benzylbenzophthalate	330
91-94-1	3,3'-Dichlorobenzidine	1600
56-55-3	Benz(a)Anthracene	330
117-81-7	bis(2-Ethylhexyl)Phthalate	
218-01-9	Chrysene	
117-84-0	Di-n-Octyl Phthalate	
205-95-2	Benz(b)Fluoranthene	
207-08-9	Benz(k)Fluoranthene	
50-32-8	Benz(a)Pyrene	
193-39-5	Indeno(1,2,3-cd)Pyrene	
53-70-3	Dibenz(a,h)Anthracene	
191-24-2	Benz(c,h,i)Perylene	✓

Organics Analysis Data Sheet
(Page 2)

Sample Number

67512

>SX542

LIMIT

Semivolatile Compounds

Concentration: Low Medium (Circle One)

Date Extracted/Prepared:

Date Analyzed: 5/3/86

Conc/Dil Factor:

SUPROGATES

%Recovery

Phenol-5- - - - - 25

2-Fluorophenol- - - 11

2,4,6-Tribromophenol 4

d-5 Nitrobenzene 53

2-Fluorobiphenyl 60

Terphenyl 58

DL ug/l or ug/Kg
(Circle One)

CAS
Number

DL ug/l or ug/Kg
(Circle One)

1,2-Dichlorodimethylamine 330

Phenol

1,2-Dichlorobenzene

1,2-Dichloroethyl Ether

1,2-Dichlorophenol

1,2-Dichlorobenzene

1,2-Dichlorobenzene

1,2-Dichlorobenzene 2.9 J

1,2-Dichlorobenzene 2.9 J

1,2-Dichlorophenol

1,2-Dichloroisopropyl Ether

1,2-Dichlorophenol

1,2-Dichloro-Di-n-Propylamine

1,2-Dichloroethane

1,2-Dichlorobenzene

1,2-Dichlorobenzene

1,2-Dichlorophenol

1,2-Dichlorophenol

1,2-Dichlorophenol

1,2-Dichlorophenol 1600

1,2-Dichlorophenol 330

1,2-Dichlorophenol

1,2-Dichlorophenol

1,2-Dichlorophenol 102 J

1,2-Dichlorophenol

1,2-Dichlorophenol

1,2-Dichlorophenol

1,2-Dichlorophenol 99 J

1,2-Dichlorophenol

1,2-Dichlorophenol

1,2-Dichlorophenol 1600

1,2-Dichlorophenol 330

1,2-Dichlorophenol 1600

1,2-Dichlorophenol 330

83-32-9 Acenaphthene 330 7 J

51-28-5 2,4-Dinitrophenol 1600

100-02-7 4-Nitrophenol 1600

132-64-9 Dibenzofuran 330 7 J

121-14-2 2,4-Dinitrotoluene

605-20-2 2,6-Dinitrotoluene

84-66-2 Diethylphthalate 3.7 J

7005-72-3 4-Chlorophenyl-phenyl ether

85-73-7 Fluorene 298

100-01-6 4-Nitroaniline 1600

534-52-1 4,6-Dinitro-2-Methylphenol 1600

86-30-6 N-Nitrosodiphenylamine (1) 330

101-55-3 4-Bromophenyl-phenyl ether

118-74-1 Hexachlorobenzene

87-86-5 Pentachlorophenol 1600

85-01-8 Phenanthrene 330 82 J

120-12-7 Anthracene 24 J

84-74-2 Di-n-Butylphthalate 17 J

206-44-0 Fluoranthene 39 J

92-87-5 Benzidine 1600

129-00-0 Pyrene 330 70 J

95-68-7 Butylbenzylphthalate 330

91-94-1 3,3'-Dichlorobenzidine 660

56-55-3 Benz(a)anthracene 330

117-81-7 bis(2-Ethylhexyl)Phthalate 164 J

218-01-9 Chrysene

117-84-0 Di-n-Octyl Phthalate

205-98-2 Benz(b)fluoranthene

207-08-9 Benz(k)fluoranthene

50-32-8 Benz(a)pyrene

193-39-5 Indeno(1,2,3-cd)Pyrene

53-70-3 Dibenz(a,h)anthracene

191-24-2 Benz(b,h,i)Perylene

67513

75X545

חומות

1 SUPROGATES

%Recover

2head-3- 37

2-Fluorphenol	8.3

2,4,6-Trisubstituted 9.2

d-5 Nitrobenzene 125

2-Fluorobenzyl	66

Terphenyl	11.3

CAS
Number

DL -ug/lor ug/Kg
(Circle One)

83-32-9	Acenaphthene	330	1425
51-23-5	2,4-Dinitrophenol	1600	
100-02-7	4-Nitrophenol	1680	
132-64-9	Dibenzofuran	330	
121-14-2	2,4-Dinitrotoluene		
605-20-2	2,6-Dinitrotoluene		
84-66-2	Diethylphthalate		
7005-72-3	4-Chlorobenzyl-phenylether		
85-73-7	Fluorene	V	892
100-01-6	4-Nitroaniline	1690	
534-52-1	4,6-Dinitro-2-Methylphenol	1606	
86-30-6	N-Nitrosodiphenylamine (1)	330	
101-55-3	4-Bromobenzyl-phenylether		
118-74-1	Hexachlorobenzene	V	
87-86-5	Pentachlorophenol	1680	
85-01-8	Phenanthrene	330	2000
120-12-7	Anthracene		1987
84-74-2	Di-n-Butylphthalate		165
206-44-0	Fluoranthene	V	4471
92-87-5	Benzidine	1680	
129-00-0	Pyrene	330	5368
95-68-7	Butylbenzylphthalate	330	1775
91-94-1	3,3'-Dichlorobenzidine	1660	
56-55-3	Benzo(a)Anthracene	330	4382
117-81-7	bis(2-Ethylhexyl)Phthalate		934
218-01-9	Chrysene		3934
117-84-0	Di-n-Octyl Phthalate		445
205-95-2	Benzo(b)Fluoranthene		2580
207-08-9	Benzo(k)Fluoranthene		3104
50-32-8	Benzo(a)Pyrene		2600
193-39-5	Indeno(1,2,3-cd)Pyrene		
53-70-3	Dibenz(a,h)Anthracene		2845
191-24-2	Benzo(c,h,i)Perylene	V	1090

67514

Limit

SUPROGATES

%Recovery:

35

2-Fluorophenol	12

2,4,6-tribromophenol 2.6

d-5 Nitrobenzene	48

2-Fluorobiphenyl	60

Terphenyl	68

CAS
Number

DL ☒ ug/l or ug/kg
(Circle One)

23-32-9	Acenaphthene	330	23 J
51-25-5	2,4-Dinitrophenol	1600	
100-02-7	4-Nitrophenol	1680	
132-64-9	Dibenzofuran	330	10 J
121-14-2	2,4-Dinitrotoluene		
605-20-2	2,6-Dinitrotoluene		
84-66-2	Diethylphthalate		
7005-72-3	4-Chlorophenyl-phenylether		
86-73-7	Fluorene	✓	57 J
100-01-6	4-Nitroaniline	1690	
534-52-1	4,6-Dinitro-2-Methylphenol	1609	
36-30-6	N-Nitrosodiphenylamine (1)	330	
101-55-3	4-Bromophenyl-phenylether		
118-74-1	Hexachlorobenzene	✓	
87-86-5	Pentachlorophenol	1680	
85-01-8	Phenanthrene	330	176 J
120-12-7	Anthracene		44 J
84-74-2	Di-n-Butylphthalate		16 J
206-44-0	Fluoranthene	✓	57 J
92-87-5	Benzidine	1680	
129-00-0	Pyrene	330	96 J
95-68-7	Butylbenzylphthalate	330	17 J
91-94-1	3,3'-Dichlorobenzidine	660	
56-55-3	Benzo(a)Anthracene	330	48 J
117-81-7	bis(2-Ethylhexyl)Phthalate		290 J
218-01-9	Chrysene		
117-84-0	Di-n-Octyl Phthalate		
205-99-2	Benzo(b)Fluoranthene		33 J
207-06-9	Benzo(k)Fluoranthene		
50-32-8	Benzo(a)Pyrene		29 J
193-39-5	Indeno(1,2,3-cd)Pyrene		
53-70-3	Dibenzo(a,h)Anthracene		
191-24-2	Benzo(a,h,i)Perylene	✓	

67515

75X544

MIT

Cone/Dil Factor:

SUPROGATES	%Recovery
Phenol-5- - - - -	47
2-Fluorophenol- - -	21
2,4,6-Tribromophenol	~~26~~ 7
d-5 Nitrobenzene	52
2-Fluorobiphenyl	59
Terphenyl	73

DL $\mu\text{g/l}$ or $\mu\text{g/Kg}$
(Circle One)

N,N-Dimethylmethanamine	330	
Benzal		
Belline		
1,2-Dichloroethyl Ether		
1,3-Dichlorobenzol		
1,4-Dichlorobenzene		
1,2,4-Trichlorobenzene		
Methyl Alcohol		2.5 J
1,2,3-Trichlorobenzene		3.1 J
1-Methoxyphenol		
1,2-Dichloroisopropyl Ether		=
1-Methoxybenzol		F -
Di-n-Propylamine		.
Dibromodithiane		
Dibromobenzene		
Dibromene		
2-Methoxybenzol		
2,6-Dimethoxyphenol	↓	
Glypic Acid	1680	
1,3-Dichloroethoxymethane	330	
1,4-Dichlorophenol		
1,2,3-Trichlorobenzene		
Phthalene		55 J
1,4-Dioxanoline		
1,2-Dichlorobutadiene		
1,3-Dichloro-3-Methylphenol		
1,2,3,4-Tetrachloronaphthalene		73 J
1,2-Dichlorocyclooctadiene		
1,2,4-Trichlorophenol	↓	
1,2,5-Trichlorophenol	1600	
1,2-Dichloronaphthalene	330	
1,4-Dioxanoline	1600	
Dimethyl Pyrazole	330	
1,2-Dichlorobenzene	330	51 J

83-32-9	Acenaphthene	330	9 J
51-28-5	2,4-Dinitrophenol	1600	
100-02-7	4-Nitrophenol	1650	
132-64-9	Dibenzofuran	330	8.6 J
121-14-2	2,4-Dinitrotoluene	1	
605-20-2	2,6-Dinitrotoluene	1	
84-66-2	Diethylphthalate	1	
7005-72-3	4-Chlorophenyl-phenylether	1	
86-73-7	Fluorene	✓	92 J
100-01-6	4-Nitroaniline	1650	
534-52-1	4,6-Dinitro-2-Methylphenol	1600	
86-30-6	N-Nitrosodiphenylamine (1)	330	
101-55-3	4-Bromophenyl-phenylether	1	
118-74-1	Hexachlorobenzene	✓	
87-86-5	Pentachlorophenol	1600	
85-01-8	Phenanthrene	330	590
120-12-7	Anthracene	1	118 J
84-74-2	Di-n-Butylphthalate	1	15 J
205-44-0	Fluoranthene	✓	235 J
92-87-5	Benzidine	1600	
129-00-0	Pyrene	330	468
85-68-7	Butylbenzylphthalate	330	27 J
91-94-1	3,3'-Dichlorobenzidine	660	
56-55-3	Benzo(a)Anthracene	330	186 J
117-81-7	bis(2-Ethylhexyl)Phthalate	1	50 J
218-01-9	Chrysene	1	178 J
117-84-0	Di-n-Octyl Phthalate	1	11 J
205-95-2	Benzo(b)Fluoranthene	1	25 J
207-08-9	Benzo(k)Fluoranthene	1	
50-32-8	Benzo(a)Pyrene	1	123 J
153-39-5	Indeno(1,2,3-cd)Pyrene	1	
53-70-3	Dibenz(a,h)Anthracene	1	
191-24-2	Benzo(c,h,i)Perylene	✓	54 J

QUANT REPORT

ID: TONY

Quant Rev: 4 Quant Time: 860503 19:25

File: ^SX541::01

Injected at: 860503 18:24

File: ^SX541::L3

Dilution Factor: 1.11

File: 364492 MB

FILE COUNTY

BTL#11

ID DA: 01

SINGLE PT. <ID>-FILE

Calibration: 860503 15:49

Compound	R.T.	Scan#	Area	Conc	Units	q
Dichlorobenzene d-4	9.35	273	1018565	40.00	UG/L/KG	97
Chlorophenol (surr)	7.00	144	245294	15.06	UG/L/KG	97
Chlorobenzene d-5 (surr)	8.75	240	431672	33.76	UG/L/KG	94
Phthalene d-8	12.64	454	1707992	40.00	UG/L/KG	96
Chlorobenzene d-5 (surr)	10.75	350	399059	28.75	UG/L/KG	95
Phthalene d-10	18.00	748	493352	40.00	UG/L/KG	91
Chlorobiphenyl (surr)	16.01	639	530023	35.33	UG/L/KG	97
2,4,6-Tribromophenol (surr)	20.45	883	1085	.97	UG/L/KG	97
Anthracene d-10	22.51	996	301411	40.00	UG/L/KG	98
Butylphthalate	24.78	1121	1677	.29	UG/L/KG	92
Benzene d-12	30.75	1449	23859	40.00	UG/L/KG	98
Phenyl d-14 (surr)	27.62	1277	43841	37.06	UG/L/KG	99
Styrene d-12	34.97	1681	15194	40.00	UG/L/KG	98

ISTD

Laboratory Name: OBG LABORATORIES, INC.Case No: MONROE COUNTY

Sample Number

85800 NB

WATER

Organics Analysis Data Sheet
(Page 2)

DL = DETECTION LIMIT

Semivolatile Compounds

Concentration: Low Medium (Circle One)

Date Extracted/Prepared: 5/12/86Date Analyzed: 5/13/86

Conc./Dil Factor: _____

SUPROGATES	%Recover
Phenol-5- - - - -	27
2-Fluorophenol- - -	57
2,4,6-Tribromophenol	42
d-5 Nitrobenzene	95
2-Fluorobiphenyl - -	109
Terphenyl	52

AS
NumberDL ug/l or ug/Kg
(Circle One)

2-75-9	N-Nitrosodimethylamine	10
08-95-2	Phenol	
E2-53-3	Aniline	
11-44-4	bis(2-Chloroethyl)Ether	
5-57-8	2-Chlorophenol	
541-73-1	1,3-Dichlorobenzene	
06-46-7	1,4-Dichlorobenzene	
00-51-6	Benzyl Alcohol	
95-50-1	1,2-Dichlorobenzene	
5-46-7	2-Methylphenol	
3538-32-9	bis(2-chloroisopropyl)Ether	
106-44-5	4-Methylphenol	
21-64-7	N-Nitroso-Di-n-Propylamine	
57-72-1	Hexachloroethane	
98-95-3	Nitrobenzene	
8-59-1	Isophorone	
58-75-5	2-Nitrophenol	
105-67-9	2,4-Dimethylphenol	✓
5-85-0	Benzoic Acid	50
111-91-1	bis(2-Chloroethoxy)Methane	10
20-83-2	2,4-Dichlorophenol	
20-82-1	1,2,4-Trichlorobenzene	
91-20-3	Naphthalene	
05-47-8	4-Chloroaniline	
7-66-3	Hexachlorobutadiene	
59-50-7	4-Chloro-3-Methylphenol	
1-57-6	2-Methylnaphthalene	
7-47-4	Hexachlorocyclopentadiene	
28-05-2	2,4,6-Trichlorophenol	✓
5-95-4	2,4,5-Trichlorophenol	50
1-58-7	2-Chloronaphthalene	10
88-74-4	2-Nitroaniline	50
31-11-3	Dimethyl Phthalate	10
08-96-8	Acenaphthylene	10
00-00-0	2-Nitroaniline	50

CAS
Numberug/l or ug/Kg
(Circle One)

83-32-9	Acenaphthene	10
51-28-5	2,4-Dinitrophenol	50
100-02-7	4-Nitrophenol	50
132-64-9	Dibenzofuran	10
121-14-2	2,4-Dinitrotoluene	
606-20-2	2,6-Dinitrotoluene	
84-66-2	Diethylphthalate	
7005-72-3	4-Chlorophenyl-phenylether	
86-73-7	Fluorene	✓
100-01-6	4-Nitroaniline	50
534-52-1	4,6-Dinitro-2-Methylphenol	50
86-30-6	N-Nitrosodiphenylamine (1)	10
101-55-3	4-Bromophenyl-phenylether	10
118-74-1	Hexachlorobenzene	10
87-86-5	Pentachlorophenol	50
85-01-8	Phenanthrene	10
120-12-7	Anthracene	
84-74-2	Di-n-Butylphthalate	
206-44-0	Fluoranthene	✓
92-87-5	Benzidine	50
129-00-0	Pyrene	10
95-68-7	Butylbenzylphthalate	10
91-94-1	3,3'-Dichlorobenzidine	20
56-55-3	Benzo(a)Anthracene	10
117-81-7	bis(2-Ethylhexyl)Phthalate	
218-01-9	Chrysene	
117-84-0	Di-n-Octyl Phthalate	20
205-95-2	Benzo(b)Fluoranthene	
207-08-9	Benzo(k)Fluoranthene	
50-32-8	Benzo(a)Pyrene	
1193-35-5	Indeno(1,2,3-cd)Pyrene	
53-70-3	Dibenz(a,h)Anthracene	
191-24-2	Benzo(g,h,i)Perylene	✓

Laboratory Name: OBG LABORATORIES, INC.Case No: MONROE COUNTY

Sample Number

85790

WATER

Organics Analysis Data Sheet
(Page 2)24 hr LEACHATE OF
#67513

DL = DETECTION LIMIT.

Semivolatile Compounds

Concentration: Low Medium (Circle One)

Date Extracted/Prepared: 5/12/86Date Analyzed: 5/13/86

Conc/Dil Factor: _____

SUPROGATES	%Recover
Phenol-5- - - - -	34
2-Fluorophenol- - -	48
2,4,6-Tribromophenol	79
d-5 Nitrobenzene	97
2-Fluorobiphenyl- -	115
Terphenyl	49

CAS

Number

DL ug/l or ug/Kg
(Circle One)

2-75-9	N-Nitrosodimethylamine	10
108-95-2	Phenol	
12-53-3	Aniline	
11-44-4	bis(2-Chloroethyl)Ether	
95-57-8	2-Chlorophenol	
41-73-1	1,3-Dichlorobenzene	
06-46-7	1,4-Dichlorobenzene	
100-51-6	Benzyl Alcohol	
5-50-1	1,2-Dichlorobenzene	
5-48-7	2-Methylphenol	
39638-32-9	bis(2-chloroisopropyl)Ether	
06-44-5	4-Methylphenol	
21-64-7	N-Nitroso-Di-n-Propylamine	
67-72-1	Hexachloroethane	
8-95-3	Nitrobenzene	
8-59-1	Isophorone	
88-75-5	2-Nitrophenol	
05-67-9	2,4-Dimethylphenol	✓
5-85-0	Benzoic Acid	50
111-91-1	bis(2-Chloroethoxy)Methane	10
20-83-2	2,4-Dichlorophenol	
120-82-1	1,2,4-Trichlorobenzene	
91-20-3	Naphthalene	3.2
06-47-8	4-Chloroaniline	
97-68-3	Hexachlorobutadiene	
59-50-7	4-Chloro-3-Methylphenol	
1-57-6	2-Methylnaphthalene	2.0
77-47-4	Hexachlorocyclopentadiene	
78-06-2	2,4,6-Trichlorophenol	✓
5-95-4	2,4,5-Trichlorophenol	50
91-58-7	2-Chloronaphthalene	10
78-74-4	2-Nitroaniline	50
31-11-3	Dimethyl Phthalate	10
208-96-8	Acenaphthylene	10 5.8

CAS
Numberug/l or ug/Kg
(Circle One)

83-32-9	Acenaphthene	10	3.7
51-28-5	2,4-Dinitrophenol	50	
100-02-7	4-Nitrophenol	50	
132-64-9	Dibenzofuran	10	
121-14-2	2,4-Dinitrotoluene		
505-20-2	2,6-Dinitrotoluene		
84-66-2	Diethylphthalate		
7005-72-3	4-Chlorophenyl-phenylether		
86-73-7	Fluorene	✓	9.7
100-01-6	4-Nitroaniline	50	
534-52-1	4,6-Dinitro-2-Methylphenol	50	
86-30-6	N-Nitrosodiphenylamine (1)	10	
101-55-3	4-Bromophenyl-phenylether	10	
118-74-1	Hexachlorobenzene	10	
87-86-5	Pentachlorophenol	50	
85-01-8	Phenanthrene	10	6.4
120-12-7	Anthracene		19
84-74-2	Di-n-Butylphthalate		
205-44-0	Fluoranthene	✓	121
92-87-5	Benzidine	50	
129-00-0	Pyrene	10	46
95-68-7	Butylbenzylphthalate	10	0.9
91-94-1	3,3'-Dichlorobenzidine	20	
56-55-3	Benzo(a)Anthracene	10	30
117-81-7	bis(2-Ethylhexyl)Phthalate		
218-01-9	Chrysene		29
117-84-0	Di-n-Octyl Phthalate		6.7
205-99-2	Benzo(b)Fluoranthene		8.0
207-06-9	Benzo(k)Fluoranthene		
50-32-8	Benzo(a)Pyrene		13
193-39-5	Indeno(1,2,3-cd)Pyrene		
53-70-3	Dibenz(a,h)Anthracene		0.9
191-24-2	Benzo(g,h,i)Perylene	✓	5.6

SECTION 4.3
REF. 27

Laboratory Name: OBG LABORATORIES, INC.

Case No: MONROE COUNTY

Sample Number

85799

48^{hr} LEACHATE of
#67513

WATER

Organics Analysis Data Sheet (Page 2)

DL = DETECTION LIMIT

Semivolatile Compounds

Concentration: Low Medium (Circle One)

Date Extracted/Prepared: 5/12/86

Date Analyzed: 5/13/86

Conc/Dil Factor: _____

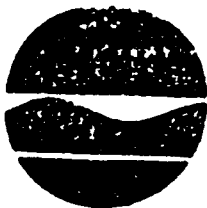
SUPROGATES	%Recover
Phenol-5- - - - -	26
2-Fluorophenol- - -	46
2,4,6-Tribromophenol	41
d-5 Nitrobenzene	116
2-Fluorobiphenyl - -	134
Terphenyl	52

CAS Number DL ug/l or ug/Kg
(Circle One)

2-75-9	N-Nitrosodimethylamine	10
108-95-2	Phenol	
12-53-3	Aniline	
11-44-4	bis(2-Chloroethyl)Ether	
95-57-8	2-Chlorophenol	
41-73-1	1,3-Dichlorobenzene	
106-46-7	1,4-Dichlorobenzene	
100-51-6	Benzyl Alcohol	
5-50-1	1,2-Dichlorobenzene	
5-48-7	2-Methylphenol	
39538-32-9	bis(2-chloroisopropyl)Ether	
106-44-5	4-Methylphenol	
21-64-7	N-Nitroso-Di-n-Propylamine	
67-72-1	Hexachloroethane	
8-95-3	Nitrobenzene	
8-55-1	Isophorone	
88-75-5	2-Nitrophenol	
05-67-9	2,4-Dimethylphenol	✓
5-85-0	Benzoic Acid	50
111-91-1	bis(2-Chloroethoxy)Methane	10
20-83-2	2,4-Dichlorophenol	
120-82-1	1,2,4-Trichlorobenzene	
91-20-3	Naphthalene	1.5
05-47-8	4-Chloroaniline	
57-68-3	Hexachlorobutadiene	
59-50-7	4-Chloro-3-Methylphenol	
1-57-6	2-Methylnaphthalene	0.8
17-47-4	Hexachlorocyclopentadiene	
28-05-2	2,4,6-Trichlorophenol	✓
5-85-4	2,4,5-Trichlorophenol	50
91-58-7	2-Chloronaphthalene	10
28-74-4	2-Nitroaniline	50
31-11-3	Dimethyl Phthalate	10
203-96-8	Acenaphthylene	10 1.4

CAS Number ug/l or ug/Kg
(Circle One)

83-32-9	Acenaphthene	10 1.4
51-28-5	2,4-Dinitrophenol	50
100-02-7	4-Nitrophenol	50
132-64-9	Dibenzofuran	10
121-14-2	2,4-Dinitrotoluene	
605-20-2	2,6-Dinitrotoluene	
84-66-2	Diethylphthalate	
7005-72-3	4-Chlorophenyl-phenylether	
86-73-7	Fluorene	✓ 4.3
100-01-6	4-Nitroaniline	50
534-52-1	4,6-Dinitro-2-Methylphenol	50
86-30-6	N-Nitrosodiphenylamine (1)	10
101-55-3	4-Bromophenyl-phenylether	10
118-74-1	Hexachlorobenzene	10
87-86-5	Pentachlorophenol	50
85-01-8	Phenanthrene	10 1.3
120-12-7	Anthracene	1 7.5
84-74-2	Di-n-Butylphthalate	
206-44-0	Fluoranthene	✓ 3.2
92-87-5	Benzo(a)pyrene	50
129-00-0	Pyrene	10 2.3
95-68-7	Benzylbenzylphthalate	10 0.8
91-94-1	3,3'-Dichlorobenzidine	20
56-55-3	Benzo(a)Anthracene	10 6.9
117-81-7	bis(2-Ethylhexyl)Phthalate	
218-01-5	Chrysene	1 8.6
117-84-0	Di-n-Octyl Phthalate	1 2.2
205-99-2	Benzo(b)Fluoranthene	1 2.2
207-08-9	Benzo(k)Fluoranthene	
50-32-8	Benzo(a)Pyrene	1 2.5
193-39-5	Indeno(1,2,3-cd)Pyrene	
53-70-3	Dibenz(a,h)Anthracene	
191-24-2	Benzo(b,h,i)Perylene	✓



NEW YORK STATE
DEPARTMENT OF ENVIRONMENTAL CONSERVATION
DIVISION OF SOLID & HAZARDOUS WASTE
M E M O R A N D U M
Region #8

~~745~~
745
SECTION 4.3
REF 28

TO: Frank Keller, Frank Shattuck

FROM: John Swanson *John A. Swanson*

RE: Sampling of Wetland Area and Surface Impoundments
at Brewer Street site on May 27, 1986

DATE: May 29, 1986

Arrived at Brewer Street site (East bank) at 12:30 pm. Northerly pond (larger) is nearly completely drained with a small flow from a two inch hose in the northeast corner, 1 to 3 gallons/minute from sump at northwest corner near river bank. A very dark, oily, creosote liquid flowed from hose to west end of pond along bottom. This flow has eroded a one foot± wide by .5 foot deep trench across bottom of pond diagonally from northeast corner towards southern dike of pond.

Southern pond (small) is still full with 2± feet of freeboard. This pond appears stagnant.

Dwight MacArthur and Doug Crawford, O'Brien and Gere from Syracuse office arrived at 12:45 pm; John Terwilliger, Project Engineer with O'Brien and Gere, accompanied them.

Sampling tools: round-point shovel - wipe with dry paper towel
for decontamination
8 inch slender spatula for 40 ml sample containers-
-pint size wide mouth with teflon lined caps
-40 ml glass vials for BTX analysis

<u>Location</u>	<u>Site Description</u>	<u>Samples</u>	<u>Type</u>	<u>Depth</u>
WL-1	Edge of wetland NE, at outlet of ditch	1 pint 2-40 ml	soil, oily	0-6"
WL-2	Oil sheen on water Same as WL-1	2-40 ml 1 pint	soil, oily	12"
WL-3	20 feet SSE of WL 1 & 2 in wetland; oil sheen on water	2-40 ml 1 pint	sediment very wet, oily	surface
WL-4	100'± West of South end of muck pile; see plan	2-40 ml 1 pint	soil very wet, oily	surface
WL-5	100'± West of S end of muck pile; see plan Same as WL-4	2-40 ml 1 pint	soil very wet, oily	9"
WL-6	75' north of willow tree in marsh reeds, water in hole clear	2-40 ml 1 pint	soil very wet	6"

- 2 -

<u>Location</u>	<u>Site Description</u>	<u>Samples</u>	<u>Type</u>	<u>Depth</u>
LA-1	sump leak area 10' south of sump	2-40 ml 1 pint	soil dry	surface
LA-2	sump leak area 10' south of sump Same as LA-1	2-40 ml 1 pint	soil dry	12"
LP-1	NW corner of large pond (northern) 6" down from top of dike	2-40 ml 1 pint	soil oily	6"
LP-2	NE corner of large pond (northern) 6' from top of dike	2-40 ml 1 pint	soil oily	6"
LP-3	NE corner large pond (northern) 4' from top	2-40 ml 1 pint	soil "clean"	8"
SP-1	south bank middle 1' above water level, 1' outside of water	2-40 ml 1 pint	soil moist	6"
SP-2	south bank middle 1' above water level, 1' outside of water; Same as SP-1	2-40 ml 1 pint	soil moist, black	18"
PB-1	former pond, tunnel invert cleanings	2-40 ml 1 pint	tunnel muck	surface
PB-2	former pond, tunnel invert cleanings; Same as PB-1	2-40 ml 1 pint	tunnel muck	15"

Sampling completed at 4:45 pm.

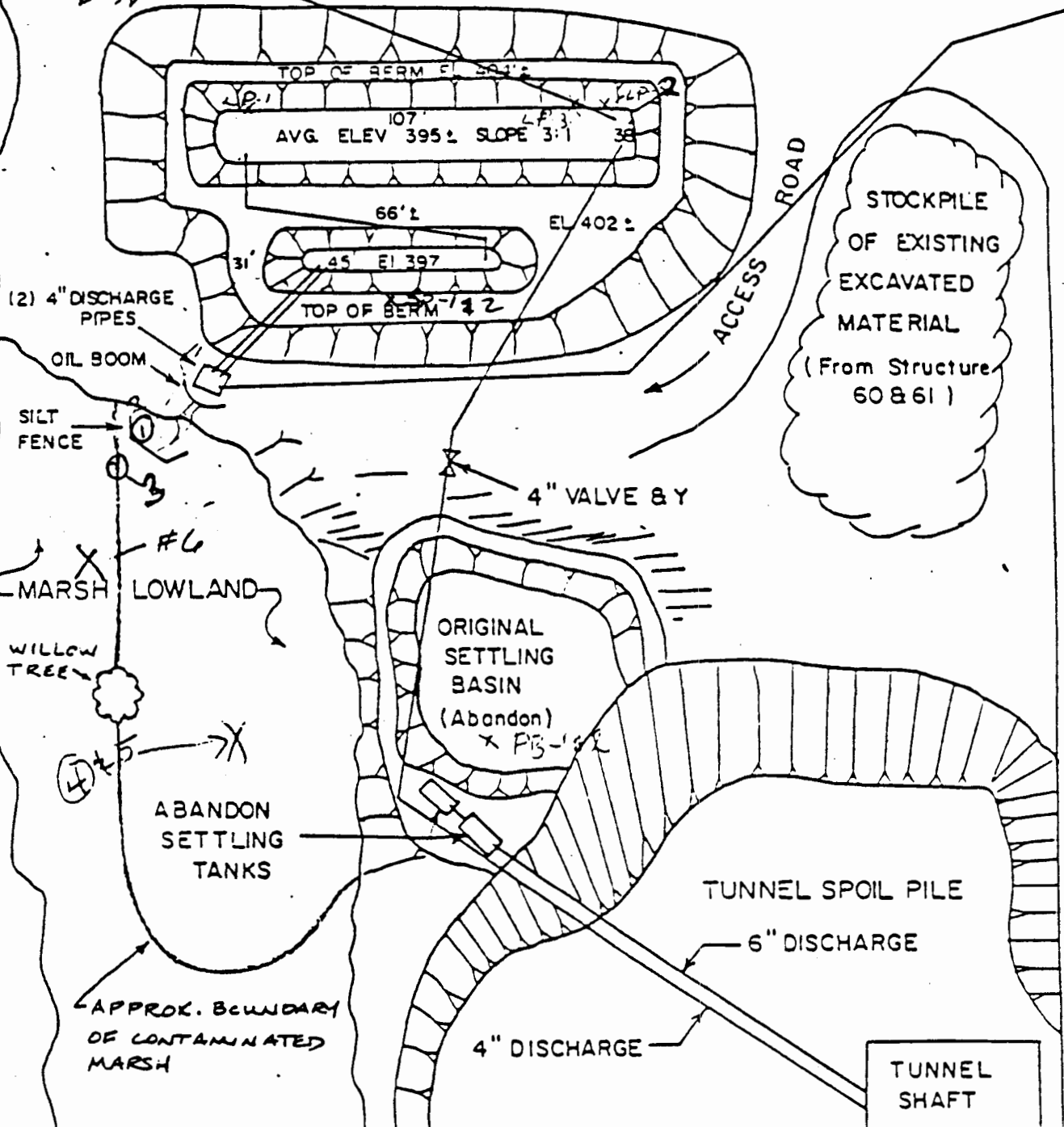
JAS:vv

cc: Vince Dick

RG & E

GENESEE RIVER FLOW

BREWER ST.

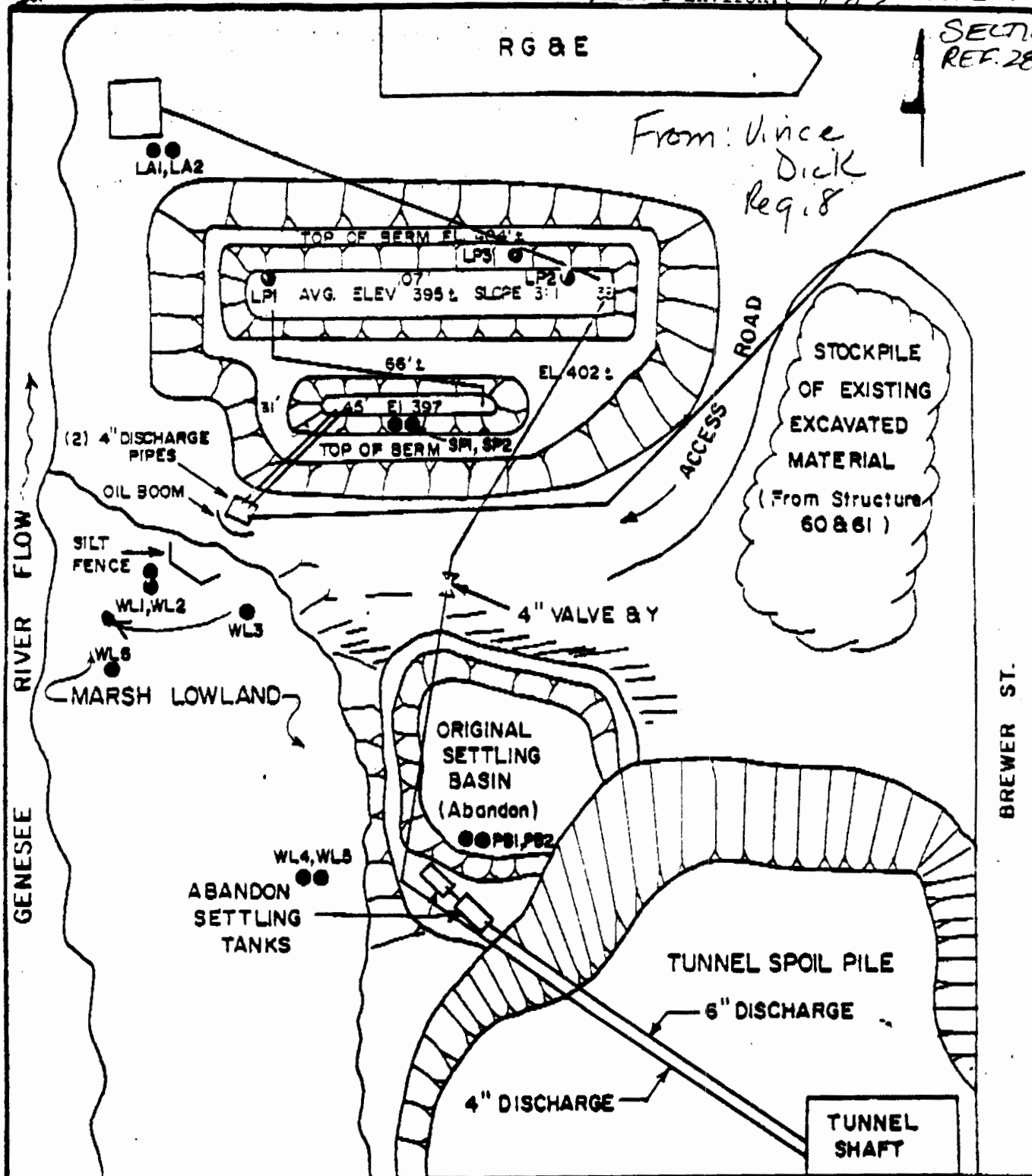


BREWER STREET SIPHON TUNNEL SITE

SITE MAP

NOT TO SCALE

SECTION 4.3
REF. 28



BREWER STREET SIPHON TUNNEL SITE

SITE MAP

NOT TO SCALE

● - APPROXIMATE LOCATION OF SOIL SAMPLES (5/27/86)

TABLE 1
ANALYTICAL RESULTS OF SDH SAMPLES¹

Sample	Oil & Grease	pH (S.U.)	Percent Solids	Flash-point (°C)	POC	Benzene	Toluene	Ethylbenzene	Xylene	Trichloroethylene	Tetrachloroethane	Halogenated Organics (% by weight)	Aromatic Organics (% by weight)	Nitrogenated Organics (% by weight)	Low Molecular Wt. Organics (% by weight)	DEU	% Ash	% Sulfur
ML-1	✓ 16,000	7.9	84.0	37	10,200	LT 1	3.6	3.6	49	LT 1	LT 1	--	--	--	--			
ML-2	✓ 360	8.3	--	70	--	LT 0.1	LT 0.1	LT 0.1	1.5	--	--	--	--	--	--			
ML-3	✓ 140,000	7.8	--	--	--	11	30	12	71	--	--	--	--	--	--			
ML-4	✓ 5,300	7.2	--	--	--	LT 0.1	0.70	3.8	90	--	--	--	--	--	--			
ML-5	130	7.0	--	--	--	0.16	0.032	0.013	0.070	--	--	--	--	--	--			
ML-6	10	0.0	--	--	--	LT 0.05	0.016	0.023	0.040	--	--	--	--	--	--			
LA-1	✓ 1,500	7.0	--	--	--	LT 0.05	0.11	LT 0.050	0.040	--	--	--	--	--	--			
LA-2	590	8.0	--	--	--	LT 0.05	0.075	LT 0.050	0.32	--	--	--	--	--	--			
LP-1	✓ 120,000	8.9	62.0	70	51,000	240	500	75	570	LT 10	LT 10	LT 0.01	1.2	LT 0.1	3.2	3,060	50	LT 1
LP-2	✓ 210,000	11.7	--	>70	--	260	350	42	320	--	--	--	--	--	--			
LP-3	✓ 1,000	7.1	--	52	--	LT 0.05	LT 0.001	LT 0.010	LT 0.010	--	--	LT 0.01	LT 0.01	LT 0.1	LT 0.1			
SP-1	73	8.2	--	>70	--	0.22	0.33	0.045	0.43	--	--	--	--	--	--			
SP-2	44	7.0	--	>70	--	0.33	0.40	0.000	0.43	--	--	--	--	--	--			
PR-1	✓ 3,100	7.6	--	24	--	LT 0.1	1.2	0.400	7.3	--	--	--	--	--	--			
PR-2	✓ 3,400	8.8	--	42	--	5.7	19	6.5	40	--	--	--	--	--	--			
SPV-1L	✓ --	--	--	42	6,000	1.4	1.1	0.24	1.7	LT 0.10	LT 0.10	--	--	--	--			
SPV-1S	✓ --	--	--	42	50,000	230	000	150	1,000	LT 10	LT 10	--	--	--	--	0,300	10	LT 1

¹ Reported on an as received basis in units of ppm unless otherwise noted.

LT indicates "less than"

From:
Vince Dick
REF. 28
Section 4.3
Req. 8



O'BRIEN & GERE

September 23, 1986

Mr. Harold Bilow, P.E.
Chief of Construction
MONROE COUNTY DEPARTMENT
OF ENGINEERING
350 E. Henrietta Road
Rochester, New York 14620

RECEIVED
OCT 1 1986
SOLID WASTE
D.E.C. REG. #3

Re: Rochester Pure Waters District
Contract 13 (C-36-745-05)
Brewer Street Closure Plan
Site Operating Plan

File: 888.075.210

Dear Mr. Bilow:

Attached please find a Site Operating Plan (SOP) which describes the near-term site closure activities which will be taking place at the Brewer Street construction site. This SOP has been prepared by OBG Technical Services to define the procedures and mobilization phases of the overall closure plan.

There are other aspects of the closure plan which should be in place before actual excavation and solidification processes are initiated. These aspects are as follows:

1. A detailed site survey will be prepared which locates all pertinent features on the job site, including locations of the small and large settling ponds, the original Peter B. settling pond, the pond effluent sump box, the leak area, etc. We will be using Om Popli, P.C. to complete this survey. I will be meeting Mr. Popli at the job site on Tuesday, September 23, 1986 to describe the survey limits. The survey data will be tied into existing benchmarks used for other aspects of Contract 13.
2. Once the site survey is completed, a detailed map will be prepared which will define the locations of the various cleanup equipment and work areas. Access pathways, areas containing contaminated materials and equipment, and decontamination zones will be identified for present and future reference.

Mr. Harold Bilow, P.E.
September 23, 1986
Page -2-

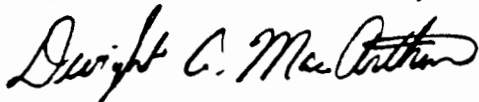
3. A site health, safety, and decontamination plan will be developed to assure that all on-site personnel are provided adequate protection against overexposure to the various chemical compounds at the site. This plan will briefly describe the various on-site monitoring equipment (e.g., Draeger tubes for air quality monitoring), necessary protective equipment for workers (chemical respirators), and procedures for the access and egress of personnel, equipment, and materials to and from the contamination zones. At this time, it appears that it will not be necessary for workers to wear respirators; however, such protection should be available should conditions warrant.

As indicated on the attached schedule, mobilization activities will be underway beginning Monday, September 22, 1986. We are currently waiting for a response from Mr. Mike Oliver of Waste Technology Services, Inc. as to the request to NYSDEC Region 9 for a waiver on organic content of the contaminated materials. Once approval is obtained for landburial at SCA Chemical in Niagara Falls, actual transportation of the solidified materials can be initiated.

If you should have any questions regarding the enclosed, please contact me as soon as possible. We will keep you up to date on the above-described cleanup activities.

Very truly yours,

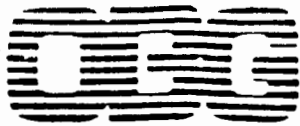
O'BRIEN & GERE ENGINEERS, INC.



Dwight A. MacArthur, P.E.
Managing Engineer

DAM:jld:22:07

cc: Mr. T. Brown, OBG Tech Services
Mr. J. Terwilliger, OBG Engineers
Dr. C. Murphy, Jr., OBG Engineers



TECHNICAL SERVICES

P.O. Box 4873 / 1304 Buckley Road / Syracuse, New York 13221 / 315 451-1331

SECTION 4.3
REF. 29
Transmittal

To: Mr. Dwight MacArthur
O'Brien & Gere Engineers, Inc.
1304 Buckley Road
Syracuse, NY 13221

Date: September 22, 1986

File: C33

Re:

Gentlemen: We are sending you X herewith _____ under separate cover
_____ drawings X descriptive literature _____ letters

Quan.	Date	Description
1		Project Schedule - Brewer Street Lagoon Closure
1		Description of On-Site Activities - Brewer Street Lagoon Closure

THESE ARE TRANSMITTED as checked below:

☐ For approval	☐ Approved as submitted	☐ Resubmit _____ copies for approval
☐ For your use	☐ Approved as noted	☐ Submit _____ copies for distribution
☐ As requested	☐ Returned for corrections	☐ Return _____ corrected prints
☐ For review and comment	☐ _____	
☒ FOR BIDS DUE _____ 19____	☐ PRINTS RETURNED AFTER LOAN TO US	

REMARKS:

If material received is not as listed, please notify us at once.

cc. Mr. Harold Bilow
Chief of Construction
Monroe County
Department of Engineering
350 East Henrietta Blvd.
Rochester, NY 14620

Very truly yours,

OBG TECHNICAL SERVICES, INC.

Terry L. Brown, P.E.
Vice President

DRAFT

DESCRIPTION OF ON-SITE ACTIVITIES
BREWER STREET LAGOON CLOSURE

September 22, 1986

It is the purpose of this Operational Plan to outline the series of activities which will be undertaken for the closure of the Brewer Street Construction Site.

On September 19, 1986 a meeting was held at the site with officials from Monroe County, New York State Department of Environmental Conservation, Waste Technology Services, American Environmental and OBG Technical Services to discuss the implementation of the closure plan. This meeting has been documented under separate cover.

During the week of September 22, 1986, OBG Technical Services will mobilize by undertaking the following activities:

1. Delivery of equipment to consist of 907C Kolbolo backhoe, D3 Caterpillar Dozer and six-yard dump truck.
2. Construction of mixing container approximately 10 cubic yards in volume.
3. Delivery of office trailer.

Once fully mobilized, the small lagoon will be excavated removing all the contaminated contents and placing them in the large lagoon. The small lagoon will be prepared as a staging area for curing, the blended additives and contaminated materials. This work is scheduled to begin September 29, 1986 and will be done in conjunction with the placing of the mixing equipment, dragging equipment and site cleanup. During the week of September 29, all on-site miscellaneous materials will be decontaminated as necessary and properly staged on-site.

The solidification operation, scheduled to begin October 6, 1986 will be done by the use of a dragline system which will operate off a pulley anchored on the west bank. Material will be moved to the east bank where a backhoe will place it into a ten (10) cubic yard (+) mixing pan. Solidification additives will be added within the pan at the prescribed rates and at times which enhance the mixing operation. The backhoe will blend the materials together, load the material into a six-yard dump truck for transfer to the small pond for curing.

It is estimated that eighty (80) cubic yards will be solidified per day with a projected completion date of October 24, 1986.

Loading of the solidified material will begin October 13, 1986 and will proceed at a rate to match the solidification effort.

Operational Plan
Brewer Street Lagoon Closure
September 22, 1986
Page 2

During the operation, OBG Technical Services will coordinate with NYSDEC and Monroe County Officials as necessary but will keep O'Brien & Gere Engineers informed of any notifications.

American Environmental; OBG Technical Services' subcontractor, will be responsible for all coordination of disposal trucks as well as properly preparing manifests.

Once all material has been solidified and removed from the site, all areas disturbed by the operation will be restored to their previous condition and all equipment and materials will be removed from the site.



O'BRIEN & GERE

December 17, 1986

Mr. Harold Bilow
Chief of Construction
MONROE COUNTY
DEPARTMENT OF ENGINEERING
350 E. Henrietta Road
Rochester, NY 14620

Re: Rochester Pure Waters District
Contract 13 (C-36-745-05)
Brewer Street Site Closure
Soil Sampling Results

File: 888.075.210

Dear Mr. Bilow:

Substantial progress was made in October and November, 1986 regarding cleanup of the contaminated areas and materials at the Brewer Street site. On November 10, 1986 the last of 73 loads of solidified visibly contaminated soil was transported from the work site to the Fondersey hazardous waste disposal facility in Oregon, Ohio. The site conditions were observed by members of your staff, NYSDEC, and O'Brien & Gere on Friday, November 7 with, as I understand it, general agreement among the various parties that the site had been sufficiently cleaned of all visibly contaminated materials (with the exception of a small area in the marsh, and the area of the small pond containing the soil removed on the following Monday).

why
do they
write
this?

On Monday, November 10, we also collected soil samples at various locations on the site to help define the levels of any residual "coal tar" contamination that remained after removal of the visibly contaminated materials. The locations of the sampling points are shown on the attached Figure 1 and the analytical results are presented in the attached laboratory reports. Comments regarding the analytical results follow:

1. Concentrations of benzene greater than 1 ppm were noted in four of the thirty-one samples - three within the large pond at a depth of 0 to 12 inches, and a fourth near the bottom of the sump at the northwest corner of the large pond. The maximum value measured was 4.0 ppm at LPSE-1. No benzene was detected at a depth greater than 12 inches.

Mr. Harold Bilow, P.E.
December 17, 1986
Page 2

2. Concentrations of toluene, ethylbenzene and xylenes in excess of 1 ppm were detected in soil at the bottom of the large pond, the bottom of the small pond, the sump, and in the silt fence area.
 - a. In the large pond detection of these compounds was found only at 0 to 12 inches at three spots (LPSE-1, LPSW-1, and LPNE-1), and at both depths at one spot (LPSW-2). At LPSW-2 the concentrations, although greater than 1 ppm, were less than 20% of the concentrations measured from 0 to 12 inches (LPSW-1).
 - b. In the small pond mixed results were observed. Comparison of SPE-1 and SPE-2 indicates higher concentrations at the greater depth, while comparison of SPW-1 with SPW-2 indicates less than 1 ppm at the greater depth with higher concentrations in the 0 to 12 inch sample. (Note: The east end of the small pond was used as a curing area for soils mixed with solidifying agents prior to removal from the site. The higher concentrations observed in the deep sample (SPE-2) is likely due to disturbance of the soil layers by backhoe operations.)
 - c. In the Peter B. Pond area, one sample PBS-2 reflected concentrations of ethylbenzene and xylenes slightly greater than 1 ppm, although no toluene was detected.
 - d. In the sump area, nothing greater than 1 ppm was detected near the top of the sump, but all BTEX parameters were detected near the bottom at greater than 1 ppm.
 - e. In the area of the silt fence no benzene was detected, although toluene, ethylbenzene, and xylenes were all detected at greater than 1 ppm. The source of this contamination is unclear since discharges in this area were limited to clear water discharges from tunnel operations. It is possible that a contaminated discharge occurred at this location during construction of the settling pond system, but no definite information is available to confirm this possibility.
3. Naphthalene was measured to be greater than 1 ppm at nearly all sampling locations (exceptions: LPBW-2, PBN-2, Sump-1). The heavier concentrations generally were measured at the bottoms of the large and small ponds as well as at the north sampling point of the Peter B. Pond (PBS). Concentrations ranged from 15 to 790 ppm in these locations. Concentrations in the area of the silt fence were also measured at 180 to 220 ppm.

Mr. Harold Bilow, P.E.
December 17, 1986
Page 3

Comparison of these recent soil sampling results with the concentrations of BTEX as measured prior to the removal of visibly contaminated soils (See Table 1) indicates that substantial removals of the benzene, xylenes, ethylbenzene and toluenes have been achieved:

	Avg. Conc, (ppm)			
<u>Large Pond (0-12")</u>	<u>Benzene</u>	<u>Toluene</u>	<u>Ethylbenzene</u>	<u>Xylene</u>
pre-soil removal	250	425	59	445
post-soil removal	2.2	20	7	35
% removal	99+	95+	88+	92+
<u>Small Pond (0-20")</u>				
pre-soil removal	230	880	150	1100
post-soil removal	<1	6	4	19
% removal	99+	99+	97+	98+

Further efforts to reduce the concentrations of these constituents to even lower levels is likely to be as expensive as has been incurred to date for the visibly contaminated soils removal. We are currently doing a further evaluation of the significance of the the remaining constituent levels on environmental and public health risk. For example, 1) if the area is properly covered, graded and seeded, there would be no exposure risk from direct contact, and 2) leachate concentrations of these compounds from infiltrating rainfall would not violate water quality standards. In addition, the characteristics of the individual compounds (mobility of naphthalene in soil and the solubility of xylenes) is being examined in light of the potential adverse impacts vs cost to remove from the soil.

We are in the process of conducting a leachate test on a composite of selected samples collected on November 10, 1986 to determine the rate of leaching of any remaining compounds from the site. An assessment will then be made to determine long-term impacts from these compounds if allowed to remain on site. We would be prepared to make a full presentation to NYSDEC after this task is completed.

As you are aware, we have not as yet closed the impoundments. A letter to RG&E has been transmitted requesting their comments on the proposed final grading plan. However, as a concern you had expressed much earlier, water will continue to accumulate in the ponds and sump area so long as no positive drainage is provided. Development of an oily sheen on the water surface may continue to occur and has been observed as noted in the December 4, 1986 letter from NYSDEC. Until the ponds are fully closed, this will be a recurring problem with its corresponding remedial costs.

Mr. Harold Bilow, P.E.
December 17, 1986
Page 4

If you have any questions regarding the enclosed, please contact me.

Very truly yours,

O'BRIEN & GERE ENGINEERS, INC.



Dwight A. MacArthur, P.E.
Managing Engineer

DAM:dn:2:6

Enclosure

cc: Dr. C.B. Murphy, Jr., OB&G
Mr. John Davis, MCDOE
Mr. Terry Brown, OBG Tech Services
Mr. Vince Dick, Avon DEC
Mr. Frank Keller, Avon DEC
Mr. Richard Elliott, MCDOH

RECEIVED

DEC 19 1986

SOLID WASTE
D.E.C. REG. #6

ROCHESTER PURE WATERS DISTRICT
CONTRACT 13 (C-36-745-05)
BREWER STREET CLOSURE PLAN

ANALYTICAL RESULTS FOLLOWING REMOVAL
OF VISIBLY CONTAMINATED SOILS

KEY TO SAMPLE DESIGNATIONS

Sample Designations

MP	-	Muck Pile
PBN	-	Peter B. Pond (North)
PBS	-	Peter B. Pond (South)
LPBW	-	Large Pond Berm (West)
LPSE	-	Large Pond South (East) (pond bottom)
LPSW	-	Large Pond South (West) (pond bottom)
LPBE	-	Large Pond Berm (East)
LPNE	-	Large Pond North (East) (pond bottom)
LPNW	-	Large Pond North (West) (pond bottom)
SPE	-	Small Pond East (pond bottom)
SPW	-	Small Pond West (pond bottom)
SPBS	-	Small Pond Berm (South)
SPBN	-	Small Pond Berm (North)
Sump	-	Sump at northwest corner of large pond
Side Sump	-	Area between Sump and Large Pond
Silt	-	Area of silt fence just west of Peter B. pond (clearwater discharge)

Analytical Parameter

B	-	benzene
T	-	toluene
E	-	ethylbenzene
X	-	xlenes
N	-	naphthalene
Total Hydrocarbons		

Laboratory
Report

CLIENT Monroe County JOB NO. 888.075.150
DESCRIPTION Brewer Street Project 888.075.210

DATE COLLECTED 11/10/86 DATE REC'D. 11/11/86 DATE ANALYZED 12/1/86-12/4/86

Site	Depth	Lab #	B	T	E	X	Naptha- lene	Total Hydro.
MP-1	10-12	D1388	<1.	<1.	<1.	<1.	<1.	150.
MP-2	12-24	D1389	<1.	<1.	<1.	<1.	21.	64.
LPBW-1	0-12	D1390	<1.	<1.	<1.	<1.	<1.	<5.
LPBW-2	12-24	D1391	<1.	<1.	<1.	<1.	<1.	<5.
LPSE-1	0-12	D1392	<1.	<1.	<1.	<1.	<1.	<5.
LPSE-2	12-24	D1393	<1.	<1.	<1.	<1.	42.	76.
LPSW-1	0-12	D1394	<1.	<1.	<1.	<1.	<1.	<5.
LPSW-2	12-24	D1395	<1.	2.5	1.2	5.4	200.	330.
PBN-1	0-12	D1396	<1.	<1.	<1.	<1.	<1.	<5.
PBN-2	12-24	D1397	<1.	<1.	<1.	<1.	<1.	<5.
PBS-1	0-12	D1398	<1.	<1.	<1.	<1.	<1.	<5.
PBS-2	12-24	D1399	<1.	<1.	2.0	3.8	160.	290.
LPBE-1	0-12	D1400	<1.	<1.	<1.	<1.	<1.	<5.
LPBE-2	12-24	D1401	<1.	<1.	<1.	<1.	1.3	<5.
LPNE-1	0-12	D1402	<1.	<1.	<1.	<1.	<1.	<5.
LPNE-2	12-24	D1403	<1.	<1.	<1.	<1.	27.	40.
LPNW-1	0-12	D1404	<1.	<1.	<1.	<1.	<1.	<5.
LPNW-2	12-24	D1405	<1.	<1.	<1.	1.	58.	93.
SPE-1	0-12	D1406	<1.	<1.	<1.	<1.	<1.	<5.
SPE-2	12-20	D1407	<1.	6.4	7.4	39.	790.	2,000.
SPW-1	0-12	D1408	<1.	<1.	<1.	<1.	<1.	<5.

Methodology: Federal Register — 40 CFR, Part 136, October 26, 1984

Units: mg/l (ppm) unless otherwise noted
mg/kg wet weight

Comments:

Authorized:



Laboratory Report

CLIENT Monroe County JOB NO. 888.075.150
DESCRIPTION Brewer Street Project 888.075.210

DATE COLLECTED 11/10/86 DATE REC'D. 11/11/86 DATE ANALYZED 12/1/86-12/4/86

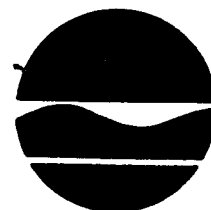
Site	Depth	Lab #	B	T	E	X	Naptha- lene	Total Hydro.
SPN-2	12-20	D1409	<1.	<1.	<1.	<1.	<1.	<1.
SPBS-1	0-12	D1410	<1.	<1.	<1.	<1.	5.9	32.
SPBS-2	12-24	D1411	<1.	<1.	<1.	<1.	<1.	<1.
Sump-1	0-12	D1412	<1.	<1.	<1.	<1.	<1.	<5.
Sump-2	12-24	D1413	<1.	<1.	<1.	<1.	<1.	<1.
SPBN-1	0-12	D1414	<1.	<1.	<1.	<1.	53.	80.
SPBN-2	12-24	D1415	<1.	<1.	<1.	<1.	<1.	<1.
Silt-1	0-12	D1416	<1.	2.8	1.9	8.7	180.	330.
Silt-2	12-24	D1417	<1.	2.8	2.0	11.0	220.	480.
Side Sump	12	D1418	<1.	<1.	<1.	<1.	3.3	26.

SECTION 43
REF 31

f

New York State Department of Environmental Conservation

6274 East Avon-Lima Road, Avon, New York 14414
TELEPHONE: 716/226-2466



Henry G. Williams
Commissioner

Eric A. Seiffer
Regional Director

January 8, 1987

Mr. John Davis, Director
Monroe County Department of Engineering
350 East Henrietta Road
Rochester, NY 14620

Dear Mr. Davis:

RE: Rochester Pure Waters District
Brewer Street Construction Site Closure

A copy of Dwight MacArthur's December 17, 1986 letter describing sample results from the Brewer Street site has been received and reviewed.

While Mr. MacArthur's statement in the letter is correct (that the majority of the visibly contaminated materials have been removed from the site), the fact remains that virtually all of the confirmation samples show values of the target constituents above the 1 ppm threshold established in August 1986. Therefore the site is not yet considered to be "clean".

Based on the County's approved closure plan, continued removal or some alternative treatment to complete site closure will be necessary. In this regard, we would be interested in results of the impact assessment being performed by O'Brien & Gere and would be willing to consider alternatives to continued soil removal. Please advise me when this work will be completed by O'Brien & Gere.

In the meantime, it is strongly suggested that the pond and sump areas be secured for the winter with snow fencing or other means to prevent access.

Once we receive the information mentioned above, I suggest we meet to discuss this matter in more detail.

Yours very truly,

Frank E. Shattuck, P. E.
Regional Solid and Hazardous
Waste Engineer

VBD:vv

VBD001.LTR

cc: Dwight MacArthur

Harold Bilow: Frank Keller

bcc: Stephen MacIntyre

SECTION 4.3
REF. 31

TABLE 1

ANALYTICAL RESULTS OF SETTLING BASIN SEDIMENT SAMPLES¹

Sample	Oil & Grease	pH (S.U.)	Percent Solids	Flash-point (°C)	TOC	Benzene	Toluene	Ethylbenzene	Xylene	Trichloroethylene	Tetrachloroethene	Halogenated Organics (% by weight)	Aromatic Organics (% by weight)	Nitrogenated Organics (% by weight)	Low Molecular Wt. Organics (% by weight)	BTU (BTU/lb)	% Ash	% Sulfur
LP-1	120,000	8.9	62.8	48	51,000	240	500	75	570	LT 10	LT 10	LT 0.01	1.2	LT 0.1	3.2	3,860	50	LT 1
LP-2	210,000	11.7	--	--	--	260	350	42	320	--	--	--	--	--	--	--	--	--
LP-3	1,000	7.1	--	52	--	LT 0.05	LT 0.001	LT 0.010	LT 0.010	--	--	LT 0.01	LT 0.01	LT 0.1	LT 0.1	--	--	--
SP-1	73	8.2	--	--	--	0.22	0.33	0.045	0.43	--	--	--	--	--	--	--	--	--
SP-2	44	7.8	--	--	--	0.33	0.40	0.080	0.43	--	--	--	--	--	--	--	--	--
SPV-1L	--	--	--	62	6,600	1.4	1.1	0.24	1.7	LT 0.10	LT 0.10	--	--	--	--	--	--	--
SPV-1S	--	--	--	42	50,000	230	880	150	1,100	LT 10	LT 10	--	--	--	--	8,300	14	LT 1

¹ Reported on an as received basis in units of ppm unless otherwise noted.

LT indicates "less than"



SECTION 4.3
REF. 32

RECRA ENVIRONMENTAL LABORATORIES

Division of Recra Research, Inc.

August 29, 1984

Mr. Richard Burton
Monroe County Environmental
Health Laboratory
435 East Henrietta Road
Rochester, NY 14620

Re: Analytical Results

Dear Mr. Burton:

Please find enclosed partial results of the analyses of the samples received at our laboratories on August 3, 1984.

Additional results will be forwarded as soon as they become available.

If you have any questions concerning these data, do not hesitate to contact our Customer Service Representative at (716) 692-7620.

Sincerely,

RECRA ENVIRONMENTAL LABORATORIES

James A. Ploscyca
Laboratory Manager

DJT/JAP/mdc
Enclosure

I.D. #84-790 partial

SECTION 4.3
REF. 32

ANALYTICAL RESULTS

MONROE COUNTY ENVIRONMENTAL HEALTH LABORATORY
PRIORITY POLLUTANT ANALYSES

Report Date: 8/29/84

COMMENTS:

Comments pertain to data on one or all pages of this report.

Analyses were performed according to U.S. Environmental Protection Agency methodology.

Results of the analysis of specific organic compounds are based upon the matching of retention times, between samples and standards, on a single gas chromatographic column.

The values reported as "less than" (<) indicate the working detection limit for the particular sample and/or parameter.

Results of the analysis of soils are corrected for moisture content and reported on a dry weight basis.

FOR RECRA ENVIRONMENTAL LABORATORIES

Heborah J. Pravis

DATE

8/29/84



SAMPLING SITE DESCRIPTIONS

<u>SITE</u>	<u>DESCRIPTION</u>
1-1 (center) 1-2 (east) 1-3 (west)	100 yds south of Gates-Chili-Ogden treatment plant, across River
2-1 (center) 2-2 (west) 2-3 (east)	100 yds north of Gates-Chili-Ogden treatment plant, across River
203-1 (east) 203-2 (center) 203-3 (west)	Canal Junction, across River
DS KOD West (Lower)	Downstream of Eastman Kodak treatment plant, west side of River, lower half of core
DS KOD West (Upper)	Downstream of Eastman Kodak treatment plant, west side of River, upper half of core
Cemetery	Riverside Cemetery
Downstream	1000 yds north of Eastman Kodak treatment plant
Upstream	1000 yds south of Eastman Kodak treatment plant

ANALYTICAL RESULTS

MONROE COUNTY ENVIRONMENTAL HEALTH LABORATORY
GAS CHROMATOGRAPHY
PRIORITY POLLUTANT ANALYSES

Report Date: 8/29/84

PESTICIDES/PCB'S

COMPOUND	UNITS OF MEASURE	SAMPLE IDENTIFICATION (DATE)		
		1-1 (8/2/84)	1-2 (8/2/84)	1-3 (8/2/84)
aldrin	ug/g dry	<0.01	<0.01	<0.01
α -BHC	ug/g dry	<0.01	<0.01	<0.01
β -BHC	ug/g dry	<0.01	<0.01	<0.01
δ -BHC	ug/g dry	<0.01	<0.01	<0.01
γ -BHC	ug/g dry	<0.01	<0.01	<0.01
chlordane	ug/g dry	<0.1	<0.1	<0.1
4,4'-DDD	ug/g dry	<0.01	<0.01	<0.01
4,4'-DDE	ug/g dry	<0.01	<0.01	<0.01
4,4'-DDT	ug/g dry	<0.01	<0.01	<0.01
dieldrin	ug/g dry	<0.01	<0.01	<0.01
α -endosulfan	ug/g dry	<0.01	<0.01	<0.01
β -endosulfan	ug/g dry	<0.01	<0.01	<0.01
endosulfan sulfate	ug/g dry	<0.01	<0.01	<0.01
endrin	ug/g dry	<0.01	<0.01	<0.01
endrin aldehyde	ug/g dry	<0.01	<0.01	<0.01
heptachlor	ug/g dry	<0.01	<0.01	<0.01
heptachlor epoxide	ug/g dry	<0.01	<0.01	<0.01
PCB-1016	ug/g dry	<0.1	<0.1	<0.1
PCB-1221	ug/g dry	<0.2	<0.2	<0.2
PCB-1232	ug/g dry	<0.2	<0.2	<0.2
PCB-1242	ug/g dry	<0.1	<0.1	<0.1
PCB-1248	ug/g dry	<0.1	<0.1	<0.1
PCB-1254	ug/g dry	<0.1	<0.1	<0.1
PCB-1260	ug/g dry	<0.1	<0.1	<0.1
toxaphene	ug/g dry	<0.1	<0.1	<0.1

FOR RECRA ENVIRONMENTAL LABORATORIES

Heborah F. Marino

DATE

8/29/84

RECRA ENVIRONMENTAL LABORATORIES

I.D. #84-790

SECTION 43
REF. 32

ANALYTICAL RESULTS

MONROE COUNTY ENVIRONMENTAL HEALTH LABORATORY GAS CHROMATOGRAPHY PRIORITY POLLUTANT ANALYSES

Report Date: 8/29/84

PESTICIDES/PCB'S

COMPOUND	UNITS OF MEASURE	SAMPLE IDENTIFICATION (DATE)		
		2-1 (8/2/84)	2-2 (8/2/84)	2-3 (8/2/84)
aldrin	ug/g dry	<0.01	<0.01	<0.01
α-BHC	ug/g dry	<0.01	<0.01	<0.01
β-BHC	ug/g dry	<0.01	<0.01	<0.01
δ-BHC	ug/g dry	<0.01	<0.01	<0.01
γ-BHC	ug/g dry	<0.01	<0.01	<0.01
chlordan	ug/g dry	<0.1	<0.1	<0.1
4,4'-DDD	ug/g dry	<0.01	<0.01	<0.01
4,4'-DDE	ug/g dry	<0.01	<0.01	<0.01
4,4'-DDT	ug/g dry	<0.01	<0.01	<0.01
dieldrin	ug/g dry	<0.01	<0.01	<0.01
α-endosulfan	ug/g dry	<0.01	<0.01	<0.01
β-endosulfan	ug/g dry	<0.01	<0.01	<0.01
endosulfan sulfate	ug/g dry	<0.01	<0.01	<0.01
endrin	ug/g dry	<0.01	<0.01	<0.01
endrin aldehyde	ug/g dry	<0.01	<0.01	<0.01
heptachlor	ug/g dry	<0.01	<0.01	<0.01
heptachlor epoxide	ug/g dry	<0.01	<0.01	<0.01
PCB-1016	ug/g dry	<0.1	<0.1	<0.1
PCB-1221	ug/g dry	<0.2	<0.2	<0.2
PCB-1232	ug/g dry	<0.2	<0.2	<0.2
PCB-1242	ug/g dry	<0.1	<0.1	<0.1
PCB-1248	ug/g dry	<0.1	<0.1	<0.1
PCB-1254	ug/g dry	<0.1	<0.1	<0.1
PCB-1260	ug/g dry	<0.1	<0.1	<0.1
toxaphene	ug/g dry	<0.1	<0.1	<0.1

FOR RECRA ENVIRONMENTAL LABORATORIES

DATE

Urbah/Gravio
8/29/84



RECRA ENVIRONMENTAL LABORATORIES
I.D. #84-790

ANALYTICAL RESULTS

MONROE COUNTY ENVIRONMENTAL HEALTH LABORATORY
GAS CHROMATOGRAPHY
PRIORITY POLLUTANT ANALYSES

Report Date: 8/29/84

PESTICIDES/PCB'S

COMPOUND	UNITS OF MEASURE	SAMPLE IDENTIFICATION (DATE)		
		203-1 (8/2/84)	203-2 (8/2/84)	203-3 (8/2/84)
aldrin	ug/g dry	<0.01	<0.01	<0.01
α -BHC	ug/g dry	<0.01	<0.01	<0.01
β -BHC	ug/g dry	<0.01	<0.01	<0.01
δ -BHC	ug/g dry	<0.01	<0.01	<0.01
γ -BHC	ug/g dry	<0.01	<0.01	<0.01
chlordan	ug/g dry	<0.1	<0.1	<0.1
4,4'-DDD	ug/g dry	<0.01	<0.01	<0.01
4,4'-DDE	ug/g dry	<0.01	<0.01	<0.01
4,4'-DDT	ug/g dry	<0.01	<0.01	<0.01
dieldrin	ug/g dry	<0.01	<0.01	<0.01
α -endosulfan	ug/g dry	<0.01	<0.01	<0.01
β -endosulfan	ug/g dry	<0.01	<0.01	<0.01
endosulfan sulfate	ug/g dry	<0.01	<0.01	<0.01
endrin	ug/g dry	<0.01	<0.01	<0.01
endrin aldehyde	ug/g dry	<0.01	<0.01	<0.01
heptachlor	ug/g dry	<0.01	<0.01	<0.01
heptachlor epoxide	ug/g dry	<0.01	<0.01	<0.01
PCB-1016	ug/g dry	<0.1	<0.1	<0.1
PCB-1221	ug/g dry	<0.2	<0.2	<0.2
PCB-1232	ug/g dry	<0.2	<0.2	<0.2
PCB-1242	ug/g dry	<0.1	<0.1	<0.1
PCB-1248	ug/g dry	<0.1	<0.1	<0.1
PCB-1254	ug/g dry	<0.1	<0.1	<0.1
PCB-1260	ug/g dry	<0.1	<0.1	<0.1
toxaphene	ug/g dry	<0.1	<0.1	<0.1

FOR RECRA ENVIRONMENTAL LABORATORIES

DATE

Lab. 4016 F. 12/10/84
8/29/84

ANALYTICAL RESULTS

MONROE COUNTY ENVIRONMENTAL HEALTH LABORATORY
GAS CHROMATOGRAPHY
PRIORITY POLLUTANT ANALYSES

Report Date: 8/29/84

PESTICIDES/PCB'S

COMPOUND	UNITS OF MEASURE	SAMPLE IDENTIFICATION (DATE)	
		DS KOD WEST (LOWER) (8/2/84)	DS KOD WEST (UPPER) (8/2/84)
aldrin	ug/g dry	<0.01	<0.01
α -BHC	ug/g dry	<0.01	<0.01
β -BHC	ug/g dry	<0.01	<0.01
δ -BHC	ug/g dry	<0.01	<0.01
γ -BHC	ug/g dry	<0.01	<0.01
chlordan	ug/g dry	<0.1	<0.1
4,4'-DDD	ug/g dry	<0.01	<0.01
4,4'-DDE	ug/g dry	<0.01	<0.01
4,4'-DDT	ug/g dry	<0.01	<0.01
dieldrin	ug/g dry	<0.01	<0.01
α -endosulfan	ug/g dry	<0.01	<0.01
β -endosulfan	ug/g dry	<0.01	<0.01
endosulfan sulfate	ug/g dry	<0.01	<0.01
endrin	ug/g dry	<0.01	<0.01
endrin aldehyde	ug/g dry	<0.01	<0.01
heptachlor	ug/g dry	<0.01	<0.01
heptachlor epoxide	ug/g dry	<0.01	<0.01
PCB-1016	ug/g dry	<0.1	<0.1
PCB-1221	ug/g dry	<0.2	<0.2
PCB-1232	ug/g dry	<0.2	<0.2
PCB-1242	ug/g dry	<0.1	<0.1
PCB-1248	ug/g dry	<0.1	<0.1
PCB-1254	ug/g dry	<0.1	<0.1
PCB-1260	ug/g dry	<0.1	<0.1
toxaphene	ug/g dry	<0.1	<0.1

FOR RECRA ENVIRONMENTAL LABORATORIES

DATE

Monroe County
8/29/84

ANALYTICAL RESULTS

MONROE COUNTY ENVIRONMENTAL HEALTH LABORATORY
GAS CHROMATOGRAPHY
PRIORITY POLLUTANT ANALYSES

Report Date: 8/29/84

PESTICIDES/PCB'S

COMPOUND	UNITS OF MEASURE	SAMPLE IDENTIFICATION (DATE)		
		CEMETARY (8/3/84)	DOWNSTREAM (8/3/84)	UPSTREAM (8/3/84)
aldrin	ug/g dry	<0.01	<0.01	<0.01
α -BHC	ug/g dry	<0.01	<0.01	<0.01
β -BHC	ug/g dry	<0.01	<0.01	<0.01
δ -BHC	ug/g dry	<0.01	<0.01	<0.01
γ -BHC	ug/g dry	<0.01	<0.01	<0.01
chlordan	ug/g dry	<0.1	<0.1	<0.1
4,4'-DDD	ug/g dry	<0.01	<0.01	<0.01
4,4'-DDE	ug/g dry	<0.01	<0.01	<0.01
4,4'-DDT	ug/g dry	<0.01	<0.01	<0.01
dieldrin	ug/g dry	<0.01	<0.01	<0.01
α -endosulfan	ug/g dry	<0.01	<0.01	<0.01
β -endosulfan	ug/g dry	<0.01	<0.01	<0.01
endosulfan sulfate	ug/g dry	<0.01	<0.01	<0.01
endrin	ug/g dry	<0.01	<0.01	<0.01
endrin aldehyde	ug/g dry	<0.01	<0.01	<0.01
heptachlor	ug/g dry	<0.01	<0.01	<0.01
heptachlor epoxide	ug/g dry	<0.01	<0.01	<0.01
PCB-1016	ug/g dry	<0.1	<0.1	<0.1
PCB-1221	ug/g dry	<0.2	<0.2	<0.2
PCB-1232	ug/g dry	<0.2	<0.2	<0.2
PCB-1242	ug/g dry	<0.1	<0.1	<0.1
PCB-1248	ug/g dry	<0.1	<0.1	<0.1
PCB-1254	ug/g dry	<0.1	<0.1	<0.1
PCB-1260	ug/g dry	<0.1	<0.1	<0.1
toxaphene	ug/g dry	<0.1	<0.1	<0.1

FOR RECRA ENVIRONMENTAL LABORATORIES

DATE

Urbah J. Prosser
8/29/84

ANALYTICAL RESULTS

SECTION 4.3
REF. 32

MONROE COUNTY ENVIRONMENTAL HEALTH LABORATORY

Report Date: 8/29/84

SAMPLE IDENTIFICATION	SAMPLE DATE	PARAMETER (UNITS OF MEASURE)
		DRY WEIGHT/103°C (%)
1-1	8/2/84	71
1-2	8/2/84	74
1-3	8/2/84	76
2-1	8/2/84	64
2-2	8/2/84	62
2-3	8/2/84	72
203-1	8/2/84	79
203-2	8/2/84	63
203-3	8/2/84	75
DS KOD WEST (LOWER)	8/2/84	68
DS KOD WEST (UPPER)	8/2/84	59
Cemetery	8/3/84	64
Downstream	8/3/84	65
Upstream	8/3/84	77

FOR RECRA ENVIRONMENTAL LABORATORIES

Lebaron J. Prasio

DATE

8/29/84

RECRA ENVIRONMENTAL LABORATORIES

I.D. #84-790

SECTION 243
REF. 32

ANALYTICAL RESULTS

MONROE COUNTY ENVIRONMENTAL HEALTH LABORATORY
GAS CHROMATOGRAPHY
PRIORITY POLLUTANT ANALYSES
QUALITY CONTROL

Report Date: 8/29/84

RECOVERY ANALYSIS OF
METHOD BLANK

COMPOUND IDENTIFICATION	ng OF SPIKE	ng RECOVERED	% RECOVERY
Aroclor 1221	1.0	0.95	95
Aroclor 1242	1.0	0.78	78
Aroclor 1254	1.0	0.75	75

FOR RECRA ENVIRONMENTAL LABORATORIES

DATE

Heborah J. Davis
8/29/84



RECRA ENVIRONMENTAL LABORATORIES

I.D. #84-790

VACUUM OIL COMPANY

*Significant amount of oil leaking from buried sagging, abandoned pipe at Atkinson Street sewer and old canal. Naptha ran through the sewer from Franklin Street to Platt Street to Municipal Gas Works. Refuse in sewer was supposed cause. Naptha was the actual cause. Around 1870, 30 barrels of naptha were released into the Genesee Valley Canal. A pit was made at the works to burn refuse from the production of gas and naptha, but complaints from residents caused the Vacuum Oil Company to abandon the pit. The newspaper article was not specific about a location of the pit. Another pipe that crossed the canal and the Erie RR tracks was broken by a passing canal boat. That pipe led to the river and the Municipal Gas Works. The Glasgow Street pipe leaked oil for two years of the date of this report. Enough oil leaked to be scooped into barrels. Tank number 5 vent allows oil to run into the canal. Twelve thousand gallons of naptha are unaccounted for - "disappeared." Surplus water used in the boilers also runs into the river. One hundred barrels a day are used. (Union & Advertiser, December. 28, 1887, 3-1).

*A break in the Atkinson Street sewer caused a naptha explosion in 1887. Naptha was being run from a pipe that ran from Vacuum Oil Company to the Municipal Gas Works. The pipe running through Glasgow Street was laid in 1881 and abandoned at some point when they no longer sent refined oil to the Central Hudson and Buffalo, Rochester & Pittsburgh Railroad. (Union & Advertise, December 30, 1887, 6-2).

*A pipe 2 to 3 inches thick runs through Glasgow and other streets between Vacuum Oil Works and its warehouse on Glasgow Street. The pipe also ran to the Genesee Valley Canal Bridge on W. Main Street and West Avenue and Litchfield and King Streets, and across the Cent. Hud. Buffalo, Rochester and Pittsburgh RR. The pipe was authorized to carry refined oil but was used to carry naptha to the Municipal Gas Works. (Union & Advertiser, December 31, 1887, 3-1).

*Vacuum Oil Company accused of dumping refuse into the river below the dam. The oil smell is said to be string. Vacuum Oil Company makes 35 barrels of naptha a day for Municipal Gas Works. The amount of production is slightly seasonal. Citizens Gas and Rochester Gas Works do not manufacture naptha. The Vacuum Oil Company denied that they put naptha into the river. They claim they have burned it for the last 3 to 5 years from the date of this article. All that is not burned is waste acid that is put into tanks and sent to Buffalo. There are 10,000 barrels of oil stored at the oil company. One person recalled a fire on the river from naptha. Real estate values have decreased a reported 20% from the nuisances.

Several residents complained about the smell from the naptha in the sewer. One man said he lost a child because of the fumes. A company spokesman said, "Of course the fume of naptha taken into the lungs in sufficiently large quantities will suffocate a person, but if that person be resuscitated he is uninjured." A coroner's jury found the Vacuum Oil Company responsible for the deaths of several people as a result of naptha in the public sewer. (Union & Advertiser, January 7, 1883, 3-3).

*A fire burned in the Clinton Mill for more than a week. The bins. (unspecified number) are 90 feet deep and nearly full. The fire from the naptha explosion caught the bins. It is proposed that a pipe from the Vacuum Oil Works has tow outlets; one to the sewer and one to the Municipal Gas Works. (Union & Advertiser, December 27, 1887).

*Men dug 8 to 9 feet on West Avenue near the Old Genesee Valley Canal Bridge but found no pipe. The article reported, "There is considerable water in the hole and an oily substance, presumably naptha, can be seen floating on the surface." (Union & Advertiser, December 23, 1887, 2-6).

*There was a pipe on Glasgow Street but it was abandoned and partially torn up. "Only two sewers connected with the works and both of these empty into the river. It was further claimed on the part of the company that the trap at the entrance to the sewers separates the oil from the water and that only inflammable fluid enters the sewer." (Union & Advertiser, December 23, 1887, 8).

GENESEE OIL WORKS

*Lyell and Saxon Street sewers are filled with the stench from the oil works. An injunction is sought by residents to stop production. (Union & Advertiser, January 10, 1862, 2-4).

INCINERATION

*Two barrels of garbage were burned at the Co-operative Foundry. The fire bed revealed no vestiges of garbage. No burial site of any ashes is mentioned. (Union & Advertiser, July 1, 1885, 2-3).

GENESECO CORP.

Makes paint and oil at the foot of Ambrose Street. No further information was found on the company. This is from a 1918 city directory.

- To The File
- From Deborah Jackson Region 8 DEC. 624-3350 Called her re detailed map
- Date March 14, 1985
- Re Meeting - March 12, 1985 - Louisa Falls
- With Dick Burton - MCHD
- Louise Hartshorn - HCEMC
- Rick Spota - Concerned citizens with knowledge of the area.

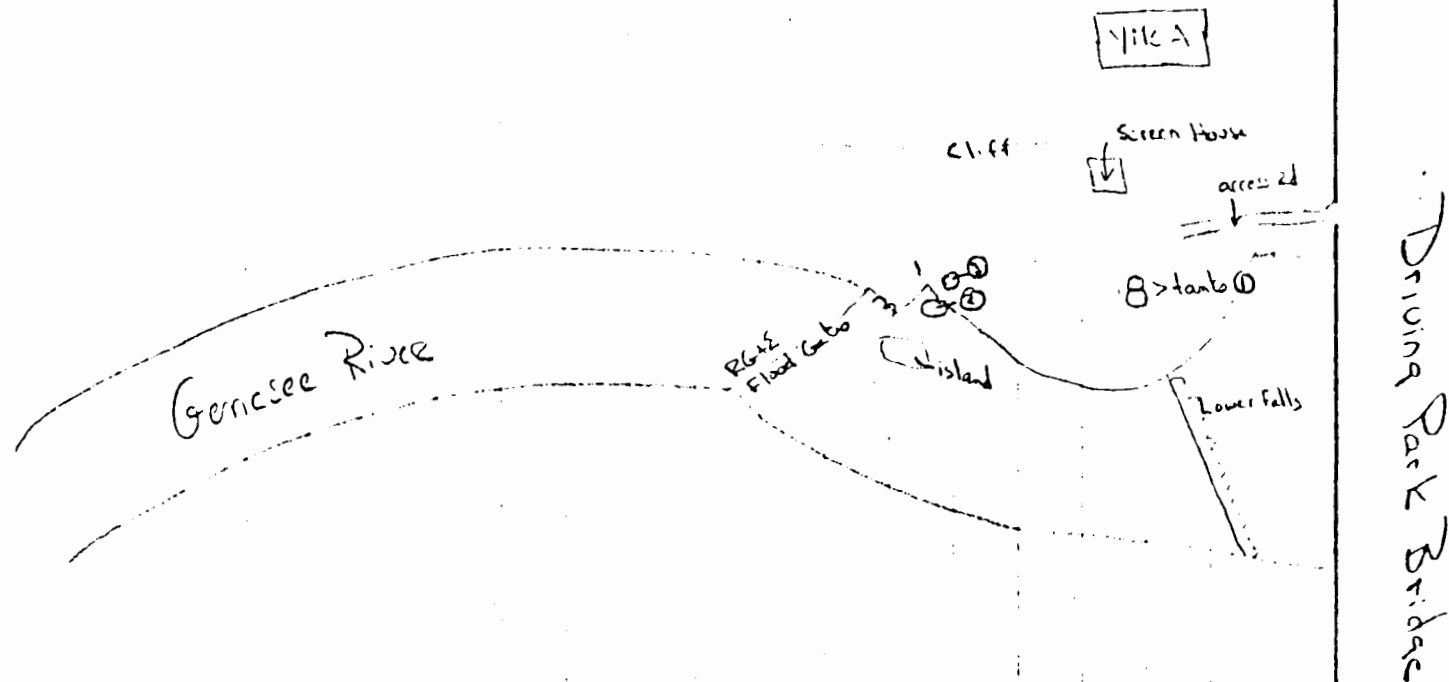
Met the above mentioned individuals at 9:00 am near the Downing Park Bridge. Mr. Spota remembers where tanks and black slinky material were disposed, due to his activities in this area as a child. After showing us these locations, was agreed upon that an orthophotomap with details of these locations would be drawn up by Louisa and sent to Rick Spota for review.

Mr. Spota also agreed to meet again, if we had questions during the Phase II investigations.

It was also recommended, that we contact De Clark Eastman Kodak, in regards to old aerial photo of this area.

Louise Hartshorn did take pictures during this inspection for future reference.

at N



- ①. buried approx 30 feet
- ② gas like material dumped along the river bank
- ③. foundation where black sludge material was dumped

To: The File

from: Deborah Jackson

Date: March 14, 1985

Re: Meeting March 12, 1985 - Lower Falls

with: Dick Burton - MCHU

Louise Haulshorn - MCHC

Mr. C - concerned citizen with knowledge of the area.

Met with the above mentioned individuals at 11:30 AM at Dick Burton's office discussing the area north of the St. Paul Tunnel Project.

Mr. C described the construction of RG+E's Unit 12 on the west side of the river, south of the old stations. Construction started 1955 or 56 and was completed in 1968. This construction was due to hanging from coal gas to natural gas.

Sludges in the tanks on the east side were emptied to trucks - may have been Atlas Wrecking Company. It disposed of on the west side of the river, south of the Peoria St. Bridge near an old access road. Area buried was approx. 30' x 50' approx 4-8' deep. Material was disposed in 1967-68. Construction pictures from before 1960 show the disposal area. Peoria St. Coal Pile was only used as a reserve.

The East Station was used basically as a filling area. In West Station is where all the room facemaking was done.

Access Rd
Current Location -
Sludge

Genesee
River

Coal Gasification
Manufacturing

Coal
Piles

①
②
③
④
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Witch +
Lomb

→ tanks
→ oxidizer boxes

① Oxidizer Disposal Area

02
St. Paul Interceptor
Tunnel Project

Furnace 6
L.F.
Riser
Flame
Gates
Lower
Falls

Division Park Bridge

Record of Meeting Concerning NYS Superfund Sites in Monroe County

Persons Present: Richard Burton, MCDH
Richard Elliott, MCDH
Louise Hartshorn, MCEMC
Mark Hanna, URS Engineers

Record Prepared by: Mark Hanna, URS Engineers January 31, 1985.

Lower Falls

- Old maps and photographs were used to identify industries along Deep Hollow Creek - especially ^{Sanborn} ~~Sanford~~ Fire Insurance Maps, the oldest of which were developed during the 1930's. Sanborn Fire Insurance maps date back to the 1860's - LAM
- The mills along Hastings Street were unsewered and discharged their wastewaters to a mill race along the west bank of the Genesee River. and/or sluices from the race to the river
- The Deep Hollow ravine was filled in using construction and excavation debris (including many large boulders) from the city. Also, numerous junked cars were buried in this area.
- The integrity of the City of Rochester's sewer siphons were threatened when the ravine was filled in due to the weight of the backfilled materials. - apparently intact
- Mechanics industrial laundry, which is still in operation, is a possible source of solvents. These solutions were derived from barrels of cloths delivered for cleaning, and were supposedly dumped into a holding tank in the back parking lot. Disposal records were not available to investigators.

- Upton ~~Coal~~ ^{Coke} Storage on Cliff Street (next to Rae Oil) may have used deep shaft storage for industrial wastes.
- The Rochester Gas and Electric synthetic gas plants (no longer existing) involved a coking operation, and may also have been a source of organic contaminants. ^{East & West} near Smith St. Bridge
- The RG&E tunnel, which ^{has been} ~~is~~ felt to be the source of the creosote seep, was ^{shored up for ~150'} ~~constructed~~ with untreated ^{timbers} ~~lumber~~ and ^{reported} ~~waterproofed~~ by pumping creosote into the voids behind the wood. This tunnel has been empty three times in the last six years, and creosote seeps were documented in areas where the voids were filled with creosote. The H & A of NY report which didn't discuss pockets of creosote was based on borings which were made in the wrong locations ^{to assess this} (in the opinion of Mr. Burton). The area of greatest concern is under the island in the river, and H & A of NY did not drill there. ^{H & A drilled where they needed info, NOT to track this problem.}
- The seeps from the Lower Falls ^{were first noticed} ~~began~~ in the early 1970's after part of the face of the falls fell off.
- The lower seep is comprised of creosote, while the upper seeps include fuel oil, gasoline and other chemicals. The upper seeps are located near the end of the former mill race used by the closed industries (most of which is now covered).
- The City sewer, which also crosses the mill race, could also be a source of contamination.
- The MCDH has been working on this problem for approximately 10 years, and has exhausted all records that could be found. RG&E Station 5 is one source of many old records. George Becker, an old operator of the station (who retired 4 years ago) has some recollections also.

- The Lower Falls has many stress fractures, and installing wells in this area may not provide conclusive results concerning the contaminants detected.
- MCDH has recommended to RG&E that sources should be ^{further investigated} ~~eliminated~~ the next time the tunnel is repaired.

Railroad Car Shop

- The shop was probably first used by the Penn Central Railroad, and later by the New York Central Railroad. The Conrail system was the last owner, using the shop through the early 1970's.
- The ravine behind the shop was filled with much metal, coal, cinders, etc. It was an active site during the 1950's and was filled in over a long period of time.
- Many underground tanks were located on the site which held solvents and petroleum products.
- Many complaints about surface water contamination were made in this area. Leachate was collected by the MCDH from storm sewers which are part of an area drainage collection system. Measurable quantities of various contaminants were detected.

Plumb Gravel

- The landfill boundary was defined in a report by Bergmann and Associates.
- NYSDEC has required much investigative work on the site in response to an application for the development of an industrial park.
- Considered one of the least important sites in the County.

Pittsford Dump

- Not considered to be a problem.

Pittsford DOT - Monroe Avenue

- Agencies have no information.

As was discussed and recommended at the beginning of this meeting, this typed copy of the meeting notes has been prepared and is presented for evaluation and acceptance by the County representatives involved. If you agree that the interpretation of our conversation which is provided above is correct, please sign this report on the bottom in the space provided. If you feel any corrections are necessary, please make the changes on the text of this record and initial them. Also, if you have any additional information on these sites which you feel is pertinent, please attach a sheet and sign it at the bottom.

I agree with the information as it is presented above.

Richard S. Burton - with pencil comments

Richard Burton,
Monroe County Environmental Laboratory

Richard S. Elliott

Richard Elliott, P.E.
Monroe County Department of Health

Louise G. Harshorn

Louise Harshorn,
Monroe County Environmental Management Council

Appendix C

Section 4.1

Ref. 10

*copy for Bureau
return only to me*

S. County of Monroe

NEW YORK



Division of Pure Waters
55 Broad Street - Rm. 100
Rochester, New York 14614

XXXXXXXXXXXXXXXXXXXX

Robert L. Fitch, P.E.
Acting Director

*5 copy Dr. W. ...
this is an example of
the sort of situation
that exist. This seems
would be an excellent
first choice for
organics ident.
R. Gordon*

TELEPHONE:
428-5260

August 25, 1975

Mr. G. Richard Sutherland
Associate Public Health Engineer
MONROE COUNTY DEPARTMENT OF HEALTH
111 Westfall Road
Rochester, New York 14602

Dear Dick:

In reply to your letter of August 19, 1975 regarding oil seepage into the Genesee Gorge at Lower Falls, please be advised that some time last year we were made aware of this situation by your office and/or Delta Laboratories. We spent most of a day in that area trying to pinpoint a source for this oil. We were unable to arrive at any specific conclusion, but found the following:

1. There is a Lake Avenue Auto Parts outfit that is located on Lake Avenue directly above the area of the seepage. In a conversation with the owner of this auto parts company we learned that there may be as many as 50 feet of junk cars stacked up and used as fill directly under the ground level at which he was operating. It seems that his father and grandfather before him operated in that area for many years, and their operation included stripping cars for parts and leaving them on the premises. It would be interesting if an analysis of the oil seeping could relate this oil to automotive use.
2. On the west side of Lake Avenue there is a large lot which has been used as a dump for many years. We climbed down the embankment and found that there were many drums, pails, etc. which had been thrown into this deep ravine.

These were the only two places which showed a potential as a contributory agent.

Very truly yours,

EMIL ZENIE
Supervisor of
Industrial Waste

EZ:sjf

RECEIVED

AUG 26 1975

MONROE COUNTY
HEALTH DEPARTMENT

THE GEOLOGIC EVOLUTION OF THE GENESEE VALLEY REGION AND EARLY LAKE ONTARIO: A REVIEW OF RECENT PROGRESS.

Richard A. Young

Department of Geological Sciences, SUNY College at Geneseo, Geneseo, New York 14454

ABSTRACT

When the last glacial ice sheet retreated from the northern Adirondacks and the St. Lawrence valley became the major glacial meltwater outlet for the Ontario basin, a series of low-level lakes were created as the isostatically depressed crust slowly rose concurrently with the glacially lowered sea level. The progressive southwestward tilting of the Ontario basin produced emergent shoreline features at the east end of the lake as the west end became submerged. The Irondequoit Bay bar sediments near Rochester contain a unique record of these events that can be compared with lake level indicators already tentatively correlated from the Thousand Island region across the Lake to Hamilton, Ontario. The shorelines at Rochester were at least 140 to 200 feet below the present level of Lake Ontario. As the lake basin was gradually tilted to the southwest, Irondequoit Bay was flooded, submerging the ancestral Genesee River valley located beneath it. Most of the southwest shore of the lake continues to be submerged at a rate of about 1 foot each century.

Recent engineering borings for deep sewer tunnel construction near Rochester have defined several zones of faulting and open folding that are not parallel to the prominent Appalachian structures to the south. Care must be taken to distinguish these deep-seated structures from surficial ice-thrust deformation, which also appears to be a common regional phenomenon.

The northwest trending folds and fault zones may correlate with some of the glacially scoured gaps in the Niagara Escarpment, and may be reflecting the influence of deeper seated, Grenville age basement structures exposed further north in Ontario.

Our ability to understand and interpret many of these regional events and features owes much to the basic observations and writings of the early scientists such as H. L. Fairchild.

INTRODUCTION

The region around Rochester, N. Y., contains a variety of interesting landforms and sedimentary deposits created or modified by the processes of continental glaciation. The most recent ice advance (the Wisconsin Stage) began about 75,000 years ago, and the ice finally retreated from the Rochester area about 13,000 years ago. Events during the glacial recession were dominated by the formation of a series of proglacial lakes that paralleled the ice margin. The relict shorelines of these glacial lakes and the buried valley beneath Irondequoit Bay (presumed to represent an ancestral Genesee River course) are two of the many glacial features studied by H. L. Fairchild that are most familiar to area naturalists, amateur geologists, and the public. Because of their influence on the geography of the Rochester area and its surroundings, the geologic explanations of these features have intrigued many individuals outside the academic community of Quaternary and Pleistocene geologists.

Fairchild and the other geologists who first described the extent and nature of these glacial features in detail provided modern geologists with the broad framework of the important geologic events that characterized the late glacial history of central and western New York. These early geologists also have preserved in their writings an important photographic and descriptive record of many glacial features that have since been paved over or destroyed by urban expansion and excavation.

Prior to the 1950's, geologists did not have the advantage of the extensive radiocarbon chronology that has since helped to resolve some of the controversial interpretations of events in the late glacial history of the northern United States. In addition to an improved chronology, the radiocarbon ages have permitted some of the basic data, such as post-glacial uplift rates, to be used in the development of more quantitative models of the earth's geophysical properties, such as the elastic properties of the lithosphere and the viscosity of the upper mantle. Thus, as in many basic geologic investigations, information obtained in the course of numerous local studies ultimately contributes to the solutions of more fundamental or theoretical geologic problems.

Fairchild's studies of the sequence of proglacial lakes that formed as the last ice sheet retreated from central New York state provide the basic chronologic framework for ongoing studies of many

directly or indirectly related phenomena. The changes in proglacial lake levels, especially those following Lake Iroquois, place significant constraints on the behavior of the retreating ice sheets, the chronology of deglaciation in the St. Lawrence Valley, and the worldwide rise of sea level during deglaciation.

The thickness and nature of the glacial deposits in the ancestral Genesee River valley beneath Irondequoit Bay contain important clues to the final sequence of glacial events, shedding light on the limits of earlier fluvial erosion, changes in local base levels (Lake Ontario), and the competency or magnitude of subglacial erosion and deposition processes. In addition, the barrier bar at the mouth of the bay has preserved a unique sequence of postglacial lacustrine and shoreline deposits that can be used to verify speculative correlations of early Lake Ontario low water stages, which have only been studied in detail at the eastern end of the lake.

The ice erosion that reshaped the eroded bedrock surface in the vicinity of Rochester is inferred to have produced shallow deformational structures in the bedrock, termed "ice-thrust features." Although deformation produced by this mechanism may have been correctly interpreted in some surficial exposures or shallow excavations, there are also significant, unmapped, high-angle faults and compressional folds that extend to greater depths and probably reflect regional tectonic stresses produced during the Appalachian orogeny.

The primary purpose of this paper is to review recent discoveries that can be used to update and refine Fairchild's work on the youngest series of proglacial lake levels and on ice erosion processes. A secondary purpose is to describe the existence of significant structural deformation in the bedrock that has not been well documented in the past and that might be confused with features formed by shallow ice-thrust deformation.

POST IROQUOIS LOW-LEVEL LAKE STAGES

Lake Iroquois is the name given to the highest, major late Wisconsin stage of the proglacial lakes in the Ontario basin before ice recession opened the much lower outlet through the St. Lawrence valley region (Figure 1). The outlet for Lake Iroquois was through the Mohawk valley, and the shoreline at Rochester is marked by the prominent ridge followed by Ridge Road, approximately 190 feet above Lake Ontario (Figure 2).

Fairchild (1906) and others (Coleman, 1922) described the existence of a postglacial low water lake stage(s) that was created when the ice first withdrew from Covey Hill on the north side of the Adirondacks and allowed the glacial meltwaters to exit via the St. Lawrence valley. Such low water stages were made possible due to the combined effects of a lowered glacial sea level and isostatic depression of the land surface from the weight of the ice sheet. Postglacial rebound of the land surface began as the ice sheet was retreating. Most of the isostatic compensation (postglacial rebound) was completed soon after the ice retreated, but postglacial differential tilting continues even to the present at a reduced rate of about 1 foot every hundred years across the Ontario basin. The uplift has been greatest in the vicinity of Hudson Bay.

When the new outlet opened near Covey Hill (about halfway between the St. Lawrence River and Lake Champlain on the U.S.-Canadian border), the ice-dammed Lake Iroquois phase ended. The meltwater flowed northeastward through the St. Lawrence Valley, which was then depressed 300 to 400 feet lower than its present elevation. When the ice retreated, the maximum rate of postglacial rebound of the land along the St. Lawrence lowland was greatest in the vicinity of Montreal and decreased southwestward toward Lake Ontario. Sea level rose slowly in concert with the wasting ice sheets. The resulting balance between the isostatic rebound, the recession of the ice, and the rise of sea level created an arm of the ocean, the Champlain Sea, which penetrated at least as far up the St. Lawrence as Brockville, Ontario, before the steady uplift blocked a further marine invasion (Figure 1). Fairchild had envisioned a more westerly extension of the Champlain Sea into the Lake Ontario basin, which he called the Gilbert Gulf. However, the current evidence, recently reviewed by Terasmae (1980), indicates that the Champlain Sea invasion stopped about 40 miles short of the eastern end of Lake Ontario. The more rapidly rising land to the northeast had the effect of tilting the Lake Ontario basin to the southwest, toward Buffalo, about a hinge line trending $N75^{\circ}W$. This regional tilting gradually forced the Champlain Sea to retreat eastward as the level of Lake Ontario at Rochester rose toward its present level. The low water lake stage that connected with the advancing Champlain Sea was called the Admiralty Lake (Coleman, 1922), and it could only have existed during the short interval when sea level was still low and only a limited amount of isostatic rebound had occurred.

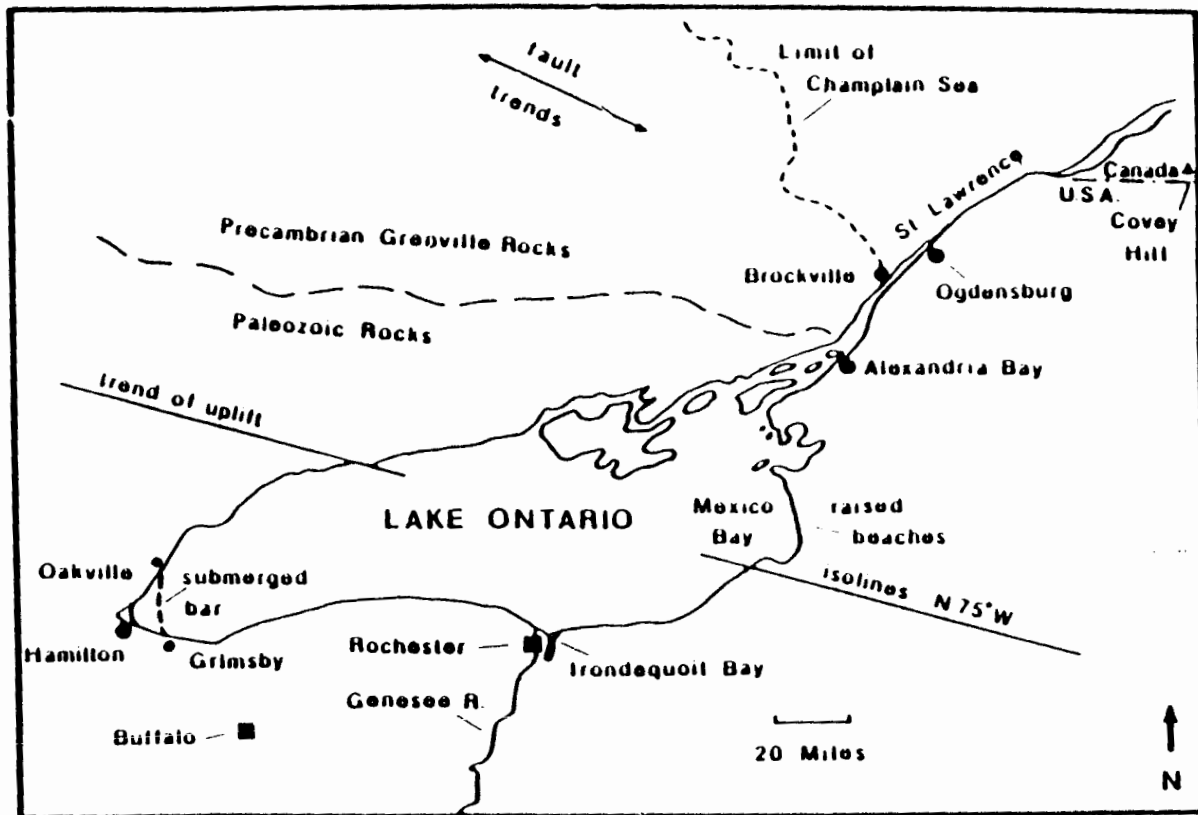


FIGURE 1: Important geologic features and locations in the Lake Ontario-St. Lawrence valley region
Trend of uplift isolines approximate.

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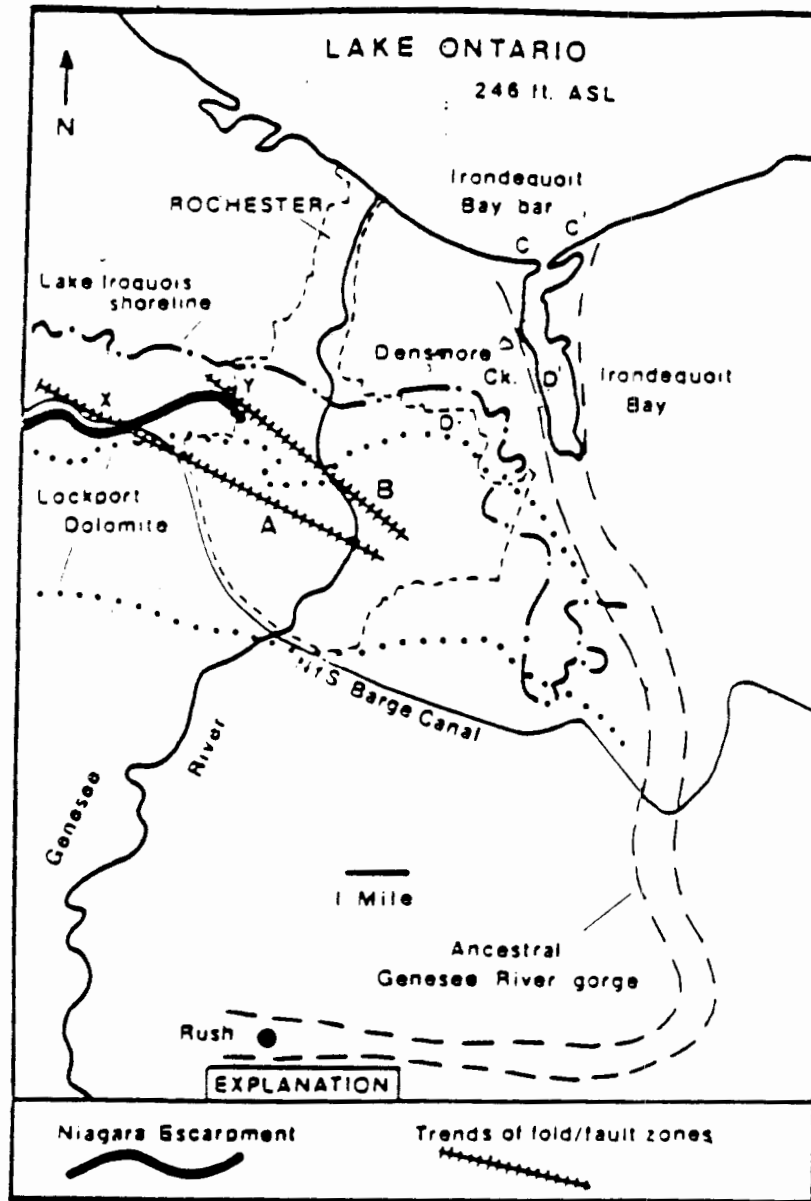


FIGURE 2. Geologic features in the Rochester-Irondequoit Bay region. Letters X and Y locate places where deformational structures (folds, faults) appear to intersect the Niagara Escarpment and account for increased differential ice erosion. C-C' and D-D' locate composite profile of ancestral Genesee River valley on Figure 6. Lake Iroquois shoreline (Coadrich, 1917).

The southwestward tilting of the Ontario lake basin gradually created a series of emergent shorelines around the eastern end of the lake while those same shorelines were being submerged near Rochester and further west. Sutton et al. (1972) described the evidence for the different shoreline stages following Lake Iroquois and documented the amount of tilting across the lake basin. They speculated on an important relationship between the Lake Iroquois shoreline and the Sandy Creek shoreline about 325 feet below it. These two parallel shorelines (330 to 320 feet apart) formed during a time when rapid differential uplift was occurring from northeast to southwest across the Lake (Figure 3). They inferred that the distance between these two prominent shorelines represented the rapid fall of the lake level following the draining of Lake Iroquois, when the St. Lawrence valley first became the meltwater outlet. However, they were hesitant to specifically correlate the low Sandy Creek Stage with Coleman's Admiralty Lake. In addition, their correlations were based on the elevations of water level planes (beaches) projected northward into the Alexandria Bay area (Thousand Islands) and correlated with some deeply buried organic horizons (Figure 3) near Hamilton, Ontario, at the opposite (west) end of the lake (Karrow et al., 1961). At that time a tentative date of 11,000 to 12,000 years was assigned to the buried deposits (Karrow et al., 1961; Sutton et al., 1972). Thus the correlations and the ages of the shoreline features were speculative. However, the individual shoreline stages are well developed above the modern lake at its eastern end. Since those correlations were made in 1972, the approximate date for the draining of Lake Iroquois has been suggested as closer to 12,000 $\pm$ years B.P. (Terasmae, 1980), and deep borings in the vicinity of Irondequoit Bay have provided significant new data (Young, 1980) with which to test the ideas of Sutton et al. (1972).

The evidence from deep borings occurs within the ice-scoured, sediment-filled valley of the ancestral Genesee River at the mouth of Irondequoit Bay (Figure 4). Several test wells drilled for the Village of Webster during water-supply investigations have defined the bedrock profile of the ice-scoured trough and have penetrated old beach and lacustrine deposits at depths of approximately 40 feet, 140 feet, and 200 feet below the present lake level (246 feet). If the most persistent beach deposit (140 feet below lake level) is plotted on a diagram similar to that constructed by Sutton et al. (1972), it falls precisely on the line connecting their Sandy Creek Stage with the buried peat deposit near Hamilton (Figure 3). In addition, the younger (less tilted) Dune Stage shoreline, which documents the effect of differential isostatic rebound between the Lake Iroquois phase and 4,800 $\pm$ years B.P., appears to be represented by sand and peat deposits at a mean depth of 40 to 60 feet below lake level.

The fit of the points of these two shorelines curves was determined by measuring all distances perpendicular to the inferred tilt axis, which trends N 75° W. The excellent fit of all the points on both the Sandy Creek and Dune shoreline curves gives added confidence to the correlations suggested by Sutton et al. (1972).

In the Irondequoit Bay cores there are other sand lenses 40 to 60 feet below what is inferred to be the Sandy Creek Stage. These lower sands are below silts and clays that are similar to the lacustrine sediments in the higher sections of the cores. When compared with the raised beaches described at the east end of the lake (Sutton et al., 1972), these sands are the same distance below the Sandy Creek shoreline as are the Skinner Creek shoreline features. If the lowermost sands at Irondequoit Bay are projected westward, parallel to the Sandy Creek and Iroquois shorelines, they intersect a submerged bar (Figure 1), described by Lewis and Sly (1971), which runs under the lake between Grimsby and Oakville (about 10 miles east of Hamilton).

Sutton et al. (1972) suggested that the Skinner Creek shoreline represented a *drop* in lake level from the Sandy Creek shoreline and thus considered it a younger feature. The evidence at Irondequoit Bay implies that the Skinner Creek stage formed first and that it correlates with the Oakville-Grimsby bar, which Lewis and Sly (1971) equated with the Admiralty Lake phase. The Irondequoit Bay bar represents a continuous sequence of increasingly younger deposits from the lowest lacustrine sediments upward. Unlike the raised terraces at the east end of the lake, the sediments in the barmer bar cannot become *younger* with decreasing elevation (increasing depth in the cores) (Figure 5).

The uniform parallelism of the three shorelines, Iroquois, Sandy Creek, and Skinner Creek, as projected through the Irondequoit Bay section to the west end of the lake, suggests that the Skinner Creek Stage is the oldest and lowest shoreline. All three stages cannot be significantly different in age if they are essentially parallel to each other. A calculation of the differential tilt rate across the Lake Ontario basin immediately following the draining of Lake Iroquois indicates a *minimum* differential tilting of the basin of 6 to 7 feet per 100 years at that time. Therefore, any shorelines in the range of 11,000 to 12,000 years old would have measurably different slopes if they differed in age by 200 years or more.

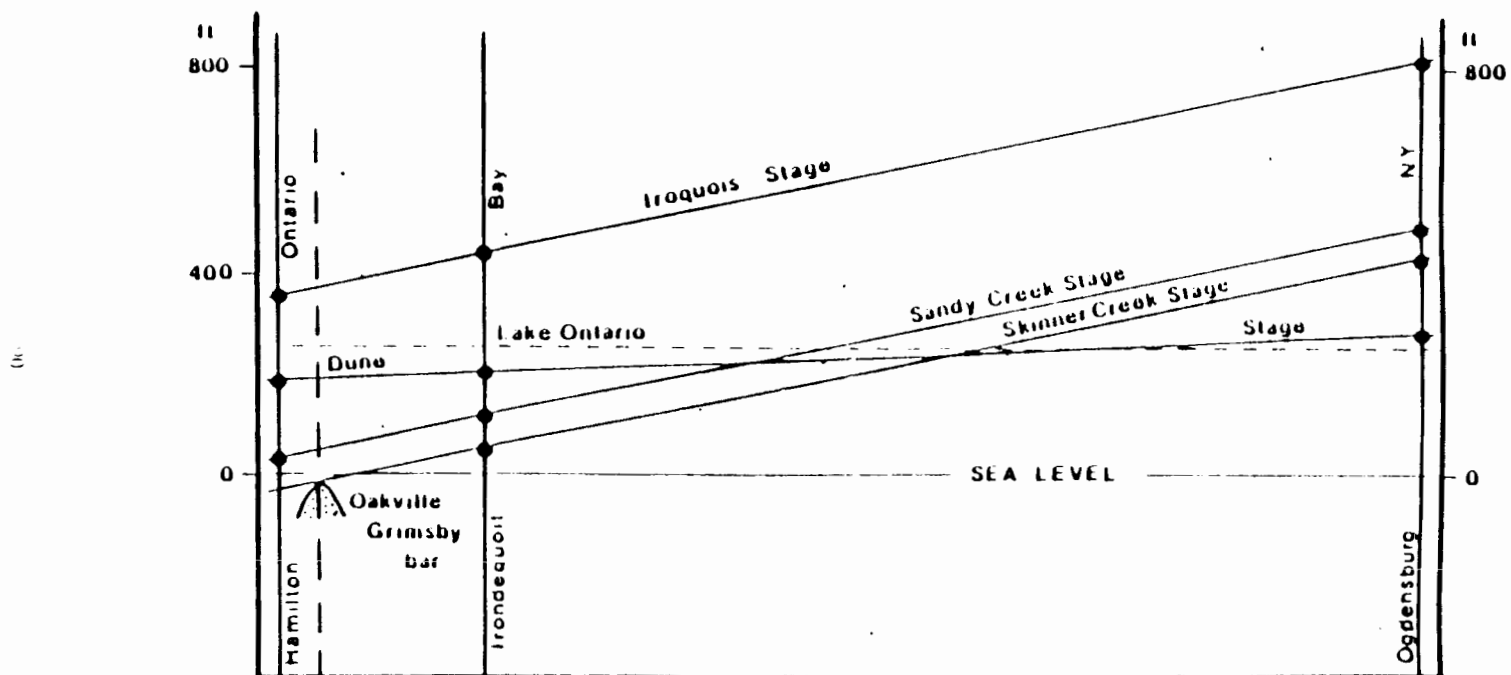


FIGURE 3 Elevation relations of shoreline stages from the St. Lawrence valley to the west end of Lake Ontario. See stages defined by Sutton et al. (1970) for comparison. Locations on Figure 1.

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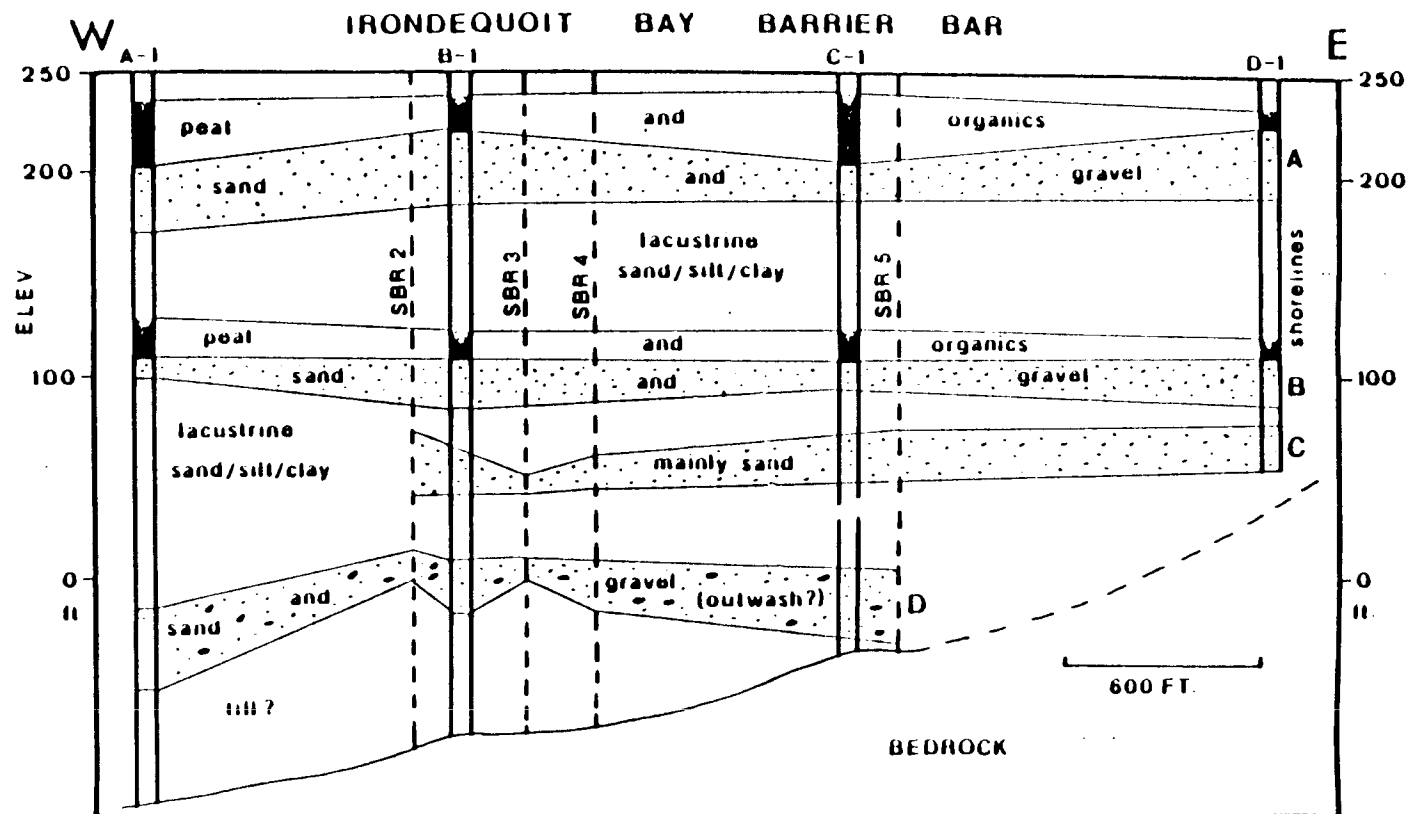


FIGURE 1. Subsurface cross section (generalized) interpreted from 8 borings through Irondequoit Bay bar. Dashed lines are approximate locations of preliminary borings (Village of Webster, 1975). Compare with Figure 5.

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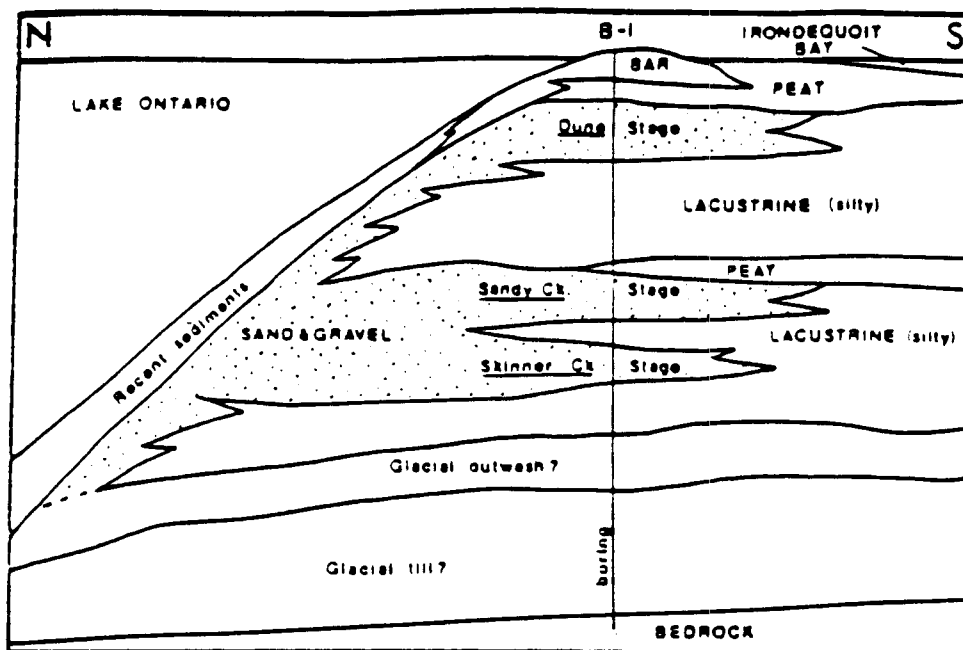


FIGURE 5. Diagrammatic north-south section through Irondequoit Bay bar to illustrate hypothetical facies relations created by rising lake stages as harbor bar grew by longshore transport. Development and stabilization of bar created lagoonal environments in bay, accounting for organic horizons. Vertical scale similar to Figure 4; horizontal scale diagrammatic only.

The correlations depicted on Figure 3 provide strong evidence of the probable sequence of low water (post Iroquois) lake levels in the Ontario basin immediately following the ice withdrawal from the St. Lawrence valley.

The elevation relationships from east to west across the lake explain why the Champlain Sea probably did not invade the Ontario basin. Restoration of the total maximum tilting from Hamilton to the vicinity of Ogdensburg would put the Skinner Creek stage near present-day sea level. The line of zero postglacial uplift lies very close to the Hamilton area and implies that the west end of the lake has undergone little absolute uplift. Thus, in order for the sea to invade Lake Ontario, postglacial sea level recovery would have to have occurred almost immediately after the ice retreated from the St. Lawrence Valley and before significant isostatic rebound of the land had begun. However, the recovery of sea level to its present position could not have occurred while the shrinking ice sheet still extended as far south as the St. Lawrence. Several studies have shown that sea level was more than 100 feet below its present position about 12,000 years ago and that a return to near its present position could not have occurred until about 6,000 years ago (Moran and Bryson, 1969).

CHARACTER AND ORIGIN OF THE ANCESTRAL GENESSEE RIVER GORGE

The drill hole data along the Irondequoit Bay bar can be combined with the deep borings completed for the Cross-Irondequoit and the Culver-Goodman sewer interceptor tunnels to provide a composite profile of the bedrock surfaces beneath Seneca Lake (the most deeply eroded Finger Lake basin) and the Letchworth Park gorge (the largest postglacial gorge along the Genesee River). These true scale profiles demonstrate that, although such features are impressive when viewed at ground level, they do not represent extreme departures from the general surface formed and modified by differential ice erosion of the region. The Letchworth gorge profile is included to indicate what portion of the other glaciated valleys could be attributed to fluvial erosion prior to any glacial enlargement.

The bedrock trough beneath Irondequoit Bay has obviously been considerably enlarged by the processes of glacial scouring, which deepened and widened an older valley that had formed during either

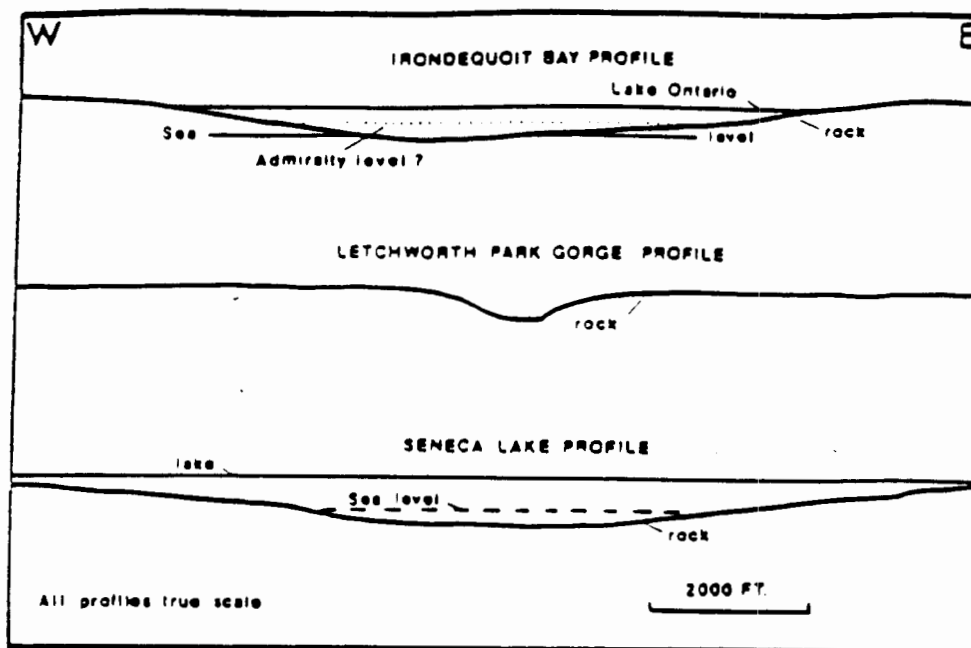


FIGURE 6: True scale bedrock profiles of 2 glaciated valleys compared with the postglacial Letchworth gorge to emphasize the effects of glacial scouring. Irondequoit Bay profile on Figure 2. Data for Seneca Lake from von Engel (1961).

preglacial or interglacial time. Neither the apparent low level of the Admiralty Lake nor the low stand of sea level at about the time that Lake Iroquois probably drained out through the St. Lawrence was low enough to permit fluvial erosion to operate at the lowest level of the rock profile beneath the center of the bay. Furthermore, it is likely that any extended interglacial erosion of an ancestral Genesee River channel would have to be accomplished while a moderately deep lake occupied the Ontario basin. Any periods of low sea levels and low lake stages following other glacial recessions would have been equally brief. The redevelopment of any ancestral Genesee River between glaciations would require that erosion of the older glacial drift be accomplished before any preexisting bedrock gorge could be fluvially deepened. Borings on the western edge of Irondequoit Bay used to construct the profile of Figure 6 indicate a minimum of 132 feet of glacial till above bedrock near the axis of the glaciated valley. Seventy feet of fine sands and silts overlie the till. A newly reestablished river would also have to simultaneously transport its normal sediment load out into the Lake Ontario basin while any postulated downcutting was occurring.

All of the aforementioned conditions and limitations make it extremely unlikely that the bedrock profile beneath Irondequoit Bay was formed mainly by fluvial erosion during times of low lake levels. It is more likely that a volume of rock similar to that represented by the Letchworth Gorge section was initially removed by a river that developed prior to or between glacial epochs. This valley, of unknown size, was then glacially scoured by one or more ice advances to create the modern profile preserved in the bedrock surface beneath the glacial drift. It is likely that glacial scouring of the rock only occurred when the ice sheets were thickest, and that basal till deposition then took place during ice thinning and recession (Sugden, 1977).

BEDROCK DEFORMATION: SHALLOW ICE-THRUST FEATURES OR DEEP-SEATED TECTONIC STRUCTURES

It is well known that advancing glacial ice can produce shallow, thrust-like dislocations or superficial folds in relatively incompetent bedrock, especially where ice sheets encounter escarpments such as the one along the southern shore of Lake Ontario (Flint, 1971). James Hall (1843) reported features that probably were formed by this mechanism along the south shore of Lake Erie. Shallow ice-thrust structures exposed in excavations have been reported in the Rochester area, but few have been documented or described in the literature. One such instance may have occurred during excavation for the Resources Recovery facility on Emerson Street (informal communication and photographs, H and A of New York, Inc.).

Recently, a well-exposed, shallow ice-thrust feature was described in Rochester along Densmore Creek (Andrews, 1980). Coincidentally, borings for the Culver-Goodman sewer interceptor tunnel encountered a deeper, more vertical fault in bedrock almost directly below the ice-thrust feature. Because few other faults had been reported in the Rochester area, the two structures were initially presumed to be related in some way. However, examination of the deeper fault during construction of the Culver-Goodman sewer interceptor tunnel demonstrated that the deeper structure is a small reverse fault with a more northwesterly strike. The bedrock offset in the tunnel is at a depth of over 100 feet below the top of rock, whereas the shallow glacial thrust surface is at a depth of only 10 to 15 feet throughout most of its exposed length. The discovery of other high angle faults and small folds extending to depths in excess of 140 feet during continuing sewer interceptor design studies has demonstrated that tectonic structures, unrelated to ice deformation, are probably common in the region (Figure 2). Fairchild photographed the surface exposure of one such fault zone in the Barge Canal (Fairchild, 1928), and other zones of structural deformation have been located (Figure 2). Some of the faults are visible in the Genesee River gorge (H and A of N.Y., 1981). It appears likely that the faults are commonly associated with open folds of low amplitude, such as the feature shown in Figure 2, located along the Barge Canal.

The faults in the bedrock along these structures are not apparent as offsets at the top of rock. Thus they predate the glacial erosion. No evidence of offset in any glacial deposits has yet been detected.

The structures are most likely related to the stresses accompanying the Appalachian Orogeny in late Paleozoic time. However, the trends of the structures in the Rochester area are approximately northwest, whereas the known Appalachian structures immediately to the south have ENE trends (Engelder and Geiser, 1980). It is possible that the structural trends in the Rochester area reflect the influence of older Grenville Province (Precambrian) basement structures exposed farther north in Ontario (Figure 1). It is not uncommon for younger faulting to involve reactivation of older basement structures, which represent natural zones of weakness in the underlying rocks (Young, 1979, 1982).

INFLUENCE OF STRUCTURAL FEATURES ON SURFACE TOPOGRAPHY AND ICE EROSION

The two best documented zones of folding and faulting shown on Figure 2 can be projected northward to the Lockport (Niagara) Escarpment, which parallels Ridgeway Avenue north of the N.Y. State Barge Canal and the abandoned segment of the old Erie Canal. The projected intersections of these two structural zones with the prominent Niagara Escarpment are marked by conspicuous gaps. The easternmost curve in the scarp parallels the west edge of Driving Park Avenue (Figure 2). Two and one half miles further west along the scarp another conspicuous gap occurs between Elmgrove and Long Pond Roads (Figure 2). Both of these irregularities in the scarp are in line with the projected trends of the structures shown on Figure 2.

It is inferred that where the escarpment was intersected by the zones of folded or faulted rocks, subaerial and glacial erosion and chemical weathering have been locally enhanced. Glacial scouring of the fracture zones and more deeply weathered rock probably account for these two relatively localized gaps or irregularities now expressed in the surface topography.



FIGURE 7. Central portion of broad fold-fault structure visible in N.Y. State Barge Canal (structure zone A, Figure 2). View to southeast. Zone A and B are inferred to consist of numerous subparallel offsets or flexures with a maximum measured displacement of 18 feet on one fault penetrated by a boring (H & A of New York, 1981).

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SUMMARY AND CONCLUSIONS

To fully appreciate the present physiography and surficial geology of the Rochester region, it is necessary to understand both the direct and indirect influences that have combined to produce the modern landscape. Irondequoit Bay has been flooded by the regional postglacial isostatic tilting and the accompanying rise in the level of Lake Ontario, which amounts to approximately 200 feet at Rochester in the last 12,000 years. More precise radiocarbon dating of the shorelines buried in the Irondequoit Bay bar could help resolve the uncertainty concerning the timing of the draining of Lake Iroquois and the precise interval during which the low lake stages occupied the Ontario basin.

These events, in turn, place limits on the amount of fluvial erosion that could have been realistically involved in the creation of the present depth and shape of the ancestral Genesee River valley beneath Irondequoit Bay. It can be concluded that the present depth and shape of this valley are predominantly due to glacial scouring of a much smaller fluvial valley.

In an area where glacial drift covers much of the bedrock, some care must be exercised to discriminate between glacially induced, shallow, ice-thrust deformation and older structures of deep-seated, tectonic origin. In addition, the older, preglacial structures may have significantly influenced the differential ice erosion of the underlying bedrock. In such regions, where mapping of bedrock structure is difficult and incomplete, it may be possible to use topographic variations in prominent bedrock-controlled landforms as a clue to the location of major zones of structural deformation (differential ice erosion of fault zones).

A better understanding of the origin of the northwest-trending bedrock folds and faults in the Rochester area might improve our knowledge of the regional tectonics of the St. Lawrence — Ontario Basin region. Clearly, the structural trends are very different from those in the Appalachian Plateau to the south and nearly at right angles to the Clarendon-Linden fault zone to the west.

Progress in our understanding of the geology of an area with as little apparent complexity as central New York can still benefit greatly from the integration of knowledge obtained by many geologists far beyond the confines of the Genesee Valley. Although geologists have tended to become more specialized, it is still important to attempt an integrated analysis of data which, upon first examination, may appear to be unrelated. Fairchild and many of his contemporaries exemplified this kind of approach to the understanding of earth history. It is also important for us to remind ourselves that many of the relationships we uncover in our sometimes limited field research are made possible by the fundamental observations of the early geologists like H.L. Fairchild, who studied large areas without benefit of aerial photography, detailed topographic maps, extensive subsurface boring logs, comfortable transportation, or modern laboratory equipment.

ACKNOWLEDGEMENTS

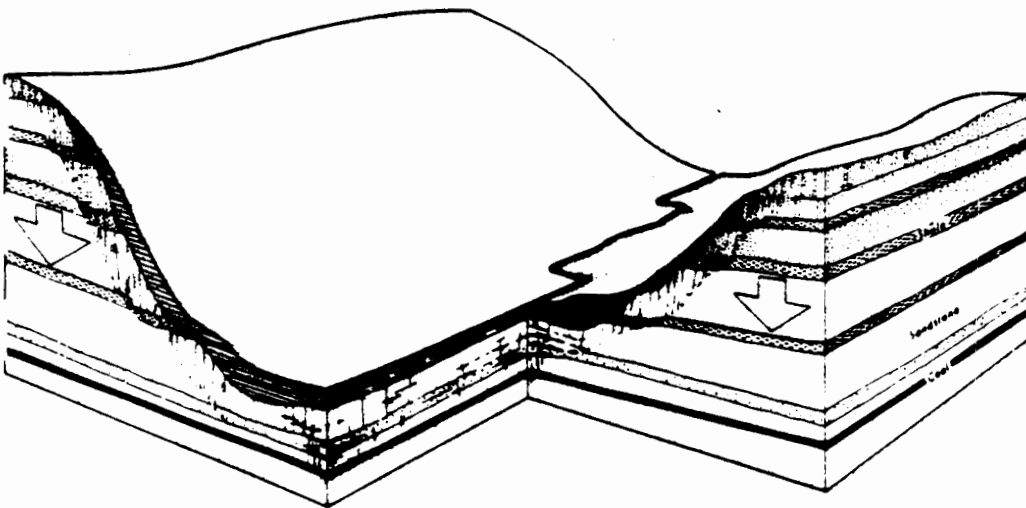
I am grateful to H & A of New York for providing their reports on the subsurface geology of Rochester compiled during the Pure Waters Combined Sewer Overflow Abatement Program, in which the author participated. The excellent information in these reports, little of which was used in this paper, should be of great value in many future geologic studies. Thanks are also due to the Village of Webster and Mr. William Shearer for providing copies of the report on the Irondequoit Bay sand bar by Hydrology Consultants Limited. The wealth of subsurface engineering data that now exists on the Rochester-Irondequoit Bay area could form the basis for a number of detailed reports on the stratigraphy and structural geology, which will be better understood after completion of the deep sewer tunnel construction projects currently in the design stage.

Dr. Robert G. Sutton (University of Rochester) and Dr. Peter G. Sly (Canada Centre Inland Waters) reviewed the final draft of the manuscript.

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Ref 15

- Hydrologic Effects of - Stress-Relief Fracturing - In an Appalachian Valley

UNITED STATES
GEOLOGICAL
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PAPER 2177



Appendix C
Section 4.2 From
Ref. 15

Hydrologic Effects of Stress-Relief Fracturing In an Appalachian Valley

By GRANVILLE G. WYRICK and JAMES W. BORCHERS

GEOLOGICAL SURVEY WATER-SUPPLY PAPER 2177



UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON 1981

UNITED STATES DEPARTMENT OF THE INTERIOR

JAMES G. WATT, *Secretary*

GEOLOGICAL SURVEY

Dovle G. Frederick, *Acting Director*

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FACTORS FOR CONVERTING INCH-POUND UNITS TO INTERNATIONAL SYSTEM (SI) UNITS

The following factors may be used to convert the inch-pound units published herein to the International System of Units (SI):

Multiply inch-pound	By	To obtain SI units
Length		
inches (in)	25.4	millimeters (mm)
	0.0254	meters (m)
feet (ft)	0.3048	meters (m)
miles (mi)	1.609	kilometers (km)
Area		
square miles (mi ²)	2.590	square kilometers (km ²)
Volume		
gallons (gal)	3.785	liters (L)
	3.785	cubic decimeters (dm ³)
	3.785x10 ⁻³	cubic meters (m ³)
million gallons (10 ⁶ gal)	3785	cubic meters (m ³)
	3.785x10 ⁻³	cubic hectometers (hm ³)
cubic feet (ft ³)	28.32	cubic decimeters (dm ³)
	0.02832	cubic meters (m ³)
Flow		
cubic feet per second (ft ³ /s)	28.32	*liters per second (L/s)
	28.32	cubic decimeters per second (dm ³ /s)
	0.02832	cubic meters per second (m ³ /s)
gallons per minute (gal/min)	0.06309	liters per second (L/s)
	0.06309	cubic decimeters per second (dm ³ /s)
	6.309x10 ⁻⁵	cubic meters per second (m ³ /s)
million gallons per day (10 ⁶ gal/d)	43.81	cubic decimeters per second (dm ³ /s)
	0.04381	cubic meters per second (m ³ /s)
*The unit liter is accepted for use with the International System (SI). See NBS Special Bulletin 330, p. 13, 1977 edition.		

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HYDROLOGIC EFFECTS OF STRESS-RELIEF FRACTURING IN AN APPALACHIAN VALLEY

By G.G. Wyrick and J.W. Borchers

ABSTRACT

A hydrologic study at Twin Falls State Park, Wyoming County, West Virginia, was made to determine how fracture systems affect the occurrence and movement of ground water in a typical valley of the Appalachian Plateaus Physiographic Province. Twin Falls was selected because it is generally unaffected by factors that would complicate an analysis of the data. The study area was the Black Fork Valley at Twin Falls. The valley is about 3 miles long and 400 to 600 feet wide and is cut into massive sandstone units interbedded with thin coal and shale beds. The study was made to determine how aquifer characteristics were related to fracture systems in this valley, so that the relation could be applied to studies of other valleys.

Two sites were selected for test drilling, pumping tests, and geophysical studies. One site is in the upper part of the valley, and the second is near the lower central part. At both sites, ground water occurs mainly in horizontal bedding-plane fractures under the valley floor and in nearly vertical and horizontal slump fractures along the valley wall. The aquifer is

under confined conditions under the valley floor and unconfined conditions along the valley wall. The fractures pinch out under the valley walls, which form impermeable barriers. Tests of wells near the valley center indicated a change in storage coefficient as the cone of depression caused by pumping reached the confined-unconfined boundaries; the tests also indicated barrier-image effects when the cone reached the impermeable boundaries. Drawdown from pumping near the center of the valley affected water levels at both sites, indicating a hydraulic connection from the upper to the lower end of the valley. Stream gain-and-loss studies show that ground water discharges to the stream from horizontal fractures beneath Black Fork Falls, near the mouth of Black Fork. The fracture systems that constitute most of the transmissive part of the aquifer at Twin Falls are like those described as being formed from stress relief. As stress-relief fractures have been described in other valleys of the Appalachian Plateaus, the same aquifer conditions may exist in those valleys.

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1.0 INTRODUCTION

The Investigations at Twin Falls State Park Provide Better Understanding of Ground-Water Occurrence and Movement

The investigations at Twin Falls State Park in Wyoming County, W. Va., provided a better understanding of the occurrence and movement of ground water in the valleys of the Appalachian Plateaus. Originally, the investigative method consisted of drilling three test wells and making a pumping test at Test Site 1 (fig. 1.0-1) as part of the Guyandotte basin study; later, however, other methods were used, including additional drilling and testing, geophysical investigations, and gain-and-loss studies, all of which aided in providing a better understanding of the ground-water hydrology.

The investigations at Twin Falls State Park, Wyoming County, W. Va., were undertaken in an effort to improve the knowledge of the occurrence and movement of ground water in valleys of the Appalachian Plateaus. Analysis of pumping-test data from many studies in the past had not been satisfactory because of a lack of understanding of how fracture systems affect ground-water hydrology; as a part of the Guyandotte basin study, therefore, it was determined that pumping tests in a small valley in the Appalachian Plateaus would be tightly controlled.

Three test wells were drilled at Test Site 1 (fig. 1.0-1), as a part of the Guyandotte basin study, by the U.S. Geological Survey in cooperation with the West Virginia Geological and Economic Survey. Upon completion of the Guyandotte basin study, the remainder of the study at Twin Falls State Park was done as a part of a Federally funded research project on mine hydrology by the U.S. Geological Survey.

Methods of study originally included only the drilling of observation wells and aquifer testing at Site 1. As a better understanding of the ground-water hydrology developed, however, more holes were drilled and tested, along with geophysical testing and stream gain-and-loss studies. All aided in a better understanding of the hydrology of the valley.

The organizational system used in the preparation of this report is known as **STOP** (an acronym for **Sequential Thematic Organization of Publications**). The STOP technique was adapted from industrial publications for use in earth-science publications by the West Virginia Geological and Economic Survey in 1973. For more information, contact the West Virginia Geological and Economic Survey, P.O. Box 879, Morgantown, West Virginia 26505, for the reprint titled "STOP: A path to more useful Earth science reports," by James A. Carte and Ronald A. Landers.

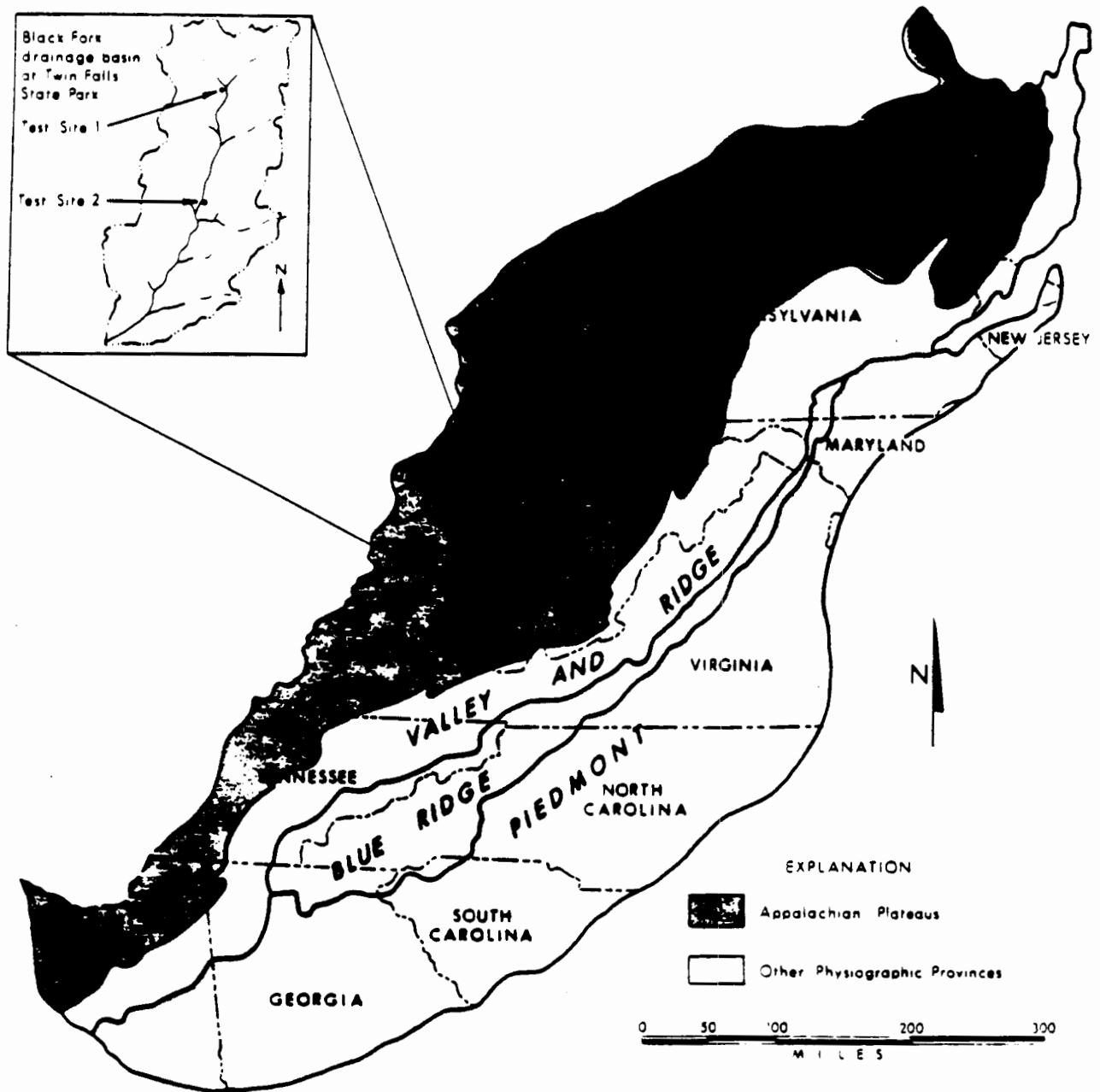


Figure 1.0-1. Appalachian Plateaus and study area at Twin Falls State Park

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2.0 CONCLUSIONS AND APPLICATIONS

Stress-Relief Fractures Are Most Transmissive Part of Aquifer and Affect Surface-Water Hydrology of a Valley in Appalachian Plateaus

Stress-relief fractures constitute the most transmissive part of the aquifer and affect the surface-water hydrology of a valley in the Appalachian Plateaus. The predictable pattern of fractures and the associated hydrologic effects resulting from stress relief may have wide transfer value in interpreting the hydrology of other, similar valleys. Applications of the hydrologic effects of stress-relief fracturing may prove useful in developing ground-water supplies, in monitoring the hydrologic effects of surface and deep mining, and in understanding relations between surface water and ground water in small valleys.

The stress-relief fractures at Twin Falls constitute the most transmissive part of the aquifer shown as the blue area on figure 2.0-1. This area is underlain by horizontal fractures under the valley floor and slump fractures along the valley walls. The fractures are interconnected at the base of the valley walls. The aquifer is recharged along the valley walls, where the aquifer is unconfined and where fractures may intercept surface runoff. The aquifer is discharged where the fracture system crops out in the stream channel at the change in stream gradient below Black Fork Falls. Because of the ground-water discharge below the falls, the streamflow characteristics above and below the falls are quite different.

The transfer value of the interpretations in this report can be tested by investigating other valleys. Engineering reports have described stress-relief fracturing in valleys in the Appalachian Plateaus and elsewhere in the United States and foreign countries. Also, study of hydrologically more complicated valleys—valleys affected by deep mining beneath them or by fractures associated with anticlines, synclines, and regional fracture systems—could refine the interpretations in this report. The concept of stress-relief fracturing may be used to interpret the aquifer characteristics in many valleys.

Some applications of knowing the hydrologic effects of stress-relief fracturing are:

- Better well sites can be selected if fracture patterns resulting from stress relief are understood.

- Dispersion of contaminants from landfills, injection wells, septic tanks, and the like into aquifers might be better understood and monitored by knowledge of the hydrology of stress-relief fractures.
- Water losses from reservoirs and seepage under locks and dams may be understood and explained, in some places, by interpreting the hydrologic effects of stress-relief fractures.
- Inflow to deep mines underlying valleys may be estimated by testing overlying aquifers affected by stress-relief fractures.
- Strip-mine benches in the Appalachian Plateaus are cut through the slump-fracture zone along valley walls, which can affect hydrology significantly. First, aquifer recharge may be increased in several ways during mining by uncovering slump fractures, so that they intercept more surface runoff. The strip-mine bench may be so sloped that it retains more runoff water, facilitating aquifer recharge. Second, reclamation regulations require backfilling benches. Such backfilling can seal slump fractures and reduce aquifer recharge if impermeable fill material is used. Third, exposing rocks to weathering and solution on the strip-mine bench can change the chemical quality of aquifer recharge markedly. As these effects must all be monitored, an understanding of stress-relief fracturing can help in designing monitoring systems.

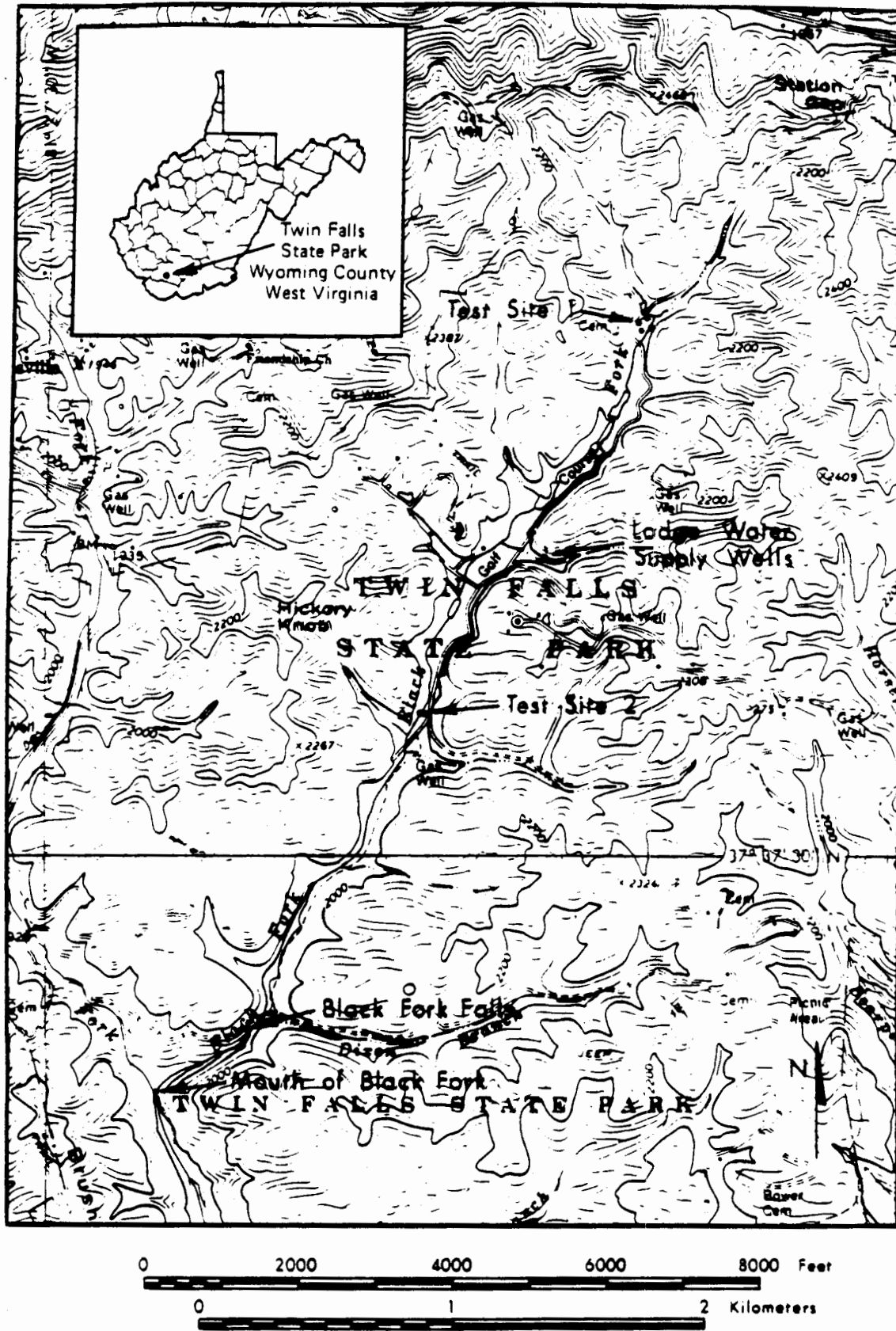


Figure 2.0-1. Topographic map showing the aquifer at Twin Falls State Park

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3.0 PERMEABILITY AND STRESS RELIEF

3.0 PERMEABILITY AND STRESS RELIEF

3.1 Primary and Secondary Permeability

Secondary Permeability Generally More Significant Than Primary Permeability in Aquifers of Appalachian Plateaus

Permeability is a measure of the ease with which a liquid will move through a rock. Primary permeability refers to movement through intergranular pore spaces, and secondary permeability refers to movement through rock fractures. Intergranular pore spaces in rocks in the Appalachian Plateaus are generally filled with cementing material, and the rocks have been fractured by earth movement; therefore, secondary permeability is generally more significant to the occurrence and movement of ground water in the plateaus than primary permeability.

Sedimentary materials—such as sand, silt, clay, and organic material—are generally deposited as individual particles in layers. These layers, or beds, may be covered by subsequent beds that compact them. Permeability in bedded material is a measure of the ease with which a liquid will move through intergranular pore spaces and their interconnections. Unconsolidated rocks will generally flex without fracturing; consequently, their only permeability is primary permeability.

Water infiltrating unconsolidated rocks may deposit cementing materials in pore spaces and their interconnections. Deposited material, such as carbonate or silicate, in unconsolidated rocks reduces the intergranular pore space and their interconnections and causes the rocks to consolidate, making them more brittle and subject to fracturing. Fracturing, in turn, causes openings in the rocks through which a liquid may move. This type of permeability is referred to as secondary permeability. The features of both primary and secondary permeability are shown in figure 3.1-1.

Rocks may have both primary and secondary permeability in varying degrees. Surficial rocks in

the Appalachian Plateaus seem to have low primary permeability and much higher secondary permeability. Generally, wells that do not penetrate fractures will not produce usable amounts of water, indicating negligible primary permeability. Wells that penetrate numerous fractures will generally have higher yields, per foot of water-level drawdown, than those penetrating few fractures. The yield of a well, in gallons per minute per foot of drawdown, for a given period of pumping, is called the "specific capacity" of the well.

An analysis of the probability of high specific capacity in the Greenbrier-Upper New River basin was made by Clark and others (in press) who found two factors significant in high specific capacity. These are related to topography and major structural features. Wells along major anticlines had significantly higher specific capacity than those along synclines or in undisturbed rocks. Wells in valleys had higher specific capacity than those on hillsides or hilltops. Fractures along the axis of an anticline may be numerous, of course, because of stress, and they may also be numerous under valley floors because of relief of stress.

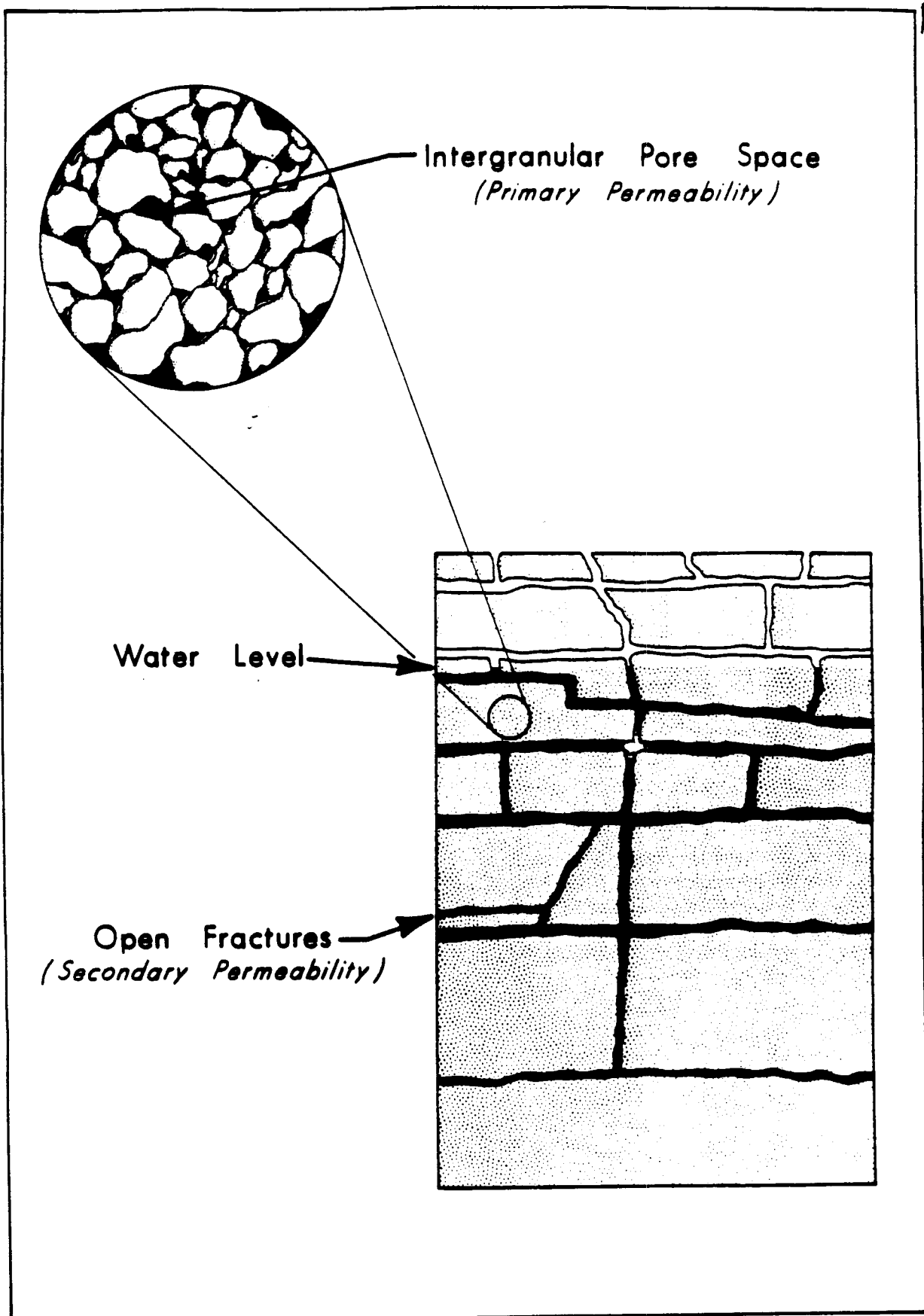


Figure 3.1-1. Features of primary and secondary permeability

3.2 Stress Relief

Predictable Fracture Patterns Are Result of Stress Relief

Stress relief, the removal of compressional stress on underlying rocks by erosion of overlying rocks, results in predictable fracture patterns in valleys. The fractures are generally horizontal under valley floors and are generally vertical along valley walls, where the rocks are nearly flat-lying, as in the Appalachian Plateaus.

When rocks are buried by younger rock material, they are subjected to compressional stress by the weight of overlying rock material. After an uplift, the compressional stress on rocks of a valley floor will be relieved where weighty overlying rocks are removed by erosion. Other rocks of the same unit that forms the valley floor remain under compressional stress beneath adjacent hills. The large black arrows in figures 3.2-1 and 3.2-2 indicate compressional stresses, and the large red arrow represents the resultant stress. One result of this imbalance of forces is the upward arching of rocks in the valley floor.

Unequal arching of beds, the upper beds arching more than the lower, results in slippage and fracturing along horizontal planes of weakness. These planes of weakness are generally the bedding planes, but weakness may also prevail along planes where grain size or lithology differs slightly. In this report, horizontal openings are referred to as bedding-plane separations, bedding-plane fractures, or bedding-plane openings. Arching also causes minor vertical fracturing near the axis of the arch.

Another result of unequal stress distribution is vertical and horizontal fracturing along valley walls. Where material is eroded from a valley, its walls are subjected to unequal horizontal stresses. These stresses result in vertical tensile fractures along the

valley walls. The vertical fractures allow the valley walls to slump downward, causing compressional fractures at the base of the valley walls. The horizontal and vertical fracture systems are interconnected and thus become conduits for the movement of ground water.

The geologic setting in figures 3.2-1 and 3.2-2 has been modified to conform to a generalization of the geologic setting observed at outcrops and during test drilling at Twin Falls State Park. The rocks are composed mainly of hard sandstone and interbedded shale and coal. The main features of stress-relief fracturing in these illustrations were taken from Ferguson (1974). That report applies to valleys of the Appalachian Plateaus. Reports by others discuss stress-relief fracturing in many parts of the world. References to stress relief in the United States, Great Britain, Germany, Romania, India, and Canada are listed in Section 7.2 of this report.

Theories on the formation of valleys have led to many controversies. The authors recognize that valleys must initially form along weaknesses in rock. The weaknesses may result from any number of causes. This paper, however, is not concerned with the origin of valleys but, rather, with the effects of stress-relief fracturing on ground-water hydrology.

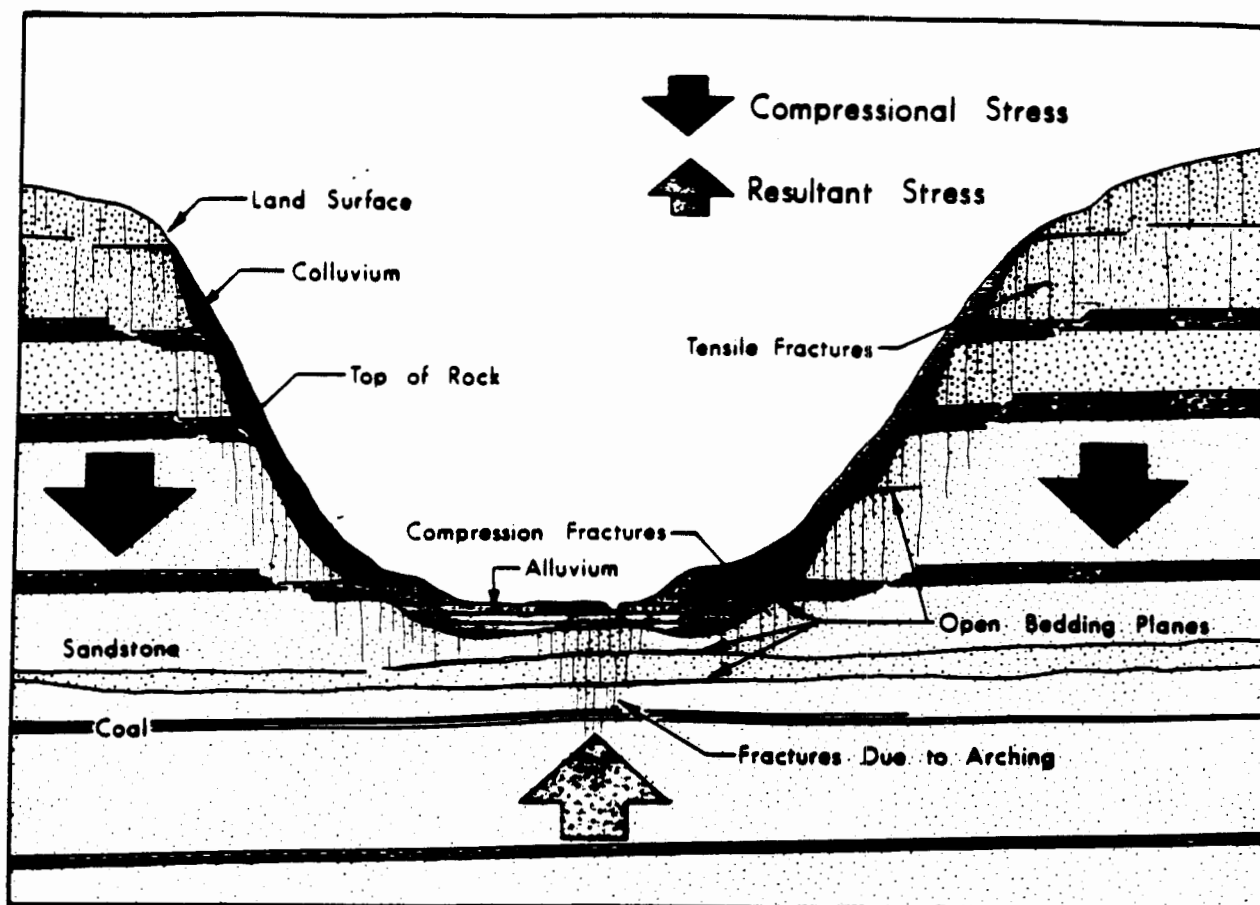


Figure 3.2-1. Generalized geologic section showing features of stress-relief fracturing [after Ferguson (1974)]

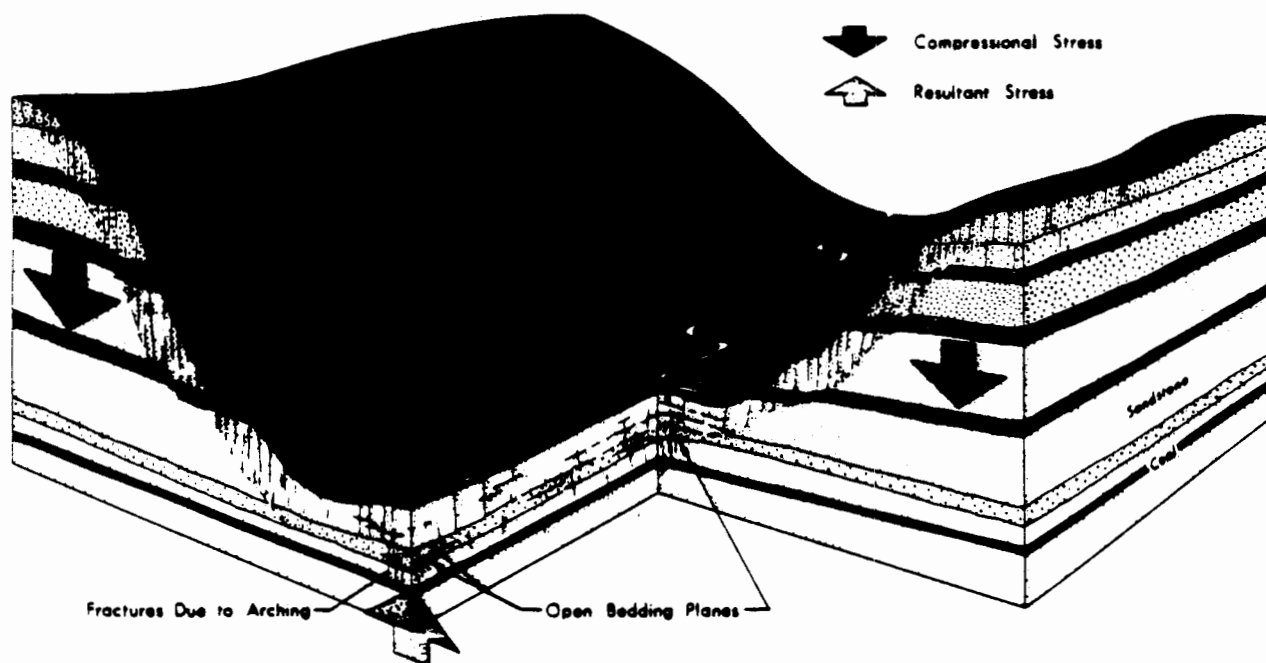


Figure 3.2-2. Block diagram of generalized geologic section showing features of stress-relief fracturing [after Ferguson (1974)]

4.0 SELECTION OF TEST AREA

4.0 SELECTION OF TEST AREA

4.1 Location of Area

Twin Falls State Park Selected Because It Meets Strict Criteria for Test Area

Twin Falls State Park in east-central Wyoming County, W.Va., was selected because it meets the strict criteria established for a test area. These criteria were established to eliminate problems that were encountered in analyzing pumping-test data from previous tests in other valleys of the Appalachian Plateaus.

The strict criteria established for a test area consist of selecting an area that: (1) is relatively unaffected by man's activities, (2) is not situated along major tectonic features, and (3) is geologically and topographically similar to other valleys in the Appalachian Plateaus. Twin Falls State Park is in the heavily mined southern coal fields of West Virginia, but no coal has been mined in the Park. Park personnel control all pumping in the valley, which provides hydrologic control during tests. The main valley in the Park is parallel to and about 5 miles northeast of the nearest significant tectonic feature, an anticline. This distance is considered to be adequate for the Park to be unaffected by fracturing along the axis of the anticline. The Park is similar in topography and geology to many other small valleys in the Appalachian Plateaus and is well within the boundaries of the Appalachian Plateaus. (See fig. 4.1-1.) For these

reasons, the park met most, if not all, criteria for a test area.

Pumping tests of wells in valleys of the Appalachian Plateaus have been unsatisfactory in some previous studies. Indicated aquifer characteristics have been unrealistic. Aquifer characteristics such as transmissivity and storage coefficient are determined by matching water-level drawdown curves to type curves. Departures of drawdown curves from type curves, which make interpretation difficult, have variously been attributed to interference caused by nearby pumping wells, interference from nearby mine dewatering or, possibly, the unpredictable hydrologic effect of irregular fracture patterns. As all of these factors could be controlled or accommodated at Twin Falls State Park, the park met the criteria for a test area.

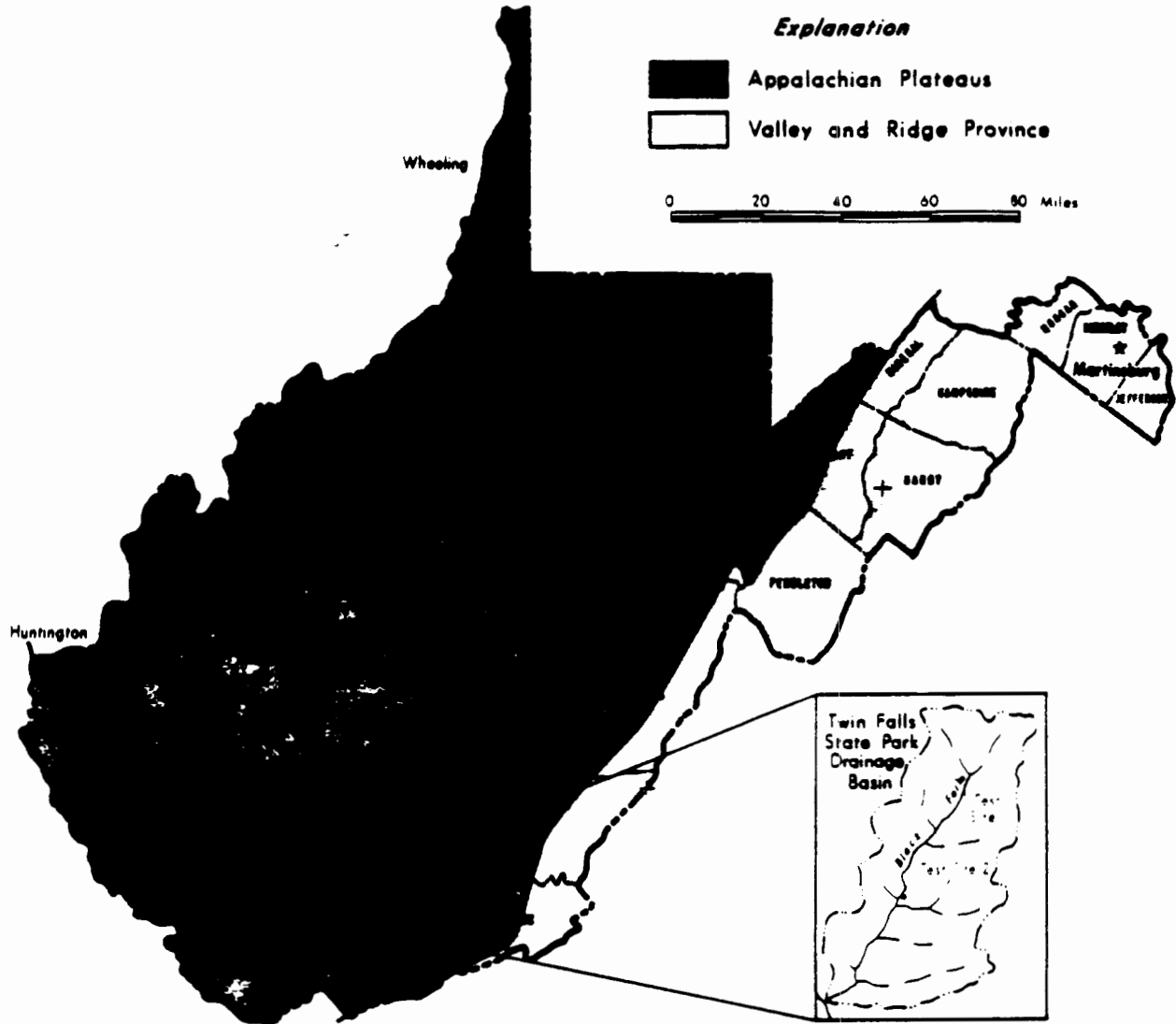


Figure 4.1-1. Appalachian Plateaus and Test Sites at Twin Falls State Park

4.2 Description of Area

Black Fork Is Nearly Straight Stream that Flows from Headwaters Near Test Site 1 to Mouth at Cabin Creek

Black Fork is a nearly straight stream, about 3 miles long, trending southwestward from headwaters near Test Site 1 to its mouth at Cabin Creek. (See fig. 4.2-1.) The stream flows through massive sandstone formations interbedded with thin shale and coal beds. The stream channel and the valley parallel the strike of the geologic formations. Relief in the park is about 400 feet from hilltops to the stream channel. The stream channel drops about 200 feet from Test Site 1 to the mouth at Cabin Creek.

Black Fork valley has an average width of about 400 feet. The valley floor is generally flat from Test Site 1 to Black Fork Falls, with a gradient of about 25 feet per mile. In contrast, the gradient from Black Fork Falls to the mouth is much steeper (approximately 450 feet per mile).

The valley floor above Black Fork Falls is composed of alluvium, mainly sand and clay. Below Black Fork Falls alluvium is absent, and the stream channel is cut mostly in hard sandstone. The hilltops and valley walls are covered by colluvium, mostly sand and gravel. The colluvium covers massive sandstone formations, which dip gently to the northwest at about 100 feet per mile.

Test drilling and surface-geophysics studies indi-

cate that the alluvium in the valley floor is composed of sandy clay near the land surface that grades to dense clay at depth. Surface-resistivity profiles and surface-magnetometer studies indicate that the vertical fractures near the center of the valley are clay-filled from the overlying clay beds.

The hilltops, valley walls, and valley floor below Test Site 2 are heavily wooded. The valley floor from near Test Site 2 to above Test Site 1 is grass-covered and is used for a golf course.

Intermittent springs near the base of the valley walls are common. These springs flow for a short time, immediately after heavy rains, when the water levels in the unconfined aquifers are at or above the valley floor.

Figure 4.2-1. Topographic map of Twin Falls State Park

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5.0 HYDROLOGY AT TEST SITES

5.0 HYDROLOGY AT TEST SITES

5.1 Hydrology at Test Site 1

5.1.1 Introduction and description of Test Site 1

Four Well Locations Were Selected at Test Site 1 So Directional-Permeability Formulas Could Be Used

The well field at Test Site 1 was designed at a time when it was believed that ground water in the Appalachian Plateaus occurred in random high-angle fractures. In such a fracture system, differences in permeability parallel to and perpendicular to the major fracture system would be large. Four 80-foot wells at Site 1 were located so that formulas related to directional permeability could be used in analyzing the test data.

Test Site 1 (see fig. 4.2-1) near the upper end of Black Fork Valley is the location of irrigation wells, used seasonally, for the golf course. Well J68 (see fig. 5.1.1-1) is an irrigation well equipped with a pump capable of pumping more than 80 gal/min (gallons per minute). The locations of the observation wells—Wells 001, 002, and 003—were selected so that the width of the valley would be monitored during tests and so that none of the wells were at 90- or 180-degree angles to any other well (Papadopoulos, 1965).

The observation wells were drilled, and well J68 was pumped at 70 gal/min for 24 hours. Data from the pumped well and observation wells could not be analyzed for the aquifer characteristics—transmissivity (T) and storage coefficient (S)—because the effect of multiple images and other effects inter-

fered with computations. Although values for T and S could not be computed, two significant things were learned about Test Site 1 from the test: (1) the drawdowns in Wells 002 and 003 were approximately equal throughout the test, indicating that permeability in those directions was probably equal and (2) the multiple-barrier effects were felt early in the test, indicating a narrow aquifer bounded by impermeable barriers.

Based upon what was learned from the first test, additional physical and geophysical data were collected at Test Site 1, and a second pumping test was designed to pump at a lower rate near the center of the valley, so that values for T and S could be determined before measurable image effects interfered with the data analysis.

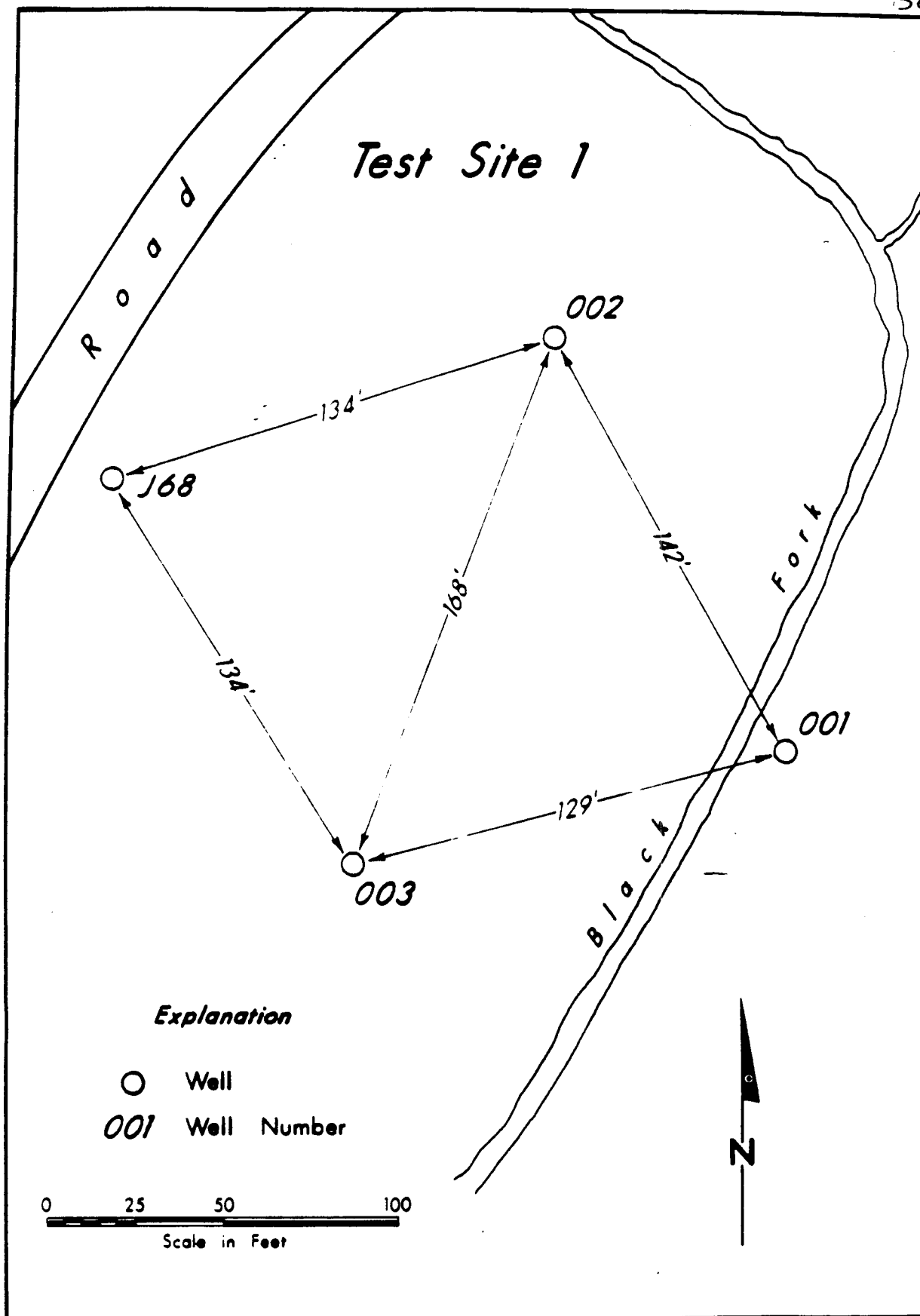


Figure 5.1.1-1. Well locations at Test Site 1

5.0 HYDROLOGY AT TEST SITES (Continued)

5.1 Hydrology at Test Site 1 (Continued)

5.1.2 Well data

Wells Near Valley Center Obtain Water from Bedding-Plane Separations; Well Near Valley Wall Obtains Water from Shallow Slump Fractures

The lithology of the consolidated rock units correlates closely from well to well at Site 1. The depths of water inflow to the wells drilled near the valley center do not correlate with the depth of inflow to a well near the valley wall. Geophysical logs and current-meter studies indicate that water is derived from bedding-plane separations at depths between 40 and 65 feet near the center of the valley and from fractures between 30 and 40 feet deep in the slump zone near the valley walls.

The lithologic logs (fig. 5.1.2-1) were compiled after examination of well cuttings collected during well drilling. Wells 001, 002, and 003 were drilled by the cable-tool method, and the well cuttings were collected at intervals of 2 to 5 feet. The lithology correlates closely from hole to hole for units more than 2 feet thick.

The relative velocity of flow is a measure of the flow of water in the wells from points of inflow, up the well, to a pump intake in the casing. Flow was not measurable in the wells when they were not pumping. When they were pumped at about 20 gal/min, the relative velocity of flow in the hole showed where water entered. If the wells had tapped rocks of uniform permeability and if the hole diameter had been constant, the relative-velocity curve would have been a smooth curve, showing a gradual increase in velocity from the bottom of the well to the bottom of the casing. Because the water entered at fractures, the relative velocity of flow increased abruptly where the meter came up past a water-bearing fracture and decreased when the hole

diameter increased because of caving of poorly indurated rock. The curves for Wells 002 and 003 show abrupt increases between 50 and 65 feet, where they intercepted water-bearing fractures. Both curves showed a marked decrease at 40 to 45 feet, where the shale bed caved and enlarged the hole diameter during drilling. Well 001 had no inflow below the shallow fractures between depths of 30 to 40 feet. A comparison of the data indicates that the bedding-plane fractures at Wells 002 and 003 did not occur in the same rock units at Well 001 and that the shallow fractures at Well 001 did not occur in the same rock units at Wells 002 and 003.

The down-hole relative-resistivity logs and the surface-resistivity depth-probe logs correlate with major lithic changes and also, to some extent, with fracture depths indicated by the relative-velocity curves. Resistivity increased abruptly at fractures because the open, water-filled fractures offer more resistance to the flow of electric current than the rocks.

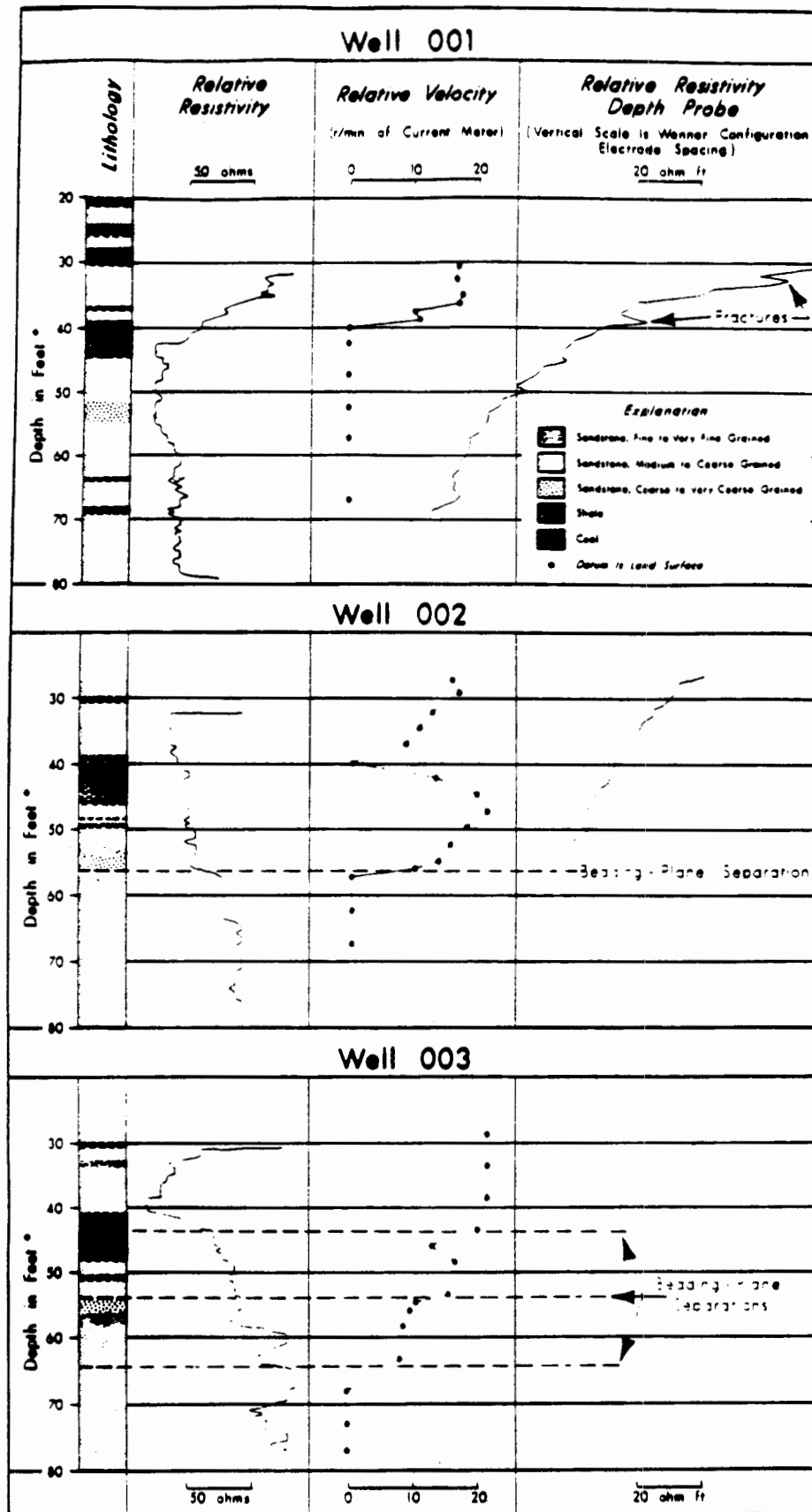


Figure 5.1.2-1. Physical data for Wells 001, 002, and 003 at Test Site 1

5.0 HYDROLOGY AT TEST SITES (Continued)

5.1 Hydrology at Test Site 1 (Continued)

5.1.3 Hydrograph of Well 002

Well 002 Hydrograph Shows Changes in Water Level Before and After Pumping Test on October 26, 1977

A hydrograph of the water level in Well 002 shows effects of the pumping test itself, the regional water-level trend, and interference effects of pumping other wells before and after the pumping test on October 26, 1977.

The hydrograph, a graph of water level related to time, shows changes in water level in Well 002 for about 4 days. (See fig. 5.1.3-1.) The pumping test was made during the middle of this period. Data shown on the hydrograph were recorded each hour.

The hydrograph shows the effects of pumping about 3,300 feet from Site 1 on October 24 and 27. Pumping at the Lodge wells started at about 8 a.m. and lasted for 9 hours, until the storage tanks were filled. The pumping rate was 17 gal/min. This pumping lowered water levels at Site 1 about 0.2 foot after 9 hours. The Lodge well was not pumped during the test on October 26.

Rain was heavy on October 25, recharging the aquifer and causing regional ground-water levels to rise. The rise began about noon on the 25th and, except for during the time of control-pumping of Well 003 on the 25th, continued until about 8 a.m. on the morning of the test. The rising trend in water level was hardly measurable by 9 a.m. on the 26th. By this time, the aquifer had also recovered from pumping on the 25th. As the water level would have continued to rise (if the test had not been made) only about 0.005 foot during the time of the test on October 26, correcting for the rise was considered unnecessary in analyzing the test data. Well 003 was pumped at 6 gal/min, starting at about 9 a.m. on October 26.

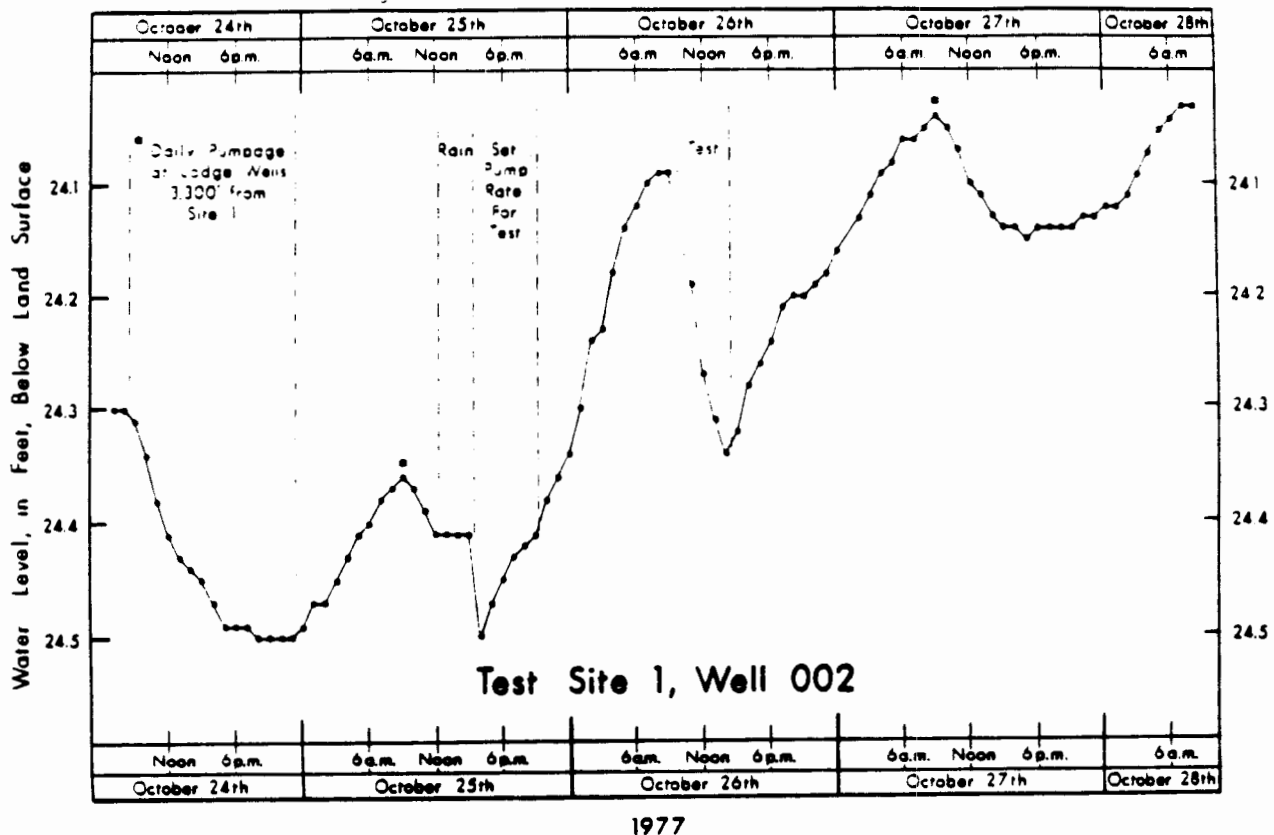


Figure 5.1.3-1. Hydrograph of Well 002 at Test Site 1

5.0 HYDROLOGY AT TEST SITES (Continued)

5.1 Hydrology at Test Site 1 (Continued)

5.1.4 Analysis of pumping-test data

Convergence of All Drawdown Curves Near End of Test Indicates Water Level in All Wells Draws Down Same Amount at Same Time

Water-level drawdowns in the pumped and observation wells during the pumping test on October 26, 1977, are plotted on figure 5.1.4-1. The drawdown plotted for observation Wells 002 and J68 (solid-red circles and solid-blue circles, respectively) and pumped Well 003 (solid-black circles) indicates that these wells tap an aquifer of extremely high transmissivity—only 0.3 foot of drawdown in 3.3 hours. On the other hand, the drawdown curve for Well 001 (solid-black triangles) indicates that this well taps an aquifer of lower transmissivity. The convergence of all the drawdown curves near the end of the test indicates that the water level in all the wells is drawing down the same amount at about the same time, which would happen if the aquifer system were bounded laterally by impermeable barriers.

The drawdown curves for Wells 002, J68, and 003 illustrate the drawdown of water level in these wells caused by pumping Well 003 at 6 gal/min. Drawdown in Wells 002, 003, and J68 began 10 to 35 seconds after pumping began. These wells tap the aquifer formed by open fractures below the valley floor. The nearly equal amount of drawdown at almost the same time in the pumped and observation wells indicates extremely high transmissivity. The water level in Well 001 responded to pumping Well 003 considerably later in the test, and, initially, its drawdown was much less. This well taps the aquifer formed by slump fractures along the valley wall, where transmissivity is much lower. As pumping continued, drawdown of water level in all the wells became nearly equal, as would happen if an interconnected aquifer system bounded by two or more impermeable barriers were to be pumped. The situation would be analogous to pumping from a lake or reservoir. Drawdown of lake or reservoir level would be the same, under pumping, no matter where on the lake or reservoir the level was measured.

The profiles of the water level from Well J68 through Well 003 to Well 001, under pumping, are shown in figure 5.1.4-2. As may be seen by the near parallelism of the connecting lines, the water level in Wells J68 and 003 declined at approximately the same rate in the same time intervals. During the first hour of the test, the drawdown in Well 001 lagged

behind drawdown in other wells because Well 001 is in the unconfined aquifer, which has a larger storage coefficient and is not as transmissive as the aquifer below the valley floor. After the first hour, the image effects caused by the impermeable boundaries had increased to the extent that the water level in all wells was declining at the same rate.

Two methods were used to try to determine T and S values of the aquifers: (1) a mathematical model of the valley constructed by S.S. Papadopoulos was used, and (2) computations through the use of the image-well theory were used to reproduce the drawdown measured at Well 002 while Well 003 was being pumped. In both methods, it was found that a large number of values for transmissivity (T) would produce drawdown curves that matched the measured drawdown if the proper storage-coefficient (S) values were used. Thus, it was concluded that the shapes of the curves indicate an aquifer with an extremely high T value bounded by aquifers with lower T values, which, in turn, are bounded by impermeable barriers. The above is an interpretation of the ground-water part of the hydrologic system in the valley. This is the type of hydrologic system that would result from stress-relief fracturing. Until equipment capable of measuring extremely small changes in water level over extremely short time intervals becomes available, T and S values cannot be quantitatively determined in a valley of this size.

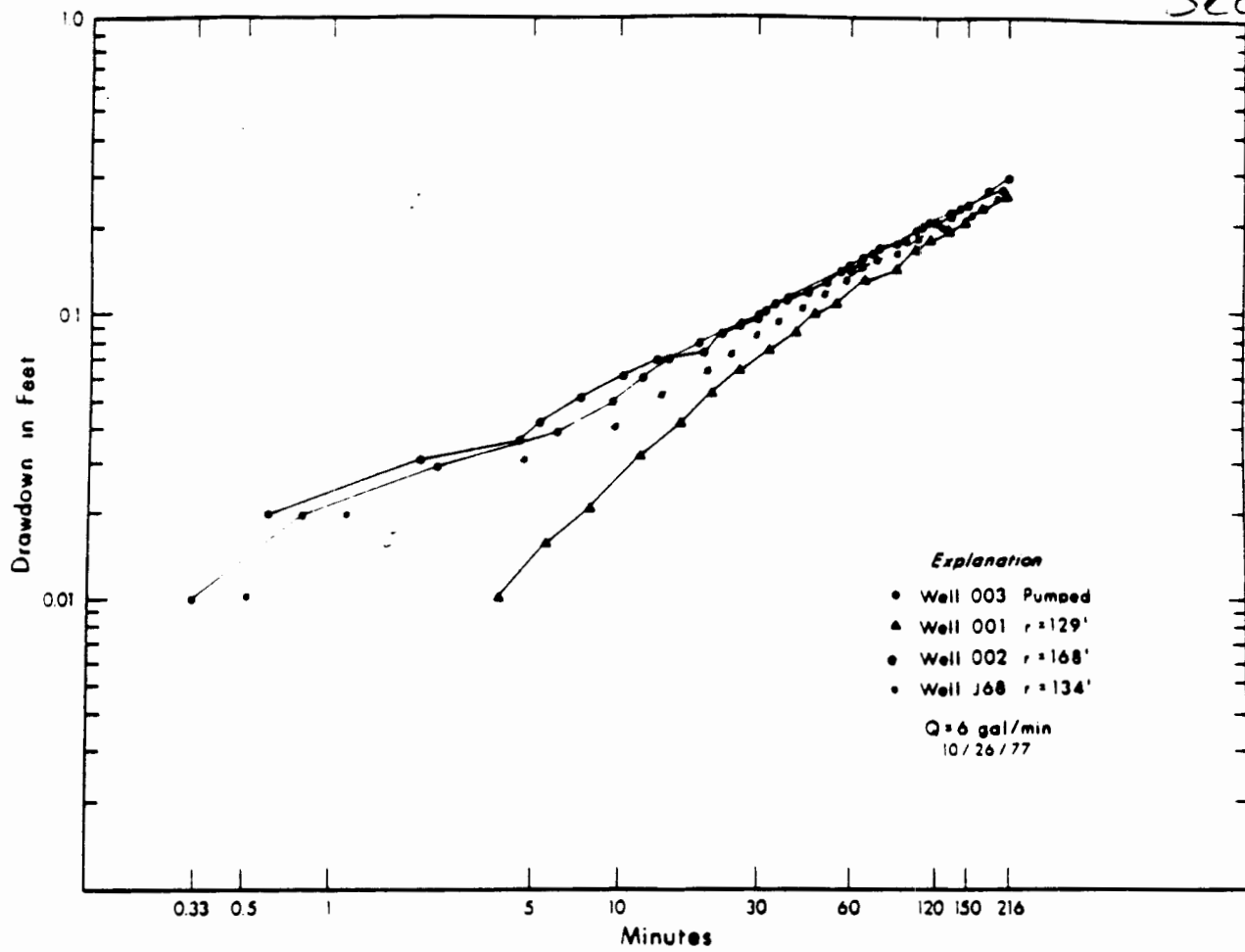


Figure 5.1.4-1. Pumping-test data for Test Site 1

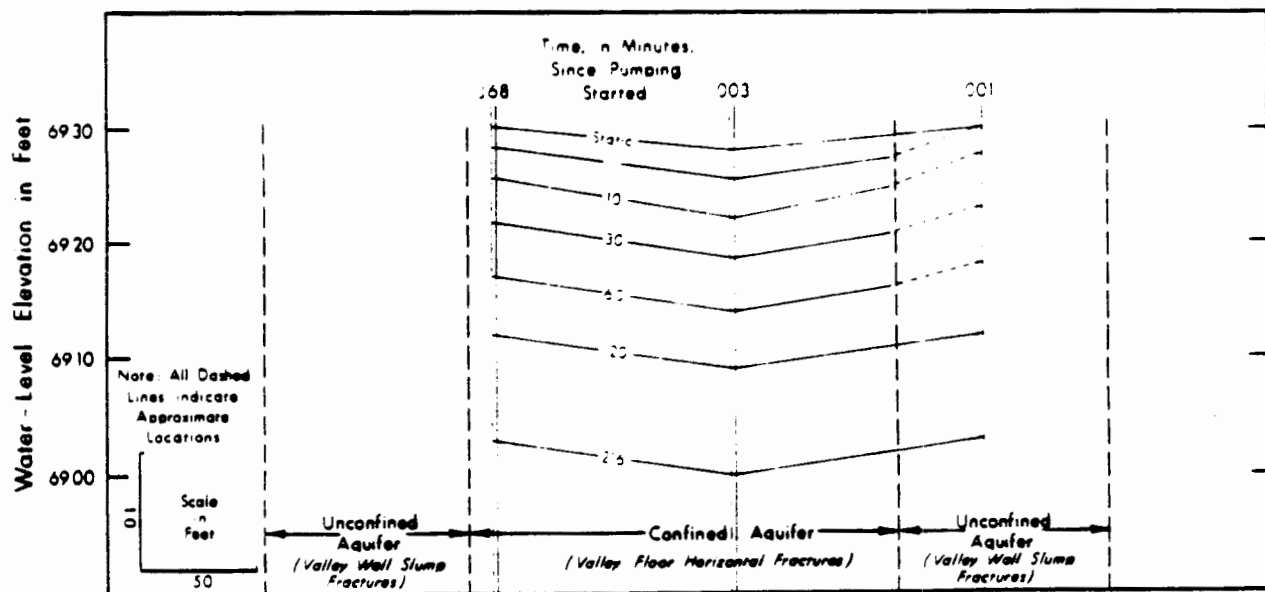


Figure 5.1.4-2. Water-level profiles during pumping tests at Test Site 1

5.0 HYDROLOGY AT TEST SITES (Continued)

5.1 Hydrology at Test Site 1 (Continued)

5.1.5 Interpretation of data

Data Interpretation Indicates that Aquifer At Site 1 Is Stress-Relief Fracture System

Interpretation of all the data from Test Site 1 indicates that the aquifer incorporates a system of stress-relief fractures. Wells tap bedding-plane fractures under the valley floor where water is under confined conditions. Near the valley walls, the water is under unconfined conditions in the valley-wall slump fractures. The horizontal bedding-plane fractures pinch out under the valley walls, effectively forming impermeable barriers. Stress-relief fracturing accounts for the aquifer characteristics at Test Site 1.

The aquifer is confined by alluvial clay under the valley floor. (See fig. 5.1.5-1.) As can be seen, the water levels in wells cased through the clay layer will rise above the bottom of the confining clay layer. Near the valley walls, at Well 001, the water is unconfined in fractures formed by valley-wall slump. Black Fork flows in a channel in the sand and clay bed, which is about 20 feet above the head in the aquifer. There is no indication of hydrologic connection between Black Fork and the aquifer under the valley at Test Site 1.

The distance estimated from Well 001 to the effective barriers defines the width of the aquifer and thus the width of the fractured zone. The width of the fractured zone would include both the bedding-plane fractures and the slump-zone fractures (see fig. 5.1.5-2), as the sets of fractures are hydraulically interconnected. All the data indicate that the fracture system resulting from stress relief constitutes most of the transmissive part of the aquifer system at Test Site 1.

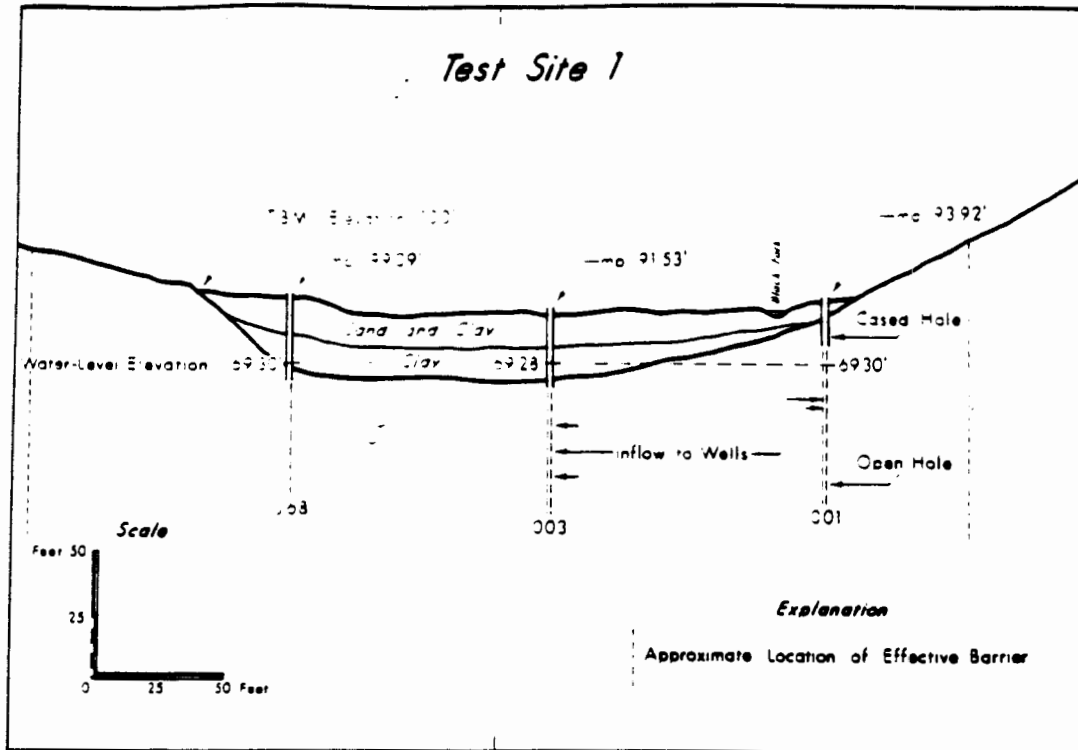


Figure 5.1.5-1. Scaled cross section at Test Site 1

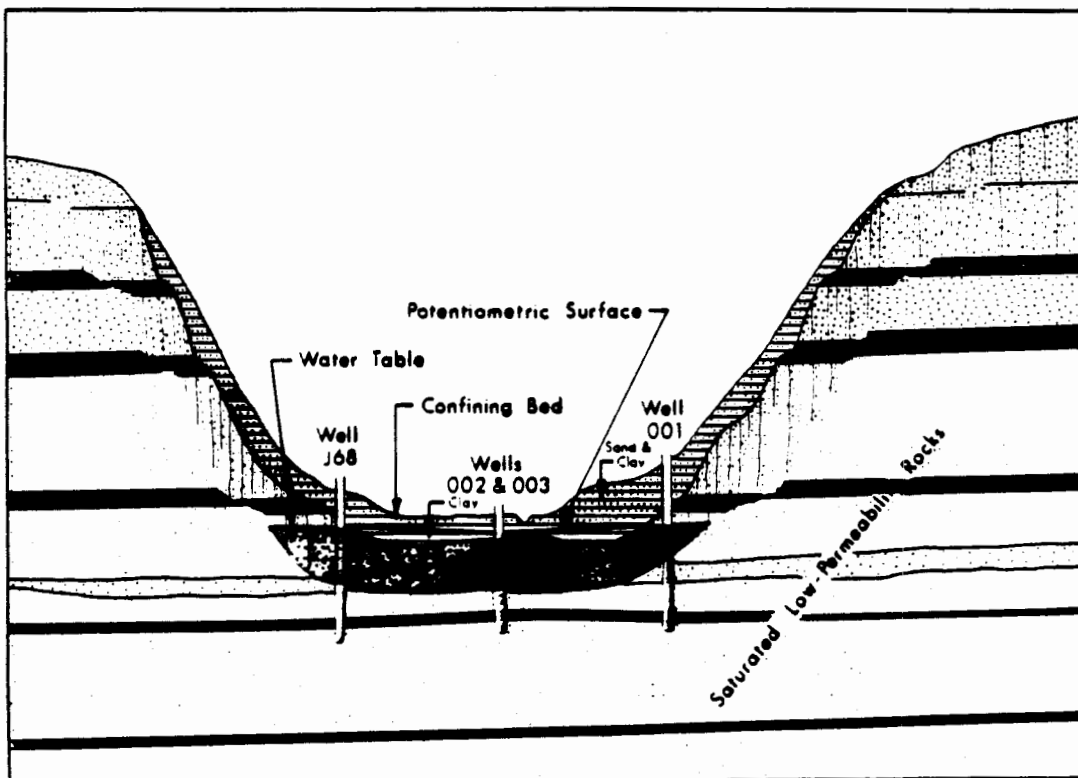


Figure 5.1.5-2. Generalized cross section of aquifer at Test Site 1

5.0 HYDROLOGY AT TEST SITES (Continued)

5.2 Hydrology at Test Site 2

5.2.1 Introduction and description of Test Site 2

Site 2 Location Selected to Correlate Lower-Valley and Upper-Valley Aquifer Conditions

The location of Test Site 2 was selected to determine if aquifer conditions in the lower part of the valley are the same as those in the upper part of the valley at Test Site 1.

Test Site 2 is in a narrow part of the valley about halfway between Test Site 1 and Black Fork Falls. (See fig. 4.2-1.) The location of Test Site 2 allows a comparison of aquifer conditions in the lower-central part of the valley with those at Test Site 1 in the upper part of the valley and with those observed in outcrops below Black Fork Falls near the mouth of

the valley.

Two wells were drilled at Test Site 2. (See fig. 5.2.1-1.) Well A is near the center of the valley near Black Fork, and Well B is about halfway between Well A and the east wall of the valley. Test Site 2 is in a constriction in the valley where the valley is about 200 feet wide.

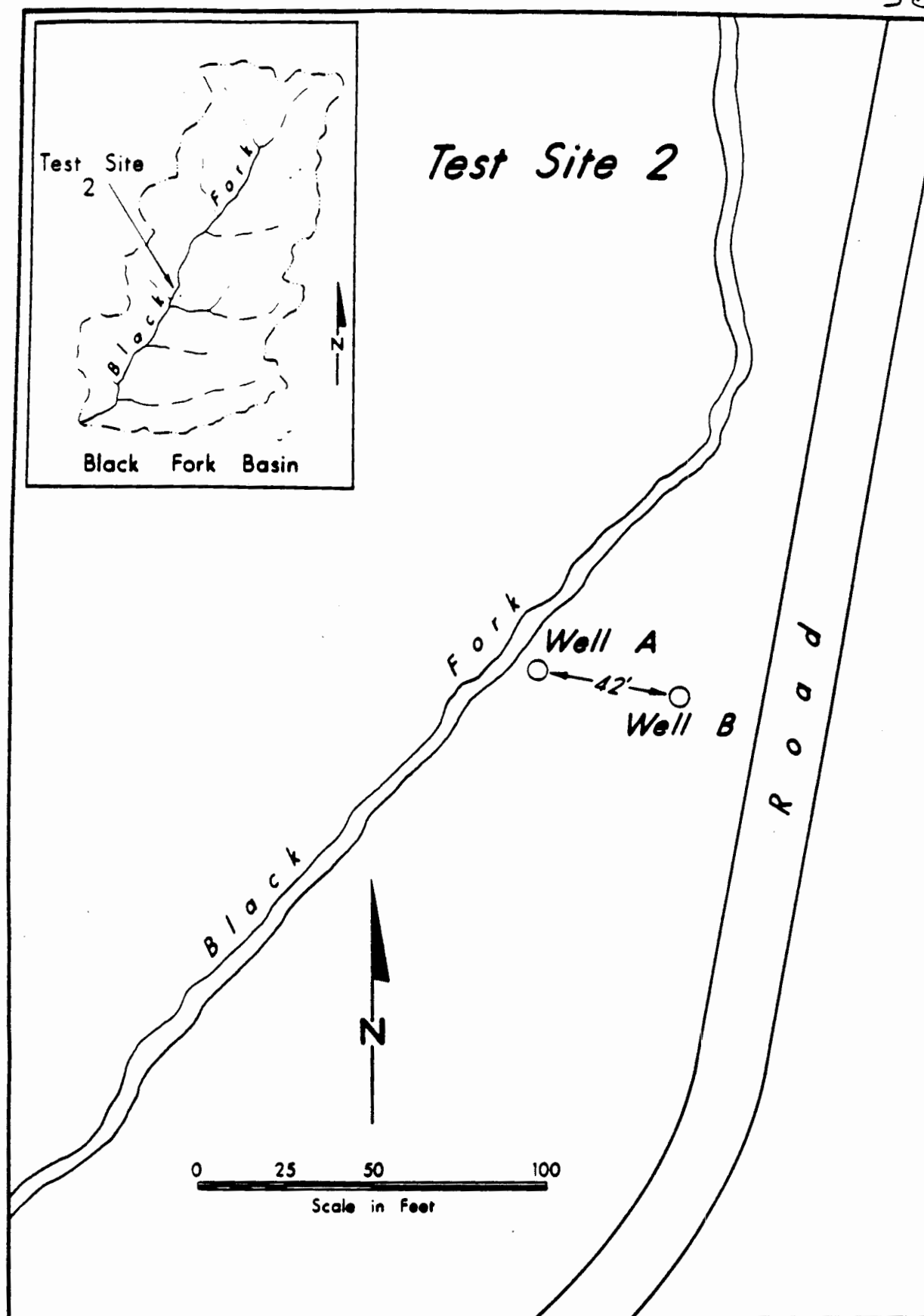


Figure 5.2.1-1. Well locations at Test Site 2

5.0 HYDROLOGY AT TEST SITES (Continued)

5.2 Hydrology at Test Site 2 (Continued)

5.2.2 Well data

Well A Data Indicate Similar Geologic Conditions as at Site 1

The data collected at Well A indicate the same general type of geologic conditions as those at Test Site 1. Inflow to the well is derived from three bedding-plane separations between 20 and 60 feet below land surface. These three openings may be correlated with changes in bedding indicated by changes in drilling rate and relative resistivity. The well data indicate that water occurs under the same type of aquifer conditions at Test Site 2 as were determined for wells in the confined aquifer at Test Site 1.

The correlation of lithology, drilling time, relative resistivity, and relative velocity for Well A is excellent. The drilling time, in feet drilled per hour, is an indication of the relative hardness of the rock penetrated by the drill bit during drilling and indicates where the rock type changes with depth. The relative velocity indicates where water enters the well when the well is pumped at about 20 gal/min. The relative resistivity is a measure of the resistance of the rock to the flow of an electric current, thus indicating changes in rock type.

The lithologic log (see fig. 5.2.2-1) shows a change from fine-grained sandstone to coarse-to-very coarse-

grained sandstone at a depth of 33 feet. The drilling rate decreased abruptly at this depth, and the relative velocity indicated an abrupt increase in flow to the well at this depth. The relative resistivity shows a decrease in resistance in the fine-grained sandstone section. These would be interpreted as a bedding-plane fracture at 33 feet, which supplies water to the pumping well.

The data indicate three bedding-plane fractures that supply water to the well. These are shown on figure 5.2.2-1 at depths of 22, 33, and 52 feet. Well data and interpretation indicate similar ground-water conditions at Test Sites 1 and 2.

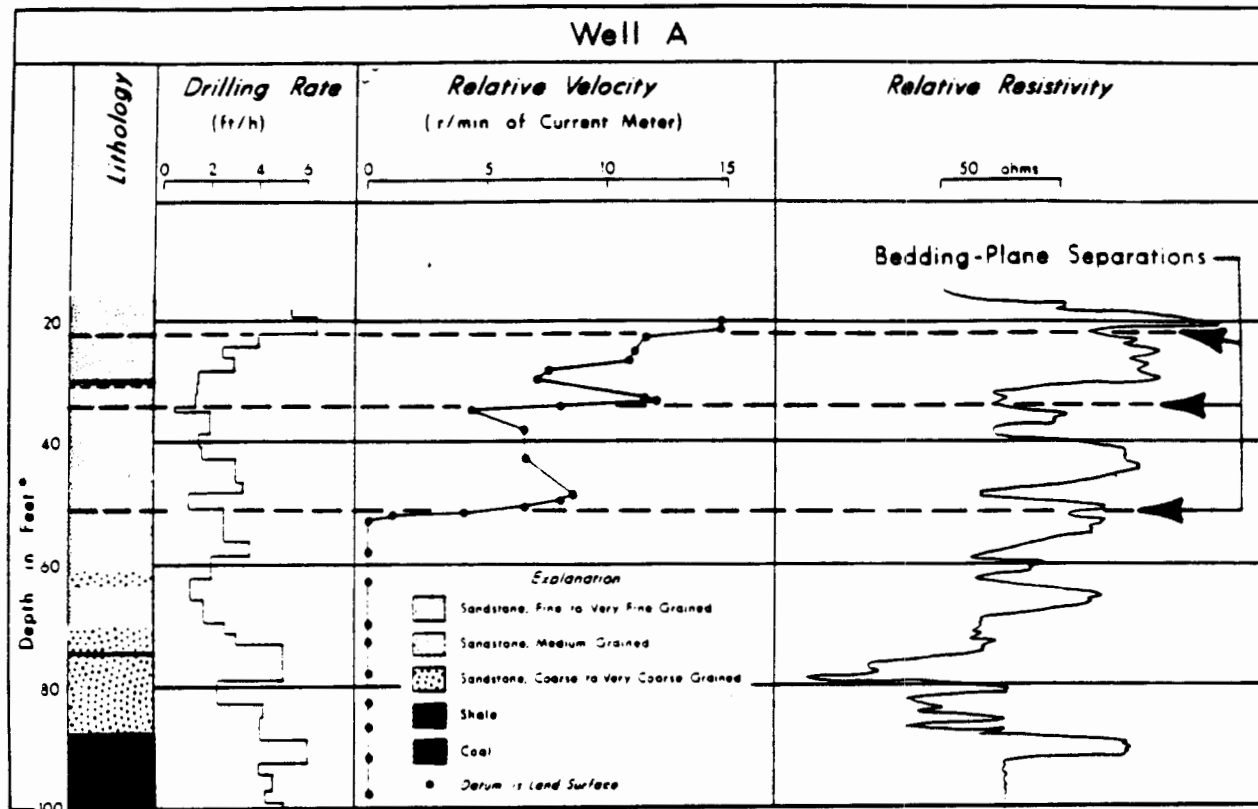


Figure 5.2.2-1. Physical data for Well A at Test Site 2

5.0 HYDROLOGY AT TEST SITES (Continued)

5.2 Hydrology at Test Site 2 (Continued)

5.2.3 Analysis and interpretation of slug-test and pumping-test data

Test-Data Analysis Indicates Aquifer Characteristics At Test Site 2 Are Similar to Those at Test Site 1

An analysis of the slug-test data shows the multiple-image effects of impermeable barriers at Test Site 2. These aquifer conditions are similar to those at Test Site 1.

Slug tests were made at Well A and Well B at Test Site 2 on November 28 and 29, 1978, respectively. Each test consisted of dumping 55 gallons of water into the well and measuring the decay of the head built up by the dumped water. The head effects of adding water to the aquifer system are the exact opposite of pumping water from the aquifer. The effects of impermeable barriers are to delay the decay of the residual head, which results in departure of the measured curve above the type curve.

The type curves used were developed by Cooper and others (1954) and Papadopoulos and others (1973). The early measurements matched to the curve show an almost horizontal shift from the curve for $\alpha = 10^{-1}$ to the curve for $\alpha = 10^{-10}$ (fig. 5.2.3-1). The measured curve departed above the type curve,

indicating impermeable-boundary effects. Because of these departures of the measured curve, values for transmissivity and storage coefficient could not be determined at Test Site 2. However, the shape of the measured curve, compared with the type curves, does indicate the same aquifer conditions at Test Site 2 as at Test Site 1.

When Well A was pumped at 8 gal/min on November 29, 1978, the drawdown in Wells A and B was the same at the same time intervals throughout the test. This indicates an extremely high transmissivity in the horizontal fractures, as at Test Site 1 (fig. 5.2.3-1). Because image effects from the barriers were significant before the first 10 seconds of the test, T and S cannot be computed.

Appendix C
Section 4.2
Reference 15

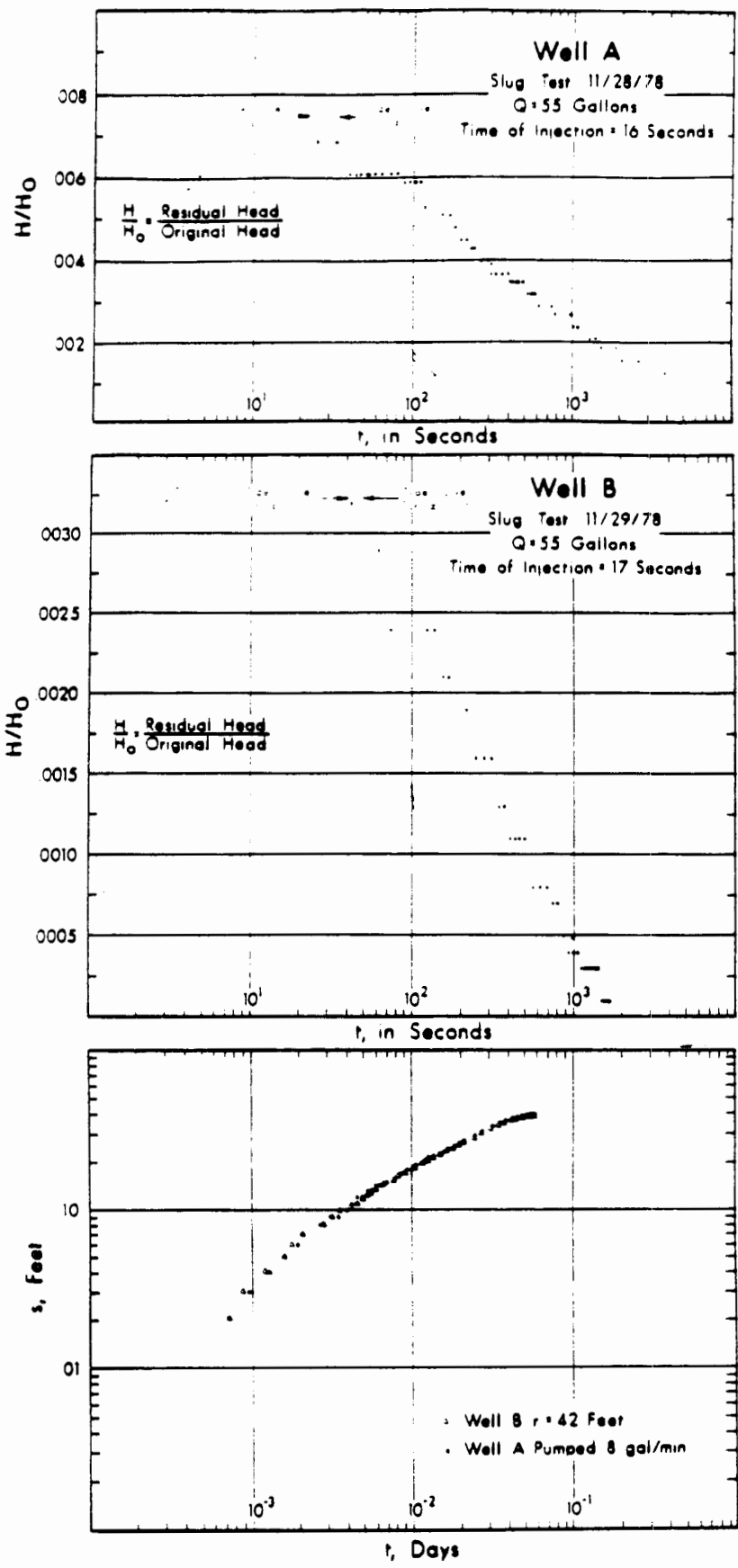


Figure 5.2.3-1. Data from slug test and pumping test at Test Site 2

Appendix C
Section 4.2
Reference 15

6.0 HYDROLOGY OF THE VALLEY

6.0 HYDROLOGY OF THE VALLEY

6.1 Pumping Lodge Water-Supply Well

Pumping Well at Lodge Shows that Aquifer Is Continuous from Test Site 1 to Test Site 2

The water-supply well for the Lodge was pumped for about 5 hours to see if levels were lowered at both Test Sites 1 and 2. Well 002 at Test Site 1 and Well A at Test Site 2 both had measurable drawdown, indicating that the aquifer is continuous from Test Site 1 to Test Site 2.

The Lodge well was pumped at 17 gal/min for about 5 hours on February 21, 1979 (fig. 6.1-1). The water levels in the pumped well, Well 002, and Well A were measured during the pumping. The resulting drawdowns in all three wells are shown in figure 6.1-1. Well 002 is about 3,300 feet upvalley from the Lodge well, and Well A is about 2,400 feet downvalley. As wells at both sites, more than a mile apart, were affected, the aquifer is concluded to be

continuous between the test sites. Because of the interference of impermeable-boundary effects and changes in aquifer shape at tributary valleys, no attempt was made to analyze for values of transmissivity (T) and storage coefficient (S) in this test. Changes in the slope of the curves for Wells 002 and A at about 11 a.m. are attributed to the influence of changes in aquifer width at tributary valleys.

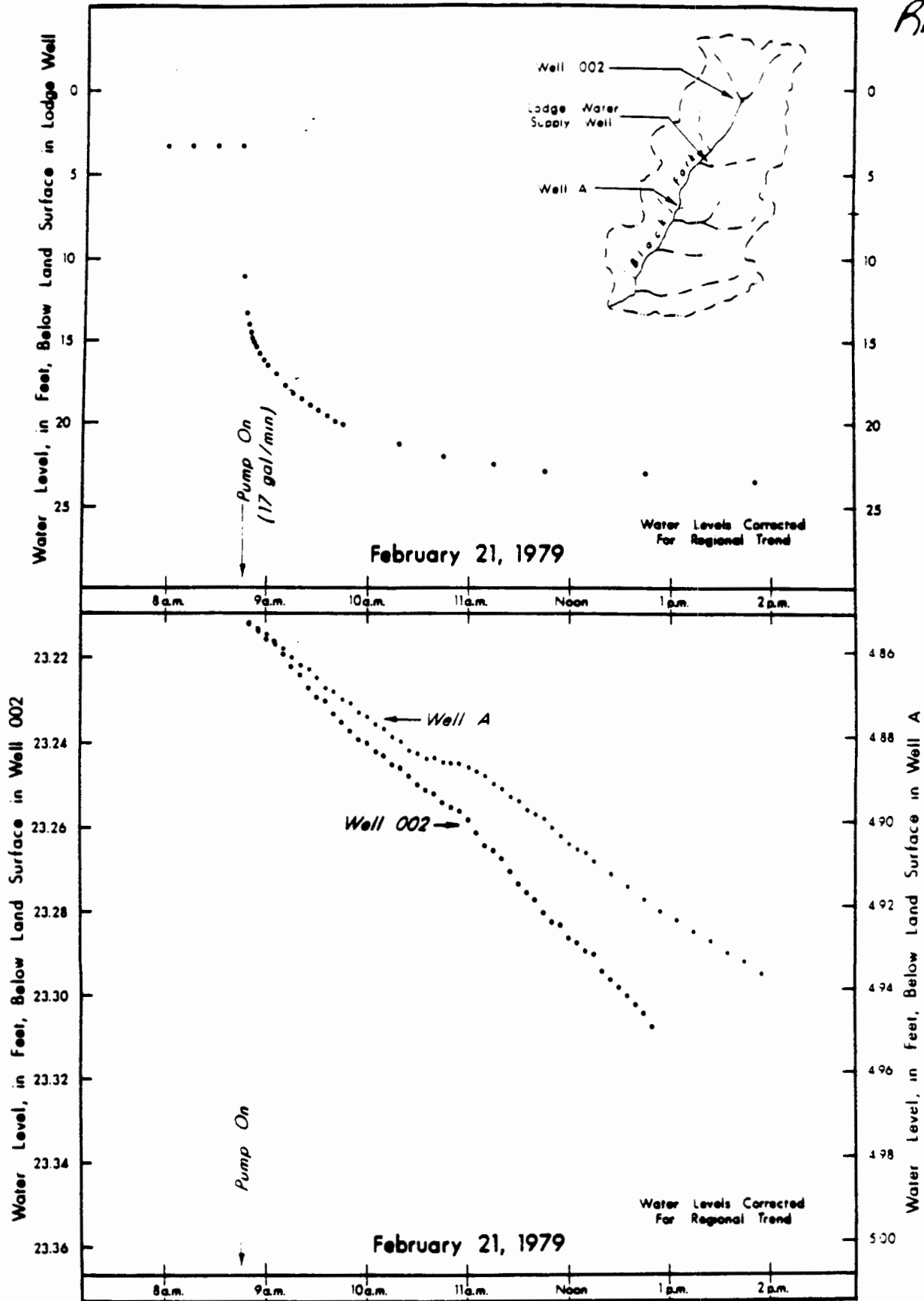


Figure 6.1-1. Drawdown at pumped Lodge well and at Wells 002 (Test Site 1) and A (Test Site 2)

6.0 HYDROLOGY OF THE VALLEY (Continued)

6.2 Stream-Discharge Profile and Runoff

11 to 6 Times Greater Stream Runoff Per Square Mile Below Falls Than Above Falls Caused by Ground-Water Discharge

The stream runoff per square mile below Black Fork Falls is 11 to 6 times as much as above the falls because of ground-water discharge to the stream at the falls. The ground water is discharged through horizontal bedding-plane fractures that crop out in the stream under the falls.

Runoff in Black Fork is a combination of overland runoff and ground-water discharge to the stream. As can be seen in figure 6.2-1, the runoff per square mile of drainage area below Black Fork Falls is about 11 times greater than above the falls during periods of low flow and more than 6 times greater during higher flow. The illustration also shows the stream profile and the results of a stream gain-and-loss study made downstream from near Test Site 2 to the mouth in November 1978. The flow nearly doubles from immediately above the falls to just below the falls. The

bedding-plane fractures below the stream channel above the falls crop out in the zone of large increase in streamflow below the falls. Some fractures may be observed cropping out along the face of the falls and below it. Also, numerous iron oxy-hydroxide deposits can be seen on the rocks below the falls where iron-rich ground water is discharged.

The aquifer that contains stress-relief fractures at Black Fork Falls discharges water into the stream at the falls through bedding-plane fractures where there is no confining alluvium.

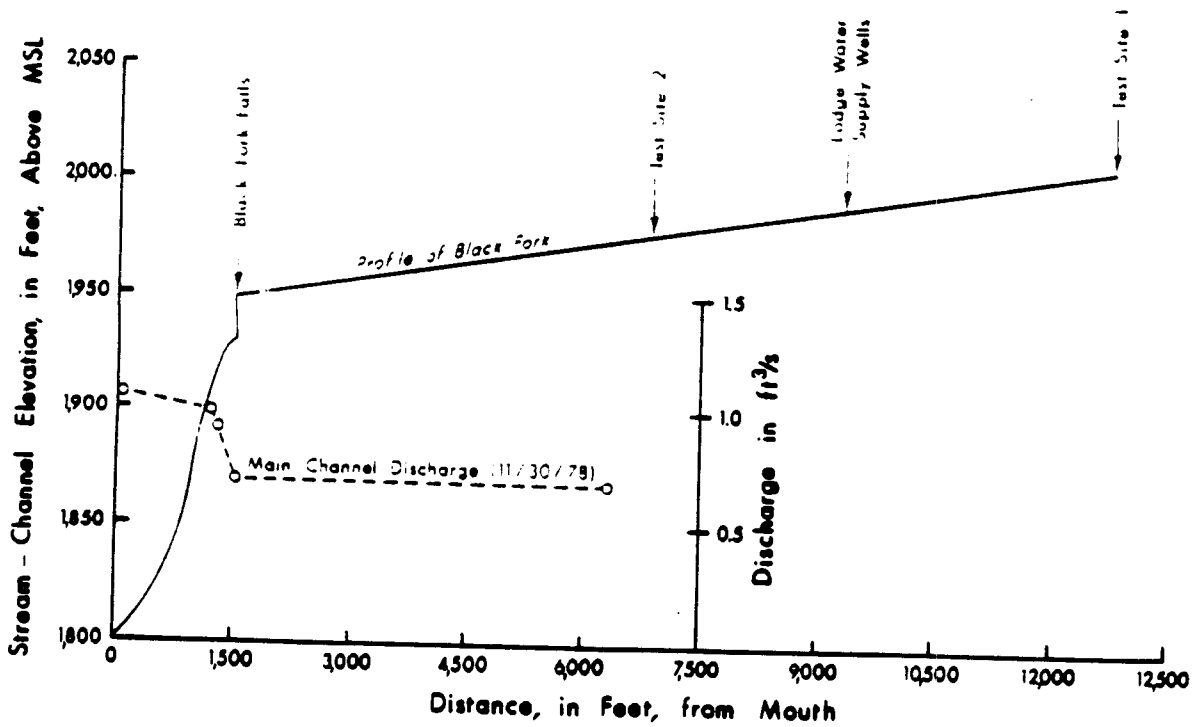
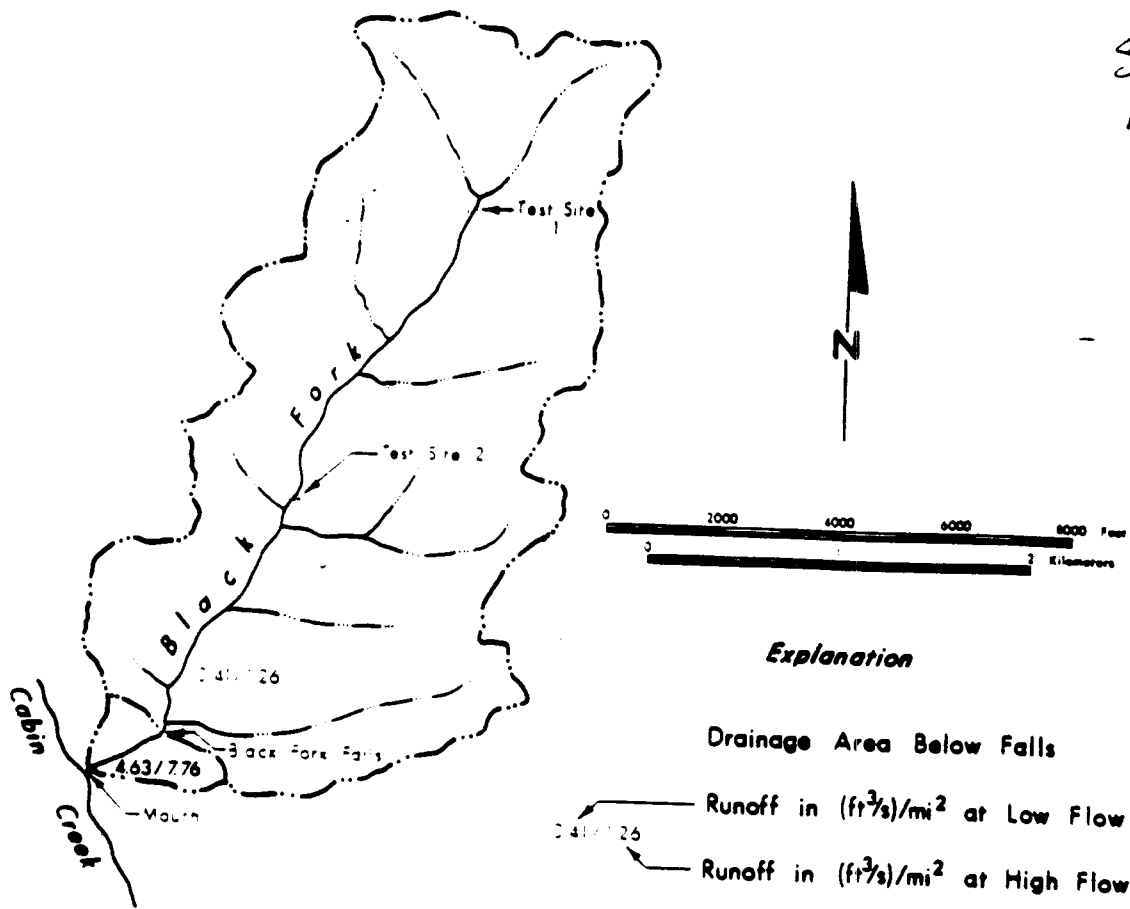


Figure 6.2-1. Profile and runoff map for Black Fork

6.0 HYDROLOGY OF THE VALLEY (Continued)

6.3 Relation of Ground-Water Levels to Ground-Water Discharge

Change in Rate of Ground-Water Discharge Below Falls Is Directly Related to Changes in Ground-Water Level

The change in rate of ground-water discharge below Black Fork Falls is directly related to the changes in ground-water levels at Test Sites 1 and 2. As water levels in Well 002 (Site 1) and Well A (Site 2) rise or decline, the ground-water discharge to the stream below Black Fork Falls increases or decreases.

One form of Darcy's Law states that, if aquifer characteristics remain constant, discharge from an aquifer is directly proportional to head at a given point. In Black Fork Valley, the size and shape of the aquifer and transmissivity are constant with time. The only variables with time are head and discharge. The relation of these variables is shown in figure

6.3-1. Well 002 is 9,200 feet from the discharge point at the falls, and Well A is 4,600 feet from the discharge point. Note that Well 002 is about twice the distance from the discharge point and has about twice the head for the same discharge. This implies that the fracture zones are relatively uniform throughout the valley.

Reference
15
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Appendix C

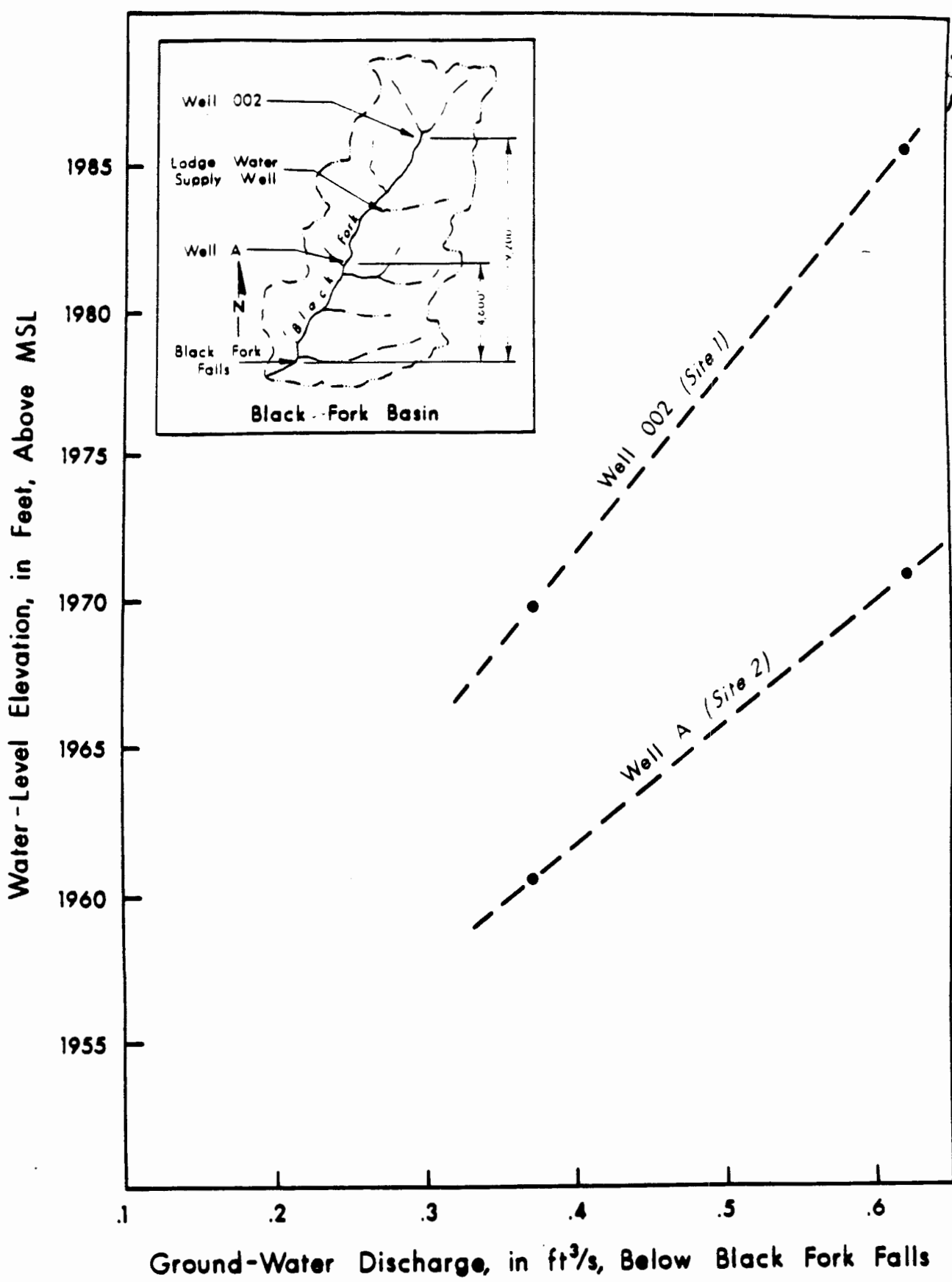


Figure 6.3-1. Ground-water level and discharge relationship in Black Fork Valley

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Section 4.2
Ref. 15

7.0 REFERENCES

7.0 REFERENCES

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- Papadopoulos, I.S., Bredehoeft, J.D., and Cooper, H.H., Jr., 1973, On the analysis of slug test data: *Water Resources Research*, v. 3, no. 1, p. 1087-1089.

*"I.S." Papadopoulos and "S.S." Papadopoulos referred to throughout this report are the same person, and both "I.S." and "S.S." are correct where used.



RECRA ENVIRONMENTAL LABORATORIES

Division of Recra Research, Inc.

ANALYTICAL RESULTS

MONROE COUNTY ENVIRONMENTAL HEALTH LABORATORY PRIORITY POLLUTANT ANALYSES

Prepared For:

Monroe County Environmental
Health Laboratory
435 East Henrietta Road
Rochester, NY 14620

Prepared By:

Recra Environmental Laboratories
4248 Ridge Lea Road
Amherst, NY 14226

Report Date: September 24, 1984



RECRA ENVIRONMENTAL LABORATORIES

Division of Recra Research, Inc.

September 24, 1984

Mr. Richard Burton
Monroe County Environmental
Health Laboratory
435 East Henrietta Road
Rochester, NY 14620

Re: Analytical Results

Dear Mr. Burton:

Please find enclosed results of the analyses of the samples received at our laboratories on August 3, 1984.

If you have any questions concerning these data, do not hesitate to contact our Customer Service Representative at (716) 692-7620.

Sincerely,

RECRA ENVIRONMENTAL LABORATORIES

James A. Ploscyca
Laboratory Manager

BJK/JAP/mdc
Enclosure

I.D. #84-790 Final

ANALYTICAL RESULTS

MONROE COUNTY ENVIRONMENTAL HEALTH LABORATORY PRIORITY POLLUTANT ANALYSES

Report Date:

INTRODUCTION:

On August 3, 1984 samples were received at Recra Environmental Laboratories. A request was made by Monroe County Environmental Health Laboratory to have the samples analyzed for selected fractions of the Environmental Protection Agency decreed priority pollutants. In addition all fractions analyzed via Gas Chromatography/Mass Spectrometry were to undergo a library comparison search to identify and quantify all non-priority peaks.

This report will address the results of those analyses.

METHODS:

Priority pollutant analyses were conducted according to Environmental Protection Agency (EPA) methodologies.

Organic priority pollutants were analyzed by Gas Chromatography/Mass Spectrometry (GC/MS).

RESULTS AND DISCUSSION:

Detection limits for the GC/MS analyses are based upon weight of sample extracted, final volume of extract, volume injected, sample dry weight, and chromatographic response.

Sample DS KOD WEST (LOWER) was analyzed in replicate for base neutral/acid phenolic compounds and sample CEMETERY was analyzed in replicate for volatiles but no positive values resulted.

RESULTS AND DISCUSSION (CONT'D.):

Computer identification for the library comparison search is based upon a visual comparison of the sample spectra with the main library choices for the presence and relative intensities of the major ions. None of the compounds listed under the library comparison search could be identified in the absence of specific standards.

The estimated concentration for the library comparison search components is obtained by the internal standard method, using raw area counts and assuming a response factor of 1. This value is a rough estimation, since instrumental responses have been known to vary as much as three orders of magnitude.

Benzo(a)anthracene/chrysene and benzo(b)fluoranthene/benzo(k) fluoranthene coelute and have similar mass spectra. Therefore, positive values are listed once and should be interpreted as indicating the presence of one and/or both isomers.

Compounds reported as ND are "not detected". Compounds reported as BDL are confirmed as being present in the sample at a level "below detection limit", and are not subject to reliable quantitation.

Respectfully Submitted,

RECRA ENVIRONMENTAL LABORATORIES



Barbara J. Krajewski
GC/MS Supervisor

BJK/mdc



ANALYTICAL RESULTS

MONROE COUNTY ENVIRONMENTAL HEALTH LABORATORY

Report Date: 9/24/84

SAMPLE IDENTIFICATION	DRY WEIGHT (%)
203-1	79
203-2 } Canal Junction	63
203-3 }	75
1-1 }	71
1-2 } Downstream of GCO	74
1-3 }	76
2-1 }	64
2-2 } Upstream of GCO	68
2-3 }	72
Upstream of Kodak	77
Downstream of Kodak	65
Cemetery Riverside	64
DS KOD West (Upper)	59
DS KOD West (Lower)	68

FOR RECRA ENVIRONMENTAL LABORATORIES

DATE

Barbara J. Kiyendin
9/24/84

ANALYTICAL RESULTS

MONROE COUNTY ENVIRONMENTAL HEALTH LABORATORY
GAS CHROMATOGRAPHY/MASS SPECTROMETRY
PRIORITY POLLUTANT ANALYSES

Report Date: 9/24/84

ACID/PHENOLICS

COMPOUND	DETECTION LIMIT (ug/g drv)	SAMPLE IDENTIFICATION			
		203-1	203-2	203-3	1-1
2-chlorophenol	1	ND	ND	ND	ND
2,4-dichlorophenol	1	ND	ND	ND	ND
2,4-dimethylphenol	1	ND	ND	ND	ND
4,6-dinitro-o-cresol	2	ND	ND	ND	ND
2,4-dinitrophenol	3	ND	ND	ND	ND
2-nitrophenol	1	ND	ND	ND	ND
4-nitrophenol	1	ND	ND	ND	ND
p-chloro-m-cresol	1	ND	ND	ND	ND
pentachlorophenol	1	ND	ND	ND	ND
phenol	1	ND	ND	ND	ND
2,4,6-trichlorophenol	1	ND	ND	ND	ND

ADDITIONAL SAMPLE INFORMATION

Sample Date	8/2/84	8/2/84	8/2/84	8/2/84
Extraction Date	8/13/84	8/13/84	8/13/84	8/13/84
Analysis Date	8/27/84	8/27/84	8/27/84	8/27/84
Internal Standard (IS) - Level	2.0 ug/g	2.0 ug/g	2.0 ug/g	2.0 ug/g
deuterated phenanthrene - Recovery	66%	79%	117%	110%
Surrogate Standard (SS1) - Level	6.0 ug/g	6.0 ug/g	6.0 ug/g	6.0 ug/g
2-fluorophenol - Recovery	35%	34%	69%	56%
Surrogate Standard (SS2) - Level	6.0 ug/g	6.0 ug/g	6.0 ug/g	6.0 ug/g
pentafluorophenol - Recovery	61%	28%	63%	48%

FOR RECRA ENVIRONMENTAL LABORATORIES

DATE

Barbara J. Krajewski
9/24/84

ANALYTICAL RESULTS

MONROE COUNTY ENVIRONMENTAL HEALTH LABORATORY
GAS CHROMATOGRAPHY/MASS SPECTROMETRY
PRIORITY POLLUTANT ANALYSES

Report Date: 9/24/84

ACID/PHENOLICS

COMPOUND	DETECTION LIMIT ($\mu\text{g/g dry}$)	SAMPLE IDENTIFICATION			
		1-2	1-3	2-1	2-2
2-chlorophenol	1	ND	ND	ND	ND
2,4-dichlorophenol	1	ND	ND	ND	ND
2,4-dimethylphenol	1	ND	ND	ND	ND
4,6-dinitro-o-cresol	2	ND	ND	ND	ND
2,4-dinitrophenol	3	ND	ND	ND	ND
2-nitrophenol	1	ND	ND	ND	ND
4-nitrophenol	1	ND	ND	ND	ND
p-chloro-m-cresol	1	ND	ND	ND	ND
pentachlorophenol	1	ND	ND	ND	ND
phenol	1	ND	ND	ND	ND
2,4,6-trichlorophenol	1	ND	ND	ND	ND

ADDITIONAL SAMPLE INFORMATION

Sample Date	8/2/84	8/2/84	8/2/84	8/2/84
Extraction Date	8/13/84	8/13/84	8/13/84	8/13/84
Analysis Date	8/27/84	8/27/84	8/27/84	8/27/84
Internal Standard (IS) - Level	2.0 $\mu\text{g/g}$	2.0 $\mu\text{g/g}$	2.0 $\mu\text{g/g}$	2.0 $\mu\text{g/g}$
deuterated phenanthrene - Recovery	116%	130%	89%	109%
Surrogate Standard (SS1) - Level	6.0 $\mu\text{g/g}$	6.0 $\mu\text{g/g}$	6.0 $\mu\text{g/g}$	6.0 $\mu\text{g/g}$
2-fluorophenol - Recovery	81%	61%	82%	68%
Surrogate Standard (SS2) - Level	6.0 $\mu\text{g/g}$	6.0 $\mu\text{g/g}$	6.0 $\mu\text{g/g}$	6.0 $\mu\text{g/g}$
pentafluorophenol - Recovery	60%	44%	57%	51%

FOR RECRA ENVIRONMENTAL LABORATORIES

DATE

Barbara J. Kasper
9/24/84

ANALYTICAL RESULTS

MONROE COUNTY ENVIRONMENTAL HEALTH LABORATORY
GAS CHROMATOGRAPHY/MASS SPECTROMETRY
PRIORITY POLLUTANT ANALYSES

Report Date: 9/24/84

ACID/PHENOLICS

COMPOUND	DETECTION LIMIT (ug/g dry)	SAMPLE IDENTIFICATION			
		2-3	UPSTREAM	DOWNSTREAM	CEMETERY
2-chlorophenol	1	ND	ND	ND	ND
2,4-dichlorophenol	1	ND	ND	ND	ND
2,4-dimethylphenol	1	ND	ND	ND	ND
4,6-dinitro-o-cresol	2	ND	ND	ND	ND
2,4-dinitrophenol	3	ND	ND	ND	ND
2-nitrophenol	1	ND	ND	ND	ND
4-nitrophenol	1	ND	ND	ND	ND
p-chloro-m-cresol	1	ND	ND	ND	BDL
pentachlorophenol	1	ND	ND	ND	ND
phenol	1	ND	ND	ND	ND
2,4,6-trichlorophenol	1	ND	ND	ND	ND

ADDITIONAL SAMPLE INFORMATION

Sample Date	8/2/84	8/3/84	8/3/84	8/3/84
Extraction Date	8/13/84	8/13/84	8/13/84	8/13/84
Analysis Date	8/27/84	8/28/84	8/28/84	8/28/84
Internal Standard (IS) - Level	2.0 ug/g	2.0 ug/g	2.0 ug/g	2.0 ug/g
deuterated phenanthrene - Recovery	93%	71%	92%	68%
Surrogate Standard (SS1) - Level	6.0 ug/g	6.0 ug/g	6.0 ug/g	6.0 ug/g
2-fluorophenol - Recovery	57%	74%	84%	110%
Surrogate Standard (SS2) - Level	6.0 ug/g	6.0 ug/g	6.0 ug/g	6.0 ug/g
pentafluorophenol - Recovery	37%	83%	71%	66%

FOR RECRA ENVIRONMENTAL LABORATORIES

DATE

Barbara J. Kuzenli
9/24/84

ANALYTICAL RESULTS

MONROE COUNTY ENVIRONMENTAL HEALTH LABORATORY
GAS CHROMATOGRAPHY/MASS SPECTROMETRY
PRIORITY POLLUTANT ANALYSES

Report Date: 9/24/84

ACID/PHENOLICS

COMPOUND	DETECTION LIMIT (ug/g dry)	SAMPLE IDENTIFICATION	
		DS KOD WEST UPPER	DS KOD WEST LOWER
2-chlorophenol	1	ND	ND
2,4-dichlorophenol	1	ND	ND
2,4-dimethylphenol	1	ND	ND
4,6-dinitro-o-cresol	2	ND	ND
2,4-dinitrophenol	3	ND	ND
2-nitrophenol	1	ND	ND
4-nitrophenol	1	ND	ND
p-chloro-m-cresol	1	ND	ND
pentachlorophenol	1	ND	ND
phenol	1	ND	ND
2,4,6-trichlorophenol	1	ND	ND

ADDITIONAL SAMPLE INFORMATION

Sample Date	8/2/84	8/2/84
Extraction Date	8/13/84	8/13/84
Analysis Date	8/28/84	8/28/84
Internal Standard (IS) - Level	2.0 ug/g	2.0 ug/g
deuterated phenanthrene - Recovery	98%	80%
Surrogate Standard (SS1) - Level	6.0 ug/g	6.0 ug/g
2-fluorophenol - Recovery	100%	100%
Surrogate Standard (SS2) - Level	6.0 ug/g	6.0 ug/g
pentafluorophenol - Recovery	88%	84%

FOR RECRA ENVIRONMENTAL LABORATORIES

DATE

Barbara J. Krasinski
9/24/84

ANALYTICAL RESULTS

MONROE COUNTY ENVIRONMENTAL HEALTH LABORATORY
GAS CHROMATOGRAPHY/MASS SPECTROMETRY
PRIORITY POLLUTANT ANALYSES

Report Date: 9/24/84

BASE/NEUTRALS

COMPOUND	DETECTION LIMIT (ug/g drv)	SAMPLE IDENTIFICATION			
		203-1	203-2	203-3	1-1
acenaphthene	1	ND	ND	ND	ND
acenaphthylene	1	ND	ND	ND	ND
anthracene	1	ND	ND	ND	ND
benzidine	3	ND	ND	ND	ND
benzo(a)anthracene	1	ND	ND	ND	ND
benzo(a)pyrene	1	ND	ND	ND	ND
benzo(b)fluoranthene	1	ND	ND	ND	ND
benzo(g,h,i)perylene	1	ND	ND	ND	ND
benzo(k)fluoranthene	1	ND	ND	ND	ND
bis(2-chloroethoxy)methane	1	ND	ND	ND	ND
bis(2-chloroethyl)ether	1	ND	ND	ND	ND
bis(2-chloroisopropyl)ether	1	ND	ND	ND	ND
bis(2-ethylhexyl)phthalate	1	ND	ND	ND	ND
4-bromophenylphenylether	1	ND	ND	ND	ND
butylbenzylphthalate	1	ND	ND	ND	ND
2-chloronaphthalene	1	ND	ND	ND	ND
4-chlorophenylphenylether	1	ND	ND	ND	ND
chrysene	1	ND	ND	ND	ND
dibenzo(a,h)anthracene	1	ND	ND	ND	ND
1,2-dichlorobenzene	1	ND	ND	ND	ND
1,3-dichlorobenzene	1	ND	ND	ND	ND
1,4-dichlorobenzene	1	ND	ND	ND	ND
3,3'-dichlorobenzidine	2	ND	ND	ND	ND
diethylphthalate	2	ND	ND	ND	ND
dimethylphthalate	1	ND	ND	ND	ND
di-n-butylphthalate	1	ND	ND	ND	ND

(Continued)



ANALYTICAL RESULTS

MONROE COUNTY ENVIRONMENTAL HEALTH LABORATORY
GAS CHROMATOGRAPHY/MASS SPECTROMETRY
PRIORITY POLLUTANT ANALYSES

Report Date: 9/24/84

BASE/NEUTRALS

COMPOUND	DETECTION LIMIT (ug/g drv)	SAMPLE IDENTIFICATION			
		203-1	203-2	203-3	1-1
2,6-dinitrotoluene	1	ND	ND	ND	ND
2,4-dinitrotoluene	1	ND	ND	ND	ND
di-n-octylphthalate	1	ND	ND	ND	ND
1,2-diphenylhydrazine	2	ND	ND	ND	ND
fluoranthene	1	ND	ND	ND	ND
fluorene	1	ND	ND	ND	ND
hexachlorobenzene	1	ND	ND	ND	ND
hexachlorobutadiene	1	ND	ND	ND	ND
hexachlorocyclopentadiene	2	ND	ND	ND	ND
hexachloroethane	1	ND	ND	ND	ND
indeno(1,2,3-cd)pyrene	1	ND	ND	ND	ND
isophorone	1	ND	ND	ND	ND
naphthalene	1	ND	ND	ND	ND
nitrobenzene	1	ND	ND	ND	ND
N-nitrosodimethylamine	2	ND	ND	ND	ND
N-nitrosodi-n-propylamine	2	ND	ND	ND	ND
N-nitrosodiphenylamine	1	ND	ND	ND	ND
phenanthrene	1	ND	ND	ND	ND
pyrene	1	ND	ND	ND	ND
1,2,4-trichlorobenzene	1	ND	ND	ND	ND

ADDITIONAL SAMPLE INFORMATION

Sample Date	8/2/84	8/2/84	8/2/84	8/2/84
Extraction Date	8/13/84	8/13/84	8/13/84	8/13/84
Analysis Date	8/27/84	8/27/84	8/27/84	8/27/84
Internal Standard - Level	2.0 ug/g	2.0 ug/g	2.0 ug/g	2.0 ug/g
deuterated phenanthrene - Recovery	66%	79%	119%	110%
Surrogate Standard (SS3) - Level	6.0 ug/g	6.0 ug/g	6.0 ug/g	6.0 ug/g
decafluorobiphenyl - Recovery	78%	42%	93%	58%
Surrogate Standard (SS4) - Level	5.0 ug/g	5.0 ug/g	5.0 ug/g	5.0 ug/g
2-fluorobiphenyl - Recovery	75%	42%	97%	64%

FOR RECRA ENVIRONMENTAL LABORATORIES

DATE

Barbara J. Kojewski
9/24/84

ANALYTICAL RESULTS

MONROE COUNTY ENVIRONMENTAL HEALTH LABORATORY
GAS CHROMATOGRAPHY/MASS SPECTROMETRY
PRIORITY POLLUTANT ANALYSES

Report Date: 9/24/84

BASE/NEUTRALS

COMPOUND	DETECTION LIMIT (ug/g dry)	SAMPLE IDENTIFICATION			
		1-2	1-3	2-1	2-2
acenaphthene	1	ND	ND	ND	ND
acenaphthylene	1	ND	ND	ND	ND
anthracene	1	ND	ND	ND	ND
benzidine	3	ND	ND	ND	ND
benzo(a)anthracene	1	ND	ND	ND	ND
benzo(a)pyrene	1	ND	ND	ND	ND
benzo(b)fluoranthene	1	ND	ND	ND	ND
benzo(g,h,i)perylene	1	ND	ND	ND	ND
benzo(k)fluoranthene	1	ND	ND	ND	ND
bis(2-chloroethoxy)methane	1	ND	ND	ND	ND
bis(2-chloroethyl)ether	1	ND	ND	ND	ND
bis(2-chloroisopropyl)ether	1	ND	ND	ND	ND
bis(2-ethylhexyl)phthalate	1	ND	ND	ND	ND
4-bromophenylphenylether	1	ND	ND	ND	ND
butylbenzylphthalate	1	ND	ND	ND	ND
2-chloronaphthalene	1	ND	ND	ND	ND
4-chlorophenylphenylether	1	ND	ND	ND	ND
chrysene	1	ND	ND	ND	ND
dibenzo(a,h)anthracene	1	ND	ND	ND	ND
1,2-dichlorobenzene	1	ND	ND	ND	ND
1,3-dichlorobenzene	1	ND	ND	ND	ND
1,4-dichlorobenzene	1	ND	ND	ND	ND
3,3'-dichlorobenzidine	2	ND	ND	ND	ND
diethylphthalate	2	ND	ND	ND	ND
dimethylphthalate	1	ND	ND	ND	ND
di-n-butylphthalate	1	ND	ND	ND	ND

(Continued)



ANALYTICAL RESULTS

MONROE COUNTY ENVIRONMENTAL HEALTH LABORATORY
GAS CHROMATOGRAPHY/MASS SPECTROMETRY
PRIORITY POLLUTANT ANALYSES

Report Date: 9/24/84

BASE/NEUTRALS

COMPOUND	DETECTION LIMIT (ug/g dry)	SAMPLE IDENTIFICATION			
		1-2	1-3	2-1	2-2
2,6-dinitrotoluene	1	ND	ND	ND	ND
2,4-dinitrotoluene	1	ND	ND	ND	ND
di-n-octylphthalate	1	ND	ND	ND	ND
1,2-diphenylhydrazine	2	ND	ND	ND	ND
fluoranthene	1	ND	ND	ND	ND
fluorene	1	ND	ND	ND	ND
hexachlorobenzene	1	ND	ND	ND	ND
hexachlorobutadiene	1	ND	ND	ND	ND
hexachlorocyclopentadiene	2	ND	ND	ND	ND
hexachloroethane	1	ND	ND	ND	ND
indeno(1,2,3-cd)pyrene	1	ND	ND	ND	ND
isophorone	1	ND	ND	ND	ND
naphthalene	1	ND	ND	ND	ND
nitrobenzene	1	ND	ND	ND	ND
N-nitrosodimethylamine	2	ND	ND	ND	ND
N-nitrosodi-n-propylamine	2	ND	ND	ND	ND
N-nitrosodiphenylamine	1	ND	ND	ND	ND
phenanthrene	1	ND	ND	ND	ND
pyrene	1	ND	ND	ND	ND
1,2,4-trichlorobenzene	1	ND	ND	ND	ND

ADDITIONAL SAMPLE INFORMATION

Sample Date	8/2/84	8/2/84	8/2/84	8/2/84
Extraction Date	8/13/84	8/13/84	8/13/84	8/13/84
Analysis Date	8/27/84	8/27/84	8/27/84	8/27/84
Internal Standard - Level	2.0 ug/g	2.0 ug/g	2.0 ug/g	2.0 ug/g
deuterated phenanthrene - Recovery	116%	132%	89%	109%
Surrogate Standard (SS3) - Level	6.0 ug/g	6.0 ug/g	6.0 ug/g	6.0 ug/g
decafluorobiphenyl - Recovery	76%	62%	79%	69%
Surrogate Standard (SS4) - Level	5.0 ug/g	5.0 ug/g	5.0 ug/g	5.0 ug/g
2-fluorobiphenyl - Recovery	77%	50%	76%	65%

FOR RECRA ENVIRONMENTAL LABORATORIES

DATE

Barbara J. Kasper
9/24/84



ANALYTICAL RESULTS

MONROE COUNTY ENVIRONMENTAL HEALTH LABORATORY
GAS CHROMATOGRAPHY/MASS SPECTROMETRY
PRIORITY POLLUTANT ANALYSES

Report Date: 9/24/84

BASE/NEUTRALS

COMPOUND	DETECTION LIMIT (ug/g drv)	SAMPLE IDENTIFICATION			
		2-3	UPSTREAM	DOWNSTREAM	CEMETERY
acenaphthene	1	ND	ND	ND	ND
acenaphthylene	1	ND	ND	ND	ND
anthracene	1	ND	BDL	BDL	ND
benzidine	3	ND	ND	ND	ND
benzo(a)anthracene	1	ND	BDL	BDL	BDL
benzo(a)pyrene	1	ND	BDL	ND	ND
benzo(b)fluoranthene	1	ND	BDL	ND	ND
benzo(g,h,i)perylene	1	ND	ND	ND	ND
benzo(k)fluoranthene	1	ND	-	ND	ND
bis(2-chloroethoxy)methane	1	ND	ND	ND	ND
bis(2-chloroethyl)ether	1	ND	ND	ND	ND
bis(2-chloroisopropyl)ether	1	ND	ND	ND	ND
bis(2-ethylhexyl)phthalate	1	ND	ND	ND	ND
4-bromophenylphenylether	1	ND	ND	ND	ND
butylbenzylphthalate	1	ND	ND	ND	ND
2-chloronaphthalene	1	ND	ND	ND	ND
4-chlorophenylphenylether	1	ND	ND	ND	ND
chrysene	1	ND	-	ND	ND
dibenzo(a,h)anthracene	1	ND	ND	ND	ND
1,2-dichlorobenzene	1	ND	ND	ND	ND
1,3-dichlorobenzene	1	ND	ND	ND	ND
1,4-dichlorobenzene	1	ND	ND	ND	ND
3,3'-dichlorobenzidine	1	ND	ND	ND	ND
diethylphthalate	1	ND	ND	ND	ND
dimethylphthalate	1	ND	ND	ND	ND
di-n-butylphthalate	1	ND	ND	ND	ND

(Continued)



ANALYTICAL RESULTS

MONROE COUNTY ENVIRONMENTAL HEALTH LABORATORY
GAS CHROMATOGRAPHY/MASS SPECTROMETRY
PRIORITY POLLUTANT ANALYSES

Report Date: 9/24/84

BASE/NEUTRALS

COMPOUND	DETECTION LIMIT (ug/g dry)	SAMPLE IDENTIFICATION			
		2-3	UPSTREAM	DOWNSTREAM	CEMETERY
2,6-dinitrotoluene	1	ND	ND	ND	ND
2,4-dinitrotoluene	1	ND	ND	ND	ND
di-n-octylphthalate	1	ND	ND	ND	ND
1,2-diphenylhydrazine	2	ND	ND	ND	ND
fluoranthene	1	ND	1.9	BDL	BDL
fluorene	1	ND	BDL	ND	BDL
hexachlorobenzene	1	ND	ND	ND	ND
hexachlorobutadiene	1	ND	ND	ND	ND
hexachlorocyclopentadiene	2	ND	ND	ND	ND
hexachloroethane	1	ND	ND	ND	ND
indeno(1,2,3-cd)pyrene	1	ND	ND	ND	ND
isophorone	1	ND	ND	ND	ND
naphthalene	1	ND	BDL	BDL	BDL
nitrobenzene	1	ND	ND	ND	ND
N-nitrosodimethylamine	2	ND	ND	ND	ND
N-nitrosodi-n-propylamine	2	ND	ND	ND	ND
N-nitrosodiphenylamine	1	ND	ND	ND	ND
phenanthrene	1	ND	1.4	BDL	ND
pyrene	1	ND	3.1	BDL	BDL
1,2,4-trichlorobenzene	1	ND	ND	ND	ND

ADDITIONAL SAMPLE INFORMATION

Sample Date	8/2/84	8/3/84	8/3/84	8/3/84
Extraction Date	8/13/84	8/13/84	8/13/84	8/13/84
Analysis Date	8/27/84	8/28/84	8/28/84	8/28/84
Internal Standard - Level	2.0 ug/g	2.0 ug/g	2.0 ug/g	2.0 ug/g
deuterated phenanthrene - Recovery	93%	71%	92%	68%
Surrogate Standard (SS3) - Level	6.0 ug/g	6.0 ug/g	6.0 ug/g	6.0 ug/g
decafluorobiphenyl - Recovery	60%	120%	107%	80%
Surrogate Standard (SS4) - Level	5.0 ug/g	5.0 ug/g	5.0 ug/g	5.0 ug/g
2-fluorobiphenyl - Recovery	55%	130%	105%	82%

FOR RECRA ENVIRONMENTAL LABORATORIES

DATE

Babara J. Kraybill
9/24/84

ANALYTICAL RESULTS

MONROE COUNTY ENVIRONMENTAL HEALTH LABORATORY
GAS CHROMATOGRAPHY/MASS SPECTROMETRY
PRIORITY POLLUTANT ANALYSES

Report Date: 9/24/84

BASE/NEUTRALS

COMPOUND	DETECTION LIMIT (ug/g dry)	SAMPLE IDENTIFICATION	
		DS KOD WEST UPPER	DS KOD WEST LOWER
acenaphthene	1	ND	ND
acenaphthylene	1	ND	ND
anthracene	1	ND	ND
benzidine	3	ND	ND
benzo(a)anthracene	1	ND	ND
benzo(a)pyrene	1	ND	ND
benzo(b)fluoranthene	1	ND	ND
benzo(g,h,i)perylene	1	ND	ND
benzo(k)fluoranthene	1	ND	ND
bis(2-chloroethoxy)methane	1	ND	ND
bis(2-chloroethyl)ether	1	ND	ND
bis(2-chloroisopropyl)ether	1	ND	ND
bis(2-ethylhexyl)phthalate	1	ND	ND
4-bromophenylphenylether	1	ND	ND
butylbenzylphthalate	1	ND	ND
2-chloronaphthalene	1	ND	ND
4-chlorophenylphenylether	1	ND	ND
chrysene	1	ND	ND
dibenzo(a,h)anthracene	1	ND	ND
1,2-dichlorobenzene	1	ND	ND
1,3-dichlorobenzene	1	ND	ND
1,4-dichlorobenzene	1	ND	ND
3,3'-dichlorobenzidine	2	ND	ND
diethylphthalate	2	ND	ND
dimethylphthalate	1	ND	ND
di-n-butylphthalate	1	ND	ND

(Continued)



ANALYTICAL RESULTS

MONROE COUNTY ENVIRONMENTAL HEALTH LABORATORY
GAS CHROMATOGRAPHY/MASS SPECTROMETRY
PRIORITY POLLUTANT ANALYSES

Report Date: 9/24/84

BASE/NEUTRALS

COMPOUND	DETECTION LIMIT ($\mu\text{g/g dry}$)	SAMPLE IDENTIFICATION	
		DS KOD WEST UPPER	DS KOD WEST LOWER
2,6-dinitrotoluene	1	ND	ND
2,4-dinitrotoluene	1	ND	ND
di-n-octylphthalate	1	ND	ND
1,2-diphenylhydrazine	2	ND	ND
fluoranthene	1	BDL	ND
fluorene	1	ND	ND
hexachlorobenzene	1	ND	ND
hexachlorobutadiene	1	ND	ND
hexachlorocyclopentadiene	2	ND	ND
hexachloroethane	1	ND	ND
indeno(1,2,3-cd)pyrene	1	ND	ND
isophorone	1	ND	ND
naphthalene	1	ND	ND
nitrobenzene	1	ND	ND
N-nitrosodimethylamine	2	ND	ND
N-nitrosodi-n-propylamine	2	ND	ND
N-nitrosodiphenylamine	1	ND	ND
phenanthrene	1	ND	ND
pyrene	1	BDL	ND
1,2,4-trichlorobenzene	1	ND	ND

ADDITIONAL SAMPLE INFORMATION

Sample Date	8/2/84	8/2/84
Extraction Date	8/13/84	8/13/84
Analysis Date	8/28/84	8/28/84
Internal Standard - Level	2.0 $\mu\text{g/g}$	2.0 $\mu\text{g/g}$
deuterated phenanthrene - Recovery	98%	80%
Surrogate Standard (SS3) - Level	6.0 $\mu\text{g/g}$	6.0 $\mu\text{g/g}$
decafluorobiphenyl - Recovery	75%	71%
Surrogate Standard (SS4) - Level	5.0 $\mu\text{g/g}$	5.0 $\mu\text{g/g}$
2-fluorobiphenyl - Recovery	100%	80%

FOR RECRA ENVIRONMENTAL LABORATORIES

DATE

Barbara J. Kajewski
9/24/84

ANALYTICAL RESULTS

MONROE COUNTY ENVIRONMENTAL HEALTH LABORATORY GAS CHROMATOGRAPHY/MASS SPECTROMETRY PRIORITY POLLUTANT ANALYSES

Report Date: 9/24/84

VOLATILES

COMPOUND	DETECTION LIMIT (µg/kg dry)	SAMPLE IDENTIFICATION		
		203-1	203-2	203-3
acrolein	600	ND	ND	ND
acrylonitrile	600	ND	ND	ND
benzene	6.3	ND	ND	ND
bromodichloromethane	3.1	ND	ND	ND
bromoform	6.7	ND	ND	ND
bromomethane	14	ND	ND	ND
carbon tetrachloride	4.0	ND	ND	ND
chlorobenzene	8.6	ND	ND	ND
chloroethane	14	ND	ND	ND
2-chloroethylvinyl ether	14	ND	ND	ND
chloroform	2.3	ND	ND	ND
chloromethane	14	ND	ND	ND
dibromochloromethane	4.4	ND	ND	ND
1,1-dichloroethane	6.7	ND	ND	ND
1,2-dichloroethane	4.0	ND	ND	ND
1,1-dichloroethylene	4.0	ND	ND	ND
trans-1,2-dichloroethylene	2.3	ND	ND	ND
1,2-dichloropropane	8.6	ND	ND	ND
1,3-dichloropropene	7.1	ND	ND	ND
ethylbenzene	10	ND	ND	ND
methylene chloride	4.0	ND	ND	ND
1,1,2,2-tetrachloroethane	9.8	ND	ND	ND
tetrachloroethylene	5.8	ND	ND	ND

(Continued)



ANALYTICAL RESULTS

MONROE COUNTY ENVIRONMENTAL HEALTH LABORATORY
GAS CHROMATOGRAPHY/MASS SPECTROMETRY
PRIORITY POLLUTANT ANALYSES

Report Date: 9/24/84

VOLATILES

COMPOUND	DETECTION LIMIT (ug/kg dry)	SAMPLE IDENTIFICATION		
		203-1	203-2	203-3
toluene	8.6	ND	ND	ND
1,1,1-trichloroethane	5.4	ND	ND	ND
1,1,2-trichloroethane	7.1	ND	ND	ND
trichloroethylene	2.7	ND	ND	ND
vinyl chloride	14	ND	ND	ND

ADDITIONAL SAMPLE INFORMATION

Sample Date	8/2/84	8/2/84	8/2/84
Analysis Date	9/12/84	9/14/84	9/14/84
Internal Standard - Level	40 ug/kg	40 ug/kg	40 ug/kg
bromochloromethane - Recovery	96%	74%	108%
Internal Standard - Level	40 ug/kg	40 ug/kg	40 ug/kg
2-bromo-1-chloropropane - Recovery	89%	79%	112%
Internal Standard - Level	40 ug/kg	40 ug/kg	40 ug/kg
1,4-dichlorobutane - Recovery	100%	100%	130%

FOR RECRA ENVIRONMENTAL LABORATORIES

DATE

Barbara J. Kasper
9/24/84



ANALYTICAL RESULTS

MONROE COUNTY ENVIRONMENTAL HEALTH LABORATORY GAS CHROMATOGRAPHY/MASS SPECTROMETRY PRIORITY POLLUTANT ANALYSES

Report Date: 9/24/84

VOLATILES

COMPOUND	DETECTION LIMIT (ug/kg dry)	SAMPLE IDENTIFICATION		
		1-1	1-2	1-3
acrolein	600	ND	ND	ND
acrylonitrile	600	ND	ND	ND
benzene	6.3	ND	ND	ND
bromodichloromethane	3.1	ND	ND	ND
bromoform	6.7	ND	ND	ND
bromomethane	14	ND	ND	ND
carbon tetrachloride	4.0	ND	ND	ND
chlorobenzene	8.6	ND	ND	ND
chloroethane	14	ND	ND	ND
2-chloroethylvinyl ether	14	ND	ND	ND
chloroform	2.3	ND	ND	4.4 ug/kg dry
chloromethane	14	ND	ND	ND
dibromochloromethane	4.4	ND	ND	ND
1,1-dichloroethane	6.7	ND	ND	ND
1,2-dichloroethane	4.0	ND	ND	ND
1,1-dichloroethylene	4.0	ND	ND	ND
trans-1,2-dichloroethylene	2.3	ND	ND	ND
1,2-dichloropropane	8.6	ND	ND	ND
1,3-dichloropropene	7.1	ND	ND	ND
ethylbenzene	10	ND	ND	ND
methylene chloride	4.0	ND	ND	ND
1,1,2,2-tetrachloroethane	9.8	ND	ND	ND
tetrachloroethylene	5.8	ND	ND	ND

(Continued)



ANALYTICAL RESULTS

MONROE COUNTY ENVIRONMENTAL HEALTH LABORATORY
GAS CHROMATOGRAPHY/MASS SPECTROMETRY
PRIORITY POLLUTANT ANALYSES

Report Date: 9/24/84

VOLATILES

COMPOUND	DETECTION LIMIT (ug/kg drv)	SAMPLE IDENTIFICATION		
		1-1	1-2	1-3
toluene	8.6	360 ug/kg drv	ND	ND
1,1,1-trichloroethane	5.4	ND	ND	ND
1,1,2-trichloroethane	7.1	ND	ND	ND
trichloroethylene	2.7	ND	ND	ND
vinyl chloride	14	ND	ND	ND

ADDITIONAL SAMPLE INFORMATION

Sample Date	8/2/84	8/2/84	8/2/84
Analysis Date	9/14/84	9/12/84	9/12/84
Internal Standard - Level	40 ug/kg	40 ug/kg	40 ug/kg
bromochloromethane - Recovery	140%	115%	100%
Internal Standard - Level	40 ug/kg	40 ug/kg	40 ug/kg
2-bromo-1-chloropropane - Recovery	140%	81%	84%
Internal Standard - Level	40 ug/kg	40 ug/kg	40 ug/kg
1,4-dichlorobutane - Recovery	140%	90%	89%

FOR RECRA ENVIRONMENTAL LABORATORIES

DATE

Barbara J. Kasper
9/24/84



ANALYTICAL RESULTS

MONROE COUNTY ENVIRONMENTAL HEALTH LABORATORY GAS CHROMATOGRAPHY/MASS SPECTROMETRY PRIORITY POLLUTANT ANALYSES

Report Date: 9/24/84

VOLATILES

COMPOUND	DETECTION LIMIT (ug/kg dry)	SAMPLE IDENTIFICATION		
		2-1	2-2	2-3
acrolein	600	ND	ND	ND
acrylonitrile	600	ND	ND	ND
benzene	6.3	ND	ND	ND
bromodichloromethane	3.1	ND	ND	ND
bromoform	6.7	ND	ND	ND
bromomethane	14	ND	ND	ND
carbon tetrachloride	4.0	ND	ND	ND
chlorobenzene	8.6	ND	ND	ND
chloroethane	14	ND	ND	ND
2-chloroethylvinyl ether	14	ND	ND	ND
chloroform	2.3	ND	ND	ND
chloromethane	14	ND	ND	ND
dibromochloromethane	4.4	ND	ND	ND
1,1-dichloroethane	6.7	ND	ND	ND
1,2-dichloroethane	4.0	ND	ND	ND
1,1-dichloroethylene	4.0	ND	ND	ND
trans-1,2-dichloroethylene	2.3	ND	ND	ND
1,2-dichloropropane	8.6	ND	ND	ND
1,3-dichloropropene	7.1	ND	ND	ND
ethylbenzene	10	ND	ND	ND
methylene chloride	4.0	ND	ND	ND
1,1,2,2-tetrachloroethane	9.8	ND	ND	ND
tetrachloroethylene	5.8	ND	ND	ND

(Continued)



ANALYTICAL RESULTS

MONROE COUNTY ENVIRONMENTAL HEALTH LABORATORY
GAS CHROMATOGRAPHY/MASS SPECTROMETRY
PRIORITY POLLUTANT ANALYSES

Report Date: 9/24/84

VOLATILES

COMPOUND	DETECTION LIMIT (ug/kg dry)	SAMPLE IDENTIFICATION		
		2-1	2-2	2-3
toluene	8.6	560 ug/kg dry	ND	ND
1,1,1-trichloroethane	5.4	ND	ND	ND
1,1,2-trichloroethane	7.1	ND	ND	ND
trichloroethylene	2.7	ND	ND	ND
vinyl chloride	14	ND	ND	ND

ADDITIONAL SAMPLE INFORMATION

Sample Date	8/2/84	8/2/84	8/2/84
Analysis Date	9/15/84	9/12/84	9/12/84
Internal Standard - Level	40 ug/kg	40 ug/kg	40 ug/kg
bromochloromethane - Recovery	110%	97%	130%
Internal Standard - Level	40 ug/kg	40 ug/kg	40 ug/kg
2-bromo-1-chloropropane - Recovery	140%	77%	98%
Internal Standard - Level	40 ug/kg	40 ug/kg	40 ug/kg
1,4-dichlorobutane - Recovery	140%	87%	100%

FOR RECRA ENVIRONMENTAL LABORATORIES

DATE

Bulane J. Kojewski
9/24/84

ANALYTICAL RESULTS

MONROE COUNTY ENVIRONMENTAL HEALTH LABORATORY
GAS CHROMATOGRAPHY/MASS SPECTROMETRY
PRIORITY POLLUTANT ANALYSES

Report Date: 9/24/84

VOLATILES

COMPOUND	DETECTION LIMIT (ug/kg dry)	SAMPLE IDENTIFICATION		
		UPSTREAM	DOWNSTREAM	CEMETERY
acrolein	600	ND	ND	ND
acrylonitrile	600	ND	ND	ND
benzene	6.3	ND	ND	ND
bromodichloromethane	3.1	ND	ND	ND
bromoform	6.7	ND	ND	ND
bromomethane	14	ND	ND	ND
carbon tetrachloride	4.0	ND	ND	ND
chlorobenzene	8.6	ND	ND	ND
chloroethane	14	ND	ND	ND
2-chloroethylvinyl ether	14	ND	ND	ND
chloroform	2.3	ND	ND	ND
chloromethane	14	ND	ND	ND
dibromochloromethane	4.4	ND	ND	ND
1,1-dichloroethane	6.7	ND	ND	ND
1,2-dichloroethane	4.0	ND	ND	ND
1,1-dichloroethylene	4.0	ND	ND	ND
trans-1,2-dichloroethylene	2.3	ND	ND	ND
1,2-dichloropropane	8.6	ND	ND	ND
1,3-dichloropropane	7.1	ND	ND	ND
ethylbenzene	10	ND	ND	ND
methylene chloride	4.0	ND	ND	ND
1,1,2,2-tetrachloroethane	9.8	ND	ND	ND
tetrachloroethylene	5.8	ND	ND	ND

(Continued)



ANALYTICAL RESULTS

MONROE COUNTY ENVIRONMENTAL HEALTH LABORATORY GAS CHROMATOGRAPHY/MASS SPECTROMETRY PRIORITY POLLUTANT ANALYSES

Report Date: 9/24/84

VOLATILES

COMPOUND	DETECTION LIMIT (ug/kg dry)	SAMPLE IDENTIFICATION		
		UPSTREAM	DOWNSTREAM	CEMETERY
toluene	8.6	ND	1700 ug/kg dry	ND
1,1,1-trichloroethane	5.4	ND	ND	ND
1,1,2-trichloroethane	7.1	ND	ND	ND
trichloroethylene	2.7	ND	ND	ND
vinyl chloride	14	ND	ND	ND

ADDITIONAL SAMPLE INFORMATION

Sample Date	8/2/84	8/3/84	8/3/84
Analysis Date	8/23/84	8/23/84	8/23/84
Internal Standard - Level	40 ug/kg	40 ug/kg	40 ug/kg
bromochloromethane - Recovery	130%	110%	88%
Internal Standard - Level	40 ug/kg	40 ug/kg	40 ug/kg
2-bromo-1-chloropropane - Recovery	110%	120%	88%
Internal Standard - Level	40 ug/kg	40 ug/kg	40 ug/kg
1,4-dichlorobutane - Recovery	120%	110%	85%

FOR RECRA ENVIRONMENTAL LABORATORIES

DATE

Barbara J. Kasper
9/24/84



ANALYTICAL RESULTS

MONROE COUNTY ENVIRONMENTAL HEALTH LABORATORY
GAS CHROMATOGRAPHY/MASS SPECTROMETRY
PRIORITY POLLUTANT ANALYSES

Report Date: 9/24/84

VOLATILES

COMPOUND	DETECTION LIMIT (ug/kg drv)	SAMPLE IDENTIFICATION	
		DS KOD WEST (UPPER)	DS KOD WEST (LOWER)
acrolein	600	ND	ND
acrylonitrile	600	ND	ND
benzene	6.3	ND	ND
bromodichloromethane	3.1	ND	ND
bromoform	6.7	ND	ND
bromomethane	14	ND	ND
carbon tetrachloride	4.0	ND	ND
chlorobenzene	8.6	ND	ND
chloroethane	14	ND	ND
2-chloroethylvinyl ether	14	ND	ND
chloroform	2.3	ND	ND
chloromethane	14	ND	ND
dibromochloromethane	4.4	ND	ND
1,1-dichloroethane	6.7	ND	ND
1,2-dichloroethane	4.0	ND	ND
1,1-dichloroethylene	4.0	ND	ND
trans-1,2-dichloroethylene	2.3	ND	ND
1,2-dichloropropane	8.6	ND	ND
1,3-dichloropropene	7.1	ND	ND
ethylbenzene	10	ND	ND
methylene chloride	4.0	ND	ND
1,1,2,2-tetrachloroethane	9.8	ND	ND
tetrachloroethylene	5.8	ND	ND

(Continued)



ANALYTICAL RESULTS

MONROE COUNTY ENVIRONMENTAL HEALTH LABORATORY
GAS CHROMATOGRAPHY/MASS SPECTROMETRY
PRIORITY POLLUTANT ANALYSES

Report Date: 9/24/84

VOLATILES

COMPOUND	DETECTION LIMIT (ug/kg drv)	SAMPLE IDENTIFICATION	
		DS KOD WEST (UPPER)	DS KOD WEST (LOWER)
toluene	8.6	ND	ND
1,1,1-trichloroethane	5.4	ND	ND
1,1,2-trichloroethane	7.1	ND	ND
trichloroethylene	2.7	ND	ND
vinyl chloride	14	ND	ND

ADDITIONAL SAMPLE INFORMATION

Sample Date	8/2/84	8/2/84
Analysis Date	9/12/84	9/12/84
Internal Standard - Level	40 ug/kg	40 ug/kg
bromochloromethane - Recovery	89%	93%
Internal Standard - Level	40 ug/kg	40 ug/kg
2-bromo-1-chloropropane - Recovery	78%	71%
Internal Standard - Level	40 ug/kg	40 ug/kg
1,4-dichlorobutane - Recovery	81%	78%

FOR RECRA ENVIRONMENTAL LABORATORIES

DATE

Barbara J. Krajewski
9/24/84



ANALYTICAL RESULTS

MONROE COUNTY ENVIRONMENTAL HEALTH LABORATORY
GAS CHROMATOGRAPHY/MASS SPECTROMETRY
PRIORITY POLLUTANT ANALYSES
QUALITY CONTROL

Report Date: 9/24/84

EXTRACTABLE RECOVERY ANALYSIS OF
METHOD BLANK

COMPOUND IDENTIFICATION	ng OF SPIKE	ng RECOVERED	% RECOVERY
2-chlorophenol	50	38	76
1,3-dichlorobenzene	50	38	76
2,4-dichlorophenol	50	37	74
di-n-octylphthalate	50	43	86
fluoranthene	50	42	84
naphthalene	50	39	78
nitrobenzene	50	31	62
2,4,6-trichlorophenol	50	37	74

ADDITIONAL SAMPLE INFORMATION

Sample Date	8/2/84
Extraction Date	8/13/84
Analysis Date	8/28/84
Internal Standard (IS) - Level	20 µg/l
deuterated phenanthrene - Recovery	107%
Surrogate Standard (SS1) - Level	120 µg/l
2-fluorophenol - Recovery	81%
Surrogate Standard (SS2) - Level	120 µg/l
pentafluorophenol - Recovery	66%
Surrogate Standard (SS3) - Level	120 µg/l
Decafluorobiphenyl - Recovery	98%
Surrogate Standard (SS4) - Level	100 µg/l
2-fluorobiphenyl - Recovery	80%

FOR RECRA ENVIRONMENTAL LABORATORIES

DATE

Barbara J. Kojewski
9/24/84

ANALYTICAL RESULTS

MONROE COUNTY ENVIRONMENTAL HEALTH LABORATORY
GAS CHROMATOGRAPHY/MASS SPECTROMETRY
PRIORITY POLLUTANT ANALYSES
QUALITY CONTROL

Report Date: 9/24/84

VOLATILE RECOVERY ANALYSIS OF
SAMPLE 1-1

COMPOUND IDENTIFICATION	ng OF SPIKE	ng RECOVERED	% RECOVERY
bromomethane	80	84	105
carbon tetrachloride	80	63	79
chlorobenzene	80	83	104
chloroethane	80	78	98
chloroform	80	120	150
chloromethane	80	100	125
dibromochloromethane	80	100	125
1,1-dichloroethane	80	74	93
1,1-dichloroethylene	80	73	91
1,2-dichloropropane	80	115	140
methylene chloride	80	93	116
tetrachloroethylene	80	95	118
1,1,2-trichloroethane	80	100	125
trichloroethylene	80	91	113
vinyl chloride	80	89	110

ADDITIONAL SAMPLE INFORMATION

Sample Date	8/2/84
Analysis Date	9/14/84
Internal Standard - Level	40 ug/kg
Bromochloromethane - Recovery	98%
Internal Standard - Level	40 ug/kg
2-bromo-1-chloropropane - Recovery	86%
Internal Standard - Level	40 ug/kg
1,4-dichlorobutane - Recovery	94%

FOR RECRA ENVIRONMENTAL LABORATORIES

DATE

Barbara J. Kraperdui
9/24/84

ANALYTICAL RESULTS

MONROE COUNTY ENVIRONMENTAL HEALTH LABORATORY
GAS CHROMATOGRAPHY/MASS SPECTROMETRY
PRIORITY POLLUTANT ANALYSES
QUALITY CONTROL

Report Date: 9/24/84

REPLICATE VOLATILE ANALYSIS OF
SAMPLE 1-1

COMPOUND IDENTIFICATION	UNITS OF MEASURE	VALUE 1	VALUE 2	MEAN	STANDARD DEVIATION	PERCENT COEFFICIENT OF VARIATION
toluene	ug/kg dry	290	420	360	92	26

FOR RECRA ENVIRONMENTAL LABORATORIES

DATE

Barbara J. Krajewski
9/24/84

ANALYTICAL RESULTS

MONROE COUNTY ENVIRONMENTAL HEALTH LABORATORY
GAS CHROMATOGRAPHY/MASS SPECTROMETRY
EXTRACTABLE LIBRARY COMPARISON SEARCH

Report Date: 9/24/84

SAMPLE I.D.: DOWNSTREAM

COMPUTER LIBRARY CHOICE	CAS #	ESTIMATED CONCENTRATION
3-methylphenol	108394	1 ug/g

SAMPLE I.D.: 1-1

COMPUTER LIBRARY CHOICE	CAS #	ESTIMATED CONCENTRATION
3-methylphenol	108394	1 ug/g

FOR RECRA ENVIRONMENTAL LABORATORIES

DATE

Barbara J. Kaperis
9/24/84

ANALYTICAL RESULTS

MONROE COUNTY ENVIRONMENTAL HEALTH LABORATORY
GAS CHROMATOGRAPHY/MASS SPECTROMETRY
VOLATILE LIBRARY COMPARISON SEARCH

Report Date: 9/24/84

SAMPLE I.D.: 1-2

COMPUTER LIBRARY CHOICE	CAS #	ESTIMATED CONCENTRATION
1,1'-oxybisethane	60-29-7	10 µg/kg

SAMPLE I.D.: 1-3

COMPUTER LIBRARY CHOICE	CAS #	ESTIMATED CONCENTRATION
1,1'-oxybisethane	60-29-7	10 µg/kg

SAMPLE I.D.: 2-2

COMPUTER LIBRARY CHOICE	CAS #	ESTIMATED CONCENTRATION
1,1'-oxybisethane	60-29-7	10 µg/kg

SAMPLE I.D.: CEMETERY

COMPUTER LIBRARY CHOICE	CAS #	ESTIMATED CONCENTRATION
3-chloro-1-propene	107-05-1	1 µg/kg
1,1'-oxybisethane	60-29-7	10 µg/kg
1,1,3-trimethylcyclohexane	3073-66-3	1 µg/kg

FOR RECRA ENVIRONMENTAL LABORATORIES

DATE

Barbara J. Krajewski
9/24/84

ANALYTICAL RESULTS

MONROE COUNTY ENVIRONMENTAL HEALTH LABORATORY

Report Date: 9/24/84

METALS

COMPOUND	UNITS OF MEASURE	SAMPLE IDENTIFICATION (DATE)		
		1-1 (8/2/84)	1-2 (8/2/84)	1-3 (8/2/84)
Total antimony	ug/g drv	<0.7	<0.6	<0.7
Total arsenic	ug/g drv	9.9	17	9.8
Total beryllium	ug/g drv	<0.5	<0.4	<0.4
Total cadmium	ug/g drv	<0.7	<0.6	<0.7
Total chromium	ug/g drv	13	15	7.6
Total copper	ug/g drv	11	18	11
Total lead	ug/g drv	13	13	8.9
Total mercury	ug/g drv	<0.1	0.20	<0.2
Total nickel	ug/g drv	22	31	14
Total selenium	ug/g drv	<0.7	<0.6	<0.7
Total silver	ug/g drv	<0.7	<0.6	<0.7
Total thallium	ug/g drv	<0.7	<0.6	<0.7
Total zinc	ug/g drv	39	60	39

FOR RECRA ENVIRONMENTAL LABORATORIES

DATE

D. V. Furr
9/24/84

ANALYTICAL RESULTS

MONROE COUNTY ENVIRONMENTAL HEALTH LABORATORY

Report Date: 9/24/84

COMPOUND	UNITS OF MEASURE	METALS SAMPLE IDENTIFICATION (DATE)		
		2-1 (8/2/84)	2-2 (8/2/84)	2-3 (8/2/84)
Total antimony	ug/g dry	<0.8	<0.8	<0.7
Total arsenic	ug/g dry	14	4.4	17
Total beryllium	ug/g dry	<0.5	<0.6	<0.5
Total cadmium	ug/g dry	<0.8	<0.8	<0.7
Total chromium	ug/g dry	14	3.7	13
Total copper	ug/g dry	14	3.7	18
Total lead	ug/g dry	16	6.8	18
Total mercury	ug/g dry	0.13	<0.2	0.12
Total nickel	ug/g dry	26	9.5	27
Total selenium	ug/g dry	<0.8	<0.8	<0.7
Total silver	ug/g dry	<0.8	<0.8	<0.7
Total thallium	ug/g dry	<0.8	<0.8	<0.7
Total zinc	ug/g dry	54	10	67

FOR RECRA ENVIRONMENTAL LABORATORIES

DATE

R. V. Fin
9/24/84

ANALYTICAL RESULTS

MONROE COUNTY ENVIRONMENTAL HEALTH LABORATORY

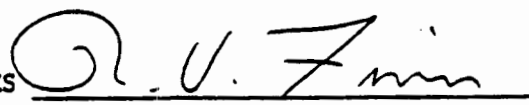
Report Date: 9/24/84

METALS

COMPOUND	UNITS OF MEASURE	SAMPLE IDENTIFICATION (DATE)		
		203-1 (8/2/84)	203-2 (8/2/84)	203-3 (8/2/84)
Total antimony	ug/g dry	<0.7	<0.8	<0.7
Total arsenic	ug/g dry	5.8	10	4.7
Total beryllium	ug/g dry	<0.4	0.62	<0.4
Total cadmium	ug/g dry	<0.7	<0.8	<0.7
Total chromium	ug/g dry	9.2	14	11
Total copper	ug/g dry	15	17	15
Total lead	ug/g dry	12	25	12
Total mercury	ug/g dry	0.21	<0.2	<0.2
Total nickel	ug/g dry	17	25	21
Total selenium	ug/g dry	<0.7	<0.8	<0.7
Total silver	ug/g dry	<0.7	<0.8	<0.7
Total thallium	ug/g dry	<0.7	<0.8	<0.7
Total zinc	ug/g dry	89	106	74

FOR RECREATION ENVIRONMENTAL LABORATORIES

DATE


9/24/84

ANALYTICAL RESULTS

MONROE COUNTY ENVIRONMENTAL HEALTH LABORATORY

Report Date: 9/24/84

METALS

COMPOUND	UNITS OF MEASURE	SAMPLE IDENTIFICATION (DATE)	
		DS KOD WEST (LOWER) (8/2/84)	DS KOD WEST (UPPER) (8/2/84)
Total antimony	ug/g drv	<0.7	<0.8
Total arsenic	ug/g drv	16	12
Total beryllium	ug/g drv	<0.5	0.81
Total cadmium	ug/g drv	6.5	27
Total chromium	ug/g drv	23	37
Total copper	ug/g drv	32	46
Total lead	ug/g drv	41	69
Total mercury	ug/g drv	0.47	0.89
Total nickel	ug/g drv	35	41
Total selenium	ug/g drv	<0.7	<0.8
Total silver	ug/g drv	12	27
Total thallium	ug/g drv	<0.7	<0.8
Total zinc	ug/g drv	194	440

FOR RECRA ENVIRONMENTAL LABORATORIES

DATE

R.V. Furrin
9/24/84

ANALYTICAL RESULTS

MONROE COUNTY ENVIRONMENTAL HEALTH LABORATORY

Report Date: 9/24/84

METALS

COMPOUND	UNITS OF MEASURE	SAMPLE IDENTIFICATION (DATE)		
		CEMETERY (8/3/84)	DOWNSTREAM (8/3/84)	UPSTREAM (8/3/84)
Total antimony	ug/g dry	<0.8	<0.8	<0.7
Total arsenic	ug/g dry	19	12	5.8
Total beryllium	ug/g dry	0.60	<0.5	<0.5
Total cadmium	ug/g dry	4.8	2.9	<0.7
Total chromium	ug/g dry	24	21	10
Total copper	ug/g dry	40	25	16
Total lead	ug/g dry	49	41	15
Total mercury	ug/g dry	0.56	0.15	<0.1
Total nickel	ug/g dry	37	29	16
Total selenium	ug/g dry	<0.8	<0.8	<0.7
Total silver	ug/g dry	20	24	1.1
Total thallium	ug/g dry	<0.8	<0.8	<0.7
Total zinc	ug/g dry	187	112	57

FOR RECRA ENVIRONMENTAL LABORATORIES

D. V. Finner

DATE

9/24/84

ANALYTICAL RESULTS

MONROE COUNTY ENVIRONMENTAL HEALTH LABORATORY
PRIORITY POLLUTANT ANALYSES

Report Date: 9/24/84

MISCELLANEOUS

COMPOUND	UNITS OF MEASURE	SAMPLE IDENTIFICATION (DATE)		
		1-1 (8/2/84)	1-2 (8/2/84)	1-3 (8/2/84)
Total cyanide	ug/g dry	<0.7	<0.7	<0.7
Total recoverable phenolics	ug/g dry	<0.7	<0.7	<0.7

FOR RECRA ENVIRONMENTAL LABORATORIES

A. V. Zinn

DATE

9/24/84



ANALYTICAL RESULTS

MONROE COUNTY ENVIRONMENTAL HEALTH LABORATORY
PRIORITY POLLUTANT ANALYSES

Report Date: 9/24/84

MISCELLANEOUS

COMPOUND	UNITS OF MEASURE	SAMPLE IDENTIFICATION (DATE)		
		2-1 (8/2/84)	2-2 (8/2/84)	2-3 (8/2/84)
Total cyanide	ug/g drv	<0.8	<0.8	<0.8
Total recoverable phenolics	ug/g drv	<0.8	<0.8	<0.8

FOR RECRA ENVIRONMENTAL LABORATORIES

R. V. Fin

DATE

9/24/84

ANALYTICAL RESULTS

MONROE COUNTY ENVIRONMENTAL HEALTH LABORATORY
PRIORITY POLLUTANT ANALYSES

Report Date: 9/24/84

MISCELLANEOUS

COMPOUND	UNITS OF MEASURE	SAMPLE IDENTIFICATION (DATE)		
		203-1 (8/2/84)	203-2 (8/2/84)	203-3 (8/2/84)
Total cyanide	µg/g dry	<0.7	<0.8	<0.7
Total recoverable phenolics	µg/g dry	<0.7	<0.8	<0.7

FOR RECRA ENVIRONMENTAL LABORATORIES

DATE

D. V. Finn
9/24/84



ANALYTICAL RESULTS

MONROE COUNTY ENVIRONMENTAL HEALTH LABORATORY
PRIORITY POLLUTANT ANALYSES

Report Date: 9/24/84

MISCELLANEOUS

COMPOUND	UNITS OF MEASURE	SAMPLE IDENTIFICATION (DATE)	
		DS KOD WEST (LOWER) (8/2/84)	DS KOD WEST (UPPER) (8/2/84)
Total cyanide	ug/g dry	10.9	4.58
Total recoverable phenolics	ug/g dry	<0.8	<0.9
Free cyanide	ug/g dry	1.43	2.61

FOR RECRA ENVIRONMENTAL LABORATORIES

DATE

D. V. F. min
9/24/84

ANALYTICAL RESULTS

MONROE COUNTY ENVIRONMENTAL HEALTH LABORATORY
PRIORITY POLLUTANT ANALYSES

Report Date: 9/24/84

MISCELLANEOUS

COMPOUND	UNITS OF MEASURE	SAMPLE IDENTIFICATION (DATE)		
		CEMETERY (8/3/84)	DOWNSTREAM (8/3/84)	UPSTREAM (8/3/84)
Total cyanide	ug/g dry	14.2	4.60	<0.7
Total recoverable phenolics	ug/g dry	<0.8	<0.8	<0.7
Free cyanide	ug/g dry	<0.8	<0.8	-

FOR RECRA ENVIRONMENTAL LABORATORIES

DATE

D. V. Finner
9/24/84

ANALYTICAL RESULTS

MONROE COUNTY ENVIRONMENTAL HEALTH LABORATORY
QUALITY CONTROL

Report Date: 9/24/84

REPLICATE ANALYSES

PARAMETER	SAMPLE I.D.	UNITS OF MEASURE	VALUE 1	VALUE 2	MEAN	STANDARD DEVIATION	PERCENT COEFFICIENT OF VARIATION
Total Antimony	Cemetery	ug/g dry	<0.8	<0.8	<0.8	-	-
Total Arsenic	Cemetery	ug/g dry	17.8	19.4	18.6	1.14	6.2
Total Beryllium	Cemetery	ug/g dry	0.61	0.59	0.60	0.015	2.5
Total Cadmium	Cemetery	ug/g dry	5.08	4.49	4.78	0.41	8.7
Total Chromium	Cemetery	ug/g dry	23.5	23.5	23.5	0	0
Total Copper	Cemetery	ug/g dry	40.7	39.7	40.2	0.71	1.8
Total Lead	Cemetery	ug/g dry	47.7	50.9	49.2	2.2	4.8
Total Mercury	Cemetery	ug/g dry	0.74	0.37	0.559	0.26	47
Total Nickel	Cemetery	ug/g dry	33.9	40.3	37.1	4.6	12
Total Selenium	Cemetery	ug/g dry	<0.8	<0.8	<0.8	-	-
Total Silver	Cemetery	ug/g dry	21.0	18.98	20.0	1.5	7.4
Total Thallium	Cemetery	ug/g dry	<0.8	<0.8	<0.8	-	-
Total Zinc	Cemetery	ug/g dry	182	191	186	6.1	3.2
Total Recoverable Phenolics	2-1	ug/g dry	<0.8	<0.8	<0.8	-	-
Total Cyanide	Downstream	ug/g dry	4.55	4.65	4.60	0.07	1.5
Free Cyanide	DS KOD West (Upper)	ug/g dry	2.47	2.71	2.59	0.17	6.5

FOR RECRA ENVIRONMENTAL LABORATORIES

DATE

D. V. Zinn
9/24/84

ANALYTICAL RESULTS

MONROE COUNTY ENVIRONMENTAL HEALTH LABORATORY
QUALITY CONTROL

Report Date: 9/24/84

RECOVERY ANALYSIS

PARAMETER	SAMPLE IDENTIFICATION	µg OF SPIKE	µg RECOVERED	% RECOVERY
Total Antimony	DS KOD West (Lower)	100	100	100
Total Arsenic	DS KOD West (Lower)	100	83	83
Total Beryllium	2-3	1,000	970	97
Total Cadmium	DS KOD West (Lower)	1,000	1,030	103
Total Chromium	DS KOD West (Lower)	1,000	940	94
Total Copper	DS KOD West (Lower)	1,000	990	99
Total Lead	DS KOD West (Lower)	100	111	111
Total Mercury	2-3	0.4	0.356	89
Total Nickel	DS KOD West (Lower)	100	129	129
Total Silver	DS KOD West (Lower)	1,000	1,000	100
Total Thallium	DS KOD West (Lower)	100	86	86
Total Zinc	DS KOD West (Lower)	1,000	980	98
Total Recoverable Phenolics	2-1	20	19	95
Total Cyanide	Downstream	10	9.5	95
Free Cyanide	DS KOD West (Upper)	50	46	92

FOR RECRA ENVIRONMENTAL LABORATORIES

DATE

R. V. Finner
9/24/84



RECRA ENVIRONMENTAL LABORATORIES

Division of Recra Research, Inc.

ANALYTICAL RESULTS

MONROE COUNTY ENVIRONMENTAL HEALTH LABORATORY PRIORITY POLLUTANT ANALYSES

Prepared For:

Monroe County Environmental
Health Laboratory
435 East Henrietta Road
Rochester, NY 14620

Prepared By:

Recra Environmental Laboratories
4248 Ridge Lea Road
Amherst, NY 14226

Report Date:

January 23, 1985

ANALYTICAL RESULTS

SECTION 4
REF 34

MONROE COUNTY ENVIRONMENTAL HEALTH LABORATORY PRIORITY POLLUTANT ANALYSES

Report Date: 1/23/85

INTRODUCTION:

On November 29, 1984 a sample was received at Recra Environmental Laboratories. A request was made by Monroe County Environmental Health Laboratory to have the sample analyzed for selected fractions of the Environmental Protection Agency decreed priority pollutants. Also, any non-priority pollutant constituents of the acid phenolic, base neutral, and volatile fractions were to be identified and quantified.

This report will address the results of those analyses.

METHODS:

Priority pollutant analyses were conducted according to Environmental Protection Agency (EPA) methodologies.

Organic priority pollutants were analyzed by Gas Chromatography/Mass Spectrometry (GC/MS). Pesticide priority pollutants were analyzed by Gas Chromatography.

RESULTS AND DISCUSSION:

Results are corrected for moisture content and are reported on a dry weight basis. The sample's dry weight was determined to be 71%.

No significant peaks were seen in the acid phenolic, base neutral, or volatile fractions; therefore, no library search of non-priority pollutant constituents was performed.



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RESULTS AND DISCUSSION (CONT'D.):

Analyses for specific Pesticides/PCB's are based upon the matching of retention times between samples and standards on a single gas chromatographic column. Gas chromatographic values reported as "less than" (<) indicate the working detection limit for the given sample and/or parameter.

Compounds reported as ND are "not detected". Compounds reported as BDL are confirmed as being present in the sample at a level "below detection limit", and are not subject to reliable quantitation.

Respectfully Submitted,

RECRA ENVIRONMENTAL LABORATORIES

Barbara J. Krajewski

Barbara J. Krajewski
GC/MS Supervisor

BJK/mdc



RECRA ENVIRONMENTAL LABORATORIES

ANALYTICAL RESULTS

MONROE COUNTY ENVIRONMENTAL HEALTH LABORATORY
GAS CHROMATOGRAPHY/MASS SPECTROMETRY
PRIORITY POLLUTANT ANALYSES

Report Date: 1/23/85

ACID/PHENOLICS

COMPOUND	DETECTION LIMIT (ug/g dry)	SAMPLE IDENTIFICATION
		BARGE CANAL
2-chlorophenol	1	ND
2,4-dichlorophenol	1	ND
2,4-dimethylphenol	1	ND
4,6-dinitro-o-cresol	2	ND
2,4-dinitrophenol	3	ND
2-nitrophenol	1	ND
4-nitrophenol	1	ND
p-chloro-m-cresol	1	ND
pentachlorophenol	1	ND
phenol	1	BDL
2,4,6-trichlorophenol	1	ND

ADDITIONAL SAMPLE INFORMATION

Sample Date	11/15/84
Extraction Date	12/6/84
Analysis Date	1/15/85
Internal Standard (IS) - Level	1 ug/g
deuterated phenanthrene - Recovery	86%
Surrogate Standard (SS1) - Level	5 ug/g
2-fluorophenol - Recovery	130%
Surrogate Standard (SS2) - Level	5 ug/g
pentafluorophenol - Recovery	56%

FOR RECRA ENVIRONMENTAL LABORATORIES

DATE

Antonia J. Kujewski
1/23/85

RECRA ENVIRONMENTAL LABORATORIES

I.D. #84-1196

ANALYTICAL RESULTS

MONROE COUNTY ENVIRONMENTAL HEALTH LABORATORY
GAS CHROMATOGRAPHY/MASS SPECTROMETRY
PRIORITY POLLUTANT ANALYSES

Report Date: 1/23/85

BASE/NEUTRALS

COMPOUND	DETECTION LIMIT ($\mu\text{g/g dry}$)	SAMPLE IDENTIFICATION
		BARGE CANAL
acenaphthene	1	ND
acenaphthylene	1	ND
anthracene	1	ND
benzidine	3	ND
benzo(a)anthracene	1	ND
benzo(a)pyrene	1	ND
benzo(b)fluoranthene	1	ND
benzo(g,h,i)perylene	1	ND
benzo(k)fluoranthene	1	ND
bis(2-chloroethoxy)methane	1	ND
bis(2-chloroethyl)ether	1	ND
bis(2-chloroisopropyl)ether	1	ND
bis(2-ethylhexyl)phthalate	1	ND
4-bromophenylphenylether	1	ND
butylbenzylphthalate	1	ND
2-chloronaphthalene	1	ND
4-chlorophenylphenylether	1	ND
chrysene	1	ND
dibenzo(a,h)anthracene	1	ND
1,2-dichlorobenzene	1	ND
1,3-dichlorobenzene	1	ND
1,4-dichlorobenzene	1	ND
3,3'-dichlorobenzidine	2	ND
diethylphthalate	2	ND
dimethylphthalate	1	ND
di-n-butylphthalate	1	ND

(Continued)



RECREA ENVIRONMENTAL LABORATORIES

I.D. #84-1196

ANALYTICAL RESULTS

MONROE COUNTY ENVIRONMENTAL HEALTH LABORATORY
GAS CHROMATOGRAPHY/MASS SPECTROMETRY
PRIORITY POLLUTANT ANALYSES

Report Date: 1/23/85

BASE/NEUTRALS

COMPOUND	DETECTION LIMIT (ug/g dry)	SAMPLE IDENTIFICATION
		BARGE CANAL
2,6-dinitrotoluene	1	ND
2,4-dinitrotoluene	1	ND
di-n-octylphthalate	1	ND
1,2-diphenylhydrazine	2	ND
fluoranthene	1	BDL
fluorene	1	BDL
hexachlorobenzene	1	ND
hexachlorobutadiene	1	ND
hexachlorocyclopentadiene	2	ND
hexachloroethane	1	ND
indeno(1,2,3-cd)pyrene	1	ND
isophorone	1	ND
naphthalene	1	ND
nitrobenzene	1	ND
N-nitrosodimethylamine	2	ND
N-nitrosodi-n-propylamine	2	ND
N-nitrosodiphenylamine	1	ND
phenanthrene	1	ND
pyrene	1	BDL
1,2,4-trichlorobenzene	1	ND

ADDITIONAL SAMPLE INFORMATION

Sample Date	11/15/84
Extraction Date	12/6/84
Analysis Date	1/5/85
Internal Standard - Level	1 ug/g
deuterated phenanthrene - Recovery	86%
Surrogate Standard (SS3) - Level	5 ug/g
decafluorobiphenyl - Recovery	88%
Surrogate Standard (SS4) - Level	5 ug/g
2-fluorobiphenyl - Recovery	92%



FOR RECRA ENVIRONMENTAL LABORATORIES

RECRA ENVIRONMENTAL LABORATORIES

I.D. #84-1196

DATE

Sulata J. Kojanli
1/23/85

ANALYTICAL RESULTS

SECTION 4.7
REF 34MONROE COUNTY ENVIRONMENTAL HEALTH LABORATORY
GAS CHROMATOGRAPHY/MASS SPECTROMETRY
PRIORITY POLLUTANT ANALYSES

Report Date: 1/23/85

VOLATILES

COMPOUND	DETECTION LIMIT (ug/kg dry)	SAMPLE IDENTIFICATION
		BARGE CANAL
acrolein	600	ND
acrylonitrile	600	ND
benzene	6.3	ND
bromodichloromethane	3.1	ND
bromoform	6.7	ND
bromomethane	14	ND
carbon tetrachloride	4.0	ND
chlorobenzene	8.6	ND
chloroethane	14	ND
2-chloroethylvinyl ether	14	ND
chloroform	2.3	ND
chloromethane	14	ND
dibromochloromethane	4.4	ND
1,1-dichloroethane	6.7	ND
1,2-dichloroethane	4.0	ND
1,1-dichloroethylene	4.0	ND
trans-1,2-dichloroethylene	2.3	ND
1,2-dichloropropane	8.6	ND
1,3-dichloropropene	7.1	ND
ethylbenzene	10	ND
methylene chloride	4.0	ND
1,1,2,2-tetrachloroethane	9.8	ND
tetrachloroethylene	5.8	ND

(Continued)



RECREA ENVIRONMENTAL LABORATORIES

I.D. #84-1196

SECTION 4.3
REF 34

ANALYTICAL RESULTS

MONROE COUNTY ENVIRONMENTAL HEALTH LABORATORY
GAS CHROMATOGRAPHY/MASS SPECTROMETRY
PRIORITY POLLUTANT ANALYSES

Report Date: 1/23/85

VOLATILES

COMPOUND	DETECTION LIMIT ($\mu\text{g}/\text{kg}$ dry)	SAMPLE IDENTIFICATION
		BARGE CANAL
toluene	8.6	ND
1,1,1-trichloroethane	5.4	ND
1,1,2-trichloroethane	7.1	ND
trichloroethylene	2.7	ND
vinyl chloride	14	ND

ADDITIONAL SAMPLE INFORMATION

Sample Date	11/15/84
Analysis Date	1/8/85
Internal Standard - Level	40 $\mu\text{g}/\text{kg}$
bromochloromethane - Recovery	95%
Internal Standard - Level	40 $\mu\text{g}/\text{kg}$
2-bromo-1-chloropropane - Recovery	78%
Internal Standard - Level	40 $\mu\text{g}/\text{kg}$
1,4-dichlorobutane - Recovery	90%

FOR RECRA ENVIRONMENTAL LABORATORIES

DATE

Lulana J. Krajewski
1/23/85



RECRA ENVIRONMENTAL LABORATORIES

I.D. #84-1196

ANALYTICAL RESULTS

MONROE COUNTY ENVIRONMENTAL HEALTH LABORATORY
GAS CHROMATOGRAPHYSECTION 7
4.3
REF 34

Report Date: 1/23/85

PESTICIDES/PCB'S

COMPOUND	UNITS OF MEASURE	SAMPLE IDENTIFICATION
		BARGE CANAL
aldrin	ug/g dry	<0.01
α -BHC	ug/g dry	<0.01
β -BHC	ug/g dry	<0.01
δ -BHC	ug/g dry	<0.01
γ -BHC	ug/g dry	<0.01
chlordane	ug/g dry	<0.1
4,4'-DDD	ug/g dry	<0.01
4,4'-DDE	ug/g dry	<0.01
4,4'-DDT	ug/g dry	<0.01
dieldrin	ug/g dry	<0.01
α -endosulfan	ug/g dry	<0.01
β -endosulfan	ug/g dry	<0.01
endosulfan sulfate	ug/g dry	<0.01
endrin	ug/g dry	<0.01
endrin aldehyde	ug/g dry	<0.01
heptachlor	ug/g dry	<0.01
heptachlor epoxide	ug/g dry	<0.01

(Continued)



RECRA ENVIRONMENTAL LABORATORIES

I.D. #84-1196

ANALYTICAL RESULTS

MONROE COUNTY ENVIRONMENTAL HEALTH LABORATORY
GAS CHROMATOGRAPHY

Report Date: 1/23/85

PESTICIDES/PCB'S

COMPOUND	UNITS OF MEASURE	SAMPLE IDENTIFICATION
		BARGE CANAL
PCB-1016	ug/g dry	<0.1
PCB-1221	ug/g dry	<0.2
PCB-1232	ug/g dry	<0.2
PCB-1242	ug/g dry	<0.1
PCB-1248	ug/g dry	<0.1
PCB-1254	ug/g dry	<0.1
PCB-1260	ug/g dry	<0.1
toxaphene	ug/g dry	<0.3

ADDITIONAL SAMPLE INFORMATION

Sample Date	11/15/84
Extraction Date	12/1/84
Analysis Date	12/12/84

FOR RECRA ENVIRONMENTAL LABORATORIES

Frederick B. Bzdek

DATE

1/23/85

RECRA ENVIRONMENTAL LABORATORIES

I.D. #84-1196

ANALYTICAL RESULTS

MONROE COUNTY ENVIRONMENTAL HEALTH LABORATORY

Report Date: 1/23/85

METALS

COMPOUND	UNITS OF MEASURE	SAMPLE IDENTIFICATION (DATE)
		BARGE CANAL (11/15/84)
Total antimony	ug/g dry	<0.6
Total arsenic	ug/g dry	4.9
Total beryllium	ug/g dry	<0.6
Total cadmium	ug/g dry	<0.8
Total chromium	ug/g dry	14
Total copper	ug/g dry	17
Total lead	ug/g dry	6.4
Total mercury	ug/g dry	0.061
Total nickel	ug/g dry	22
Total selenium	ug/g dry	<0.6
Total silver	ug/g dry	<0.6
Total thallium	ug/g dry	<0.6
Total zinc	ug/g dry	83

FOR RECRA ENVIRONMENTAL LABORATORIES

DATE

D. V. Furr
1/23/85

RECRA ENVIRONMENTAL LABORATORIES

I.D. #84-1196

ANALYTICAL RESULTS

MONROE COUNTY ENVIRONMENTAL HEALTH LABORATORY
PRIORITY POLLUTANT ANALYSESSECTION 4.3
REF 34

Report Date: 1/23/85

MISCELLANEOUS

COMPOUND	UNITS OF MEASURE	SAMPLE IDENTIFICATION (DATE)
		BARGE CANAL (11/15/84)
Total cyanide	ug/g dry	<0.7
Total recoverable phenolics	ug/g dry	0.99

FOR RECRA ENVIRONMENTAL LABORATORIES

DATE

D. V. Finn
1/23/85

RECRA ENVIRONMENTAL LABORATORIES

I.D. #84-1196

ANALYTICAL RESULTS

SECTION 4.3
REF 34MONROE COUNTY ENVIRONMENTAL HEALTH LABORATORY
GAS CHROMATOGRAPHY/MASS SPECTROMETRY
PRIORITY POLLUTANT ANALYSES
QUALITY CONTROL

Report Date: 1/23/85

EXTRACTABLE RECOVERY ANALYSIS OF
METHOD BLANK

COMPOUND IDENTIFICATION	ng OF SPIKE	ng RECOVERED	% RECOVERY
2-chlorophenol	50	31	62
1,3-dichlorobenzene	50	40	80
2,4-dichlorophenol	50	35	70
di-n-octylphthalate	50	38	76
fluoranthene	50	58	116
fluorene	50	30	60
naphthalene	50	43	86
nitrobenzene	50	33	66
2,4,6-trichlorophenol	50	30	60

ADDITIONAL SAMPLE INFORMATION

Extraction Date	12/6/84
Analysis Date	1/14/85
Internal Standard (IS) - Level	20 µg/l
deuterated phenanthrene - Recovery	120%
Surrogate Standard (SS1) - Level	100 µg/l
2-fluorophenol - Recovery	91%
Surrogate Standard (SS2) - Level	100 µg/l
pentafluorophenol - Recovery	53%
Surrogate Standard (SS3) - Level	100 µg/l
decafluorobiphenyl - Recovery	80%
Surrogate Standard (SS4) - Level	100 µg/l
2-fluorobiphenyl - Recovery	73%

FOR RECRA ENVIRONMENTAL LABORATORIES

DATE

Barbara J. Krajinski
1/23/85

RECRA ENVIRONMENTAL LABORATORIES

I.D. #84-1196

ANALYTICAL RESULTS

SECTION 4.3
REF 34MONROE COUNTY ENVIRONMENTAL HEALTH LABORATORY
GAS CHROMATOGRAPHY
QUALITY CONTROL

Report Date: 1/23/85

RECOVERY ANALYSIS OF
METHOD BLANK

COMPOUND IDENTIFICATION	ng OF SPIKE	ng RECOVERED	% RECOVERY
Aldrin	0.025	0.023	92
γ -BHC	0.021	0.021	100
4,4'-DDE	0.017	0.018	106
Endrin	0.013	0.015	115
Heptachlor	0.015	0.016	107

FOR RECRA ENVIRONMENTAL LABORATORIES

Frederick Boyle

DATE

1/23/85

RECRA ENVIRONMENTAL LABORATORIES

I.D. #84-1196

APPENDIX C

This appendix includes copies of small documents, memos or letters referenced in this report.

<u>ITEMS DISCUSSED IN SECTION(S)</u>	<u>REFERENCE NUMBER</u>	<u>TITLE</u>
4.1	3	Louise Hartshorn, Environmental Management Council, County of Monroe, April 1987, "Summary of Activity Along the Genesee River from the Lower Falls to Upper Falls".
4.1	7	Office of the City Historian, Synopsis of Articles Contained in the Union and Advertiser Newspaper, dated 1883-1887.
4.1	8	Memorandum from Deborah Jackson, DEC Representative, March 1985; "Meeting with Concerned Citizen(s) Regarding Disposal Activities Within Lower to Upper Falls Site Area".
4.1	9	Record of Meeting Concerning NYS Superfund Sites in Monroe County, by Mark Hanna, January 1985.
4.1	10	Correspondence Letter from Emil Tenie (M.C. Pure Waters) to Richard Sutherland (M.C.D.H.), August 25, 1975, regarding possible contaminant source areas near Lower Falls.
4.2	4	Richard Young, Department of Geological Sciences, SUNY, 1983, "The Geologic Evolution of the Genesee Valley Region and Early Lake Ontario". A review of recent progress in Proceedings of the Rochester Academy of Science, Vol. 15, No. 2, November 1983.
4.2	15	USGS Water Supply Paper 2177, 1981, Hydrologic Effects of Stress Relief Fracturing in an Appalachian Valley.
4.3	36	Villaume, James F., (1985), Investigations at Sites Contaminated with Dense, Non-Aqueous Phase Liquids (NAPLs), Journal Citation Unknown.
4.3	38	U.S. EPA Office of Solid Waste, (1985?), Interim Review of Available Information Polynuclear Aromatic Hydrocarbons.
4.3	39	Rossini, Frederick D., (1960), Hydrocarbons in Petroleum, J. Chem. Ed., 37(11), 554-561.
4.3	43	Unknown (?), <u>Destructive Distillation of Coal</u> , Chapter 5: Coal Chemicals

SUMMARY OF ACTIVITY ALONG THE GENESEE RIVER
FROM THE LOWER FALLS TO THE UPPER FALLS

This summary of activity is based on interpretation of 1930, 1951, 1961, 1970, and 1975 aerial photographs. Areas of disturbance or dumping/filling are recorded as areas (i.e. A, B, C, etc.) which are noted on the attached map. The numbers on the map refer to seven subareas designated by Recra Environmental, Inc.

AREA A - Deep Hollow Ravine

1930 East of Lake Avenue - active dumping into the ravine

West of Lake Avenue - no activity; the ravine is visible, trees surround the bank of the ravine

1951 East of Lake Avenue - dumping occurring into the ravine; elevation of the former ravine area is nearly the same as the surrounding area

the junk yard is visible on a portion of the filled area

West of Lake Avenue - no activity, area is vegetated

1961 East of Lake Avenue - ravine is filled, surface disturbance visible; some recent filling down bank toward river

the junk yard is visible

West of Lake Avenue - active dumping into ravine from Kay Terrace

1970 East of Lake Avenue - the junk yard is visible

minor dumping down bank toward river from behind RG&E substation

minor disturbance along Hastings Street

West of Lake Avenue - dumping continuing into ravine
from Kay Terrace

1975 East of Lake Avenue - junk yard visible

bank east of (behind) RG&E
substation is vegetated

scattered surface debris along
Hastings Street

West of Lake Avenue - dumping into ravine continues

AREA B - Brewer Street

1930 Uniform mounds of partially vegetated material

1951 Mounded material no longer visible; light-toned
material is visible; filling over bank from Brewer
Street toward river

1961 Area is vegetated

1970 Area is vegetated

1975 Area is vegetated

AREA C - Ambrose Street

1930 Coal stockpiles visible, large volume of dumping over
bank into edge of river (north of the coal piles)

1951 Coal stockpiles visible, additional dumping has
occurred over the bank since 1930

1961 Coal stockpiles visible; some dumping occurring down
bank along edge of river

1970 Considerably less volume of coal on site; one stockpile visible. No major dumping down bank at this time although additional dumping has occurred since 1961

1975 No coal stockpiles visible. Some minor dumping is occurring

North of this site dumping is occurring down bank behind buildings

AREA D - Three areas north of the railroad bridge: 1) along edge of St. Paul Blvd., 2) behind buildings located on St. Paul Blvd., 3) area along edge of river

1930 1) Dumping down bank along edge of St. Paul Blvd.
2) Dumping down bank behind buildings located on St. Paul Blvd.
3) Light-toned area is visible along edge of river; either disturbed surface or dumping

1951 1) No dumping down bank along St. Paul Blvd.
2) Some dumping/filling down bank behind buildings located along St. Paul Blvd.
3) Multi-toned material visible along edge of river under railroad bridge

1961 1) No activity along edge of St. Paul Blvd.
2) Active dumping/filling over bank into river from behind buildings located on St. Paul Blvd. The area has expanded since 1951 into area (3), where multi-toned material was visible on the 1951 photos.

1970 The three areas have been filled to the extent that they are one large area. Minor dumping/filling down bank.

1975 Minor dumping/filling down bank

AREA E - Area northeast of Bausch & Lomb buildings located on Suntru Street

1930 Minor dumping north of the buildings

1951 No activity

1961 No activity

1970 No activity

1975 No activity

AREA F - Area along river between Bausch & Lomb and RG&E property

1930 Discharge into river from unknown source

1951 Discharge into river visible

1961 Discharge into river visible

1970 Discharge not visible

1975 Discharge not visible

AREA G - Northwest of RG&E tank #11

1930 Dark-toned material visible

1951 Material visible along river; parking area to west of material

1961 Material visible

1970 Piles of multi-toned material visible

1975 Some material visible

AREA H - South of RG&E tank #11

1930 Slight disturbance of water along bank of river - discharge?

1951 Disturbance in water still visible

1961 Gas/oil separator in concrete structure is visible

1970 Gas/oil separator in concrete structure is visible

1975 Gas/oil separator in concrete structure is visible

AREA I - West side of river in the vicinity of the Bausch Street bridge

1930 Dumping/filling into river under, north, and south of the Bausch Street bridge which is under construction at this time. Access to this site is from the incinerator/garbage reduction plant

1951 Additional dumping/filling has occurred into river north of the bridge

1961 Fill area generally vegetated with some surface debris visible

1970 Additional dumping/filling is occurring on the surface of the fill area

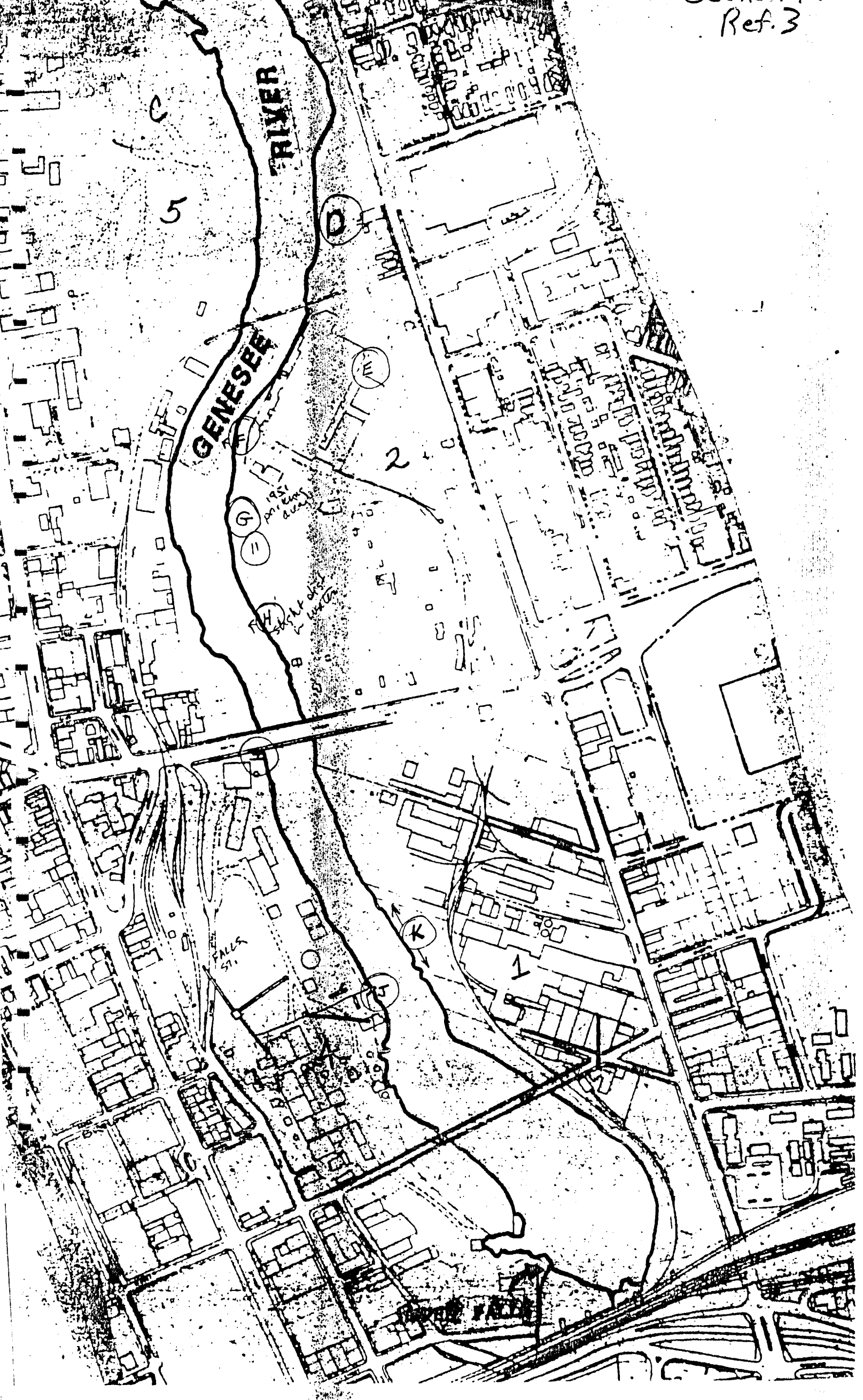
1975 A major amount of dumping/filling is occurring down bank from behind buildings located on Vincent Street (site of Upton Cold Storage)

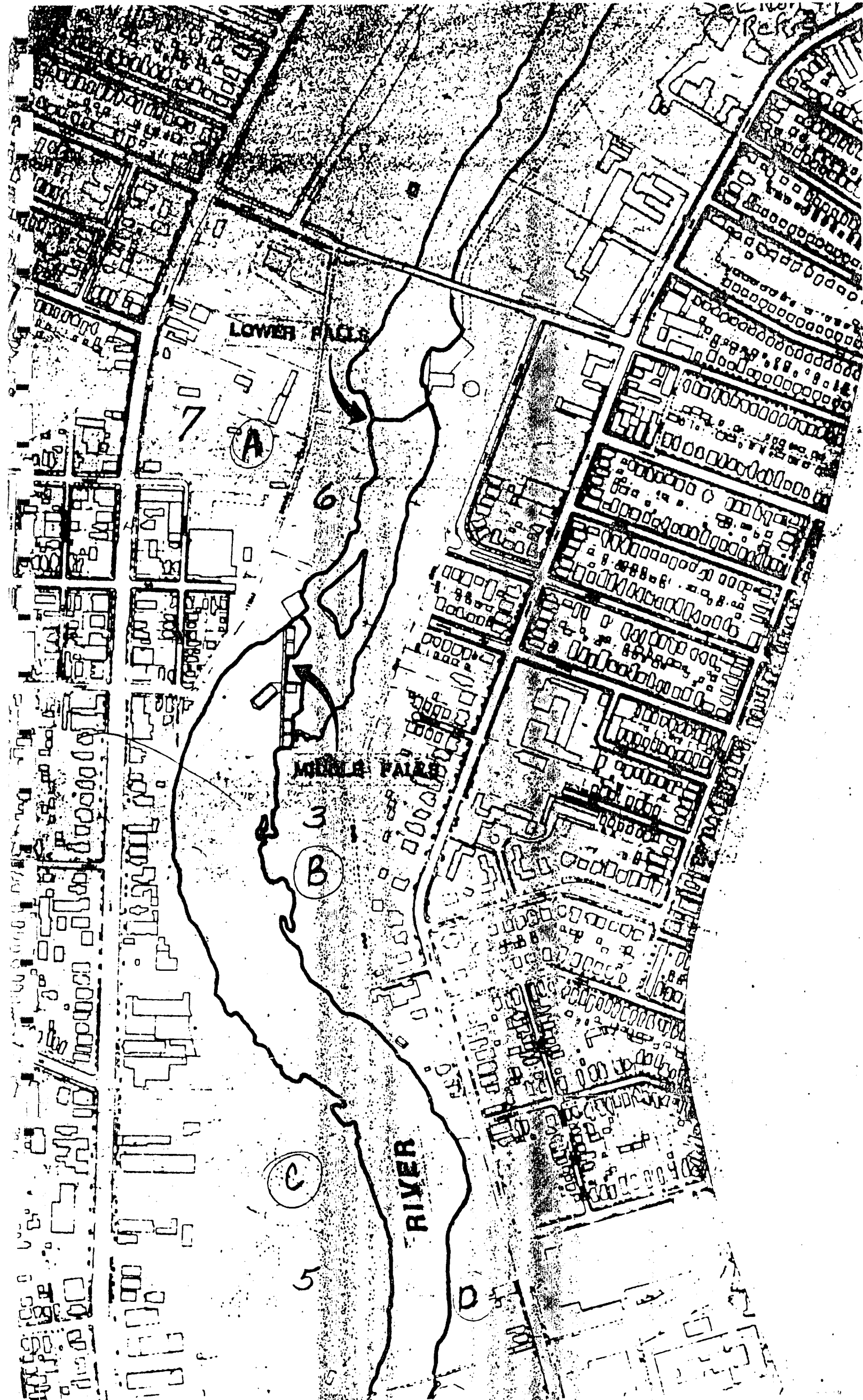
AREA J - RG&E West Station

- 1930 Discharge into river from stream which originates or surfaces at the intersection of Brown and Falls Streets (behind buildings)
- 1951 Discharge into river is visible
- 1961 Discharge not visible
- 1970 Discharge not visible
- 1975 Discharge not visible

AREA K - South of Bausch Street bridge on the east side of the river

- 1930 Dumping/filling along bank from behind buildings located on St. Paul Blvd. from the Bausch Street bridge (now under construction) to the Platt Street bridge
- 1951 Major amount of dumping/filling down bank from behind the buildings located immediately south of Bausch Street. Dumping/filling continues sporadically south to the Platt Street bridge.
- 1961 Major dumping/filling continuing behind buildings located immediately south of Bausch Street. Continued sporadic dumping/filling south to the Platt Street bridge.
- 1970 Little dumping/filling behind the buildings south of Bausch Street. However, dumping continues on the south side of a building located on the edge of the bank midway between the Bausch Street and Platt Street bridges
- 1975 Minor disturbance along bank from the Bausch Street to the Platt Street bridges





7.2 Selected References on Stress Relief and Related Phenomena

Appendix C
Section 4.2
REF 15

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Investigations at Sites Contaminated with Dense, Non-Aqueous Phase Liquids (NAPLs)

by James F. Villaume

Abstract

Increasingly, ground water supplies are being found to be contaminated with organic substances. Depending on the nature of these substances and the method by which they were introduced into the environment, they may form a second, dense liquid phase. Several such cases have been reported in the recent literature. In other cases, such a second phase might have actually been present but was not found because the principles governing its distribution were not understood and no effort was made to look for it. In this case, the undetected material could continue to migrate and act as a source of dissolved organics.

This article reviews the general principles governing the behavior of dense, immiscible second-phase organic liquids in both the unsaturated and saturated zones, based primarily on the petroleum industry literature for primary hydrocarbon migration and on the oil spill literature. This specialized knowledge can be used to conduct a meaningful and efficient investigation of such contamination sites and can also be used to select and implement successful remedial measures. Several actual case studies applying the principles of multi-phase flow are also presented.

Introduction

The presence of a separate, dense, immiscible organic liquid or liquids in the saturated (ground water) or unsaturated (vadose) zone of a porous material represents a problem in multi-phase, fluid-fluid flow. In this case, the organic liquid does not behave as it would if it were the only liquid present. In order to properly design sampling and monitoring programs for sites contaminated with such liquid wastes and to accurately interpret the results, it is important that these principles be understood and taken into account. Conventional techniques used for single-phase systems are not always appropriate.

Typical wastes and waste-producing processes described in the recent literature that could require such special techniques include polychlorinated biphenyls (Roberts et al. 1982; Schwartz et al. 1982), trichloroethylene and related chlorinated hydrocarbons (Palombo and Jacobs 1982; Carpenter 1984), coal tars from illuminating gas production (Wilson and Stevens 1981; Yazicigil and Sendlein 1981; Laformara et al. 1982; Anastos et al. 1983; Thompson et al. 1983; Unites and Houseman 1982; Villaume 1982; Adams and Atwell 1983; Villaume et al. 1983a; Villaume et al. 1983b; Villaume 1984), steel industry coking operations (Coates et al. 1982), and wood treating operations (Hult and Schoenberg 1981; Ramsey et al. 1981; Ehrlich et al. 1982; Hickok et al. 1982; Harris and Hansel 1983; Pereira et al. 1983), and other non-aqueous phase liquids (NAPLs; A.D. Little 1981). This is by no means an exhaustive listing of the literature and it does emphasize coal tar and creosote wastes, with which the author is most familiar. The author is also aware of other sites that have not been reported in the literature because of pending or potential litigation, but which contain a dense, second-phase organic liquid.

While the emphasis of this article is on dense organic liquids, most of the same principles can be applied to light organic liquids (specific gravity less than 1), especially in the unsaturated zone, but also in the ground water system where these latter materials may have become trapped (Williams and Wilder 1971). Discussed only briefly is the application of computer models to multi-phase flow. For more information the reader is referred to articles and reports by A.D. Little (1983), Tsang et al. (1983) and Faust (in press). Also discussed only briefly are remedial actions at contamination sites. For more information in this area, the reader is referred to the articles referenced in the intro-

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duction and to Unites and Solomon (in press) and Lennon and Wisniewski (1984). A general reference on remedial measures is also provided by the United States Environmental Protection Agency (1982).

Principles Governing Contaminant Distribution

In both the saturated and unsaturated zones, the contaminants of dense, immiscible organic liquids are primarily distributed as either the discrete (free) liquid (hydrocarbon phase) or as dissolved constituents in water (aqueous phase). In the aqueous phase, contaminant concentrations are determined largely by aqueous solubilities (Villaume et al. 1983). In the hydrocarbon phase, the distribution of the free liquid is controlled by a complex interplay among capillary pressure, gravitational (body) forces, and viscous (shear) forces (Villaume et al. 1983). These latter forces are discussed in detail below, first, for the saturated zone, which involves only two fluids (water and free hydrocarbon), and then for the unsaturated zone, which involves three fluids (water, free hydrocarbon and air) and represents a much more complex system. In both cases, the underlying principles are the same. The mechanisms controlling the distribution of aqueous organic species are basically the same as those involved in traditional solute transport and so will not be discussed further here, except where there is an important relationship between the dissolved and free hydrocarbon phases.

Capillary Pressure

For a hydrocarbon-water system, capillary pressure, P_c , is defined by the basic equation

$$P_c = 2\gamma \cos \theta / r \quad (1)$$

where γ is the interfacial tension between the two liquids, θ is the wetting or contact angle formed by the hydrocarbon phase against a solid surface in the presence of the pore water, and r is the radius of the water filled pore, which the hydrocarbon must enter in order to move. The interfacial tension can be viewed as an essentially liquid-liquid interaction and the wetting angle as a liquid-solid interaction, although the wetting angle is actually defined in terms of interfacial tensions according to Young's Formula.

$$\cos \theta = (\gamma_{hs} - \gamma_{ws}) / \gamma_{hw} \quad (2)$$

where γ_{hs} is the interfacial tension between the hydrocarbon and solid, γ_{ws} is the interfacial tension between the water and solid, and γ_{hw} is the interfacial tension between the water and hydrocarbon (γ in Equation 1).

Liquid-liquid interfacial tension is equal to the free surface energy at the interface formed between two immiscible or nearly immiscible liquids. The magnitude of the interfacial tension is always less than the larger of the surface tensions for the pure liquids due to the mutual attraction of unlike molecules at the interface. For dense organic liquids interfacial tension can be measured by drawing a thin platinum metal wire ring through the interface formed by placing a drop of the pore water on top of the hydrocarbon. The force required to accomplish this is then the interfacial tension, measured in units of energy over area and generally expressed in dynes/cm. Interfacial tensions for organic liquids with water range from zero for

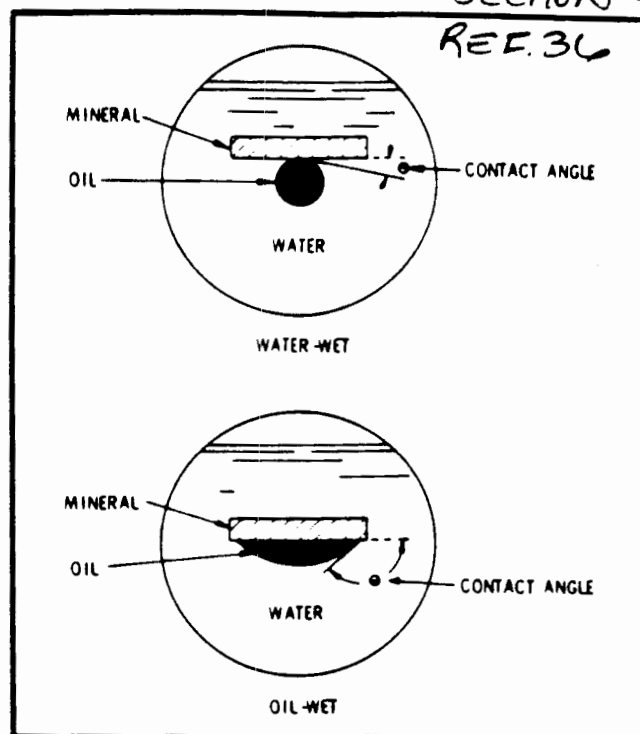


Figure 1. Determination of the contact (wetting) angle, θ , for oil in water (Treiber et al. 1972)

completely miscible liquids up to 72 dynes/cm, the surface tension of water at 77 F (25 C).

The wetting angle, in degrees, is typically measured against an ultra-clean, highly polished mineral surface (Figure 1) similar to that comprising the majority of the pore wall (porous) material. The two minerals most commonly used are calcite (simulating carbonates) and quartz (simulating sandstones and silicate rocks). The test can be run by making either the hydrocarbon advance over the water (water receding angle) or the water advance over the hydrocarbon (water advancing angle). The first test generally produces a lower result. The water receding angle models the initial hydrocarbon introduction into the ground water environment, whereas the water advancing angle models displacement of the hydrocarbon by ground water flow. A peculiarity of the test is that it typically produces a range of values until, after several days or even months, a stable value is reached. This effect is generally attributed to the presence of surfactants in the hydrocarbon (Treiber et al. 1972). Even so, the wetting angle may still be a useful indicator of whether the porous material will be preferentially wetted by either the hydrocarbon or aqueous phase. In general, if the adhesive force is greater than the cohesive force, the wetting angle is less than 90 degrees and the liquid is said to be the wetting phase.

The final parameter in the capillary pressure equation is the pore radius, or more pertinently for geologic systems, the pore structure. Unlike a single-phase system where permeability (hydraulic conductivity) and porosity are generally adequate to describe fluid flow, pore structure is a critical parameter in characterizing the movement of the fluids in a multi-phase system. Unfortunately, it is also a very difficult parameter to describe. Pore size distributions are readily developed from moisture-tension curves (Figure 2), which are widely used by soil scientists and agronomists to calibrate liquid-filled tensiometer gauges for measuring in-place soil moisture for irrigation purposes; however,

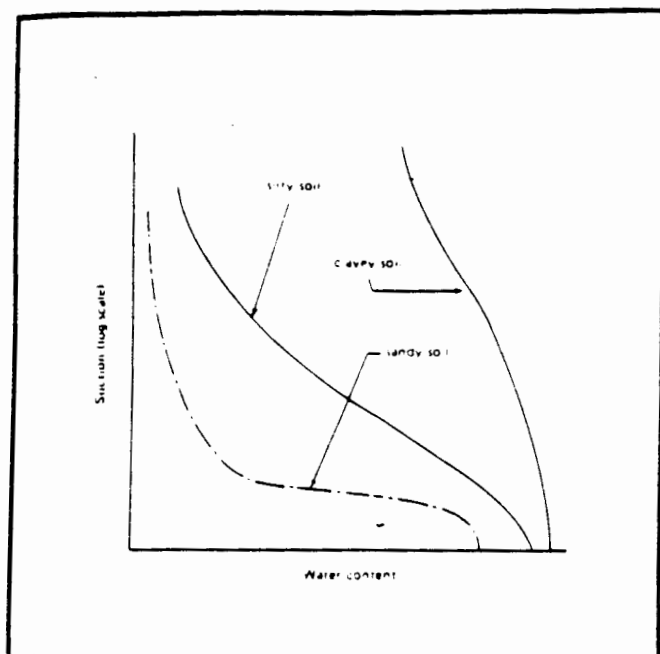


Figure 2. Typical moisture-tension curves for three types of soils with different particle size distributions (Elzeftawy and Cartwright 1983)

this is not the same as pore structure, which refers to the arrangement of interconnected pores to form passageways along which fluid movement can occur. The significance of this distinction will become apparent. For an excellent discussion of pore structure and fluid transport the reader is referred to Dullien (1979).

Relative Permeability

Relative permeability is defined as the ratio of the permeability of a fluid at a given saturation to its permeability at 100 percent saturation. Thus, it can have a value between 0 and 1. A typical relative permeability diagram for two immiscible liquids is shown in Figure 3. The relative permeability relationship is generally determined in the laboratory by simultaneously injecting each liquid at a given ratio into an undisturbed core of the porous medium until a steady flow is established. The relative permeability for that injection ratio is then calculated from Darcy's Law based on the pressures in the two liquids at either end of the core, the flow rates and the saturations. One of the greatest difficulties in performing such a test is obtaining an undisturbed sample, especially when unconsolidated sediments are involved.

Below 25 percent water saturation in the relative permeability diagram of Figure 3, the hydrocarbon exists as the continuous phase (Figure 4a) and only it will flow. This is referred to as the irreducible wetting phase (water) saturation. Between 25 and 90 percent water saturation both water and hydrocarbon exist as continuous phases and both will flow (Figure 4b). Above 90 percent water saturation hydrocarbon is present as the discontinuous phase (Figure 4c) and only water will flow. The corresponding hydrocarbon saturation (10 percent) is referred to as the residual non-wetting phase (hydrocarbon) saturation. This latter parameter is important, as it represents the concentration of hydrocarbon that will remain trapped in the ground under normal flow conditions.

Saturated Zone

In the saturated zone, the natural tendency for the

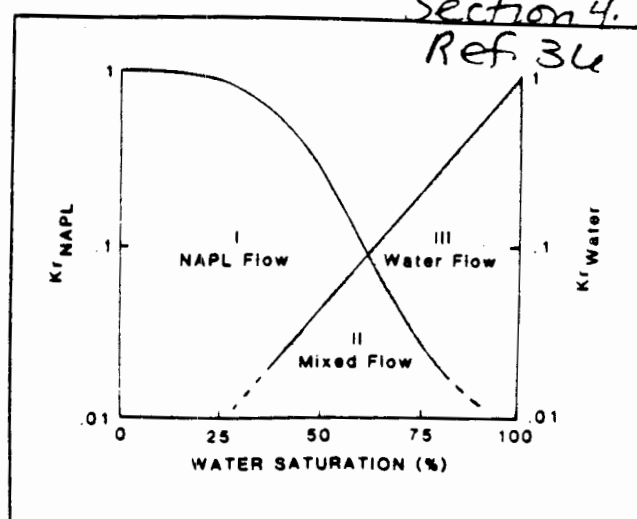


Figure 3. Example of a relative permeability (K_r) diagram for NAPL (non-aqueous phase liquid) and water (Williams and Wilder 1971)

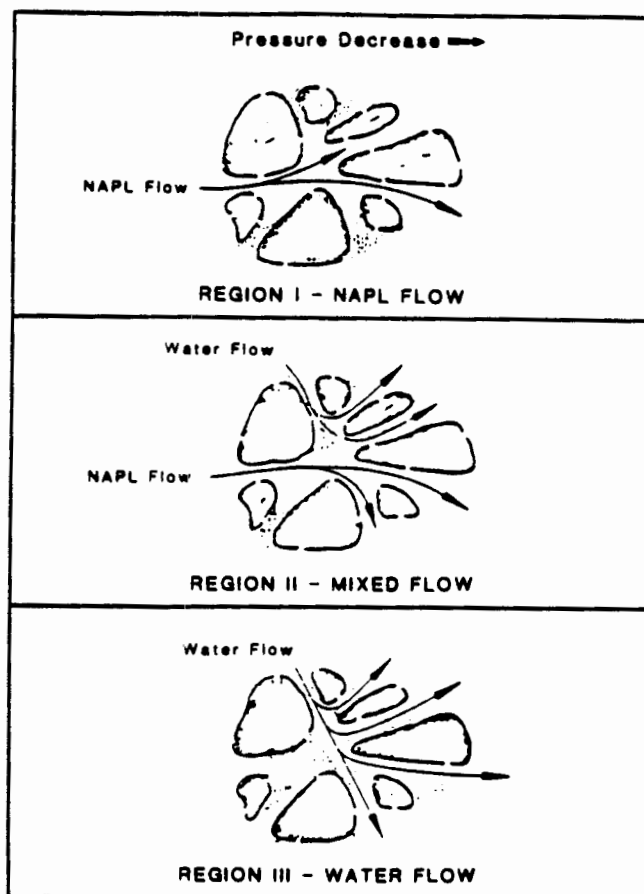


Figure 4. Relationship of continuous and discontinuous liquid phases in various regions of relative permeability diagram of Figure 3 (Williams and Wilder 1971)

free hydrocarbon phase is to move downward under the force of gravity, assuming it is more dense than water. Resisting this movement are the viscous forces within the hydrocarbon itself and the capillary pressure forces throughout the system. Superimposed on this are the effects of hydrodynamic dispersion due to ground water flow.

Hydrostatic Conditions

According to the basic capillary pressure equation

the higher the interfacial tension and the smaller the wetting angle and pore radius, the more difficult it will be for the hydrocarbon to displace the water from a given pore. The only way this displacement can occur in a natural system is for the hydrocarbon to attain a sufficient mass (weight) to overcome the capillary pressures involved. It does this by agglomerating into vertical stringers along interconnected pores. The critical height, h_c , of such a stringer needed to overcome a given capillary pressure can be calculated from Hobson's Formula (Berg 1979).

$$h_c = [2\gamma \cos \theta (1/r_t - 1/r_p)] / g(\rho_w - \rho_h) \quad (3)$$

where r_t is the pore throat radius, r_p is the pore radius, g is the acceleration due to gravity, ρ_w is the density of the pore water, ρ_h is the density of the hydrocarbon, and γ and θ have the same definitions as before. The various pore radii can be approximated from the grain size by assuming a rhombohedral (closest) packing of uniform spheres of diameter d , where

$$r_p = (\frac{1}{2})(0.414d) \text{ and} \quad (4)$$

$$r_t = (\frac{1}{2})(0.154d) \quad (5)$$

The effect of a decrease in pore (grain) size on the critical height is shown in Figure 5. In this case, the pore throat radius is that radius in the finer grained material and the pore radius is that radius in the coarser grained material.

It follows from this that, once the liquid properties (interfacial tension and density) and wetting characteristics of the system have been established, the only factor controlling the distribution of free hydrocarbon throughout the porous medium are the pore size distribution and the extent of hydrocarbon agglomeration. It is therefore possible to identify a number of distinct hydrocarbon "phases" or zones representing the degree to which the capillary pressure forces within the system have been overcome as the hydrocarbon moves downward under the influence of grav-

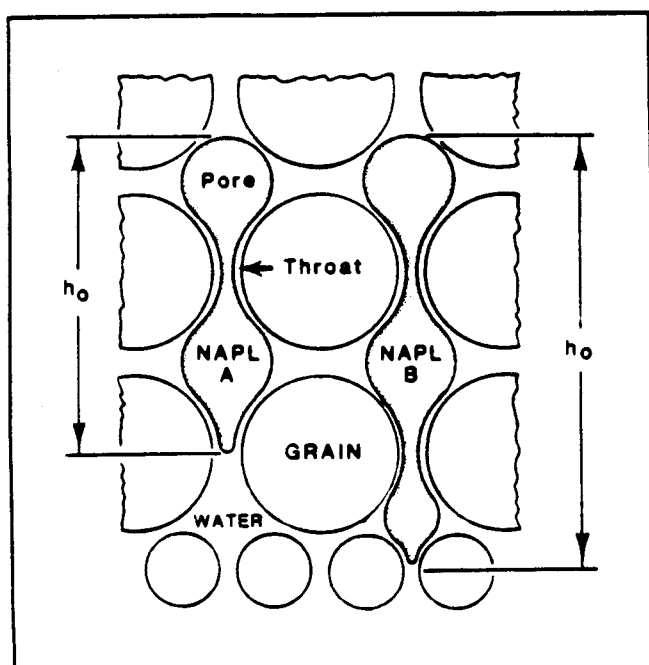


Figure 5. The effect of a decrease in grain size on the critical height, h_c , of NAPL (non-aqueous phase liquid) (Berg 1975)

ity. Figure 6 is a graphical representation of these zones for a homogeneous, coarse gravel overlying a fine silty sand; the sand acts as a confining layer to the hydrocarbon because of the greater capillary pressures involved.

Beginning at the point of initial hydrocarbon injection, the first zone encountered contains free water (water not held by strong capillary pressure forces) and that hydrocarbon that became trapped in dead ends or pore wall anfractuositites. In the next lower zone, both hydrocarbon that has not yet agglomerated sufficiently to overcome the capillary pressures involved (incomplete hydrocarbon stringers) and undisturbed water are encountered. The effect of pore size distribution on the vertical extent of this zone can be quite dramatic, as shown in Figure 7. In the zone just above the confining layer, most of the capillary pressure forces have been overcome by the hydrocarbon and the small amount of water that remains occurs in only the very smallest pores, where it is held very tightly. In this example, only dissolved hydrocarbons exist in the silty sand because of the extreme capillary pressures. In fact, under a zero net vertical hydraulic gradient, this barrier could be quite thin and would have the same effect. This is an important consideration when designing cutoff walls or other similar structures for containment.

LIQUID PHASE(S)	POROUS MEDIUM
GROUND WATER WITH DISSOLVED ORGANICS	SAND AND GRAVEL
GROUND WATER AND TRAPPED NAPL	
GROUND WATER AND NAPL	
NAPL AND 'IRREDUCIBLE' WATER	
GROUND WATER WITH DISSOLVED ORGANICS	SILTY SAND

Figure 6. Ideal NAPL (non-aqueous phase liquid) distribution under hydrostatic conditions for a coarse gravel overlying a silty sand (barrier layer)

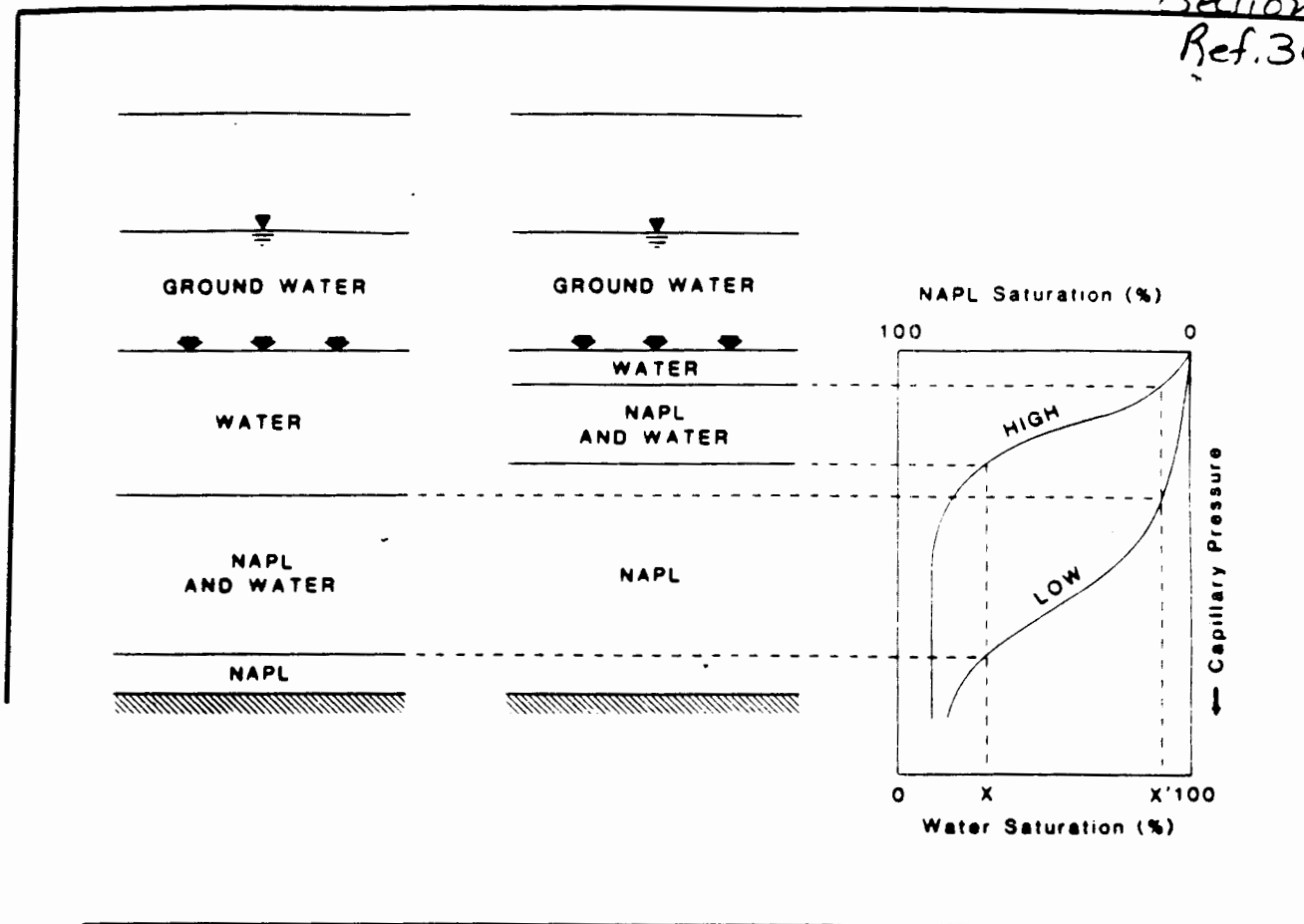


Figure 7. Effect of HIGH and LOW permeability and porosity (pore structure) on NAPL (non-aqueous phase liquid) distribution as related to capillary pressure (Arps 1954). X is the irreducible water saturation and X' the residual NAPL saturation as determined by relative permeability test. The arrows indicate the level of original NAPL injection

Hydrodynamic Conditions

So far only hydrocarbon movement under hydrostatic conditions has been discussed. Obviously, under ground water flow conditions some hydrodynamic dispersion is likely to occur. In this case, water can be said to be displacing the hydrocarbon, which is analogous to the water flooding (secondary recovery) technique used in the petroleum industry to remove residual oil from the reservoir rock. Hindering the movement of the hydrocarbon are its viscosity and the possible tendency of the hydrocarbon to now "wet" (be adsorbed onto) the pore walls (see the above discussion of wetting angles), whereas initially it may have been non-wetting. Strongly controlling this movement is the distribution of capillary pressure forces, which will allow the free hydrocarbon to enter the largest pores (or fractures) first and the smallest pores last. Thus, depending on the distribution of the various porous materials at a site, the free hydrocarbon could actually have a component of flow contrary to that of ground water.

The hydraulic gradient necessary for the horizontal movement of a free hydrocarbon phase is greater than for downward flow. For horizontal flow, the pressure gradient necessary to move a continuous hydrocarbon phase can be calculated from the equation

$$\text{grad } p = 2\gamma/L (1/r_t - 1/r_p) \quad (6)$$

where grad p is the pressure gradient, L is the length of the continuous hydrocarbon phase in the direction of flow, and r_t and r_p have the same definitions as before.

If the flow is down-dip, then the pressure gradient is decreased by a factor of $g(\sin \theta)(\rho_h - \rho_w)$, where θ in this case is the dip of the flow lines in degrees and g , ρ_h , and ρ_w have the same definitions as before. If the flow is up-dip, then the term is positive and the pressure gradient must be increased by this amount. Thus, the longer the continuous hydrocarbon phase, the lower the required pressure gradient: or, stated differently, long hydrocarbon stringers may be in motion while shorter stringers are stationary. It follows that the hydrocarbon must be of a minimum length before it can move at a given ground water flow rate, as in the case of vertical movement under hydrostatic conditions.

The relationship between flow rate, Q, and pressure gradient is given by Darcy's Law.

$$Q = \text{grad } p (k/\mu_w \phi) \quad (7)$$

where k is the permeability, ϕ is the fractional porosity, μ_w is the viscosity of the water, and p has the same meaning as before. Thus, one can create a graph relating ground water flow rate to minimum hydrocarbon stringer length for a given permeability-porosity ratio: or, stated differently, the minimum conditions for migration of a hydrocarbon through a water-wet porous material are not only a function of pore structure but are also determined to a large extent by the permeability-porosity ratio. This is different from the case of hydrostatic flow due to gravity.

A not-so-obvious effect of ground water on an

accumulation of hydrocarbon above a barrier layer occurs when ground water is removed from above that accumulation. This is analogous to what happens when a fresh water well is pumped over a denser, salt water layer. In this case, the fresh water-salt water interface upwells (upcones) due to the loss of hydrostatic head around the well. The amount of upwelling, z , is given by the simplistic Ghyben-Herzberg Formula (Bouwer 1978).

$$z = \rho_w s_w / (\rho_h - \rho_w) \quad (8)$$

where s_w is the drawdown of the water table and ρ_w and ρ_h have the same definitions as before. Thus, a drawdown of only 1 inch can produce an upwelling of more than 3 feet, assuming a salt water layer of infinite thickness and lateral extent in an isotropic aquifer. Viscosity effects in this case would be minimal, although they could be significant with some of the liquid wastes mentioned above. The relevance of this phenomenon will be pointed out later.

Unsaturated Zone

In the unsaturated zone above the water table the water that is present is under negative pressure due to its adsorption onto the surface of the "soil" solids. In a simple, two-phase flow system (air and water), part of the pore channels are filled with air, which physically obstructs water movement. Water then flows only through the smallest pore channels, which may still be saturated due to the greater surface tensions (negative pressures) involved. Thus, the unsaturated hydraulic conductivity is a function of the water content, which in turn is related to the (negative) pressure head, or "soil suction." As mentioned earlier, the moisture-tension curve can be used to develop a pore size distribution and is therefore a characteristic of the porous medium. Similarly, the moisture-permeability relationship can be developed from the moisture-tension curve (Elzeftawy and Cartwright 1983) and is therefore also a characteristic of the porous medium. Thus, as with saturated two-phase flow, the pore size characteristics are extremely important in unsaturated two-phase flow. When a second liquid phase is added, as in the case of surface spills or disposal, the complexity of the flow system is increased tremendously; however, some general principles can still be straightforwardly applied.

Pfannkuch (1983) showed, for example, that oil retention increased with decreasing mean grain size, and, to a lesser extent, sorting, when initially oil-saturated columns of silica sand were tested. Using a non-polar paraffin oil with essentially no significant surface charge, values ranged from 11.0 to 23.5 percent of pore volume for mean grain sizes of 1.00 to 2.00 ϕ units with perfect sorting. No tests were performed on partially water saturated columns.

Using a loamy sand, silt loam and clay to test two types of unsaturated zone sampling devices, Barbee (1983) found that xylene, a low solubility organic liquid with no net charge and little polarity, moved 10 times faster in the loamy sand than chloride and nitrate, two conservative (non-adsorbing) anions. He also found that the flow of the xylene varied with the antecedent water content of the loamy sand when the soil was below its field capacity for water. This is due to the availability of more and larger xylene-filled pore channels, as the water, being the wetting phase, could be expected to occupy the smaller channels.

For the moderately structured silt loam Barbee found that the xylene moved 35 times faster than the inorganic anions. This is much greater than can be explained by the effect on permeability (about 7 percent) of the differences in density and viscosity between the xylene and water even after normalizing for the two liquids using Darcy's Law. He attributes this to the preferential movement of the xylene through structurally induced macropores and references a study on a compacted clay soil where a hundredfold increase in permeability occurred when water percolating through the soil was replaced by xylene. In this study it was found that the massive structure of the original soil had changed to a blocky structure after treatment.

dePastrovich et al. (1979) provide a non-rigorous formula for approximating the maximum depth of penetration, D , of various oils into the unsaturated zone.

$$D = 1000 V / ARC \quad (9)$$

where V is the volume of infiltrated oil, A is the area of infiltration at the surface, R is the retention capacity of the particular soil involved, and C is an approximate correction factor based on the viscosity of the oil (0.5 for gasoline to 2.0 for light fuel oil). They recommend values of R , in L/m^3 , of 5 for stone to coarse gravel, 8 for gravel to coarse sand, 15 for coarse to medium sand, 25 for medium to fine sand, and 40 for fine sand to silt and note that, if the soil consists of layers with different retention capacities, an intermediate value of R should be used. These values of R are for soils with a natural moisture content. For dry soils, the retention capacity would be greater. The effect of retention capacity and

PUMP PRODUCT	LIQUID PHASE(S)	POROUS MEDIUM
		SAND AND GRAVEL
WATER	GROUND WATER WITH DISSOLVED ORGANICS	
WATER	GROUND WATER AND TRAPPED NAPL	
WATER AND NAPL	GROUND WATER AND NAPL	
NAPL	NAPL AND 'IRREDUCIBLE' WATER	
WATER	GROUND WATER WITH DISSOLVED ORGANICS	SILTY SAND

Figure 8. The effect of retention capacity (particle size) and viscosity on the maximum depth of penetration for $1m^3$ of oil infiltrating over a $10m^2$ area (dePastrovich et al. 1979)

viscosity on the maximum depth of penetration is shown graphically in Figure 8.

Once the free hydrocarbon phase reaches the capillary fringe above the ground water surface, its further downward migration will depend on the extent to which the capillary pressures in the water filled pores can be overcome, as explained earlier for the saturated zone. Thus, the water table could conceivably act as a barrier to hydrocarbon flow if the unsaturated zone is of insufficient thickness for hydrocarbon stringers of an adequate length to form.

Another phenomenon in unsaturated flow that has been documented for simple air-water (leachate) systems (Gerhardt 1984) and which could also apply to hydrocarbon migration involves the presence of a coarse-grained material underlying a fine-grained material. In this case it has been observed that leachate will migrate along the interface between the two materials rather than penetrate into the coarse material—as might at first be expected—because of the greater “soil suctions” existing in the finer material. Only after the saturation has reached a point in this latter material such that these suction forces are overcome will gravity drainage (downward migration) occur. This is basically the concept of field capacity, which, while it has been generally discounted as an oversimplification (Wilson 1980), is still heavily relied upon as a first approximation and does serve to explain some observed unsaturated zone processes.

Sampling a Multi-Phase System

From the above discussion it should be apparent that certain precautions must be taken in sampling a multi-phase system, especially in the saturated zone, in order to obtain the desired results and to be able to accurately interpret those results. Some of the special problems that can arise and the steps that can be taken to accommodate them are discussed below, with special emphasis being given to proper monitoring well design.

Hydrocarbon Characterization

The obvious first step in any investigation of a site potentially contaminated with a dense organic liquid is to characterize the material in terms of its more important physical properties. As a minimum this should include the specific gravity (density) and aqueous solubility of each organic phase, as these two properties will determine whether a separate organic liquid might be present, at least in the saturated zone. An excellent discussion of the methods available for estimating the aqueous solubilities of various organics where actual measurement data are not available is given by Lyman (1982). Values for specific gravities, on the other hand, can be found in many standard reference works, although the cost of an actual analysis is not that great and is probably preferable where a mix of chemical species exists. It is also a simple matter to put a drop of the liquid in a small vial of water to see if it sinks or floats and, if it sinks, how rapidly. Agitating the vial will also give an indication of whether there is likely to be a phase separation into “sinkers” and “floaters.” Extending this further, the effects of shear on the hydrocarbon-water mixture can be quickly examined using a blender apparatus. This will indicate whether an emulsion is likely to form under certain pumping conditions, as some of these emulsions can quickly clog discharge lines.

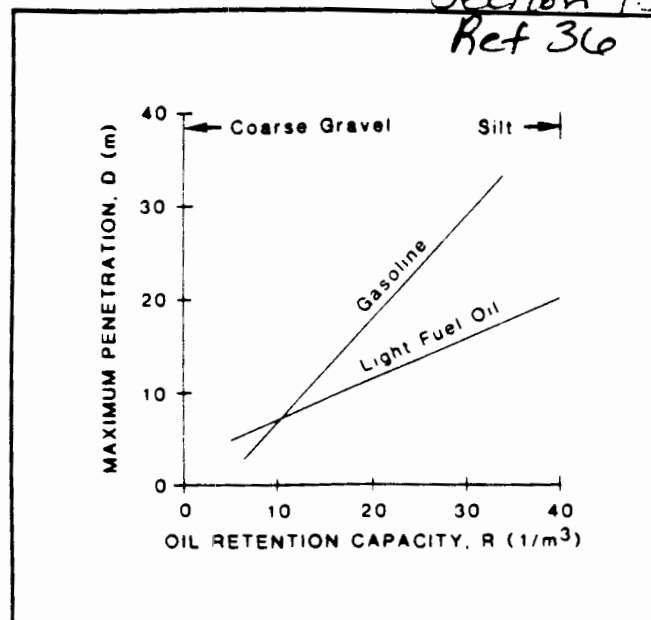


Figure 9. (a) False non-aqueous-phase liquid (NAPL) thickness due to penetration of a barrier layer by a ground water monitoring well; (b) false NAPL thickness due to removal of ground water from a partially slotted well; (c) NAPL upwelling and redistribution due to drawdown of the ground water table; and (d) NAPL suppression and redistribution due to the application of an artificial head in an open borehole during drilling

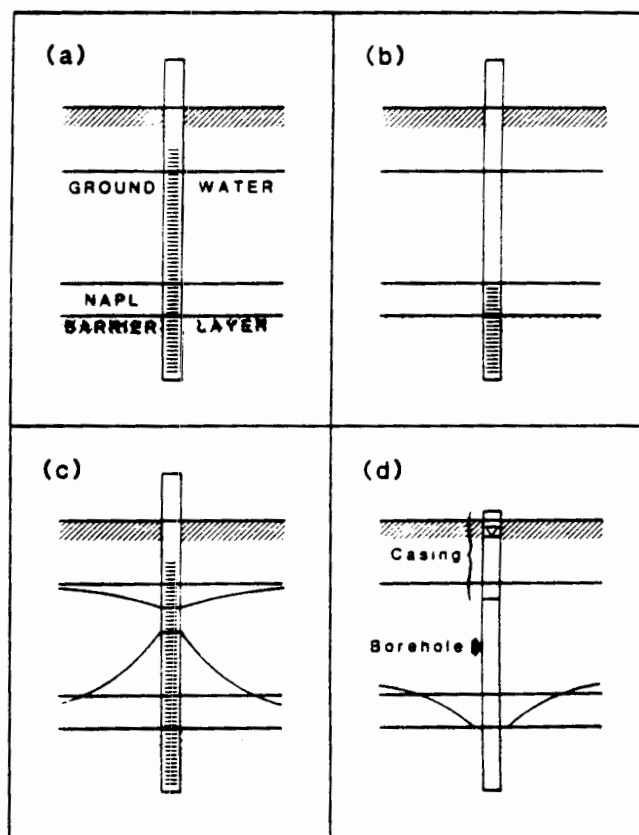


Figure 10. Relative mobilities of the liquid phases in a two-phase liquid-liquid system under pumping conditions (Arps 1954). As in Figure 6, the arrows indicate the level of original NAPL (non-aqueous phase liquid) injection into the saturated zone

The interfacial tension between the hydrocarbon and water is one of the key parameters in the capillary pressure equation, as explained earlier. However, because interfacial tension is basically a function of aqueous solubility, an approximation of its relative importance to hydrocarbon migration may already be available. If a better value is desired, reliable estimation methods are available (Grain 1982), although the standard test referred to earlier is quite inexpensive. An actual test value would again be most appropriate for hydrocarbon liquids of mixed composition.

The wetting angle, which is also a parameter in the basic capillary pressure equation, tends to be more of a curiosity than anything. Its meaning has been widely debated in the petroleum literature and no real consensus yet exists. As noted earlier, it is hysteretic, in that it depends on the wetting history of the system. Also, it is possible to measure a value above 90 degrees, so that the cosine of the angle becomes a meaningless term. Most often the system is assumed to be water-wet, at least initially in the saturated zone. In this case the term takes on a value of 1 and can therefore be ignored. However, in open fractures or soil peds in the unsaturated zone where soil suction would be expected to be small and where little or no moisture is present, the hydrocarbon would tend to wet the surfaces, thereby increasing the effective porosity. A further drawback of the test is its cost, which can approach \$1,000. Also, there are few commercial laboratories equipped to perform the test properly.

A final physical property of the hydrocarbon phase that should be examined is viscosity, as it is an important variable in the basic Darcy flow equation, whether it is being applied to a single- or a multi-phase flow system, as discussed earlier. Also of some significance is the hydrocarbon-water viscosity ratio, which can significantly lower the water saturation at which no hydrocarbon will flow (irreducible water saturation, du Prey 1973). The cost of the analysis is also quite low.

While not normally considered in most site investigations, the electrical properties of the hydrocarbon can be of some use in selecting a method for detecting whether an accumulation of the material exists. If the electrical conductivity or dielectric constant are sufficiently different from that of the pore water, various downhole sensing equipment can be used to detect the interface. Such a unit is now marketed by Oil Recovery Systems Inc. of Needham, Massachusetts, for floating hydrocarbons; however, it could be used equally well for denser materials. Color indicator paste, which reacts to water and is commonly used at oil spill sites, will obviously not work for dense organics. If the conductivity contrast is great enough, a standard electrical water metering tape may also prove successful. However, the device may have to be dedicated to the site because of the chemical attack of the cable by the hydrocarbon.

Initial Site Characterization

Because the movement of free hydrocarbon can be significantly influenced by the distribution of capillary pressure forces and because these forces are, in turn, dependent upon pore structure, it is highly important that sufficient information on a particular site first be obtained to adequately characterize the relative pore properties of the various porous materials at the site. If fractures are present, then their orientation, spacing, and vertical and lateral extent should be determined.

While it is not always possible to accurately characterize all pore properties, even a general characterization can be helpful. In this regard, grain size distribution, permeability (hydraulic conductivity), and porosity are particularly useful, although it should be understood that two vastly different materials, such as a gravel and a silt, can have the same porosity, and yet have quite different pore size distributions. If relatively undisturbed, representative samples can be obtained, the pore size distribution can be determined in the laboratory by means of a moisture-tension test, as described earlier for soil-water systems. Optical methods using thin-sections (Aschenbrenner and Achauer 1960) or casts can also be used for direct analysis of consolidated porous materials.

Another important aspect of the initial site investigation involves characterization of the free hydrocarbon plume. Determining the amount of contamination present in tube or auger samples can be difficult but is important in establishing the mechanisms of contaminant movement. In some cases, squeezer, vacuum, or centrifugation techniques (Patterson et al. 1978) for removing the liquid fractions from the sample may be appropriate for a gross characterization. In others, sample elutriation with a suitable solvent followed by chemical or gravimetric analysis may be useful (McGill and Rowell 1980). While simple visual examination for physical presence or absence of contamination might seem like a worthwhile technique, it can be very deceiving and does nothing to sort out the various liquid phases and their relationship to each other. Noel et al. (1983) give a brief review of geophysical techniques applicable to the detection of light (floaters) and dense (sinker) organic plumes, and Saunders et al. (1983) recently discussed the use of terrain conductivity in delineating subsurface oil spills.

Of concern also in the initial boring program is the tendency for the hydrocarbon, being denser than water, to run down an open hole. Thus, when extending a test boring, aquifer cross-contamination is a distinct possibility and should be guarded against. The same warning would apply to monitoring well installation and to the sounding of monitoring wells, which penetrate a barrier layer where hydrocarbon has accumulated. In this latter case, the hydrocarbon may accumulate in the well to a much greater thickness than is actually present outside the well and may thereby give a grossly inaccurate reading (Figure 9a). Also, when retrieving split-spoon or tube samples for examination or analysis, it is important to consider the possible contamination of the exterior surface of the sample. For some materials, it may be possible to simply shave off this outer rind of contamination to reveal a "fresh" surface.

In extending a borehole it is important to note that the wetting phase (usually water) can actually lubricate the non-wetting (hydrocarbon) phase if conditions are such that hydrocarbon movement is quite rapid (many large, interconnected pores). In this case evidence of such movement may not be apparent either visually or chemically. Thus, the presence or absence of contamination may be a less reliable indicator of when to terminate a boring than the location of a suitable confining layer based on capillary pressure. In one case familiar to the author, a borehole drilled through an abandoned lagoon known to have been used for the disposal of a dense, organic liquid with very evident properties (distinctive odor and dark staining color)

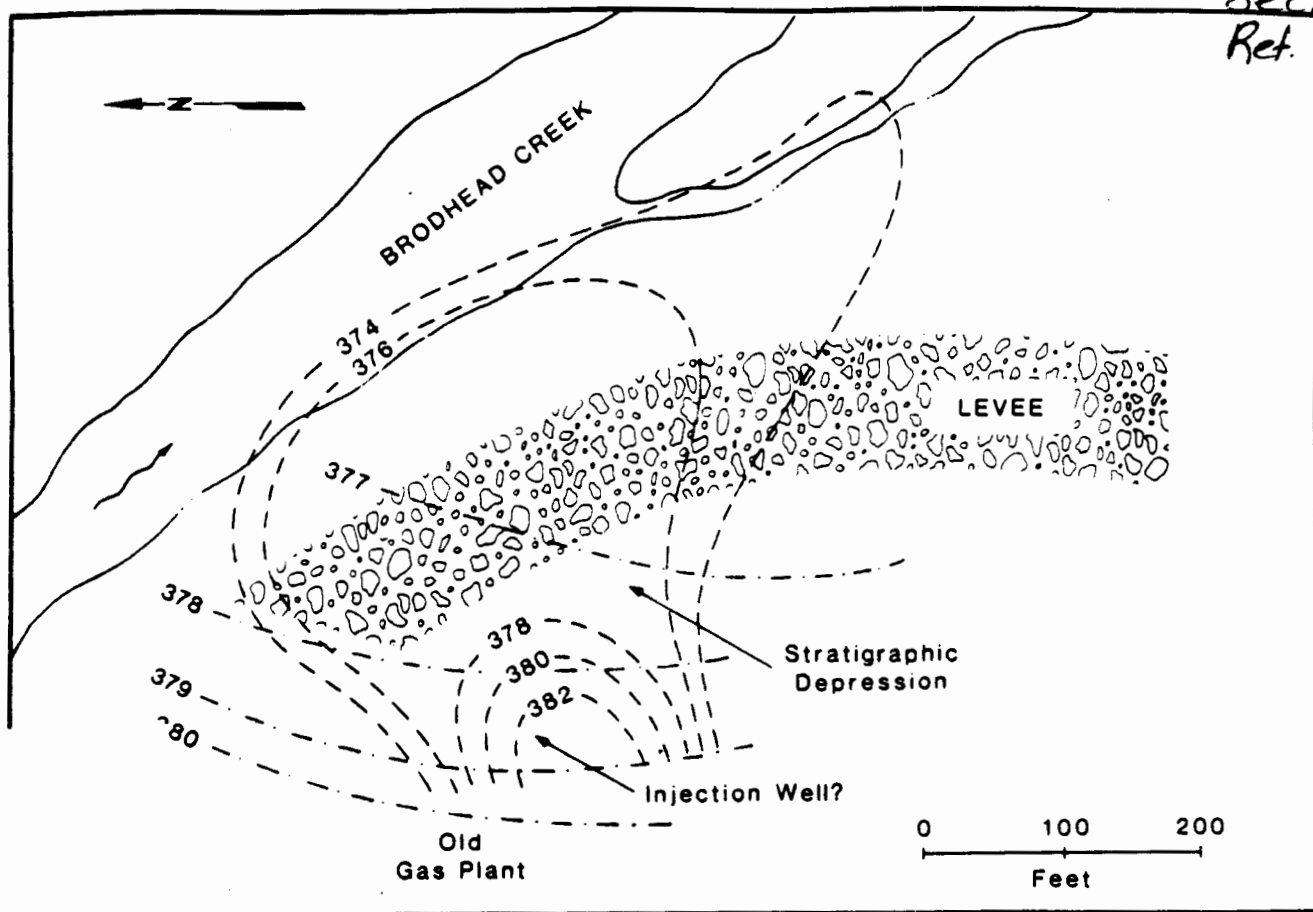


Figure 11. Top-of-sand contours (in feet) for the Stroudsburg coal tar contamination site (Villaurume et al. 1983)

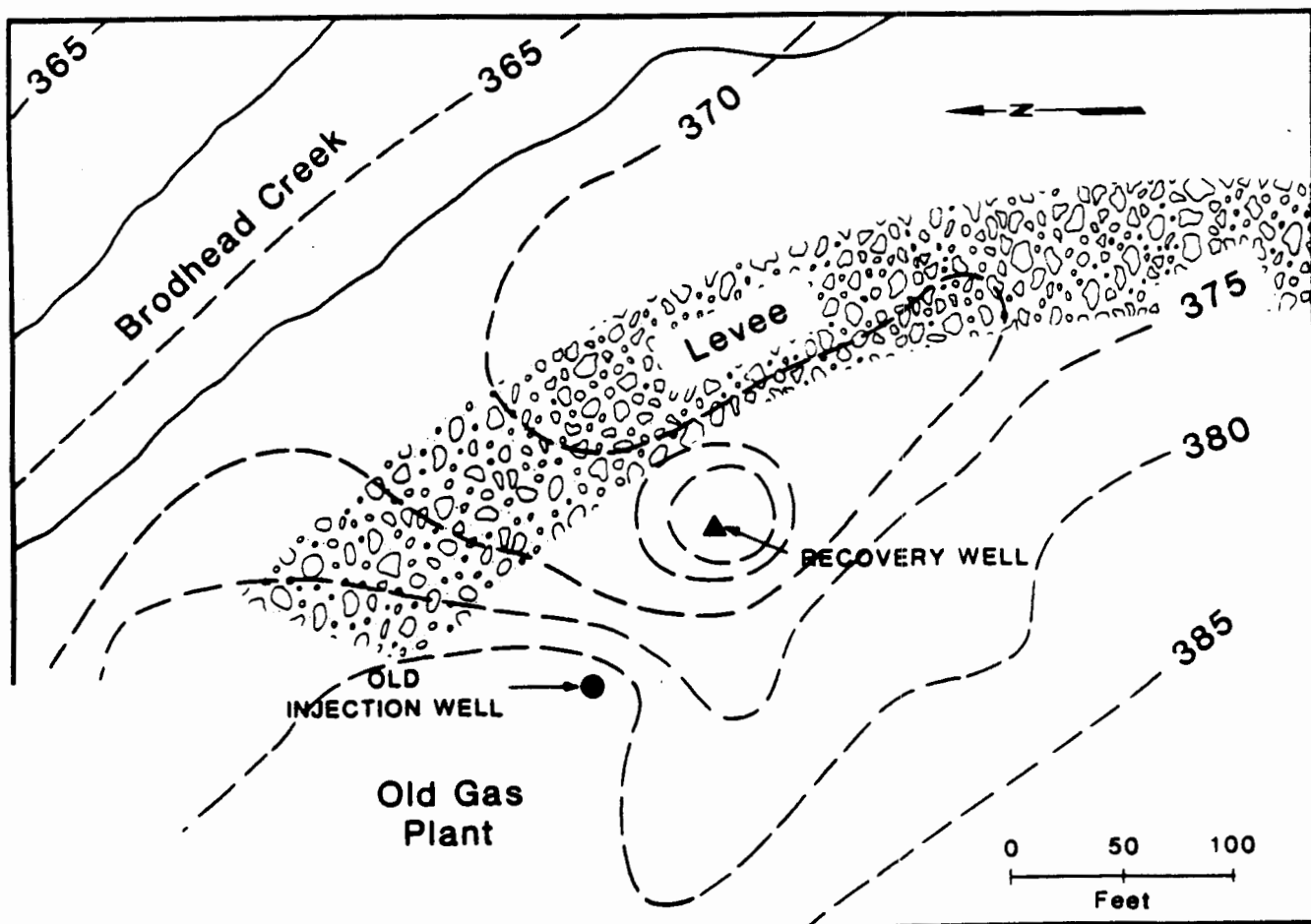


Figure 12. Stroudsburg site map showing top of contamination (dash) and ground water (dot-dash) contours (in feet). Almost no free coal tar occurs beyond the 374-foot contour (Villaurume et al. 1983)

showed signs of contamination for several tens of feet and then not again through several hundred feet of a coarse gravel until bedrock was encountered. Here, a separate, oily phase had accumulated.

Design of Monitoring Wells

The design of monitoring wells for sampling sites contaminated with dense, immiscible hydrocarbon liquids can be particularly difficult and serious errors can result if adequate precautions are not taken. In order to properly design a monitoring well, it is important to first understand the relative mobilities of the different liquid phases in the various vertical zones identified earlier. These relationships are shown in Figure 10 and will be explained further.

In the first zone, for example, both free water and trapped hydrocarbon are present. If a well screened only in this zone were pumped, it would produce only water. In the next lower zone both free water and incomplete hydrocarbon stringers are present. In this case, the hydrocarbon stringers, even though they are unable to overcome the capillary pressures involved, are mobile under an applied force, and so a well screened only in this zone would produce both water and hydrocarbon. In the lowest zone, hydrocarbon and tightly held pore water are present. A well screened only in this zone would produce only pure hydrocarbon if pumped. In fact, such a well could be used to recover hydrocarbon product if a sufficiently impermeable layer occurred below this zone. If water were removed from this latter type of well, the hydrocarbon would seek the hydrostatic level outside the well, thus giving a very false indication of the actual hydrocarbon thickness (Figure 9b).

What this means is that if a fully slotted well were installed and purged prior to sampling, a sample containing a mixture of both water and free hydrocarbon could result. If an analysis were then performed on the sample, hydrocarbon contaminant concentrations much higher than would be predicted by aqueous solubilities could be detected. Such results could lead to erroneous conclusions. Extensive purging of such a well by pumping could also result in the redistribution of contaminants due to the upwelling phenomenon described earlier (Figure 9c). On the other hand, if the purpose of the sampling program is to define the thickness of accumulated hydrocarbon above a barrier layer, then a fully slotted well is appropriate and, in fact, is probably the best way to define the static hydrocarbon surface.

Other special considerations in designing a monitoring well in materials contaminated with a dense hydrocarbon include possible attack on and loss of integrity of bentonite seals due to dehydration and shrinkage of the clay by the hydrocarbon. Also, the sizing of the gravel pack around the well should be adequate to ensure passage of the hydrocarbon phase. This can be tested in the laboratory with various gravel sizes. The same would apply to the well screen slot size. The material of the casing or screen should also be evaluated for its ability to withstand chemical attack. Such attack could result in an increase in the effective screened area of the well. An inexpensive solution might be to use fiberglass casing instead of stainless steel. Such casing is now available at Ground Water Sampling Inc., of Englewood, Colorado, in both screened and solid threaded, flush-joint sections, similar to PVC. Another precaution to consider is the use of an artificial head instead of casing to keep a borehole from collapsing. This can cause the hydrocarbon to migrate away from the borehole and possibly contaminate other areas (Figure 9d).

Case Studies of Multi-Phase Systems Case Study #1

Stroudsburg, Pennsylvania, is the site of an abandoned illuminating gas plant, which was operated from the mid-1800s until just after World War II (LaFomara et al. 1982; McManus 1982; Unites and Houseman 1982; Villaume 1982; Villaume et al. 1983a; Villaume et al. 1983b; Villaume 1984). At this plant, coal tar wastes were initially placed onto the ground and were later discharged into an underground injection well for disposal. The coal tar is just slightly denser than water (1.017 specific gravity at 15.5 C [60 F]) and has a viscosity similar to that of a medium-weight oil (18.98 centipoise at 7 C [45 F]). Its water advancing wetting angle as measured against quartz in a slightly mineralized water is 125 degrees, indicating a distinctly coal-tar wet system under hydrodynamic displacement conditions. The interfacial tension between the coal tar and water is 22 dynes/cm.

Porous materials occurring at the site consist of a coarse, clean (few fines) gravel overlying a fine silty sand. An extensive investigation of the site showed that the free coal tar contamination occurs only in the gravel and has collected in at least one depression in the top of the sand deposit (Figure 11). Applying Hobson's Formula to the site shows that a continuous column of coal tar over 10.0m (33.0 feet) long would be required to overcome the capillary pressures in the sand. Because the maximum thickness of the contamination zone anywhere on site does not exceed 4.5m (15 feet), this explains why no free coal tar was ever found in this material.

Ground water flow at the site is about 0.6m/day (2.0 ft/day), based on a measured hydraulic conductivity of 0.45×10^{-3} m/sec (1.5×10^{-3} ft/sec) and a hydraulic gradient of 0.015. Transmissivities of the gravel aquifer to ground water are on the order of 370,000 to 495,000 L/day/m (30,000 to 40,000 gal/day/ft). The transmissivity to the coal tar, on the other hand, is only 5,500 L/day/m (50 gal/day/ft), based on the behavior of the static coal tar surface during drawdown and recovery. Figure 12 shows the relationship between the ground water contours at the site and the free coal tar contamination plume. Based on historical accounts of gas plant operation, this plume apparently developed over a 30- to 40-year period.

Core flood tests performed on samples of Berea sandstone showed that the residual coal tar saturation using Stroudsburg coal tar is 30 to 35 percent. This is the amount of coal tar that can be expected to remain in similar porous materials at the site after ground water displacement. When a polymer and alkali solution were used to increase the viscosity of the flood water and to decrease the interfacial tension of the system, respectively, only 7 to 10 percent of this remaining coal tar was recovered after several pore volumes of injection (Krumrine 1983).

The free coal tar in the single stratigraphic depression below the old gas plant at Stroudsburg is presently being recovered through an in-ground pumping system, which employs selectively slotted wells. Ground water is removed from above the static coal tar surface at a slow rate in order to force the product to move into the recovery system. Pumping of product alone quickly resulted in depletion around the well due to the low transmissivity of the material. After approximately nine months of operation, the recovery system has produced more than 30,000 liters (8,000 gallons) of nearly pure coal tar, which is presently being sold as a fuel supplement.

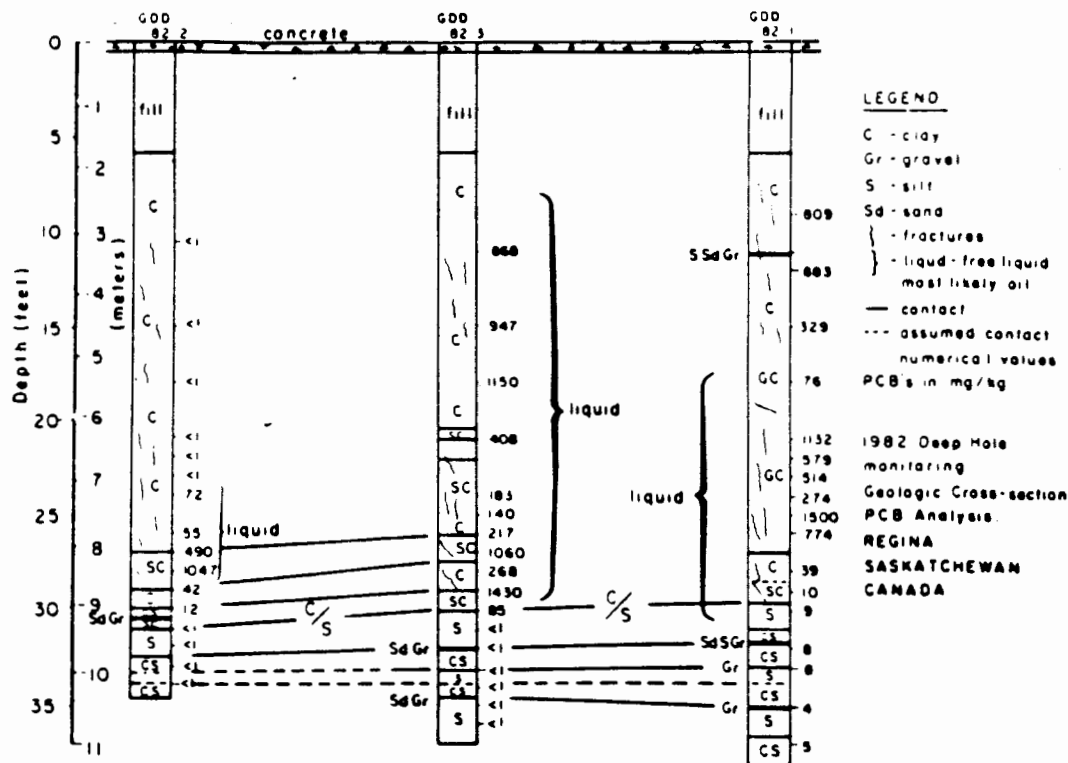


Figure 13. Deep-hole monitoring geologic cross section and PCB analysis for Regina site (Atwater 1984)

Special problems encountered at the site include attack of PVC pipe by the coal tar. This caused cracking of the pipe and, in some cases, destroyed the integrity of the selective screening. The coal tar also attacked some of the downhole, level-sensing equipment used to control the product pump in the recovery well and bridged the protective screen around this equipment, resulting in false readings. During product pumping, the coal tar appeared to increase sediment migration into the well, even though it had been properly gravel packed. This was not a problem when water alone was pumped at high, sustained rates in identically constructed wells nearby.

Case Study #2

A transformer manufacturing plant in Regina, Saskatchewan, Canada, is the site of a major spill of polychlorinated biphenyls (PCBs) and trichlorinated benzenes (TCBs; Roberts et al. 1982; Schwartz et al. 1982). The volume and duration of the spill are not known, in that it occurred primarily as the result of leakage from a buried pipeline, although periodic surface spillage during transfer operations may have also occurred.

The particular material spilled was Inerteen 70-30, a mixture of 70 percent PCBs and 30 percent TCBs. The specific gravity of Inerteen 70-30 is 1.49 to 1.50 at 60 F (15.5 C) and both components are denser than and moderately to highly insoluble in water (up to 30 mg/L for TCBs and 0.05 mg/L for PCBs). Schwartz et al. (1982) suggest that the interfacial tension of the Inerteen falls between carbon tetrachloride and water

and benzene and water, meaning that the hydrocarbon and water will exist as separate liquid phases and the hydrocarbon will have a minimal tendency to adhere to (wet) the mineral grains or to mix with the water.

The porous materials at the site consist of fill overlying a lacustrine clay, a silt, and finally, a thick glacial till of bedded silt and fine sand near the top and gravel, sand and silt below. The maximum thickness of the fill is 3m (10 feet). The clay varies in thickness from 70 to 90m (230 to 300 feet) across the site and is highly fractured. The permanent water table occurs at a depth of 7 to 15m (23 to 50 feet), with a perched water table also occurring within the fill. Flow in the fill is lateral. A steep downward hydraulic flow gradient ranging from 1.54 to 0.50 exists in the upper portion of the till below the silt; however, the hydraulic conductivity is only 5.0×10^{-9} cm/sec (0.16 ft/sec).

An extensive sampling program showed that the PCBs are distributed in the clay zone in a non-homogeneous pattern, presumably due to the tendency for the Inerteen to preferentially flow along fractures in the clay. Levels of PCBs in excess of 500 mg/kg were generally found throughout the clay to a depth of 30 feet (9m). The maximum downward penetration of the contaminant was into the top of the till, where a level of 0.27 mg/kg PCBs was measured in a single sample. Overall, the lateral spread of contamination through the fill was found to be greater than the vertical spread through the underlying materials, suggesting that, despite the presence of fractures in the clay, the permeability of the fill is much greater. High levels of contamination at one corner of the plant indicate

that PCB movement of more than 300 feet (90m) from the original spill site has occurred.

In a recent update Atwater (1984) notes that there appear to be two additional pathways for PCB migration. The two pathways are zones of porous clay, where extensive gypsum and calcite dissolution has occurred, and layers of sand and gravel within the clay and silt (Figure 13). He also notes that it appears the PCB flowed vertically down the clay fractures to the silt contact, where it was stopped and then flowed horizontally through the vertical fractures under the liquid head. Within the clay, PCB liquid was seen as the wetting phase to at least 30 feet (9m) and had penetrated fracture openings of less than 0.4 inch (0.1 cm). No free PCB liquid was found in the fractures in the silt, even though many were the same size as those in the clay containing free liquid. In the silt, water was the wetting phase, which apparently reduced the effective size of the fractures.

As part of the site investigation, more than 1,000 soil samples were collected to a depth of 33 feet (10m). Samples of intact cores were shaved and great care was taken in cleaning sampling equipment to minimize cross-contamination. Very granular and loose, dry materials were sampled directly from the auger flytes and by first cleaning the sides of hand auger holes. In the heavily fractured clay underlying the fill, a special effort was made to collect some samples from the surface of obvious fractures. This procedure maximized the probability of detecting PCBs in largely uncontaminated soil masses; but, as Roberts et al. (1982) note, such detailed sampling procedures are feasible only when rapid analytical capabilities exist at the investigation site. They also point out that, due to dilution, large bulk samples can mask the significance of migration through fractures in low permeability materials and that studies that do not specifically examine fractures and interfaces could very easily miss evidence of subsurface migration, especially in cases of limited fracturing.

In order to provide rapid, on-site analysis of a large number of samples during the site investigation, a mobile Atmospheric Pressure Chemical Ionization Mass Spectrophotometer (APCI/MS) was used. This technique requires little sample preparation and provided a rough estimate of PCB concentration, generally within a factor of two or four and at a minimum detection limit of 100 mg/kg. This was considered satisfactory because the main objective of the soil sampling program was to delineate the gross contamination pattern. Overall quality assurance was provided by performing about 15 percent of the PCB determinations using conventional gas chromatographic techniques. Other rapid analysis field techniques are described by Gruenfeld et al. (1980).

Complicating interpretation of the investigation results were the effects of the TCBs in the Inerteen and the mineral oils that may have been spilled at the site. Each of these materials can be expected to behave differently than pure PCBs in a multi-phase system. PCBs, for example, are highly soluble in the mineral oil and, because these oils have a specific gravity of less than 1.0, their direction and rate of movement will probably differ from that of the Inerteen. Also, the greater aqueous solubility of the TCBs will cause the PCB concentration in the water phase to increase to an unknown extent and, at the Regina site, was responsible for the preferential leaching of TCBs from the granular fill overlying the clay relative to the PCBs.

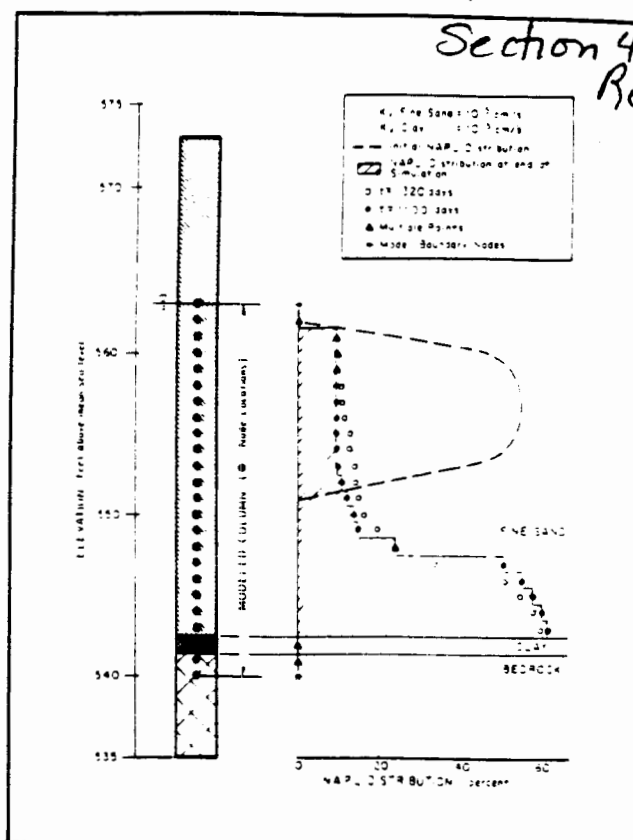


Figure 14. Results of modeling to determine effect of a 1-foot clay liner with a permeability of 10^{-5} cm/sec. under a 2-foot downward head on NAPL (non-aqueous phase liquid) migration at Case Study Site #3 (A.D. Little 1983)

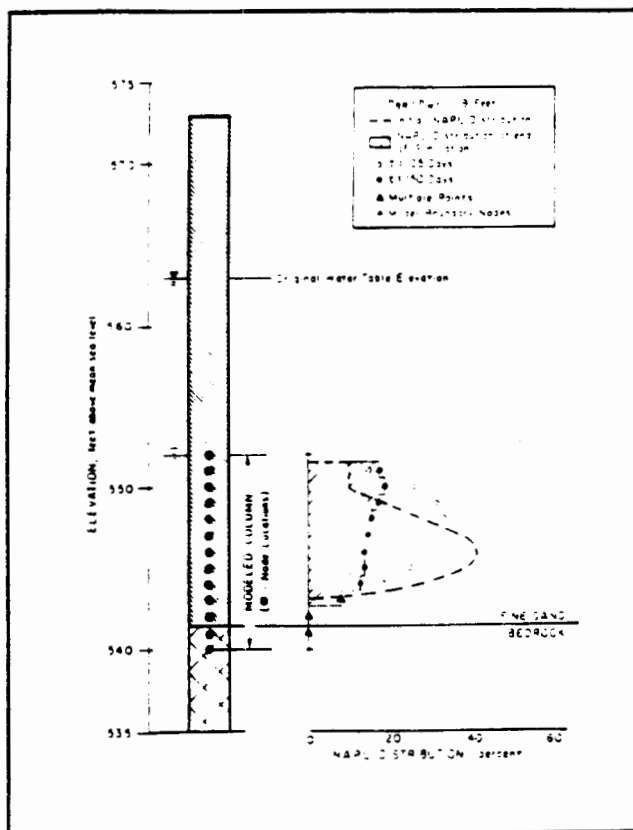


Figure 15. Results of modeling to determine effect of a 9-foot upward hydraulic head on NAPL (non-aqueous phase liquid) migration at Case Study Site #3 (A.D. Little 1983)

Case Study #3

At this site several clay-lined lagoons were used for the disposal of a nondescript, non-aqueous phase liquid with a specific gravity of about 1.5 and a viscosity similar to that of water. The unconsolidated (overburden) materials at the site consist of an average of 12.5 feet (4m) of random fill overlying 16 feet (5m) of native silty, fine sand. Underlying the sand are 1 to 17 feet (0.3 to 5m) of clayey to sandy till, although the predominant composition is silt. Bedrock beneath the till is a dolomite. Soil samples from various drilling programs were examined visually and by smell for the presence or absence of contamination, which seemed to be confined to the fill and fine sand above the till (A.D. Little 1981).

The non-aqueous phase liquid is generally found over a wide range of depths, all below the water table, which occurs roughly 10 feet (3m) below the ground surface; however, water levels measured in the overburden deposits indicate a positive head difference between this material and the underlying bedrock of approximately 2 feet (0.6m), which creates a vertical downward flow component to the bedrock. The direction of ground water flow is toward a nearby river about 500 feet (150m) away at a gradient of 0.02, with noticeable ground water mounding occurring at the upgradient end of the lagoons. Contaminants were found a maximum of 500 feet (150m) from the lagoon and did not appear to be regularly distributed (A.D. Little 1981).

A principal concern of the remedial action investigation was the apparent presence of a "window" in the confining till layer and whether the net downward hydraulic gradient would drive the hydrocarbon through this layer into the underlying bedrock. To assess this effect, a one-dimensional fluid flow model was developed to identify those hydrogeologic conditions that could be effective in preventing downward hydrocarbon migration. The model used the well-documented implicit pressure-explicit saturation method to solve a combined multi-phase flow equation, and calculate the hydrocarbon and water saturations at various nodes. Input parameters included media and fluid properties as well as saturation-dependent functions (A.D. Little 1983).

Two conditions were assessed. First, the capillary pressure differences related to the change in lithology from the coarser grained fine sand to a 1-foot (0.3m) thick finer grained clay overlying bedrock under a 2-foot (0.5m) negative head difference was evaluated. In performing the simulation, a continuous 8-foot (2.5m) long hydrocarbon zone with concentrations ranging from 3 to 42 percent of pore volume was assumed. This column length and saturation were greater than actually observed at the site. Still, the minimal clay thickness was found to be an effective barrier (Figure 14; A.D. Little 1983).

Also evaluated was the effect of lowering the water table through a drainage-pumping system to increase the upward head difference between the water table and bedrock potentiometric surface. This analysis showed (Figure 15) that an upward head difference of 9 feet (3m) was adequate to prevent downward hydrocarbon migration under the same column length and saturation conditions as in the previous simulations. With only an 8-foot (2.5m) difference some downward movement of the initial column was predicted because the sum of the downward buoyancy and capillary pressure gradients in the lower portion of the column exceeded the upward acting hydrodynamic gradient.

After 500 days, the capillary pressure gradient decreased such that the direction of hydrocarbon movement at the bottom of the column was reversed and for the remainder of the simulation remained upward (A.D. Little 1983).

Summary and Conclusions

Sites contaminated with a dense, immiscible organic liquid are continuing to be identified and reported in the literature. As a result of their near insolubility, these contaminants can exist in both the saturated and unsaturated zones as a distinct, separate fluid phase. Their movement through and distribution in the environment are governed by a complex set of principles describing multi-fluid flow through a porous medium. In such a system, once the fluid properties have been established, the pore structure (pore size, shape and distribution) and relative degree of saturation of the various fluid phases become all-important.

In order to develop an effective program to investigate such sites, a thorough understanding of these principles is essential. Where such understanding does not exist, it is possible to entirely miss a major source of potentially recoverable contaminants, which could contaminate nearby ground water supplies over a long period of time. It is also possible that in conducting the investigation itself contaminants could be unwittingly redistributed because of their rather unique response to certain pumping activities, some of which are normally considered standard practice in developing and sampling monitoring wells.

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List of Symbols

- P - Capillary pressure
- γ - Liquid-liquid interfacial tension
- cosine θ - Cosine of the wetting or contact angle, θ , formed by the hydrocarbon phase against a solid surface in the presence of the pore water
- r - Pore radius
- γ_{ns} - Interfacial tension between the hydrocarbon and water
- γ_{ws} - Interfacial tension between the water and solid
- γ_{nw} - Interfacial tension between the hydrocarbon and water
- h_o - Critical height of a continuous hydrocarbon stringer needed for downward movement under a zero net hydraulic gradient
- r_t - Pore radius
- r_p - Pore throat radius
- g - Acceleration due to gravity
- ρ_w - Density of water
- ρ_h - Density of hydrocarbon
- d - Diameter of a uniform sphere representing a particular grain size

- grad p - Ground water flow pressure gradient
- L - Length of a continuous hydrocarbon stringer under ground water flow conditions
- $\sin \theta$ - Sine of the dip of the flow lines under ground water flow conditions
- Q - Ground water flow rate
- K - Intrinsic permeability or hydraulic conductivity
- μ_w - Viscosity of ground or flood water
- z - Distance of vertical upwelling of a more dense liquid due to removal of a less dense liquid from above
- s_w - Drawdown of the water table
- D - Maximum depth of penetration of hydrocarbon into the unsaturated zone
- V - Volume of hydrocarbon infiltrating the unsaturated zone
- A - Area of hydrocarbon infiltrating the unsaturated zone
- R - Retention capacity of a particular unsaturated soil for a hydrocarbon
- C - Approximate correction factor for maximum unsaturated zone hydrocarbon infiltration based on hydrocarbon viscosity

Biographical Sketch

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II. Background Levels

General Considerations

Before describing the levels of PNA's typically found in various matrices, a number of general observations, which may affect the reported levels, should be described in order to put the data in proper perspective.

When PNAs are present in samples at low concentrations losses of the PNAs are significant. These losses are generally believed to result from physical and chemical processes which either oxidize, reduce, or otherwise remove the PNA from the samples. Oxidative mechanisms such as ultraviolet light adsorption followed by reaction with oxygen are known to occur when PNAs are not protected from UV (sun light and fluorescent light) radiation.(1) When low levels of PNAs are present (i.e. on the order of tens of ppt) adsorption on sampling equipment and sample storage containers and volatilization are also known to significantly reduce observed levels of PNAs even when storage times are minimized.(2,3) Choice of analytical method will also effect reported levels. For example, one study of PNAs in water used activated carbon as a concentrating media for the PNAs, however, the efficiency of extraction of the PNAs from the charcoal caused reported levels to be biased toward lower values than actually present.(4)

Finally, one must keep in mind that there are a number of mechanisms which would cause higher than actual values to be observed, especially if care is not taken to exclude contamination during sampling. Cigarette smoke, exhaust fumes from automobiles, and condensation from atmospheric sources have been implicated in this regard.(5,6,7,8) Therefore, unless care was taken to exclude these possible interferences, the reported levels may be higher than actual levels. Information necessary to assess whether reported levels are biased (either high or low) is often not reported in literature articles dealing with PNAs. The Agency has used the best available information in this study, however, some of the material cited may not provide this information.

As pointed out above, there are factors which operate both to decrease and increase reported values and that there effects become more pronounced at lower (i.e. ppt) levels. We believe that this information should be used in conjunction with the data presented in this report especially when low levels of PNAs are considered.

TABLE 1. CONCENTRATION OF POLYNUCLEAR AROMATIC
HYDROCARBONS IN LIQUID FUELS

Fuel Designation	Concentration, $\mu\text{g/gallon}^1$											
	Phenanthrene	Anthracene	Fluoranthene	Pyrene	Triphenylene	Benzo(a) anthracene	Chrysene	Benzo(e) pyrene	Benzo(a) pyrene	Benzo(g,h,i) perylene	Anthanthrene	Coronene
Jet A Fuel, Low Sulfur	6,000	330	45	60	16	ND (<2) ²	11	6	ND (<2)	ND (<2)	ND (<2)	ND (<2)
Jet A Fuel, High Sulfur	8,300	760	100	290	27	ND (<2)	12	63	ND (<2)	ND (<2)	ND (<2)	ND (<2)
GM-210-F	2,600,000	16,000	95,000	20,000	53,000	34,000	110,000	370	160	240	ND (<20)	ND (<20)
GM-210-F	1,100,000	20,000	60,000	20,000	17,000	13,000	16,000	200	260	110	ND (<20)	ND (<20)
GM-240-F	20,000	760	610	700	200	210	260	30	200	ND (<10)	ND (<20)	ND (<20)
GM-241-F	2,400,000	13,000	61,000	33,000	16,000	13,000	24,000	200	170	60	ND (<20)	ND (<20)
GM-242-F	800,000	6,400	20,000	7,600	6,100	2,200	2,200	64	70	ND (<10)	ND (<20)	ND (<20)
GM-243-F	2,000,000	11,000	76,000	120,000	42,000	26,000	53,000	600	320	110	ND (<20)	ND (<20)
GM-244-F	10,000	1,200	6,000	21,000	6,100	2,600	4,200	1,400	800	20	ND (<20)	ND (<20)
GM-245-F	43,000	2,200	7,000	10,000	4,200	2,000	4,200	1,200	720	10	ND (<20)	ND (<20)

ND(2): ¹ = Average from duplicate determination

² = ND(<2) - Not detected; 2 represents the detection limit for the compound in the sample analyzed.

Appendix C
Section 4.3
Ref 38

Appendix C
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REF 38.

TABLE 22
TEST FUEL INSPECTION DATA

		Composite No. 2 Fuel From 10 HESs.
API Gravity		36.9
Density		.8425
Cetane Index		50
VIA		
Aromatics		26.0
Olefins		0.5
Sulfur: %		0.17
Distillation: °F.		
10%		417
50%		498
90%		589
PMA Content ug/kg		
BaP		41
BaA		108
BaP		75
BghiP		26
Chrysene		72
Triphenylene		35
Pyrene		144
Fluoranthene		869

Sources of PNAs

Combustion and high temperature pyrolysis of organic matter are major sources of PNAs in the environment. In addition to this, however, PNAs are biosynthesized on a world wide scale by plants and microorganisms on land and in water (9).

Groundwater

PNAs have been found in uncontaminated ground water. The levels found are typically less than 50 ppt.(10,11) Concentrations for various PNAs range from less than 1 ppt (the detection limit) up to 2000 ppt.(12) The 2000 ppt value was reported for naphthalene in a lignite (brown coal) formation. Benzopyrenes and benzofluoranthenes have been reported at 10-30 ppt and 80-600 ppt, respectively.(13) Groundwater contaminated with PNAs has been observed resulting from energy-related activities (i.e. in situ coal gasification) with levels of PNAs ranging from low ppt to ppm levels.(12)

Soils

PNAs have been found in upper soil layers between 100 to 1000 ug/kg (ppb) with the highest levels found near highways and industrial areas.(9) This observation is consistent with the general view that PNAs were formed during combustion processes. Since combustion processes are more concentrated in urban and industrial areas it is reasonable to observe higher levels of PNAs in soils in these locations.

Fly Ash

PNAs in fly ash have been observed from sub ppb to 100s of ppb varying with sample source.(14) Comparable levels have been observed in municipal incinerator ash samples.

Fuels

Tables 1 and 2 summarize levels of various PNAs found in fuels used in diesel and jet engines. Levels of PNAs range from less than .7 ppb up to .1% (15,16)

Diesel Engine Particulates

Particulate matter from diesel engines is known to contain a variety of PNAs. Levels of PNAs emitted are a function of load and engine speed. The highest levels are observed under full load conditions with an average yield of 16 ug/kg fuel for both Benzo(a)pyrene and Benzo(a)anthracene. (16)

III. Migration

Direct information about the mobility of PNAs in the environment is available in the open literature.

PNAs are characterized by low aqueous solubility (e.g. 31.7 mg/l for naphthalene to 5.0×10^{-4} mg/l for dibenzo(ah)anthracene) and high octanol-water and organic carbon-water partition coefficients (e.g. 1.95×10^3 and 940 respectively, for naphthalene, to 1.5×10^6 and 5.5×10^6 respectively, for benzo(a)pyrene)(19)

The matrices studied include soil, fly ash, and water. It is generally believed that the mobility of PNAs in the environment are related to their water solubility and their ability to be adsorbed onto particulates. Two and three ring PNA's are much more mobile than four, five, or six ring PNAs. These higher member ring PNAs are not very mobile.

Soils

Migration of various PNAs on soils has been studied extensively. Partition coefficients for PNAs between soils and water (i.e. the mobile phase which transports the PNA) range as follows:

Naphthalene	1300
2 Methyl naphthalene	8500
Phenanthrene	23000
Anthracene	26000
9 Methyl Anthracene	65000
Pyrene	84000

These values were taken directly from studies conducted by the Agency(17) and compared with results obtained from similar studies conducted by other investigators(18). In both investigations actual partition coefficients were determined for several soils and sediments and the results were modeled using linear regression methods. The relationships derived compare very well considering that both groups used different compounds and soils for their investigations. (The two derived relationships differ by only a factor of 1.3).

These values indicate that PNA's are strongly adsorbed to soils and that the greater the number of rings the greater the adsorption.

Based on the data above one can estimate the leachate concentration from soil containing 1% organic carbon and 10ppm of pyrene (a four ring PNA), using the following relationship:

$$C_w = \frac{C_s}{K_{oc} f_{oc}}$$

Where C_w is the aqueous or leachable concentration of the PNA; C_s is the concentration of the PNA in the waste; K_{oc} is the organic carbon partition coefficient; and f_{oc} is the fractional mass of organic carbon in the waste (expressed as a percentage). The estimated concentration of pyrene in the leachate would be about .1 ppb pyrene.

Under similar conditions the concentration in the leachate of Benzo(a)pyrene (a five ring PNA with $K_{oc}=5.5 \times 10^6$) would be about 2 ppt.(19)

As part of this evaluation the Agency has also estimated the migration potential of benzo(a)pyrene (BaP) using a model developed by Arthur D. Little, Inc. This model, Seasonal Cycles of Water, Sediment, and Pollutants in Soil Environments (SESOIL), was used to estimate the migration of BaP in a sandy soil. The agency used this model with worst case assumptions (e.g. permeable soil with low organic content, no degradation etc.). The results of this analysis indicate that wastes containing 20 ppm of BaP in a soil type matrix do not migrate in the soil. In fact, the only losses predicted were to air at a level eight orders of magnitude (100,000,000) lower than the level in the waste.

Finally, comparison of R_f values for selected PNAs on silica and alumina indicates that no measurable migration of PNAs occur on these matrices without the use of organic solvents capable of altering the interaction of the PNAs with the support. These solvents are among the most non-polar solvents known (cyclohexane, benzene, etc.) (26). Migration of PNAs using water as the mobile phase would therefore yield R_f values many orders of magnitude lower. Furthermore, silica and alumina have been used by chemists to quantitatively separate PNAs from other material because of their ability to strongly bind PNAs. Since the R_f value is a measure of a compounds mobility in a solid/liquid system, these data support the observation that PNAs are not mobile. Also the addition of alumina or silica to an extraction column increases the PNA binding capacity (i.e., increases the number of binding sites available) of that column.

Fly Ash

PNAs are nonpolar, nonionizing organic compounds that adsorb very strongly to soils high in organic matter as well as to the aluminosilicate matrix of which fly ash is composed. Because PNAs are bound so tightly (particularly the 4, 5, and 6 ring compounds) researchers often report poor recovery of these contaminants in studies to quantify levels on solid waste matrices, e.g. soil and fly ash. A comprehensive overview of existing methods for analysis/extraction of PNA has been done(1).

Because PNAs adhere strongly to ash, the kinds and quantities recovered are influenced by the extraction procedures used. Poor recoveries of PNAs are reported by conventional solvent extraction techniques (20) Recent studies indicate that a combination of solvent extraction, rotary shaking and ultrasonication greatly improves extraction and recovery of PNAs from fly ash (21,22,23) From the available information, measured levels of PNAs on fly ash appear to be very low. Levels of PNAs on municipal incinerator and power plant fly ash typically range from sub-ppb to several hundred ppb for each individual PNA. The study by Zelenski (24), however, documented total concentrations in the low ppm range from coal and oil power plant fly ash. These were the highest concentrations reported in the literature. In a study of PNAs in coal fired power plant fly ash the following levels were determined: 26 ng/g (ppb) for 3,6-dimethyl phenanthrene to 200 ng/g for 2-methyl chrysene.(21) Griest and Guerin (20) report levels in the sub-ppb range for individual compounds, and total quantities of PNAs of approximately 4 ng/g.

Two of the available studies specifically considered the environmental hazard posed by release of PNAs from fly ash. Griest and Gurerin (20) calculated maximum concentrations of PNA in a "worst case" extract (i.e. the entire content of the constituent is extracted) of electrostatic precipitator ash using the EP Toxicity methodology (referred to by the authors as the "Toxicant Extraction Procedure"). The results for fluoranthene and pyrene were 1.0 and 1.2 ug/l respectively. In the work by Harrison et. al. (23), the authors noted that the PNAs found in largest concentrations in the extracts were naphthalene and its derivatives (total concentrations of two ring aromatics in wet scrubber (WS) and electrostatic precipitator (ESP) ash were 10 and 520 ppb respectively). The authors measured the partitioning of [¹⁴C] naphthalene between fly ash and scrubber water. The ratios for ESP fly ash and scrubber water was 1100:1 and for WS fly ash and scrubber water, 2400:1. Harrison and coworkers concluded that expected aqueous concentrations of naphthalene in equilibrium with ESP and WS fly ash would be approximately 0.08 ug/l and 0.004 ug/l respectively, and that this would constitute maximum concentration of any PNA in water (because all PNAs larger than naphthalene were lower in concentration in their extracts and are of lower aqueous solubility). The study by Roy et al. (22), focused specifically on the solubility of fly ash contaminants. As part of this study, 5 of 12 fly ash samples were extracted with benzene, and organic analyses of the extracts were conducted. These results were compared with the carbon content of the ashes. Roy and coworkers found that in two western fly ashes, less than 1% of the organic carbon present in the fly ash was extractable into benzene. In two other fly ashes, less than 0.1% of the organic carbon was extracted into benzene. The results of Roy et al. (22), demonstrate that organic contaminants of fly ash are strongly bound to the alumino-silicate matrix. Given the greater affinity of PNA compounds for an organic phase (e.g., benzene or octanol) than water, the concentration of PNA in leachate from fly ash (to water) will be extremely low.

Available water extraction data further supports the high affinity of PNAs to fly ash and their inability to be extracted with water. ERCO (1981) found PNAs to be non-detectable in water extracts from coal fly ash residues at a detection limit of 1 ppb. Data submitted by the Amoco Oil Company in support of its petition to delist refinery waste that was treated using an alumino-silicate stabilization technology, also showed non-detectable levels of PNAs in the acetic acid/water and nitric/sulfuric acid/water extracts of the EP Toxicity and Multiple Extraction procedures. (Detection limits were 10 ppb).

Extraction Efficiencies

Numerous studies have been conducted where the efficiency of extraction and concentration of PNAs are investigated. (Reference 1 contains a detailed listing of these studies). These studies, on the whole indicate that:

1. PNAs are often found in matrices from which they are not readily extracted. Recoveries of PNAs can range from less than 20% (Cl⁴Bap on fly ash) to 100% with the highest recoveries for 2 and 3 ring PNAs and the lowest recoveries for 4 or more ring PNAs.
2. Adsorption effects are significant and should be minimized.
3. Suspended solids decrease extraction efficiency.
4. Highest recoveries are observed when PNAs are adsorbed onto a resin designed to provide reversible binding.

Extraction efficiency is essentially a measure of how difficult (or easy) it is to move a particular compound or compound class from one particular matrix into a solvent system. Therefore, extraction efficiency can be considered a reflection of the binding capacity of PNAs to the matrix.

The information described above is supporting evidence that PNAs are not mobile under conditions normally experienced in the environment (e.g., aqueous mobile phases). Furthermore the data indicates, that even in the presence of strong organic solvents PNAs with 4 or more rings are poorly recovered which means that PNAs are so tightly bound to various matrices that even strong solvent is not entirely effective in mobilizing the PNA from the matrix.

Damage Cases - Migration of PNAs into Ground Water

Data obtained from the Damage Incident Data Base* (JRB Associates/SAIC) indicated that PNA contamination of ground water occurs infrequently. Ground-water supplies that are reported to be contaminated with PNAs have been found to contain only 2 and 3 ring PNAs in the majority of cases. Napthalene is the primary contaminant identified. Only in one instance was a PNA with more than 3 rings detected in ground water. Pyrene, a 4 ring PNA, was measured at levels

* This data base was developed from information contained in EPA files from Regions II and V. While this information represents the best available information documenting cases where migration of PNAs has occurred, information contained in the files may not be adequate to assess migration potential of all PNAs in all disposal situations.

of 54 ug/l in ground water below an oil and chemical service open pit disposal site. High concentrations of solvents were also present however (e.g., toluene, substituted toluenes, benzene, substituted benzenes) as well as nitro phenols and chlorophenols. Movement of pyrene to ground water at this site may have occurred by partitioning to, and transport in a liquid organic matrix, rather than dissolution and movement in water.

IV. TOXICITY OF PNAs

Limited information is available on acute or chronic toxicity of PNAs in mammalian species. From the existing data PNAs appear to be low in acute toxicity: oral LD₅₀ in rats 50 mg/kg for benzo (a) pyrene to 4360 mg/kg for 1,2 methylnaphtalene (27,28). The main toxicological concern of exposure of PNA is carcinogenicity. The majority of identified 4, 5, and 6 ring PNA are confirmed human or animal carcinogens. Anthracene, a 3 ring PNA, is a suspect human and animal carcinogen (limited evidence). There is no evidence that 2 ring PNAs are carcinogens or mutagens.

Toxicity data for PNA compounds categorized by the number of aromatic rings in general, indicates that:

1. The majority of 4, 5, and 6-ring PNAs are confirmed human or animal carcinogens, and many are experimental mutagens. 70% of all PNAs are in these structural groups;
2. Half of the 3-ring PNAs are suspected human or animal carcinogens or suspected experimental mutagens. Data on the remaining 3-ringed PNAs is insufficient to characterize;
3. Data on the 2-ring PNAs is insufficient to characterize;
4. Available acute toxicity data suggests that acute toxicity is not a common characteristic of PNAs and occurs only with very large doses (>200 mg/kg).

V. Conclusions

General

Based on the information presented in this report the Agency has made a number of tentative conclusions regarding PNAs.

1. PNAs are found in a variety of matrices including soil, fly ash, and groundwater. They occur primarily as products of combustion and have been found at levels up to 1 ppm in soils and at somewhat lower levels in fly ash and groundwater.
2. PNAs are not very mobile in the environment, especially if small particles (such as in soils, fly ash, and aquifers) are present. The two and three ring PNAs are much more mobile than the four or higher ring PNAs.
3. The chronic toxicity of PNAs is related to the number of rings they contain. Two and three ring PNAs are relatively non-toxic while the four and higher ring PNAs are extremely toxic.

Fly Ash

The quantities of solvent-extractable PNAs on fly ash (e.g., use of benzene, toluene, methylene chloride, etc.) have been typically shown to be very low. Of the PNAs present, the two and three ring compounds are most easily extracted and are found in the highest concentrations. Naphthalene and its derivatives commonly make up the greatest percentage of PNAs found in extracts. It is clear that if PNAs on fly ash cannot be readily removed by vigorous extraction with organic solvent, it is unlikely they would be removed in any environmentally significant quantity by a nonorganic solvent (e.g., water). Non-detectable PNA levels in water extracts collected to date support this. PNAs that are removed from fly ash in aqueous leachate will preferentially adsorb to soil containing organic matter. Soil-water (K_p) and organic carbon-water (K_{oc}) partition coefficients are extremely high for the 4, 5, and 6 ring PNAs. Only the two and three ring compounds are mobile in soil. The PNAs that are most mobile in the environment however, are those of the least toxicological concern. It is the 4, 5, and 6 ring compounds that adsorb most strongly to soils and fly ash that are the proven or suspect carcinogens or mutagens in animals or humans.

Fly ash has a composition very similar to soil in that it is composed chiefly of silica, alumina, carbon, etc. Most soils are chiefly composed of silica or sand (SiO_2) and Alumina (Al_2O_3). These materials usually comprise 80 to

90% of soil which is about the same percentage as in fly ash. Since fly ash is very similar to soil the Agency has used the data presented for soil (i.e., the soil water partition coefficients and the data available on BaP using the SESOIL Model) to estimate the levels of PNAs that could migrate from the ash. Furthermore, because data presented by Harrison for fly ash is in close agreement with partition coefficients derived for soil and sediment we believe this is a reasonable approach. Based on this information we estimate that 4, 5, and 6 ring PNAs on fly ash at levels in the 10 to 20 ppm range (and possibly higher) would not present a hazard to human health or the environment from a groundwater exposure route.

Soils and Alumino-Silicates

As pointed out above, PNAs are strongly bound to soils, especially when small quantities of organic carbon are present. Because of this binding the conclusions drawn about the mobility of PNAs from soils (and matrices like soils) will be the same as those from fly ash. The toxicity information is also the same.

Silicate, silica, and alumina are generally added, as reagents, during waste stabilization processes. The processes which use these reagents provide a solid support for the adsorption and subsequent immobilization of PNAs in the same manner as fly ash with similar results. The addition of these reagents to a treatment residue would be expected to increase the available number of PNA binding sites in that residue. Based on this observation and in conjunction with experimental evidence on the mobility of PNAs from particular silica stabilized wastes the Agency believes that levels in the 10 to 20 ppm range (and possibly higher) of the higher ring PNAs are not of concern when present in these matrices.

what about 1, 2 & 3
ring PNAs ?

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Petroleum, one of the most important natural resources in our world today, is a very interesting and intriguing chemical substance. Although it contains small amounts of compounds of sulfur, of nitrogen, of oxygen, and of metallic constituents, petroleum is largely hydrocarbon material, with molecules ranging in size from 1 to 50 or more carbon atoms and comprising a diversity of molecular types. Because petroleum contains many hydrocarbon compounds which are of themselves important chemicals of commerce, and because chemicals derived from petroleum are increasing greatly in number and importance, petroleum has come to be called nature's storehouse of chemicals.

Going back into history, we find that early man long wondered about the thick dark liquid that oozed from the earth or floated on natural waters. He learned many centuries ago that this strange substance would burn and give out great heat and light. Petroleum, or some portion of it, as bitumen or asphalt, is mentioned in the Bible, and records show that asphalt was used by man as early as 3800 B.C. (1, 2). Petroleum was found as an oily liquid exuding from the surface of the earth in tar springs or on shores of lakes or rising from springs beneath the beds of rivers in many places on earth, as Rumania, Iran, Italy, Trinidad, Cuba, India, and later the United States. Surface wells were dug to increase the quantity available.

But it remained for the first drilled petroleum well to start the great flow of crude oil from the earth—the famous Drake well, located near Titusville, Pennsylvania, completed in 1859 to a depth of 69½ ft. with a production of about 25 barrels per day. Since then, the annual production of petroleum from the continental United States has grown to truly astonishing amounts, as follows, in billions of barrels per year: 0.000002 in 1860; 0.026 in 1880; 0.064 in 1900; 0.44 in 1920; 1.3 in 1940; nearly 2.0 in 1950; and nearly 3.5 in 1960. The "proved" reserves of petroleum in the continental United States have also increased greatly, as follows in billions of barrels: 3 in 1900; 7 in 1920; 19 in 1940; and 35 in 1960. The ratio of the proved reserves to the annual production in any given year has decreased somewhat over the years: 21:1 in 1910; 16:1 in 1920; 15:1 in 1930; 15:1 in 1940; 13:1 in 1950; and about 10:1 in 1960.

Early Work

In 1906, Coates (3), one of the early investigators of the composition of petroleum, stated: "It is exceedingly difficult to get the hydrocarbons (from

petroleum) in a state of purity. Indeed, I do not think it can be done by distillation." In 1921, Anderson and Erskine (4) published the results of their work on the composition of "natural" gasoline. In 1926, Brown and Carr (5) published the results of the first investigation in which appreciable quantities of "pure" hydrocarbons were separated from petroleum by systematic distillation. From 1932 to 1938, notable contributions on the composition of petroleum were published by Fenske and co-workers (6, 7). The state of the existing knowledge in 1928 was well summarized by Gruse (11).

A summary of other work on the composition of petroleum, including hydrocarbon constituents, sulfur compounds, nitrogen compounds, oxygen compounds, and metallic constituents is given by Rossini, May, and Streiff (13), Lochte (14), Gruse and Stevens (15), and Smith, Dunning, Rull, and Ball (16).

The cover



The whole story of the API distillation laboratory is better revealed by this photograph. The 14 distilling assemblies, each with a separating power of 200 theoretical plates, extend through two floors. The laboratory operates 24 hours per day, seven days per week.

¹ Present address, University of Notre Dame, Notre Dame, Indiana.

In 1927, the American Petroleum Institute Research Project 6 was established at the National Bureau of Standards under the direction of Edward W. Washburn to investigate the hydrocarbon constituents of petroleum. Washburn continued to direct the work until his untimely death early in 1934. The writer then became Director of the Project and has continued actively in it for 26 years. For the past ten years, Beveridge J. Mair has been Associate Director, becoming Director in July, 1960.

An interesting historical account of the API Research Project 6 has been prepared by Hill (12). A complete list of the many professional investigators who have been associated with the Project from 1927 to 1952 is given in reference 13. The purpose of the present report is to give a self-consistent story of hydrocarbons in petroleum as developed by the approximately 500 man-years of work put on this problem by the API Research Project 6.

To get at the heart of the composition of petroleum, and to lay open the components in a way that accurately discloses their identity, the API Research Project 6 has had one representative petroleum continually under exhaustive fractionation since 1928. The work of the Project has established that substantially all of the hydrocarbons in petroleum are composed of only three kinds of component parts, namely, paraffin groups, cycloparaffin (or naphthalene) groups, and aromatic groups. Examples of these three classes of component parts are shown in Figure 1.

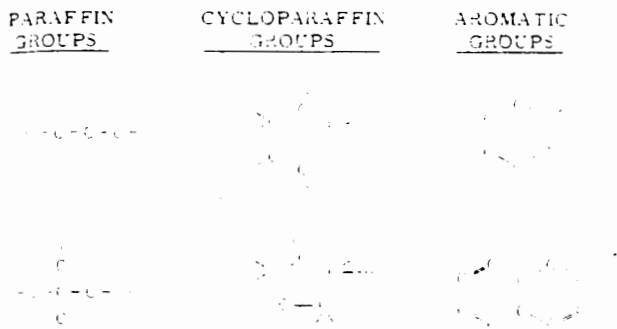


Figure 1. The three types of hydrocarbon groups from which substantially all the hydrocarbons in petroleum are made.

There are three broad classes of hydrocarbons in petroleum, as follows: (1) paraffins, which are those molecules containing only paraffin groups; (2) cycloparaffins, which are those molecules containing one or more cycloparaffin groups with or without paraffin groups; and (3) aromatics, which are those molecules containing one or more aromatic groups, with or without cycloparaffin groups and/or paraffin groups.

The precise manner in which the above groups are combined to form the individual compounds can be originally determined with accuracy only by the actual isolation of the individual compounds. Fortunately, this exhaustive fractionation need be done only once. When this basic information becomes known, shorter methods can be used to make rapid analyses of the compounds previously established to be components of petroleum.

increase our knowledge of the composition of different petroleum the world over. Some years ago, the Project completed an extended investigation on the composition of the gasoline fraction of petroleum from seven fields in the continental United States, each representing major production. The results of this investigation, supported by related findings on petroleum from other lands, provide a framework which makes it possible to translate to any new petroleum the basic information and data obtained on the one representative petroleum of the API Research Project 6.

In addition to the foregoing information, one of the important products of the work has been the development of fractionating processes of high separating power.

General Plan of Operation

The general plan of operation on the one representative petroleum has been substantially as follows: (1) one representative petroleum, more or less "intermediate" in character, was selected for examination, from the Brett No. 6 well in the Ponca City field in Oklahoma; (2) a sufficient quantity (approximately 500 gal.) of this representative petroleum was taken as starting material, so that after appropriate fractionation the principal components would be expected to be present in an adequate amount to permit identification; (3) the fractionation of the material was (and is carried out in such a way as to neither destroy constituents already present nor to produce new ones previously absent; (4) the entire petroleum is separated by distillation (at pressures low enough to keep the distilling temperature below 200°C) into convenient broad fractions, as the "gas," "gasoline," "kerosene," "light gas oil," "heavy gas oil and light lubricating distillate," and "lubricant" fractions; (5) the "gas" fraction was separated by distillation alone; (6) each of the remaining broad fractions was (or is being separated, by the use of the proper combination of fractionating processes, into classes and subclasses of hydrocarbons including, as appropriate, normal paraffins, branched paraffins, mono-cycloparaffins, bi-cycloparaffins, higher cycloparaffins, mononuclear aromatics, dinuclear aromatics, and higher nuclear aromatics; (7) each subclass of hydrocarbons is separated by distillation with high separating power according to boiling point or molecular size to produce "homogeneous" fractions containing molecules of substantially the same size and class; (8) the homogeneous fractions are further fractionated in so far as possible to yield the principal individual compounds; (9) each of the homogeneous fractions which remains unresolved with respect to individual compounds is examined as to physical and spectrographic properties in order to derive as much information as possible concerning the composition of the unresolved homogeneous fraction.

We have learned that the more thoroughly we examine the lower boiling broad fractions, as the gas, gasoline, and kerosene fractions, the more we can learn from given observations on the higher boiling fractions.

Fractionating Processes Used

The method which has been developed by the Project for separating petroleum into its principal constituents may be described as the systematic interlocking of the basic processes of fractionation and their variations. The order in which the various fractionating processes are used to separate a given fraction of petroleum into its main constituents is determined by the effectiveness of each given process in furthering the separation already attained by the preceding process. The fractionating processes used by the Project have included five forms of distillation, two forms of extraction, four forms of adsorption, two forms of crystallization, and two forms of separation with solid molecular or clathrate compounds:

Distillation (liquid and gas phases): (a) regular, at one pressure (30, 55, 214, or 760 mm Hg); (b) alternately at different pressures (30, 55, 214, and 760 mm Hg); (c) at very low pressures (0.01 to 0.1 mm Hg); (d) azeotropically, with regular polar organic compounds; (e) azeotropically, with fluoro-organic compounds.

Extraction (two liquid phases): (a) with one solvent phase; (b) with two solvent phases.

Adsorption (liquid or gas phase and solid-adsorbed phase): (a) regular; (b) with one or more added components.

Crystallization (liquid and solid phases): (a) regular; (b) with a selected solvent.

Formation of molecular or clathrate compounds: (a) in batch process; (b) in column with "reflux."

For details of the fractionating processes used in this work, the reader may consult references 15 to 17-20.

Summary of the Present Status of the Work

Using the fractionating processes mentioned above and operating systematically and exhaustively according to plan, the Project has isolated 175 hydrocarbon compounds from its one representative petroleum as of June 30, 1960. A description of the source and character of this representative petroleum is given in reference 15. Additional details may be found in reference 22.

Table 1 gives a summary of the amounts of the broad fractions constituted by the hydrocarbons isolated from this representative petroleum. Table 2 gives the distribution, by class and broad fraction, of the hydrocarbons isolated. Table 3 gives the distribution (by class and number of carbon atoms per molecule) of the hydrocarbons isolated, except for the normal paraffins, of which all 32 members (from methane, CH_4 , to normal tritriacontane, $\text{C}_{32}\text{H}_{66}$, inclusive) have been isolated.

Table 4 lists the 175 hydrocarbons isolated, according to class, and gives the normal boiling point and the amount of the given compound in this petroleum.

Table 1. Summary of the Amounts of the Broad Fractions Constituted by the Hydrocarbons Isolated from the Representative Petroleum

Broad fraction	Gas	Gasoline	Kerosine	Light gas oil	Heavy gas oil and light lubricating distillate	Lubricant fraction	Residue	Total
Boiling range at 1 atm. ($^{\circ}\text{C}$)	$<40^{\circ}$	$40^{\circ}-180^{\circ}$	$180^{\circ}-230^{\circ}$	$230^{\circ}-305^{\circ}$	$305^{\circ}-405^{\circ}$	$405^{\circ}-515^{\circ}$		
Range of normal paraffins	C_1-C_3	C_6-C_{10}	C_{11} and C_{12}	$\text{C}_{13}-\text{C}_{17}$	$\text{C}_{18}-\text{C}_{25}$	$\text{C}_{26}-\text{C}_{32}$		
Estimated percentage of the original petroleum constituted by the given fraction	4	33.2	12.7	18.6	14.5	10.9	7	100
Number of compounds isolated	7	101	37	12	10	8		175
Estimated percentage of the fraction accounted for by the hydrocarbons isolated	100	82.3	38.4	30.2	20.5	9.9		
Estimated percentage of the original petroleum accounted for by the hydrocarbons isolated	4.0	27.3 ₁	4.8 ₁	5.6 ₁	2.9 ₁	0.9 ₁		45.7 ₁

Table 2. Distribution, by Class and Broad Fraction, of the Hydrocarbons Isolated from the Representative Petroleum

Broad fraction	Gas	Gasoline	Kerosine	Light gas oil	Heavy gas oil and light lubricating distillate	Lubricant fraction	Total
Boiling range at 1 atm. ($^{\circ}\text{C}$)	$<40^{\circ}$	$40^{\circ}-180^{\circ}$	$180^{\circ}-230^{\circ}$	$230^{\circ}-305^{\circ}$	$305^{\circ}-405^{\circ}$	$405^{\circ}-515^{\circ}$	
Range of normal paraffins	C_1-C_3	C_6-C_{10}	$\text{C}_{11}-\text{C}_{12}$	$\text{C}_{13}-\text{C}_{17}$	$\text{C}_{18}-\text{C}_{25}$	$\text{C}_{26}-\text{C}_{32}$	
Number of Compounds							
Classes of hydrocarbons							
Normal paraffins	5	5	2	5	8	8	33
Branched paraffins	2	35					37
Alkyl cyclopentanes		22					22
Alkyl cyclohexanes		13	1				14
Alkyl cycloheptanes		1					1
Bicyclopentanes		4	6				10
Tricyclopentanes			1				1
Alkyl benzenes		20	20				40
Aromatic cyclopentanes		1	6	1			8
Dinuclear aromatics			1	6	1		8
Trinuclear aromatics					1		1
Total	7	101	37	12	10	8	175

Fractions by Distillation

Gas. The gas fraction, taken as the material normally boiling up to 40°C, has been fully accounted for in terms of all the possible normal paraffins and branched paraffins, C_1 to C_5 , except for 2,2-dimethyl propane which is believed to be present only in extremely small or trace amounts. These compounds are listed in Table 4.

Gasoline. The hydrocarbons of this fraction, taken as the material normally boiling from 40° to 180°C, consist of normal (C_6 to C_{10}) and branched paraffins, mono- and bicyclopentanes, and mononuclear aromatics. In Table 4 are listed the compounds isolated, together with those compounds normally boiling up to 132°C which are believed to be present in extremely small amounts.

All of the five possible normal paraffins, C_6 to C_{10} , have been accounted for. All of the possible branched paraffins in the range 40° to 132°C have been isolated, except for six compounds which are believed to be present only in extremely small amounts. Also isolated were eight branched paraffins in the range 132° to 180°C. The monocyclopentanes in the gasoline fraction consist of alkyl cyclopentanes, alkyl cyclohexanes, and very small amounts of alkyl cycloheptanes. All of the possible alkyl cyclopentanes normally boiling up to 132°C have been isolated, except for three compounds which are believed to be present only in extremely small amounts. All of the possible alkyl cyclohexanes normally boiling up to 132°C, including one C_6 , one C_7 , and eight C_8 compounds, have been isolated. In addition, three of the C_9 trimethylcyclohexanes have been isolated. Among the alkyl cycloheptanes, only cycloheptane itself, present in very small amounts, has been isolated to date. So far four bicyclopentanes have been isolated from the gasoline fraction. All of the 21 possible mononuclear aromatics have been isolated from this gasoline fraction. Of these, 20 are alkyl benzenes and one is an aromatic-cyclopentane indan.

Kerosine. The hydrocarbons of this fraction, taken as the material normally boiling from 180° to 230°C, consist of normal (C_{11} and C_{12}) and branched paraffins, mono-, bi-, and higher cyclopentanes, and mono- and dinuclear aromatics. From this material have been isolated two normal paraffins, one alkyl cyclo-

hexane, six bicyclopentanes, one tricyclopentane (adamantane), 20 alkyl benzenes, six aromatic-cyclopentanes, and one dinuclear aromatic, as listed in Table 4.

Light Gas Oil. The hydrocarbons of this fraction, taken as the material normally boiling from 230° to 305°C, consist of normal (C_{13} to C_{17}) and branched paraffins, mono-, bi-, and higher cyclopentanes, and mono- and dinuclear aromatics. From this have been isolated five normal paraffins, one aromatic-cyclopentane, and six dinuclear aromatics, listed in Table 4.

Heavy Gas Oil and Light Lubricating Distillate. The hydrocarbons of this fraction, taken as the material normally boiling from 305° to 405°C, consist of normal (C_{18} to C_{23}) and branched paraffins, mono-, bi-, and higher cyclopentanes, and mono-, di-, and higher nuclear aromatics. From this material, ten hydrocarbons have been isolated, including eight normal paraffins, one dinuclear aromatic, and one trinuclear aromatic, as listed in Table 4.

Lubricant. The hydrocarbons of this fraction, taken as the material normally boiling from 405° to 515°C, consist of normal (C_{24} to C_{28}) and branched paraffins, mono-, bi-, and higher cyclopentanes, and mono-, di-, and higher nuclear aromatics. From this material, only seven normal paraffins have been isolated, as given in Table 4.

Types of Homologs

Normal Paraffins. As indicated earlier, all of the normal paraffins, C_1 to C_{28} , have been isolated. The amount of each in the original petroleum, in per cent by volume, increases from 1.8 for C_6 to 2.3 for C_7 and then decreases gradually to an estimated value of 0.09 for C_{28} .

Branched Paraffins. A total of 37 branched paraffins have been isolated, all from the gas and gasoline fractions. Enough has been learned about this class to indicate that all possible isomers may be present, although many only in trace amounts. The most abundant isomer in any group is usually the 2-methyl isomer, with the 3-methyl and 4-methyl isomers following. In any given group of isomers, the bulk of the material will consist of the singly branched isomers with the amounts of the doubly-branched ones dropping sharply and of the triply-branched ones even more so. For example, in this representative

Table 3. Distribution, by Class and Number of Carbon Atoms per Molecule, of the Hydrocarbons Isolated

Number of carbon atoms per molecule	4	5	6	7	8	9	10	11	12	13	14	Total
Branched paraffins	1	1	4	6	15	7	3					37
Alkyl cyclopentanes		1	1	5	13	2						22
Alkyl cyclohexanes			1	1	8	3	1					14
Alkyl cycloheptanes				1								1
Bicyclopentanes					3	1		1				10
Tricyclopentanes							1					1
Alkyl benzenes			1	1	4	8	22	4				40
Aromatic cyclopentanes						1	4	3				8
Dinuclear aromatics							1	2	3	1	1	8
Trinuclear aromatics											1	1
Total	1	2	7	14	43	21	37	10	3	1	2	142
Normal paraffins, C_1 to C_{12}												33
Grand total												175

Table 4. Hydrocarbons in the Representative Petroleum of the API Research Project 6

Formula	Compound	Normal boiling point (°C)	Amount ^a percentage by volume	Formula	Compound	Normal boiling point (°C)	Amount ^a percentage by volume
<i>Normal paraffins</i>				<i>Alkyl cyclopentanes</i>			
CH ₄	Methane	-161.49	0.1	C ₅ H ₁₂	1-Methyl-trans-2-ethylcyclopentane	121.2	0.34
C ₂ H ₆	Ethane	-88.63	0.2	"	1-Methyl-1-ethylcyclopentane	121.52	0.93
C ₃ H ₈	Propane	-42.07	0.4	"	1-cis-2-cis-3-Trimethylcyclopentane	123.0	0.8
C ₄ H ₁₀	n-Butane	-0.50	0.9	"	Isopropylcyclopentane	126.42	0.61
C ₅ H ₁₂	n-Pentane	36.07	1.65	"	1-Methyl-1-cis-2-ethylcyclopentane	128.05	0.61
C ₆ H ₁₄	n-Hexane	68.74	1.8	"	n-Propylcyclopentane	130.95	0.96
C ₇ H ₁₆	n-Heptane	98.43	2.3	C ₆ H ₁₄	1,1,3,3-Tetramethylcyclopentane	137.96	0.8
C ₈ H ₁₈	n-Octane	125.66	1.9	"	1,1-cis-3-trans-4-Tetramethylcyclopentane	141.6	0.94
C ₉ H ₂₀	n-Nonane	150.80	1.8	"	1-trans-2-cis-3-trans-4-Tetramethylcyclopentane	147.4	0.15
C ₁₀ H ₂₂	n-Decane	174.12	1.8	"	1,1-cis-2-trans-3-Tetramethylcyclopentane	150	0.8
C ₁₁ H ₂₄	n-Undecane	195.89	1.6	"	1,1-cis-2-cis-3-Tetramethylcyclopentane	150	0.8
C ₁₂ H ₂₆	n-Dodecane	216.28	1.4	"	1,1-cis-2-trans-4-Tetramethylcyclopentane	150	0.8
C ₁₃ H ₂₈	n-Tridecane	235.43	1.2	"	1,1-cis-2-trans-4-Tetramethylcyclopentane	151	0.8
C ₁₄ H ₃₀	n-Tetradecane	253.52	1.0	"	1-trans-2-trans-3-cis-4-Tetramethylcyclopentane	151	0.8
C ₁₅ H ₃₂	n-Pentadecane	270.61	0.8	C ₆ H ₁₂	Cyclohexane	80.74	0.71
C ₁₆ H ₃₄	n-Hexadecane	286.79	0.7	C ₇ H ₁₄	Methylcyclohexane	100.93	1.6
C ₁₇ H ₃₆	n-Heptadecane	302.15	0.6	C ₈ H ₁₈	1-trans-4-Dimethylcyclohexane	119.35	0.25
C ₁₈ H ₃₈	n-Octadecane	316.71	0.50	C ₉ H ₂₀	1,1-Dimethylcyclohexane	119.54	0.66
C ₁₉ H ₄₀	n-Nonadecane	330.6	0.43	"	1-cis-3-Dimethylcyclohexane	120.09	0.63
C ₂₀ H ₄₂	n-Eicosane	343.8	0.37	"	1-trans-2-Dimethylcyclohexane	123.42	0.31
C ₂₁ H ₄₄	n-Heneicosane	356.5	0.32	"	1-cis-4-Dimethylcyclohexane	124.32	0.66
C ₂₂ H ₄₆	n-Docosane	368.6	0.28	"	1-trans-3-Dimethylcyclohexane	124.45	0.67
C ₂₃ H ₄₈	n-Tricosane	380.2	0.25	"	1-cis-2-Dimethylcyclohexane	129.73	0.6
C ₂₄ H ₅₀	n-Tetracosane	391.3	0.22	"	Ethylcyclohexane	131.78	0.37
C ₂₅ H ₅₂	n-Pentacosane	401.9	0.20	C ₁₀ H ₁₈	1,1,3-Trimethylcyclohexane	136.63	0.2
C ₂₆ H ₅₄	n-Hexacosane	412.2	0.18	"	1-trans-2-trans-4-Trimethylcyclohexane	141.22	0.2
C ₂₇ H ₅₆	n-Heptacosane	422.1	0.16	"	1-trans-2-cis-4-Trimethylcyclohexane	145.6	0.13
C ₂₈ H ₅₈	n-Octacosane	431.6	0.14	C ₁₀ H ₁₆	n-Butylcyclohexane	180.95	0.22
C ₂₉ H ₆₀	n-Nonacosane	440.8	0.13	<i>Cycloheptanes</i>			
C ₃₀ H ₆₂	n-Triacontane	449.7	0.12	C ₇ H ₁₄	Cycloheptane	118.79	0.01
C ₃₁ H ₆₄	n-Hentriacontane	458.0	0.11	<i>Bicycloparaffins</i>			
C ₃₂ H ₆₆	n-Dotriacontane	467.0	0.10	C ₈ H ₁₆	Methylbicyclo [2.2.1]heptane	121.5	0.001
C ₃₃ H ₆₈	n-Triacontane	475.0	0.09	"	cis-Bicyclo [3.3.0] octane	136.5	0.06
<i>Branched paraffins</i>				"	Bicyclo [3.2.1] octane	138.1	0.008
C ₄ H ₁₀	2-Methylpropane (isobutane)	-11.73	0.3	C ₉ H ₁₈	Bicycloparaffin	146.7	0.06
C ₅ H ₁₂	2,2-Dimethylpropane (neopentane)	9.50	0.5	C ₁₀ H ₂₀	Bicycloparaffin	180	0.01
C ₅ H ₁₂	2-Methylbutane (isopentane)	27.85	0.5	"	Bicycloparaffin	183.4	0.01
C ₆ H ₁₄	2,2-Dimethylbutane	49.74	0.04	"	Bicycloparaffin	183.7	0.02
"	2,3-Dimethylbutane	57.99	0.08	"	trans-Bicyclo [4.4.0] decane (trans-1,2-dimethyldronaphthalene)	187.25	0.2
"	2-Methylpentane	60.27	0.37	"	cis-Bicyclo [4.4.0] decane (cis-1,2-dimethyldronaphthalene)	195.69	0.09
C ₇ H ₁₆	2,2-Dimethylpentane	63.28	0.35	C ₁₁ H ₂₂	Bicycloparaffin	202.5	0.12
"	2,3-Dimethylpentane	79.20	0.02	<i>Tricycloparaffins</i>			
"	2,4-Dimethylpentane	80.50	0.08	C ₁₁ H ₂₀	Tricyclo [1.1.1]heptane (adamantane)	190	0.0004
"	2,2,3-Trimethylpentane	80.87	0.08	<i>Alkyl benzenes</i>			
"	2,3,4-Trimethylpentane	80.87	0.08	C ₆ H ₆	Benzene	80.10	0.15
"	2,2,4-Trimethylpentane	89.78	0.15	C ₇ H ₈	Methylbenzene (toluene)	110.62	0.51
"	2-Methylhexane	90.05	0.73	C ₈ H ₁₀	Ethylbenzene	136.19	0.19
"	3-Methylhexane	91.85	0.51	"	1,4-Dimethylbenzene (p-Xylene)	138.45	0.19
"	3-Ethylpentane	93.48	0.06	"	1,3-Dimethylbenzene (m-Xylene)	139.10	0.51
C ₈ H ₁₈	2,2,4-Trimethylpentane	99.24	0.01	"	1,2-Dimethylbenzene (o-Xylene)	144.41	0.27
"	2,2,3,4-Tetramethylbutane	106.47	0.01	C ₉ H ₁₂	Isopropylbenzene	152.39	0.07
"	2,2-Dimethylhexane	106.84	0.06	"	n-Propylbenzene	159.22	0.09
"	2,3-Dimethylhexane	109.10	0.06	"	1-Methyl-3-ethylbenzene	161.30	0.17
"	2,4-Dimethylhexane	109.43	0.06	"	1-Methyl-4-ethylbenzene	161.99	0.06
"	2,2,5-Trimethylpentane	109.84	0.004	"	1,3,5-Trimethylbenzene	164.72	0.12
"	2,3,4-Trimethylpentane	111.97	0.03	"	1-Methyl-2-ethylbenzene	165.15	0.09
"	2,3,5-Trimethylpentane	113.47	0.005	"	1,2,4-Trimethylbenzene	169.35	0.51
"	2,4,5-Trimethylpentane	114.76	0.006	"	1,2,5-Trimethylbenzene	176.08	0.19
"	2,6-Dimethylhexane	115.61	0.07	C ₁₀ H ₁₄	tert-Butylbenzene	180.12	0.01
"	2-Methyl-3-ethylpentane	115.65	0.06	"	Isobutylbenzene	172.76	0.008
"	2-Methylheptane	117.65	0.90	"	sec-Butylbenzene	173.30	0.017
"	4-Methylheptane	117.71	0.20	"	1-Methyl-3-isopropylbenzene	175.14	1.08
"	3,1-Dimethylhexane	117.72	0.13	"	1-Methyl-4-isopropylbenzene	177.10	0.04
"	3-Methyl-3-ethylpentane	118.26	0.02	"	1-Methyl-2-isopropylbenzene	178.15	0.009
"	3-Ethylhexane	118.53	0.09	"	1,3-Dimethylbenzene	181.10	0.026
"	3-Methylheptane	118.92	0.30	"	1-Methyl-4-propylbenzene	181.80	0.059
C ₉ H ₂₀	2,2,4,4-Tetramethylpentane	122.28	0.002	"	n-Butylbenzene	183.27	0.026
"	2,2,5-Trimethylhexane	124.08	0.03	"	1-Methyl-4-propylbenzene	183.30	0.027
"	2,2,4,5-Tetramethylpentane	126.54	0.03	"	1,2-Dimethylbenzene	183.42	0.005
"	2,3,5-Trimethylhexane	131.34	0.05	"	1,3-Dimethyl-5-ethylbenzene	183.58	0.063
"	2,6-Dimethylheptane	133.21	0.05	"	1,4-Dimethylbenzene	183.78	0.007
"	2,3-Dimethylheptane	142.48	0.1	"	1-Methyl-2-propylbenzene	184.80	0.046
"	4-Methyloctane	143.26	0.4	"	1,4-Dimethyl-2-ethylbenzene	186.83	0.041
"	2-Methyloctane	143.18	0.1	"	1,3-Dimethyl-3-ethylbenzene	188.20	0.050
C ₁₀ H ₂₂	3-Methyloctane	165.7	0.1	"	1,2-Dimethyl-4-ethylbenzene	189.48	0.037
"	4-Methyloctane	166.8	0.3	"	1,3-Dimethyl-2-ethylbenzene	190.01	0.014
"	2-Methylnonane	167.8	0.1	"	1,2-Dimethyl-3-ethylbenzene	193.91	0.01
"	3-Methylnonane	167.8	0.1	"	1,2,4,5-Tetramethylbenzene	196.80	0.012
<i>Alkyl cyclopentanes</i>				"	1,2,3,5-Tetramethylbenzene	198.00	0.12
C ₅ H ₁₀	Cyclopentane	49.26	0.05	"	1,2,3,4-Tetramethylbenzene	205.04	0.2
C ₆ H ₁₂	Methylcyclopentane	71.81	0.87	C ₁₁ H ₁₈	1-Methyl-4-n-butylbenzene	204.1	0.09
C ₇ H ₁₄	1,1-Dimethylcyclopentane	87.85	0.16	"	1,3-Dimethyl-4-n-propylbenzene	206.6	0.01
"	1-cis-3-Dimethylcyclopentane	90.77	0.57	"	1,2-Dimethyl-4-n-propylbenzene	208.5	0.03
"	1-trans-3-Dimethylcyclopentane	91.72	0.21	"	Trimethyl-ethylbenzene	212.3	0.04
"	1-trans-2-Dimethylcyclopentane	91.87	0.48				
"	1-cis-2-Dimethylcyclopentane	99.55	0.16				
"	Ethylcyclopentane	103.47	0.30				
C ₈ H ₁₆	1,1,3-Trimethylcyclopentane	104.89	0.22				
"	1-trans-2-cis-4-Trimethylcyclopentane	109.29	0.26				
"	1-trans-2-cis-3-Trimethylcyclopentane	110.2	0.06				
"	1,1,2-Trimethylcyclopentane	113.73	0.01				
"	1-cis-2-trans-4-Trimethylcyclopentane	116.73	0.07				
"	1-cis-2-trans-3-Trimethylcyclopentane	117.5	0.12				
"	1-cis-2-cis-4-Trimethylcyclopentane	118	0.12				
"	1-Methyl-trans-3-ethylcyclopentane	120.81	0.12				
"	1-Methyl-cis-3-ethylcyclopentane	121.4	0.12				

^a The figures in parentheses are less certain than the others. Where no value is given for a compound, it is implied that the compound is not believed to be present in very small amount, less than was detectable at the time the given material was investigated.
^b Not yet identified.

Table 4 (continued)

Formula	Compound	Normal boiling point (°C)	Amount, percentage by volume
<i>Aromatic cycloparaffins</i>			
$C_{10}H_{16}$	Indan	177.8	0.003
$C_{11}H_{18}$	1-Methylindan	190.6	0.022
"	2-Methylindan	191.4	"
"	4-Methylindan	205.5	0.03
"	1,2,3,4-Tetrahydronaphthalene	207.57	0.03
$C_{12}H_{18}$	2-Methyl-1,2,3,4-tetrahydronaphthalene	220.7	0.04
"	6-Methyl-1,2,3,4-tetrahydronaphthalene	229.3	0.09
"	5-Methyl-1,2,3,4-tetrahydronaphthalene	234.35	0.08
<i>Dinuclear aromatics</i>			
$C_{10}H_8$	Naphthalene	217.96	0.06
$C_{11}H_{10}$	2-Methylnaphthalene	241.05	0.2
"	1-Methylnaphthalene	244.64	0.1
$C_{12}H_{12}$	Biphenyl	255.2	0.03
"	2,6-Dimethylnaphthalene	262	0.35
"	Dimethylnaphthalene ^c	268	0.35
$C_{13}H_{14}$	Trimethylnaphthalene ^c	288	0.20
$C_{14}H_{16}$	Alkyl naphthalene ^c	312	0.20
<i>Trinuclear aromatics</i>			
$C_{18}H_{12}$	Phenanthrene	340	0.20

^c Not yet identified.

petroleum, the amounts of each of the C_9 branched isomers, are, in per cent, of the following orders: singly-branched, 0.1; doubly-branched, 0.01; triply-branched, 0.001; quadruply-branched, trace. Knowing (a) the total amount of the branched paraffins of a given carbon number, through analysis by type of the broad fractions, (b) the number of isomers which are singly-branched, doubly-branched, etc., and (c) the relative amounts of the compounds of different branching, it is thus possible to estimate the order of magnitude of the amount of any given branched paraffin in petroleum.

Monocycloparaffins. Most of the monocycloparaffins in petroleum are alkyl cyclopentanes and alkyl cyclohexanes, with only a small amount of alkyl cycloheptanes. In general, in a given group of isomers of the alkyl cyclopentanes, the most abundant compounds are those with the largest number of substituents, each on a different carbon atom, with the substituents on adjacent carbon atoms being "trans" to one another. Similarly, in a given group of isomers of the alkyl cyclohexanes, the most abundant compounds are those with the largest number of substituents, each on a different carbon atom, with the substituents being "equatorial" rather than "axial" to minimize steric hindrance in the molecules. These are also the isomers which are thermodynamically more stable. One interesting structure, related to other natural products occurring among the monocycloparaffins, is found in 1,1,3-trimethylcyclopentane and in 1,1,3-trimethylcyclohexane, both relatively abundant in petroleum.

Bicycloparaffins. So far, ten bicycloparaffins have been isolated, four from the gasoline fraction and six from the kerosine fraction. In Figure 2 are shown the structures of the nuclei of bicycloparaffin hydrocarbons believed to be the ones occurring in petroleum in significant amount. As may be noted, these are structures which have five or six carbon atoms in each ring, a carbon common to two rings being counted twice. The numbering system is the approved one, with the numbers representing the number of carbon atoms in each bridge.

Mononuclear Aromatics. As may be seen from Table 4, all of the 32 possible aromatic hydrocarbons normally boiling up to 190°C have been isolated from this petroleum. Sixteen additional mononuclear aromatics have also been isolated. In any given group of isomers, the alkyl benzenes which are most abundant are those which are thermodynamically more stable, as the 1,3-dialkyl or 1,2,4-trialkyl benzenes, with less preference for the 1,2-dialkyl benzenes. Also, in a given group, the compounds with more substituents are more abundant, as 1,2,4-trimethylbenzene is more abundant than 1-methyl-3-ethylbenzene. With increase in the number of carbon atoms, more of the mononuclear aromatics will be of the aromatic-cycloparaffin subclass, in which, generally, the benzene ring is joined through two common carbon atoms to a cyclopentane ring or a cyclohexane ring or multi-ring combinations of these.

Dinuclear aromatics. A total of eight dinuclear aromatics have been isolated, including naphthalene, biphenyl, and six alkyl naphthalenes. The alkyl naphthalenes are much more abundant than the alkyl biphenyls. With increasing number of carbon atoms per molecule, the dinuclear aromatics will include an increasing number of aromatic cycloparaffins, with the naphthalene nucleus attached through two common carbon atoms to a mono- or bi- or higher cycloparaffin group.

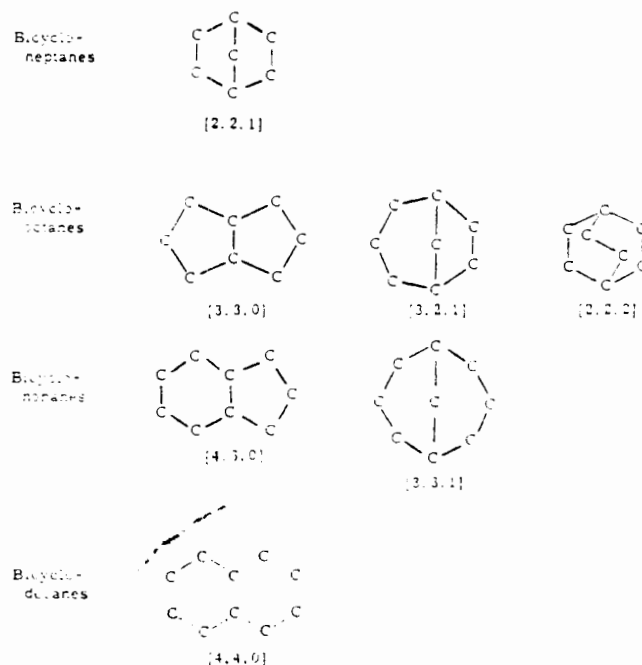


Figure 2. Structures of the nuclei of bicycloparaffin hydrocarbons believed to be the ones occurring in petroleum in significant amounts.

Higher Nuclear Aromatics. Only one compound of this group has so far been isolated, the trinuclear aromatic, phenanthrene. The alkyl phenanthrenes are expected to be more abundant than the alkyl anthracenes. Also, among the higher nuclear aromatics will occur many aromatic-cycloparaffin compounds, with the cycloparaffin portion consisting of several rings, generally condensed together with the aromatic nucleus.

Composition of Petroleums in General

Some years ago, the API Research Project 6 completed a study of the hydrocarbons from different petroleums (13, 21). The Project's one representative petroleum from Oklahoma was intermediate in type. The gasoline fractions from six additional representative petroleums were selected to represent large production in different areas of the United States and to be as different as was known at the time.

The seven representative gasoline fractions were as follows, with the type and source field: A, intermediate, Ponca, Oklahoma; B, intermediate, East Texas; C, high in paraffins, Bradford, Pennsylvania; D, high in normal paraffins, Greendale-Kawkawlin, Michigan; E, high in branched paraffins, Winkler, Texas; F, high in cycloparaffins, Midway, California; G, high in aromatics, Conroe, Texas.

By means of an extended but relatively short procedure involving the fractionating processes of adsorption and distillation, both operated at high separating power, analyses were made of the major paraffin and cycloparaffin components in the 40° to 102°C range of these gasolines and of the alkyl benzenes to 180°C. From this work, the following conclusions were reached:

All petroleums contain substantially the same hydrocarbon compounds.

The principal compounds in the gasoline fraction of each petroleum may be placed in five main classes: normal (straight-chain) paraffins; branched paraffins; alkyl cyclopentanes; alkyl cyclohexanes; alkyl benzenes.

Within each of these five classes, the individual compounds occur in proportions which are usually of the same order of magnitude for different petroleums.

Table 5 gives the relative amounts of the five main classes of hydrocarbons in the 40° to 102°C fraction of the seven petroleums, with the letters, A, B, C, D, E, F, and G representing the same petroleums as above. These figures indicate considerable variation in the relative amounts of the several classes from one petroleum to the other. For example, the ratio of normal paraffins to branched paraffins ranges from 4.8 for D to 0.15 for E, a variation of over 30-fold. Similarly, the ratio of alkyl cyclopentanes to alkyl benzenes ranges from 68 for F to 4.6 for G, a variation of 14-fold.

Table 6 shows how the relative amounts of individual compounds within given classes have nearly the same values in the different gasolines, taking three examples. (1) The relative amounts of benzene, toluene, and the four C₈ alkyl benzenes; (2) the relative amounts of cyclohexane and methylcyclohexane; (3) the relative amounts of the two methylpentanes and the two dimethylbutanes. Additional similar examples may be cited. It is to be noted that the actual amount of the compounds considered varies considerably from one gasoline to another, as indicated by the bottom row of figures for each group of compounds in Table 6.

These results mean that the exhaustive information and data being obtained on the Project's one representative petroleum can be readily translated to other petroleums by making some relatively simple observations on the other petroleums. Although the work on other petroleums has been limited to the gasoline fractions, it is quite clear that the same principles may be applied to compounds of the same class in

Table 5. Relative Amounts of the Main Classes of Hydrocarbons in the 40-102°C Fraction of the Seven Representative Gasolines

Type of gasoline → Class of hydrocarbons	A	B	C	D	E	F	G
	Relative amount by volume						
Normal paraffins	35.3	24.6	34.1	62.2	9.5	9.9	17.6
Branched paraffins	20.2	27.1	32.0	13.0	61.4	21.4	19.6
Alkyl cyclopentanes	23.1	25.9	13.4	7.8	20.4	40.7	16.6
Alkyl cyclohexanes	20.2	21.9	20.0	15.5	8.2	27.4	42.6
Alkyl benzenes	1.2	0.5	0.5	1.5	0.5	0.6	3.6
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Table 6. Relative Amounts of Individual Compounds within Given Classes in the Seven Different Gasolines

Type of gasoline → Compounds	A	B	C	D	E	F	G	Range of relative amount	Average relative amount
<i>Alkyl benzenes, C₆ to C₉</i>									
Relative amounts									
Benzene	0.09	0.04	0.04	0.13	0.10	0.05	0.06	0.04-0.13	0.07
Toluene	0.30	0.29	0.31	0.37	0.20	0.30	0.38	0.20-0.38	0.31
C ₈ alkyl benzenes	0.61	0.67	0.65	0.50	0.70	0.65	0.56	0.50-0.70	0.62
Percentage of the gasoline fraction constituted by this compound	5.4	5.9	4.9	4.8	1.3	4.3	19.5	...	...
<i>Alkyl cyclohexanes, C₆ and C₇</i>									
Relative amounts									
Cyclohexane	0.30	0.21	0.24	0.33	0.31	0.29	0.30	0.21-0.33	0.28
Methylcyclohexane	0.70	0.79	0.76	0.67	0.69	0.71	0.70	0.67-0.79	0.72
Percentage of the gasoline fraction constituted by this compound	6.9	8.4	7.3	6.1	2.1	8.4	13.7	...	...
<i>Branched paraffins, C₆</i>									
Relative amounts									
Dimethylbutanes	0.14	0.13	0.10	0.14	0.12	0.16	0.16	0.10-0.16	0.14
Methylpentanes	0.86	0.87	0.90	0.86	0.88	0.84	0.84	0.84-0.90	0.86
Percentage of the gasoline fraction constituted by this compound	2.6	4.8	6.0	2.6	6.6	3.4	3.1	...	...

the higher-boiling fractions. For example, the relative amounts found in the Project's representative petroleum for naphthalene, 1-methylnaphthalene, and 2-methylnaphthalene are expected to be of the same magnitude for other petroleum; namely, approximately 1 to 2 to 4. Similarly, the ratio of tert-butylbenzene to 1,2,4-trimethylbenzene (pseudocumene) can be expected to be about 1 to 50 approximately, in all petroleum.

A more complete separation of the petroleum into subclasses would be:

The monocycloparaffins separated into (1) alkyl cyclopentanes and (2) alkyl cyclohexanes.

The mononuclear aromatics separated into (1) alkyl benzenes and (2) aromatic cycloparaffins.

The dinuclear aromatics separated into (1) alkyl naphthalenes and (2) aromatic cycloparaffins.

If this additional separation could be performed, say on the gasoline, kerosine, and light gas oil fractions, one would be led to the following statement: An aliquot sample of all the hydrocarbons of any one subclass from one of these broad fractions, gasoline, kerosine, and light gas oil, will be substantially the same for different petroleum with respect to the magnitude of the individual compounds in the sample. That is to say, for example, a liter of all the branched paraffins from the kerosine fraction of one petroleum will be substantially the same as a liter of all the branched paraffins from the same kerosine fraction of another petroleum. Similarly, a liter of all the alkyl naphthalenes from the light gas oil fraction of one petroleum will be substantially the same as a liter of all the alkyl naphthalenes from the same light gas oil fraction of another petroleum.

Conclusion

In the past 30 years, we have come a long way in our knowledge of what petroleum is chemically. However, we still have facing us several very important scientific questions concerning petroleum, as follows:

How did petroleum get to be *what* it is chemically?

How did petroleum get to be *where* we find it in the earth?

Was petroleum made by nature in one fell swoop, once for all time, or is it being made in the earth continuously?

Because there are numerous investigators working in many different laboratories seeking to uncover these secrets of nature, we are confident that in a few years we will have some answers to these important questions.

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SINCE WE ARE GETTING INTO OLD COAL TAR SITES
THIS INFORMATION WILL BE USEFUL.

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chapter 5

COAL CHEMICALS

Chemicals from coal were initially and mostly obtained by destructive distillation of coal, furnishing chiefly aromatics. In recent years substantial production of aromatics, particularly benzene, toluene, xylene, naphthalene, and methylnaphthalenes, has been obtained by processing petrochemicals (Chap. 38). With the advancing application of chemical conversion of coal, many more chemicals can be made from coal whenever it is economical to do so. However, coal chemicals, except for metallurgical coke, are now in a very competitive field. Table 5.1 summarizes chemicals produced from coal as presented in this chapter and elsewhere in this book (see also Fig. 5.2 for many coal chemicals). Coal is not only the country's fundamental fuel, but shares with petrochemicals the furnishing of the basic raw materials for many essential industries from dyes, medicines, pesticides, and elastomers to modern plastics. "Coal also forms the world's largest reserve of concentrated organic raw materials, and it serves not only as a chemical supplier but as a cheap source of heat and power needed for processing."¹ Although gas from coal and aromatics from coal have had production curtailed by petrochemical and natural-gas competition, much new research and development is being conducted by the Bureau of Mines, Office of Coal Research, and by private industry. In Chap. 6, on Fuel Gases, reference is made to the intense efforts to manufacture a fuel gas of high Btu to compete even now for local and peak demands for such gas. These efforts may also supply a substitute for natural gas when its supply diminishes in the decades ahead. Other research is directed to making new or old chemicals from coal, lignite, and shale through improved technology and to continuing investigations with the aim of eventually supplying competitively from coal, motor fuel, and other organic chemicals.²

THE DESTRUCTIVE DISTILLATION³ OF COAL

When coal is thermally pyrolyzed or distilled by heating without contact with air, it is converted into a variety of solid, liquid, and gaseous products. The nature and amounts of each product depend upon the temperature used in the pyrolysis and the variety of coal. In ordinary practice, coke-oven temperatures are maintained above 1650°F but may range anywhere from 950 to 1800°F. The principal product by weight is coke. If a plant uses temperatures from 850 to 1300°F, the process

¹Ross, H. J., private communication: OCR Calls for Petrochemicals from Coal, Chem. Eng. News, Jan. 6, 1969, p. 40.

²Coal Gasification: Just Shy of Commercial, Chem. Eng. News, May 19, 1969, p. 11; Perry, Coal Conversion Technology, Chem. Eng. (N.Y.), 81(15), 88 (1974); Even Stev on Coal Conversion, Chem. Eng. (N.Y.), 81(15), 58 (1974); Burke, They're Making a Solid Effort to Get Clean Coal Liquids, Chem. Week, Sept. 11, 1974, p. 38.

³Lovrey, Chemistry of Coal Utilization, Suppl. Vol., chap. 11, pp. 461-494, Wiley, 1963 (121 refs.); High Temperature Carbonization, vols. 1 and 2, Wiley, 1945 (hundreds of early references); ECT, 2d ed., vol. 4, p. 400, 1964; Sess, Current's Coal Pyrolysis Process, Chem. Eng. Prog., 70(11), 72 (1974).

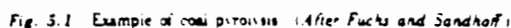
TABLE 5.1 Chemicals from Coal

Chemical conversion process	Products and procedures (numbers refer to chapters)
a. Carbonization, pyrolysis of coal, lignite, and carbonaceous shales (destructive distillation)	Coal-tar aromatics, benzene and homologs, phenol and homologs, naphthalene, anthracene, phenanthrene, etc. (5) High-temperature coke (5), low-temperature coke (5) Carbon for pigments (8), carbon for electrodes (3.8), structural material (8), activated carbon (8)
b. Reduction and refining of ores	Iron, ferro alloys, etc., aluminum (14), magnesium (14)
c. Gasification (cf. g and j) Blue and producer gas are very minor	Coal gas (6), blue water gas (6), producer gas (6), peak gas (6), synthesis gas (7), C^*_2 liquid and dry ice (7)
d. Combustion for comfort heating and power generation	Electric power utilities (4), comfort heating, retail deliveries (4), fly ash (4), sintered ashes for filter and concrete (4) Heat for manufacture of lime (10), cement (10), ceramics (9), steel and rolling mills
e. Combustion for process heating	Sodium sulfite (11.12), sodium sulfide (12), barium sulfide (20), phosphorus (16)
f. Reduction, chemical (cf. b)	Carbide process for aromatics (5), hydrogenation of coal Bergius process (5), Fischer-Tropsch liquid fuels (5.6), catalytic methanation of synthesis and pyrolysis gases (5.6)
g. Hydrogenation and hydrogenolysis, catalytic	Benzene from toluene or styrene (3.7), naphthalene from methylnaphthalenes (3.7)
h. Demethylation	Mixed aromatics (5)
i. Hydrolysis, alkaline	Synthesis gas (7) for NH_3 , CH_3OH , etc., hydrogen (7), coal acids (5), carbon monoxide (7)
j. Oxidation, partial (controlled) and complete	Graphite (8) and electrodes (8), abrasives silicon carbide (15), calcium carbide (15), cyanamide (18), carbon disulfide (15.38)
k. Electrothermal	H_2S from gas (6.7) Purite from coal
l. Sulfur recovery	Ion exchange, water softeners (3)
m. Sulfonation	Ashless coal, montan wax (28), humic acids, coumarone resins (34)
n. Solvent extraction of coal	

Sources: Lowry, *Chemistry of Coal Utilization*, Wiley, vols. 1 and 2, 1945, Suppl. Vol. 1, 1963; *Future for Fuels*, *Chem. Week*, Oct. 9, 1974, p. 46; Perry, *op. cit.* (several flowcharts); Iammartino, *Chem. Eng. Prog.*, 81(21), 68 (1974); McMinn *et al.*, *Coal Processing: A Pyrolysis Reaction for Coal Gasification*, *Chem. Eng. Prog.*, 70(6), 72 (1974); Chemical Communication Shows Promise for Coal, *Chem. Eng. News*, Sept. 2, 1974, p. 16; LOP Set to Scale Up Oil-from-Coal Process, *Chem. Eng. News*, Sept. 23, 1974, p. 7.

is termed *low-temperature* carbonization; with temperatures above 1650°F it is designated *high-temperature* carbonization. In low-temperature carbonization the quantity of gaseous products is small and that of the liquid products is relatively large, whereas in high-temperature carbonization the yield of gaseous products is larger than the yield of liquid products, the production of tar being relatively low. The liquid products are water, tar, and crude light oil; the gaseous products are hydrogen, methane, ethylene, carbon monoxide, carbon dioxide, hydrogen sulfide, ammonia, and nitrogen. The products other than coke are collectively known as coal chemicals (*coproducts*, or *by-products*).

The destructive distillation of coal, or its carbonization, is really a striking example of *chemical conversion*, or the *unit process of pyrolysis*. This chapter outlines the equipment needed to carry



1. "As the temperature is raised, the aliphatic "carbon to carbon bonds are the first to break."
2. "Carbon to hydrogen linkages are severed next as the temperature of 600°C (1100°F) is approached and exceeded."
3. "The decompositions during carbonization are essentially reactions effecting the elimination of heterocycle complexes and progressive aromatization."
4. "The average molecular weights of the volatile intermediate products constantly decrease as the temperature of carbonization rises. This decrease is marked by the evolution of water, carbon monoxide, hydrogen, methane, and other hydrocarbons."
5. "Final decompositions are at a maximum between 600 and 800°C." (1110 and 1470°F).

Fuchs and Sandhoff give several examples of coal pyrolysis, of which Fig. 5.1 is typical.

HISTORICAL It is known that coke was an article of commerce among the Chinese over 2,000 years ago, and in the Middle Ages it was used in the arts for domestic purposes. Nevertheless, it was not until 1620 that the production of coke in an oven was first recorded. Up until the middle of the nineteenth century, coal tar and coal-tar products were regarded as wastes. Synthesis of the first coal-tar color, by Sir William Perkin in 1856, caused a great demand for crude coal tar, and it became a commercial product of increasing value. Perkin, with his discovery of the brilliant violet dye mauve (Chap. 39), while attempting the synthesis of quinine through oxidation of crude aniline in England, laid the foundation of the world's coal-dye industry. In 1792 the first successful experiment involving the production of gas from coal was carried out by William Murdoch, who made it possible to light the streets of London with gas in 1812. The first battery of Smet-Solvay ovens was erected in Syracuse, N.Y., in 1893.

*Fuchs and Sandhoff, Theory of Coal Pyrolysis, *Ind. Eng. Chem.*, **34**, 367 (1942). Lower, *op. cit.*, Suppl. Vol., pp. 379-384.

³Hill and Lyon, A New Chemical Structure for Coal, *Ind. Eng. Chem.*, **54**(6), 37 (1962); *Lower*, *op. cit.*, Suppl. Vol., pp. 233-270, 295.

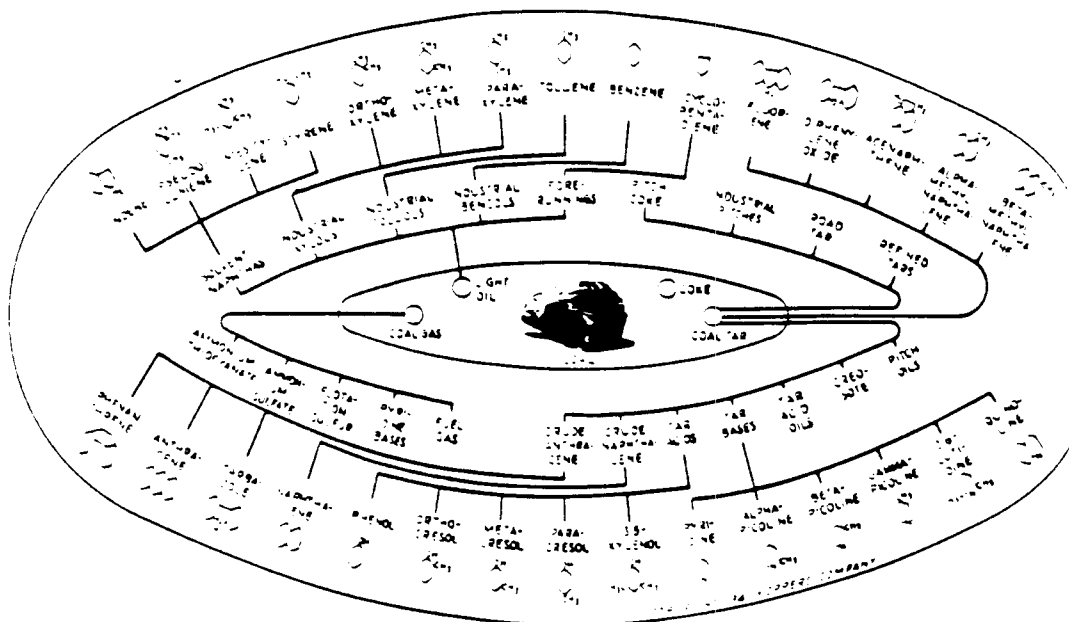


Fig. 5.2 How many grandchildren has a lump of coal? (Koppers Co., Inc.)

USES AND ECONOMICS Coke is the product of largest tonnage from the distillation of coal. The demand for coke depends on the demand for steel, so the amount of coal-tar production reflects the demand for steel. About 98% of coal-tar production is from coperduct ovens.⁹ See Table 5.2 for data on crude aromatics from coal tar and petroleum. Until recent years aromatic crudes and the pure compounds derived therefrom were based on coal tar. Now that the petroleum industry supplies so many aromatics and natural gas through its manifold pipelines, supplanting other fuel gases, the chief incentive in distilling coal is to supply coke for steel. The *liquid products*, comprising coal tar and ammonia liquor, are not so large in volume as the solid products of coal distillation, but are of importance to chemical-recovery ovens. A considerable volume of coal tar is still used as fuel in open-hearth furnaces and for roofing and roads. Aromatics from petroleum and coal tar are made into dyes, intermediates, medicinals, flavors, perfumes, resins, rubber chemicals, and thousands of other useful products that are almost indispensable in our present-day civilization.

COKING OF COAL

The two main types of coking procedures were the beehive and the coperduct. Beehive coking is the old, primitive method. In coperduct ovens the carefully blended coal charge is heated on both sides so that heat travels toward the center and thus produces shorter and more solid pieces of coke than are made in the beehive oven. No burning takes place within the oven, the heat being supplied completely from the flues on the sides. About 40% of the oven gas, after being stripped of its coperducts, is returned and burned for the underfiring of the battery of ovens, and some is used for fuel gas locally.

⁹Formerly called by-product ovens, a term still deeply entrenched in commercial usage. Chemical-recovery ovens and slot-type ovens are also terms in usage.

TABLE 5.2 U.S. Production of Tar and Tar Grades

Product	Production			
	1953	1964	1970	1972
Crude light oil, 1,000 gal	304,091	248,669	244,107	214,201
Intermediate light oil, 1,000 gal	1,062	5,392	5,066	3,704
Light-oil distillates				
Benzene, specification and industrial grades, total, 1,000 gal	272,744	730,238	1,133,520	1,252,442
Tar distillers, 1,000 gal	32,108			
Coke-oven operators, 1,000 gal	177,593	118,944	93,492	79,849
Petroleum operators, 1,000 gal	63,043	611,294	1,040,028	1,172,593
Toluene, all grades, total, 1,000 gal	156,248	495,040	829,607	915,872
Tar distillers, 1,000 gal	4,677			
Coke-oven operators, 1,000 gal	36,036	25,521	17,041	14,571
Petroleum operators, 1,000 gal	115,535	469,519	812,566	901,301
Xylene, total, 1,000 gal	113,474	343,198	537,637	739,332
Coke-oven operators, 1,000 gal	9,928	7,119	4,501	3,351
Petroleum operators, 1,000 gal	102,886	336,079	533,136	735,981
Solvent naphtha, total, 1,000 gal	15,661		4,539	
Tar distillers, 1,000 gal	9,376		832	
Coke-oven operators, 1,000 gal	6,285	4,484	3,707	2,815
Other light-oil distillates				
Total, 1,000 gal	14,657			
Tar distillers, 1,000 gal	8,560			
Coke-oven operators, 1,000 gal	6,097	9,101		6,905
Pyridine crude bases, dry basis, 1,000 gal	551	464		
Naphthalene, crude, 1,000 lb	275,799	425,690	428,086	410,075
Crude tar-acid oils, 1,000 gal	27,757		18,989	9,731
Creosote oil, dead oil, 1,000 gal	145,300	113,272	128,933	139,308
All other distillate products, 1,000 gal	18,469		90,038	
Tar, road, 1,000 gal	109,832	55,696	53,005	29,807
Tar, miscellaneous uses, 1,000 gal	36,415	19,968		14,395
Pitch of tar				
Soft and medium, 1,000 tons	1,174	886	859	582
Hard, 1,000 tons	710	991	899	786
Pitch of tar coke and pitch emulsion, 1,000 tons	38			

Source: Synthetic Organic Chemicals, 1953, 1964, 1970, and 1972 U.S. Tariff Commission. See annual reports for further details.

Beehive coking The beehive oven consists of a beehive-shaped brick chamber provided with a charging hole at the top of the dome and a discharging hole in the circumference of the lower part of the wall. The coal is introduced through the hole in the dome and spread over the floor. The heat retained in the oven is sufficient to start the distillation. The gases given off from the coal mix with the air entering at the top of the discharge door and burn; the heat of combustion is sufficient for pyrolysis and distillation.

Coproduct coking The coproduct coke oven is a narrow chamber, usually about 38 to 40 ft long, 13 ft high, and tapering in width from 17 to 18 in. at one end and to 15 or 16 in. at the other. The ovens hold from 16 to 24 tons of coal. These ovens are used for carbonizing coal only in large amounts and are built in batteries of 10 to 100 ovens. The general arrangements for the operation of a coproduct coke oven with its various accessories, followed by the initial treatment of its coproducts, are depicted⁷ in Fig. 5.3.

The coproduct coke oven is one of the most elaborate and costly of masonry structures and is erected with the closest attention to engineering details, so that it can withstand the severe strains

⁷Lowry, op. cit., Suppl. Vol., chap. 11, pp. 461-493 (121 refs.).

and the charging holes are then covered. Heating is carried out, and the charge left in the oven until it is completely coked and the evolution of volatile matter has ceased. The average temperature at the center of the charge at the end of the heating period is usually about 1800°F, and the average flue temperature is about 2350°F. Temperatures vary with the conditions of operation, the coking time, the width of the oven, the kind of coal, its moisture content, and its fineness of division. Coproduct ovens are operated to make the best quality furnace coke for steel mills, and no longer to make a large volume of high-grade coal tar or gas. At the end of the coking time (approximately 17 h) the doors at the ends of the oven are opened and the entire red-hot mass is pushed out in less than a minute by a ram electrically driven through the oven from end to end. The coke falls into a quenching car which holds the charge from one oven.

The gas from the destructive distillation of the coal, together with entrained liquid particles, passes upward through a cast-iron gooseneck into a horizontal steel trough which is connected to all the ovens in a series. This trough is known as the *collecting main*, and is sometimes called a *hydraulic main*. As the gas leaves the ovens, it is sprayed with weak ammonia water. This condenses some of the tar and ammonia from the gas into liquid. The liquids move through the main along with the gases until a settling tank is reached, where separation is effected according to density. Some of the

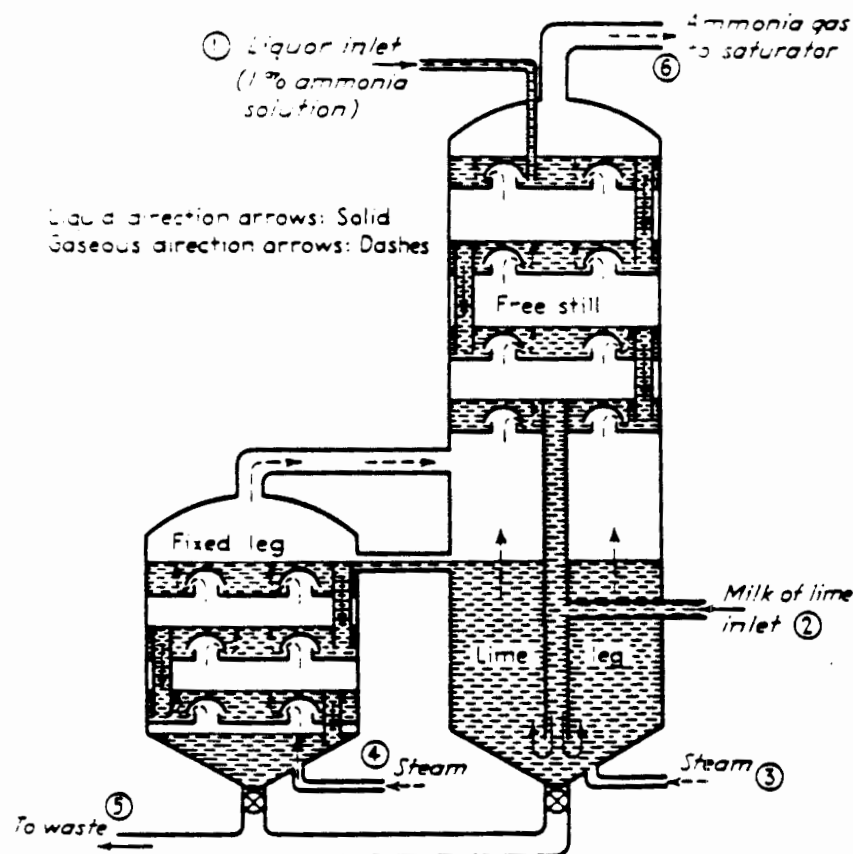


Fig. 5.5 Diagram of an ammonia still. It operates with a drain from the fixed leg open sufficiently to prevent accumulation of liquor in this section. The drain from the lime leg is closed except for cleanout.

ammonia liquor is pumped back into the pipes to help condensation; the rest goes to the ammonia still, which releases the ammonia for subsequent chemical combination in the saturator. All the tar flows to storage tanks for tar distillers or for fuel.⁸

Figure 5.3 can be divided into different steps, representing the flow of material through the various pieces of equipment, wherein the proper physical operation or chemical conversion takes place. Figure 5.3 may be thus broken down into the following sequences:

- Coal is transferred, crushed, and screened (Op).
- Coal is charged to a hot, empty oven (Op).
- Coal is chemically transformed to coke and volatiles by pyrolysis (Ch).
- Hot coke is pushed out of the oven, quenched, and transported (Op).
- Condensable products of distillation are liquefied and collected in the hydraulic main (Op).
- Foul gas is cooled, and tar extracted (Op).
- Ammonia is removed from gas as ammonium sulfate (Ch).
- Gas is cooled and subjected to benzol and toluol removal by absorption in straw oil (Op).
- Hydrogen sulfide is removed (Ch).
- Purified gas is metered and transferred to consumers (Op).

The tar separated from the collecting main and the tar extractor or electrostatic precipitators is settled from ammonia liquor and, together with light oil, subjected to the sequences represented by the flowchart (Fig. 5.6).

Koppers-Becker ovens are the most widely used vertical-flue ovens in the United States. The elevation is shown in Fig. 5.4. These ovens are all of the regenerative type and have individual heat regenerators, generally from side to side, underneath the oven. The reversal of the air and waste gas flow is made from side to side every half hour. The gas burns upward, crosses over the top of the oven, comes downward on the other side, and exits through the regenerative oven underneath. This travel is completely reversed periodically.

RECOVERY OF COAL CHEMICALS⁹ The gaseous mixture leaving the oven is made up of permanent gases which form the final purified coke-oven coal gas for fuel, accompanied by condensable water vapor, tar, and light oils, with solid particles of coal dust, heavy hydrocarbons, and complex carbon compounds. The gas is passed from the foul main (Fig. 5.3) into the primary condenser and cooler at a temperature of about 165°F. Here the gases are cooled to 85°F by means of water. The gas is conducted to an exhaustor, which serves to compress it. During the compression the temperature of the gas rises to as high as 120°F. The gas is passed to a final tar extractor, where the tar is thrown out by impingement of gas jets against metal surfaces. In newer plants the tar extractor may be replaced by electrostatic precipitators. On leaving the tar extractor, the gas carries three-fourths of the ammonia and 95% of the light oil originally present when it left the oven.

The gas is led to a saturator (Fig. 5.3), which contains a solution of 5 to 10%¹⁰ sulfuric acid, where the ammonia is absorbed with the formation of solid and crystalline ammonium sulfate. The saturator is a lead-lined, closed vessel, where the gas is fed in by a serrated distributor underneath the surface of the acid liquid. The acid concentration is maintained by the addition of 60°Bé sulfuric acid, and the temperature is kept at 140°F by the reheater and the heat of neutralization. The crystallized ammonium sulfate is removed from the bottom of the saturator by a compressed-air injector, or a centrifugal pump, and drained on a table, from which the mother liquor is run back into the saturator. The salt is dried in a centrifuge and bagged, usually in 100-lb sacks (Chap. 18).

⁸ Lowry, *op. cit.*, Suppl. Vol., pp. 462-471, for other types of ovens.

⁹ Details for the recovery of the heavy coal chemicals are to be found in Lowry, *op. cit.*, Suppl. Vol., pp. 618-628, for tar processing, pp. 629-674, for light-oil processing; ECT, 2d ed., vol. 2, p. 299, 1963.

¹⁰ At the start of a charge, the acidity is often as high as 25%, but ammonium bisulfate is liable to be formed when free sulfuric acid exceeds 10 to 11%.



Fig. 5.6 Flowchart of coal-tar continuous distillation (without tar denaturation). The pipe still is of the radiant type. The crude-tar feed inlet is at the lower right. This is filtered and pumped through the reflux vapor-tar heat exchanger, economizer, pitch-tar heat exchanger into the top of the lower third of the distillation column and out at the bottom, to the circulating pumps and into the pipe still, where the crude tar joins 4 to 5 volumes of the circulation pitch and on finally to near the top of the distillation column. The vapors, steam-distilled and superheated, pass overhead from the top of the tray-type distillation column, enter the bottom of the bubble-cap fractionating column, and are separated into four fractions: 1, 2, 3, 4, with a residue, 5, leaving at the bottom of this fractionating column. The product pitch, 6, cascades from the top of the distillation column down through the superheated steaming section to establish the desired pitch hardness and to strip this pitch of the higher boiling volatiles. It is then withdrawn from above the middle of the distillation column and conducted through the pitch-tar heat exchanger to storage. The products are:

- Side stream 1: Light oil, bp to 170°C.
- Side stream 2: Carbolic oil, bp 170-205°C.
- Side stream 3: Naphthalene oil, bp 205-240°C.
- Side stream 4: Creosote or wash oil, bp 240-280°C.
- Residue 5: The residue or asphaltene, bp 270-340°C.
- Pitch 6: Residuum or pitch, bp 325-400°C.

There are standby steam pumps in the event of failure of the motor-driven pumps. The Wilton principle of recirculation of hot pitch at 350°C, mixed with the crude tar at 120°C, raises the temperature of the pitch-tar leaving the pipe still to only 350°C and avoids thermal cracking and vaporization in the pipe still. (Chemical Engineering, Wilton's Ltd., London. See special pamphlets from this company for details.)

The gas leaving the saturator at about 140°F is taken to final coolers or condensers, where it is scrubbed with water until its temperature is 75°F. During this cooling some naphthalene separates and is carried along with the wastewater and recovered. The gas is passed into a *light-oil* or *benzol scrubber* (Fig. 5.3), over which is circulated, at about 75°F as the absorbent medium, a heavy fraction of petroleum called *straw oil*, or sometimes a coal-tar oil. The straw oil is sprayed into the top of the absorption tower while the gas flows up through the tower. Most scrubbers use spiral metal packing, although wooden grids were formerly used. The straw oil is allowed to absorb about 2 to 3% of its weight of light oil, with a removal efficiency of about 95% of the light-oil vapor in the gas.

The rich straw oil, after being warmed in heat exchangers by vapors from the light-oil still and then by hot debenzolized oil flowing out of the still, is passed to the stripping column, where the straw oil, flowing downward, is brought into direct contact with live steam. The vapors of the light oil and steam pass off and upward from the still through the heat exchanger previously mentioned and into a condenser and water separator. The lean, or stripped, straw oil is returned through the heat exchanger to the scrubbers. The gas, after being stripped of its ammonia and light oil, has the

TABLE 5.3 Approximate Yields per Ton of Coal Carbonized
(Depending on Coal and Conditions Used)

	High- temperature, lb	Low- temperature, lb
Furnace coke	1,430	
Coke breeze	93	
Semicoke (12% volatile)		1,440
Tar	78	150
Ammonium sulfate	20	18
Light oil (removed from gas by oil scrubbing; see Table 5.4)	20	16
Gas	3,500	250

Source: *Ind. Eng. Chem.*, 48, 352 (1956). See also Fig. 5.3. Note that 4 lb of technical ammonium sulfate is equivalent to 1 lb of ammonia.

sulfur removed in purifying boxes, which contain iron oxide on wood shavings, or by a solution of ethanolamine (Gurbotol) in scrubbing towers, the best present-day practice. These procedures are fully described in Chaps. 6 and 7.

U.S. Steel has built a coke-oven plant at Clairton, Pa.,¹¹ which employs new processing, furnishing a clean gas for compression and hydrogen recovery and avoiding coproduction of ammonium sulfate. The key to the new process is a recycled solution of ammonium phosphate that absorbs NH_3 from the cooled (compressed?) coke-oven gas. In a typical absorption cycle, lean 40% phosphate solution (the molar ratio of NH_3 to H_3PO_4 is less than 1.5) soaks up all but traces of NH_3 . The rich ammonium phosphate solution is reboiled in a distillation tower in which NH_3 vapor and a lean phosphate solution are separated for reuse.

LOW-TEMPERATURE CARBONIZATION¹² In this century a large amount of experimental work has been carried out on the carbonization of coal at temperatures ranging from 750 to 1100°F, with the main object of obtaining maximum yields of liquid products and producing semicokes containing from 8 to 20% volatile matter. Here again the characteristics and yields of the various products depend upon the coal, the temperature, and the treatment. Tables 5.3 and 5.5 show the difference in gas content and in yield products for high- and low-temperature systems. The Disco plant at McDonald, Pa., is the only plant in this country to utilize a low-temperature carbonization process¹³ and has a daily capacity to convert high-volatile coal into 800 tons of Disco char, a domestic fuel. The tar is sold and refined to produce tar-acid oil, tar acids, "creosote,"¹⁴ and fuel pitch. The gas, after liquid-product removal, is used for firing. The maximum temperature used in this process is 1050°F. Low-temperature carbonization has been important in several European countries, especially England, for many decades, but has never been popular in the United States.

DISTILLATION OF COAL TAR¹⁵

Coal tar is a mixture of many chemical compounds, mostly aromatic, which vary widely in composition (Figs. 5.2, 5.6, and 5.9). It is a coproduct of the destructive distillation or pyrolysis of coal. Most of the tar in this country is produced by steel companies as a coproduct from blast-furnace coke

¹¹Cool Gas for Ammonia Recovery, *Chem. Week*, Feb. 27, 1965, p. 39; U.S. Pat. 3,024,090

¹²Lowry, *op. cit.*, Suppl. Vol., chap. 10, pp. 395-460 (138 refs.).

¹³Lowry, *op. cit.*, Suppl. Vol., p. 439.

¹⁴B: definition of the American Wood Preservers Association, however, creosote is a distillate of high-temperature coke-oven tar

¹⁵Cf. Bituminous Materials in Road Construction, pp. 26ff, Dept. of Scientific and Industrial Research, HMSO, London.

production. The quality and quantity of tar from this operation will vary, depending on the rate of production of the ovens and the nature of the coal used. The specific gravity will vary from 1.15 to 1.2, and the quantity of tar will vary from 8 to 12 gal of tar per ton of coal. A typical light-tar composition is shown in Fig. 5.9. The end product of the distillation (Fig. 5.6) of coal tar is pitch, usually more than 60% of the crude tar. The objects of the distillation are to produce a salable end product, with a separation of the valuable products into useful cuts. In a modern refinery equipped with a fractionating column (Figs. 5.6 and 5.8) for the primary distillation, these products must usually be sharply fractionated, with a minimum of overlapping. The process also should be thermally economical, and the furnace (Figs. 5.6 and 5.7) so designed and constructed that repairs and fuel usage are at a minimum.

METHODS OF DISTILLATION There have been many improvements in coal-tar distillation over the years. These can be divided into three general classifications:

1. The 3,000- to 10,000-gal batch still, which has been much improved and used for special end products such as pipe enamel (Fig. 5.7).
2. The continuous still, with a single distillation column, using side streams (Fig. 5.6).
3. The continuous unit, using multiple columns with reboilers (Fig. 5.8).

PRODUCTS OF DISTILLATION Modern practice, as exemplified by the pipe still and fractionating columns, is producing such clean cut fractions that often little further purification is necessary. However, in Fig. 5.6 and below are given the fractions obtained in an ordinary continuous distillation, which will vary with the coal and with conditions.

a. *Light oils* usually comprise the cut up to 390°F. They are first crudely fractionated and agitated at a low temperature with concentrated sulfuric acid, neutralized with caustic soda, and redistilled, furnishing benzene, toluene, and homologs (Table 5.4).

b. *Middle oils, or creosote oils*, generally are the fraction from 390 to 480 or 520°F, which contains naphthalene, phenol, and cresols. The naphthalene settles out upon cooling, is separated



Fig. 5.7 Tar-distillation batch tank still, heated by gas or oil burning in large return bend flue with about 70% thermal efficiency. Two stirrers. (Raff, Tar & Chemical Co.)



Fig. 3.8 Fractionating distilling column (147 ft high) at Clairton, Pa., producing high-quality benzene, toluene, and xylene. (U.S. Steel Corp.)

by centrifuging, and is purified by sublimation. After the naphthalene is removed, phenol and other tar acids¹⁶ are obtained by extraction with a 10% caustic soda solution and neutralization, or "springing," by carbon dioxide. These are fractionally distilled.

c. *Heavy oil* may represent the fraction from 480 to 570°F, or it may be split between the middle oil and the anthracene oil.

d. *Anthracene oil* is usually the fraction from 520 or 570°F up to 660 or 750°F. It is washed with various solvents to remove phenanthrene and carbazole; the remaining solid is anthracene.

MISCELLANEOUS USES OF COAL TAR In 1976 coal tar used as fuel amounted to about 15 to 20% of the total consumption of tar for the year. Coal tar is also utilized for roads and roofs. For these purposes the tar is distilled up to the point where thermal decomposition starts. This "base tar" is then oiled back with creosote oil to ensure satisfactory rapid drying. Somewhat similar tars are used to impregnate felt and paper for waterproofing materials.

FRACTIONATION AND PURIFICATION OF COAL TAR CHEMICALS Largely because of the present competition among aromatic chemicals from petroleum (Chap. 38), interest in aromatics

¹⁶"Tar acids," in the language of the tar distiller, represent phenol and its homologs, which are soluble in caustic soda.

TABLE 5.4 Typical Composition of Light Oil from Gas

	Gallons per ton of coal
Benzene	1.85
Toluene	0.45
Xylene and light solvent naphtha	0.30
Acid washing loss (mostly unsaturated)	0.16
Heavy hydrocarbons and naphthalene	0.24
Wash oil	0.20
Total crude light oil	3.20
Pure motor fraction	2.50

Source: Lowry, *Chemistry of Coal Utilization*, vol. 2, p. 940; more detailed tabulation, Suppl. Vol., pp. 633-642.

from coal tar has temporarily decreased (see Table 5.2 for main products). Also, synthetic processes from acetaldehyde and ammonia are supplying the increased demands for pyridine, of which coal tar at one time was the sole supplier. This is also true of phenol (Chap. 34). In Europe,¹⁷ which has much coal and little petroleum, there is continued interest in coal chemicals. Table 5.6 lists some solid chemicals that could be obtained from coal tar. The product of largest potential is *phenanthrene* (the second most abundant in coal tar), of which Franck estimates that 250,000 tons can be recovered in the Western world yearly as soon as profitable uses can be found. This is based on a total recovery of 10 million tons of crude tar and with a 50% yield. *Anthracene*, or rather anthraquinone (Chap. 39), is the basis of many vat dyes, but here again it is cheaper to synthesize this compound (Chap. 39) from phthalic anhydride and benzene or preferably chlorobenzene.

COAL TO CHEMICALS

This section considers the rest of the processes listed in Table 5.1, except those designated for discussion in other chapters. In all cases further details are available in the references, especially in the monumental three volumes edited by Lowry.

Solvent extraction of coals and lignites has been tried at temperatures below and above 300°C and with and without mild hydrogenation. Although various resins and waxes result, the processes have met only minor commercial acceptance.¹⁸ *Alkaline hydrolysis*¹⁹ has likewise been investigated, with meager results. *Partial oxidation* yields the tremendously important *synthesis gas* (Chap. 7).

TABLE 5.5 Variation of Gas from Low- and High-temperature Coal Carbonization

Gas	Coking temperature, 500 C. °	Coking temperature, 1000 C. °
CO ₂	9.0	2.5
C ₂ H ₄	8.0	3.5
CO	5.5	8.0
H ₂	10.0	50.0
CH ₄ and homologs	65.0	34.0
N ₂	2.5	2.0

¹⁷Franck, *The Challenge in Coal Tar Chemicals*, *Ind. Eng. Chem.*, 55(5), 38 (1963). Many coal chemicals described.

¹⁸Lowry, *op. cit.*, Suppl. Vol., p. 1089.

¹⁹Lowry, *op. cit.*, Suppl. Vol., p. 1090.

TABLE 5.6 Some Important Constituents of European Coal Tar

Compound	Percents	Compound	Percents
Naphthalene	10	Diphenyl	0.4
Phenanthrene	5	Indole	0.2
Fluoranthene	3.3	2-Phenyl-naphthalene	0.3
Pyrene	2.1	Isoquinoline	0.2
Fluorene	2.0	Quinaldine	0.2
Chrysene	2.0	Acridine	0.6
Anthracene	1.8	Phenanthridine	0.2
Carbazole	1.5	7,8-Benzquinoline	0.2
2-Methyl-naphthalene	1.4	Thianaphene	0.3
Dibenzofuran	1.0	Diphenylene sulfide	0.3
1-Methyl-naphthalene	1.0		

Source: *Ind. Eng. Chem.*, 55(5), 38 (1963).

Dow²⁰ has experimented with caustic oxidation (oxvgen), obtaining high-molecular-weight polyfunctional aromatic coal acids, which have found limited use in thermosetting resins and water-soluble films. Sulfur²¹ recovery from coal is still small and variable, but in foreign lands that lack the U.S. sulfur raw materials (H₂S from gases and sulfur from salt domes), pyrite has been recovered from coal and is used to the extent of about 10,000 tons yearly in England and Germany. Sulfonation²² has been employed to a limited extent to manufacture ion-exchange material for water softening.

HYDROGENOLYSIS (HYDROGENATION-PYROLYSIS) Many development investigations²³ have been carried out on direct and catalytic hydrogenation of coal both in the United States and abroad. Most of these experiments are really hydrogenolyses or hydrogenations (methanation) of the pyrolysis products of coal. They were designed to yield a high-Btu gas to compete with natural gas (see peak gas, Chap. 7) or to make motor fuel in petroleum-poor countries. The results gave such a gas, but at a high cost with much of the coal left as residual carbon. The motor-fuel objectives were largely for wartime demands. The present attack on coal to secure other and hopefully cheaper coal chemicals tends to follow catalytic hydrogenation and other processing, often grouped together as "coal refining" and combined with liquid separation, coking, and hydrocracking in the presence of hydrogen, without aiming for the uneconomical total hydrogenation of the carbon.²⁴

COAL RESEARCH The Office of Coal Research, created to conduct research on mining, preparation, and utilization of coal, including chemicals, is financing industry in many efforts to upgrade coal and coal chemicals.

The energy crisis of 1973-1974, the increasing U.S. demand for fuel, and the fourfold rise in oil cost greatly improve the outlook for coal as a feedstock in place of oil.²⁵ It appears that it will be only a question of time until coal replaces a significant amount of oil as feedstock in the United States.

²⁰Montgomery, Coal Acids, *Chem. Eng. News*, Sept. 28, 1959, p. 96; Perry, *op. cit.*; Burke, *op. cit.*

²¹Burce, *op. cit.*; Institute for Gas Technology, Clean Fuels from Coal Symposium, Sept. 10-14, 1973, Project Independence: An Economic Evaluation, MIT Energy Laboratory Policy Study Group, Mar. 15, 1973.

²²Broderick and Bogard, *U.S. Bur. Mines Rep. Invest.*, 3559, 1951; Lowry, *op. cit.*, Suppl. Vol., p. 1091.

²³Farber, Pipeline Coke-Oven Charging, *Chem. Eng. (N.Y.)*, 80(29), 36 (1973); Perry, *op. cit.*

²⁴South Africa Banks on Coal for Chemical Buildup, *Chem. Week*, Sept. 25, 1974, p. 33. AECI (formerly called African Explosives and Chemical Industries), South Africa's leading chemical firm set aside \$465 million for coal-based production units in 1973-1974.

²⁵Chemicals from Coal: Best Bet in Energy Crisis, *Chem. Week*, June 12, 1974, p. 11.

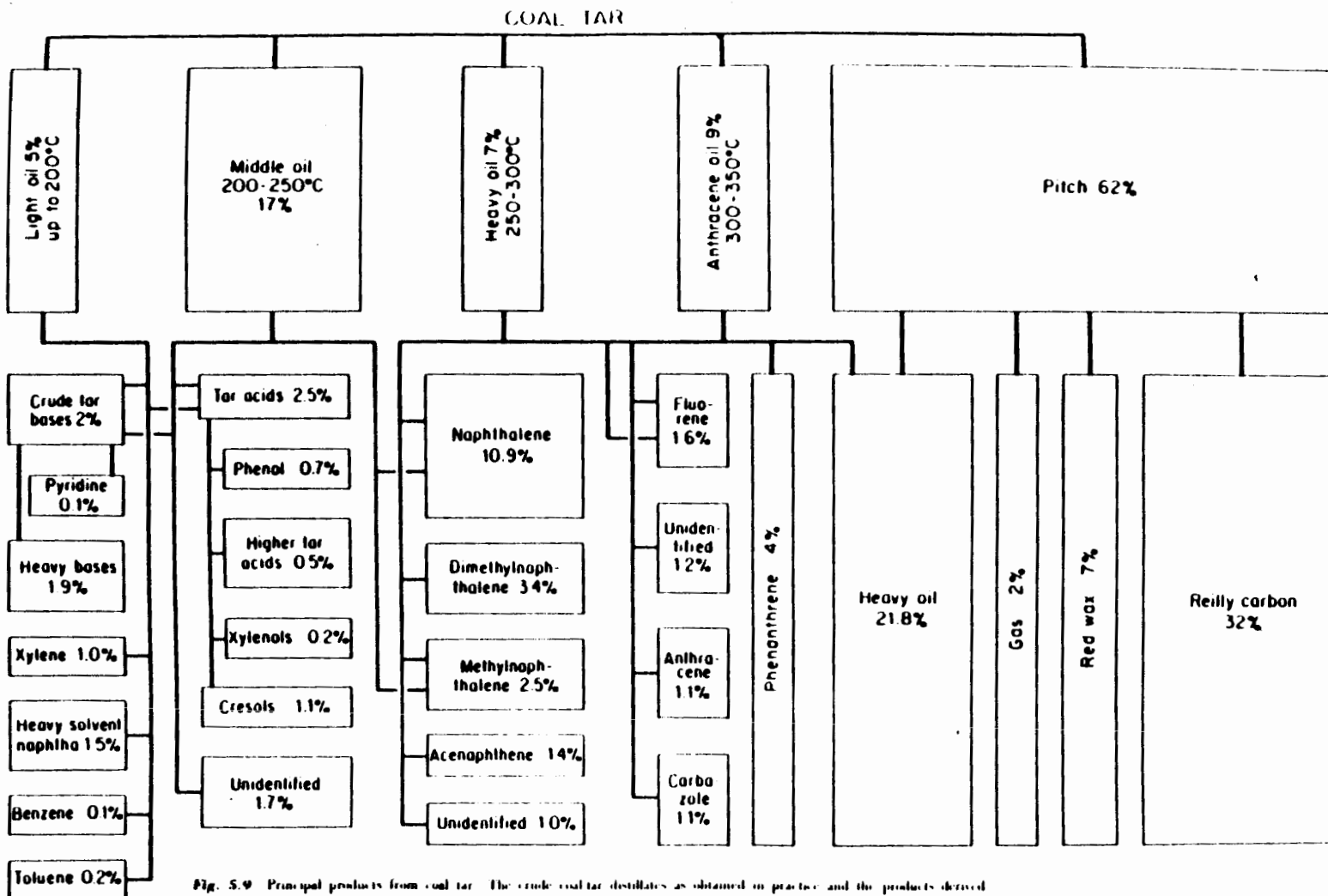


Fig. 5.9 Principal products from coal tar. The crude coal tar distillates as obtained in practice and the products derived therefrom. The percentage yields as shown and represented by the areas of the rectangles are average values based on the original tar. Yields vary with different conditions and different coals. Another coal tar of 1.1 to 1.2 sp gr analyzed as follows: benzene and toluene 1.0%, other light oils 0.7%, phenol 0.4%, cresols 0.4%, naphthalene 1.4%, cresol oil 28.4%, anthracene 0.4%, and pitch 64.8% (Reilly Tar & Chemical Corp.)

Appendix C
Section 4.3
REF 43

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