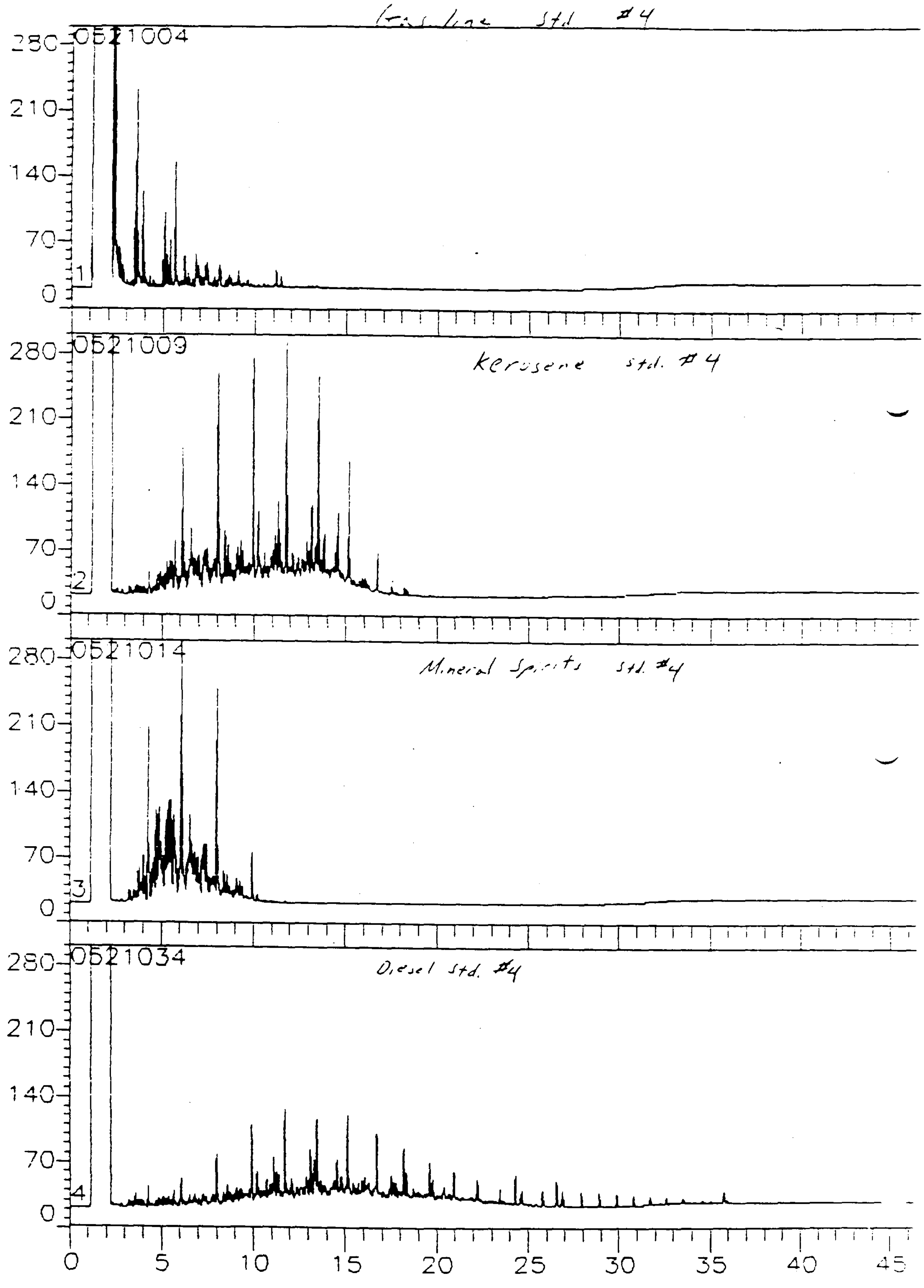
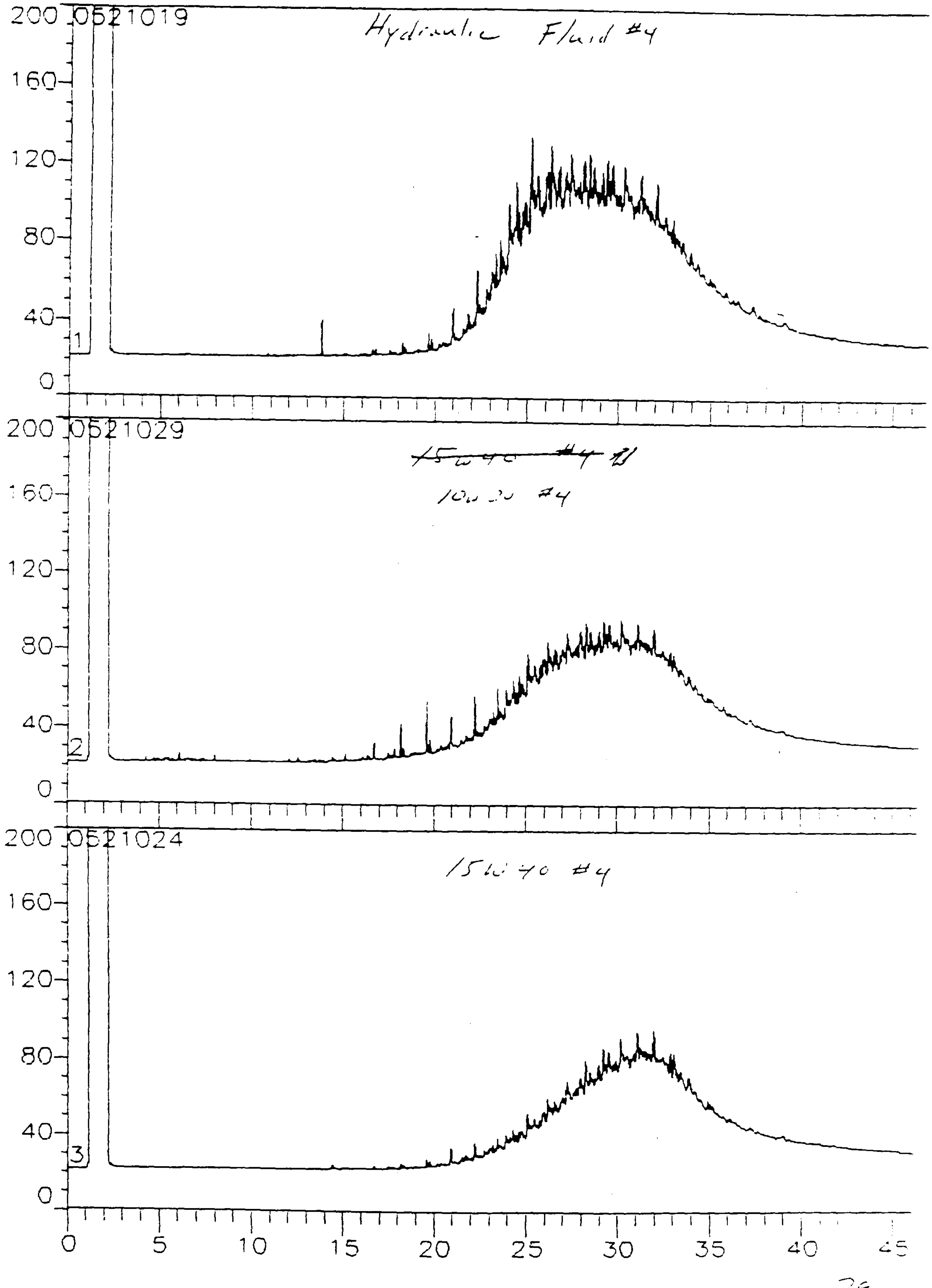
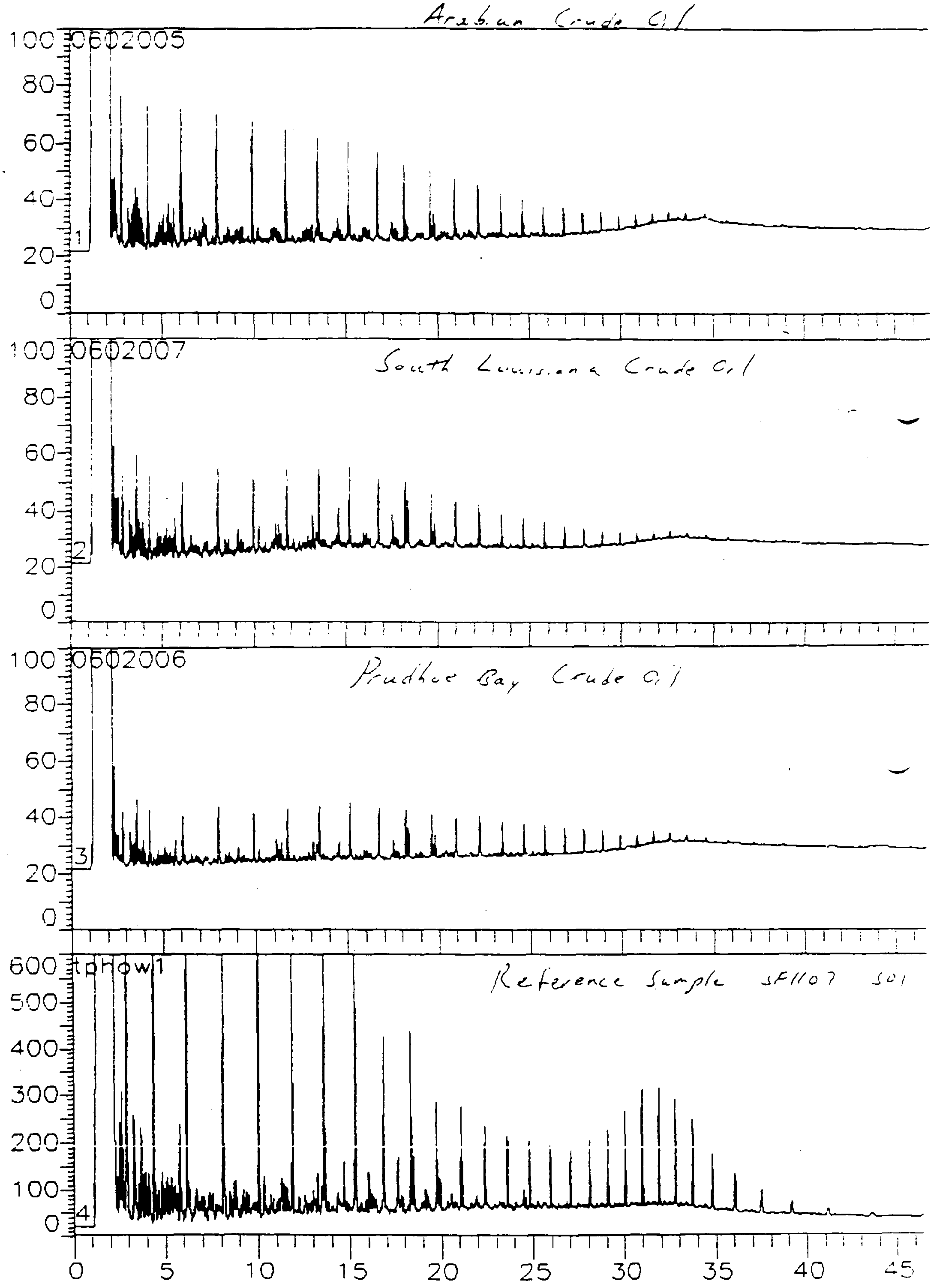
147721

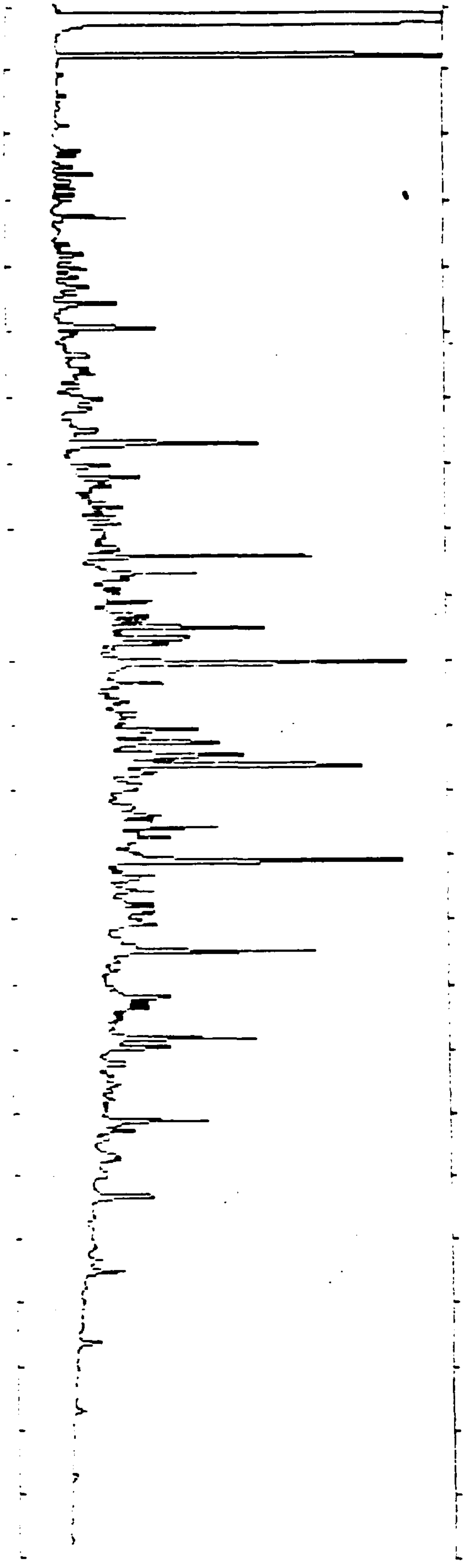
# STANDARD REFERENCE COMPARISONS


Gasoline std #4
0521004
1
Kerosene std. #4
0521009
2
Mineral Spirits std. #4
0521014
3
Diesel std. #4
0521034
4
280
210
140
70
0
0
5
10
15
20
25
30
35
40
45


200
160
120
80
40
0
0521019
1
Hydraulic Fluid #4
0521029
2
~~15w40 #4~~
10w30 #4
0521024
3
15w40 #4
0
5
10
15
20
25
30
35
40
45

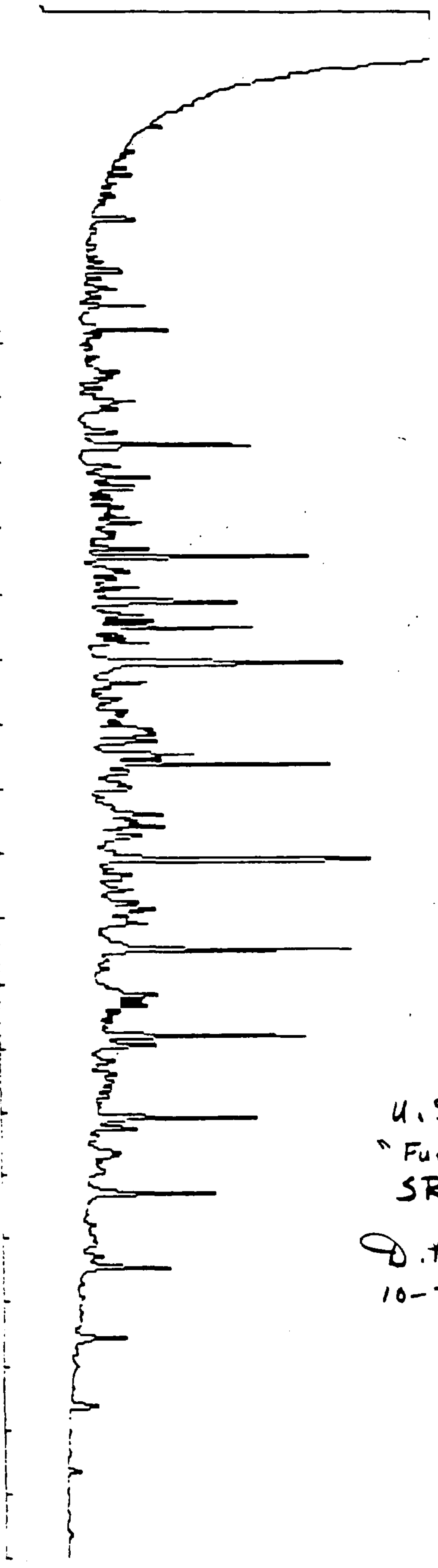

Arabian Crude Oil
100
80
60
40
20
0
0602005
1
South Louisiana Crude Oil
100
80
60
40
20
0
0602007
2
Prudhoe Bay Crude Oil
100
80
60
40
20
0
0602006
3
Reference Sample SF1107 S01
600
500
400
300
200
100
0
tphow1
4
0
5
10
15
20
25
30
35
40
45

Diesel Fuel
2010 ug/ml
Std. from M.K.



Commercial
Diesel Fuel
Standard
Used for
Organics
chemical, MI
RI
D. Payne
10-7-93

SRM
Fuel oil #2
2040 ug/ml



U.S. EPA
" Fuel Oil #2 "
SRM
D. Payne
10-7-93

P. 806 of 6

INFORMATION

| ATA SET | CRL LOG No. | SAMPLE I.D. | FILENAME | STATION | PERCENT | MATRIX | SAMPLE WT. | FINAL VOL. | DILUTION | RUN | TPH VALUE | Nom. Amt. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0001177 | 93Z814 | S05D | TPH005D | MW39G | 13.35% | soil | 11.45 | 10 | 1 | 05/14 | 213 | ug/kg | % Rec. |
| | | S11MS | TPH011MS | SB50J | 15.09% | soil | 10.87 | 10 | 1 | 05/14 | 415 | 221.2 | 137.87% |
| | | S11MSD | TPH11MSD | SB50J | 15.09% | soil | 10.70 | 10 | 1 | 05/14 | 88 | 221.2 | -9.99% |
| | | blank1 | TPHBLK | Na2SO4 | N/A | Na2SO4 | 10.30 | 10 | 1 | 05/14 | 20 U | | |
| 0001186 | 93Z814 | S98D | 05209 | SB53G | 15.86% | soil | 10.23 | 10 | 1 | 05/20 | 1114 | | |
| | 93Z815 | S04MS | 05205 | SB39E | 9.04% | soil | 9.97 | 10 | 1 | 05/20 | 2447 | 221.6 | 649.89% |
| | | S04MSD | 05206 | SB39E | 9.04% | soil | 10.23 | 10 | 1 | 05/20 | 3138 | 221.6 | 961.46% |
| | | blank #2 | 052011 | Na2SO4 | N/A | Na2SO4 | 10.00 | 10 | 1 | 05/20 | 20 U | | |
| 30001200 | 93Z815 | S97D | 0624002 | MW33E | 5.91% | soil | 10.13 | 10 | 1 | 06/24 | 1318 | | |
| | | S98MS | 0624006 | SB14 | 15.10% | soil | 10.61 | 10 | 1 | 06/24 | 4893 | 223.1 | 925.93% |
| | | S98MSD | 0624007 | SB14 | 15.10% | soil | 10.01 | 10 | 1 | 06/24 | 5617 | 223.1 | 1250.22% |
| | | blank #3 | 0624008 | Na2SO4 | N/A | Na2SO4 | 10.00 | 10 | 1 | 06/24 | 198 | | |

→ These values should not be reported as ~~the~~ the matrix spike concentration is relatively small compared to sample concentration

D. Payne
10-7-93

# SAMPLE RESULTS FORM

SAMPLE I. D.: **D930001177** **93ZB14** **blank1**

SAMPLE WEIGHT (g): 10.30
FILENAME: TPHBLK
STATION LOCATION: Na2SO4
MATRIX: Na2SO4
DATE RUN: 05/14/93

FINAL VOLUME (ml): 10
DILUTION FACTOR: 1
% MOISTURE: N/A
EXTRACTION DATE: 05/11/93

**TPH VALUE:** **20 U mg/kg**
(concentration estimated
from diesel standard)

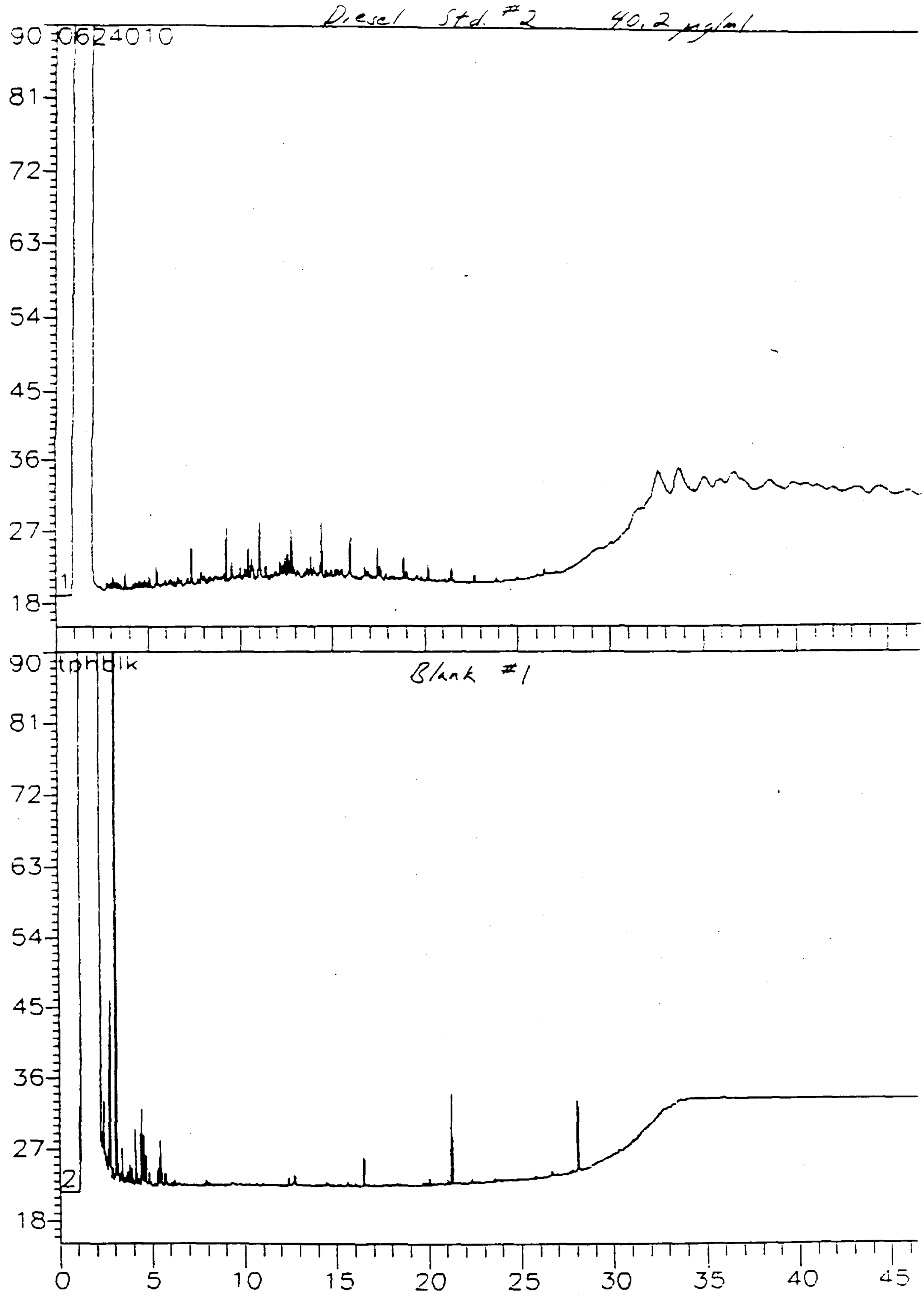
SPECIFIC PRODUCTS IDENTIFIED: none

Samples with equivalent chromatograms: N/A

COMMENTS:
Copies of the sample chromatogram and a diesel standard chromatogram are attached, as are comparisons with equivalent samples.
Diesel standards were used to quantitate the samples for a TPH value as they have similar responses.

FLAGS:

| | |
|---|---|
| U | Analyte is not present in concentrations at or above quantitation limit. |
| J | Reported value is estimated. |
| E | Analytes concentration in the sample exceeded the calibration range. |
| D | Sample was diluted. |


Diesel Std. #2 40.2 µg/ml
0624010
90
81
72
63
54
45
36
27
18
1
tphblk
Blank #1
90
81
72
63
54
45
36
27
18
2
0
5
10
15
20
25
30
35
40
45

# SAMPLE RESULTS FORM

SAMPLE I. D.: D930001186 93ZB15 blank #2

| | | | |
|---|---|---|---|
| SAMPLE WEIGHT (g): | 10.00 | | |
| FILENAME: | 052011 | FINAL VOLUME (ml): | 10 |
| STATION LOCATION: | Na2SO4 | DILUTION FACTOR: | 1 |
| MATRIX: | Na2SO4 | % MOISTURE: | N/A |
| DATE RUN: | 05/20/93 | EXTRACTION DATE: | 05/18/93 |

**TPH VALUE:** 20 U mg/kg
(concentration estimated
from diesel standard)

SPECIFIC PRODUCTS IDENTIFIED: none

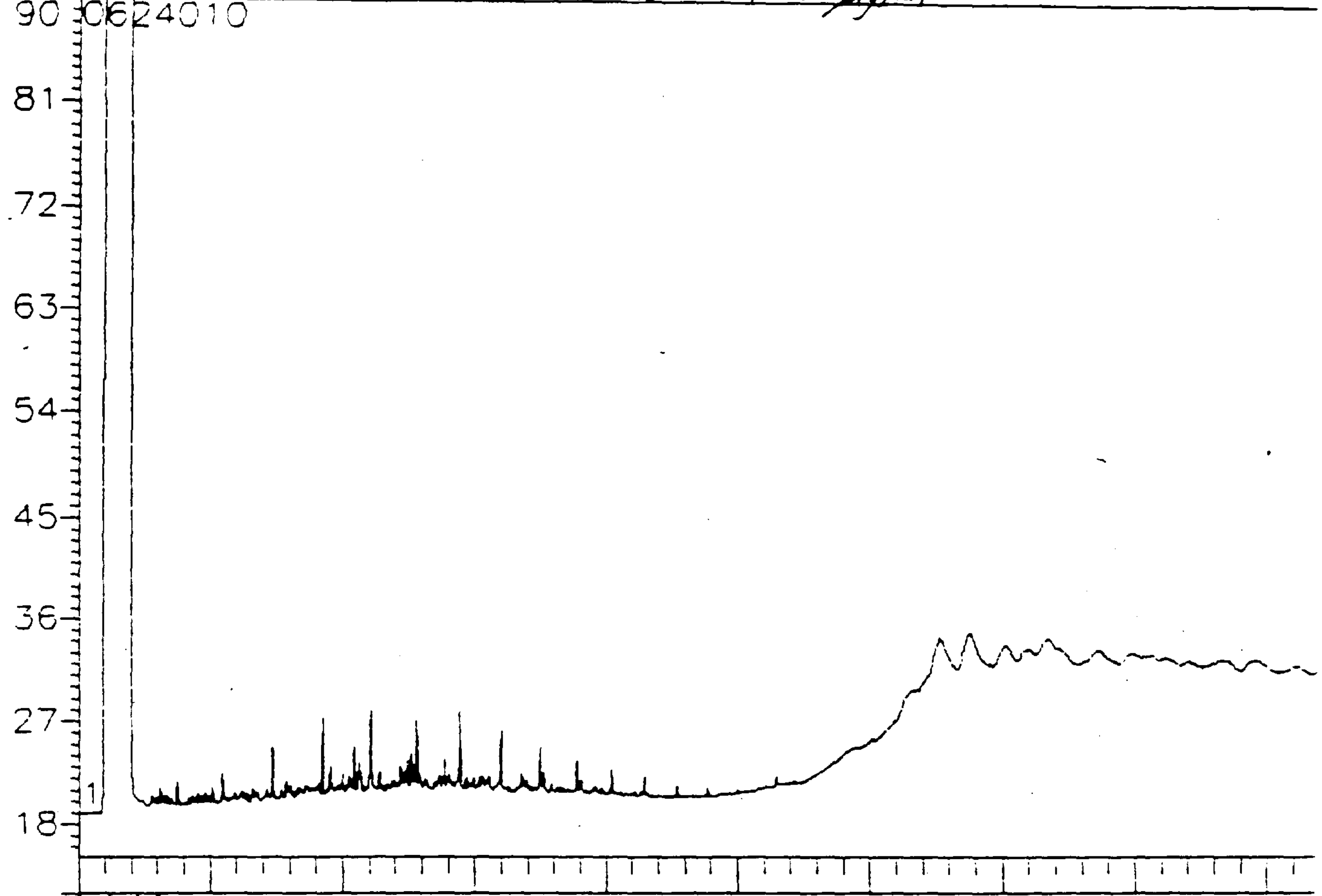
Samples with equivalent chromatograms: N/A

COMMENTS:
Copies of the sample chromatogram and a diesel standard chromatogram are attached, as are comparisons with equivalent samples.
Diesel standards were used to quantitate the samples for a TPH value as they have similar responses.

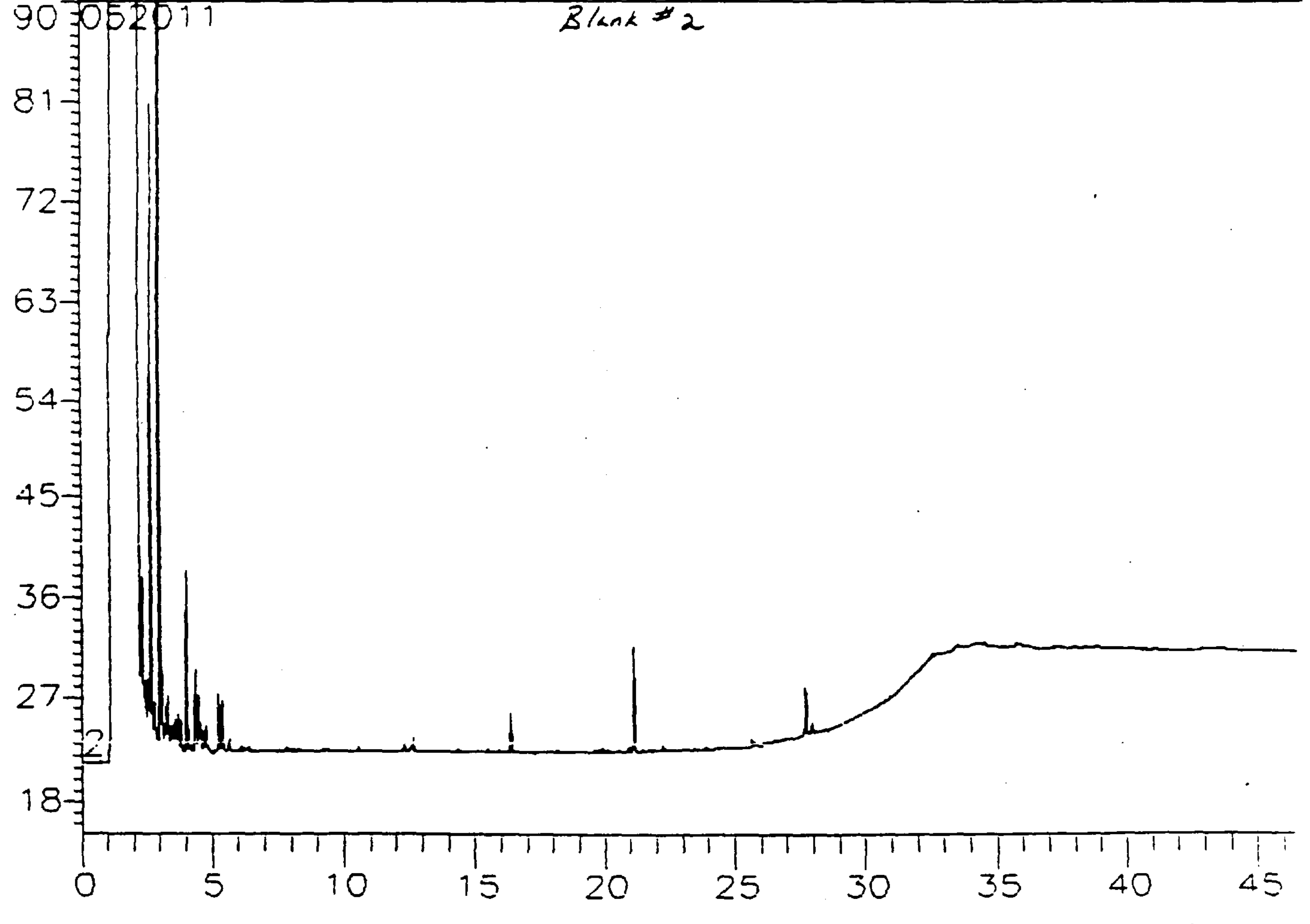
| | | |
|---|---|---|
| FLAGS: | U | Analyte is not present in concentrations at or above quantitation limit. |
| | J | Reported value is estimated. |
| | E | Analytes concentration in the sample exceeded the calibration range. |
| | D | Sample was diluted. |

R84a

Diesel Std #2 40.2 µg/ml



Blank #2



P. 846

~~82~~

# SAMPLE RESULTS FORM

SAMPLE I. D.: D930001200 93ZB15 blank #3

| | | | |
|---|---|---|---|
| SAMPLE WEIGHT (g): | 10.00 | | |
| FILENAME: | 0624008 | FINAL VOLUME (ml): | 10 |
| STATION LOCATION: | Na2SO4 | DILUTION FACTOR: | 1 |
| MATRIX: | Na2SO4 | % MOISTURE: | N/A |
| DATE RUN: | 06/24/93 | EXTRACTION DATE: | 06/22/93 |

**TPH VALUE:** 200 mg/kg
(concentration estimated
from diesel standard)

SPECIFIC PRODUCTS IDENTIFIED: none

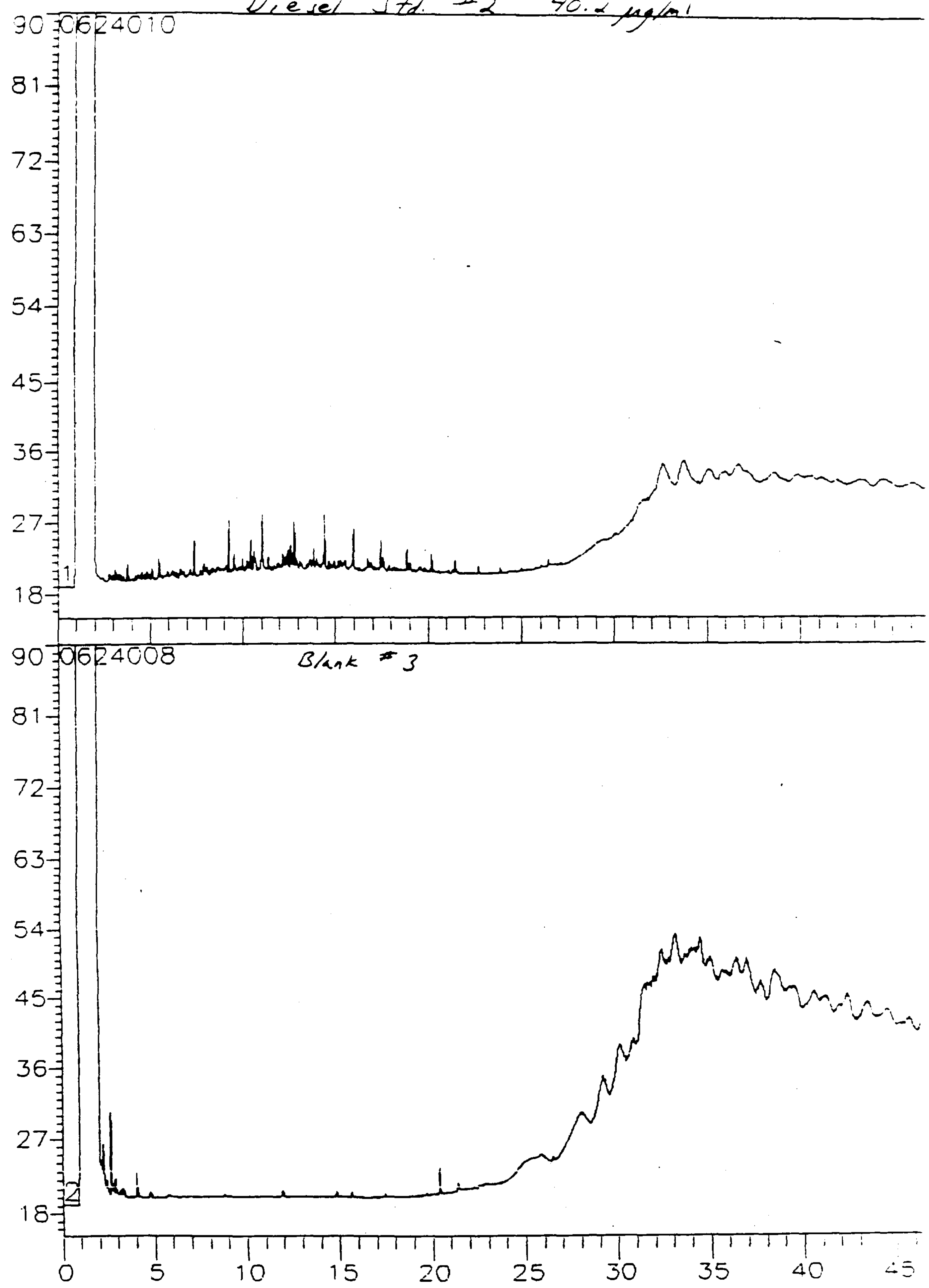
Samples with equivalent chromatograms: N/A

COMMENTS:
Copies of the sample chromatogram and a diesel standard chromatogram are attached, as are comparisons with equivalent samples.
Diesel standards were used to quantitate the samples for a TPH value as they have similar responses.

FLAGS:

| | |
|---|---|
| U | Analyte is not present in concentrations at or above quantitation limit. |
| J | Reported value is estimated. |
| E | Analytes concentration in the sample exceeded the calibration range. |
| D | Sample was diluted. |

P.85a


Diesel Std. #2 40.2 µg/ml

Blank #3

P.856

Pages 87 and 88 No longer exist

D. Payne
10-7-93

# SAMPLE RESULTS FORM

SAMPLE I. D.: D930001177 93ZB14 S11MS

| | | | |
|---|---|---|---|
| SAMPLE WEIGHT (g): | 10.87 | | |
| FILENAME: | TPH011MS | FINAL VOLUME (ml): | 10 |
| STATION LOCATION: | SB50J | DILUTION FACTOR: | 1 |
| MATRIX: | soil | % MOISTURE: | 15.1% |
| DATE RUN: | 05/14/93 | EXTRACTION DATE: | 05/11/93 |

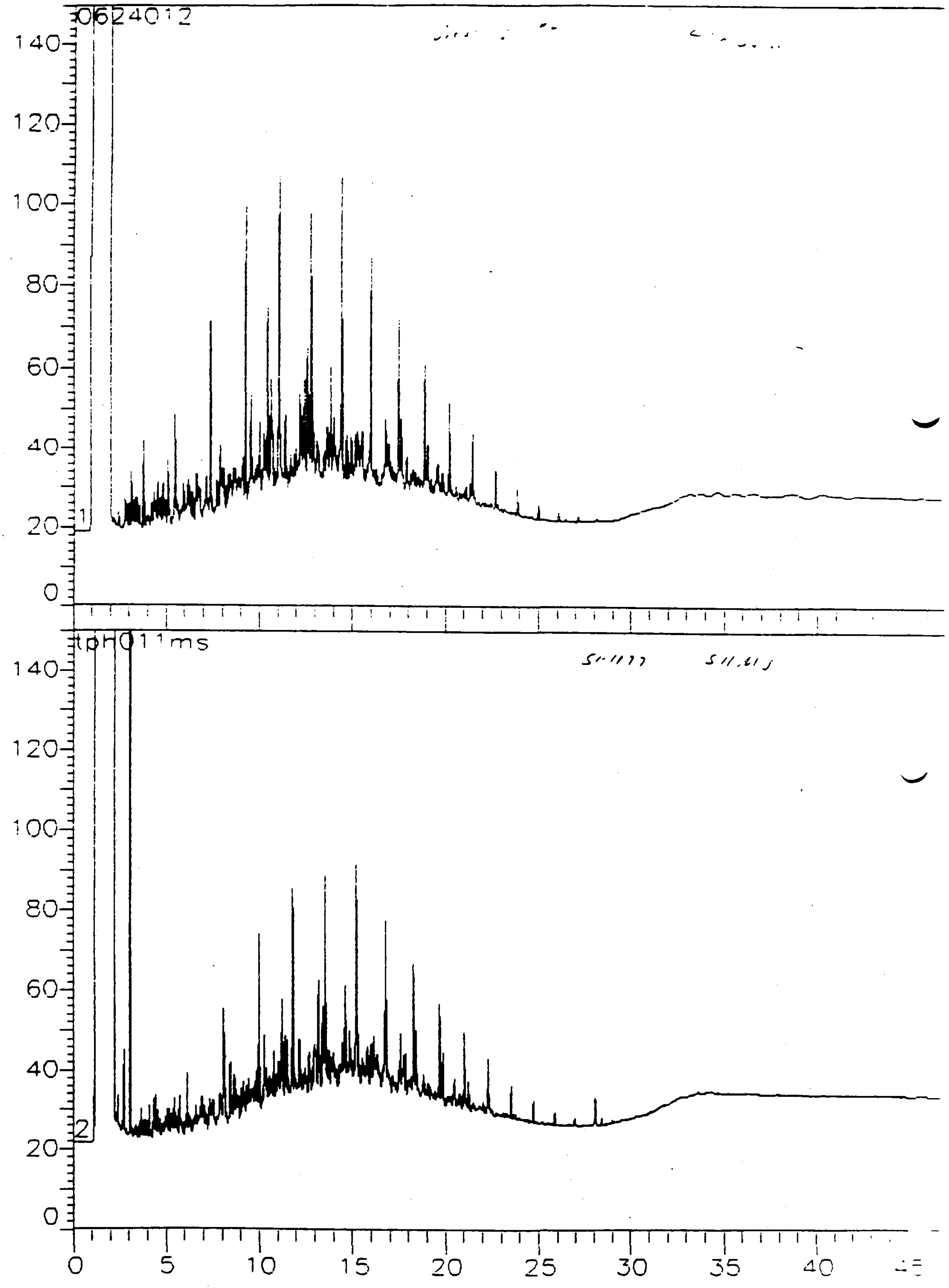
**TPH VALUE:** 410 mg/kg
(concentration estimated
from diesel standard)

SPECIFIC PRODUCTS IDENTIFIED: none

Samples with equivalent chromatograms: N/A

COMMENTS:
Copies of the sample chromatogram and a diesel standard chromatogram are attached, as are comparisons with equivalent samples.
Diesel standards were used to quantitate the samples for a TPH value as they have similar responses.

| FLAGS: | | |
|---|---|---|
| | U | Analyte is not present in concentrations at or above quantitation limit. |
| | J | Reported value is estimated. |
| | E | Analytes concentration in the sample exceeded the calibration range. |
| | D | Sample was diluted. |


0624012
1
140
120
100
80
60
40
20
0
tph011ms
2
140
120
100
80
60
40
20
0
0
5
10
15
20
25
30
35
40
45

P. 896 ~~95~~

# SAMPLE RESULTS FORM

SAMPLE I. D.: <u>D930001177</u> <u>93ZB14</u> <u>811MSD</u>

| | | | |
|---|---|---|---|
| SAMPLE WEIGHT (g): | 10.70 | | |
| FILENAME: | TPH11MSD | FINAL VOLUME (ml): | 10 |
| STATION LOCATION: | SB50J | DILUTION FACTOR: | 1 |
| MATRIX: | soil | % MOISTURE: | 15.1% |
| DATE RUN: | 05/14/93 | EXTRACTION DATE: | 05/11/93 |

**TPH VALUE:** 90 mg/kg
(concentration estimated
from diesel standard)

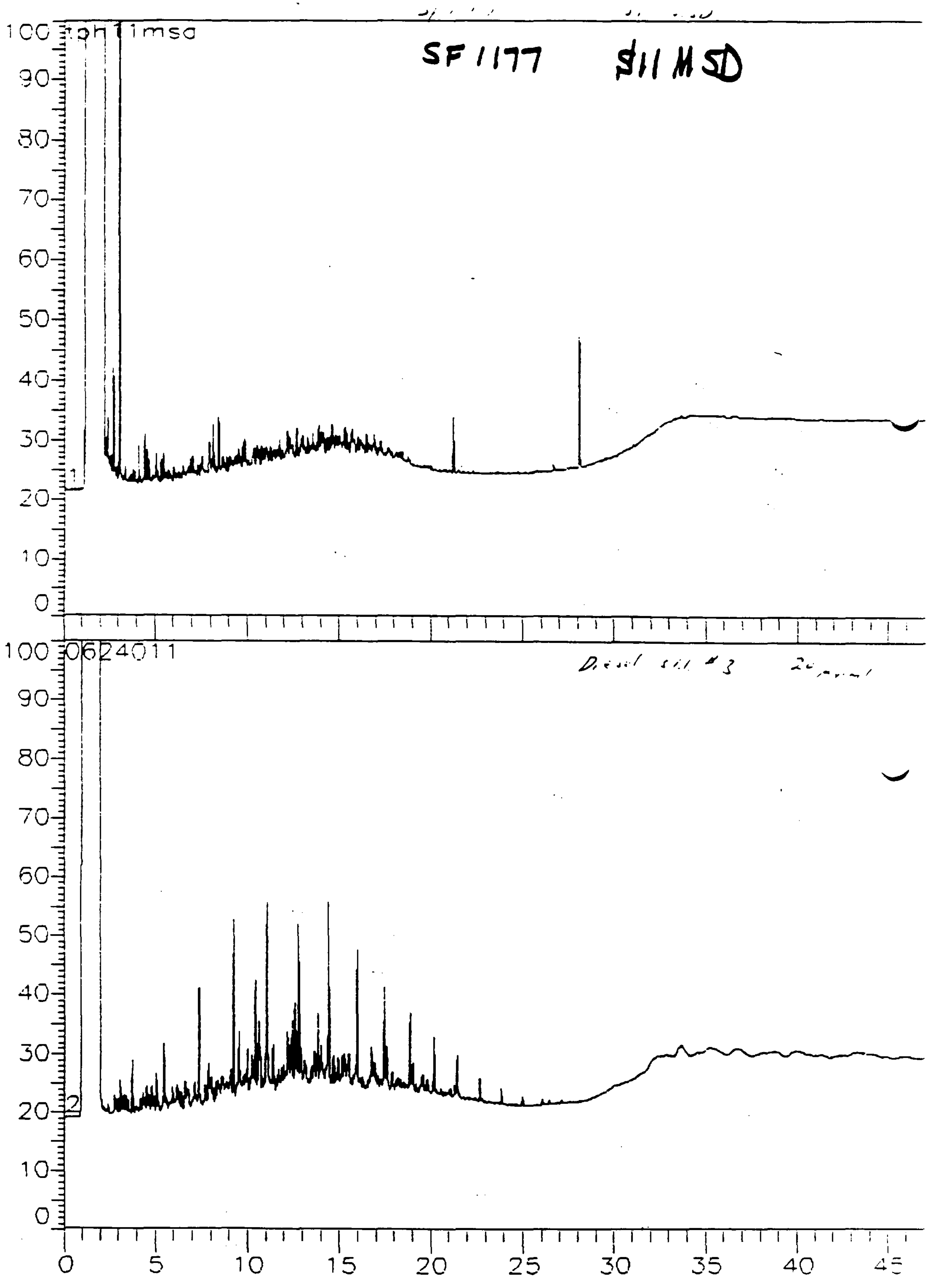
SPECIFIC PRODUCTS IDENTIFIED: none

Samples with equivalent chromatograms: N/A

COMMENTS:
Copies of the sample chromatogram and a diesel standard chromatogram are attached, as are comparisons with equivalent samples.
Diesel standards were used to quantitate the samples for a TPH value as they have similar responses.

| | | |
|---|---|---|
| FLAGS: | U | Analyte is not present in concentrations at or above quantitation limit. |
| | J | Reported value is estimated. |
| | E | Analytes concentration in the sample exceeded the calibration range. |
| | D | Sample was diluted. |

P. 90A


100
90
80
70
60
50
40
30
20
10
0
tph11msa
1
SF 1177
811 MSD
062401 1
2
Diesel std #3
20 ppm
0
5
10
15
20
25
30
35
40
45

P. 906

96

# SAMPLE RESULTS FORM

SAMPLE I. D.: **D930001186** **93ZB15** **804MS**

| | | | |
|---|---|---|---|
| SAMPLE WEIGHT (g): | 9.97 | | |
| FILENAME: | 05205 | FINAL VOLUME (ml): | 10 |
| STATION LOCATION: | SB39E | DILUTION FACTOR: | 1 |
| MATRIX: | soil | % MOISTURE: | 9.4% |
| DATE RUN: | 05/20/93 | EXTRACTION DATE: | 05/18/93 |

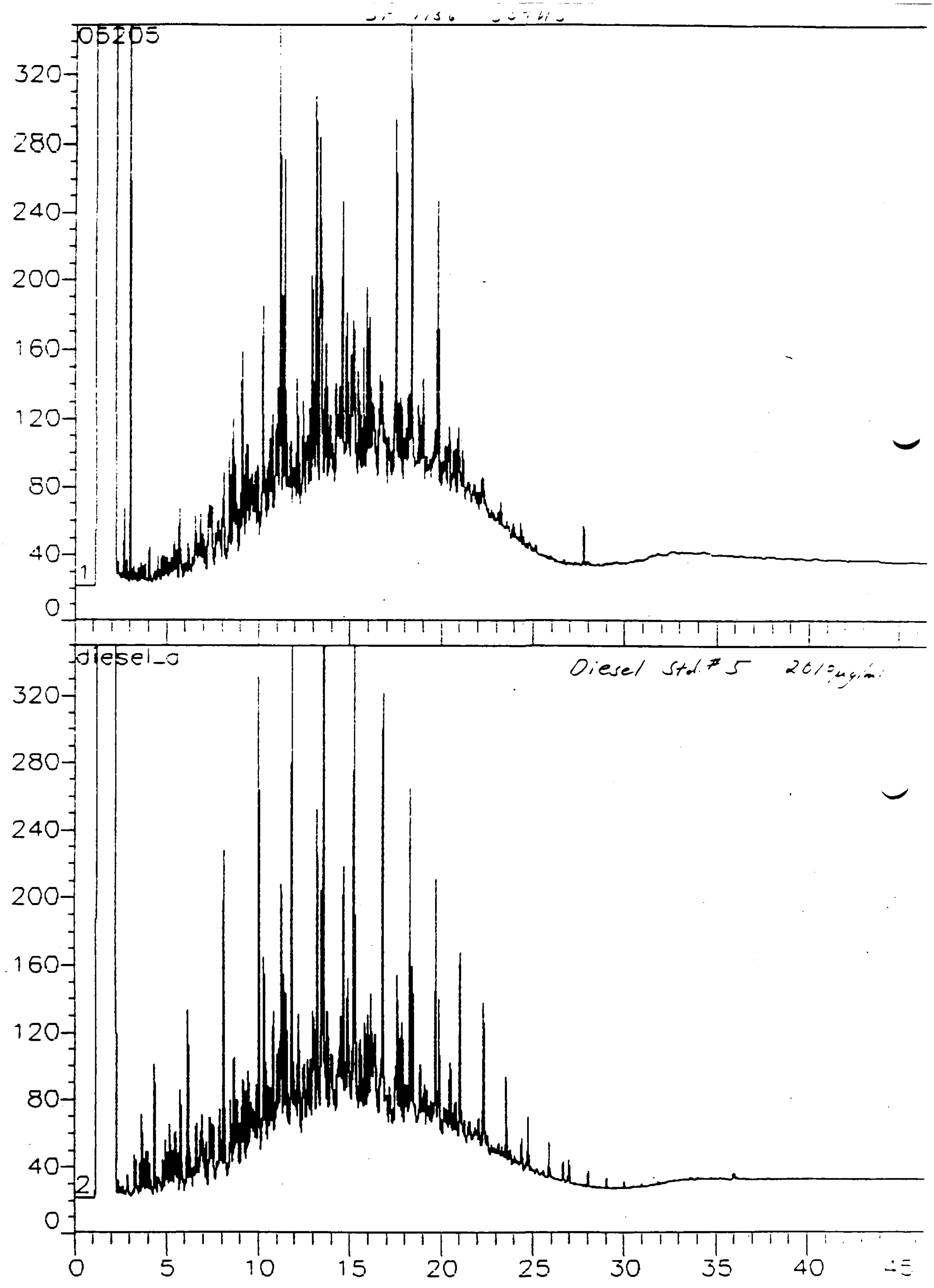
**TPH VALUE:** **2400 mg/kg**
(concentration estimated
from diesel standard)

SPECIFIC PRODUCTS IDENTIFIED: none

Samples with equivalent chromatograms: N/A

COMMENTS:
Copies of the sample chromatogram and a diesel standard chromatogram are attached, as are comparisons with equivalent samples.
Diesel standards were used to quantitate the samples for a TPH value as they have similar responses.

| | | |
|---|---|---|
| FLAGS: | U | Analyte is not present in concentrations at or above quantitation limit. |
| | J | Reported value is estimated. |
| | E | Analytes concentration in the sample exceeded the calibration range. |
| | D | Sample was diluted. |



Diesel Std. #5 2010 µg/ml

P. 916

# SAMPLE RESULTS FORM

SAMPLE I. D.: **D930001186** **93ZB15** **S04MSD**

| | | | |
|---|---|---|---|
| SAMPLE WEIGHT (g): | 10.23 | | |
| FILENAME: | 05206 | FINAL VOLUME (ml): | 10 |
| STATION LOCATION: | SB39E | DILUTION FACTOR: | 1 |
| MATRIX: | soil | % MOISTURE: | 9.0% |
| DATE RUN: | 05/20/93 | EXTRACTION DATE: | 05/18/93 |

**TPH VALUE:** **3100 mg/kg**
(concentration estimated
from diesel standard)

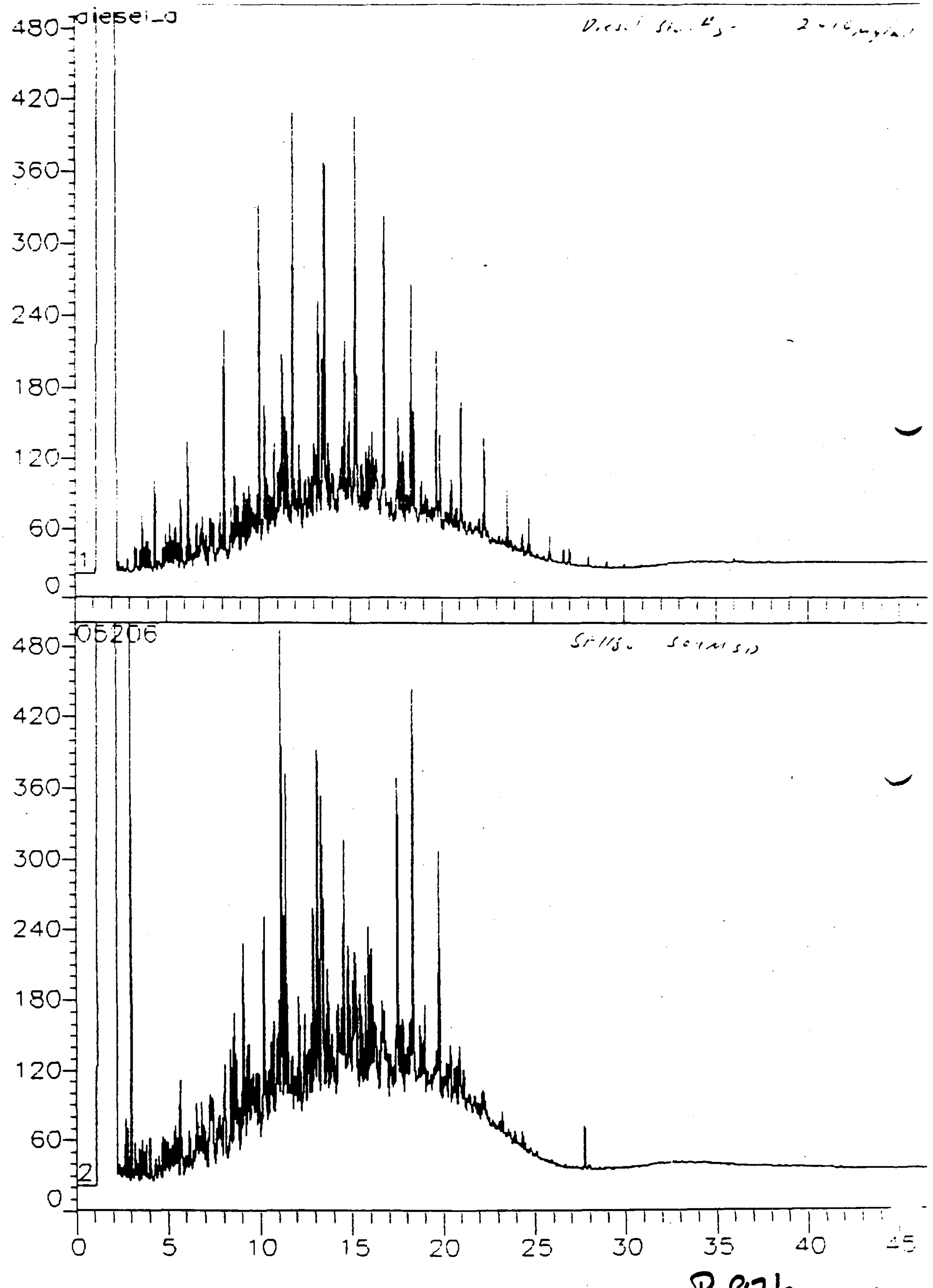
SPECIFIC PRODUCTS IDENTIFIED: none

Samples with equivalent chromatograms: N/A

COMMENTS:
Copies of the sample chromatogram and a diesel standard chromatogram are attached, as are comparisons with equivalent samples.
Diesel standards were used to quantitate the samples for a TPH value as they have similar responses.

| | | |
|---|---|---|
| FLAGS: | U | **Analyte is not present in concentrations at or above quantitation limit.** |
| | J | **Reported value is estimated.** |
| | E | **Analytes concentration in the sample exceeded the calibration range.** |
| | D | **Sample was diluted.** |

P, 92a


diesel_a
Diesel Std - 2-10 mg/ml
1
05206
SP-1150 Soil msd
2
0
60
120
180
240
300
360
420
480
0
5
10
15
20
25
30
35
40
45

# SAMPLE RESULTS FORM

SAMPLE I. D.: D930001200 93ZB15 S98MS

SAMPLE WEIGHT (g): 10.61
FILENAME: 0624006
STATION LOCATION: SB14
MATRIX: soil
DATE RUN: 06/24/93

FINAL VOLUME (ml): 10
DILUTION FACTOR: 1
% MOISTURE: 15.1%
EXTRACTION DATE: 06/22/93

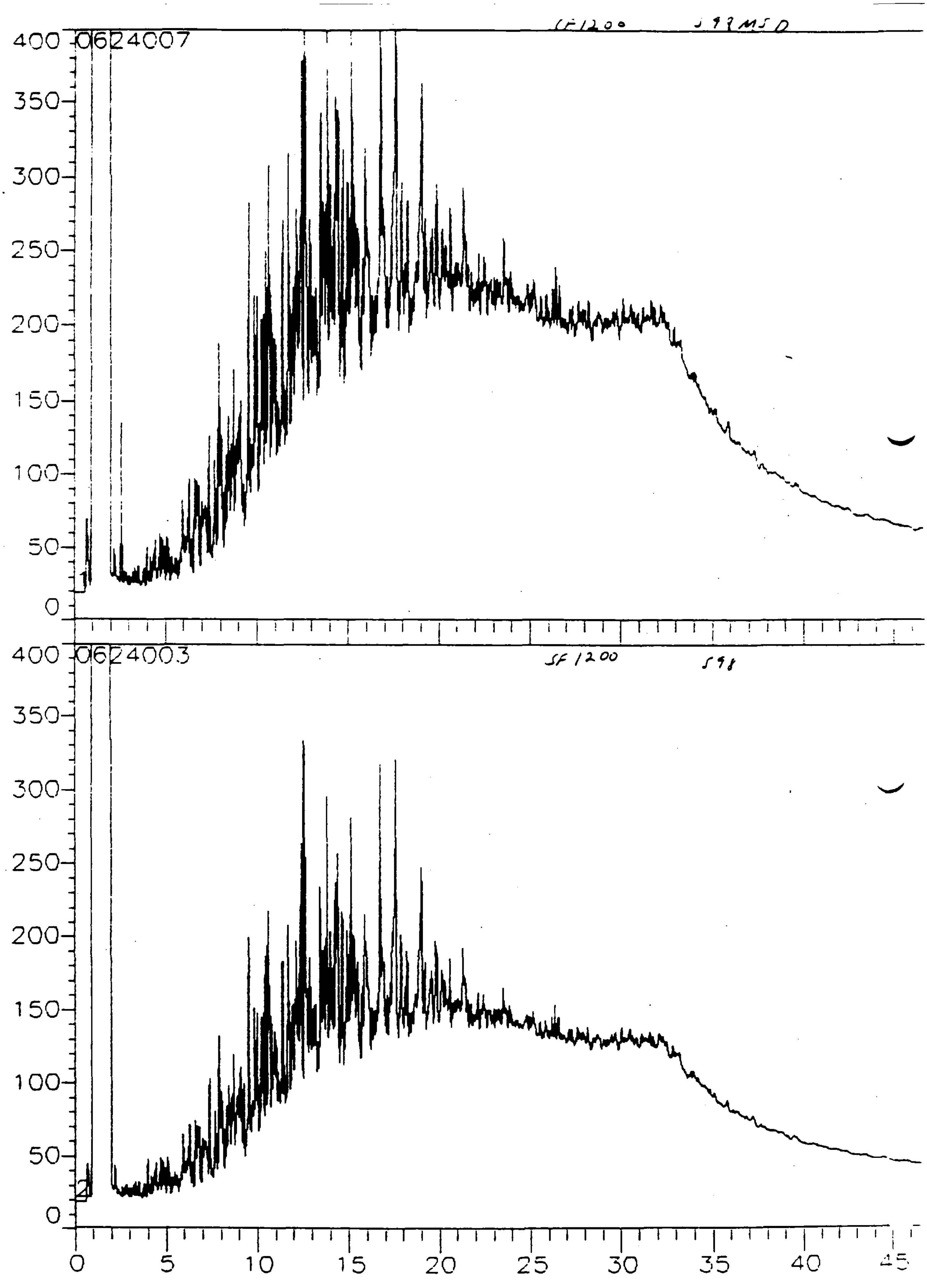
**TPH VALUE:** **4900 mg/kg**
(concentration estimated
from diesel standard)

SPECIFIC PRODUCTS IDENTIFIED: none

Samples with equivalent chromatograms: N/A

COMMENTS:
Copies of the sample chromatogram and a diesel standard chromatogram are attached, as are comparisons with equivalent samples.
Diesel standards were used to quantitate the samples for a TPH value as they have similar responses.

| | | |
|---|---|---|
| FLAGS: | U | Analyte is not present in concentrations at or above quantitation limit. |
| | J | Reported value is estimated. |
| | E | Analytes concentration in the sample exceeded the calibration range. |
| | D | Sample was diluted. |


SF1200
S99MSD
0624007
0624003
SF1200
S98
400
350
300
250
200
150
100
50
0
5
10
15
20
25
30
35
40
45

P. 93b

# SAMPLE RESULTS FORM

SAMPLE I. D.: D930001200 93ZB15 S98MSD

| | | | |
|---|---|---|---|
| SAMPLE WEIGHT (g): | 10.01 | | |
| FILENAME: | 0624007 | FINAL VOLUME (ml): | 10 |
| STATION LOCATION: | SB14 | DILUTION FACTOR: | 1 |
| MATRIX: | soil | % MOISTURE: | 15.1% |
| DATE RUN: | 06/24/93 | EXTRACTION DATE: | 06/22/93 |

**TPH VALUE:** 5600 mg/kg
(concentration estimated
from diesel standard)

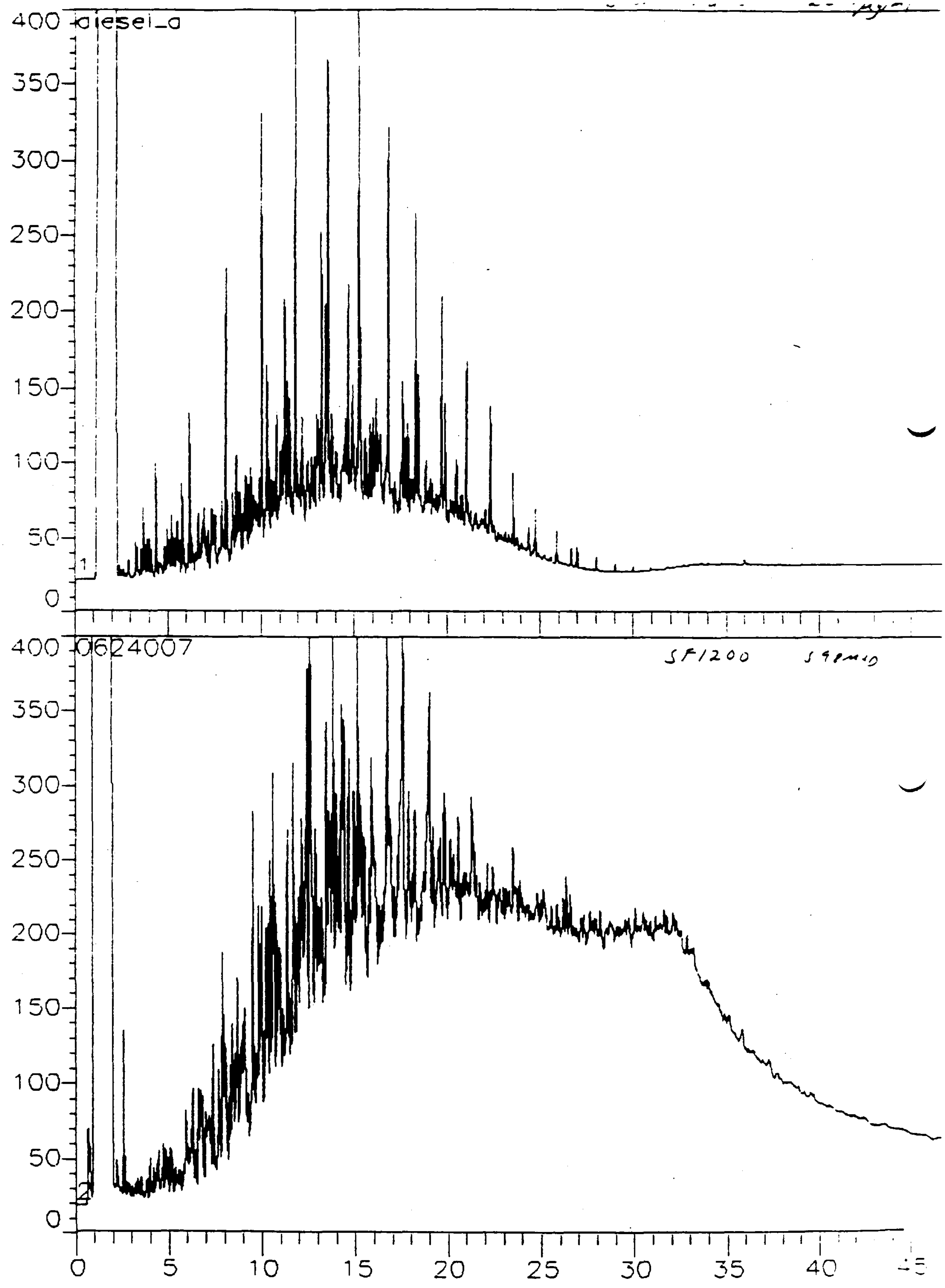
SPECIFIC PRODUCTS IDENTIFIED: none

Samples with equivalent chromatograms: N/A

COMMENTS:
Copies of the sample chromatogram and a diesel standard chromatogram are attached, as are comparisons with equivalent samples.
Diesel standards were used to quantitate the samples for a TPH value as they have similar responses.

| FLAGS: | | |
|---|---|---|
| | U | Analyte is not present in concentrations at or above quantitation limit. |
| | J | Reported value is estimated. |
| | E | Analytes concentration in the sample exceeded the calibration range. |
| | D | Sample was diluted. |

R94a ~~94~~


diesel_a
400
350
300
250
200
150
100
50
0
1
0624007
SF1200
54pmid
400
350
300
250
200
150
100
50
0
2
0
5
10
15
20
25
30
35
40
45

Pages 96-100 no longer exist

D. Payne
10-7-93

# APPENDIX H

# VERTICAL SAMPLING ANALYTICAL RESULTS

BIO-CHEM
ENVIRONMENTAL
ANALYTICAL
LABORATORY

PH 616/878-1188
Fax 616/878-0044
In Michigan 800/362-LABS

# ANALYTICAL RESULTS

DATE: May 25, 1993

CLIENT NAME:---------B&V WASTE SCIENCE
ATTN:--------------------ROBERT LANTZ
ADDRESS:----------------101 N. WACKER DR. - SUITE 1100
CHICAGO, IL 60606

PROJECT:----------------OCI
PROJECT NO: ---------- 70160.120
SAMPLE ID:--------------OCI MW34 (59.5-64.5)
SAMPLE TYPE:---------AQUEOUS

DATE RECEIVED:--------- 5/24/93
ANALYSIS DATE:----------5/24/93
QA/QC FILE NAME:------- MAY24624\0901004.D

## RESULTS

| | EPA 624 TARGET COMPOUNDS | RESULTS ( ug/L ) : ppb |
|---|---|---|
| 1 | VINYL CHLORIDE | BDL (< 1 ) |
| 2 | CHLOROMETHANE | BDL (< 1 ) |
| 3 | BROMOETHANE | BDL (< 1 ) |
| 4 | CHLOROETHANE | BDL (< 1 ) |
| 5 | TRICHLOROFLUOROMETHANE | BDL (< 1 ) |
| 6 | 1,1-DICHLOROETHENE | BDL (< 1 ) |
| 7 | METHYLENE CHLORIDE | BDL (< 1 ) |
| 8 | trans-1,2-DICHLOROETHENE | BDL (< 1 ) |
| 9 | 1,1-DICHLOROETHANE | BDL (< 1 ) |
| 10 | CHLOROFORM | 9.5 |
| 11 | 1,1,1-TRICHLOROETHANE | BDL (< 1 ) |
| 12 | 1,2-DICHLOROETHANE | BDL (< 1 ) |
| 13 | BENZENE | BDL (< 1 ) |
| 14 | CARBON TETRACHLORIDE | BDL (< 1 ) |
| 15 | 1,2-DICHLOROPROPANE | BDL (< 1 ) |
| 16 | TRICHLOROETHENE | BDL (< 1 ) |
| 17 | BROMODICHLOROMETHANE | 1.5 |
| 18 | cis-1,3-DICHLOROPROPENE | BDL (< 1 ) |
| 19 | TOLUENE | BDL (< 1 ) |
| 20 | trans-1,3-DICHLOROPROPENE | BDL (< 1 ) |
| 21 | 1,1,2-TRICHLOROETHANE | BDL (< 1 ) |
| 22 | DIBROMOCHLOROMETHANE | BDL (< 1 ) |
| 23 | TETRACHLOROETHENE | BDL (< 1 ) |
| 24 | CHLOROBENZENE | BDL (< 1 ) |
| 25 | ETHYLBENZENE | BDL (< 1 ) |
| 26 | BROMOFORM | BDL (< 1 ) |
| 27 | 1,1,2,2-TETRACHLOROETHANE | BDL (< 1 ) |
| 28 | 1,3-DICHLOROBENZENE | BDL (< 1 ) |
| 29 | 1,4-DICHLOROBENZENE | BDL (< 1 ) |
| 30 | 1,2-DICHLOROBENZENE | BDL (< 1 ) |
| 31 | XYLENES | BDL (< 3 ) |

BDL = BELOW DETECTION LIMITS

MICHAEL L. DOUGLASS
LABORATORY MANAGER

**Analysis in compliance with Environmental Protection Agency's SW846 Method 8260 GC/MS Volitiles Analysis**
**Capillary Column Type: [ phase: DB-624; ID: 530 uM; film: VTK; 3 uM film thickness ]**
**Enrichment: [ Tekmar concentrator with moisture control module and glass jet separator ]**

BIO CHEM
ENVIRONMENTAL
ANALYTICAL
LABORATORY

PH 616/878-1188
Fax 616/878-0044
In Michigan 800/362-LABS

# ANALYTICAL RESULTS

DATE: May 25, 1993

CLIENT NAME:--------B&V WASTE SCIENCE
ATTN:--------------------ROBERT LANTZ
ADDRESS:----------------101 N. WACKER DR. - SUITE 1100
CHICAGO, IL 60606

PROJECT:----------------OCI
PROJECT NO: ----------- 70160.120
SAMPLE ID:--------------OCI MW34 (64.5-69.5)
SAMPLE TYPE:---------AQUEOUS

DATE RECEIVED:---------- 5/24/93
ANALYSIS DATE:----------5/24/93
QA/QC FILE NAME:------- MAY24624\1001005.D

## RESULTS

| | EPA 624 TARGET COMPOUNDS | RESULTS ( ug/L ) : ppb |
|---|---|---|
| 1 | VINYL CHLORIDE | BDL (< 1 ) |
| 2 | CHLOROMETHANE | BDL (< 1 ) |
| 3 | BROMOETHANE | BDL (< 1 ) |
| 4 | CHLOROETHANE | BDL (< 1 ) |
| 5 | TRICHLOROFLUOROMETHANE | BDL (< 1 ) |
| 6 | 1,1-DICHLOROETHENE | BDL (< 1 ) |
| 7 | METHYLENE CHLORIDE | BDL (< 1 ) |
| 8 | trans-1,2-DICHLOROETHENE | BDL (< 1 ) |
| 9 | 1,1-DICHLOROETHANE | BDL (< 1 ) |
| 10 | CHLOROFORM | 13.6 |
| 11 | 1,1,1-TRICHLOROETHANE | BDL (< 1 ) |
| 12 | 1,2-DICHLOROETHANE | BDL (< 1 ) |
| 13 | BENZENE | BDL (< 1 ) |
| 14 | CARBON TETRACHLORIDE | BDL (< 1 ) |
| 15 | 1,2-DICHLOROPROPANE | BDL (< 1 ) |
| 16 | TRICHLOROETHENE | BDL (< 1 ) |
| 17 | BROMODICHLOROMETHANE | 3.3 |
| 18 | cis-1,3-DICHLOROPROPENE | BDL (< 1 ) |
| 19 | TOLUENE | BDL (< 1 ) |
| 20 | trans-1,3-DICHLOROPROPENE | BDL (< 1 ) |
| 21 | 1,1,2-TRICHLOROETHANE | BDL (< 1 ) |
| 22 | DIBROMOCHLOROMETHANE | 1.0 |
| 23 | TETRACHLOROETHENE | BDL (< 1 ) |
| 24 | CHLOROBENZENE | BDL (< 1 ) |
| 25 | ETHYLBENZENE | BDL (< 1 ) |
| 26 | BROMOFORM | BDL (< 1 ) |
| 27 | 1,1,2,2-TETRACHLOROETHANE | BDL (< 1 ) |
| 28 | 1,3-DICHLOROBENZENE | BDL (< 1 ) |
| 29 | 1,4-DICHLOROBENZENE | BDL (< 1 ) |
| 30 | 1,2-DICHLOROBENZENE | BDL (< 1 ) |
| 31 | XYLENES | BDL (< 3 ) |

BDL = BELOW DETECTION LIMITS

Michael Douglass
MICHAEL L. DOUGLASS
LABORATORY MANAGER

Analysis in compliance with Environmental Protection Agency's SW846 Method 8260 GC/MS Volitiles Analysis
Capillary Column Type: [ phase: DB-624; ID: 530 uM; film: VTK; 3 uM film thickness ]
Enrichment: [ Tekmar concentrator with moisture control module and glass jet separator ]

BIO-CHEM
ENVIRONMENTAL
ANALYTICAL
LABORATORY

PH 616/878-1188
Fax 616/878-0044
In Michigan 800/362-LABS

# ANALYTICAL RESULTS
DATE: May 25, 1993

CLIENT NAME:---------B&V WASTE SCIENCE
ATTN:--------------------ROBERT LANTZ
ADDRESS:----------------101 N. WACKER DR. - SUITE 1100
CHICAGO, IL 60606

PROJECT:-----------------OCI
PROJECT NO: ---------- 70160.120
SAMPLE ID:---------------OCI MW34 (69.5-74.5)
SAMPLE TYPE:----------AQUEOUS

DATE RECEIVED:--------- 5/24/93
ANALYSIS DATE:----------5/24/93
QA/QC FILE NAME:------- MAY24624\1101006.D

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## RESULTS

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| | EPA 624 TARGET COMPOUNDS | RESULTS ( ug/L ) : ppb |
|---|---|---|
| 1 | VINYL CHLORIDE | BDL (< 1) |
| 2 | CHLOROMETHANE | BDL (< 1) |
| 3 | BROMOETHANE | BDL (< 1) |
| 4 | CHLOROETHANE | BDL (< 1) |
| 5 | TRICHLOROFLUOROMETHANE | BDL (< 1) |
| 6 | 1,1-DICHLOROETHENE | BDL (< 1) |
| 7 | METHYLENE CHLORIDE | BDL (< 1) |
| 8 | trans-1,2-DICHLOROETHENE | BDL (< 1) |
| 9 | 1,1-DICHLOROETHANE | BDL (< 1) |
| 10 | CHLOROFORM | 8.3 |
| 11 | 1,1,1-TRICHLOROETHANE | BDL (< 1) |
| 12 | 1,2-DICHLOROETHANE | BDL (< 1) |
| 13 | BENZENE | BDL (< 1) |
| 14 | CARBON TETRACHLORIDE | BDL (< 1) |
| 15 | 1,2-DICHLOROPROPANE | BDL (< 1) |
| 16 | TRICHLOROETHENE | BDL (< 1) |
| 17 | BROMODICHLOROMETHANE | 1.9 |
| 18 | cis-1,3-DICHLOROPROPENE | BDL (< 1) |
| 19 | TOLUENE | BDL (< 1) |
| 20 | trans-1,3-DICHLOROPROPENE | BDL (< 1) |
| 21 | 1,1,2-TRICHLOROETHANE | BDL (< 1) |
| 22 | DIBROMOCHLOROMETHANE | BDL (< 1) |
| 23 | TETRACHLOROETHENE | BDL (< 1) |
| 24 | CHLOROBENZENE | BDL (< 1) |
| 25 | ETHYLBENZENE | BDL (< 1) |
| 26 | BROMOFORM | BDL (< 1) |
| 27 | 1,1,2,2-TETRACHLOROETHANE | BDL (< 1) |
| 28 | 1,3-DICHLOROBENZENE | BDL (< 1) |
| 29 | 1,4-DICHLOROBENZENE | BDL (< 1) |
| 30 | 1,2-DICHLOROBENZENE | BDL (< 1) |
| 31 | XYLENES | BDL (< 3) |

BDL = BELOW DETECTION LIMITS

MICHAEL L. DOUGLASS
LABORATORY MANAGER

Analysis in compliance with Environmental Protection Agency's SW846 Method 8260 GC/MS Volitiles Analysis
Capillary Column Type: [ phase: DB-624; ID: 530 uM; film: VTK; 3 uM film thickness ]
Enrichment: [ Tekmar concentrator with moisture control module and glass jet separator ]

BIO CHEM
ENVIRONMENTAL
ANALYTICAL
LABORATORY

PH 616/878-1188
Fax 616/878-0044
In Michigan 800/362-LABS

# ANALYTICAL RESULTS

DATE: May 25, 1993

CLIENT NAME:---------B&V WASTE SCIENCE
ATTN:---------------------ROBERT LANTZ
ADDRESS:----------------101 N. WACKER DR. - SUITE 1100
CHICAGO, IL 60606

PROJECT:-----------------OCI
PROJECT NO:----------70160.120
SAMPLE ID:---------------OCI MW34 (74.5-79.5)
SAMPLE TYPE:----------AQUEOUS

DATE RECEIVED:---------- 5/24/93
ANALYSIS DATE:-----------5/24/93
QA/QC FILE NAME:------- MAY24624\1201007.D

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## RESULTS

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| | EPA 624 TARGET COMPOUNDS | RESULTS ( ug/L ) : ppb |
|---|---|---|
| 1 | VINYL CHLORIDE | BDL (< 1) |
| 2 | CHLOROMETHANE | BDL (< 1) |
| 3 | BROMOETHANE | BDL (< 1) |
| 4 | CHLOROETHANE | BDL (< 1) |
| 5 | TRICHLOROFLUOROMETHANE | BDL (< 1) |
| 6 | 1,1-DICHLOROETHENE | BDL (< 1) |
| 7 | METHYLENE CHLORIDE | BDL (< 1) |
| 8 | trans-1,2-DICHLOROETHENE | BDL (< 1) |
| 9 | 1,1-DICHLOROETHANE | BDL (< 1) |
| 10 | CHLOROFORM | 9.9 |
| 11 | 1,1,1-TRICHLOROETHANE | BDL (< 1) |
| 12 | 1,2-DICHLOROETHANE | BDL (< 1) |
| 13 | BENZENE | BDL (< 1) |
| 14 | CARBON TETRACHLORIDE | BDL (< 1) |
| 15 | 1,2-DICHLOROPROPANE | BDL (< 1) |
| 16 | TRICHLOROETHENE | BDL (< 1) |
| 17 | BROMODICHLOROMETHANE | 3.1 |
| 18 | cis-1,3-DICHLOROPROPENE | BDL (< 1) |
| 19 | TOLUENE | BDL (< 1) |
| 20 | trans-1,3-DICHLOROPROPENE | BDL (< 1) |
| 21 | 1,1,2-TRICHLOROETHANE | BDL (< 1) |
| 22 | DIBROMOCHLOROMETHANE | BDL (< 1) |
| 23 | TETRACHLOROETHENE | BDL (< 1) |
| 24 | CHLOROBENZENE | BDL (< 1) |
| 25 | ETHYLBENZENE | BDL (< 1) |
| 26 | BROMOFORM | BDL (< 1) |
| 27 | 1,1,2,2-TETRACHLOROETHANE | BDL (< 1) |
| 28 | 1,3-DICHLOROBENZENE | BDL (< 1) |
| 29 | 1,4-DICHLOROBENZENE | BDL (< 1) |
| 30 | 1,2-DICHLOROBENZENE | BDL (< 1) |
| 31 | XYLENES | BDL (< 3) |

BDL = BELOW DETECTION LIMITS

MICHAEL L. DOUGLASS
LABORATORY MANAGER

Analysis in compliance with Environmental Protection Agency's SW846 Method 8260 GC/MS Volitiles Analysis
Capillary Column Type: [ phase: DB-624; ID: 530 uM; film: VTK; 3 uM film thickness ]
Enrichment: [ Tekmar concentrator with moisture control module and glass jet separator ]

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ANALYTICAL
LABORATORY

PH 616/878-1188
Fax 616/878-0044
In Michigan 800/362-LABS

# ANALYTICAL RESULTS

DATE: June 4, 1993

CLIENT NAME:---------B&V WASTE SCIENCE
ATTN:-----------------------ROBERT LANTZ
ADDRESS:------------------101 N. WACKER DR. - SUITE 1100
CHICAGO, IL 60606

PROJECT:------------------ORGANIC CHEMICALS, INC.
PROJECT NO: ----------- 70160.125
SAMPLE ID:--------------OCI MW35 (60'-55')
SAMPLE TYPE:----------AQUEOUS

DATE RECEIVED:---------- 6/4/93
ANALYSIS DATE:-----------6/4/93
QA/QC FILE NAME:------- JUN03624\1601010.D

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## RESULTS

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| | EPA 624 TARGET COMPOUNDS | RESULTS ( ug/L ) : ppb |
|---|---|---|
| 1 | VINYL CHLORIDE | BDL (< 1) |
| 2 | CHLOROMETHANE | BDL (< 1) |
| 3 | BROMOETHANE | BDL (< 1) |
| 4 | CHLOROETHANE | BDL (< 1) |
| 5 | TRICHLOROFLUOROMETHANE | BDL (< 1) |
| 6 | 1,1-DICHLOROETHENE | BDL (< 1) |
| 7 | METHYLENE CHLORIDE | BDL (< 1) |
| 8 | trans-1,2-DICHLOROETHENE | BDL (< 1) |
| 9 | 1,1-DICHLOROETHANE | BDL (< 1) |
| 10 | CHLOROFORM | 14.4 |
| 11 | 1,1,1-TRICHLOROETHANE | BDL (< 1) |
| 12 | 1,2-DICHLOROETHANE | BDL (< 1) |
| 13 | BENZENE | BDL (< 1) |
| 14 | CARBON TETRACHLORIDE | BDL (< 1) |
| 15 | 1,2-DICHLOROPROPANE | BDL (< 1) |
| 16 | TRICHLOROETHENE | BDL (< 1) |
| 17 | BROMODICHLOROMETHANE | 1.5 |
| 18 | cis-1,3-DICHLOROPROPENE | BDL (< 1) |
| 19 | TOLUENE | 14.5 |
| 20 | trans-1,3-DICHLOROPROPENE | BDL (< 1) |
| 21 | 1,1,2-TRICHLOROETHANE | BDL (< 1) |
| 22 | DIBROMOCHLOROMETHANE | BDL (< 1) |
| 23 | TETRACHLOROETHENE | BDL (< 1) |
| 24 | CHLOROBENZENE | BDL (< 1) |
| 25 | ETHYLBENZENE | BDL (< 1) |
| 26 | BROMOFORM | BDL (< 1) |
| 27 | 1,1,2,2-TETRACHLOROETHANE | BDL (< 1) |
| 28 | 1,3-DICHLOROBENZENE | BDL (< 1) |
| 29 | 1,4-DICHLOROBENZENE | BDL (< 1) |
| 30 | 1,2-DICHLOROBENZENE | BDL (< 1) |
| 31 | XYLENES | 5.8 |

BDL = BELOW DETECTION LIMITS

MICHAEL L. DOUGLASS
LABORATORY MANAGER

**Analysis in compliance with Environmental Protection Agency's SW846 Method 8260 GC/MS Volitiles Analysis**
**Capillary Column Type: [ phase: DB-624; ID: 530 uM; film: VTK; 3 uM film thickness ]**
**Enrichment: [ Tekmar concentrator with moisture control module and glass jet separator ]**

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PH 616/878-1188
Fax 616/878-0044
In Michigan 800/362-LABS

# ANALYTICAL RESULTS

DATE: June 4, 1993

CLIENT NAME:----------B&V WASTE SCIENCE
ATTN:----------------------ROBERT LANTZ
ADDRESS:-----------------101 N. WACKER DR. - SUITE 1100
CHICAGO, IL 60606

PROJECT:-----------------ORGANIC CHEMICALS, INC.
PROJECT NO: ----------- 70160.125
SAMPLE ID:---------------OCI MW35 (65'-60')
SAMPLE TYPE:----------AQUEOUS

DATE RECEIVED:---------- 6/4/93
ANALYSIS DATE:-----------6/4/93
QA/QC FILE NAME:------- JUN03624\1501009.D

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## RESULTS

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| | EPA 624 TARGET COMPOUNDS | RESULTS ( ug/L ) : ppb |
|---|---|---|
| 1 | VINYL CHLORIDE | BDL (< 1) |
| 2 | CHLOROMETHANE | BDL (< 1) |
| 3 | BROMOETHANE | BDL (< 1) |
| 4 | CHLOROETHANE | BDL (< 1) |
| 5 | TRICHLOROFLUOROMETHANE | BDL (< 1) |
| 6 | 1,1-DICHLOROETHENE | BDL (< 1) |
| 7 | METHYLENE CHLORIDE | BDL (< 1) |
| 8 | trans-1,2-DICHLOROETHENE | BDL (< 1) |
| 9 | 1,1-DICHLOROETHANE | BDL (< 1) |
| 10 | CHLOROFORM | 16.8 |
| 11 | 1,1,1-TRICHLOROETHANE | BDL (< 1) |
| 12 | 1,2-DICHLOROETHANE | BDL (< 1) |
| 13 | BENZENE | BDL (< 1) |
| 14 | CARBON TETRACHLORIDE | BDL (< 1) |
| 15 | 1,2-DICHLOROPROPANE | BDL (< 1) |
| 16 | TRICHLOROETHENE | BDL (< 1) |
| 17 | BROMODICHLOROMETHANE | 1.2 |
| 18 | cis-1,3-DICHLOROPROPENE | BDL (< 1) |
| 19 | TOLUENE | 24.3 |
| 20 | trans-1,3-DICHLOROPROPENE | BDL (< 1) |
| 21 | 1,1,2-TRICHLOROETHANE | BDL (< 1) |
| 22 | DIBROMOCHLOROMETHANE | BDL (< 1) |
| 23 | TETRACHLOROETHENE | BDL (< 1) |
| 24 | CHLOROBENZENE | BDL (< 1) |
| 25 | ETHYLBENZENE | BDL (< 1) |
| 26 | BROMOFORM | BDL (< 1) |
| 27 | 1,1,2,2-TETRACHLOROETHANE | BDL (< 1) |
| 28 | 1,3-DICHLOROBENZENE | BDL (< 1) |
| 29 | 1,4-DICHLOROBENZENE | BDL (< 1) |
| 30 | 1,2-DICHLOROBENZENE | BDL (< 1) |
| 31 | XYLENES | BDL (< 3) |

BDL = BELOW DETECTION LIMITS

MICHAEL L. DOUGLASS
LABORATORY MANAGER

Analysis in compliance with Environmental Protection Agency's SW846 Method 8260 GC/MS Volitiles Analysis
Capillary Column Type: [ phase: DB-624; ID: 530 uM; film: VTK; 3 uM film thickness ]
Enrichment: [ Tekmar concentrator with moisture control module and glass jet separator ]

BIO-CHEM
ENVIRONMENTAL
ANALYTICAL
LABORATORY

PH 616/878-1188
Fax 616/878-0044
In Michigan 800/362-LABS

# ANALYTICAL RESULTS

DATE: June 4, 1993

CLIENT NAME:---------B&V WASTE SCIENCE
ATTN:---------------------ROBERT LANTZ
ADDRESS:----------------101 N. WACKER DR. - SUITE 1100
CHICAGO, IL 60606

PROJECT:-----------------ORGANIC CHEMICALS, INC.
PROJECT NO:----------- 70160.125
SAMPLE ID:--------------OCI MW35 (70-65)
SAMPLE TYPE:---------AQUEOUS

DATE RECEIVED:---------- 6/3/93
ANALYSIS DATE:-----------6/4/93
QA/QC FILE NAME:-------- JUN03624\1101006.D

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## RESULTS

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| | EPA 624 TARGET COMPOUNDS | RESULTS ( ug/L ) : ppb |
|---|---|---|
| 1 | VINYL CHLORIDE | BDL (< 1 ) |
| 2 | CHLOROMETHANE | BDL (< 1 ) |
| 3 | BROMOETHANE | BDL (< 1 ) |
| 4 | CHLOROETHANE | BDL (< 1 ) |
| 5 | TRICHLOROFLUOROMETHANE | BDL (< 1 ) |
| 6 | 1,1-DICHLOROETHENE | BDL (< 1 ) |
| 7 | METHYLENE CHLORIDE | BDL (< 1 ) |
| 8 | trans-1,2-DICHLOROETHENE | BDL (< 1 ) |
| 9 | 1,1-DICHLOROETHANE | BDL (< 1 ) |
| 10 | CHLOROFORM | 25.1 |
| 11 | 1,1,1-TRICHLOROETHANE | BDL (< 1 ) |
| 12 | 1,2-DICHLOROETHANE | BDL (< 1 ) |
| 13 | BENZENE | 1.3 |
| 14 | CARBON TETRACHLORIDE | BDL (< 1 ) |
| 15 | 1,2-DICHLOROPROPANE | BDL (< 1 ) |
| 16 | TRICHLOROETHENE | BDL (< 1 ) |
| 17 | BROMODICHLOROMETHANE | 4.4 |
| 18 | cis-1,3-DICHLOROPROPENE | BDL (< 1 ) |
| 19 | TOLUENE | 4.8 |
| 20 | trans-1,3-DICHLOROPROPENE | BDL (< 1 ) |
| 21 | 1,1,2-TRICHLOROETHANE | BDL (< 1 ) |
| 22 | DIBROMOCHLOROMETHANE | 1.3 |
| 23 | TETRACHLOROETHENE | BDL (< 1 ) |
| 24 | CHLOROBENZENE | BDL (< 1 ) |
| 25 | ETHYLBENZENE | BDL (< 1 ) |
| 26 | BROMOFORM | BDL (< 1 ) |
| 27 | 1,1,2,2-TETRACHLOROETHANE | BDL (< 1 ) |
| 28 | 1,3-DICHLOROBENZENE | BDL (< 1 ) |
| 29 | 1,4-DICHLOROBENZENE | BDL (< 1 ) |
| 30 | 1,2-DICHLOROBENZENE | BDL (< 1 ) |
| 31 | XYLENES | BDL (< 3 ) |

BDL = BELOW DETECTION LIMITS

MICHAEL L. DOUGLASS
LABORATORY MANAGER

*Analysis in compliance with Environmental Protection Agency's SW846 Method 8260 GC/MS Volitiles Analysis*
*Capillary Column Type: [ phase: DB-624; ID: 530 uM; film: VTK; 3 uM film thickness ]*
*Enrichment: [ Tekmar concentrator with moisture control module and glass jet separator ]*

BIO-CHEM
ENVIRONMENTAL
ANALYTICAL
LABORATORY

PH 616/878-1188
Fax 616/878-0044
In Michigan 800/362-LABS

# ANALYTICAL RESULTS

DATE: June 4, 1993

CLIENT NAME:---------B&V WASTE SCIENCE
ATTN:---------------------ROBERT LANTZ
ADDRESS:----------------101 N. WACKER DR. - SUITE 1100
CHICAGO, IL 60606

PROJECT:-----------------ORGANIC CHEMICALS, INC.
PROJECT NO:-----------70160.125
SAMPLE ID:--------------OCI MW35 (75-70)
SAMPLE TYPE:----------AQUEOUS

DATE RECEIVED:---------- 6/3/93
ANALYSIS DATE:----------6/4/93
QA/QC FILE NAME:------- JUN03624\1301008.D

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## RESULTS

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| | EPA 624 TARGET COMPOUNDS | RESULTS ( ug/L ) : ppb |
|---|---|---|
| 1 | VINYL CHLORIDE | BDL (< 1) |
| 2 | CHLOROMETHANE | BDL (< 1) |
| 3 | BROMOETHANE | BDL (< 1) |
| 4 | CHLOROETHANE | BDL (< 1) |
| 5 | TRICHLOROFLUOROMETHANE | BDL (< 1) |
| 6 | 1,1-DICHLOROETHENE | BDL (< 1) |
| 7 | METHYLENE CHLORIDE | BDL (< 1) |
| 8 | trans-1,2-DICHLOROETHENE | BDL (< 1) |
| 9 | 1,1-DICHLOROETHANE | BDL (< 1) |
| 10 | CHLOROFORM | 23.9 |
| 11 | 1,1,1-TRICHLOROETHANE | BDL (< 1) |
| 12 | 1,2-DICHLOROETHANE | BDL (< 1) |
| 13 | BENZENE | BDL (< 1) |
| 14 | CARBON TETRACHLORIDE | BDL (< 1) |
| 15 | 1,2-DICHLOROPROPANE | BDL (< 1) |
| 16 | TRICHLOROETHENE | BDL (< 1) |
| 17 | BROMODICHLOROMETHANE | 4.5 |
| 18 | cis-1,3-DICHLOROPROPENE | BDL (< 1) |
| 19 | TOLUENE | 4.0 |
| 20 | trans-1,3-DICHLOROPROPENE | BDL (< 1) |
| 21 | 1,1,2-TRICHLOROETHANE | BDL (< 1) |
| 22 | DIBROMOCHLOROMETHANE | 1.4 |
| 23 | TETRACHLOROETHENE | BDL (< 1) |
| 24 | CHLOROBENZENE | BDL (< 1) |
| 25 | ETHYLBENZENE | BDL (< 1) |
| 26 | BROMOFORM | BDL (< 1) |
| 27 | 1,1,2,2-TETRACHLOROETHANE | BDL (< 1) |
| 28 | 1,3-DICHLOROBENZENE | BDL (< 1) |
| 29 | 1,4-DICHLOROBENZENE | BDL (< 1) |
| 30 | 1,2-DICHLOROBENZENE | BDL (< 1) |
| 31 | XYLENES | BDL (< 3) |

BDL = BELOW DETECTION LIMITS

MICHAEL L. DOUGLASS
LABORATORY MANAGER

Analysis in compliance with Environmental Protection Agency's SW846 Method 8260 GC/MS Volitiles Analysis
Capillary Column Type: [ phase: DB-624; ID: 530 uM; film: VTK; 3 uM film thickness ]
Enrichment: [ Tekmar concentrator with moisture control module and glass jet separator ]

BIO CHEM

# ANALYTICAL RESULTS

DATE: May 10, 1993

PH 616/878-1188
Fax 616/878-0044
In Michigan 800/362-LABS

CLIENT NAME:———B&V WASTE SCIENCE
ATTN:———ROBERT LANTZ
ADDRESS:———101 N. WACKER DR. - SUITE 1100
CHICAGO, IL 60606

PROJECT:———OCI
PROJECT NO:———70160.125
SAMPLE ID:———OCI MW36 (67-72)
SAMPLE TYPE:———AQUEOUS

DATE RECEIVED:——— 5/7/93
ANALYSIS DATE:———5/9/93
QA/QC FILE NAME:——— MAY75624\0301003.D

## RESULTS

| | EPA 624 TARGET COMPOUNDS | RESULTS ( ug/L ) : ppb |
|---|---|---|
| 1 | VINYL CHLORIDE | BDL (< 1 ) |
| 2 | CHLOROMETHANE | BDL (< 1 ) |
| 3 | BROMOETHANE | BDL (< 1 ) |
| 4 | CHLOROETHANE | BDL (< 1 ) |
| 5 | TRICHLOROFLUOROMETHANE | BDL (< 1 ) |
| 6 | 1,1-DICHLOROETHENE | BDL (< 1 ) |
| 7 | METHYLENE CHLORIDE | BDL (< 1 ) |
| 8 | trans-1,2-DICHLOROETHENE | BDL (< 1 ) |
| 9 | 1,1-DICHLOROETHANE | BDL (< 1 ) |
| 10 | CHLOROFORM | 9.9 |
| 11 | 1,1,1-TRICHLOROETHANE | BDL (< 1 ) |
| 12 | 1,2-DICHLOROETHANE | 4.1 |
| 13 | BENZENE | BDL (< 1 ) |
| 14 | CARBON TETRACHLORIDE | BDL (< 1 ) |
| 15 | 1,2-DICHLOROPROPANE | BDL (< 1 ) |
| 16 | TRICHLOROETHENE | BDL (< 1 ) |
| 17 | BROMODICHLOROMETHANE | 3.1 |
| 18 | cis-1,3-DICHLOROPROPENE | BDL (< 1 ) |
| 19 | TOLUENE | BDL (< 1 ) |
| 20 | trans-1,3-DICHLOROPROPENE | BDL (< 1 ) |
| 21 | 1,1,2-TRICHLOROETHANE | BDL (< 1 ) |
| 22 | DIBROMOCHLOROMETHANE | BDL (< 1 ) |
| 23 | TETRACHLOROETHENE | BDL (< 1 ) |
| 24 | CHLOROBENZENE | BDL (< 1 ) |
| 25 | ETHYLBENZENE | BDL (< 1 ) |
| 26 | BROMOFORM | BDL (< 1 ) |
| 27 | 1,1,2,2-TETRACHLOROETHANE | BDL (< 1 ) |
| 28 | 1,3-DICHLOROBENZENE | BDL (< 1 ) |
| 29 | 1,4-DICHLOROBENZENE | BDL (< 1 ) |
| 30 | 1,2-DICHLOROBENZENE | BDL (< 1 ) |
| 31 | XYLENES | BDL (< 3 ) |

BDL = BELOW DETECTION LIMITS

MICHAEL L. DOUGLASS
LABORATORY MANAGER

Analysis in compliance with Environmental Protection Agency's SW846 Method 8260 GC/MS Volatiles Analysis
Capillary Column Type: [ phase: DB-624; ID: .530 uM; film: VTK 3 uM film thickness ]
Enrichment: [ Tekmar concentrator with moisture control module and glass jet separator ]

TOTAL P.09

PH 616/878-1188
Fax 616/878-0044
In Michigan 800/362-LABS

# ANALYTICAL RESULTS

DATE: May 10, 1993

CLIENT NAME:--------B&V WASTE SCIENCE
ATTN:--------------------ROBERT LANTZ
ADDRESS:-------------101 N. WACKER DR. - SUITE 1100
CHICAGO, IL 60606

PROJECT:---------------OCI
PROJECT NO:----------70160.125
SAMPLE ID:-------------OCI MW36 (61-66)
SAMPLE TYPE:---------AQUEOUS

DATE RECEIVED:--------5/7/93
ANALYSIS DATE:---------5/10/93
QA/QC FILE NAME:------MAY10624\0101001.D

## RESULTS

| | EPA 624 TARGET COMPOUNDS | RESULTS ( ug/L ) : ppb |
|---|---|---|
| 1 | VINYL CHLORIDE | BDL (< 1 ) |
| 2 | CHLOROMETHANE | BDL (< 1 ) |
| 3 | BROMOETHANE | BDL (< 1 ) |
| 4 | CHLOROETHANE | BDL (< 1 ) |
| 5 | TRICHLOROFLUOROMETHANE | BDL (< 1 ) |
| 6 | 1,1-DICHLOROETHENE | BDL (< 1 ) |
| 7 | METHYLENE CHLORIDE | BDL (< 1 ) |
| 8 | trans-1,2-DICHLOROETHENE | BDL (< 1 ) |
| 9 | 1,1-DICHLOROETHANE | BDL (< 1 ) |
| 10 | CHLOROFORM | 10.6 |
| 11 | 1,1,1-TRICHLOROETHANE | BDL (< 1 ) |
| 12 | 1,2-DICHLOROETHANE | 6.9 |
| 13 | BENZENE | BDL (< 1 ) |
| 14 | CARBON TETRACHLORIDE | BDL (< 1 ) |
| 15 | 1,2-DICHLOROPROPANE | BDL (< 1 ) |
| 16 | TRICHLOROETHENE | BDL (< 1 ) |
| 17 | BROMODICHLOROMETHANE | 4.6 |
| 18 | cis-1,3-DICHLOROPROPENE | BDL (< 1 ) |
| 19 | TOLUENE | BDL (< 1 ) |
| 20 | trans-1,3-DICHLOROPROPENE | BDL (< 1 ) |
| 21 | 1,1,2-TRICHLOROETHANE | BDL (< 1 ) |
| 22 | DIBROMOCHLOROMETHANE | 1.6 |
| 23 | TETRACHLOROETHENE | BDL (< 1 ) |
| 24 | CHLOROBENZENE | BDL (< 1 ) |
| 25 | ETHYLBENZENE | BDL (< 1 ) |
| 26 | BROMOFORM | BDL (< 1 ) |
| 27 | 1,1,2,2-TETRACHLOROETHANE | BDL (< 1 ) |
| 28 | 1,3-DICHLOROBENZENE | BDL (< 1 ) |
| 29 | 1,4-DICHLOROBENZENE | BDL (< 1 ) |
| 30 | 1,2-DICHLOROBENZENE | BDL (< 1 ) |
| 31 | XYLENES | BDL (< 3 ) |

BDL = BELOW DETECTION LIMITS

MICHAEL L. DOUGLASS
LABORATORY MANAGER

Analysis in compliance with Environmental Protection Agency's SW846 Method 8260 GC/MS Volatiles Analysis
Capillary Column Type: [ phase: DB-624; ID: 530 uM; Film: VTK; 3 uM film thickness ]
Enrichment: [ Tekmar concentrator with moisture control module and glass jet separator ]

BIO CHEM
[illegible]

PH 616/878-1188
Fax 616/878-0044
In Michigan 800/362-LABS

# ANALYTICAL RESULTS

DATE: May 14, 1993

CLIENT NAME:--------B&V WASTE SCIENCE
ATTN:----------------ROBERT LANTZ
ADDRESS:-------------101 N. WACKER DR. - SUITE 1100
CHICAGO, IL 60606

PROJECT:--------------ORGANIC CHEMICAL INC
PROJECT NO:----------N/A
SAMPLE ID:------------OCI MW36 (56-61)
SAMPLE TYPE:---------AQUEOUS

DATE RECEIVED:---------5/11/93
ANALYSIS DATE:-----------5/13/93
QA/QC FILE NAME:------MAY13624\0701004.D

## RESULTS

| | EPA 624 TARGET COMPOUNDS | RESULTS ( ug/L ) : ppb |
|---|---|---|
| 1 | VINYL CHLORIDE | BDL (< 1) |
| 2 | CHLOROMETHANE | BDL (< 1) |
| 3 | BROMOETHANE | BDL (< 1) |
| 4 | CHLOROETHANE | BDL (< 1) |
| 5 | TRICHLOROFLUOROMETHANE | BDL (< 1) |
| 6 | 1,1-DICHLOROETHENE | BDL (< 1) |
| 7 | METHYLENE CHLORIDE | BDL (< 1) |
| 8 | trans-1,2-DICHLOROETHENE | BDL (< 1) |
| 9 | 1,1-DICHLOROETHANE | BDL (< 1) |
| 10 | CHLOROFORM | 10.7 |
| 11 | 1,1,1-TRICHLOROETHANE | BDL (< 1) |
| 12 | 1,2-DICHLOROETHANE | 5.3 |
| 13 | BENZENE | BDL (< 1) |
| 14 | CARBON TETRACHLORIDE | BDL (< 1) |
| 15 | 1,2-DICHLOROPROPANE | BDL (< 1) |
| 16 | TRICHLOROETHENE | BDL (< 1) |
| 17 | BROMODICHLOROMETHANE | BDL (< 1) |
| 18 | cis-1,3-DICHLOROPROPENE | BDL (< 1) |
| 19 | TOLUENE | BDL (< 1) |
| 20 | trans-1,3-DICHLOROPROPENE | BDL (< 1) |
| 21 | 1,1,2-TRICHLOROETHANE | BDL (< 1) |
| 22 | DIBROMOCHLOROMETHANE | BDL (< 1) |
| 23 | TETRACHLOROETHENE | BDL (< 1) |
| 24 | CHLOROBENZENE | BDL (< 1) |
| 25 | ETHYLBENZENE | BDL (< 1) |
| 26 | BROMOFORM | BDL (< 1) |
| 27 | 1,1,2,2-TETRACHLOROETHANE | BDL (< 1) |
| 28 | 1,3-DICHLOROBENZENE | BDL (< 1) |
| 29 | 1,4-DICHLOROBENZENE | BDL (< 1) |
| 30 | 1,2-DICHLOROBENZENE | BDL (< 1) |
| 31 | XYLENES | BDL (< 3) |

BDL = BELOW DETECTION LIMITS

MICHAEL L. DOUGLASS
LABORATORY MANAGER

Analysis in compliance with Environmental Protection Agency's SW846 Method 8260 GC/MS Volatiles Analysis
Capillary Column Type: [ phase: DB-624: ID: 530 uM: film: VTK: 3 uM film thickness ]
Enrichment: [ Tekmar concentrator with moisture control module and glass jet seperator ]

BIOCHEM

PH 616/878-1188
Fax 616/878-0044
In Michigan 800/362-LABS

# ANALYTICAL RESULTS

DATE: May 14, 1993

CLIENT NAME:———B&V WASTE SCIENCE
ATTN:——————ROBERT LANTZ
ADDRESS:——————101 N. WACKER DR. - SUITE 1100
CHICAGO, IL 60606

PROJECT:——————ORGANIC CHEMICAL INC
PROJECT NO:————N/A
SAMPLE ID:—————OCI MW36 (51-56)
SAMPLE TYPE:————AQUEOUS

DATE RECEIVED:———— 5/11/93
ANALYSIS DATE:—————5/13/93
QA/QC FILE NAME:——— MAY13624\0501002.D

## RESULTS

| | EPA 624 TARGET COMPOUNDS | RESULTS ( ug/L ) : ppb |
|---|---|---|
| 1 | VINYL CHLORIDE | BDL (< 1) |
| 2 | CHLOROMETHANE | BDL (< 1) |
| 3 | BROMOETHANE | BDL (< 1) |
| 4 | CHLOROETHANE | BDL (< 1) |
| 5 | TRICHLOROFLUOROMETHANE | BDL (< 1) |
| 6 | 1,1-DICHLOROETHENE | BDL (< 1) |
| 7 | METHYLENE CHLORIDE | BDL (< 1) |
| 8 | trans-1,2-DICHLOROETHENE | BDL (< 1) |
| 9 | 1,1-DICHLOROETHANE | BDL (< 1) |
| 10 | CHLOROFORM | 7.3 |
| 11 | 1,1,1-TRICHLOROETHANE | BDL (< 1) |
| 12 | 1,2-DICHLOROETHANE | 4.9 |
| 13 | BENZENE | BDL (< 1) |
| 14 | CARBON TETRACHLORIDE | BDL (< 1) |
| 15 | 1,2-DICHLOROPROPANE | BDL (< 1) |
| 16 | TRICHLOROETHENE | BDL (< 1) |
| 17 | BROMODICHLOROMETHANE | BDL (< 1) |
| 18 | cis-1,3-DICHLOROPROPENE | BDL (< 1) |
| 19 | TOLUENE | BDL (< 1) |
| 20 | trans-1,3-DICHLOROPROPENE | BDL (< 1) |
| 21 | 1,1,2-TRICHLOROETHANE | BDL (< 1) |
| 22 | DIBROMOCHLOROMETHANE | BDL (< 1) |
| 23 | TETRACHLOROETHENE | BDL (< 1) |
| 24 | CHLOROBENZENE | BDL (< 1) |
| 25 | ETHYLBENZENE | BDL (< 1) |
| 26 | BROMOFORM | BDL (< 1) |
| 27 | 1,1,2,2-TETRACHLOROETHANE | BDL (< 1) |
| 28 | 1,3-DICHLOROBENZENE | BDL (< 1) |
| 29 | 1,4-DICHLOROBENZENE | BDL (< 1) |
| 30 | 1,2-DICHLOROBENZENE | BDL (< 1) |
| 31 | XYLENES | BDL (< 3) |

BDL = BELOW DETECTION LIMITS

MICHAEL L. DOUGLASS
LABORATORY MANAGER

Analysis in compliance with Environmental Protection Agency's SW846 Method 8260 GC/MS Volatiles Analysis
Capillary Column Type: ( phase: DB-624; ID: 530 uM; film: VTX; 3 uM film thickness )
Enrichment: [ Tekmar concentrator with moisture control module and glass jet separator ]

BIO-CHEM
ENVIRONMENTAL
ANALYTICAL
LABORATORY

PH 616/878-1188
Fax 616/878-0044
In Michigan 800/362-LABS

# ANALYTICAL RESULTS

DATE: May 24, 1993

CLIENT NAME:---------B&V WASTE SCIENCE
ATTN:-------------------ROBERT LANTZ
ADDRESS:---------------101 N. WACKER DR. - SUITE 1100
CHICAGO, IL 60606

PROJECT:-----------------OCI
PROJECT NO:-----------70160.125
SAMPLE ID:--------------OCI MW37 (36-41)
SAMPLE TYPE:----------AQUEOUS

DATE RECEIVED:---------- 5/20/93
ANALYSIS DATE:-----------5/20/93
QA/QC FILE NAME:-------524MAR\1201004.D

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## RESULTS

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| | EPA 624 TARGET COMPOUNDS | RESULTS ( ug/L ) : ppb |
|---|---|---|
| 1 | VINYL CHLORIDE | BDL (< 1 ) |
| 2 | CHLOROMETHANE | BDL (< 1 ) |
| 3 | BROMOETHANE | BDL (< 1 ) |
| 4 | CHLOROETHANE | BDL (< 1 ) |
| 5 | TRICHLOROFLUOROMETHANE | BDL (< 1 ) |
| 6 | 1,1-DICHLOROETHENE | BDL (< 1 ) |
| 7 | METHYLENE CHLORIDE | BDL (< 1 ) |
| 8 | trans-1,2-DICHLOROETHENE | BDL (< 1 ) |
| 9 | 1,1-DICHLOROETHANE | BDL (< 1 ) |
| 10 | CHLOROFORM | 47.8 |
| 11 | 1,1,1-TRICHLOROETHANE | BDL (< 1 ) |
| 12 | 1,2-DICHLOROETHANE | 9.0 |
| 13 | BENZENE | BDL (< 1 ) |
| 14 | CARBON TETRACHLORIDE | BDL (< 1 ) |
| 15 | 1,2-DICHLOROPROPANE | BDL (< 1 ) |
| 16 | TRICHLOROETHENE | BDL (< 1 ) |
| 17 | BROMODICHLOROMETHANE | 3.9 |
| 18 | cis-1,3-DICHLOROPROPENE | BDL (< 1 ) |
| 19 | TOLUENE | BDL (< 1 ) |
| 20 | trans-1,3-DICHLOROPROPENE | BDL (< 1 ) |
| 21 | 1,1,2-TRICHLOROETHANE | BDL (< 1 ) |
| 22 | DIBROMOCHLOROMETHANE | 1.1 |
| 23 | TETRACHLOROETHENE | BDL (< 1 ) |
| 24 | CHLOROBENZENE | BDL (< 1 ) |
| 25 | ETHYLBENZENE | BDL (< 1 ) |
| 26 | BROMOFORM | BDL (< 1 ) |
| 27 | 1,1,2,2-TETRACHLOROETHANE | BDL (< 1 ) |
| 28 | 1,3-DICHLOROBENZENE | BDL (< 1 ) |
| 29 | 1,4-DICHLOROBENZENE | BDL (< 1 ) |
| 30 | 1,2-DICHLOROBENZENE | BDL (< 1 ) |
| 31 | XYLENES | BDL (< 3 ) |

BDL = BELOW DETECTION LIMITS

MICHAEL L. DOUGLASS
LABORATORY MANAGER

Analysis in compliance with Environmental Protection Agency's SW846 Method 8260 GC/MS Volitiles Analysis
Capillary Column Type: [ phase: DB-624; ID: 530 uM; film: VTK; 3 uM film thickness ]
Enrichment: [ Tekmar concentrator with moisture control module and glass jet separator ]

BIO CHEM
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LABORATORY

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Fax 616/878-0044
In Michigan 800/362-LABS

# ANALYTICAL RESULTS

DATE: May 24, 1993

CLIENT NAME:----------B&V WASTE SCIENCE
ATTN:-----------------------ROBERT LANTZ
ADDRESS:------------------101 N. WACKER DR. - SUITE 1100
CHICAGO, IL 60606

PROJECT:-----------------OCI
PROJECT NO:------------70160.125
SAMPLE ID:--------------OCI MW37 (41-46)
SAMPLE TYPE:----------AQUEOUS

DATE RECEIVED:---------- 5/20/93
ANALYSIS DATE:-----------5/20/93
QA/QC FILE NAME:-------- 524MAR\1101003.D

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## RESULTS

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| | EPA 624 TARGET COMPOUNDS | RESULTS ( ug/L ) : ppb |
|---|---|---|
| 1 | VINYL CHLORIDE | BDL (< 1) |
| 2 | CHLOROMETHANE | BDL (< 1) |
| 3 | BROMOETHANE | BDL (< 1) |
| 4 | CHLOROETHANE | BDL (< 1) |
| 5 | TRICHLOROFLUOROMETHANE | BDL (< 1) |
| 6 | 1,1-DICHLOROETHENE | BDL (< 1) |
| 7 | METHYLENE CHLORIDE | BDL (< 1) |
| 8 | trans-1,2-DICHLOROETHENE | BDL (< 1) |
| 9 | 1,1-DICHLOROETHANE | BDL (< 1) |
| 10 | CHLOROFORM | 37.5 |
| 11 | 1,1,1-TRICHLOROETHANE | BDL (< 1) |
| 12 | 1,2-DICHLOROETHANE | 5.5 |
| 13 | BENZENE | BDL (< 1) |
| 14 | CARBON TETRACHLORIDE | BDL (< 1) |
| 15 | 1,2-DICHLOROPROPANE | BDL (< 1) |
| 16 | TRICHLOROETHENE | BDL (< 1) |
| 17 | BROMODICHLOROMETHANE | 4.9 |
| 18 | cis-1,3-DICHLOROPROPENE | BDL (< 1) |
| 19 | TOLUENE | BDL (< 1) |
| 20 | trans-1,3-DICHLOROPROPENE | BDL (< 1) |
| 21 | 1,1,2-TRICHLOROETHANE | BDL (< 1) |
| 22 | DIBROMOCHLOROMETHANE | 1.4 |
| 23 | TETRACHLOROETHENE | BDL (< 1) |
| 24 | CHLOROBENZENE | BDL (< 1) |
| 25 | ETHYLBENZENE | BDL (< 1) |
| 26 | BROMOFORM | BDL (< 1) |
| 27 | 1,1,2,2-TETRACHLOROETHANE | BDL (< 1) |
| 28 | 1,3-DICHLOROBENZENE | BDL (< 1) |
| 29 | 1,4-DICHLOROBENZENE | BDL (< 1) |
| 30 | 1,2-DICHLOROBENZENE | BDL (< 1) |
| 31 | XYLENES | BDL (< 3) |

BDL = BELOW DETECTION LIMITS

MICHAEL L. DOUGLASS
LABORATORY MANAGER

Analysis in compliance with Environmental Protection Agency's SW846 Method 8260 GC/MS Volitiles Analysis
Capillary Column Type: [ phase: DB-624; ID: 530 uM; film: VTK; 3 uM film thickness ]
Enrichment: [ Tekmar concentrator with moisture control module and glass jet separator ]

BIO-CHEM
ENVIRONMENTAL
ANALYTICAL
LABORATORY

PH 616/878-1188
Fax 616/878-0044
In Michigan 800/362-LABS

# ANALYTICAL RESULTS

DATE: May 24, 1993

CLIENT NAME:---------B&V WASTE SCIENCE
ATTN:----------------------ROBERT LANTZ
ADDRESS:-----------------101 N. WACKER DR. - SUITE 1100
CHICAGO, IL 60606

PROJECT:------------------OCI
PROJECT NO:-----------70160.125
SAMPLE ID:--------------OCI MW37 (46-51)
SAMPLE TYPE:---------AQUEOUS

DATE RECEIVED:---------- 5/20/93
ANALYSIS DATE:-----------5/20/93
QA/QC FILE NAME:-------- 524MAR\1001002.D

## RESULTS

| | EPA 624 TARGET COMPOUNDS | RESULTS ( ug/L ) : ppb |
|---|---|---|
| 1 | VINYL CHLORIDE | BDL (< 1 ) |
| 2 | CHLOROMETHANE | BDL (< 1 ) |
| 3 | BROMOETHANE | BDL (< 1 ) |
| 4 | CHLOROETHANE | BDL (< 1 ) |
| 5 | TRICHLOROFLUOROMETHANE | BDL (< 1 ) |
| 6 | 1,1-DICHLOROETHENE | BDL (< 1 ) |
| 7 | METHYLENE CHLORIDE | BDL (< 1 ) |
| 8 | trans-1,2-DICHLOROETHENE | BDL (< 1 ) |
| 9 | 1,1-DICHLOROETHANE | BDL (< 1 ) |
| 10 | CHLOROFORM | 33.5 |
| 11 | 1,1,1-TRICHLOROETHANE | BDL (< 1 ) |
| 12 | 1,2-DICHLOROETHANE | 11.9 |
| 13 | BENZENE | BDL (< 1 ) |
| 14 | CARBON TETRACHLORIDE | BDL (< 1 ) |
| 15 | 1,2-DICHLOROPROPANE | BDL (< 1 ) |
| 16 | TRICHLOROETHENE | BDL (< 1 ) |
| 17 | BROMODICHLOROMETHANE | 4.8 |
| 18 | cis-1,3-DICHLOROPROPENE | BDL (< 1 ) |
| 19 | TOLUENE | 1.6 |
| 20 | trans-1,3-DICHLOROPROPENE | BDL (< 1 ) |
| 21 | 1,1,2-TRICHLOROETHANE | BDL (< 1 ) |
| 22 | DIBROMOCHLOROMETHANE | BDL (< 1 ) |
| 23 | TETRACHLOROETHENE | BDL (< 1 ) |
| 24 | CHLOROBENZENE | BDL (< 1 ) |
| 25 | ETHYLBENZENE | BDL (< 1 ) |
| 26 | BROMOFORM | BDL (< 1 ) |
| 27 | 1,1,2,2-TETRACHLOROETHANE | BDL (< 1 ) |
| 28 | 1,3-DICHLOROBENZENE | BDL (< 1 ) |
| 29 | 1,4-DICHLOROBENZENE | BDL (< 1 ) |
| 30 | 1,2-DICHLOROBENZENE | BDL (< 1 ) |
| 31 | XYLENES | BDL (< 3 ) |

BDL = BELOW DETECTION LIMITS

MICHAEL L. DOUGLASS
LABORATORY MANAGER

Analysis in compliance with Environmental Protection Agency's SW846 Method 8260 GC/MS Volitiles Analysis
Capillary Column Type: [ phase: DB-624; ID: 530 uM; film: VTK; 3 uM film thickness ]
Enrichment: [ Tekmar concentrator with moisture control module and glass jet separator ]

BIO-CHEM
ENVIRONMENTAL
ANALYTICAL
LABORATORY

PH 616/878-1188
Fax 616/878-0044
In Michigan 800/362-LABS

# ANALYTICAL RESULTS

DATE: May 24, 1993

CLIENT NAME:---------B&V WASTE SCIENCE
ATTN:----------------------ROBERT LANTZ
ADDRESS:-----------------101 N. WACKER DR. - SUITE 1100
CHICAGO, IL 60606

PROJECT:-----------------OCI
PROJECT NO:------------70160.125
SAMPLE ID:---------------OCI MW37 (51-56)
SAMPLE TYPE:----------AQUEOUS

DATE RECEIVED:---------- 5/20/93
ANALYSIS DATE:-----------5/20/93
QA/QC FILE NAME:-------- 524MAR\0901001.D

## RESULTS

| | EPA 624 TARGET COMPOUNDS | RESULTS ( ug/L ) . : ppb |
|---|---|---|
| 1 | VINYL CHLORIDE | BDL (< 1 ) |
| 2 | CHLOROMETHANE | BDL (< 1 ) |
| 3 | BROMOETHANE | BDL (< 1 ) |
| 4 | CHLOROETHANE | BDL (< 1 ) |
| 5 | TRICHLOROFLUOROMETHANE | BDL (< 1 ) |
| 6 | 1,1-DICHLOROETHENE | BDL (< 1 ) |
| 7 | METHYLENE CHLORIDE | BDL (< 1 ) |
| 8 | trans-1,2-DICHLOROETHENE | BDL (< 1 ) |
| 9 | 1,1-DICHLOROETHANE | BDL (< 1 ) |
| 10 | CHLOROFORM | 23.5 |
| 11 | 1,1,1-TRICHLOROETHANE | BDL (< 1 ) |
| 12 | 1,2-DICHLOROETHANE | 11.3 |
| 13 | BENZENE | BDL (< 1 ) |
| 14 | CARBON TETRACHLORIDE | BDL (< 1 ) |
| 15 | 1,2-DICHLOROPROPANE | BDL (< 1 ) |
| 16 | TRICHLOROETHENE | BDL (< 1 ) |
| 17 | BROMODICHLOROMETHANE | 5.1 |
| 18 | cis-1,3-DICHLOROPROPENE | BDL (< 1 ) |
| 19 | TOLUENE | 1.5 |
| 20 | trans-1,3-DICHLOROPROPENE | BDL (< 1 ) |
| 21 | 1,1,2-TRICHLOROETHANE | BDL (< 1 ) |
| 22 | DIBROMOCHLOROMETHANE | 1.5 |
| 23 | TETRACHLOROETHENE | BDL (< 1 ) |
| 24 | CHLOROBENZENE | BDL (< 1 ) |
| 25 | ETHYLBENZENE | BDL (< 1 ) |
| 26 | BROMOFORM | BDL (< 1 ) |
| 27 | 1,1,2,2-TETRACHLOROETHANE | BDL (< 1 ) |
| 28 | 1,3-DICHLOROBENZENE | BDL (< 1 ) |
| 29 | 1,4-DICHLOROBENZENE | BDL (< 1 ) |
| 30 | 1,2-DICHLOROBENZENE | BDL (< 1 ) |
| 31 | XYLENES | BDL (< 3 ) |

BDL = BELOW DETECTION LIMITS

MICHAEL L. DOUGLASS
LABORATORY MANAGER

**Analysis in compliance with Environmental Protection Agency's SW846 Method 8260 GC/MS Volitiles Analysis**
**Capillary Column Type: [ phase: DB-624; ID: 530 uM; film: VTK; 3 uM film thickness ]**
**Enrichment: [ Tekmar concentrator with moisture control module and glass jet separator ]**

BIO-CHEM
ENVIRONMENTAL
ANALYTICAL
LABORATORY

## ANALYTICAL RESULTS

DATE: May 24, 1993

PH 616/878-1188
Fax 616/878-0044
In Michigan 800/362-LABS

CLIENT NAME:---------B&V WASTE SCIENCE
ATTN:----------------------ROBERT LANTZ
ADDRESS:-----------------101 N. WACKER DR. - SUITE 1100
CHICAGO, IL 60606

PROJECT:-----------------OCI
PROJECT NO:------------ 70160.120
SAMPLE ID:---------------OCI MW38 (45.5-50.5)
SAMPLE TYPE:----------AQUEOUS

DATE RECEIVED:---------- 5/22/93
ANALYSIS DATE:-----------5/23/93
QA/QC FILE NAME:------- MAY22624\0501005.D

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## RESULTS

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| | EPA 624 TARGET COMPOUNDS | RESULTS ( ug/L ) : ppb |
|---|---|---|
| 1 | VINYL CHLORIDE | BDL (< 1 ) |
| 2 | CHLOROMETHANE | BDL (< 1 ) |
| 3 | BROMOETHANE | BDL (< 1 ) |
| 4 | CHLOROETHANE | BDL (< 1 ) |
| 5 | TRICHLOROFLUOROMETHANE | BDL (< 1 ) |
| 6 | 1,1-DICHLOROETHENE | BDL (< 1 ) |
| 7 | METHYLENE CHLORIDE | BDL (< 1 ) |
| 8 | trans-1,2-DICHLOROETHENE | BDL (< 1 ) |
| 9 | 1,1-DICHLOROETHANE | BDL (< 1 ) |
| 10 | CHLOROFORM | 35.4 |
| 11 | 1,1,1-TRICHLOROETHANE | BDL (< 1 ) |
| 12 | 1,2-DICHLOROETHANE | BDL (< 1 ) |
| 13 | BENZENE | BDL (< 1 ) |
| 14 | CARBON TETRACHLORIDE | BDL (< 1 ) |
| 15 | 1,2-DICHLOROPROPANE | BDL (< 1 ) |
| 16 | TRICHLOROETHENE | BDL (< 1 ) |
| 17 | BROMODICHLOROMETHANE | 6.9 |
| 18 | cis-1,3-DICHLOROPROPENE | BDL (< 1 ) |
| 19 | TOLUENE | BDL (< 1 ) |
| 20 | trans-1,3-DICHLOROPROPENE | BDL (< 1 ) |
| 21 | 1,1,2-TRICHLOROETHANE | BDL (< 1 ) |
| 22 | DIBROMOCHLOROMETHANE | 1.2 |
| 23 | TETRACHLOROETHENE | BDL (< 1 ) |
| 24 | CHLOROBENZENE | BDL (< 1 ) |
| 25 | ETHYLBENZENE | BDL (< 1 ) |
| 26 | BROMOFORM | BDL (< 1 ) |
| 27 | 1,1,2,2-TETRACHLOROETHANE | BDL (< 1 ) |
| 28 | 1,3-DICHLOROBENZENE | BDL (< 1 ) |
| 29 | 1,4-DICHLOROBENZENE | BDL (< 1 ) |
| 30 | 1,2-DICHLOROBENZENE | BDL (< 1 ) |
| 31 | XYLENES | BDL (< 3 ) |

BDL = BELOW DETECTION LIMITS

MICHAEL L. DOUGLASS
LABORATORY MANAGER

Analysis in compliance with Environmental Protection Agency's SW846 Method 8260 GC/MS Volitiles Analysis
Capillary Column Type: [ phase: DB-624; ID: 530 uM; film: VTK; 3 uM film thickness ]
Enrichment: [ Tekmar concentrator with moisture control module and glass jet separator ]

BIO-CHEM
ENVIRONMENTAL
ANALYTICAL
LABORATORY

PH 616/878-1188
Fax 616/878-0044
In Michigan 800/362-LABS

## ANALYTICAL RESULTS
DATE: May 24, 1993

CLIENT NAME:----------B&V WASTE SCIENCE
ATTN:---------------------ROBERT LANTZ
ADDRESS:----------------101 N. WACKER DR. - SUITE 1100
CHICAGO, IL 60606

PROJECT:-----------------OCI
PROJECT NO: ----------- 70160.120
SAMPLE ID:--------------OCI MW3B (50.5-55.5)
SAMPLE TYPE:---------AQUEOUS

DATE RECEIVED:--------- 5/22/93
ANALYSIS DATE:----------5/23/93
QA/QC FILE NAME:------- MAY22624\0401004.D

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## RESULTS

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| | EPA 624 TARGET COMPOUNDS | RESULTS ( ug/L ) : ppb |
|---|---|---|
| 1 | VINYL CHLORIDE | BDL (< 1) |
| 2 | CHLOROMETHANE | BDL (< 1) |
| 3 | BROMOETHANE | BDL (< 1) |
| 4 | CHLOROETHANE | BDL (< 1) |
| 5 | TRICHLOROFLUOROMETHANE | BDL (< 1) |
| 6 | 1,1-DICHLOROETHENE | BDL (< 1) |
| 7 | METHYLENE CHLORIDE | BDL (< 1) |
| 8 | trans-1,2-DICHLOROETHENE | BDL (< 1) |
| 9 | 1,1-DICHLOROETHANE | BDL (< 1) |
| 10 | CHLOROFORM | 31.5 |
| 11 | 1,1,1-TRICHLOROETHANE | BDL (< 1) |
| 12 | 1,2-DICHLOROETHANE | BDL (< 1) |
| 13 | BENZENE | BDL (< 1) |
| 14 | CARBON TETRACHLORIDE | BDL (< 1) |
| 15 | 1,2-DICHLOROPROPANE | BDL (< 1) |
| 16 | TRICHLOROETHENE | BDL (< 1) |
| 17 | BROMODICHLOROMETHANE | 9.4 |
| 18 | cis-1,3-DICHLOROPROPENE | BDL (< 1) |
| 19 | TOLUENE | BDL (< 1) |
| 20 | trans-1,3-DICHLOROPROPENE | BDL (< 1) |
| 21 | 1,1,2-TRICHLOROETHANE | BDL (< 1) |
| 22 | DIBROMOCHLOROMETHANE | 3.0 |
| 23 | TETRACHLOROETHENE | BDL (< 1) |
| 24 | CHLOROBENZENE | BDL (< 1) |
| 25 | ETHYLBENZENE | BDL (< 1) |
| 26 | BROMOFORM | BDL (< 1) |
| 27 | 1,1,2,2-TETRACHLOROETHANE | BDL (< 1) |
| 28 | 1,3-DICHLOROBENZENE | BDL (< 1) |
| 29 | 1,4-DICHLOROBENZENE | BDL (< 1) |
| 30 | 1,2-DICHLOROBENZENE | BDL (< 1) |
| 31 | XYLENES | BDL (< 3) |

BDL = BELOW DETECTION LIMITS

Michael L. Douglass
MICHAEL L. DOUGLASS
LABORATORY MANAGER

**Analysis in compliance with Environmental Protection Agency's SW846 Method 8260 GC/MS Volitiles Analysis**
**Capillary Column Type: [ phase: DB-624; ID: 530 uM; film: VTK; 3 uM film thickness ]**
**Enrichment: [ Tekmar concentrator with moisture control module and glass jet separator ]**

BIO-CHEM
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ANALYTICAL
LABORATORY

# ANALYTICAL RESULTS

DATE: May 24, 1993

PH 616/878-1188
Fax 616/878-0044
In Michigan 800/362-LABS

CLIENT NAME:----------B&V WASTE SCIENCE
ATTN:----------------------ROBERT LANTZ
ADDRESS:-----------------101 N. WACKER DR. - SUITE 1100
CHICAGO, IL 60606

PROJECT:-------------------OCI
PROJECT NO:------------70160.120
SAMPLE ID:----------------OCI MW38 (55.5-60.5)
SAMPLE TYPE:-----------AQUEOUS

DATE RECEIVED:---------- 5/22/93
ANALYSIS DATE:-----------5/23/93
QA/QC FILE NAME:------- MAY22624\0301003.D

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## RESULTS

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| | EPA 624 TARGET COMPOUNDS | RESULTS ( ug/L ) : ppb |
|---|---|---|
| 1 | VINYL CHLORIDE | BDL (< 1 ) |
| 2 | CHLOROMETHANE | BDL (< 1 ) |
| 3 | BROMOETHANE | BDL (< 1 ) |
| 4 | CHLOROETHANE | BDL (< 1 ) |
| 5 | TRICHLOROFLUOROMETHANE | BDL (< 1 ) |
| 6 | 1,1-DICHLOROETHENE | BDL (< 1 ) |
| 7 | METHYLENE CHLORIDE | BDL (< 1 ) |
| 8 | trans-1,2-DICHLOROETHENE | BDL (< 1 ) |
| 9 | 1,1-DICHLOROETHANE | BDL (< 1 ) |
| 10 | CHLOROFORM | 31.5 |
| 11 | 1,1,1-TRICHLOROETHANE | BDL (< 1 ) |
| 12 | 1,2-DICHLOROETHANE | BDL (< 1 ) |
| 13 | BENZENE | BDL (< 1 ) |
| 14 | CARBON TETRACHLORIDE | BDL (< 1 ) |
| 15 | 1,2-DICHLOROPROPANE | BDL (< 1 ) |
| 16 | TRICHLOROETHENE | BDL (< 1 ) |
| 17 | BROMODICHLOROMETHANE | 6.7 |
| 18 | cis-1,3-DICHLOROPROPENE | BDL (< 1 ) |
| 19 | TOLUENE | BDL (< 1 ) |
| 20 | trans-1,3-DICHLOROPROPENE | BDL (< 1 ) |
| 21 | 1,1,2-TRICHLOROETHANE | BDL (< 1 ) |
| 22 | DIBROMOCHLOROMETHANE | 1.5 |
| 23 | TETRACHLOROETHENE | BDL (< 1 ) |
| 24 | CHLOROBENZENE | BDL (< 1 ) |
| 25 | ETHYLBENZENE | BDL (< 1 ) |
| 26 | BROMOFORM | BDL (< 1 ) |
| 27 | 1,1,2,2-TETRACHLOROETHANE | BDL (< 1 ) |
| 28 | 1,3-DICHLOROBENZENE | BDL (< 1 ) |
| 29 | 1,4-DICHLOROBENZENE | BDL (< 1 ) |
| 30 | 1,2-DICHLOROBENZENE | BDL (< 1 ) |
| 31 | XYLENES | BDL (< 3 ) |

BDL = BELOW DETECTION LIMITS

MICHAEL L. DOUGLASS
LABORATORY MANAGER

**Analysis in compliance with Environmental Protection Agency's SW846 Method 8260 GC/MS Volitiles Analysis**
**Capillary Column Type: [ phase: DB-624; ID: 530 uM; film: VTK; 3 uM film thickness ]**
**Enrichment: [ Tekmar concentrator with moisture control module and glass jet separator ]**

BIO CHEM
ENVIRONMENTAL
ANALYTICAL
LABORATORY

## ANALYTICAL RESULTS

DATE: May 24, 1993

PH 616/878-1188
Fax 616/878-0044
In Michigan 800/362-LABS

CLIENT NAME:----------B&V WASTE SCIENCE
ATTN:------------------------ROBERT LANTZ
ADDRESS:-----------------101 N. WACKER DR. - SUITE 1100
CHICAGO, IL 60606

PROJECT:------------------OCI
PROJECT NO: ------------ 70160.120
SAMPLE ID:---------------OCI MW38 (60.5-65.5)
SAMPLE TYPE:----------AQUEOUS

DATE RECEIVED:---------- 5/22/93
ANALYSIS DATE:-----------5/23/93
QA/QC FILE NAME:------- MAY22624\0201002.D

## RESULTS

| | EPA 624 TARGET COMPOUNDS | RESULTS ( ug/L ) : ppb |
|---|---|---|
| 1 | VINYL CHLORIDE | BDL (< 1 ) |
| 2 | CHLOROMETHANE | BDL (< 1 ) |
| 3 | BROMOETHANE | BDL (< 1 ) |
| 4 | CHLOROETHANE | BDL (< 1 ) |
| 5 | TRICHLOROFLUOROMETHANE | BDL (< 1 ) |
| 6 | 1,1-DICHLOROETHENE | BDL (< 1 ) |
| 7 | METHYLENE CHLORIDE | BDL (< 1 ) |
| 8 | trans-1,2-DICHLOROETHENE | BDL (< 1 ) |
| 9 | 1,1-DICHLOROETHANE | BDL (< 1 ) |
| 10 | CHLOROFORM | 14.6 |
| 11 | 1,1,1-TRICHLOROETHANE | BDL (< 1 ) |
| 12 | 1,2-DICHLOROETHANE | BDL (< 1 ) |
| 13 | BENZENE | BDL (< 1 ) |
| 14 | CARBON TETRACHLORIDE | BDL (< 1 ) |
| 15 | 1,2-DICHLOROPROPANE | BDL (< 1 ) |
| 16 | TRICHLOROETHENE | BDL (< 1 ) |
| 17 | BROMODICHLOROMETHANE | 1.2 |
| 18 | cis-1,3-DICHLOROPROPENE | BDL (< 1 ) |
| 19 | TOLUENE | BDL (< 1 ) |
| 20 | trans-1,3-DICHLOROPROPENE | BDL (< 1 ) |
| 21 | 1,1,2-TRICHLOROETHANE | BDL (< 1 ) |
| 22 | DIBROMOCHLOROMETHANE | BDL (< 1 ) |
| 23 | TETRACHLOROETHENE | BDL (< 1 ) |
| 24 | CHLOROBENZENE | BDL (< 1 ) |
| 25 | ETHYLBENZENE | BDL (< 1 ) |
| 26 | BROMOFORM | BDL (< 1 ) |
| 27 | 1,1,2,2-TETRACHLOROETHANE | BDL (< 1 ) |
| 28 | 1,3-DICHLOROBENZENE | BDL (< 1 ) |
| 29 | 1,4-DICHLOROBENZENE | BDL (< 1 ) |
| 30 | 1,2-DICHLOROBENZENE | BDL (< 1 ) |
| 31 | XYLENES | BDL (< 3 ) |

BDL = BELOW DETECTION LIMITS

MICHAEL L. DOUGLASS
LABORATORY MANAGER

Analysis in compliance with Environmental Protection Agency's SW846 Method 8260 GC/MS Volitiles Analysis
Capillary Column Type: [ phase: DB-624; ID: 530 uM; film: VTK; 3 uM film thickness ]
Enrichment: [ Tekmar concentrator with moisture control module and glass jet separator ]

BIO-CHEM
ENVIRONMENTAL
ANALYTICAL
LABORATORY

PH 616/878-1188
Fax 616/878-0044
In Michigan 800/362-LABS

## ANALYTICAL RESULTS

DATE: May 24, 1993

CLIENT NAME:---------B&V WASTE SCIENCE
ATTN:--------------------ROBERT LANTZ
ADDRESS:-----------------101 N. WACKER DR. - SUITE 1100
CHICAGO, IL 60606

PROJECT:-----------------OCI
PROJECT NO: ----------- 70160.125
SAMPLE ID:---------------OCI MW39 (47.5-52.5)
SAMPLE TYPE:----------AQUEOUS

DATE RECEIVED:---------- 5/20/93
ANALYSIS DATE:-----------5/20/93
QA/QC FILE NAME:------- 524MAR\1601008.D

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## RESULTS

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| | EPA 624 TARGET COMPOUNDS | RESULTS ( ug/L ) : ppb |
|---|---|---|
| 1 | VINYL CHLORIDE | BDL (< 1) |
| 2 | CHLOROMETHANE | BDL (< 1) |
| 3 | BROMOETHANE | BDL (< 1) |
| 4 | CHLOROETHANE | BDL (< 1) |
| 5 | TRICHLOROFLUOROMETHANE | BDL (< 1) |
| 6 | 1,1-DICHLOROETHENE | BDL (< 1) |
| 7 | METHYLENE CHLORIDE | BDL (< 1) |
| 8 | trans-1,2-DICHLOROETHENE | BDL (< 1) |
| 9 | 1,1-DICHLOROETHANE | BDL (< 1) |
| 10 | CHLOROFORM | 9.7 |
| 11 | 1,1,1-TRICHLOROETHANE | BDL (< 1) |
| 12 | 1,2-DICHLOROETHANE | 12.6 |
| 13 | BENZENE | BDL (< 1) |
| 14 | CARBON TETRACHLORIDE | BDL (< 1) |
| 15 | 1,2-DICHLOROPROPANE | BDL (< 1) |
| 16 | TRICHLOROETHENE | BDL (< 1) |
| 17 | BROMODICHLOROMETHANE | 7.1 |
| 18 | cis-1,3-DICHLOROPROPENE | BDL (< 1) |
| 19 | TOLUENE | BDL (< 1) |
| 20 | trans-1,3-DICHLOROPROPENE | BDL (< 1) |
| 21 | 1,1,2-TRICHLOROETHANE | BDL (< 1) |
| 22 | DIBROMOCHLOROMETHANE | 2.1 |
| 23 | TETRACHLOROETHENE | BDL (< 1) |
| 24 | CHLOROBENZENE | BDL (< 1) |
| 25 | ETHYLBENZENE | BDL (< 1) |
| 26 | BROMOFORM | BDL (< 1) |
| 27 | 1,1,2,2-TETRACHLOROETHANE | BDL (< 1) |
| 28 | 1,3-DICHLOROBENZENE | BDL (< 1) |
| 29 | 1,4-DICHLOROBENZENE | BDL (< 1) |
| 30 | 1,2-DICHLOROBENZENE | BDL (< 1) |
| 31 | XYLENES | BDL (< 3) |

BDL = BELOW DETECTION LIMITS

MICHAEL L. DOUGLASS
LABORATORY MANAGER

**Analysis in compliance with Environmental Protection Agency's SW846 Method 8260 GC/MS Volitiles Analysis**
**Capillary Column Type: [ phase: DB-624; ID: 530 uM; film: VTK; 3 uM film thickness ]**
**Enrichment: [ *Tekmar concentrator with moisture control module and glass jet separator* ]**

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PH 616/878-1188
Fax 616/878-0044
In Michigan 800/362-LABS

# ANALYTICAL RESULTS

DATE: May 24, 1993

CLIENT NAME:---------B&V WASTE SCIENCE
ATTN:------------------------ROBERT LANTZ
ADDRESS:----------------101 N. WACKER DR. - SUITE 1100
CHICAGO, IL 60606

PROJECT:------------------OCI
PROJECT NO: ----------- 70160.125
SAMPLE ID:--------------OCI MW39 (52.5-57.5)
SAMPLE TYPE:---------AQUEOUS

DATE RECEIVED:---------- 5/20/93
ANALYSIS DATE:-----------5/20/93
QA/QC FILE NAME:------- 524MAR\1501007.D

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## RESULTS

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| | EPA 624 TARGET COMPOUNDS | RESULTS ( ug/L ) : ppb |
|---|---|---|
| 1 | VINYL CHLORIDE | BDL (< 1 ) |
| 2 | CHLOROMETHANE | BDL (< 1 ) |
| 3 | BROMOETHANE | BDL (< 1 ) |
| 4 | CHLOROETHANE | BDL (< 1 ) |
| 5 | TRICHLOROFLUOROMETHANE | BDL (< 1 ) |
| 6 | 1,1-DICHLOROETHENE | BDL (< 1 ) |
| 7 | METHYLENE CHLORIDE | BDL (< 1 ) |
| 8 | trans-1,2-DICHLOROETHENE | BDL (< 1 ) |
| 9 | 1,1-DICHLOROETHANE | BDL (< 1 ) |
| 10 | CHLOROFORM | 35.1 |
| 11 | 1,1,1-TRICHLOROETHANE | BDL (< 1 ) |
| 12 | 1,2-DICHLOROETHANE | 9.3 |
| 13 | BENZENE | BDL (< 1 ) |
| 14 | CARBON TETRACHLORIDE | BDL (< 1 ) |
| 15 | 1,2-DICHLOROPROPANE | BDL (< 1 ) |
| 16 | TRICHLOROETHENE | BDL (< 1 ) |
| 17 | BROMODICHLOROMETHANE | 7.2 |
| 18 | cis-1,3-DICHLOROPROPENE | BDL (< 1 ) |
| 19 | TOLUENE | BDL (< 1 ) |
| 20 | trans-1,3-DICHLOROPROPENE | BDL (< 1 ) |
| 21 | 1,1,2-TRICHLOROETHANE | BDL (< 1 ) |
| 22 | DIBROMOCHLOROMETHANE | 2.3 |
| 23 | TETRACHLOROETHENE | BDL (< 1 ) |
| 24 | CHLOROBENZENE | BDL (< 1 ) |
| 25 | ETHYLBENZENE | BDL (< 1 ) |
| 26 | BROMOFORM | BDL (< 1 ) |
| 27 | 1,1,2,2-TETRACHLOROETHANE | BDL (< 1 ) |
| 28 | 1,3-DICHLOROBENZENE | BDL (< 1 ) |
| 29 | 1,4-DICHLOROBENZENE | BDL (< 1 ) |
| 30 | 1,2-DICHLOROBENZENE | BDL (< 1 ) |
| 31 | XYLENES | BDL (< 3 ) |

BDL = BELOW DETECTION LIMITS

MICHAEL L. DOUGLASS
LABORATORY MANAGER

Analysis in compliance with Environmental Protection Agency's SW846 Method 8260 GC/MS Volitiles Analysis
Capillary Column Type: [ phase: DB-624; ID: 530 uM; film: VTK; 3 uM film thickness ]
Enrichment: [ Tekmar concentrator with moisture control module and glass jet separator ]

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PH 616/878-1188
Fax 616/878-0044
In Michigan 800/362-LABS

# ANALYTICAL RESULTS

DATE: May 24, 1993

CLIENT NAME: B&V WASTE SCIENCE
ATTN: ROBERT LANTZ
ADDRESS: 101 N. WACKER DR. - SUITE 1100
CHICAGO, IL 60606

PROJECT: OCI
PROJECT NO: 70160.125
SAMPLE ID: OCI MW39 (57.5-62.5)
SAMPLE TYPE: AQUEOUS

DATE RECEIVED: 5/20/93
ANALYSIS DATE: 5/20/93
QA/QC FILE NAME: 524MAR\1401006.D

## RESULTS

| | EPA 624 TARGET COMPOUNDS | RESULTS ( ug/L ) : ppb |
|---|---|---|
| 1 | VINYL CHLORIDE | BDL (< 1 ) |
| 2 | CHLOROMETHANE | BDL (< 1 ) |
| 3 | BROMOETHANE | BDL (< 1 ) |
| 4 | CHLOROETHANE | BDL (< 1 ) |
| 5 | TRICHLOROFLUOROMETHANE | BDL (< 1 ) |
| 6 | 1,1-DICHLOROETHENE | BDL (< 1 ) |
| 7 | METHYLENE CHLORIDE | BDL (< 1 ) |
| 8 | trans-1,2-DICHLOROETHENE | BDL (< 1 ) |
| 9 | 1,1-DICHLOROETHANE | BDL (< 1 ) |
| 10 | CHLOROFORM | 25.3 |
| 11 | 1,1,1-TRICHLOROETHANE | BDL (< 1 ) |
| 12 | 1,2-DICHLOROETHANE | 12.7 |
| 13 | BENZENE | BDL (< 1 ) |
| 14 | CARBON TETRACHLORIDE | BDL (< 1 ) |
| 15 | 1,2-DICHLOROPROPANE | BDL (< 1 ) |
| 16 | TRICHLOROETHENE | BDL (< 1 ) |
| 17 | BROMODICHLOROMETHANE | 6.3 |
| 18 | cis-1,3-DICHLOROPROPENE | BDL (< 1 ) |
| 19 | TOLUENE | BDL (< 1 ) |
| 20 | trans-1,3-DICHLOROPROPENE | BDL (< 1 ) |
| 21 | 1,1,2-TRICHLOROETHANE | BDL (< 1 ) |
| 22 | DIBROMOCHLOROMETHANE | 2.0 |
| 23 | TETRACHLOROETHENE | BDL (< 1 ) |
| 24 | CHLOROBENZENE | BDL (< 1 ) |
| 25 | ETHYLBENZENE | BDL (< 1 ) |
| 26 | BROMOFORM | BDL (< 1 ) |
| 27 | 1,1,2,2-TETRACHLOROETHANE | BDL (< 1 ) |
| 28 | 1,3-DICHLOROBENZENE | BDL (< 1 ) |
| 29 | 1,4-DICHLOROBENZENE | BDL (< 1 ) |
| 30 | 1,2-DICHLOROBENZENE | BDL (< 1 ) |
| 31 | XYLENES | BDL (< 3 ) |

BDL = BELOW DETECTION LIMITS

MICHAEL L. DOUGLASS
LABORATORY MANAGER

**Analysis in compliance with Environmental Protection Agency's SW846 Method 8260 GC/MS Volitiles Analysis**
**Capillary Column Type: [ phase: DB-624; ID: 530 uM; film: VTK; 3 uM film thickness ]**
**Enrichment: [ Tekmar concentrator with moisture control module and glass jet separator ]**

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ANALYTICAL
LABORATORY

PH 616/878-1188
Fax 616/878-0044
In Michigan 800/362-LABS

# ANALYTICAL RESULTS

DATE: May 24, 1993

CLIENT NAME:----------B&V WASTE SCIENCE
ATTN:----------------------ROBERT LANTZ
ADDRESS:-----------------101 N. WACKER DR. - SUITE 1100
CHICAGO, IL 60606

PROJECT:-----------------OCI
PROJECT NO:-----------70160.125
SAMPLE ID:--------------OCI MW39 (62.5-67.5)
SAMPLE TYPE:---------AQUEOUS

DATE RECEIVED:---------5/20/93
ANALYSIS DATE:----------5/20/93
QA/QC FILE NAME:-------524MAR\1301005.D

* * *

## RESULTS

* * *

| | EPA 624 TARGET COMPOUNDS | RESULTS ( ug/L ) : ppb |
|---|---|---|
| 1 | VINYL CHLORIDE | BDL (< 1 ) |
| 2 | CHLOROMETHANE | BDL (< 1 ) |
| 3 | BROMOETHANE | BDL (< 1 ) |
| 4 | CHLOROETHANE | BDL (< 1 ) |
| 5 | TRICHLOROFLUOROMETHANE | BDL (< 1 ) |
| 6 | 1,1-DICHLOROETHENE | BDL (< 1 ) |
| 7 | METHYLENE CHLORIDE | BDL (< 1 ) |
| 8 | trans-1,2-DICHLOROETHENE | BDL (< 1 ) |
| 9 | 1,1-DICHLOROETHANE | BDL (< 1 ) |
| 10 | CHLOROFORM | 12.6 |
| 11 | 1,1,1-TRICHLOROETHANE | BDL (< 1 ) |
| 12 | 1,2-DICHLOROETHANE | 18.1 |
| 13 | BENZENE | BDL (< 1 ) |
| 14 | CARBON TETRACHLORIDE | BDL (< 1 ) |
| 15 | 1,2-DICHLOROPROPANE | BDL (< 1 ) |
| 16 | TRICHLOROETHENE | BDL (< 1 ) |
| 17 | BROMODICHLOROMETHANE | 2.3 |
| 18 | cis-1,3-DICHLOROPROPENE | BDL (< 1 ) |
| 19 | TOLUENE | BDL (< 1 ) |
| 20 | trans-1,3-DICHLOROPROPENE | BDL (< 1 ) |
| 21 | 1,1,2-TRICHLOROETHANE | BDL (< 1 ) |
| 22 | DIBROMOCHLOROMETHANE | 2.8 |
| 23 | TETRACHLOROETHENE | BDL (< 1 ) |
| 24 | CHLOROBENZENE | BDL (< 1 ) |
| 25 | ETHYLBENZENE | BDL (< 1 ) |
| 26 | BROMOFORM | BDL (< 1 ) |
| 27 | 1,1,2,2-TETRACHLOROETHANE | BDL (< 1 ) |
| 28 | 1,3-DICHLOROBENZENE | BDL (< 1 ) |
| 29 | 1,4-DICHLOROBENZENE | BDL (< 1 ) |
| 30 | 1,2-DICHLOROBENZENE | BDL (< 1 ) |
| 31 | XYLENES | BDL (< 3 ) |

BDL = BELOW DETECTION LIMITS

MICHAEL L. DOUGLASS
LABORATORY MANAGER

Analysis in compliance with Environmental Protection Agency's SW846 Method 8260 GC/MS Volitiles Analysis
Capillary Column Type: [ phase: DB-624; ID: 530 uM; film: VTK; 3 uM film thickness ]
Enrichment: [ Tekmar concentrator with moisture control module and glass jet separator ]

BIO-CHEM
ENVIRONMENTAL
ANALYTICAL
LABORATORY

PH 616/878-1188
Fax 616/878-0044
In Michigan 800/362-LABS

# ANALYTICAL RESULTS

DATE: May 24, 1993

CLIENT NAME:---------B&V WASTE SCIENCE
ATTN:---------------------ROBERT LANTZ
ADDRESS:----------------101 N. WACKER DR. - SUITE 1100
CHICAGO, IL 60606

PROJECT:-----------------ORGANIC CHEMICALS, INC.
PROJECT NO: ----------- 70160.125
SAMPLE ID:-------------OCI MW40 (55.7-60.7)
SAMPLE TYPE:---------AQUEOUS

DATE RECEIVED:---------- 5/24/93
ANALYSIS DATE:-----------5/24/93
QA/QC FILE NAME:------- MAY24624\0101001.D

## RESULTS

| | EPA 624 TARGET COMPOUNDS | RESULTS ( ug/L ) : ppb |
|---|---|---|
| 1 | VINYL CHLORIDE | BDL (< 1 ) |
| 2 | CHLOROMETHANE | BDL (< 1 ) |
| 3 | BROMOETHANE | BDL (< 1 ) |
| 4 | CHLOROETHANE | BDL (< 1 ) |
| 5 | TRICHLOROFLUOROMETHANE | BDL (< 1 ) |
| 6 | 1,1-DICHLOROETHENE | BDL (< 1 ) |
| 7 | METHYLENE CHLORIDE | BDL (< 1 ) |
| 8 | trans-1,2-DICHLOROETHENE | BDL (< 1 ) |
| 9 | 1,1-DICHLOROETHANE | BDL (< 1 ) |
| 10 | CHLOROFORM | 38.6 |
| 11 | 1,1,1-TRICHLOROETHANE | BDL (< 1 ) |
| 12 | 1,2-DICHLOROETHANE | BDL (< 1 ) |
| 13 | BENZENE | BDL (< 1 ) |
| 14 | CARBON TETRACHLORIDE | BDL (< 1 ) |
| 15 | 1,2-DICHLOROPROPANE | BDL (< 1 ) |
| 16 | TRICHLOROETHENE | BDL (< 1 ) |
| 17 | BROMODICHLOROMETHANE | 11.9 |
| 18 | cis-1,3-DICHLOROPROPENE | BDL (< 1 ) |
| 19 | TOLUENE | BDL (< 1 ) |
| 20 | trans-1,3-DICHLOROPROPENE | BDL (< 1 ) |
| 21 | 1,1,2-TRICHLOROETHANE | BDL (< 1 ) |
| 22 | DIBROMOCHLOROMETHANE | 1.4 |
| 23 | TETRACHLOROETHENE | BDL (< 1 ) |
| 24 | CHLOROBENZENE | BDL (< 1 ) |
| 25 | ETHYLBENZENE | BDL (< 1 ) |
| 26 | BROMOFORM | BDL (< 1 ) |
| 27 | 1,1,2,2-TETRACHLOROETHANE | BDL (< 1 ) |
| 28 | 1,3-DICHLOROBENZENE | BDL (< 1 ) |
| 29 | 1,4-DICHLOROBENZENE | BDL (< 1 ) |
| 30 | 1,2-DICHLOROBENZENE | BDL (< 1 ) |
| 31 | XYLENES | BDL (< 3 ) |

BDL = BELOW DETECTION LIMITS

MICHAEL L. DOUGLASS
LABORATORY MANAGER

Analysis in compliance with Environmental Protection Agency's SW846 Method 8260 GC/MS Volitiles Analysis
Capillary Column Type: [ phase: DB-624; ID: 530 uM; film: VTK; 3 uM film thickness ]
Enrichment: [ Tekmar concentrator with moisture control module and glass jet separator ]

BIO CHEM
ENVIRONMENTAL
ANALYTICAL
LABORATORY

PH 616/878-1188
Fax 616/878-0044
In Michigan 800/362-LABS

# ANALYTICAL RESULTS

DATE: May 24, 1993

CLIENT NAME:---------B&V WASTE SCIENCE
ATTN:--------------------ROBERT LANTZ
ADDRESS:--------------101 N. WACKER DR. - SUITE 1100
CHICAGO, IL 60606

PROJECT:-----------------ORGANIC CHEMICALS, INC.
PROJECT NO: ----------- 70160.125
SAMPLE ID:--------------OCI MW40 (60.7-65.7)
SAMPLE TYPE:---------AQUEOUS

DATE RECEIVED:--------- 5/24/93
ANALYSIS DATE:----------5/24/93
QA/QC FILE NAME:------- MAY24624\0201002.D

****************************************************************************************************

## RESULTS

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| | EPA 624 TARGET COMPOUNDS | RESULTS ( ug/L ) : ppb |
|---|---|---|
| 1 | VINYL CHLORIDE | BDL (< 1 ) |
| 2 | CHLOROMETHANE | BDL (< 1 ) |
| 3 | BROMOETHANE | BDL (< 1 ) |
| 4 | CHLOROETHANE | BDL (< 1 ) |
| 5 | TRICHLOROFLUOROMETHANE | BDL (< 1 ) |
| 6 | 1,1-DICHLOROETHENE | BDL (< 1 ) |
| 7 | METHYLENE CHLORIDE | BDL (< 1 ) |
| 8 | trans-1,2-DICHLOROETHENE | BDL (< 1 ) |
| 9 | 1,1-DICHLOROETHANE | BDL (< 1 ) |
| 10 | CHLOROFORM | 25.7 |
| 11 | 1,1,1-TRICHLOROETHANE | BDL (< 1 ) |
| 12 | 1,2-DICHLOROETHANE | BDL (< 1 ) |
| 13 | BENZENE | BDL (< 1 ) |
| 14 | CARBON TETRACHLORIDE | BDL (< 1 ) |
| 15 | 1,2-DICHLOROPROPANE | BDL (< 1 ) |
| 16 | TRICHLOROETHENE | BDL (< 1 ) |
| 17 | BROMODICHLOROMETHANE | 7.7 |
| 18 | cis-1,3-DICHLOROPROPENE | BDL (< 1 ) |
| 19 | TOLUENE | BDL (< 1 ) |
| 20 | trans-1,3-DICHLOROPROPENE | BDL (< 1 ) |
| 21 | 1,1,2-TRICHLOROETHANE | BDL (< 1 ) |
| 22 | DIBROMOCHLOROMETHANE | 2.6 |
| 23 | TETRACHLOROETHENE | BDL (< 1 ) |
| 24 | CHLOROBENZENE | BDL (< 1 ) |
| 25 | ETHYLBENZENE | BDL (< 1 ) |
| 26 | BROMOFORM | BDL (< 1 ) |
| 27 | 1,1,2,2-TETRACHLOROETHANE | BDL (< 1 ) |
| 28 | 1,3-DICHLOROBENZENE | BDL (< 1 ) |
| 29 | 1,4-DICHLOROBENZENE | BDL (< 1 ) |
| 30 | 1,2-DICHLOROBENZENE | BDL (< 1 ) |
| 31 | XYLENES | BDL (< 3 ) |

BDL = BELOW DETECTION LIMITS

MICHAEL L. DOUGLASS
LABORATORY MANAGER

Analysis in compliance with Environmental Protection Agency's SW846 Method 8260 GC/MS Volitiles Analysis
Capillary Column Type: [ phase: DB-624; ID: 530 uM; film: VTK; 3 uM film thickness ]
Enrichment: [ Tekmar concentrator with moisture control module and glass jet separator ]

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PH 616/878-1188
Fax 616/878-0044
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## ANALYTICAL RESULTS

DATE: June 4, 1993

CLIENT NAME:---------B&V WASTE SCIENCE
ATTN:----------------------ROBERT LANTZ
ADDRESS:-----------------101 N. WACKER DR. - SUITE 1100
CHICAGO, IL 60606

PROJECT:-----------------ORGANIC CHEMICALS, INC.
PROJECT NO: ------------ 70160.125
SAMPLE ID:--------------- OCI MW41 (102.5'-97.5')
SAMPLE TYPE:----------AQUEOUS

DATE RECEIVED:---------- 6/3/93
ANALYSIS DATE:-----------6/3/93
QA/QC FILE NAME:------- JUN03624\0801004.D

## RESULTS

| EPA 624 TARGET COMPOUNDS | | RESULTS ( ug/L ) : ppb |
|---|---|---|
| 1 | VINYL CHLORIDE | BDL (< 1 ) |
| 2 | CHLOROMETHANE | BDL (< 1 ) |
| 3 | BROMOETHANE | BDL (< 1 ) |
| 4 | CHLOROETHANE | BDL (< 1 ) |
| 5 | TRICHLOROFLUOROMETHANE | BDL (< 1 ) |
| 6 | 1,1-DICHLOROETHENE | BDL (< 1 ) |
| 7 | METHYLENE CHLORIDE | BDL (< 1 ) |
| 8 | trans-1,2-DICHLOROETHENE | BDL (< 1 ) |
| 9 | 1,1-DICHLOROETHANE | BDL (< 1 ) |
| 10 | CHLOROFORM | 2.8 |
| 11 | 1,1,1-TRICHLOROETHANE | BDL (< 1 ) |
| 12 | 1,2-DICHLOROETHANE | BDL (< 1 ) |
| 13 | BENZENE | BDL (< 1 ) |
| 14 | CARBON TETRACHLORIDE | BDL (< 1 ) |
| 15 | 1,2-DICHLOROPROPANE | BDL (< 1 ) |
| 16 | TRICHLOROETHENE | BDL (< 1 ) |
| 17 | BROMODICHLOROMETHANE | BDL (< 1 ) |
| 18 | cis-1,3-DICHLOROPROPENE | BDL (< 1 ) |
| 19 | TOLUENE | BDL (< 1 ) |
| 20 | trans-1,3-DICHLOROPROPENE | BDL (< 1 ) |
| 21 | 1,1,2-TRICHLOROETHANE | BDL (< 1 ) |
| 22 | DIBROMOCHLOROMETHANE | BDL (< 1 ) |
| 23 | TETRACHLOROETHENE | BDL (< 1 ) |
| 24 | CHLOROBENZENE | BDL (< 1 ) |
| 25 | ETHYLBENZENE | BDL (< 1 ) |
| 26 | BROMOFORM | BDL (< 1 ) |
| 27 | 1,1,2,2-TETRACHLOROETHANE | BDL (< 1 ) |
| 28 | 1,3-DICHLOROBENZENE | BDL (< 1 ) |
| 29 | 1,4-DICHLOROBENZENE | BDL (< 1 ) |
| 30 | 1,2-DICHLOROBENZENE | BDL (< 1 ) |
| 31 | XYLENES | BDL (< 3 ) |

BDL = BELOW DETECTION LIMITS

Michael L Douglass
MICHAEL L. DOUGLASS
LABORATORY MANAGER

Analysis in compliance with Environmental Protection Agency's SW846 Method 8260 GC/MS Volitiles Analysis
Capillary Column Type: [ phase: DB-624; ID: 530 uM; film: VTK; 3 uM film thickness ]
Enrichment: [ Tekmar concentrator with moisture control module and glass jet separator ]

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Fax 616/878-0044
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## ANALYTICAL RESULTS

DATE: June 4, 1993 .

CLIENT NAME:---------B&V WASTE SCIENCE
ATTN:----------------------ROBERT LANTZ
ADDRESS:------------------101 N. WACKER DR. - SUITE 1100
CHICAGO, IL 60606

PROJECT:------------------ORGANIC CHEMICALS, INC.
PROJECT NO: ----------- 70160.125
SAMPLE ID:-------------- OCI MW41 (107.5'-102.5')
SAMPLE TYPE:---------AQUEOUS

DATE RECEIVED:--------- 6/3/93
ANALYSIS DATE:-----------6/3/93
QA/QC FILE NAME:------ JUN03624\0701003.D

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## RESULTS

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| | EPA 624 TARGET COMPOUNDS | RESULTS ( ug/L ) : ppb |
|---|---|---|
| 1 | VINYL CHLORIDE | BDL (< 1 ) |
| 2 | CHLOROMETHANE | BDL (< 1 ) |
| 3 | BROMOETHANE | BDL (< 1 ) |
| 4 | CHLOROETHANE | BDL (< 1 ) |
| 5 | TRICHLOROFLUOROMETHANE | BDL (< 1 ) |
| 6 | 1,1-DICHLOROETHENE | BDL (< 1 ) |
| 7 | METHYLENE CHLORIDE | BDL (< 1 ) |
| 8 | trans-1,2-DICHLOROETHENE | BDL (< 1 ) |
| 9 | 1,1-DICHLOROETHANE | BDL (< 1 ) |
| 10 | CHLOROFORM | 2.3 |
| 11 | 1,1,1-TRICHLOROETHANE | BDL (< 1 ) |
| 12 | 1,2-DICHLOROETHANE | BDL (< 1 ) |
| 13 | BENZENE | BDL (< 1 ) |
| 14 | CARBON TETRACHLORIDE | BDL (< 1 ) |
| 15 | 1,2-DICHLOROPROPANE | BDL (< 1 ) |
| 16 | TRICHLOROETHENE | BDL (< 1 ) |
| 17 | BROMODICHLOROMETHANE | BDL (< 1 ) |
| 18 | cis-1,3-DICHLOROPROPENE | BDL (< 1 ) |
| 19 | TOLUENE | BDL (< 1 ) |
| 20 | trans-1,3-DICHLOROPROPENE | BDL (< 1 ) |
| 21 | 1,1,2-TRICHLOROETHANE | BDL (< 1 ) |
| 22 | DIBROMOCHLOROMETHANE | BDL (< 1 ) |
| 23 | TETRACHLOROETHENE | BDL (< 1 ) |
| 24 | CHLOROBENZENE | BDL (< 1 ) |
| 25 | ETHYLBENZENE | BDL (< 1 ) |
| 26 | BROMOFORM | BDL (< 1 ) |
| 27 | 1,1,2,2-TETRACHLOROETHANE | BDL (< 1 ) |
| 28 | 1,3-DICHLOROBENZENE | BDL (< 1 ) |
| 29 | 1,4-DICHLOROBENZENE | BDL (< 1 ) |
| 30 | 1,2-DICHLOROBENZENE | BDL (< 1 ) |
| 31 | XYLENES | BDL (< 3 ) |

BDL = BELOW DETECTION LIMITS

Michael L Douglass
MICHAEL L. DOUGLASS
LABORATORY MANAGER

**Analysis in compliance with Environmental Protection Agency's SW846 Method 8260 GC/MS Volitiles Analysis**
**Capillary Column Type: [ phase: DB-624; ID: 530 uM; film: VTK; 3 uM film thickness ]**
**Enrichment: [ Tekmar concentrator with moisture control module and glass jet separator ]**

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PH 616/878-1188
Fax 616/878-0044
In Michigan 800/362-LABS

# ANALYTICAL RESULTS

DATE: June 4, 1993

CLIENT NAME:----------B&V WASTE SCIENCE
ATTN:------------------------ROBERT LANTZ
ADDRESS:-----------------101 N. WACKER DR. - SUITE 1100
CHICAGO, IL 60606

PROJECT:------------------ORGANIC CHEMICALS, INC.
PROJECT NO: ----------- 70160.125
SAMPLE ID:--------------OCI MW41 (112.5'-107.5')
SAMPLE TYPE:----------AQUEOUS

DATE RECEIVED:---------- 6/3/93
ANALYSIS DATE:-----------6/3/93
QA/QC FILE NAME:-------- JUN03624\0601002.D

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## RESULTS

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| | EPA 624 TARGET COMPOUNDS | RESULTS ( ug/L ) : ppb |
|---|---|---|
| 1 | VINYL CHLORIDE | BDL (< 1 ) |
| 2 | CHLOROMETHANE | BDL (< 1 ) |
| 3 | BROMOETHANE | BDL (< 1 ) |
| 4 | CHLOROETHANE | BDL (< 1 ) |
| 5 | TRICHLOROFLUOROMETHANE | BDL (< 1 ) |
| 6 | 1,1-DICHLOROETHENE | BDL (< 1 ) |
| 7 | METHYLENE CHLORIDE | BDL (< 1 ) |
| 8 | trans-1,2-DICHLOROETHENE | BDL (< 1 ) |
| 9 | 1,1-DICHLOROETHANE | BDL (< 1 ) |
| 10 | CHLOROFORM | 3.2 |
| 11 | 1,1,1-TRICHLOROETHANE | BDL (< 1 ) |
| 12 | 1,2-DICHLOROETHANE | BDL (< 1 ) |
| 13 | BENZENE | BDL (< 1 ) |
| 14 | CARBON TETRACHLORIDE | BDL (< 1 ) |
| 15 | 1,2-DICHLOROPROPANE | BDL (< 1 ) |
| 16 | TRICHLOROETHENE | BDL (< 1 ) |
| 17 | BROMODICHLOROMETHANE | BDL (< 1 ) |
| 18 | cis-1,3-DICHLOROPROPENE | BDL (< 1 ) |
| 19 | TOLUENE | BDL (< 1 ) |
| 20 | trans-1,3-DICHLOROPROPENE | BDL (< 1 ) |
| 21 | 1,1,2-TRICHLOROETHANE | BDL (< 1 ) |
| 22 | DIBROMOCHLOROMETHANE | BDL (< 1 ) |
| 23 | TETRACHLOROETHENE | BDL (< 1 ) |
| 24 | CHLOROBENZENE | BDL (< 1 ) |
| 25 | ETHYLBENZENE | BDL (< 1 ) |
| 26 | BROMOFORM | BDL (< 1 ) |
| 27 | 1,1,2,2-TETRACHLOROETHANE | BDL (< 1 ) |
| 28 | 1,3-DICHLOROBENZENE | BDL (< 1 ) |
| 29 | 1,4-DICHLOROBENZENE | BDL (< 1 ) |
| 30 | 1,2-DICHLOROBENZENE | BDL (< 1 ) |
| 31 | XYLENES | BDL (< 3 ) |

BDL = BELOW DETECTION LIMITS

MICHAEL L. DOUGLASS
LABORATORY MANAGER

**Analysis in compliance with Environmental Protection Agency's SW846 Method 8260 GC/MS Volitiles Analysis**
**Capillary Column Type: [ phase: DB-624; ID: 530 uM; film: VTK; 3 uM film thickness ]**
**Enrichment: [ Tekmar concentrator with moisture control module and glass jet separator ]**

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In Michigan 800/362-LABS

# ANALYTICAL RESULTS

DATE: June 4, 1993

CLIENT NAME:----------B&V WASTE SCIENCE
ATTN:-------------------------ROBERT LANTZ
ADDRESS:-----------------101 N. WACKER DR. - SUITE 1100
CHICAGO, IL 60606

PROJECT:-------------------ORGANIC CHEMICALS, INC.
PROJECT NO:------------70160.125
SAMPLE ID:---------------OCI MW41 (117.5'-112.5')
SAMPLE TYPE:----------AQUEOUS

DATE RECEIVED:----------6/3/93
ANALYSIS DATE:-----------6/4/93
QA/QC FILE NAME:-------JUN03624\1201007.D

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## RESULTS

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| | EPA 624 TARGET COMPOUNDS | RESULTS ( ug/L ) : ppb |
|---|---|---|
| 1 | VINYL CHLORIDE | BDL (< 1 ) |
| 2 | CHLOROMETHANE | BDL (< 1 ) |
| 3 | BROMOETHANE | BDL (< 1 ) |
| 4 | CHLOROETHANE | BDL (< 1 ) |
| 5 | TRICHLOROFLUOROMETHANE | BDL (< 1 ) |
| 6 | 1,1-DICHLOROETHENE | BDL (< 1 ) |
| 7 | METHYLENE CHLORIDE | BDL (< 1 ) |
| 8 | trans-1,2-DICHLOROETHENE | BDL (< 1 ) |
| 9 | 1,1-DICHLOROETHANE | BDL (< 1 ) |
| 10 | CHLOROFORM | 3.4 |
| 11 | 1,1,1-TRICHLOROETHANE | BDL (< 1 ) |
| 12 | 1,2-DICHLOROETHANE | BDL (< 1 ) |
| 13 | BENZENE | BDL (< 1 ) |
| 14 | CARBON TETRACHLORIDE | BDL (< 1 ) |
| 15 | 1,2-DICHLOROPROPANE | BDL (< 1 ) |
| 16 | TRICHLOROETHENE | BDL (< 1 ) |
| 17 | BROMODICHLOROMETHANE | BDL (< 1 ) |
| 18 | cis-1,3-DICHLOROPROPENE | BDL (< 1 ) |
| 19 | TOLUENE | 2.1 |
| 20 | trans-1,3-DICHLOROPROPENE | BDL (< 1 ) |
| 21 | 1,1,2-TRICHLOROETHANE | BDL (< 1 ) |
| 22 | DIBROMOCHLOROMETHANE | BDL (< 1 ) |
| 23 | TETRACHLOROETHENE | BDL (< 1 ) |
| 24 | CHLOROBENZENE | BDL (< 1 ) |
| 25 | ETHYLBENZENE | BDL (< 1 ) |
| 26 | BROMOFORM | BDL (< 1 ) |
| 27 | 1,1,2,2-TETRACHLOROETHANE | BDL (< 1 ) |
| 28 | 1,3-DICHLOROBENZENE | BDL (< 1 ) |
| 29 | 1,4-DICHLOROBENZENE | BDL (< 1 ) |
| 30 | 1,2-DICHLOROBENZENE | BDL (< 1 ) |
| 31 | XYLENES | BDL (< 3 ) |

BDL = BELOW DETECTION LIMITS

MICHAEL L. DOUGLASS
LABORATORY MANAGER

**Analysis in compliance with Environmental Protection Agency's SW846 Method 8260 GC/MS Volitiles Analysis**
**Capillary Column Type: [ phase: DB-624; ID: 530 uM; film: VTK; 3 uM film thickness ]**
**Enrichment: [ Tekmar concentrator with moisture control module and glass jet separator ]**

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In Michigan 800/362-LABS

# ANALYTICAL RESULTS

DATE: May 18, 1993

CLIENT NAME:----------B&V WASTE SCIENCE
ATTN:-----------------------RICHARD MCAVOY
ADDRESS:-----------------101 N. WACKER DR. - SUITE 1100
CHICAGO, IL 60606

PROJECT:-----------------ORGANIC CHEMICAL INC
PROJECT NO: ------------ N/A
SAMPLE ID:--------------MW42 (79-84)
SAMPLE TYPE:----------AQUEOUS

DATE RECEIVED:---------- 5/17/93
ANALYSIS DATE:-----------5/17/93
QA/QC FILE NAME:------- MAY17624\0701007.D

* * *

## RESULTS

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| | EPA 624 TARGET COMPOUNDS | RESULTS ( ug/L ) : ppb |
|---|---|---|
| 1 | VINYL CHLORIDE | BDL (< 1 ) |
| 2 | CHLOROMETHANE | BDL (< 1 ) |
| 3 | BROMOETHANE | BDL (< 1 ) |
| 4 | CHLOROETHANE | BDL (< 1 ) |
| 5 | TRICHLOROFLUOROMETHANE | BDL (< 1 ) |
| 6 | 1,1-DICHLOROETHENE | BDL (< 1 ) |
| 7 | METHYLENE CHLORIDE | BDL (< 1 ) |
| 8 | trans-1,2-DICHLOROETHENE | BDL (< 1 ) |
| 9 | 1,1-DICHLOROETHANE | BDL (< 1 ) |
| 10 | CHLOROFORM | BDL (< 1 ) |
| 11 | 1,1,1-TRICHLOROETHANE | BDL (< 1 ) |
| 12 | 1,2-DICHLOROETHANE | 4.5 |
| 13 | BENZENE | BDL (< 1 ) |
| 14 | CARBON TETRACHLORIDE | BDL (< 1 ) |
| 15 | 1,2-DICHLOROPROPANE | BDL (< 1 ) |
| 16 | TRICHLOROETHENE | BDL (< 1 ) |
| 17 | BROMODICHLOROMETHANE | BDL (< 1 ) |
| 18 | cis-1,3-DICHLOROPROPENE | BDL (< 1 ) |
| 19 | TOLUENE | BDL (< 1 ) |
| 20 | trans-1,3-DICHLOROPROPENE | BDL (< 1 ) |
| 21 | 1,1,2-TRICHLOROETHANE | BDL (< 1 ) |
| 22 | DIBROMOCHLOROMETHANE | BDL (< 1 ) |
| 23 | TETRACHLOROETHENE | BDL (< 1 ) |
| 24 | CHLOROBENZENE | BDL (< 1 ) |
| 25 | ETHYLBENZENE | BDL (< 1 ) |
| 26 | BROMOFORM | BDL (< 1 ) |
| 27 | 1,1,2,2-TETRACHLOROETHANE | BDL (< 1 ) |
| 28 | 1,3-DICHLOROBENZENE | BDL (< 1 ) |
| 29 | 1,4-DICHLOROBENZENE | BDL (< 1 ) |
| 30 | 1,2-DICHLOROBENZENE | BDL (< 1 ) |
| 31 | XYLENES | BDL (< 3 ) |

BDL = BELOW DETECTION LIMITS

MICHAEL L. DOUGLASS
LABORATORY MANAGER

**Analysis in compliance with Environmental Protection Agency's SW846 Method 8260 GC/MS Volitiles Analysis**
**Capillary Column Type: [ phase: DB-624; ID: 530 uM; film: VTK; 3 uM film thickness ]**
**Enrichment: [ Tekmar concentrator with moisture control module and glass jet separator ]**

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Fax 616/878-0044
In Michigan 800/362-LABS

# ANALYTICAL RESULTS

DATE: May 18, 1993

CLIENT NAME:----------B&V WASTE SCIENCE
ATTN:----------------------RICHARD MCAVOY
ADDRESS:------------------101 N. WACKER DR. - SUITE 1100
CHICAGO, IL 60606

PROJECT:------------------ORGANIC CHEMICAL INC
PROJECT NO: ------------ N/A
SAMPLE ID:---------------MW42 (84-89)
SAMPLE TYPE:----------AQUEOUS

DATE RECEIVED:---------- 5/17/93
ANALYSIS DATE:----------5/17/93
QA/QC FILE NAME:------- MAY17624\1001010.D

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## RESULTS

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| | EPA 624 TARGET COMPOUNDS | RESULTS ( ug/L ) : ppb |
|---|---|---|
| 1 | VINYL CHLORIDE | BDL (< 1 ) |
| 2 | CHLOROMETHANE | BDL (< 1 ) |
| 3 | BROMOETHANE | BDL (< 1 ) |
| 4 | CHLOROETHANE | BDL (< 1 ) |
| 5 | TRICHLOROFLUOROMETHANE | BDL (< 1 ) |
| 6 | 1,1-DICHLOROETHENE | BDL (< 1 ) |
| 7 | METHYLENE CHLORIDE | BDL (< 1 ) |
| 8 | trans-1,2-DICHLOROETHENE | BDL (< 1 ) |
| 9 | 1,1-DICHLOROETHANE | BDL (< 1 ) |
| 10 | CHLOROFORM | BDL (< 1 ) |
| 11 | 1,1,1-TRICHLOROETHANE | BDL (< 1 ) |
| 12 | 1,2-DICHLOROETHANE | 6.1 |
| 13 | BENZENE | BDL (< 1 ) |
| 14 | CARBON TETRACHLORIDE | BDL (< 1 ) |
| 15 | 1,2-DICHLOROPROPANE | BDL (< 1 ) |
| 16 | TRICHLOROETHENE | BDL (< 1 ) |
| 17 | BROMODICHLOROMETHANE | BDL (< 1 ) |
| 18 | cis-1,3-DICHLOROPROPENE | BDL (< 1 ) |
| 19 | TOLUENE | BDL (< 1 ) |
| 20 | trans-1,3-DICHLOROPROPENE | BDL (< 1 ) |
| 21 | 1,1,2-TRICHLOROETHANE | BDL (< 1 ) |
| 22 | DIBROMOCHLOROMETHANE | BDL (< 1 ) |
| 23 | TETRACHLOROETHENE | BDL (< 1 ) |
| 24 | CHLOROBENZENE | BDL (< 1 ) |
| 25 | ETHYLBENZENE | BDL (< 1 ) |
| 26 | BROMOFORM | BDL (< 1 ) |
| 27 | 1,1,2,2-TETRACHLOROETHANE | BDL (< 1 ) |
| 28 | 1,3-DICHLOROBENZENE | BDL (< 1 ) |
| 29 | 1,4-DICHLOROBENZENE | BDL (< 1 ) |
| 30 | 1,2-DICHLOROBENZENE | BDL (< 1 ) |
| 31 | XYLENES | BDL (< 3 ) |

BDL = BELOW DETECTION LIMITS

MICHAEL L. DOUGLASS
LABORATORY MANAGER

Analysis in compliance with Environmental Protection Agency's SW846 Method 8260 GC/MS Volitiles Analysis
Capillary Column Type: [ phase: DB-624; ID: 530 uM; film: VTK; 3 uM film thickness ]
Enrichment: [ Tekmar concentrator with moisture control module and glass jet separator ]

BIO-CHEM
ENVIRONMENTAL
ANALYTICAL
LABORATORY

PH 616/878-1188
Fax 616/878-0044
In Michigan 800/362-LABS

# ANALYTICAL RESULTS

DATE: May 18, 1993

CLIENT NAME:----------B&V WASTE SCIENCE
ATTN:------------------------RICHARD MCAVOY
ADDRESS:-----------------101 N. WACKER DR. - SUITE 1100
CHICAGO, IL 60606

PROJECT:------------------ORGANIC CHEMICAL INC
PROJECT NO: ------------ N/A
SAMPLE ID:----------------MW42 (89-94)
SAMPLE TYPE:----------AQUEOUS

DATE RECEIVED:---------- 5/17/93
ANALYSIS DATE:------------5/17/93
QA/QC FILE NAME:------- MAY17624\0801008.D

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## RESULTS

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| | EPA 624 TARGET COMPOUNDS | RESULTS ( ug/L ) : ppb |
|---|---|---|
| 1 | VINYL CHLORIDE | BDL (< 1 ) |
| 2 | CHLOROMETHANE | BDL (< 1 ) |
| 3 | BROMOETHANE | BDL (< 1 ) |
| 4 | CHLOROETHANE | BDL (< 1 ) |
| 5 | TRICHLOROFLUOROMETHANE | BDL (< 1 ) |
| 6 | 1,1-DICHLOROETHENE | BDL (< 1 ) |
| 7 | METHYLENE CHLORIDE | BDL (< 1 ) |
| 8 | trans-1,2-DICHLOROETHENE | BDL (< 1 ) |
| 9 | 1,1-DICHLOROETHANE | BDL (< 1 ) |
| 10 | CHLOROFORM | BDL (< 1 ) |
| 11 | 1,1,1-TRICHLOROETHANE | BDL (< 1 ) |
| 12 | 1,2-DICHLOROETHANE | 4.7 |
| 13 | BENZENE | BDL (< 1 ) |
| 14 | CARBON TETRACHLORIDE | BDL (< 1 ) |
| 15 | 1,2-DICHLOROPROPANE | BDL (< 1 ) |
| 16 | TRICHLOROETHENE | BDL (< 1 ) |
| 17 | BROMODICHLOROMETHANE | BDL (< 1 ) |
| 18 | cis-1,3-DICHLOROPROPENE | BDL (< 1 ) |
| 19 | TOLUENE | BDL (< 1 ) |
| 20 | trans-1,3-DICHLOROPROPENE | BDL (< 1 ) |
| 21 | 1,1,2-TRICHLOROETHANE | BDL (< 1 ) |
| 22 | DIBROMOCHLOROMETHANE | BDL (< 1 ) |
| 23 | TETRACHLOROETHENE | BDL (< 1 ) |
| 24 | CHLOROBENZENE | BDL (< 1 ) |
| 25 | ETHYLBENZENE | BDL (< 1 ) |
| 26 | BROMOFORM | BDL (< 1 ) |
| 27 | 1,1,2,2-TETRACHLOROETHANE | BDL (< 1 ) |
| 28 | 1,3-DICHLOROBENZENE | BDL (< 1 ) |
| 29 | 1,4-DICHLOROBENZENE | BDL (< 1 ) |
| 30 | 1,2-DICHLOROBENZENE | BDL (< 1 ) |
| 31 | XYLENES | BDL (< 3 ) |

BDL = BELOW DETECTION LIMITS

MICHAEL L. DOUGLASS
LABORATORY MANAGER

**Analysis in compliance with Environmental Protection Agency's SW846 Method 8260 GC/MS Volitiles Analysis**
**Capillary Column Type: [ phase: DB-624; ID: 530 uM; film: VTK; 3 uM film thickness ]**
**Enrichment: [ Tekmar concentrator with moisture control module and glass jet separator ]**

**BIO-CHEM**
**ENVIRONMENTAL**
**ANALYTICAL**
**LABORATORY**

PH 616/878-1188
Fax 616/878-0044
In Michigan 800/362-LABS

# ANALYTICAL RESULTS

DATE: May 18, 1993

CLIENT NAME:---------B&V WASTE SCIENCE
ATTN:----------------------RICHARD MCAVOY
ADDRESS:----------------101 N. WACKER DR. - SUITE 1100
CHICAGO, IL 60606

PROJECT:------------------ORGANIC CHEMICAL INC
PROJECT NO: -----------N/A
SAMPLE ID:--------------MW42 (94-99)
SAMPLE TYPE:----------AQUEOUS

DATE RECEIVED:---------- 5/17/93
ANALYSIS DATE:-----------5/18/93
QA/QC FILE NAME:------- MAY18624\0301003.D

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## RESULTS

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| | EPA 624 TARGET COMPOUNDS | RESULTS ( ug/L ) : ppb |
|---|---|---|
| 1 | VINYL CHLORIDE | BDL (< 1) |
| 2 | CHLOROMETHANE | BDL (< 1) |
| 3 | BROMOETHANE | BDL (< 1) |
| 4 | CHLOROETHANE | BDL (< 1) |
| 5 | TRICHLOROFLUOROMETHANE | BDL (< 1) |
| 6 | 1,1-DICHLOROETHENE | BDL (< 1) |
| 7 | METHYLENE CHLORIDE | BDL (< 1) |
| 8 | trans-1,2-DICHLOROETHENE | BDL (< 1) |
| 9 | 1,1-DICHLOROETHANE | BDL (< 1) |
| 10 | CHLOROFORM | BDL (< 1) |
| 11 | 1,1,1-TRICHLOROETHANE | BDL (< 1) |
| 12 | 1,2-DICHLOROETHANE | 3.9 |
| 13 | BENZENE | BDL (< 1) |
| 14 | CARBON TETRACHLORIDE | BDL (< 1) |
| 15 | 1,2-DICHLOROPROPANE | BDL (< 1) |
| 16 | TRICHLOROETHENE | BDL (< 1) |
| 17 | BROMODICHLOROMETHANE | BDL (< 1) |
| 18 | cis-1,3-DICHLOROPROPENE | BDL (< 1) |
| 19 | TOLUENE | BDL (< 1) |
| 20 | trans-1,3-DICHLOROPROPENE | BDL (< 1) |
| 21 | 1,1,2-TRICHLOROETHANE | BDL (< 1) |
| 22 | DIBROMOCHLOROMETHANE | BDL (< 1) |
| 23 | TETRACHLOROETHENE | BDL (< 1) |
| 24 | CHLOROBENZENE | BDL (< 1) |
| 25 | ETHYLBENZENE | BDL (< 1) |
| 26 | BROMOFORM | BDL (< 1) |
| 27 | 1,1,2,2-TETRACHLOROETHANE | BDL (< 1) |
| 28 | 1,3-DICHLOROBENZENE | BDL (< 1) |
| 29 | 1,4-DICHLOROBENZENE | BDL (< 1) |
| 30 | 1,2-DICHLOROBENZENE | BDL (< 1) |
| 31 | XYLENES | BDL (< 3) |

BDL = BELOW DETECTION LIMITS

MICHAEL L. DOUGLASS
LABORATORY MANAGER

**Analysis in compliance with Environmental Protection Agency's SW846 Method 8260 GC/MS Volitiles Analysis**
**Capillary Column Type: [ phase: DB-624; ID: 530 uM; film: VTK; 3 uM film thickness ]**
**Enrichment: [ Tekmar concentrator with moisture control module and glass jet separator ]**

BIO-CHEM
ENVIRONMENTAL
ANALYTICAL
LABORATORY

PH 616/878-1188
Fax 616/878-0044
In Michigan 800/362-LABS

# ANALYTICAL RESULTS

DATE: May 18, 1993

CLIENT NAME:---------B&V WASTE SCIENCE
ATTN:----------------------RICHARD MCAVOY
ADDRESS:----------------101 N. WACKER DR. - SUITE 1100
CHICAGO, IL 60606

PROJECT:-----------------ORGANIC CHEMICAL INC
PROJECT NO: -----------N/A
SAMPLE ID:--------------MW43 (60-65) BLANK
SAMPLE TYPE:----------AQUEOUS

DATE RECEIVED:---------- 5/17/93
ANALYSIS DATE:-----------5/17/93
QA/QC FILE NAME:------- MAY17624\0901009.D

*************************************************************************************

## RESULTS

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| | EPA 624 TARGET COMPOUNDS | RESULTS ( ug/L ) : ppb |
|---|---|---|
| 1 | VINYL CHLORIDE | BDL (< 1 ) |
| 2 | CHLOROMETHANE | BDL (< 1 ) |
| 3 | BROMOETHANE | BDL (< 1 ) |
| 4 | CHLOROETHANE | BDL (< 1 ) |
| 5 | TRICHLOROFLUOROMETHANE | BDL (< 1 ) |
| 6 | 1,1-DICHLOROETHENE | BDL (< 1 ) |
| 7 | METHYLENE CHLORIDE | BDL (< 1 ) |
| 8 | trans-1,2-DICHLOROETHENE | BDL (< 1 ) |
| 9 | 1,1-DICHLOROETHANE | BDL (< 1 ) |
| 10 | CHLOROFORM | BDL (< 1 ) |
| 11 | 1,1,1-TRICHLOROETHANE | BDL (< 1 ) |
| 12 | 1,2-DICHLOROETHANE | 3.6 |
| 13 | BENZENE | BDL (< 1 ) |
| 14 | CARBON TETRACHLORIDE | BDL (< 1 ) |
| 15 | 1,2-DICHLOROPROPANE | BDL (< 1 ) |
| 16 | TRICHLOROETHENE | BDL (< 1 ) |
| 17 | BROMODICHLOROMETHANE | BDL (< 1 ) |
| 18 | cis-1,3-DICHLOROPROPENE | BDL (< 1 ) |
| 19 | TOLUENE | BDL (< 1 ) |
| 20 | trans-1,3-DICHLOROPROPENE | BDL (< 1 ) |
| 21 | 1,1,2-TRICHLOROETHANE | BDL (< 1 ) |
| 22 | DIBROMOCHLOROMETHANE | BDL (< 1 ) |
| 23 | TETRACHLOROETHENE | BDL (< 1 ) |
| 24 | CHLOROBENZENE | BDL (< 1 ) |
| 25 | ETHYLBENZENE | BDL (< 1 ) |
| 26 | BROMOFORM | BDL (< 1 ) |
| 27 | 1,1,2,2-TETRACHLOROETHANE | BDL (< 1 ) |
| 28 | 1,3-DICHLOROBENZENE | BDL (< 1 ) |
| 29 | 1,4-DICHLOROBENZENE | BDL (< 1 ) |
| 30 | 1,2-DICHLOROBENZENE | BDL (< 1 ) |
| 31 | XYLENES | BDL (< 3 ) |

BDL = BELOW DETECTION LIMITS

MICHAEL L. DOUGLASS
LABORATORY MANAGER

**Analysis in compliance with Environmental Protection Agency's SW846 Method 8260 GC/MS Volitiles Analysis**
**Capillary Column Type: [ phase: DB-624; ID: 530 uM; film: VTK; 3 uM film thickness ]**
**Enrichment: [ Tekmar concentrator with moisture control module and glass jet separator ]**

BIO-CHEM
ENVIRONMENTAL
ANALYTICAL
LABORATORY

PH 616/878-1188
Fax 616/878-0044
In Michigan 800/362-LABS

# ANALYTICAL RESULTS

DATE: May 24, 1993

CLIENT NAME:----------B&V WASTE SCIENCE
ATTN:----------------------ROBERT LANTZ
ADDRESS:------------------101 N. WACKER DR. - SUITE 1100
CHICAGO, IL 60606

PROJECT:------------------OCI
PROJECT NO: ------------ 70160.125
SAMPLE ID:---------------BIO-CHEM BLANK WATER
SAMPLE TYPE:----------AQUEOUS

DATE RECEIVED:---------- 5/20/93
ANALYSIS DATE:-----------5/20/93
QA/QC FILE NAME:-------- 524MAR\0701001.D

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## RESULTS

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| | EPA 624 TARGET COMPOUNDS | RESULTS ( ug/L ) : ppb |
|---|---|---|
| 1 | VINYL CHLORIDE | BDL (< 1 ) |
| 2 | CHLOROMETHANE | BDL (< 1 ) |
| 3 | BROMOETHANE | BDL (< 1 ) |
| 4 | CHLOROETHANE | BDL (< 1 ) |
| 5 | TRICHLOROFLUOROMETHANE | BDL (< 1 ) |
| 6 | 1,1-DICHLOROETHENE | BDL (< 1 ) |
| 7 | METHYLENE CHLORIDE | BDL (< 1 ) |
| 8 | trans-1,2-DICHLOROETHENE | BDL (< 1 ) |
| 9 | 1,1-DICHLOROETHANE | BDL (< 1 ) |
| 10 | CHLOROFORM | BDL (< 1 ) |
| 11 | 1,1,1-TRICHLOROETHANE | BDL (< 1 ) |
| 12 | 1,2-DICHLOROETHANE | BDL (< 1 ) |
| 13 | BENZENE | BDL (< 1 ) |
| 14 | CARBON TETRACHLORIDE | BDL (< 1 ) |
| 15 | 1,2-DICHLOROPROPANE | BDL (< 1 ) |
| 16 | TRICHLOROETHENE | BDL (< 1 ) |
| 17 | BROMODICHLOROMETHANE | BDL (< 1 ) |
| 18 | cis-1,3-DICHLOROPROPENE | BDL (< 1 ) |
| 19 | TOLUENE | BDL (< 1 ) |
| 20 | trans-1,3-DICHLOROPROPENE | BDL (< 1 ) |
| 21 | 1,1,2-TRICHLOROETHANE | BDL (< 1 ) |
| 22 | DIBROMOCHLOROMETHANE | BDL (< 1 ) |
| 23 | TETRACHLOROETHENE | BDL (< 1 ) |
| 24 | CHLOROBENZENE | BDL (< 1 ) |
| 25 | ETHYLBENZENE | BDL (< 1 ) |
| 26 | BROMOFORM | BDL (< 1 ) |
| 27 | 1,1,2,2-TETRACHLOROETHANE | BDL (< 1 ) |
| 28 | 1,3-DICHLOROBENZENE | BDL (< 1 ) |
| 29 | 1,4-DICHLOROBENZENE | BDL (< 1 ) |
| 30 | 1,2-DICHLOROBENZENE | BDL (< 1 ) |
| 31 | XYLENES | BDL (< 3 ) |

BDL = BELOW DETECTION LIMITS

MICHAEL L. DOUGLASS
LABORATORY MANAGER

Analysis in compliance with Environmental Protection Agency's SW846 Method 8260 GC/MS Volitiles Analysis
Capillary Column Type: [ phase: DB-624; ID: 530 uM; film: VTK; 3 uM film thickness ]
Enrichment: [ Tekmar concentrator with moisture control module and glass jet separator ]

BIO-CHEM
ENVIRONMENTAL
ANALYTICAL
LABORATORY

# ANALYTICAL RESULTS
DATE: May 21, 1993

PH 616/878-1188
Fax 616/878-0044
In Michigan 800/362-LABS

CLIENT NAME:----------B&V WASTE SCIENCE
ATTN:------------------------ROBERT LANTZ
ADDRESS:----------------101 N. WACKER DR. - SUITE 1100
CHICAGO, IL 60606

PROJECT:------------------OCI
PROJECT NO: ------------ 70160.125
SAMPLE ID:---------------OCI VIALS - BIO-CHEMS WATER
SAMPLE TYPE:----------AQUEOUS

DATE RECEIVED:---------- 5/20/93
ANALYSIS DATE:-----------5/20/93
QA/QC FILE NAME:------- 524MAR\0801001.D

## RESULTS

| | EPA 624 TARGET COMPOUNDS | RESULTS ( ug/L ) : ppb |
|---|---|---|
| 1 | VINYL CHLORIDE | BDL (< 1 ) |
| 2 | CHLOROMETHANE | BDL (< 1 ) |
| 3 | BROMOETHANE | BDL (< 1 ) |
| 4 | CHLOROETHANE | BDL (< 1 ) |
| 5 | TRICHLOROFLUOROMETHANE | BDL (< 1 ) |
| 6 | 1,1-DICHLOROETHENE | BDL (< 1 ) |
| 7 | METHYLENE CHLORIDE | BDL (< 1 ) |
| 8 | trans-1,2-DICHLOROETHENE | BDL (< 1 ) |
| 9 | 1,1-DICHLOROETHANE | BDL (< 1 ) |
| 10 | CHLOROFORM | BDL (< 1 ) |
| 11 | 1,1,1-TRICHLOROETHANE | BDL (< 1 ) |
| 12 | 1,2-DICHLOROETHANE | 6.6 |
| 13 | BENZENE | BDL (< 1 ) |
| 14 | CARBON TETRACHLORIDE | BDL (< 1 ) |
| 15 | 1,2-DICHLOROPROPANE | BDL (< 1 ) |
| 16 | TRICHLOROETHENE | BDL (< 1 ) |
| 17 | BROMODICHLOROMETHANE | BDL (< 1 ) |
| 18 | cis-1,3-DICHLOROPROPENE | BDL (< 1 ) |
| 19 | TOLUENE | BDL (< 1 ) |
| 20 | trans-1,3-DICHLOROPROPENE | BDL (< 1 ) |
| 21 | 1,1,2-TRICHLOROETHANE | BDL (< 1 ) |
| 22 | DIBROMOCHLOROMETHANE | BDL (< 1 ) |
| 23 | TETRACHLOROETHENE | BDL (< 1 ) |
| 24 | CHLOROBENZENE | BDL (< 1 ) |
| 25 | ETHYLBENZENE | BDL (< 1 ) |
| 26 | BROMOFORM | BDL (< 1 ) |
| 27 | 1,1,2,2-TETRACHLOROETHANE | BDL (< 1 ) |
| 28 | 1,3-DICHLOROBENZENE | BDL (< 1 ) |
| 29 | 1,4-DICHLOROBENZENE | BDL (< 1 ) |
| 30 | 1,2-DICHLOROBENZENE | BDL (< 1 ) |
| 31 | XYLENES | BDL (< 3 ) |

BDL = BELOW DETECTION LIMITS

MICHAEL L. DOUGLASS
LABORATORY MANAGER

Analysis in compliance with Environmental Protection Agency's SW846 Method 8260 GC/MS Volitiles Analysis
Capillary Column Type: [ phase: DB-624; ID: 530 uM; film: VTK; 3 uM film thickness ]
Enrichment: [ Tekmar concentrator with moisture control module and glass jet separator ]

# APPENDIX I

# GEOPHYSICAL INVESTIGATION REPORT

Gartner
Lee

*Professional Services in Environmental Management*

Gartner
Lee

# Geophysical Investigation
# Organic Chemicals Superfund Site
# Grandville, Michigan

Prepared by:

Gartner Lee, Inc.
105 Main Street
Niagara Falls, NY, 14303

Prepared for:

B&V Waste Science & Technology Corp.
230 West Monroe
Chicago, IL 60606

Project No. 92-801

April 3, 1992

Distribution: Client - 4
File - 2

**Gartner Lee, Inc.**

105 Main Street
Niagara Falls, NY 14303
Fax (716) 285-8275

(716) 285-5448

*Professional Services in Environmental Management*

April 2, 1992

Mr. Richard McAvoy
B&V Waste Science and Technology Corp.
230 West Monroe
Suite 2250
Chicago, IL 60606

Dear Mr. McAvoy:

Re: Geophysical Investigation, Organic Chemicals Superfund Site, Grandville, Michigan

## 1.0 Introduction, Background Information, Purpose and Scope

On March 9th through March 13th, 1992, an electromagnetic (EM) survey was performed at the Organic Chemicals Superfund Site in Grandville, Michigan.

The Organic Chemicals, Inc. (OCI) facility is an abandoned chemical manufacturing and solvent recovery operation. The OCI facility operated from 1969 to 1991 at this location. The OCI site property was previously utilized as a bulk petroleum terminal and crude oil refinery. The area to the north and northwest of the OCI facility was mined for sand and gravel. After mining operations were completed, the area was backfilled with construction and demolition debris, foundry sand, and other solid wastes. Areas of concrete, metal and re-enforcement bar were noted at surface in these previously mined areas during data collection. A sewer line was also noted north of the OCI facility. The sewer line appeared to trend east-west as defined by manholes located approximately 500 feet apart. The sewer line appeared to mark the southern boundary of landfilling in the areas northwest of the OCI facility.

The geology of the site, as defined by test borings and monitor wells located in and around the site, is as follows:

- Near surface sand and gravel layer with lesser amounts of silty sands, clayey sands clayey silts and silts. This unit is believed to be continuous across the site with varying thicknesses of 4 to 41 feet;

snow covered construction and demolition debris fill, an east-west trending buried sewer line, fences, buildings and other anthropogenic features, data were only collected in profile format at this site.

A base line was established that trended approximately S3°W with a Sokkia Automatic Level, stadia rod and tape measure. The base line was referenced to existing structures and the eastern edge of pavement of Sanford Avenue. The base line was designated Line 1 and each additional profile line was referenced to it. Profile Line 1 through Line 6 were staked at 50 foot intervals with alternating colors of red and yellow wire survey flags (Figure 1).

Survey Line 7 was established at the request of B&V personnel (Figure 1). It was requested that data be collected along the eastern property boundary of the adjacent, abandoned Hagar-Busch Facility. Line 7 was established and staked using the EM34-3XL's 20 meter reference cable as a chain. Line 7 was staked at 65.6 foot (20 meter) intervals with red wire survey flags. Line 7 was subsequently tied into the existing reference grid. Individual stations were referenced to the eastern property boundary of the Hagar-Busch facility.

Each data point collected on-site was referenced to the survey grid in units of feet. The coordinates of each station were translated into true northings and eastings utilizing the software package GEOSOFT. The coordinates were then re-translated by rotating the grid 30° at station location 0 North, 0 East. The grid translation was performed so that the grid could be scaled and matched to an aerial photograph provided by B&V (Figure 1). It should be noted that as a result of the coordinate grid translation, the station values labelled on the flags at the site no longer match the grid coordinates of Figure 1.

Upon completion of the geophysical survey, relative elevation data were recorded at 100 foot horizontal increments. The relative elevation data were referenced to the top of the sewer manhole located approximately 275 feet south along Line 1.

Relative elevation data is important when interpreting stratigraphy with EM equipment as changes in elevation may result in changes in observed apparent soil conductivities. Relative elevation data were collected along survey lines that were free of surface or near surface buried metals. Relative elevation data were not recorded along profile Line 3 and the northern most 275 feet of profile Line 1 due to problems associated with the presence of fill and near surface metals.

## 2.2 EM34-3XL Survey

A Geonics EM34-3XL Frequency Domain Terrain Conductivity meter was used to collect apparent conductivity data along the seven profile lines (designated Line 1 through Line 7, Figure 1). Data were collected at 25 foot station increments along profile Lines 1 through 6, and at 65.6 foot (20 m) increments along Line 7.

The EM34-3XL device is equipped with a transmitter coil and a receiver coil that can be separated by 10, 20 or 40 meter intercoil spacings. The instruments depth of investigation is dependant upon coil separation and dipole orientation. Data are collected with the receiver and transmitter coils' dipoles oriented either both vertically or horizontally.

The EM34-3XL was used to measure the quadrature component of the electromagnetic field at each station. The quadrature component data are a measurement of the apparent ground conductivity in units of milliSiemens per meter (mS/m). The quadrature component data are representative of changes in the electrical conductivity of pore fluids, the presence of buried metals and fills, soil types, changes in bedrock lithology, and the presence of saturated bedrock fractures and faults.

Data were collected at 10 and 20 meter intercoil spacings and in the horizontal and vertical dipole mode at the OCI site. The approximate depth of investigation for the EM34-3XL is 0.75 times the intercoil spacing when the dipoles are oriented horizontally and 1.50 times the intercoil spacing when the dipoles are oriented vertically. The depth of investigation for the various dipole orientations and intercoil spacings for data collected at the OCI site are as follows:

- 10 meter intercoil spacing, horizontal dipole mode: surface to 7.5 meters.
- 10 meter intercoil spacing, vertical dipole mode: near surface to 15 meters.
- 20 meter intercoil spacing, horizontal dipole mode: surface to 15 meters.
- 20 meter intercoil spacing, vertical dipole mode: near surface to 30 meters.

A base station was established on-site that was believed to be free of fill, surface metal or other sources of potential signal interference. The EM34-3XL was calibrated at the base station twice daily following procedures specified in the operations manual. Readings were periodically taken at previously surveyed stations to check for instrument drift and malfunction. Readings were automatically stored in a solid state data logger and recorded by hand during the survey. The data logger was interfaced daily to a portable laptop computer and the data were transferred to a floppy disk for subsequent processing and interpretation.

## 2.3 EM31-DL Survey

It was noted during the site reconnaissance that areas of fill were present across the site. To better identify these areas of fill and to gain information on the apparent conductivities of the near surface soils, Gartner Lee mobilized a Geonics EM31-DL Frequency Domain Terrain Conductivity meter to the site. The EM31-DL, which has a depth of exploration of approximately 12 to 15 feet, was used to supplement the data collected from the deeper investigating EM34-3XL survey.

A total of 1,995 data points were collected along survey lines 1 through 7 with the EM31-DL and solid state data logger. Quadrature and in-phase data were simultaneously collected at virtually continuous intervals (approximately every 2 to 3 feet) along the survey lines. The quadrature component data, as mentioned above, are a measurement of the apparent ground conductivity. Quadrature component data were collected in units of mS/m. The EM31-DL also records the in-phase component of the electromagnetic field measured in units of parts per thousand (ppt). The in-phase component data are susceptible to the presence of electrically conductive materials such as metals. All readings with the EM31-DL were taken with the instrument oriented parallel to the direction of travel, in the vertical dipole mode and with the instrument at waist height.

The EM31-DL was calibrated daily at an established base station following procedures specified in the operations manual. Readings were automatically stored in a solid state data logger during the survey. The data logger was interfaced to a portable computer and the data were transferred to a floppy disk for subsequent processing and interpretation.

## 2.4 Data Reduction

Both EM34-3XL and EM31-DL data were edited and analyzed utilizing the Geonics software packages DAT34-3/DAT31Q respectively. Additional survey line editing was then performed using the software LOTUS 123 and GEOSOFT. Line and station locations were then transformed, scaled and plotted as Figure 1 using the software package GEOSOFT. GEOSOFT was also used to grid, low pass filter and color contour the EM34-3XL 20 meter horizontal dipole data as presented in Figure 2. Data were interpretated and presented as profile plots utilizing the software package GRAPHER. The EM34-3XL, EM31-DL and the relative elevation data are presented as Figures 3 through 16. Observed anomalies are annotated on each figure and a brief discussion of our interpretations are presented in Section 3.1.

## 3.0 Results

The purpose of the geophysical investigation was to define areas where the clay layer thins or is absent beneath the site. The near surface sand and gravel soils and the limestone bedrock typically produce low apparent conductivity responses with EM equipment. Saturated clays tend to produce relatively high apparent conductivity responses with EM equipment. Due to this apparent conductivity contrast, areas where the clay layer thins or is discontinuous should produce a relatively low apparent conductivity (high apparent resistivity) response. Unfortunately, the presence of fill material, buried metals and/or ground water contamination can make identifying a stratigraphic unit such as a clay layer difficult with EM equipment.

### 3.1 EM34-3XL and EM31-DL Survey Results

The EM34-3XL and EM31-DL surveys revealed five apparent conductivity lows that may be associated with a thinning of the clay layer. These observed apparent low conductivity anomalies were observed along Lines 1, 2, 4, 6 and 7. Due to the fill material present along the northern portion of Lines 1 and 5, the eastern extent of Line 4 and the entire length of Line 3, a determination as to the presence or absence of a clay layer could not accurately be made.

The following is a discussion of the observed anomalies noted along each profile line. Observed anomalies are annotated with capital letters for horizontal dipole anomalies and small case letters for vertical anomalies.

#### Color Contours of the 20 Meter EM34-3XL Horizontal Site Data (Figure2)

Figure 2 is a color contour representation of the EM34-3XL 20 meter horizontal data for the site. Shades of green and green-yellow appear to represent background conditions. Shades of dark greens and blue-greens are believed to be representative of the thinning clay layer and/or thickening sand lenses. Shades of reds and purples are representative of fill material, buried metallic debris and conductive or contaminated soils.

An acetate overlay of a site aerial photograph is provided in the back pocket of the report. This overlay was created to use with Figure 2 to gain a better understanding of the anomalies locations relative to monitoring wells and other known structures.

Line 1 (Figure 2, Figures 3 and 4)

Line 1 was located on the west side of the site and trended approximately north-south (Figure 1). Data were collected in a south to north direction. An east-west trending sewer line was located at line position 175 South. Fill and surface metal was observed along the northern-most portions of this survey line. The following anomalies were observed:

(A,a) Anomaly "A,a" was observed to be a broad smooth apparent conductivity low. This anomaly is shown in shades of blue-green in Figure 2. This anomaly was observed in the EM31-DL data, EM34-3XL horizontal data and to a lesser extent in the EM34-3XL vertical data (Figures 3 and 4). Test boring B-27A, SB-6 and monitor MW-8 were in the vicinity of this anomaly. These drilling logs show the presence of a clay layer at a depth of 12 to 17.5 feet, 12.5 to 16.5 feet and 13 to 18 feet, respectively. The near surface layer is described in the log of MW-8 as a silty gravel. It was observed that a two foot thick sand lens was observed at 7 to 9 feet below grade at MW-8. Bedrock was confirmed in boring SB-6 at a depth of 16.5 feet. This anomaly may represent a thinning of the clay layer, an increase in the thickness of the sand lens, or both.

(B,b) Anomaly "B,b" was observed as an extremely "noisy" signal response as a result of the presence of fill and buried metals. Anomaly "B" is shown in shades of yellow and red (Figure 2). This response was noted between station locations 0 North and -200 North. It appeared that the presence of an east-west trending sewer marked the southern boundary of the filled area at this location.

Line 2 (Figure 2, Figures 5 and 6)

Line 2 was an east-west trending survey line located in the western area of the site (Figure 1). Line 2 appeared to be free of surface metal or fill. Buried utilities and above ground power lines that parallel Sanford Avenue were noted near the western extent of the survey line. These services appeared to only cause signal interference on the 20 meter vertical data at the two western most stations. The following anomalies were observed:

(C) Apparent conductivity values appeared to decrease as the survey line trended west. Anomaly "C" is shown in shades of green and blue-greens (Figure 2). Monitor MW-12 was noted in the vicinity of this survey line. Clay was noted at 18.0 to 18.5 feet below surface. The boring terminated at 18.5 feet below surface. A sand lense was noted at 9.0 to 15.5 feet below surface and a gravel layer was noted at 15.5 to 18 feet below surface. Anomaly "C" may be due to the presence of a thinning clay layer or a thickening sand and gravel lens or both.

(c) Anomaly "c" was noted in the 20 meter intercoil spacing vertical dipole data. Overhead power lines and a buried water line were noted along Sanford Avenue. Anomaly "c" was observed as a conductivity high, possibly due to the presence of overhead power lines and buried utilities noted along Sanford Avenue.

Line 3 (Figure 2, Figures 7 and 8)

Line 3 was an east-west trending survey line that was located in an area that was previously mined and backfilled (Figure 1). The near surface material appeared to contain concrete, re-enforcement bar and other debris. Extreme signal interference (signal noise) was observed with the EM equipment at this location. Relative elevation data were not collected along this line due to the observed signal interference. The signal interference was probably due to areas of buried metallic objects or other highly conductive material within the fill at this location.

**(D,d)** Anomaly "D,d" was observed as a conductivity high in the horizontal dipole orientation and as a negative response in the vertical dipole orientation. Anomaly "D" is shown is shades of purple on Figure 2. This anomaly was located along the western extent of Line 3. Monitors MW-14 and SB-10 were located west and east of this anomaly respectively. This anomaly is probably due to the presence of surface and buried metallic objects and/or contaminated, highly conductive soils.

**(E,e)** Anomaly "E,e" was observed as a conductivity high in the horizontal dipole orientation and as a negative response in the vertical dipole orientation. Anomaly "E" is shown in shades of purple on Figure 2. A truck frame was noted approximated 50 feet north of this anomaly and may have contributed to the observed values. Anomaly "E,e" is probably due to the presence of surface metals and large buried metallic objects, and/or highly conductive contaminated fill material.

**(F,f)** Anomaly "F,f" was observed as a conductivity high in the horizontal dipole orientation and as a negative response in the vertical dipole orientation. Anomaly "F" is shown in shades of reds and yellows on Figure 2. This anomaly was observed west of monitors SB-8/MW-10. Steel re-enforcement bar was observed at surface near this anomaly. This anomaly is probably due to surface and buried metallic objects and/or highly conductive contaminated fill material.

Line 4 (Figure 2, Figures 9 and 10)

Line 4 was an east-west trending survey line that was located north of the Hagar-Busch and OCI facilities (Figure 1). It appeared that sand and gravel mining activity may have occurred near the center of the survey line. The eastern areas of the survey line contained hummocky areas and some surface debris was noted. These areas may have received fill material.

**(G,g)** Anomaly "G,g" was observed as a broad conductivity low in the horizontal and vertical dipole data. Anomaly "G" is shown in shades of blue-green on Figure 2. This anomaly may be due to the presence of a thinning clay layer or a thickening sand lense.

**(H,h)** Anomaly "H,h" was observed as a "noisy" conductivity high in the horizontal dipole data and the EM31-DL data. A strong negative response was noted in the vertical dipole data and the EM31-DL data at the eastern extent of the survey line. Anomaly "H" is shown in shades of green-yellows on Figure 2. Monitors MW-5 and MW-6 were noted in the vicinity of these anomalies. Fill was noted at boring MW-6 and stained soils with strong hydrocarbon odors were noted on both boring logs. Some surface debris and surface metals were noted in the vicinity of MW-6. These anomalies are probably representative of fill material, contaminated soils and ground water, and/or surface and buried metallic objects.

Line 5 (Figure 2, Figures 11 and 12)

Line 5 was a north-south trending survey line located north of the OCI facility (Figure 1). A three to four foot rise was noted near the northern extent of the survey line. An east west trending sewer line was crossed near station 875 South. It appeared that the northern extent of this line may have received fill material.

**(I,i)** Anomaly "I,i", was observed as "noisy" apparent conductivity highs in the horizontal and vertical dipole data. Anomaly "I" is shown as shades of yellow and green-yellow on Figure 1. The signal interference at this anomaly location probably represents the presence of fill, contaminated soils and/or buried metallic debris.

Line 6 (Figure 2, Figures 13 and 14)

Line 6 was located along an access road in the central area of the site (Figure 1). Line 6 trends approximately north-south.

(J) A conductivity low was observed in the 20 meter horizontal data at this location. This anomaly is represented as shades of green on Figure 2. The drilling logs for Monitors MW-9 and SB-7 indicate that the near surface soils are gravel with some silt. The clay is present at 13.5 to 16.5 and 11.5 to 15.5 feet below surface respectively. Bedrock was confirmed in boring SB-7 at 15.5 feet below surface. A sand lens was not observed in either boring log. The 10 meter horizontal data and the EM31-DL data were "noisy" at this location. The "noisy" response suggests that near surface fill may be present. This anomaly may be due to the thinning of the clay layer at this location.

(j) A "noisy" vertical dipole signal response was observed at this line location. This "noisy" response is probably due to the presence of near surface fill.

### Line 7 (Figure 2, Figures 15 and 16)

Line 7 was located along the eastern property boundary within the abandoned Hagar-Busch facility (Figure 1). Fill materials were noted at the northern extent of the survey line.

(K,k) Anomaly "K,k" was observed as an apparent conductivity low at the southern end of Line 7 (Figure 1). The anomaly is represented as shades of blue-greens on Figure 2. A "noisy" signal response was observed with the EM31-DL at this location which suggests the presence of near surface fill. Monitors MW-3 and MW-19 were noted in the vicinity of the observed anomaly. The drilling log for MW-19 revealed a silty gravel deposit near surface with a sand layer from 10.0 to 17.5 feet below surface. Two silty clay layers were observed from 21.0 to 23.5 and from 27 to 44 feet below surface. The drilling log for MW-3 revealed a near surface silty gravel deposit with a sand lens present from 8.0 to 16.5 feet below surface. A silty clay unit was observed from 18.5 to 22.0 feet below surface. Anomaly "K,k" may represent an increase in the thickness of the sand layer and/or a thinning/deepening of the clay layer.

(L,l) Anomaly "L,l" was observed as an apparent conductivity low at the northern extent of Line 7 (Figure 1). This anomaly is represented as shades of blue-green on Figure 2. An increase in surface elevation was noted at the northern end of the survey line as a result of the presence of fill. A "noisy" signal response was observed in the EM31 and the EM34-3XL vertical dipole data. This anomaly is probably due to the presence of fill material.

## 4.0 Conclusions and Recommendations

Five anomalies were identified during this investigation that may be related to a thinning clay layer or the presence of thickening sand lenses. These anomalies are A, C, G, J and K (Figure 2). As the data were collected profile format, it was difficult to determine if the anomalies were due to sand lenses or thinning clay layers. It was also difficult to determine the trend of these anomalies and the extent to which they are laterally continuous.

Fill materials, buried metals and/or possible contaminated soils/ground waters were observed at anomaly locations B, D, E, F, H, I and L (Figure 2). Line 3 and the northern extents of Lines 1 and 5 are believed to be located over fill materials (Figure 1). Line 3 appeared to contain areas of large, buried metallic objects and/or very conductive soils. Areas of fill with buried metals appeared to be laterally extensive along the northern areas of the site.

Signal interference was observed along the northern extent of Lines 1 and 7 due to the presence of surface metals and fill materials.

The following recommendations are provided for your consideration:

1). Anomalies A, C, G, and J may represent areas of thinning clay layers or thickening sand lenses. These anomalous areas should be drilled or test pitted to confirm the EM responses.

2). The site should be cleared of dense vegetation and resurveyed with the EM equipment at regular line and station spacings. A color contour map of the EM results could then be produced in plan view which would allow for a better understanding of the lateral continuity of the clay layer and the sand lenses.

3). An EM31-DL survey should be performed over the northern areas of the site to define the lateral extent of contaminated soils related to landfilling operations. The EM31-DL survey would also allow for the identification of areas of buried metals possibly representative of drums or other waste.

4). From a health and safety perspective, any future monitors or test borings planned in or around areas of the site thought to have received fill should be screened for buried metallic hazards with an EM31-DL.

5). Consideration should be given to performing down-hole induction and natural gamma logging with a Geonics EM39 to gain information concerning the actual conductivities of the stratigraphic layers. This survey would allow the site to be modelled such that stratigraphic target layer depths could be estimated. A down-hole induction survey in existing PVC monitors may also provide important information on screen locations relative to conductive contaminated ground water.

At this time we would like to thank B&V for involving us in this most interesting study. If there are any questions or comments please feel free to contact our office.

Respectfully submitted,

GARTNER LEE, INC.

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DD Slaine

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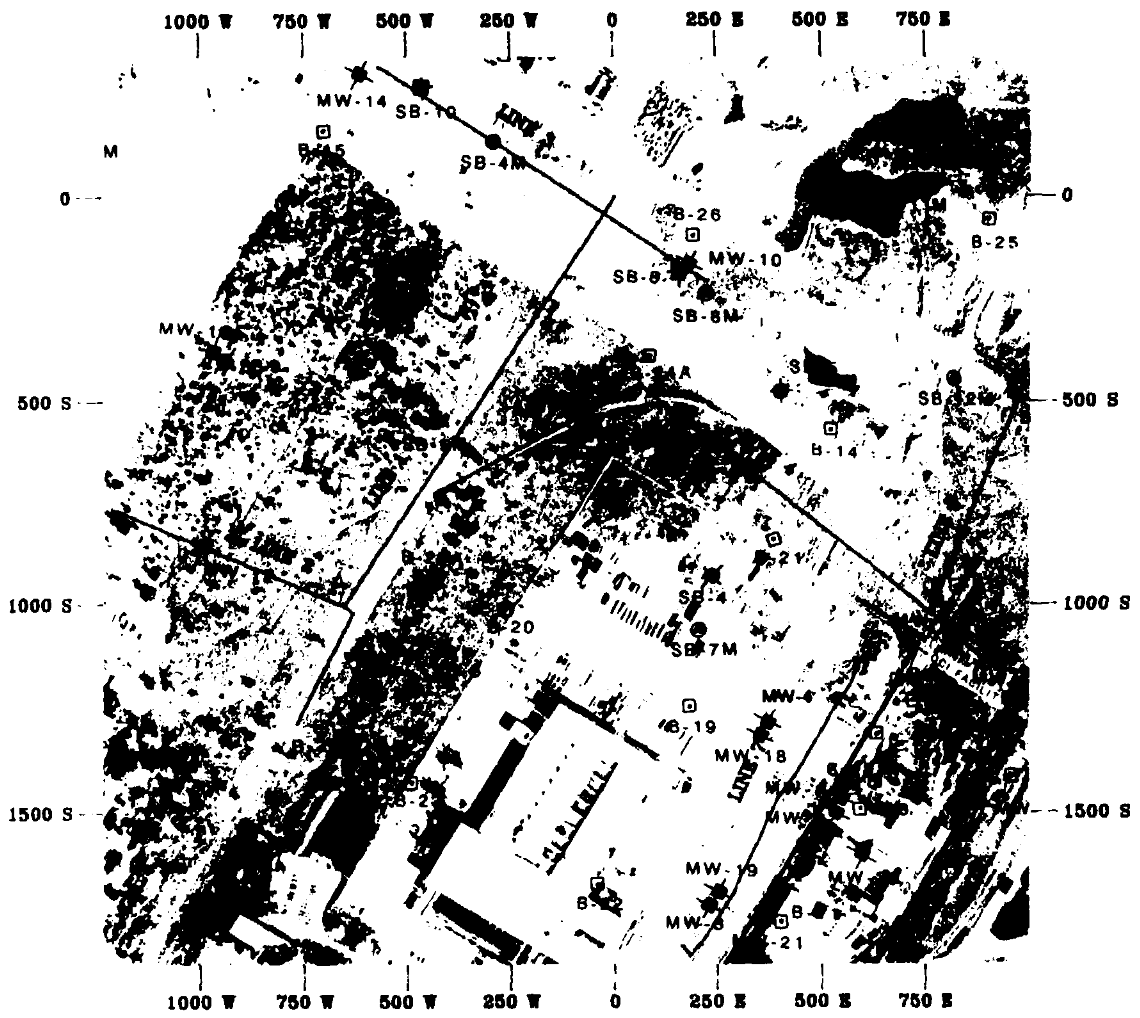
TEJ/DDS:pmk

# FIGURES



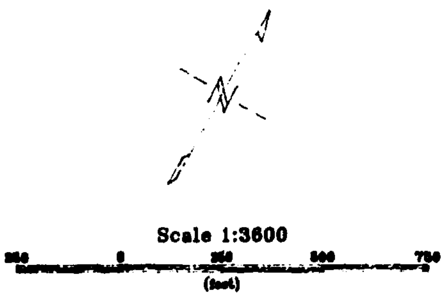
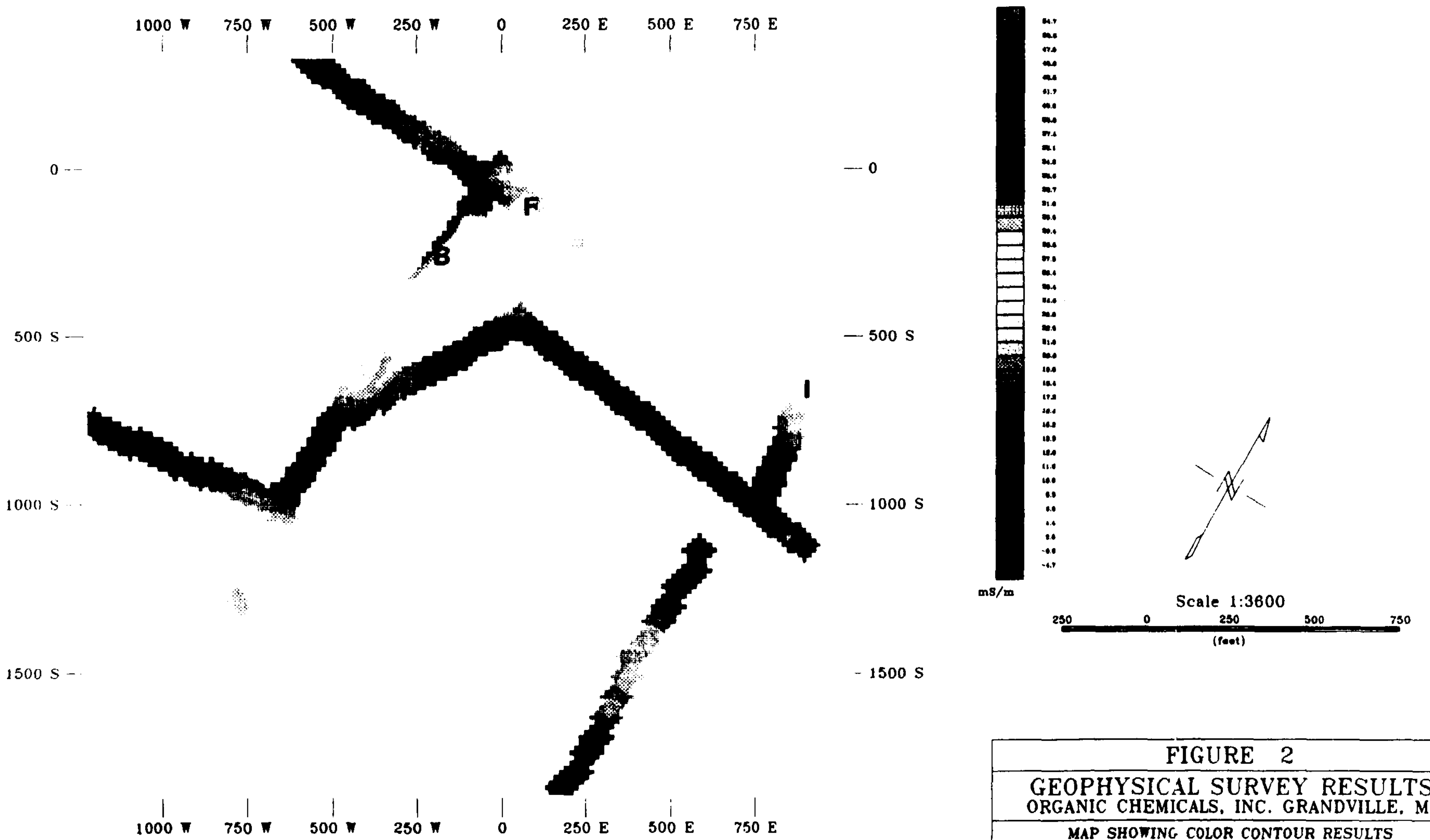


FIGURE 1

GEOPHYSICAL SURVEY RESULTS
ORGANIC CHEMICALS, INC. GRANDVILLE, MI

MAP SHOWING EM31 AND EM34-3XL
SURVEY LINE LOCATIONS
MARCH 1992 PROJECT #92601

*GARTNER LEE, INC. NIAGARA FALLS, NY*



# FIGURE 2

## GEOPHYSICAL SURVEY RESULTS

ORGANIC CHEMICALS, INC. GRANDVILLE, MI

MAP SHOWING COLOR CONTOUR RESULTS
EM34-3XL 20 METER HORIZONTAL DIPOLE DATA
MARCH 1992 PROJECT #92801

*GARTNER LEE, INC. NIAGARA FALLS, NY*

# GEOPHYSICAL SURVEY RESULTS
# ORGANIC CHEMICALS SITE, GRANDVILLE, MI
## LINE 1
## HORIZONTAL DIPOLE DATA

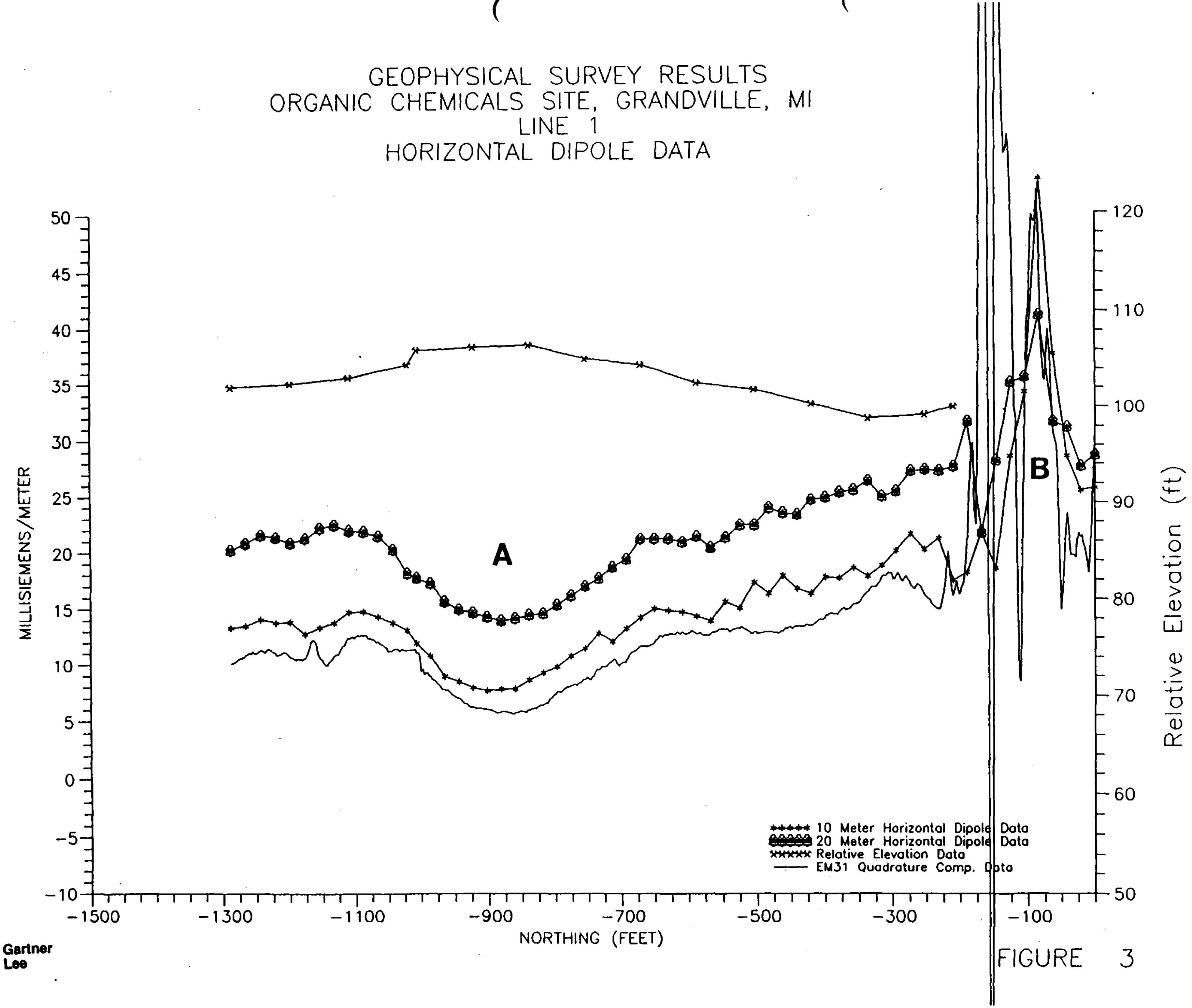


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FIGURE 3

# GEOPHYSICAL SURVEY RESULTS
# ORGANIC CHEMICALS SITE, GRANDVILLE, MI
## LINE 1
## VERTICAL DIPOLE DATA

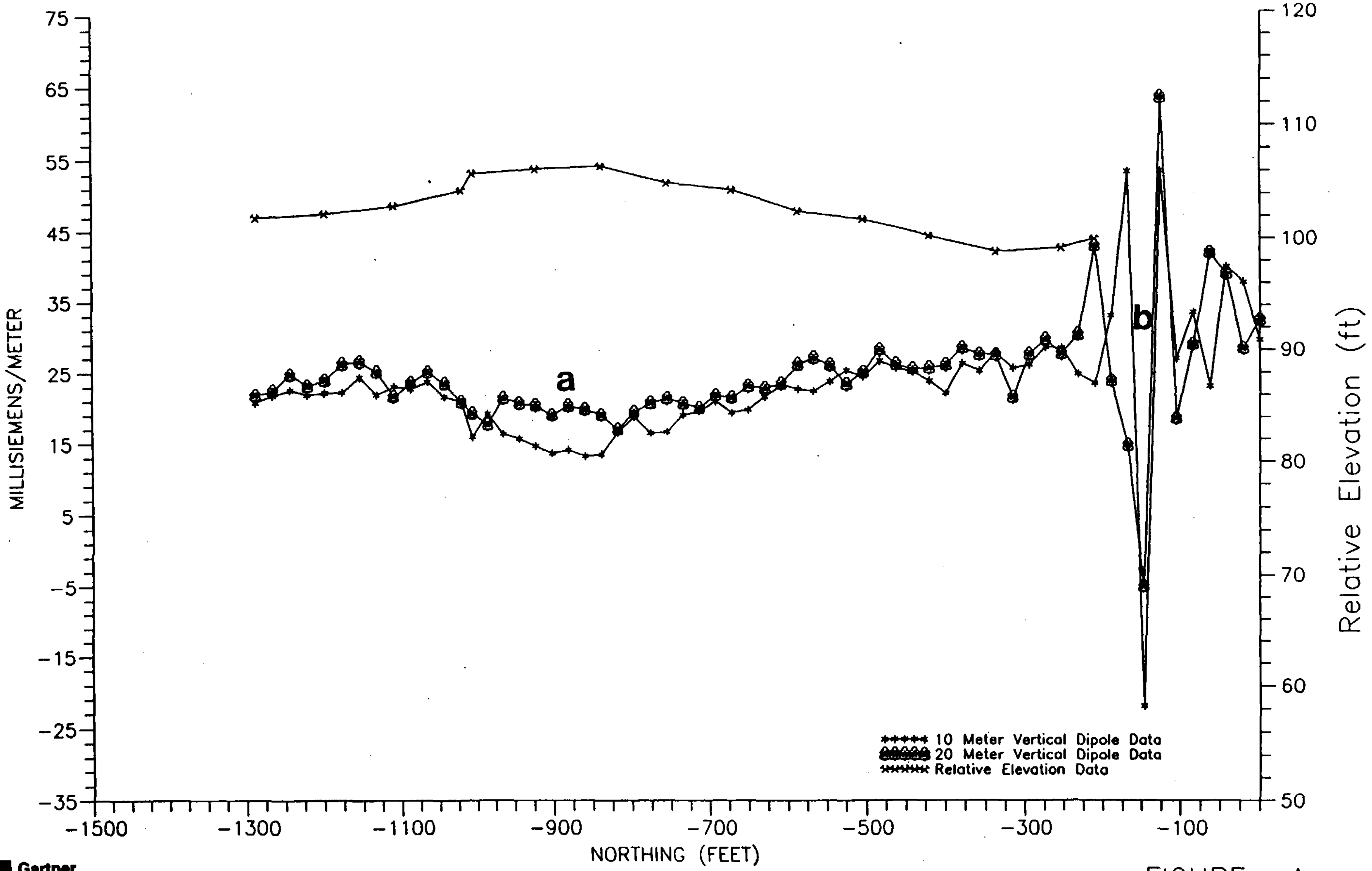

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FIGURE 4

# GEOPHYSICAL SURVEY RESULTS
# ORGANIC CHEMICALS SITE, GRANDVILLE, MI
## LINE 2
## HORIZONTAL DIPOLE DATA

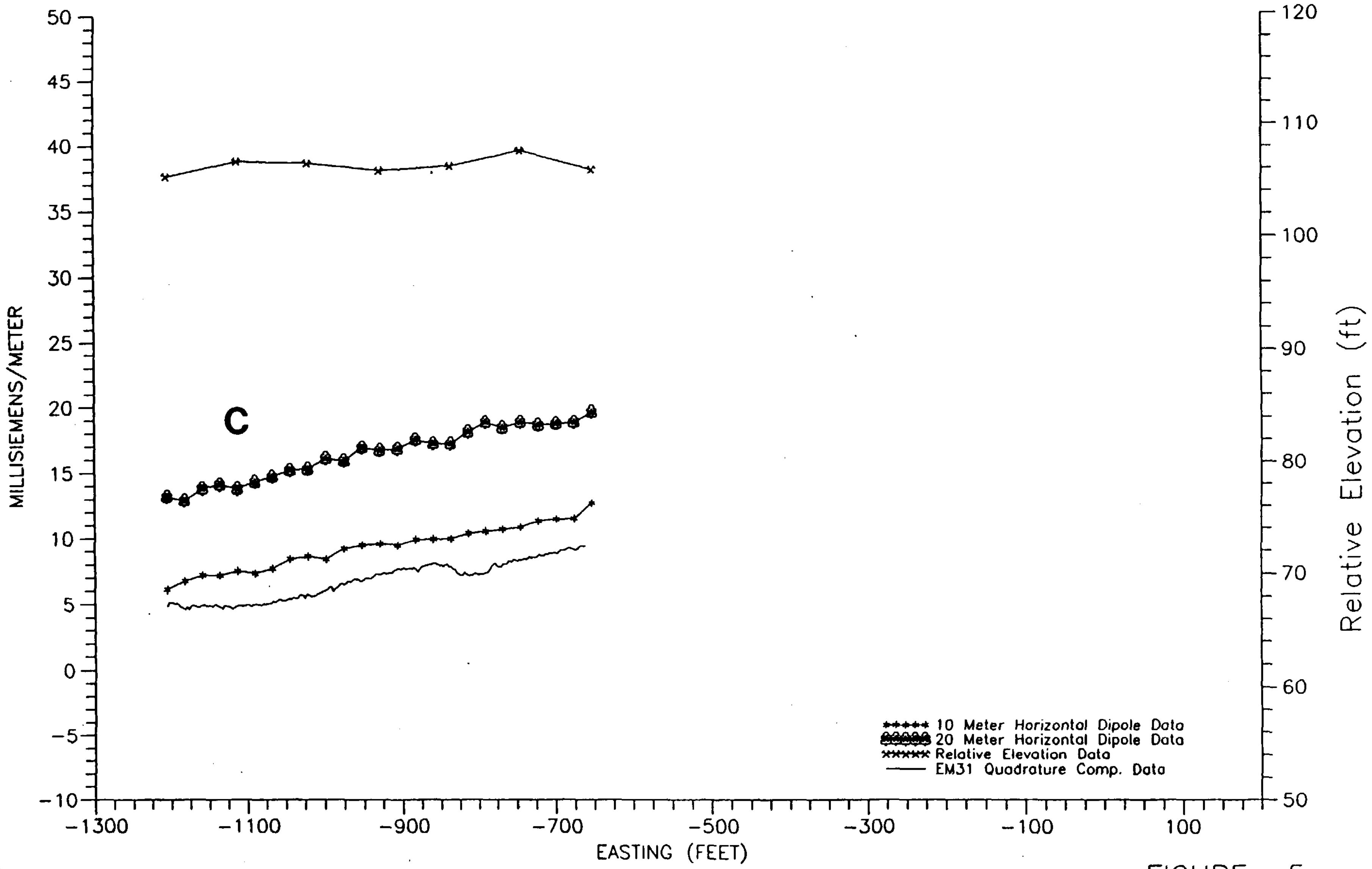

FIGURE 5

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# GEOPHYSICAL SURVEY RESULTS
# ORGANIC CHEMICALS SITE, GRANDVILLE, MI
## LINE 2
## VERTICAL DIPOLE DATA

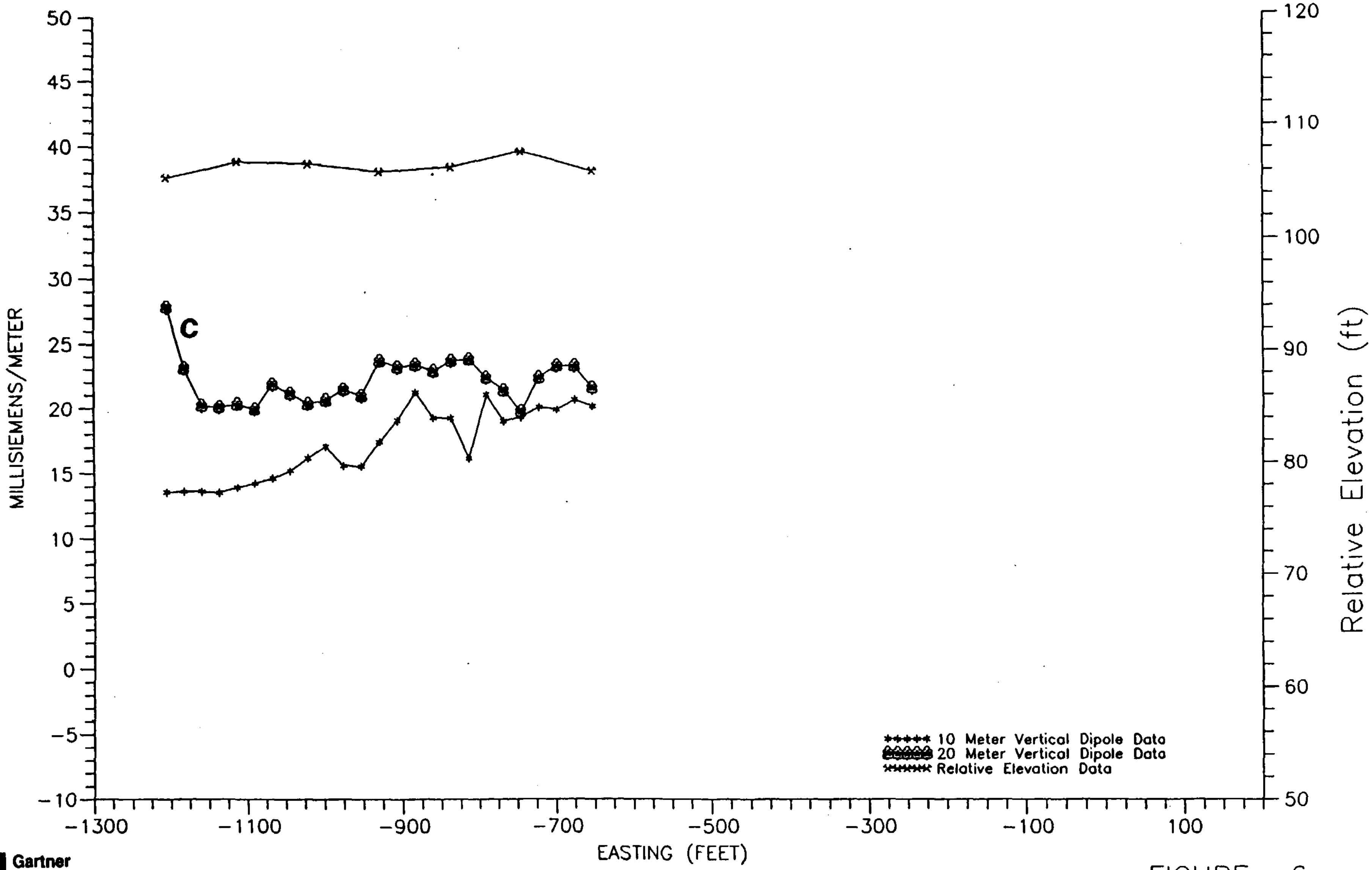

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FIGURE 6

# GEOPHYSICAL SURVEY RESULTS
# ORGANIC CHEMICALS SITE, GRANDVILLE, MI
## LINE 3
## HORIZONTAL DIPOLE DATA

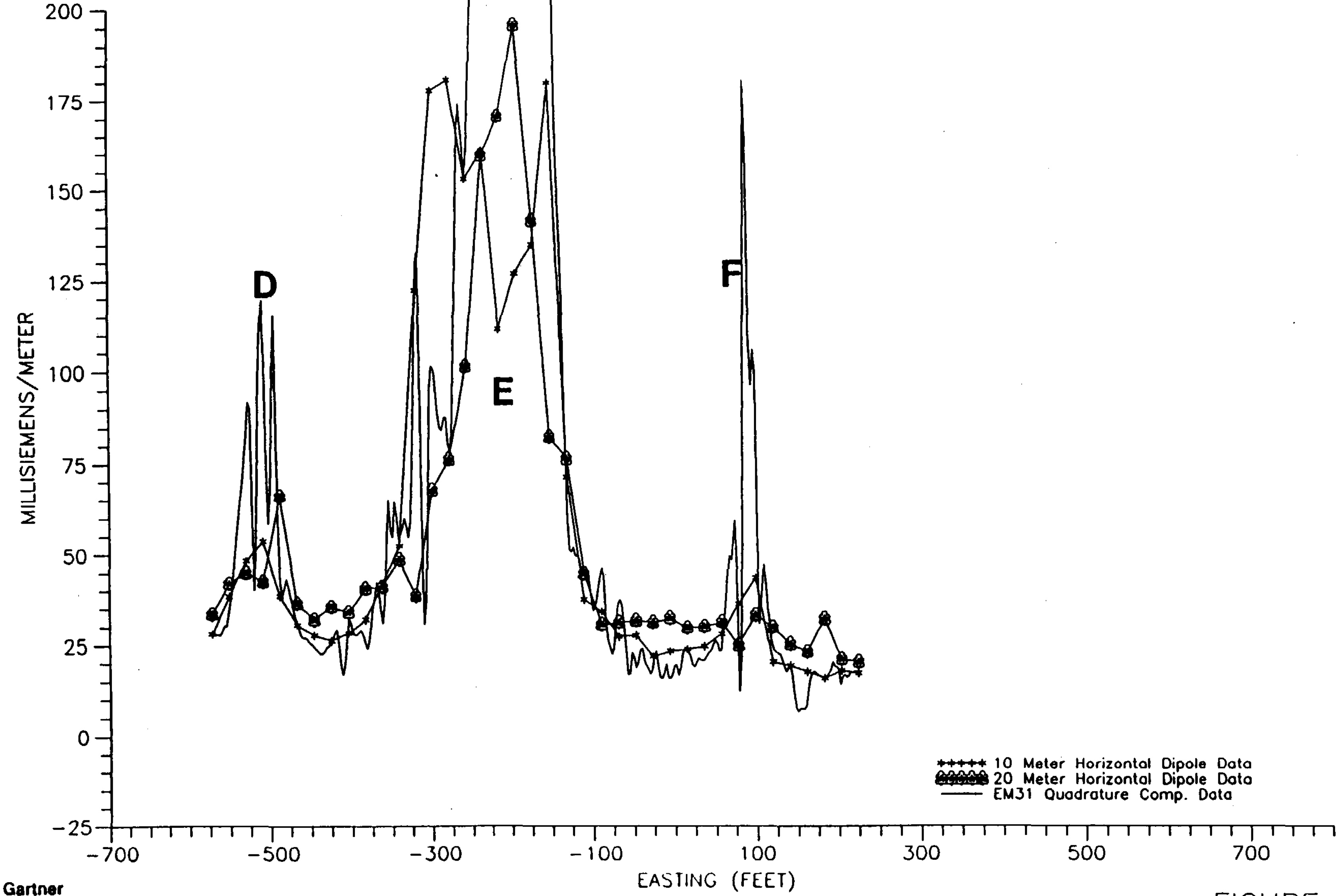

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FIGURE 7

GEOPHYSICAL SURVEY RESULTS
ORGANIC CHEMICALS SITE, GRANDVILLE, MI
LINE 3
VERTICAL DIPOLE DATA

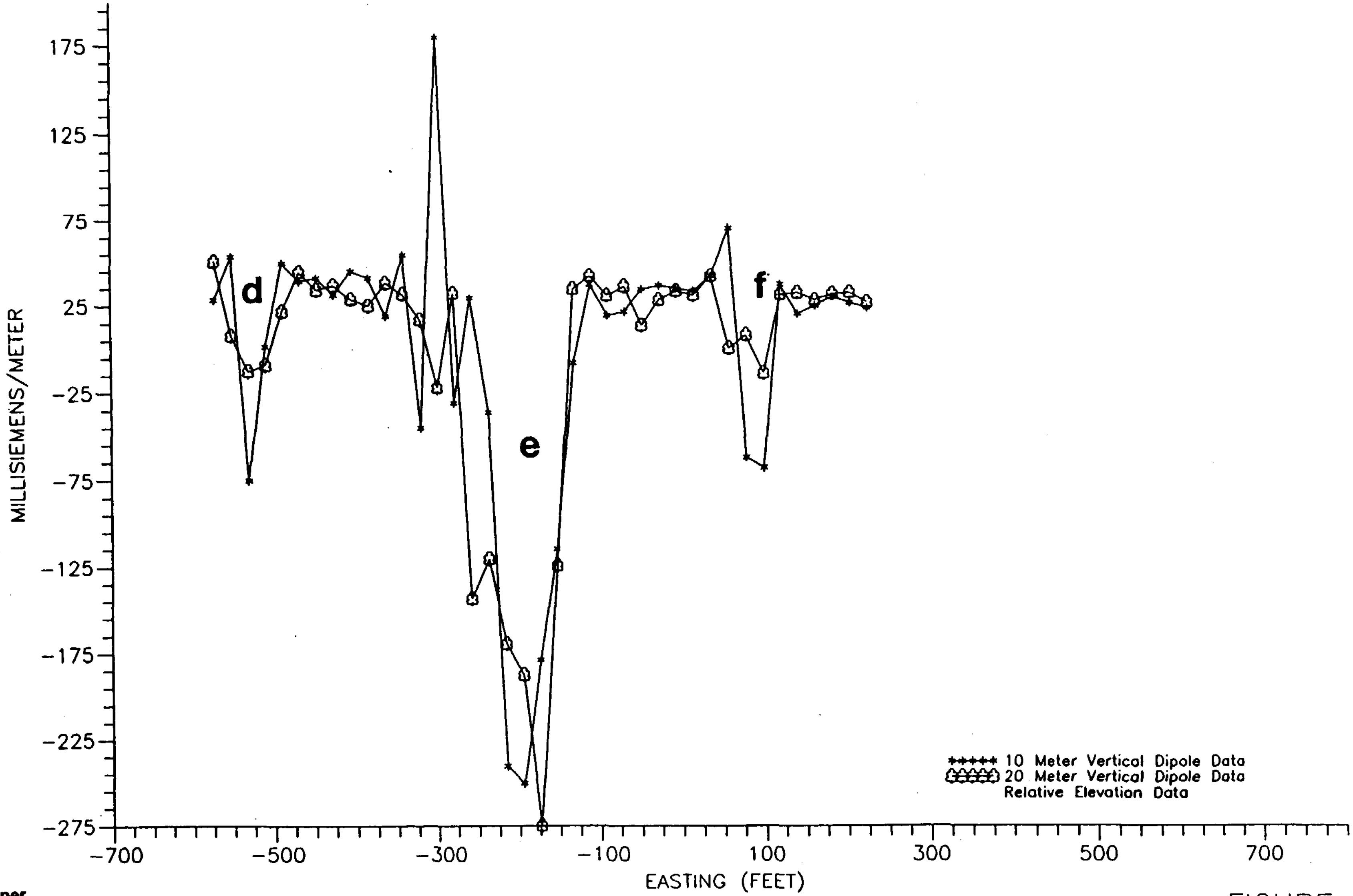

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FIGURE 8

GEOPHYSICAL SURVEY RESULTS
ORGANIC CHEMICALS SITE, GRANDVILLE, MI
LINE 4
HORIZONTAL DIPOLE DATA

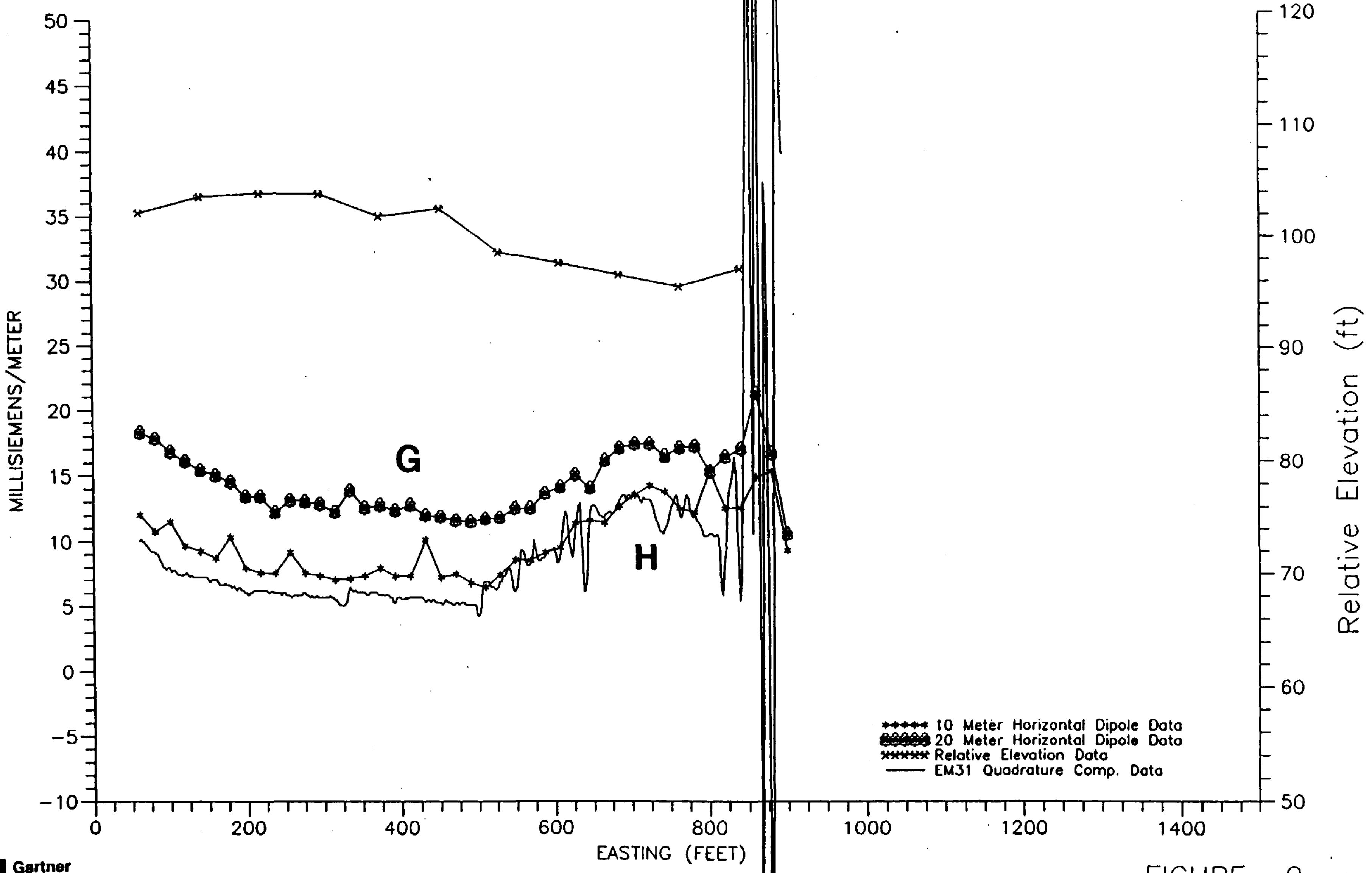

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FIGURE 9

## GEOPHYSICAL SURVEY RESULTS
## ORGANIC CHEMICALS SITE, GRANDVILLE, MI
## LINE 4
## VERTICAL DIPOLE DATA

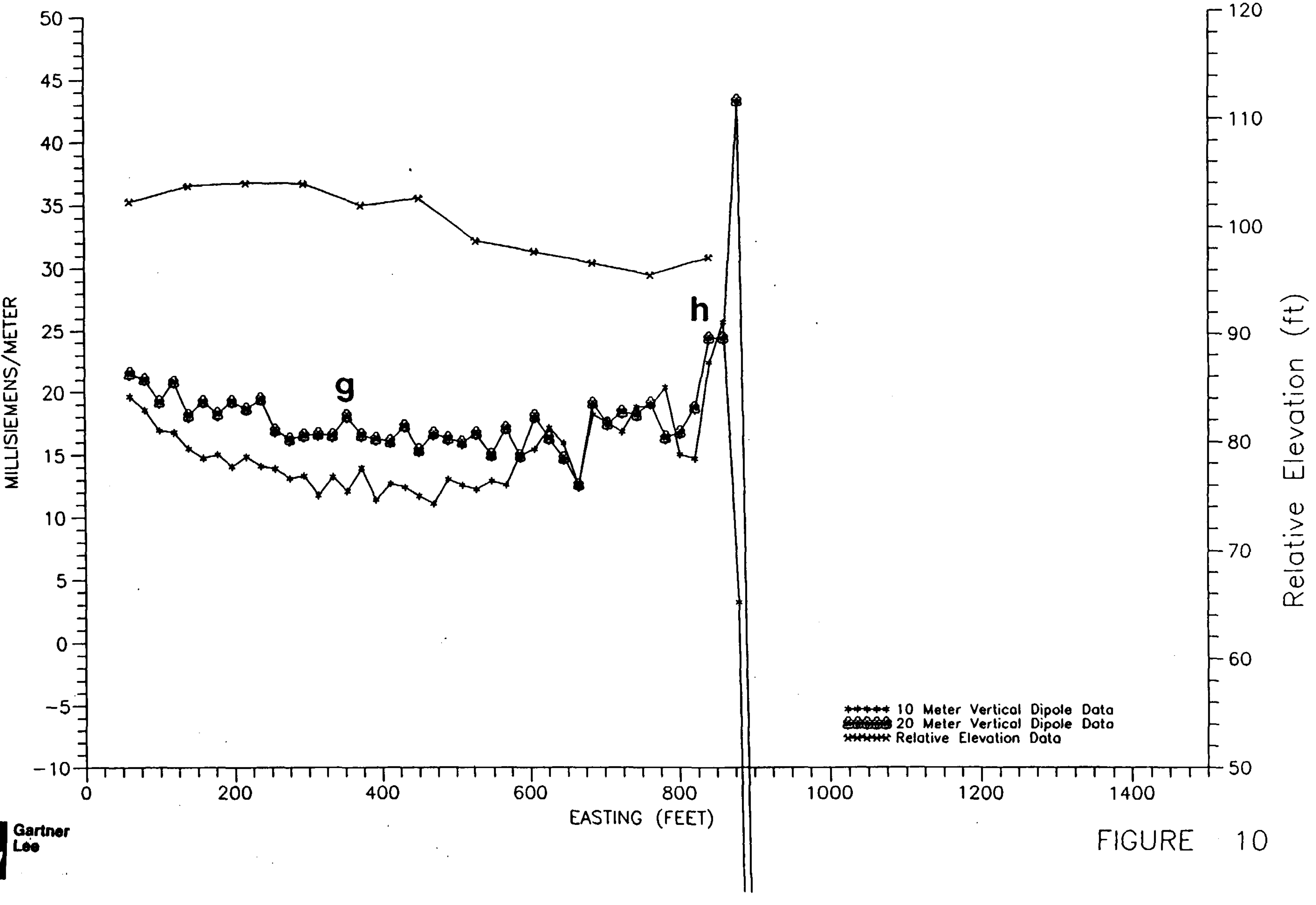

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FIGURE 10

# GEOPHYSICAL SURVEY RESULTS
# ORGANIC CHEMICALS SITE, GRANDVILLE, MI
## LINE 5
## HORIZONTAL DIPOLE DATA

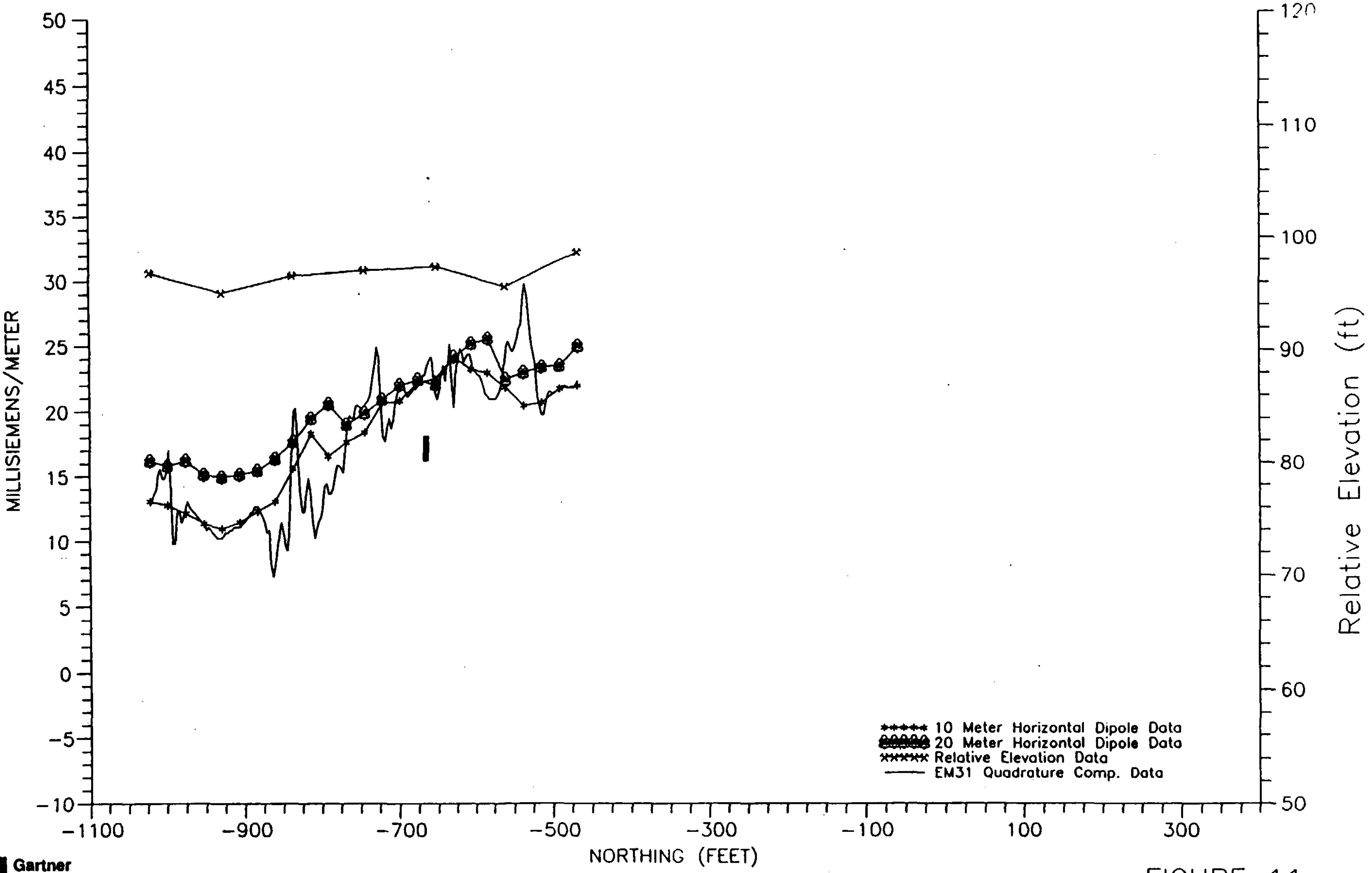

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FIGURE 11

# GEOPHYSICAL SURVEY RESULTS
# ORGANIC CHEMICALS SITE, GRANDVILLE, MI
# LINE 5
# VERTICAL DIPOLE DATA

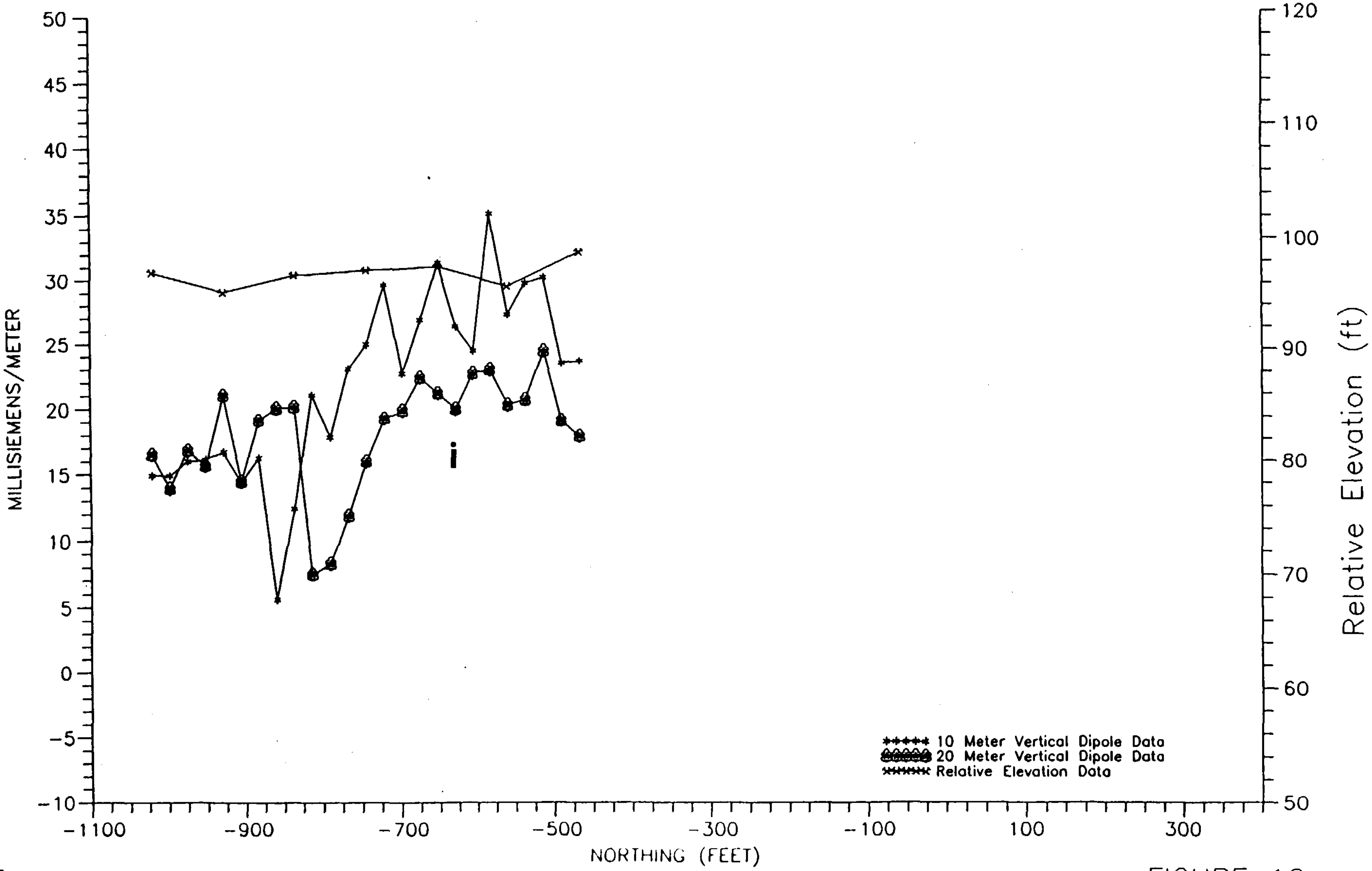

FIGURE 12

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# GEOPHYSICAL SURVEY RESULTS
# ORGANIC CHEMICALS SITE, GRANDVILLE, MI
## LINE 6
## HORIZONTAL DIPOLE DATA

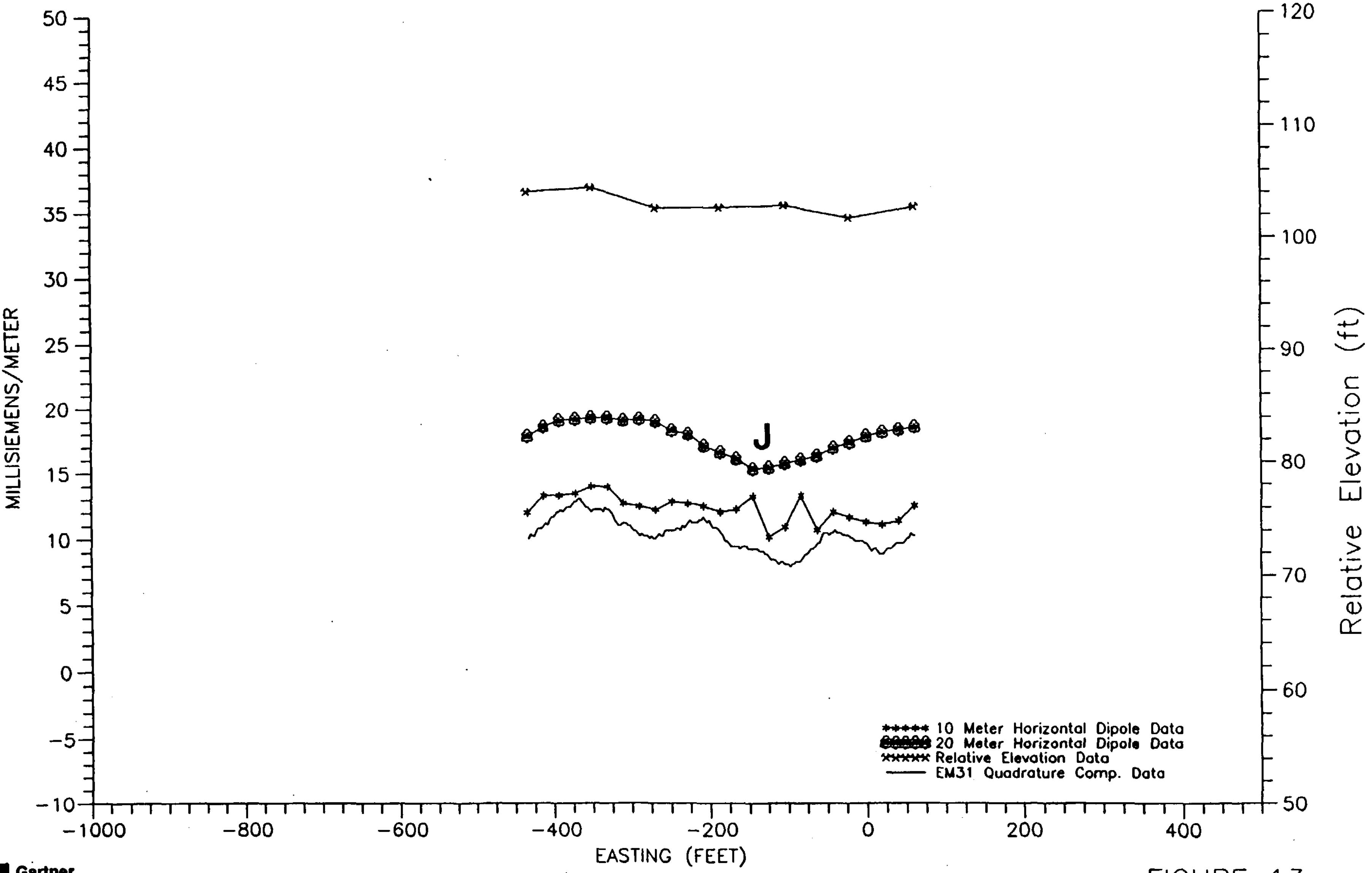

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FIGURE 13

## GEOPHYSICAL SURVEY RESULTS
## ORGANIC CHEMICALS SITE, GRANDVILLE, MI
## LINE 6
## VERTICAL DIPOLE DATA

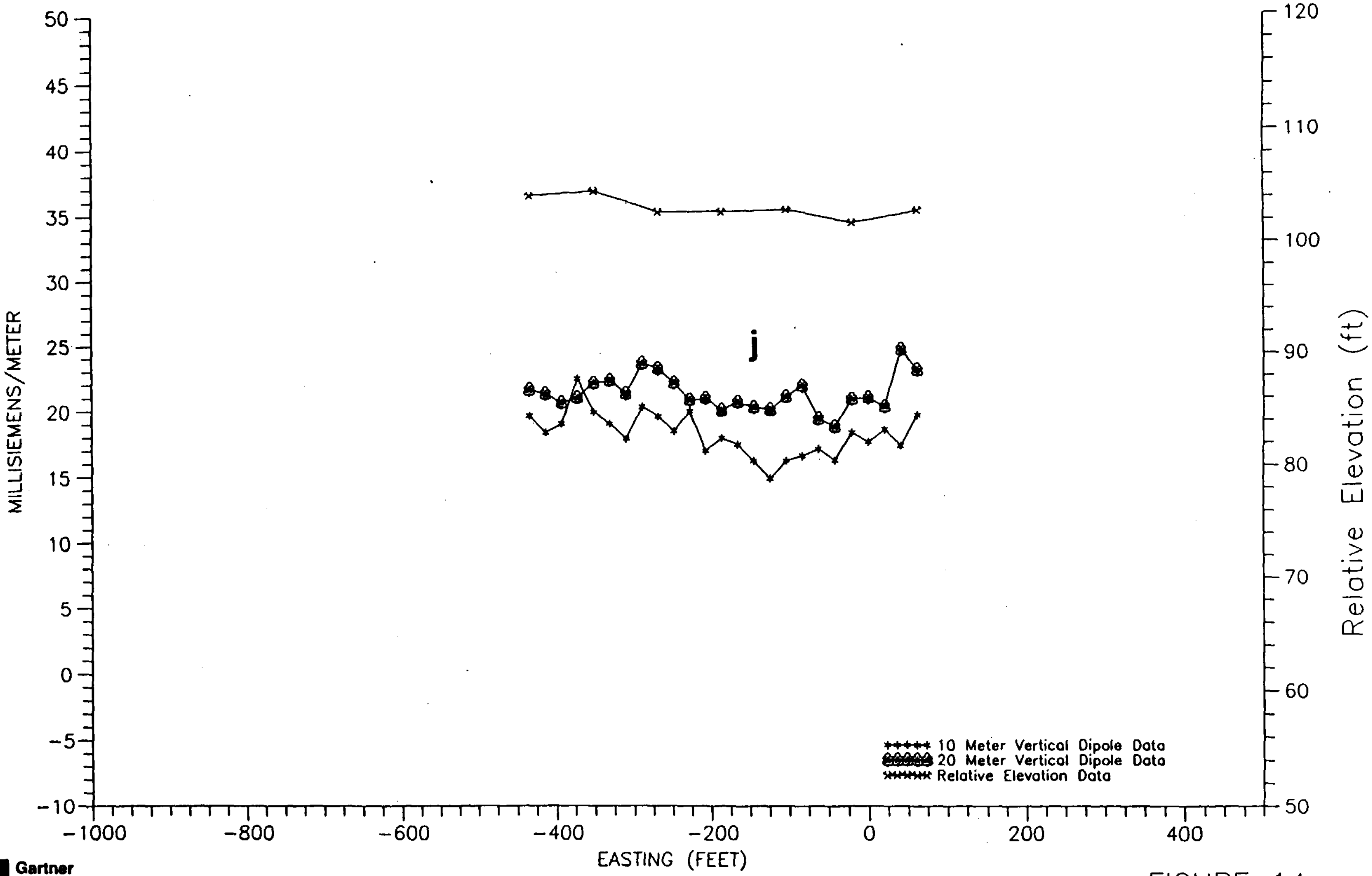

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FIGURE 14

# GEOPHYSICAL SURVEY RESULTS
# ORGANIC CHEMICALS SITE, GRANDVILLE, MI
## LINE 7
## HORIZONTAL DIPOLE DATA

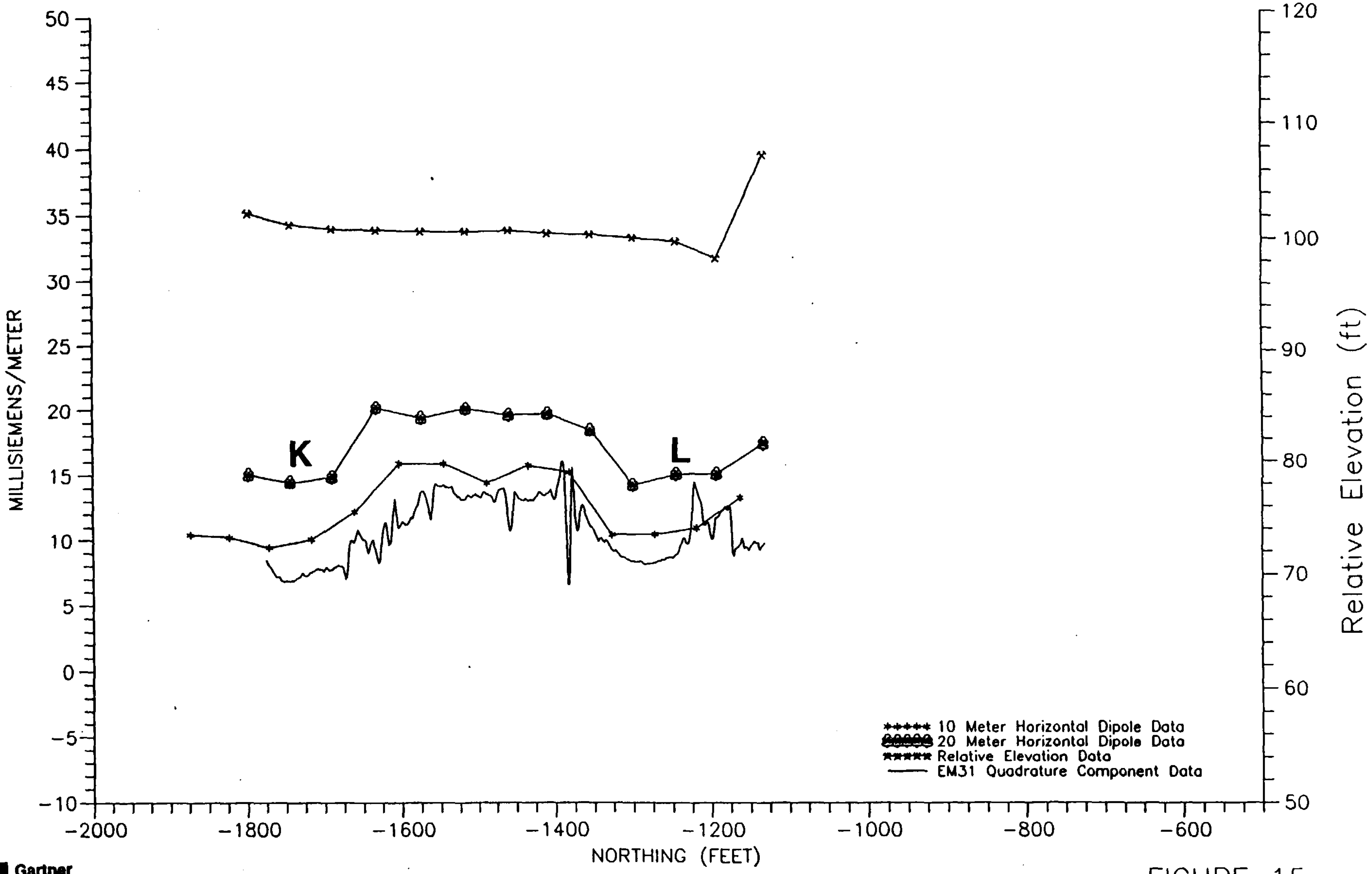

FIGURE 15

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# GEOPHYSICAL SURVEY RESULTS
# ORGANIC CHEMICALS SITE, GRANDVILLE, MI
## LINE 7
## VERTICAL DIPOLE DATA

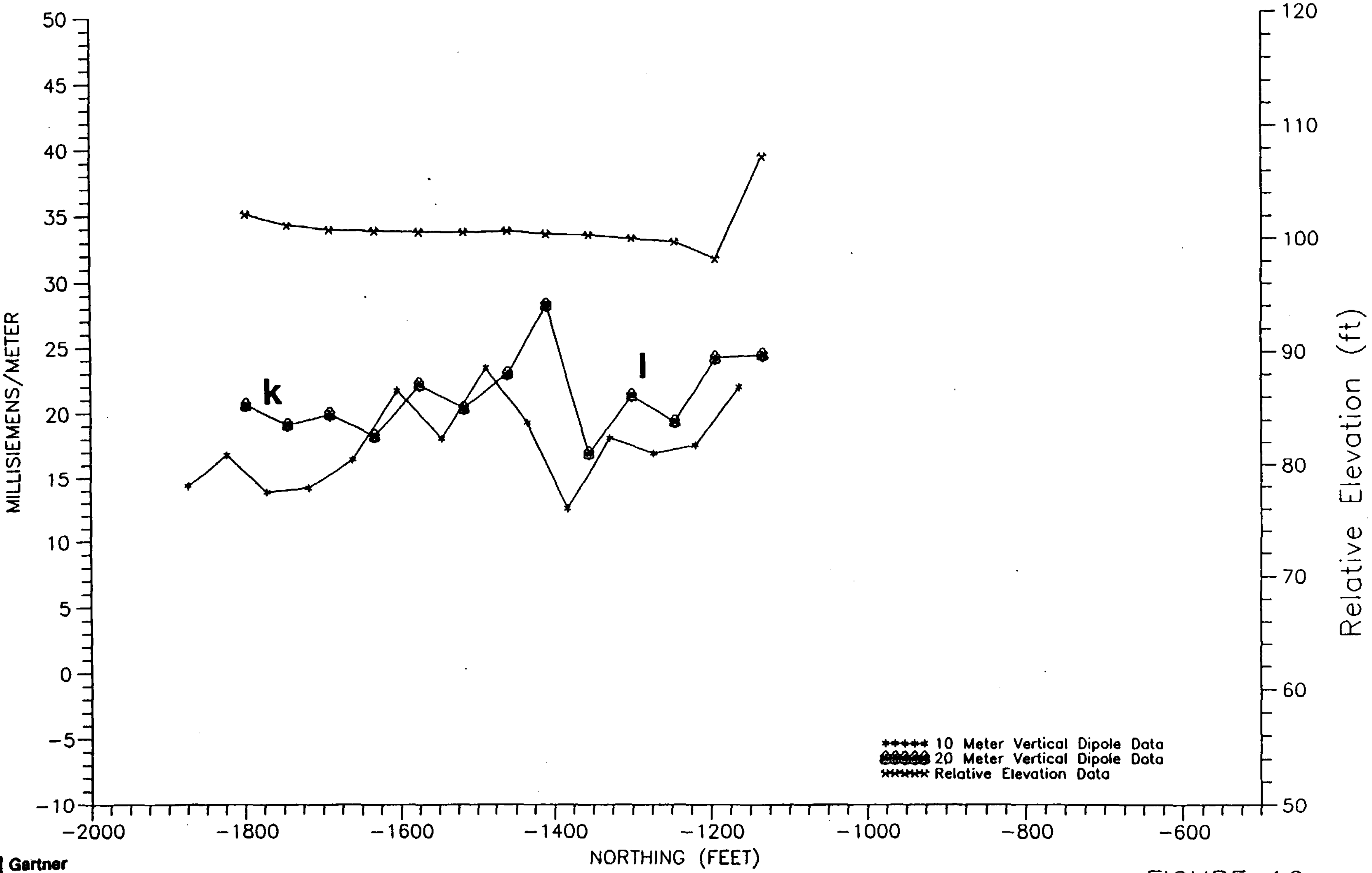

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FIGURE 16

# APPENDIX J

# HYDRAULIC CONDUCTIVITY TEST DATA AND CALCULATIONS

## Method of Analysis

Hvorslev equation for unconfined conditions:

$$K = \frac{r^2 \ln\left(\frac{L}{R}\right)}{2LT_o}$$

Hvorslev equation for confined conditions:

$$K = \frac{r^2 \ln\left(\frac{2L}{R}\right)}{2LT_o}$$

where:
L = length of screen (ft.)
R = radius of borehole (ft.)
$T_o$ = Basic time lag (min) measured off plot of head vs. time
H = water level at some time t (ft.)
$H_o$ = water level at start of test (ft.)
r = radius of well (ft.)
K = hydraulic conductivity (ft/day)

$T_o$ is determined by plotting $H/H_o$ versus t on semilogarithmic paper. Using standard english units in the Hvorslev equation gives the hydraulic conductivity in ft/day. To change this value to cm/sec, $3.53 \times 10^{-4}$ is the multiplier.

## Hydraulic Conductivity Determined From Slug Test
## Organic Chemicals Inc.

Well #: MW-11
Test Date: February 1994

| Run # | Radius of Well (inches) r | Length of Screen (inches) L | Radius of Borehole (inches) R | Basic Time Lag (min.) T | Hydraulic Conductivity (ft/day) K | Hydraulic Conductivity (cm/sec) K |
|---|---|---|---|---|---|---|
| 1 | 1 | 54 | 4 | 0.031 | 93 | 3.28E-02 |
| 2 | 1 | 54 | 4 | 0.05 | 57.6 | 2.03E-02 |
| 3 | 1 | 54 | 4 | 0.033 | 87.3 | 3.08E-02 |
| | | | | Geometric Mean = | 77.6 | 2.74E-02 |

Run #1

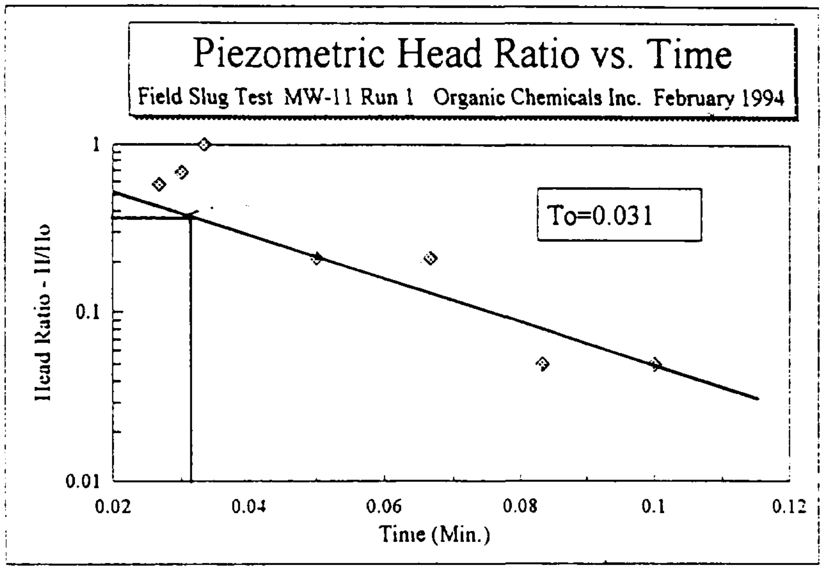
| Elapsed Time | Value | Time | H/H0 |
|---|---|---|---|
| 0.0133 | 0.00 | 0.0133 | 0.00 |
| 0.0166 | 0.05 | 0.0166 | 0.16 |
| 0.0200 | 0.13 | 0.0200 | 0.41 |
| 0.0233 | 0.20 | 0.0233 | 0.63 |
| 0.0266 | 0.32 | 0.0266 | 1.00 |
| 0.0300 | 0.14 | 0.0300 | 0.44 |
| 0.0333 | -0.02 | 0.0333 | 0.06 |
| 0.0500 | 0.04 | 0.0500 | 0.13 |
| 0.0666 | -0.01 | 0.0666 | 0.03 |
| 0.0833 | -0.01 | 0.0833 | 0.03 |

Run #2

| Elapsed Time | Value | Time | H/H0 |
|---|---|---|---|
| 0.0000 | 0.00 | 0.0200 | 0.07 |
| 0.0033 | 0.00 | 0.0233 | 0.29 |
| 0.0066 | 0.02 | 0.0266 | 0.71 |
| 0.0099 | -0.05 | 0.0300 | 1.00 |
| 0.0133 | -0.18 | 0.0333 | 0.93 |
| 0.0166 | -0.18 | 0.0500 | 0.36 |
| 0.0200 | 0.01 | 0.0666 | 0.07 |
| 0.0233 | -0.04 | 0.0833 | 0.00 |
| 0.0266 | -0.10 | | |
| 0.0300 | -0.14 | | |
| 0.0333 | -0.13 | | |
| 0.0500 | -0.05 | | |
| 0.0666 | -0.01 | | |
| 0.0833 | 0.00 | | |

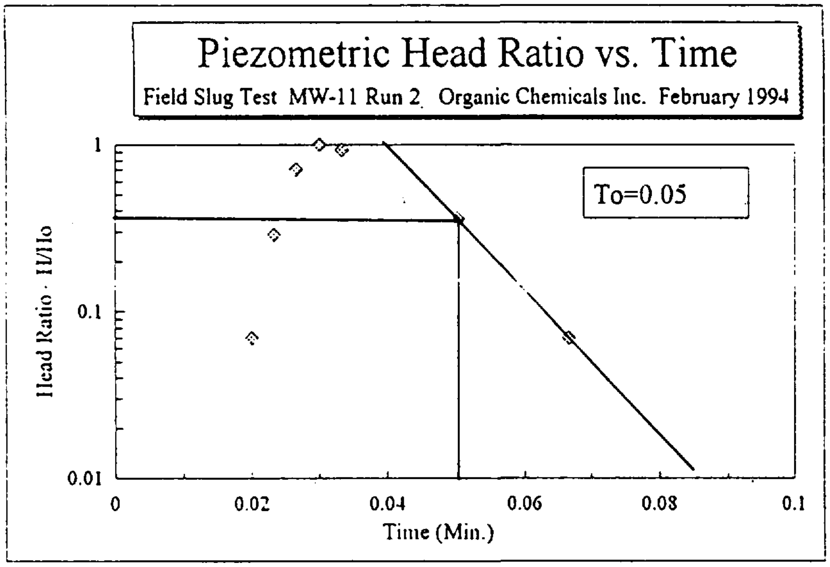
Run #3

| Elapsed Time | Value | Time | H/H0 |
|---|---|---|---|
| 0.0133 | 0.00 | 0.0266 | 0.58 |
| 0.0166 | 0.03 | 0.0300 | 0.68 |
| 0.0200 | 0.11 | 0.0333 | 1.00 |
| 0.0233 | 0.11 | 0.0500 | 0.21 |
| 0.0266 | 0.11 | 0.0666 | 0.21 |
| 0.0300 | 0.13 | 0.0833 | 0.05 |
| 0.0333 | 0.19 | 0.1000 | 0.05 |
| 0.0500 | 0.04 | | |
| 0.0666 | 0.04 | | |
| 0.0833 | -0.01 | | |
| 0.1000 | -0.01 | | |



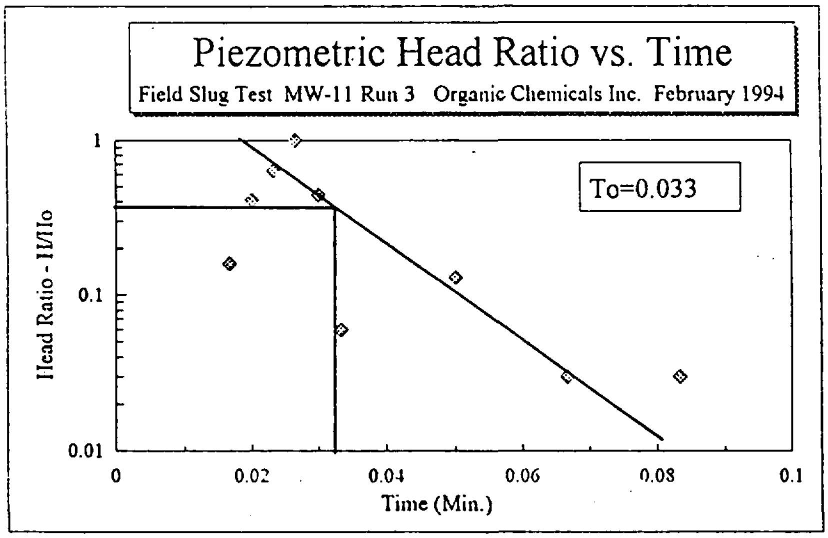
Piezometric Head Ratio vs. Time

Field Slug Test MW-11 Run 1 Organic Chemicals Inc. February 1994



Piezometric Head Ratio vs. Time

Field Slug Test MW-11 Run 2 Organic Chemicals Inc. February 1994



Piezometric Head Ratio vs. Time

Field Slug Test MW-11 Run 3 Organic Chemicals Inc. February 1994

## Hydraulic Conductivity Determined From Slug Test
## Organic Chemicals Inc.

Well #: MW-22

Test Date: February 1994

| Run # | Radius of Well (inches) r | Length of Screen (inches) L | Radius of Borehole (inches) R | Basic Time Lag (min.) T | Hydraulic Conductivity (ft/day) K | Hydraulic Conductivity (cm/sec) K |
|---|---|---|---|---|---|---|
| 1 | Insufficient Data | | | | | |
| 2 | 1 | 54 | 4 | 0.054 | 53.3 | 1.88E-02 |
| 3 | 1 | 54 | 4 | 0.037 | 76.9 | 2.72E-02 |
| | | | Geometric Mean = | | 64 | 2.26E-02 |

Run #1

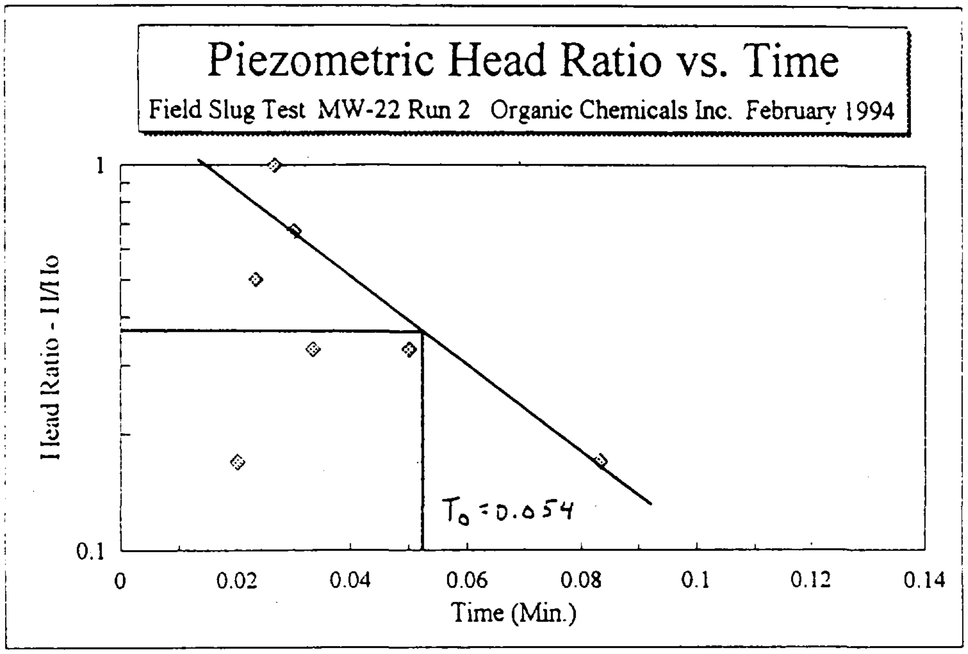
| Elapsed Time | Value | Time | H/H0 |
|---|---|---|---|
| 0.0233 | 0.00 | 0.0233 | 0.00 |
| 0.0266 | 0.23 | 0.0266 | 1.00 |
| 0.0300 | -0.14 | 0.0300 | 0.61 |
| 0.0333 | 0.00 | 0.0333 | 0.00 |
| 0.0500 | -0.03 | 0.0500 | 0.13 |
| 0.0666 | 0.00 | 0.0666 | 0.00 |

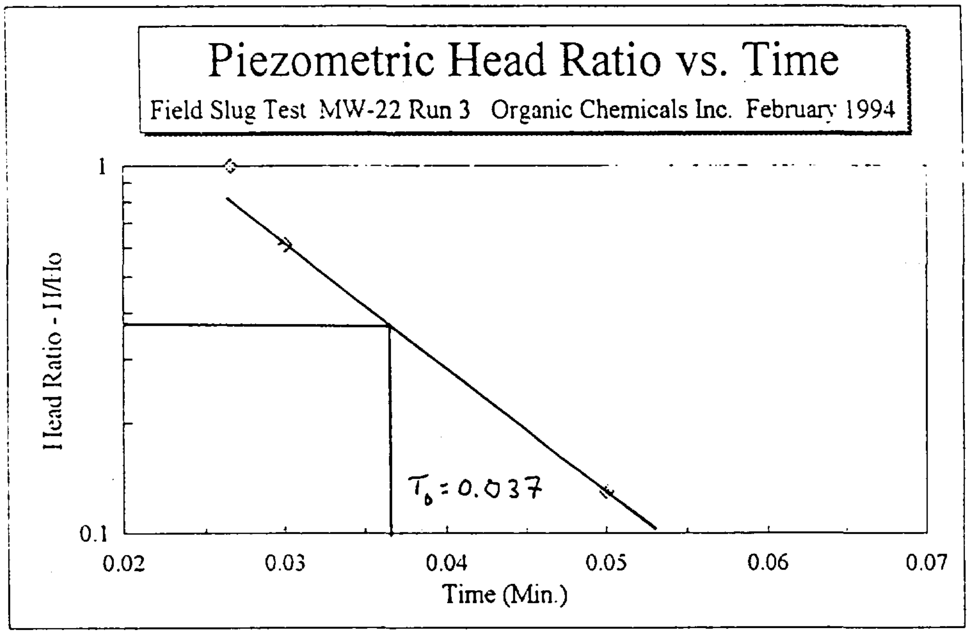
Run #2

| Elapsed Time | Value | Time | H/H0 |
|---|---|---|---|
| 0.0200 | -0.01 | 0.0200 | 0.17 |
| 0.0233 | -0.03 | 0.0233 | 0.50 |
| 0.0266 | -0.06 | 0.0266 | 1.00 |
| 0.0300 | -0.04 | 0.0300 | 0.67 |
| 0.0333 | -0.02 | 0.0333 | 0.33 |
| 0.0500 | 0.02 | 0.0500 | 0.33 |
| 0.0666 | 0.00 | 0.0666 | 0.00 |
| 0.0833 | -0.01 | 0.0833 | 0.17 |
| 0.1000 | 0.00 | 0.1000 | 0.00 |
| 0.1166 | 0.00 | 0.1166 | 0.00 |

Run #3

| Elapsed Time | Value | Time | H/H0 |
|---|---|---|---|
| 0.0333 | 0.00 | 0.0333 | 0.00 |
| 0.0500 | 0.03 | 0.0500 | 1.00 |
| 0.0666 | 0.00 | 0.0666 | 0.00 |
| 0.0833 | -0.04 | 0.0833 | 0.00 |
| 0.1000 | 0.00 | 0.1000 | |
| 0.1166 | 0.01 | 0.1166 | |
| 0.1333 | 0.00 | 0.1333 | |
| 0.1500 | 0.00 | 0.1500 | |


Piezometric Head Ratio vs. Time
Field Slug Test MW-22 Run 2 Organic Chemicals Inc. February 1994
Head Ratio - H/Ho
1
0.1
0
0.02
0.04
0.06
0.08
0.1
0.12
0.14
Time (Min.)
$T_0$ = 0.054


Piezometric Head Ratio vs. Time
Field Slug Test MW-22 Run 3 Organic Chemicals Inc. February 1994
Head Ratio - H/Ho
1
0.1
0.02
0.03
0.04
0.05
0.06
0.07
Time (Min.)
$T_0$ = 0.037

## Hydraulic Conductivity Determined From Slug Test
## Organic Chemicals Inc.

Well #: MW-24
Test Date: February 1994

| Run # | Radius of Well (inches) r | Length of Screen (inches) L | Radius of Borehole (inches) R | Basic Time Lag (min.) T | Hydraulic Conductivity (ft/day) K | Hydraulic Conductivity (cm/sec) K |
|---|---|---|---|---|---|---|
| 1 | 1 | 54 | 4 | 0.055 | 52.4 | 1.85E-02 |
| 2 | 1 | 54 | 4 | 0.1 | 28.8 | 1.02E-02 |
| 3 | 1 | 54 | 4 | 0.06 | 48 | 1.69E-02 |
|  |  |  | Geometric Mean = |  | 41.7 | 1.47E-02 |

Run #1

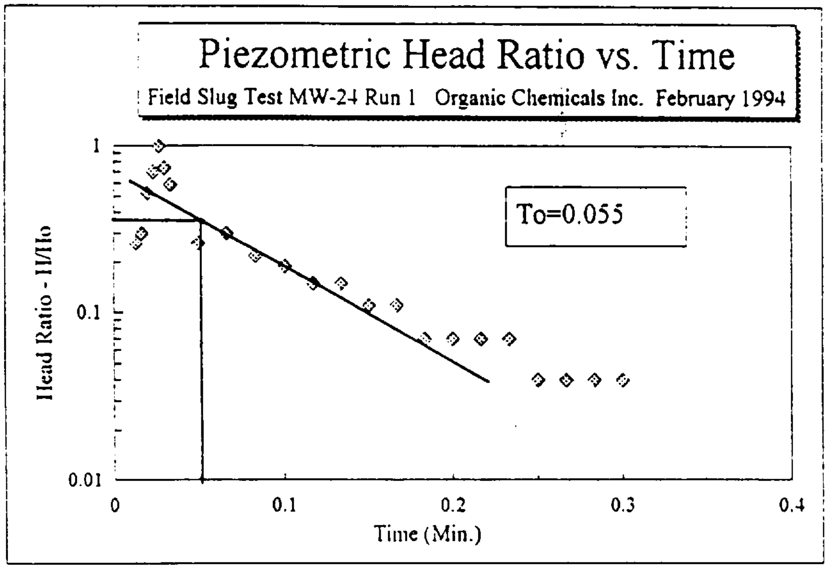
| Elapsed Time | Value | Time | H/H0 |
|---|---|---|---|
| 0.0266 | 0.07 | 0.0266 | 0.30 |
| 0.0300 | 0.15 | 0.0300 | 0.65 |
| 0.0333 | 0.23 | 0.0333 | 1.00 |
| 0.0500 | 0.10 | 0.0500 | 0.43 |
| 0.0666 | 0.08 | 0.0666 | 0.35 |
| 0.0833 | 0.06 | 0.0833 | 0.26 |
| 0.1000 | 0.05 | 0.1000 | 0.22 |
| 0.1166 | 0.04 | 0.1166 | 0.17 |
| 0.1333 | 0.03 | 0.1333 | 0.13 |
| 0.1500 | 0.02 | 0.1500 | 0.09 |
| 0.1666 | 0.02 | 0.1666 | 0.09 |
| 0.1833 | 0.02 | 0.1833 | 0.09 |
| 0.2000 | 0.02 | 0.2000 | 0.09 |
| 0.2166 | 0.01 | 0.2166 | 0.04 |
| 0.2333 | 0.01 | 0.2333 | 0.04 |
| 0.2500 | 0.01 | 0.2500 | 0.04 |
| 0.2666 | 0.01 | 0.2666 | 0.04 |
| 0.2833 | 0.01 | 0.2833 | 0.04 |
| 0.3000 | 0.01 | 0.3000 | 0.04 |
| 0.3166 | 0.01 | 0.3166 | 0.04 |
| 0.3333 | 0.00 | 0.3333 | 0.00 |
| 0.4167 | 0.00 | 0.4167 | 0.00 |

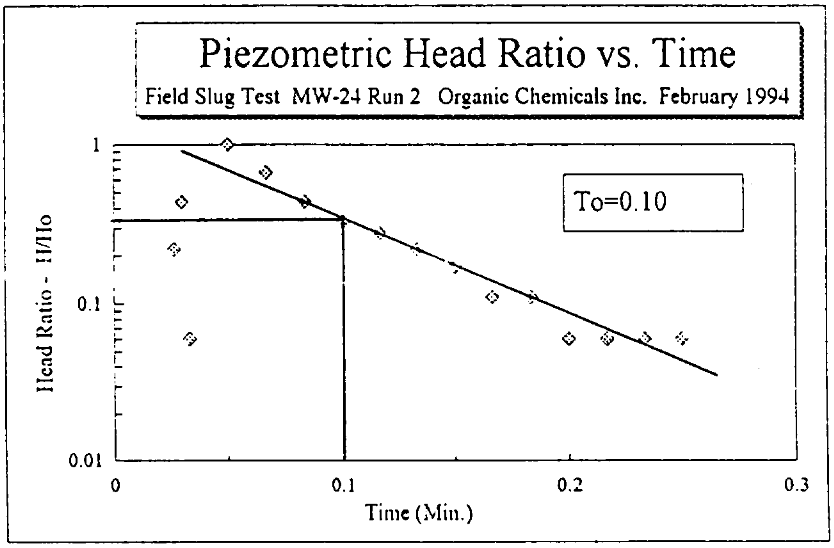
Run #2

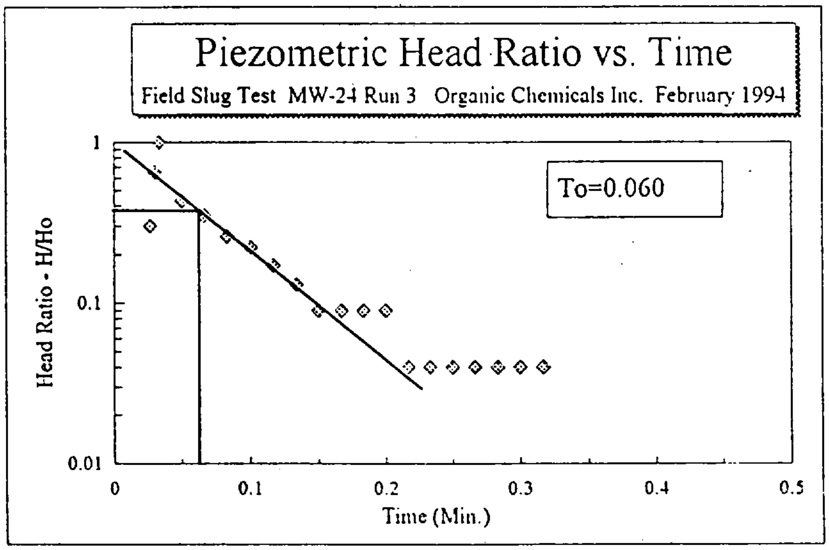
| Elapsed Time | Value | Time | H/H0 |
|---|---|---|---|
| 0.0266 | -0.04 | 0.0266 | 0.22 |
| 0.0300 | -0.08 | 0.0300 | 0.44 |
| 0.0333 | -0.01 | 0.0333 | 0.06 |
| 0.0500 | -0.18 | 0.0500 | 1.00 |
| 0.0666 | -0.12 | 0.0666 | 0.67 |
| 0.0833 | -0.08 | 0.0833 | 0.44 |
| 0.1000 | -0.06 | 0.1000 | 0.33 |
| 0.1166 | -0.05 | 0.1166 | 0.28 |
| 0.1333 | -0.04 | 0.1333 | 0.22 |
| 0.1500 | -0.03 | 0.1500 | 0.17 |
| 0.1666 | -0.02 | 0.1666 | 0.11 |
| 0.1833 | -0.02 | 0.1833 | 0.11 |
| 0.2000 | -0.01 | 0.2000 | 0.06 |
| 0.2166 | -0.01 | 0.2166 | 0.06 |
| 0.2333 | -0.01 | 0.2333 | 0.06 |
| 0.2500 | -0.01 | 0.2500 | 0.06 |
| 0.2666 | 0.00 | 0.2666 | 0.00 |

Run #3

| Elapsed Time | Value | Time | H/H0 |
|---|---|---|---|
| 0.0099 | 0.00 | 0.0099 | 0.00 |
| 0.0133 | 0.07 | 0.0133 | 0.26 |
| 0.0166 | 0.08 | 0.0166 | 0.30 |
| 0.0200 | 0.14 | 0.0200 | 0.52 |
| 0.0233 | 0.19 | 0.0233 | 0.70 |
| 0.0266 | 0.27 | 0.0266 | 1.00 |
| 0.0300 | 0.20 | 0.0300 | 0.74 |
| 0.0333 | 0.16 | 0.0333 | 0.59 |
| 0.0500 | 0.07 | 0.0500 | 0.26 |
| 0.0666 | 0.08 | 0.0666 | 0.30 |
| 0.0833 | 0.06 | 0.0833 | 0.22 |
| 0.1000 | 0.05 | 0.1000 | 0.19 |
| 0.1166 | 0.04 | 0.1166 | 0.15 |
| 0.1333 | 0.04 | 0.1333 | 0.15 |
| 0.1500 | 0.03 | 0.1500 | 0.11 |
| 0.1666 | 0.03 | 0.1666 | 0.11 |
| 0.1833 | 0.02 | 0.1833 | 0.07 |
| 0.2000 | 0.02 | 0.2000 | 0.07 |
| 0.2166 | 0.02 | 0.2166 | 0.07 |
| 0.2333 | 0.02 | 0.2333 | 0.07 |
| 0.2500 | 0.01 | 0.2500 | 0.04 |
| 0.2666 | 0.01 | 0.2666 | 0.04 |
| 0.2833 | 0.01 | 0.2833 | 0.04 |
| 0.3000 | 0.01 | 0.3000 | 0.04 |


Piezometric Head Ratio vs. Time
Field Slug Test MW-24 Run 1 Organic Chemicals Inc. February 1994
To=0.055
Head Ratio - H/Ho
1
0.1
0.01
0
0.1
0.2
0.3
0.4
Time (Min.)


Piezometric Head Ratio vs. Time
Field Slug Test MW-24 Run 2 Organic Chemicals Inc. February 1994
To=0.10
Head Ratio - H/Ho
1
0.1
0.01
0
0.1
0.2
0.3
Time (Min.)


Piezometric Head Ratio vs. Time
Field Slug Test MW-24 Run 3 Organic Chemicals Inc. February 1994
To=0.060
Head Ratio - H/Ho
1
0.1
0.01
0
0.1
0.2
0.3
0.4
0.5
Time (Min.)

## Hydraulic Conductivity Determined From Slug Test
## Organic Chemicals Inc.

Well #: MW-26
Test Date: February 1994

| Run # | Radius of Well (inches) r | Length of Screen (inches) L | Radius of Borehole (inches) R | Basic Time Lag (min.) T | Hydraulic Conductivi (ft/day) K | Hydraulic Conductivi (cm/sec) K |
|---|---|---|---|---|---|---|
| 1 | 1 | 54 | 4 | 0.034 | 84.7 | 2.99E-02 |
| 2 | 1 | 54 | 4 | 0.03 | 96.1 | 3.39E-02 |
| 3 | 1 | 54 | 4 | 0.037 | 77.8 | 2.75E-02 |
|  |  |  | Geometric Mean = |  | 85.9 | 3.03E-02 |

Run #1

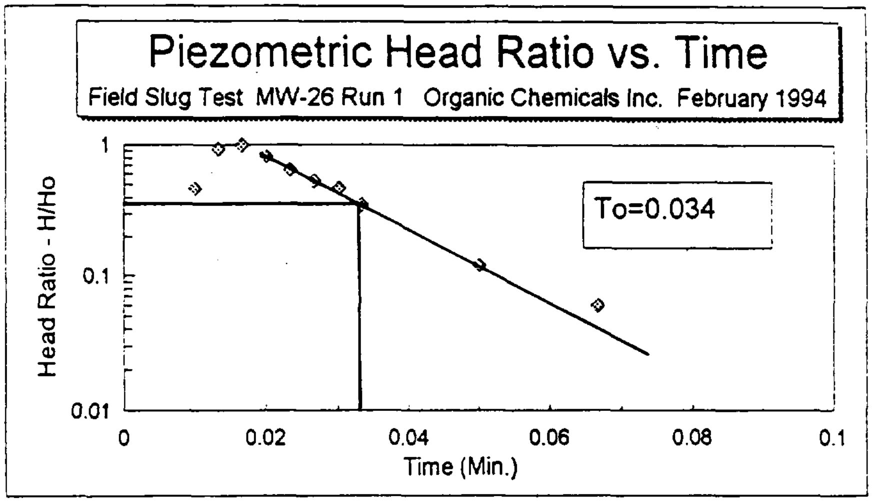
| Elapsed Time | Valu | Time | H/HO |
|---|---|---|---|
| 0.0000 | 0.00 | 0.0000 | 0.00 |
| 0.0033 | -0.10 | 0.0033 | 0.59 |
| 0.0066 | -0.11 | 0.0066 | 0.65 |
| 0.0099 | -0.12 | 0.0099 | 0.71 |
| 0.0133 | -0.11 | 0.0133 | 0.65 |
| 0.0166 | -0.17 | 0.0166 | 1.00 |
| 0.0200 | -0.15 | 0.0200 | 0.88 |
| 0.0233 | -0.12 | 0.0233 | 0.71 |
| 0.0266 | -0.10 | 0.0266 | 0.59 |
| 0.0300 | -0.09 | 0.0300 | 0.53 |
| 0.0333 | -0.07 | 0.0333 | 0.41 |
| 0.0500 | -0.03 | 0.0500 | 0.18 |
| 0.0666 | -0.02 | 0.0666 | 0.12 |
| 0.0833 | -0.01 | 0.0833 | 0.06 |
| 0.1000 | -0.01 | 0.1000 | 0.06 |
| 0.1166 | -0.01 | 0.1166 | 0.06 |

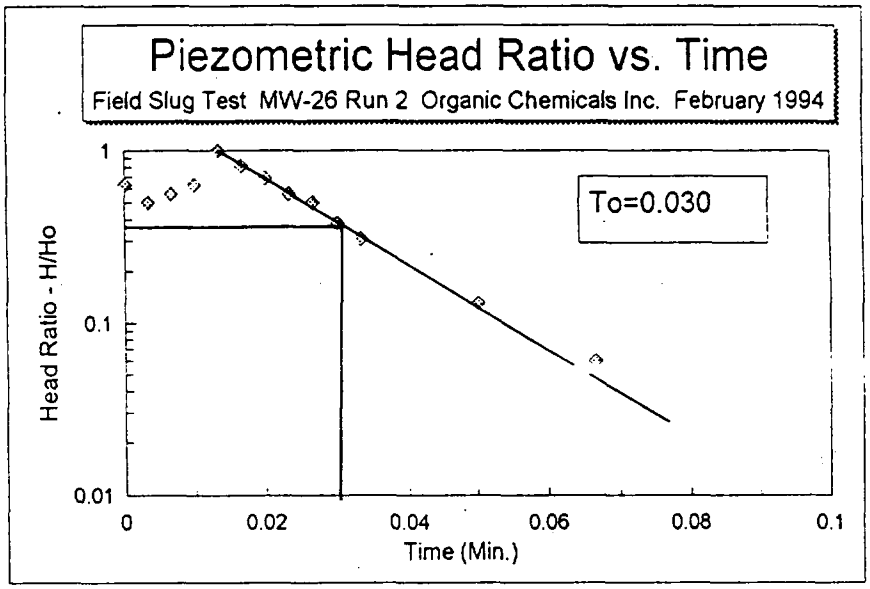
Run #2

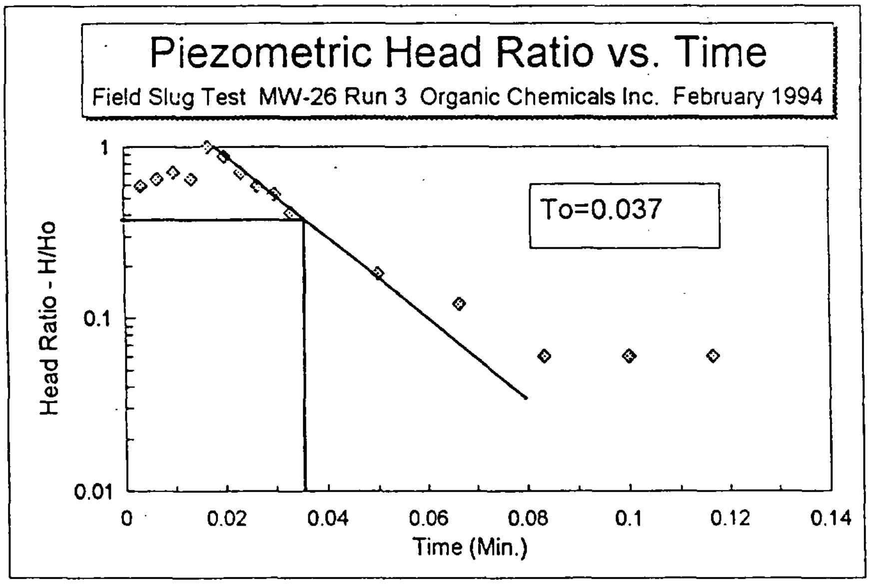
| Elapsed Time | Valu | Time | H/HO |
|---|---|---|---|
| 0.0000 | -0.10 | 0.0000 | 0.63 |
| 0.0033 | -0.08 | 0.0033 | 0.50 |
| 0.0066 | -0.09 | 0.0066 | 0.56 |
| 0.0099 | -0.10 | 0.0099 | 0.63 |
| 0.0133 | -0.16 | 0.0133 | 1.00 |
| 0.0166 | -0.13 | 0.0166 | 0.81 |
| 0.0200 | -0.11 | 0.0200 | 0.69 |
| 0.0233 | -0.09 | 0.0233 | 0.56 |
| 0.0266 | -0.08 | 0.0266 | 0.50 |
| 0.0300 | -0.06 | 0.0300 | 0.38 |
| 0.0333 | -0.05 | 0.0333 | 0.31 |
| 0.0500 | -0.02 | 0.0500 | 0.13 |
| 0.0666 | -0.01 | 0.0666 | 0.06 |
| 0.0833 | 0.00 | 0.0833 | 0.00 |

Run #3

| Elapsed Time | Valu | Time | H/HO |
|---|---|---|---|
| 0.0099 | -0.08 | 0.0099 | 0.47 |
| 0.0133 | -0.16 | 0.0133 | 0.94 |
| 0.0166 | -0.17 | 0.0166 | 1.00 |
| 0.0200 | -0.14 | 0.0200 | 0.82 |
| 0.0233 | -0.11 | 0.0233 | 0.65 |
| 0.0266 | -0.09 | 0.0266 | 0.53 |
| 0.0300 | -0.08 | 0.0300 | 0.47 |
| 0.0333 | -0.06 | 0.0333 | 0.35 |
| 0.0500 | -0.02 | 0.0500 | 0.12 |
| 0.0666 | -0.01 | 0.0666 | 0.06 |
| 0.0833 | 0.00 | 0.0833 | 0.00 |


Piezometric Head Ratio vs. Time
Field Slug Test MW-26 Run 1 Organic Chemicals Inc. February 1994


Piezometric Head Ratio vs. Time
Field Slug Test MW-26 Run 2 Organic Chemicals Inc. February 1994


Piezometric Head Ratio vs. Time
Field Slug Test MW-26 Run 3 Organic Chemicals Inc. February 1994

## Hydraulic Conductivity Determined From Slug Test
## Organic Chemicals Inc.

Well #: MW-28
Test Date: February 1994

| Run # | Radius of well (inches) r | Lenght of Screen (inches) L | Radius of Borehole (inches) R | Basic Time Lag (min.) T | Hydraulic Conductivit (ft/day) K | Hydraulic Conductivity (cm/sec) K |
|---|---|---|---|---|---|---|
| 1 | 1 | 54 | 4 | 0.45 | 6.4 | 2.26E-03 |
| 2 | 1 | 54 | 4 | 0.4 | 7.2 | 2.54E-03 |
| 3 | 1 | 54 | 4 | 0.3 | 9.5 | 3.36E-03 |
| | | | Geometric Mean = | | 7.6 | 2.58E-03 |

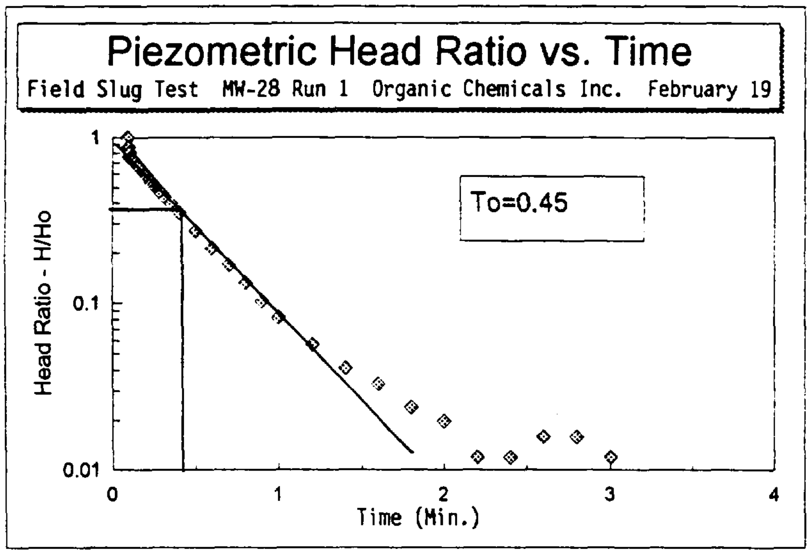
| Run #3 | | | Run #2 | | | Run #1 | | |
|---|---|---|---|---|---|---|---|---|
| Time | Value | H/H0 | Time | Value | H/H0 | Time | Value | H/H0 |
| 0.0866 | -0.648 | 0.856 | 0.0566 | 0.450 | 0.584 | 0.0600 | -0.247 | 0.355 |
| 0.0900 | -0.757 | 1.000 | 0.0600 | 0.770 | 1.000 | 0.0633 | -0.209 | 0.301 |
| 0.0933 | -0.663 | 0.876 | 0.0633 | 0.754 | 0.979 | 0.0666 | -0.526 | 0.757 |
| 0.0966 | -0.579 | 0.765 | 0.0666 | 0.692 | 0.899 | 0.0700 | -0.638 | 0.918 |
| 0.1000 | -0.616 | 0.814 | 0.0700 | 0.726 | 0.943 | 0.0733 | -0.695 | 1.000 |
| 0.1100 | -0.569 | 0.752 | 0.0733 | 0.682 | 0.886 | 0.0766 | -0.516 | 0.742 |
| 0.1200 | -0.557 | 0.736 | 0.0766 | 0.720 | 0.935 | 0.0800 | -0.400 | 0.576 |
| 0.1300 | -0.541 | 0.715 | 0.0800 | 0.682 | 0.886 | 0.0833 | -0.482 | 0.694 |
| 0.1400 | -0.529 | 0.699 | 0.0833 | 0.679 | 0.882 | 0.0866 | -0.513 | 0.738 |
| 0.1500 | -0.513 | 0.678 | 0.0866 | 0.660 | 0.857 | 0.0900 | -0.466 | 0.671 |
| 0.1600 | -0.497 | 0.657 | 0.0900 | 0.651 | 0.845 | 0.0933 | -0.463 | 0.666 |
| 0.1700 | -0.485 | 0.641 | 0.0933 | 0.641 | 0.832 | 0.0966 | -0.501 | 0.721 |
| 0.1800 | -0.469 | 0.620 | 0.0966 | 0.632 | 0.821 | 0.1000 | -0.460 | 0.662 |
| 0.1900 | -0.457 | 0.604 | 0.1000 | 0.626 | 0.813 | 0.1033 | -0.450 | 0.647 |
| 0.2000 | -0.444 | 0.587 | 0.1033 | 0.613 | 0.796 | 0.1066 | -0.463 | 0.666 |
| 0.2100 | -0.432 | 0.571 | 0.1066 | 0.607 | 0.788 | 0.1100 | -0.450 | 0.647 |
| 0.2200 | -0.422 | 0.557 | 0.1100 | 0.598 | 0.777 | 0.1133 | -0.413 | 0.594 |
| 0.2300 | -0.410 | 0.542 | 0.1133 | 0.588 | 0.764 | 0.1166 | -0.237 | 0.341 |
| 0.2400 | -0.397 | 0.524 | 0.1166 | 0.582 | 0.756 | 0.1200 | -0.585 | 0.842 |
| 0.2500 | -0.388 | 0.513 | 0.1200 | 0.573 | 0.744 | 0.1233 | -0.516 | 0.742 |
| 0.2600 | -0.378 | 0.499 | 0.1233 | 0.566 | 0.735 | 0.1266 | -0.335 | 0.482 |
| 0.2700 | -0.369 | 0.487 | 0.1266 | 0.560 | 0.727 | 0.1300 | -0.425 | 0.612 |
| 0.2800 | -0.360 | 0.476 | 0.1300 | 0.554 | 0.719 | 0.1333 | -0.457 | 0.658 |
| 0.2900 | -0.350 | 0.462 | 0.1333 | 0.544 | 0.706 | 0.1366 | -0.400 | 0.576 |
| 0.3000 | -0.344 | 0.454 | 0.1366 | 0.541 | 0.703 | 0.1400 | -0.400 | 0.576 |
| 0.3200 | -0.325 | 0.429 | 0.1400 | 0.532 | 0.691 | 0.1433 | -0.419 | 0.603 |
| 0.3500 | -0.303 | 0.400 | 0.1433 | 0.526 | 0.683 | 0.1466 | -0.400 | 0.576 |
| 0.4000 | -0.266 | 0.351 | 0.1466 | 0.519 | 0.674 | 0.1500 | -0.391 | 0.563 |
| 0.5000 | -0.206 | 0.272 | 0.1500 | 0.516 | 0.670 | 0.1533 | -0.397 | 0.571 |
| 0.6000 | -0.162 | 0.214 | 0.1533 | 0.510 | 0.662 | 0.1566 | -0.391 | 0.563 |
| 0.7000 | -0.128 | 0.169 | 0.1566 | 0.504 | 0.655 | 0.1600 | -0.378 | 0.544 |
| 0.8000 | -0.100 | 0.132 | 0.1600 | 0.497 | 0.645 | 0.1633 | -0.378 | 0.544 |
| 0.9000 | -0.078 | 0.103 | 0.1633 | 0.491 | 0.638 | 0.1666 | -0.378 | 0.544 |
| 1.0000 | -0.062 | 0.082 | 0.1666 | 0.488 | 0.634 | 0.1700 | -0.454 | 0.653 |
| 1.2000 | -0.043 | 0.057 | 0.1700 | 0.479 | 0.622 | 0.1733 | -0.400 | 0.576 |
| 1.4000 | -0.031 | 0.041 | 0.1733 | 0.475 | 0.617 | 0.1766 | -0.375 | 0.540 |
| 1.6000 | -0.025 | 0.033 | 0.1766 | 0.469 | 0.609 | 0.1800 | -0.382 | 0.550 |
| 1.8000 | -0.018 | 0.024 | 0.1800 | 0.466 | 0.605 | 0.1833 | -0.363 | 0.522 |
| 2.0000 | -0.015 | 0.020 | 0.1833 | 0.460 | 0.597 | 0.1866 | -0.356 | 0.512 |
| 2.2000 | -0.009 | 0.012 | 0.1866 | 0.454 | 0.590 | 0.1900 | -0.360 | 0.518 |
| 2.4000 | -0.009 | 0.012 | 0.1900 | 0.450 | 0.584 | 0.1933 | -0.353 | 0.508 |
| 2.6000 | -0.012 | 0.016 | 0.1933 | 0.444 | 0.577 | 0.1966 | -0.347 | 0.499 |
| 2.8000 | -0.012 | 0.016 | 0.1966 | 0.441 | 0.573 | 0.2000 | -0.347 | 0.499 |
| 3.0000 | -0.009 | 0.012 | 0.2000 | 0.435 | 0.565 | 0.2033 | -0.341 | 0.491 |
| 3.2000 | -0.006 | 0.008 | 0.2033 | 0.432 | 0.561 | 0.2066 | -0.338 | 0.486 |
| | | | 0.2066 | 0.429 | 0.557 | 0.2100 | -0.335 | 0.482 |
| | | | 0.2100 | 0.422 | 0.548 | 0.2133 | -0.331 | 0.476 |
| | | | 0.2133 | 0.416 | 0.540 | 0.2166 | -0.328 | 0.472 |
| | | | 0.2166 | 0.416 | 0.540 | 0.2200 | -0.325 | 0.468 |
| | | | 0.2200 | 0.410 | 0.532 | 0.2233 | -0.322 | 0.463 |
| | | | 0.2233 | 0.407 | 0.529 | 0.2266 | -0.319 | 0.459 |
| | | | 0.2266 | 0.403 | 0.523 | 0.2300 | -0.316 | 0.455 |
| | | | 0.2300 | 0.400 | 0.519 | 0.2333 | -0.313 | 0.450 |
| | | | 0.2333 | 0.394 | 0.512 | 0.2366 | -0.310 | 0.446 |
| | | | 0.2366 | 0.391 | 0.508 | 0.2400 | -0.306 | 0.440 |
| | | | 0.2400 | 0.388 | 0.504 | 0.2433 | -0.303 | 0.436 |
| | | | 0.2433 | 0.382 | 0.496 | 0.2466 | -0.300 | 0.432 |
| | | | 0.2466 | 0.378 | 0.491 | 0.2500 | -0.297 | 0.427 |
| | | | 0.2500 | 0.375 | 0.487 | 0.2533 | -0.294 | 0.423 |
| | | | 0.2533 | 0.372 | 0.483 | 0.2566 | -0.291 | 0.419 |
| | | | 0.2566 | 0.366 | 0.475 | 0.2600 | -0.291 | 0.419 |

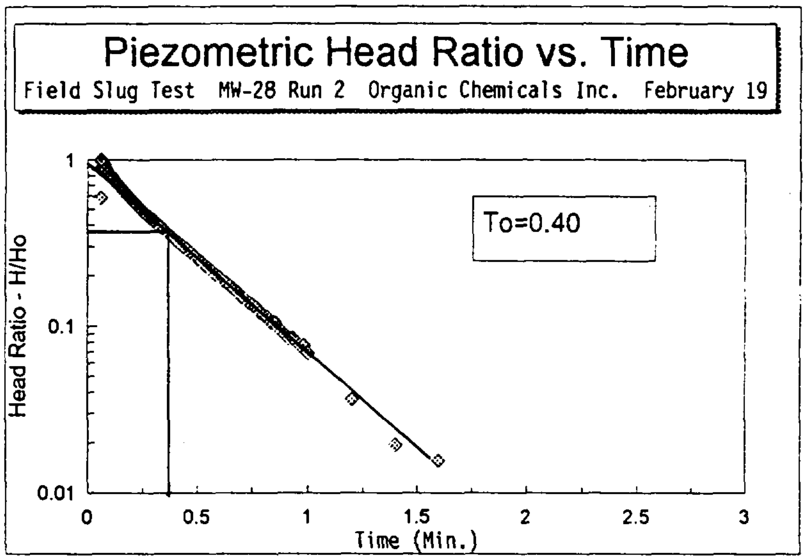
Run #2

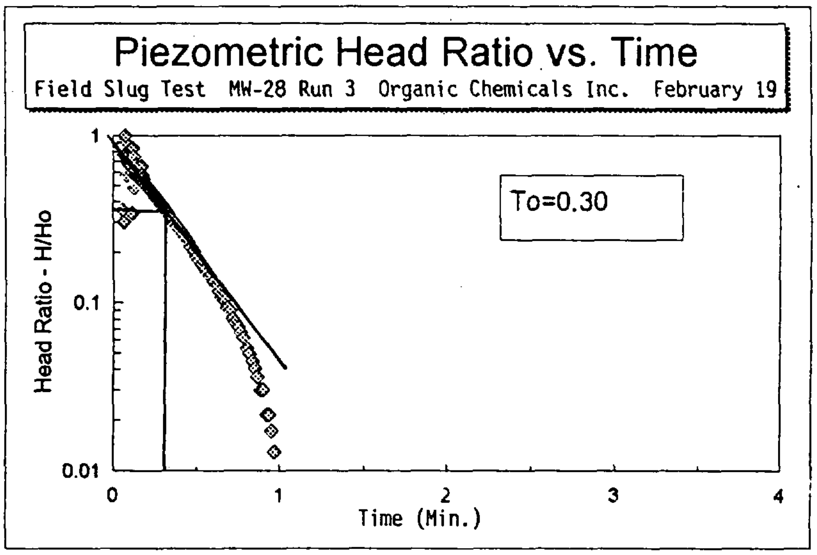
| Time | Value | H/H0 |
|---|---|---|
| 0.2600 | 0.363 | 0.471 |
| 0.2633 | 0.360 | 0.468 |
| 0.2666 | 0.356 | 0.462 |
| 0.2700 | 0.353 | 0.458 |
| 0.2733 | 0.350 | 0.455 |
| 0.2766 | 0.347 | 0.451 |
| 0.2800 | 0.344 | 0.447 |
| 0.2833 | 0.341 | 0.443 |
| 0.2866 | 0.338 | 0.439 |
| 0.2900 | 0.335 | 0.435 |
| 0.2933 | 0.331 | 0.430 |
| 0.2966 | 0.328 | 0.426 |
| 0.3000 | 0.328 | 0.426 |
| 0.3033 | 0.325 | 0.422 |
| 0.3066 | 0.322 | 0.418 |
| 0.3100 | 0.319 | 0.414 |
| 0.3133 | 0.316 | 0.410 |
| 0.3166 | 0.313 | 0.406 |
| 0.3200 | 0.313 | 0.406 |
| 0.3233 | 0.310 | 0.403 |
| 0.3266 | 0.306 | 0.397 |
| 0.3300 | 0.303 | 0.394 |
| 0.3333 | 0.300 | 0.390 |
| 0.3500 | 0.288 | 0.374 |
| 0.3666 | 0.275 | 0.357 |
| 0.3833 | 0.263 | 0.342 |
| 0.4000 | 0.250 | 0.325 |
| 0.4166 | 0.241 | 0.313 |
| 0.4333 | 0.231 | 0.300 |
| 0.4500 | 0.222 | 0.288 |
| 0.4666 | 0.212 | 0.275 |
| 0.4833 | 0.203 | 0.264 |
| 0.5000 | 0.194 | 0.252 |
| 0.5166 | 0.187 | 0.243 |
| 0.5333 | 0.178 | 0.231 |
| 0.5500 | 0.172 | 0.223 |
| 0.5666 | 0.165 | 0.214 |
| 0.5833 | 0.156 | 0.203 |
| 0.6000 | 0.150 | 0.195 |
| 0.6166 | 0.144 | 0.187 |
| 0.6333 | 0.140 | 0.182 |
| 0.6500 | 0.134 | 0.174 |
| 0.6666 | 0.128 | 0.166 |
| 0.6833 | 0.122 | 0.158 |
| 0.7000 | 0.115 | 0.149 |
| 0.7166 | 0.112 | 0.145 |
| 0.7333 | 0.106 | 0.138 |
| 0.7500 | 0.103 | 0.134 |
| 0.7666 | 0.100 | 0.130 |
| 0.7833 | 0.093 | 0.121 |
| 0.8000 | 0.090 | 0.117 |
| 0.8166 | 0.087 | 0.113 |
| 0.8333 | 0.081 | 0.105 |
| 0.8500 | 0.081 | 0.105 |
| 0.8666 | 0.075 | 0.097 |
| 0.8833 | 0.072 | 0.094 |
| 0.9000 | 0.068 | 0.088 |
| 0.9166 | 0.065 | 0.084 |
| 0.9333 | 0.065 | 0.084 |
| 0.9500 | 0.062 | 0.081 |
| 0.9666 | 0.059 | 0.077 |
| 0.9833 | 0.059 | 0.077 |
| 1.0000 | 0.053 | 0.069 |
| 1.2000 | 0.028 | 0.036 |
| 1.4000 | 0.015 | 0.019 |
| 1.6000 | 0.012 | 0.016 |
| 1.8000 | 0.003 | 0.004 |
| 2.0000 | 0.003 | 0.004 |
| 2.2000 | 0.000 | 0.000 |
| 2.4000 | 0.000 | 0.000 |
| 2.6000 | -0.003 | |
| 2.8000 | -0.003 | |
| 3.0000 | -0.003 | |

Run #1

| Time | Value | H/H0 |
|---|---|---|
| 0.2633 | -0.284 | 0.409 |
| 0.2666 | -0.284 | 0.409 |
| 0.2700 | -0.281 | 0.404 |
| 0.2733 | -0.278 | 0.400 |
| 0.2766 | -0.275 | 0.396 |
| 0.2800 | -0.272 | 0.391 |
| 0.2833 | -0.269 | 0.387 |
| 0.2866 | -0.269 | 0.387 |
| 0.2900 | -0.266 | 0.383 |
| 0.2933 | -0.263 | 0.378 |
| 0.2966 | -0.259 | 0.373 |
| 0.3000 | -0.256 | 0.368 |
| 0.3033 | -0.253 | 0.364 |
| 0.3066 | -0.250 | 0.360 |
| 0.3100 | -0.250 | 0.360 |
| 0.3133 | -0.247 | 0.355 |
| 0.3166 | -0.244 | 0.351 |
| 0.3200 | -0.241 | 0.347 |
| 0.3233 | -0.237 | 0.341 |
| 0.3266 | -0.237 | 0.341 |
| 0.3300 | -0.234 | 0.337 |
| 0.3333 | -0.231 | 0.332 |
| 0.3500 | -0.219 | 0.315 |
| 0.3666 | -0.206 | 0.296 |
| 0.3833 | -0.197 | 0.283 |
| 0.4000 | -0.187 | 0.269 |
| 0.4166 | -0.178 | 0.256 |
| 0.4333 | -0.169 | 0.243 |
| 0.4500 | -0.159 | 0.229 |
| 0.4666 | -0.150 | 0.216 |
| 0.4833 | -0.140 | 0.201 |
| 0.5000 | -0.131 | 0.188 |
| 0.5166 | -0.125 | 0.180 |
| 0.5333 | -0.118 | 0.170 |
| 0.5500 | -0.112 | 0.161 |
| 0.5666 | -0.106 | 0.153 |
| 0.5833 | -0.100 | 0.144 |
| 0.6000 | -0.093 | 0.134 |
| 0.6166 | -0.087 | 0.125 |
| 0.6333 | -0.081 | 0.117 |
| 0.6500 | -0.075 | 0.108 |
| 0.6666 | -0.072 | 0.104 |
| 0.6833 | -0.065 | 0.094 |
| 0.7000 | -0.062 | 0.089 |
| 0.7166 | -0.056 | 0.081 |
| 0.7333 | -0.053 | 0.076 |
| 0.7500 | -0.050 | 0.072 |
| 0.7666 | -0.046 | 0.066 |
| 0.7833 | -0.043 | 0.062 |
| 0.8000 | -0.037 | 0.053 |
| 0.8166 | -0.034 | 0.049 |
| 0.8333 | -0.031 | 0.045 |
| 0.8500 | -0.028 | 0.040 |
| 0.8666 | -0.025 | 0.036 |
| 0.8833 | -0.021 | 0.030 |
| 0.9000 | -0.021 | 0.030 |
| 0.9166 | -0.015 | 0.022 |
| 0.9333 | -0.015 | 0.022 |
| 0.9500 | -0.012 | 0.017 |
| 0.9666 | -0.009 | 0.013 |
| 0.9833 | -0.006 | 0.009 |
| 1.0000 | -0.006 | 0.009 |
| 1.2000 | 0.018 | -0.026 |
| 1.4000 | 0.034 | -0.049 |
| 1.6000 | 0.040 | -0.058 |
| 1.8000 | 0.043 | -0.062 |
| 2.0000 | 0.050 | -0.072 |
| 2.2000 | 0.050 | -0.072 |
| 2.4000 | 0.053 | -0.076 |
| 2.6000 | 0.053 | -0.076 |
| 2.8000 | 0.056 | -0.081 |
| 3.0000 | 0.053 | -0.076 |


Piezometric Head Ratio vs. Time
Field Slug Test MW-28 Run 1 Organic Chemicals Inc. February 19
To=0.45
Head Ratio - H/Ho
1
0.1
0.01
0
1
2
3
4
Time (Min.)


Piezometric Head Ratio vs. Time
Field Slug Test MW-28 Run 2 Organic Chemicals Inc. February 19
To=0.40
Head Ratio - H/Ho
1
0.1
0.01
0
0.5
1
1.5
2
2.5
3
Time (Min.)


Piezometric Head Ratio vs. Time
Field Slug Test MW-28 Run 3 Organic Chemicals Inc. February 19
To=0.30
Head Ratio - H/Ho
1
0.1
0.01
0
1
2
3
4
Time (Min.)

## Hydraulic Conductivity Determined From Slug Test
Organic Chemicals Inc.

Well #: MW-29
Test Date: February 1994

| Run # | Radius of Well (inches) r | Length of Screen (inches) L | Radius of Borehole (inches) R | Basic Time Lag (min.) T | Hydraulic Conductivity (ft/day) K | Hydraulic Conductivity (cm/sec) K |
|---|---|---|---|---|---|---|
| 1 | 1 | 54 | 4 | 0.074 | 38.9 | 1.37E-02 |
| 2 | 1 | 54 | 4 | 0.047 | 61.3 | 2.17E-02 |
| 3 | 1 | 54 | 4 | 0.11 | 26.2 | 9.24E-03 |
| | | | Geometric Mean = | | 39.7 | 1.40E-02 |

Run #1

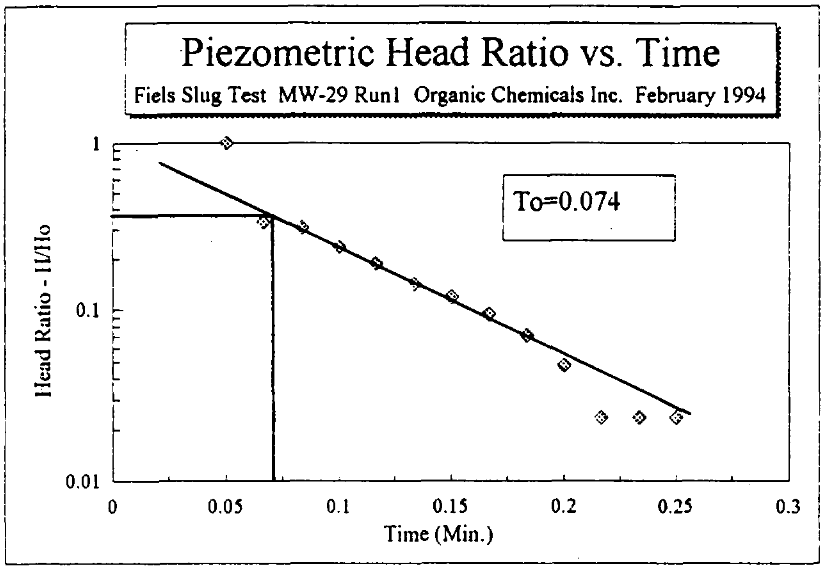
| Elapsed Time | Value | Time | H/H0 |
|---|---|---|---|
| 0.0000 | 0.00 | 0.0000 | 0.00 |
| 0.0300 | 0.10 | 0.0300 | 0.59 |
| 0.0333 | 0.17 | 0.0333 | 1.00 |
| 0.0500 | 0.15 | 0.0500 | 0.88 |
| 0.0666 | 0.12 | 0.0666 | 0.71 |
| 0.0833 | 0.09 | 0.0833 | 0.53 |
| 0.1000 | 0.07 | 0.1000 | 0.41 |
| 0.1166 | 0.05 | 0.1166 | 0.29 |
| 0.1333 | 0.04 | 0.1333 | 0.24 |
| 0.1500 | 0.03 | 0.1500 | 0.18 |
| 0.1666 | 0.02 | 0.1666 | 0.12 |
| 0.1833 | 0.01 | 0.1833 | 0.06 |
| 0.2000 | 0.01 | 0.2000 | 0.06 |
| 0.2166 | 0.01 | 0.2166 | 0.06 |
| 0.2333 | 0.00 | 0.2333 | 0.00 |

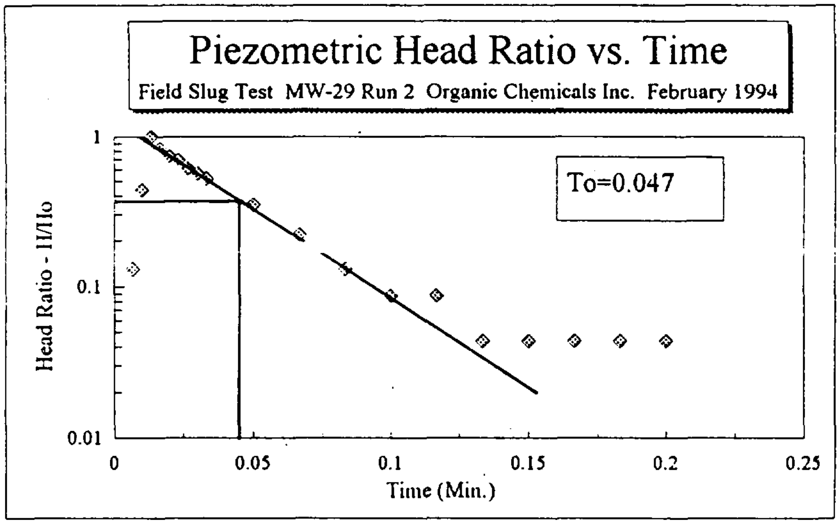
Run #2

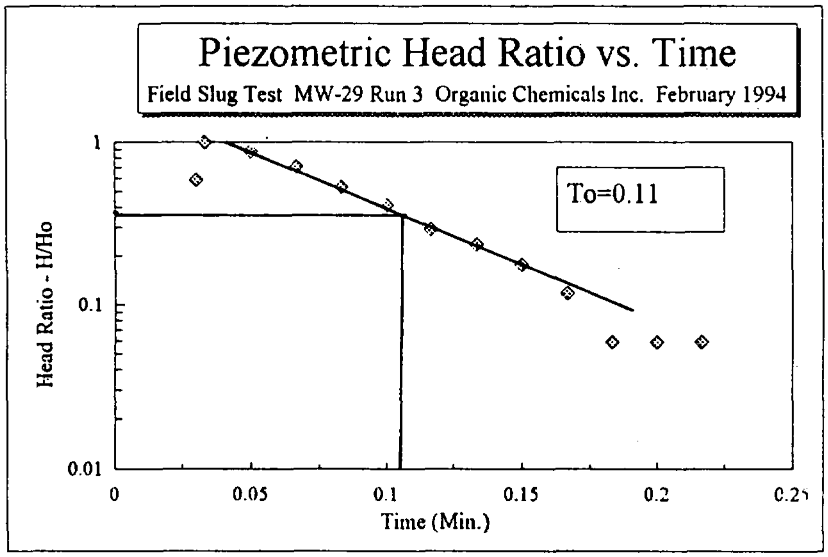
| Elapsed Time | Value | Time | H/H0 |
|---|---|---|---|
| 0.0066 | -0.03 | 0.0066 | 0.13 |
| 0.0099 | -0.10 | 0.0099 | 0.43 |
| 0.0133 | -0.23 | 0.0133 | 1.00 |
| 0.0166 | -0.19 | 0.0166 | 0.83 |
| 0.0200 | -0.17 | 0.0200 | 0.74 |
| 0.0233 | -0.16 | 0.0233 | 0.70 |
| 0.0266 | -0.14 | 0.0266 | 0.61 |
| 0.0300 | -0.13 | 0.0300 | 0.57 |
| 0.0333 | -0.12 | 0.0333 | 0.52 |
| 0.0500 | -0.08 | 0.0500 | 0.35 |
| 0.0666 | -0.05 | 0.0666 | 0.22 |
| 0.0833 | -0.03 | 0.0833 | 0.13 |
| 0.1000 | -0.02 | 0.1000 | 0.09 |
| 0.1166 | -0.02 | 0.1166 | 0.09 |
| 0.1333 | -0.01 | 0.1333 | 0.04 |
| 0.1500 | -0.01 | 0.1500 | 0.04 |
| 0.1666 | -0.01 | 0.1666 | 0.04 |
| 0.1833 | -0.01 | 0.1833 | 0.04 |
| 0.2000 | -0.01 | 0.2000 | 0.04 |
| 0.2166 | 0.00 | 0.2166 | 0.00 |

Run #3

| Elapsed Time | Value | Time | H/H0 |
|---|---|---|---|
| 0.0333 | 0.00 | 0.0333 | 0.00 |
| 0.0500 | 0.42 | 0.0500 | 1.00 |
| 0.0666 | 0.14 | 0.0666 | 0.33 |
| 0.0833 | 0.13 | 0.0833 | 0.31 |
| 0.1000 | 0.10 | 0.1000 | 0.24 |
| 0.1166 | 0.08 | 0.1166 | 0.19 |
| 0.1333 | 0.06 | 0.1333 | 0.14 |
| 0.1500 | 0.05 | 0.1500 | 0.12 |
| 0.1666 | 0.04 | 0.1666 | 0.10 |
| 0.1833 | 0.03 | 0.1833 | 0.07 |
| 0.2000 | 0.02 | 0.2000 | 0.05 |
| 0.2166 | 0.01 | 0.2166 | 0.02 |
| 0.2333 | 0.01 | 0.2333 | 0.02 |
| 0.2500 | 0.01 | 0.2500 | 0.02 |
| 0.2666 | 0.00 | 0.2666 | 0.00 |


Piezometric Head Ratio vs. Time
Fiels Slug Test MW-29 Run1 Organic Chemicals Inc. February 1994
To=0.074
Head Ratio - H/Ho
1
0.1
0.01
0
0.05
0.1
0.15
0.2
0.25
0.3
Time (Min.)


Piezometric Head Ratio vs. Time
Field Slug Test MW-29 Run 2 Organic Chemicals Inc. February 1994
To=0.047
Head Ratio - H/Ho
1
0.1
0.01
0
0.05
0.1
0.15
0.2
0.25
Time (Min.)


Piezometric Head Ratio vs. Time
Field Slug Test MW-29 Run 3 Organic Chemicals Inc. February 1994
To=0.11
Head Ratio - H/Ho
1
0.1
0.01
0
0.05
0.1
0.15
0.2
0.25
Time (Min.)

## Hydraulic Conductivity Determined From Slug Test
## Organic Chemicals Inc.

Well #: MW-30
Test Date: February 1994

| Run # | Radius of Well (inches) r | Length of Screen (inches) L | Radius of Borehole (inches) R | Basic Time Lag (min.) T | Hydraulic Conductivity (ft/day) K | Hydraulic Conductivity (cm/sec) K |
|---|---|---|---|---|---|---|
| 1 | 1 | 54 | 4 | 0.125 | 23 | 8.12E-03 |
| 2 | 1 | 54 | 4 | 0.175 | 16.4 | 5.79E-03 |
| 3 | 1 | 54 | 4 | 0.04 | 71.9 | 2.54E-02 |
|  |  |  | Geometric Mean = |  | 30 | 1.06E-02 |

Run #1

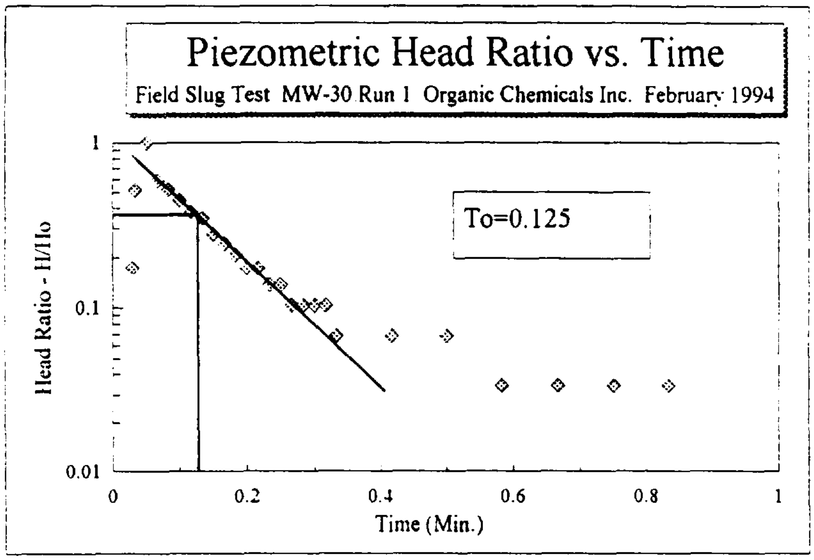
| Elapsed Time | Value | Time | H/H0 |
|---|---|---|---|
| 0.0099 | 0.00 | 0.0099 | 0.00 |
| 0.0133 | 0.06 | 0.0133 | 0.11 |
| 0.0166 | 0.16 | 0.0166 | 0.30 |
| 0.0200 | 0.31 | 0.0200 | 0.58 |
| 0.0233 | 0.53 | 0.0233 | 1.00 |
| 0.0266 | 0.43 | 0.0266 | 0.81 |
| 0.0333 | 0.25 | 0.0333 | 0.47 |
| 0.0500 | 0.16 | 0.0500 | 0.30 |
| 0.0666 | 0.13 | 0.0666 | 0.25 |
| 0.0833 | 0.11 | 0.0833 | 0.21 |
| 0.1000 | 0.09 | 0.1000 | 0.17 |
| 0.1166 | 0.08 | 0.1166 | 0.15 |
| 0.1333 | 0.06 | 0.1333 | 0.11 |
| 0.1500 | 0.05 | 0.1500 | 0.09 |
| 0.1666 | 0.04 | 0.1666 | 0.08 |
| 0.1833 | 0.04 | 0.1833 | 0.08 |
| 0.2000 | 0.03 | 0.2000 | 0.06 |
| 0.2166 | 0.02 | 0.2166 | 0.04 |
| 0.2333 | 0.02 | 0.2333 | 0.04 |
| 0.2500 | 0.01 | 0.2500 | 0.02 |
| 0.2666 | 0.01 | 0.2666 | 0.02 |
| 0.2833 | 0.01 | 0.2833 | 0.02 |
| 0.3000 | 0.01 | 0.3000 | 0.02 |
| 0.3166 | 0.00 | 0.3166 | 0.00 |

Run #2

| Elapsed Time | Value | Time | H/H0 |
|---|---|---|---|
| 0.0200 | -0.05 | 0.0200 | 0.22 |
| 0.0233 | -0.10 | 0.0233 | 0.43 |
| 0.0266 | -0.16 | 0.0266 | 0.70 |
| 0.0300 | -0.23 | 0.0300 | 1.00 |
| 0.0333 | -0.22 | 0.0333 | 0.96 |
| 0.0500 | -0.17 | 0.0500 | 0.74 |
| 0.0666 | -0.19 | 0.0666 | 0.83 |
| 0.0833 | -0.16 | 0.0833 | 0.70 |
| 0.1000 | -0.14 | 0.1000 | 0.61 |
| 0.1166 | -0.12 | 0.1166 | 0.52 |
| 0.1333 | -0.11 | 0.1333 | 0.48 |
| 0.1500 | -0.10 | 0.1500 | 0.43 |
| 0.1666 | -0.09 | 0.1666 | 0.39 |
| 0.1833 | -0.08 | 0.1833 | 0.35 |
| 0.2000 | -0.07 | 0.2000 | 0.30 |
| 0.2166 | -0.07 | 0.2166 | 0.30 |
| 0.2333 | -0.06 | 0.2333 | 0.26 |
| 0.2500 | -0.06 | 0.2500 | 0.26 |
| 0.2666 | -0.06 | 0.2666 | 0.26 |
| 0.2833 | -0.05 | 0.2833 | 0.22 |
| 0.3000 | -0.05 | 0.3000 | 0.22 |
| 0.3166 | -0.05 | 0.3166 | 0.22 |
| 0.3333 | -0.05 | 0.3333 | 0.22 |
| 0.4167 | -0.04 | 0.4167 | 0.17 |
| 0.5000 | -0.04 | 0.5000 | 0.17 |
| 0.5833 | -0.04 | 0.5833 | 0.17 |
| 0.6667 | -0.04 | 0.6667 | 0.17 |

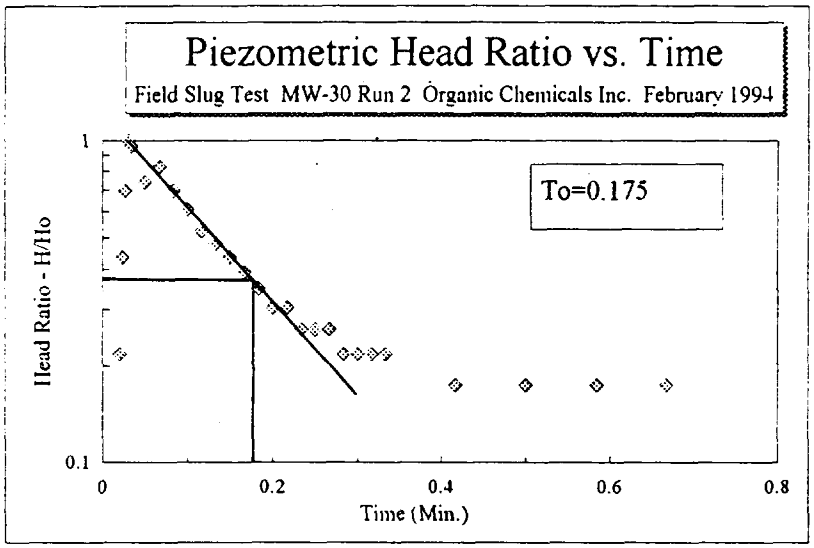
Run #3

| Elapsed Time | Value | Time | H/H0 |
|---|---|---|---|
| 0.0000 | 0.00 | 0.0000 | 0.00 |
| 0.0300 | 0.05 | 0.0300 | 0.17 |
| 0.0333 | 0.15 | 0.0333 | 0.52 |
| 0.0500 | 0.29 | 0.0500 | 1.00 |
| 0.0666 | 0.17 | 0.0666 | 0.59 |
| 0.0833 | 0.15 | 0.0833 | 0.52 |
| 0.1000 | 0.13 | 0.1000 | 0.45 |
| 0.1166 | 0.11 | 0.1166 | 0.38 |
| 0.1333 | 0.10 | 0.1333 | 0.34 |
| 0.1500 | 0.08 | 0.1500 | 0.28 |
| 0.1666 | 0.07 | 0.1666 | 0.24 |
| 0.1833 | 0.06 | 0.1833 | 0.21 |
| 0.2000 | 0.05 | 0.2000 | 0.17 |
| 0.2166 | 0.05 | 0.2166 | 0.17 |
| 0.2333 | 0.04 | 0.2333 | 0.14 |
| 0.2500 | 0.04 | 0.2500 | 0.14 |
| 0.2666 | 0.03 | 0.2666 | 0.10 |
| 0.2833 | 0.03 | 0.2833 | 0.10 |
| 0.3000 | 0.03 | 0.3000 | 0.10 |
| 0.3166 | 0.03 | 0.3166 | 0.10 |
| 0.3333 | 0.02 | 0.3333 | 0.07 |
| 0.4167 | 0.02 | 0.4167 | 0.07 |
| 0.5000 | 0.02 | 0.5000 | 0.07 |
| 0.5833 | 0.01 | 0.5833 | 0.03 |
| 0.6667 | 0.01 | 0.6667 | 0.03 |
| 0.7500 | 0.01 | 0.7500 | 0.03 |
| 0.8333 | 0.01 | 0.8333 | 0.03 |



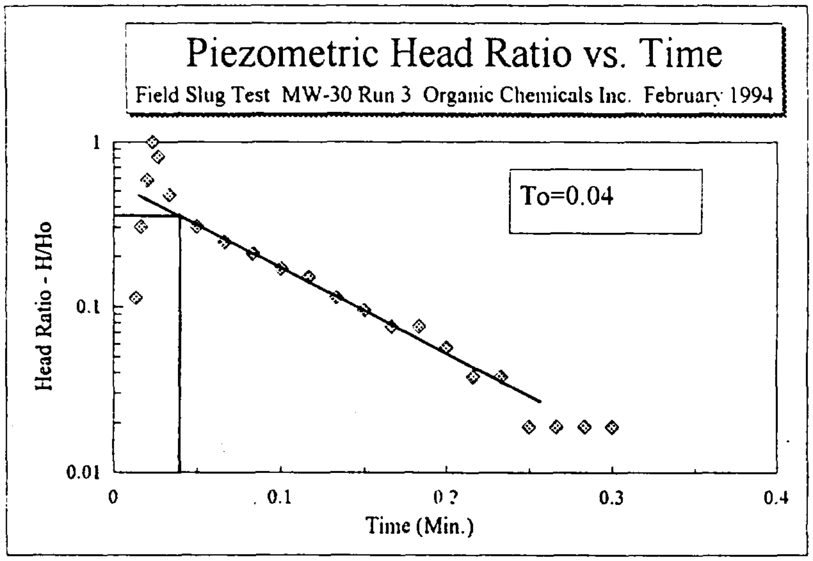
Piezometric Head Ratio vs. Time

Field Slug Test MW-30 Run 1 Organic Chemicals Inc. February 1994



Piezometric Head Ratio vs. Time

Field Slug Test MW-30 Run 2 Organic Chemicals Inc. February 1994



Piezometric Head Ratio vs. Time

Field Slug Test MW-30 Run 3 Organic Chemicals Inc. February 1994

# Hydraulic Conductivity Determined From Slug Test
## Organic Chemicals Inc.

Well #: MW-31

Test Date: February 1994

| Run # | Radius of Well (inches) r | Length of Screen (inches) L | Radius of Borehole (inches) R | Basic Time Lag (min.) T | Hydraulic Conductivity (ft/day) K | Hydraulic Conductivity (cm/sec) K |
|---|---|---|---|---|---|---|
| 1 | 1 | 54 | 4 | 0.033 | 87.3 | 3.08E-02 |
| 2 | 1 | 54 | 4 | 0.051 | 56.5 | 1.99E-02 |
| 3 | 1 | 54 | 4 | 0.039 | 73.8 | 2.61E-02 |
| | | | Geometric Mean = | | 71.4 | 2.52E-02 |

Run #1

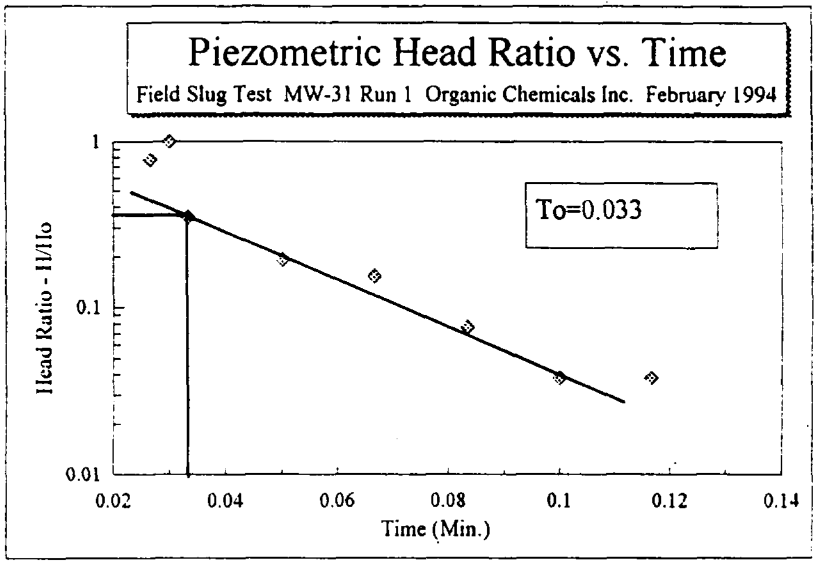
| Elapsed Time | Value | Time | H/H0 |
|---|---|---|---|
| 0.0233 | 0.13 | 0.0233 | 0.46 |
| 0.0266 | 0.28 | 0.0266 | 1.00 |
| 0.0300 | 0.28 | 0.0300 | 1.00 |
| 0.0333 | 0.14 | 0.0333 | 0.50 |
| 0.0500 | 0.03 | 0.0500 | 0.11 |
| 0.0666 | 0.03 | 0.0666 | 0.11 |
| 0.0833 | 0.01 | 0.0833 | 0.04 |
| 0.1000 | 0.02 | 0.1000 | 0.07 |
| 0.1166 | 0.00 | 0.1166 | 0.00 |

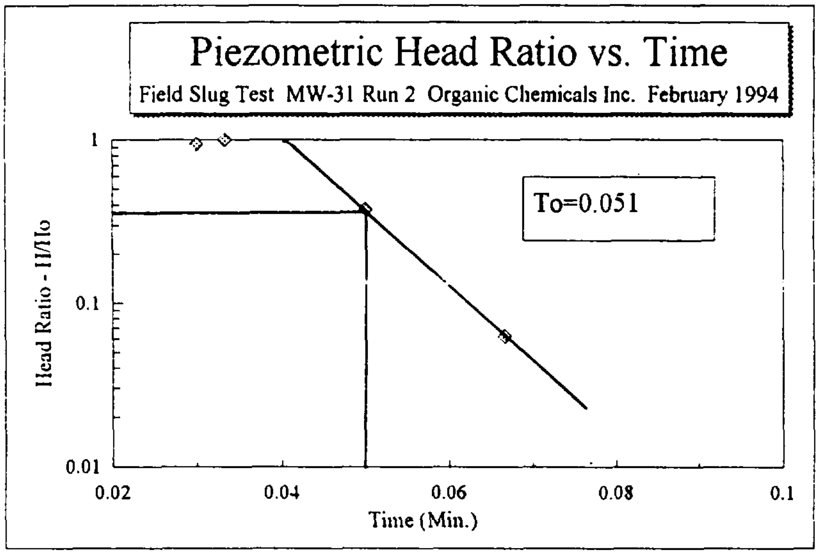
Run #2

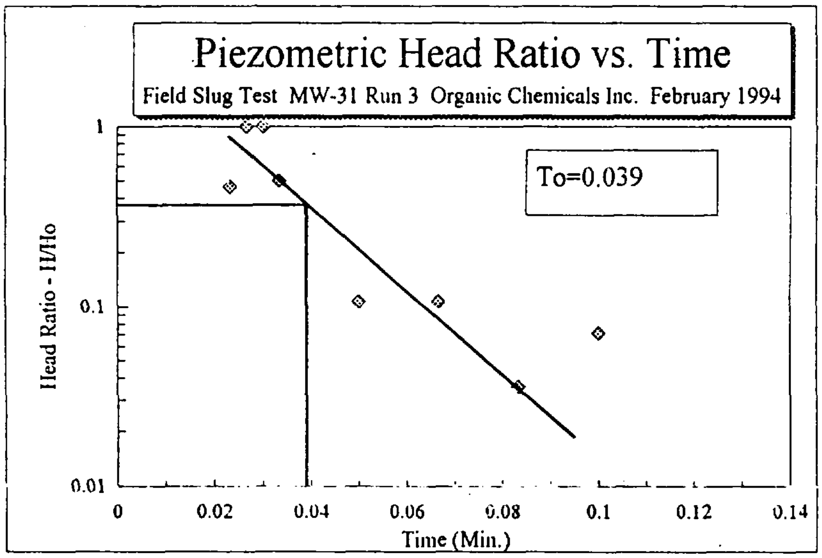
| Elapsed Time | Value | Time | H/H0 |
|---|---|---|---|
| 0.0300 | -0.15 | 0.0300 | 0.94 |
| 0.0333 | -0.16 | 0.0333 | 1.00 |
| 0.0500 | -0.06 | 0.0500 | 0.38 |
| 0.0666 | -0.01 | 0.0666 | 0.06 |
| 0.0833 | 0.00 | 0.0833 | 0.00 |

Run #3

| Elapsed Time | Value | Time | H/H0 |
|---|---|---|---|
| 0.0266 | 0.20 | 0.0266 | 0.77 |
| 0.0300 | 0.26 | 0.0300 | 1.00 |
| 0.0333 | 0.09 | 0.0333 | 0.35 |
| 0.0500 | 0.05 | 0.0500 | 0.19 |
| 0.0666 | 0.04 | 0.0666 | 0.15 |
| 0.0833 | 0.02 | 0.0833 | 0.08 |
| 0.1000 | 0.01 | 0.1000 | 0.04 |
| 0.1166 | 0.01 | 0.1166 | 0.04 |
| 0.1333 | 0.00 | 0.1333 | 0.00 |


Piezometric Head Ratio vs. Time
Field Slug Test MW-31 Run 1 Organic Chemicals Inc. February 1994
To=0.033
Head Ratio - H/Ho
1
0.1
0.01
0.02
0.04
0.06
0.08
0.1
0.12
0.14
Time (Min.)


Piezometric Head Ratio vs. Time
Field Slug Test MW-31 Run 2 Organic Chemicals Inc. February 1994
To=0.051
Head Ratio - H/Ho
1
0.1
0.01
0.02
0.04
0.06
0.08
0.1
Time (Min.)


Piezometric Head Ratio vs. Time
Field Slug Test MW-31 Run 3 Organic Chemicals Inc. February 1994
To=0.039
Head Ratio - H/Ho
1
0.1
0.01
0
0.02
0.04
0.06
0.08
0.1
0.12
0.14
Time (Min.)

## Hydraulic Conductivity Determined From Slug Test
## Organic Chemicals Inc.

Well #: MW-32

Test Date: February 1994

| Run # | Radius of Well (inches) r | Length of Screen (inches) L | Radius of Borehole (inches) R | Basic Time Lag (min.) T | Hydraulic Conductivity (ft/day) K | Hydraulic Conductivity (cm/sec) K |
|---|---|---|---|---|---|---|
| 1 | 1 | 54 | 4 | 4 | 0.719 | 2.54E-04 |
| 2 | 1 | 54 | 4 | 3.13 | 0.922 | 3.25E-04 |
| 3 | 1 | 54 | 4 | 3.6 | 0.8 | 2.82E-04 |
| | | | | Geometric Mean = | 0.809 | 2.86E-04 |

Run #1

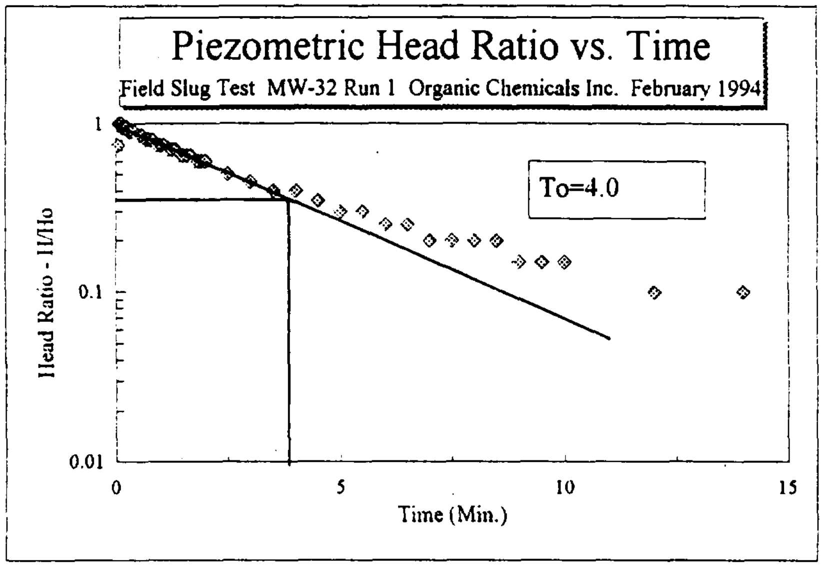
| Elapsed Time | Value | Time | H/H0 |
|---|---|---|---|
| 0.0833 | 0.20 | 0.0833 | 0.95 |
| 0.1000 | 0.21 | 0.1000 | 1.00 |
| 0.1166 | 0.21 | 0.1166 | 1.00 |
| 0.1333 | 0.20 | 0.1333 | 0.95 |
| 0.1500 | 0.20 | 0.1500 | 0.95 |
| 0.1666 | 0.20 | 0.1666 | 0.95 |
| 0.1833 | 0.20 | 0.1833 | 0.95 |
| 0.2000 | 0.20 | 0.2000 | 0.95 |
| 0.2166 | 0.20 | 0.2166 | 0.95 |
| 0.2333 | 0.20 | 0.2333 | 0.95 |
| 0.2500 | 0.20 | 0.2500 | 0.95 |
| 0.2666 | 0.19 | 0.2666 | 0.90 |
| 0.2833 | 0.19 | 0.2833 | 0.90 |
| 0.3000 | 0.19 | 0.3000 | 0.90 |
| 0.3166 | 0.19 | 0.3166 | 0.90 |
| 0.3333 | 0.20 | 0.3333 | 0.95 |
| 0.4167 | 0.18 | 0.4167 | 0.86 |
| 0.5000 | 0.18 | 0.5000 | 0.86 |
| 0.5833 | 0.17 | 0.5833 | 0.81 |
| 0.6667 | 0.17 | 0.6667 | 0.81 |
| 0.7500 | 0.16 | 0.7500 | 0.76 |
| 0.8333 | 0.16 | 0.8333 | 0.76 |
| 0.9167 | 0.16 | 0.9167 | 0.76 |
| 1.0000 | 0.15 | 1.0000 | 0.71 |
| 1.0833 | 0.15 | 1.0833 | 0.71 |
| 1.1667 | 0.14 | 1.1667 | 0.67 |
| 1.2500 | 0.14 | 1.2500 | 0.67 |
| 1.3333 | 0.14 | 1.3333 | 0.67 |
| 1.4166 | 0.14 | 1.4166 | 0.67 |
| 1.5000 | 0.13 | 1.5000 | 0.62 |
| 1.5833 | 0.13 | 1.5833 | 0.62 |
| 1.6667 | 0.13 | 1.6667 | 0.62 |
| 1.7500 | 0.12 | 1.7500 | 0.57 |
| 1.8333 | 0.12 | 1.8333 | 0.57 |
| 1.9167 | 0.12 | 1.9167 | 0.57 |
| 2.0000 | 0.12 | 2.0000 | 0.57 |
| 2.5000 | 0.10 | 2.5000 | 0.48 |
| 3.0000 | 0.09 | 3.0000 | 0.43 |
| 3.5000 | 0.08 | 3.5000 | 0.38 |
| 4.0000 | 0.07 | 4.0000 | 0.33 |
| 4.5000 | 0.06 | 4.5000 | 0.29 |
| 5.0000 | 0.06 | 5.0000 | 0.29 |
| 5.5000 | 0.05 | 5.5000 | 0.24 |
| 6.0000 | 0.04 | 6.0000 | 0.19 |
| 6.5000 | 0.04 | 6.5000 | 0.19 |
| 7.0000 | 0.03 | 7.0000 | 0.14 |
| 7.5000 | 0.03 | 7.5000 | 0.14 |
| 8.0000 | 0.02 | 8.0000 | 0.10 |
| 8.5000 | 0.02 | 8.5000 | 0.10 |
| 9.0000 | 0.02 | 9.0000 | 0.10 |
| 9.5000 | 0.02 | 9.5000 | 0.10 |
| 10.0000 | 0.01 | 10.0000 | 0.05 |
| 12.0000 | 0.00 | 12.0000 | 0.00 |

Run #2

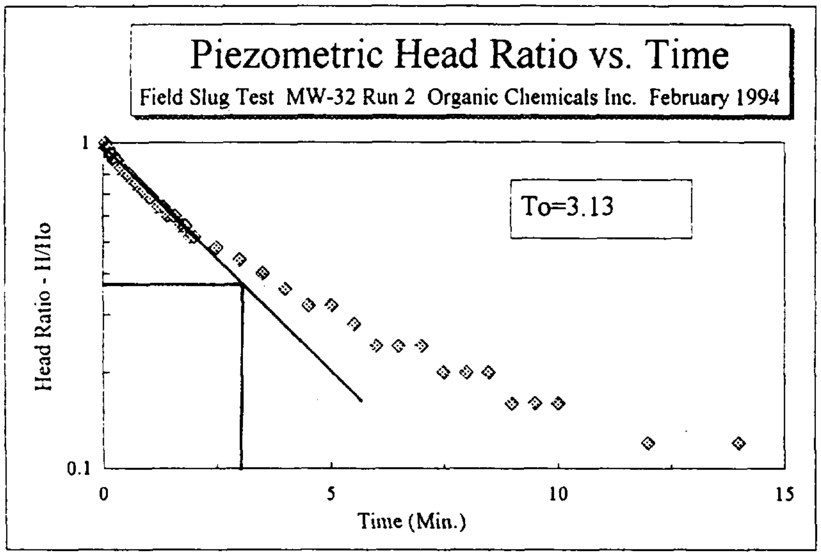
| Elapsed Time | Value | Time | H/H0 |
|---|---|---|---|
| 0.0500 | -0.24 | 0.0500 | 0.96 |
| 0.0666 | -0.25 | 0.0666 | 1.00 |
| 0.0833 | -0.24 | 0.0833 | 0.96 |
| 0.1000 | -0.24 | 0.1000 | 0.96 |
| 0.1166 | -0.24 | 0.1166 | 0.96 |
| 0.1333 | -0.24 | 0.1333 | 0.96 |
| 0.1500 | -0.23 | 0.1500 | 0.92 |
| 0.1666 | -0.23 | 0.1666 | 0.92 |
| 0.1833 | -0.23 | 0.1833 | 0.92 |
| 0.2000 | -0.23 | 0.2000 | 0.92 |
| 0.2166 | -0.23 | 0.2166 | 0.92 |
| 0.2333 | -0.22 | 0.2333 | 0.88 |
| 0.2500 | -0.22 | 0.2500 | 0.88 |
| 0.2666 | -0.22 | 0.2666 | 0.88 |
| 0.2833 | -0.22 | 0.2833 | 0.88 |
| 0.3000 | -0.22 | 0.3000 | 0.88 |
| 0.3166 | -0.22 | 0.3166 | 0.88 |
| 0.3333 | -0.21 | 0.3333 | 0.84 |
| 0.4167 | -0.21 | 0.4167 | 0.84 |
| 0.5000 | -0.20 | 0.5000 | 0.80 |
| 0.5833 | -0.20 | 0.5833 | 0.80 |
| 0.6667 | -0.19 | 0.6667 | 0.76 |
| 0.7500 | -0.19 | 0.7500 | 0.76 |
| 0.8333 | -0.18 | 0.8333 | 0.72 |
| 0.9167 | -0.18 | 0.9167 | 0.72 |
| 1.0000 | -0.17 | 1.0000 | 0.68 |
| 1.0833 | -0.17 | 1.0833 | 0.68 |
| 1.1667 | -0.16 | 1.1667 | 0.64 |
| 1.2500 | -0.16 | 1.2500 | 0.64 |
| 1.3333 | -0.16 | 1.3333 | 0.64 |
| 1.4166 | -0.15 | 1.4166 | 0.60 |
| 1.5000 | -0.15 | 1.5000 | 0.60 |
| 1.5833 | -0.15 | 1.5833 | 0.60 |
| 1.6667 | -0.14 | 1.6667 | 0.56 |
| 1.7500 | -0.14 | 1.7500 | 0.56 |
| 1.8333 | -0.14 | 1.8333 | 0.56 |
| 1.9167 | -0.13 | 1.9167 | 0.52 |
| 2.0000 | -0.13 | 2.0000 | 0.52 |
| 2.5000 | -0.12 | 2.5000 | 0.48 |
| 3.0000 | -0.11 | 3.0000 | 0.44 |
| 3.5000 | -0.10 | 3.5000 | 0.40 |
| 4.0000 | -0.09 | 4.0000 | 0.36 |
| 4.5000 | -0.08 | 4.5000 | 0.32 |
| 5.0000 | -0.08 | 5.0000 | 0.32 |
| 5.5000 | -0.07 | 5.5000 | 0.28 |
| 6.0000 | -0.06 | 6.0000 | 0.24 |
| 6.5000 | -0.06 | 6.5000 | 0.24 |
| 7.0000 | -0.06 | 7.0000 | 0.24 |
| 7.5000 | -0.05 | 7.5000 | 0.20 |
| 8.0000 | -0.05 | 8.0000 | 0.20 |
| 8.5000 | -0.05 | 8.5000 | 0.20 |
| 9.0000 | -0.04 | 9.0000 | 0.16 |
| 9.5000 | -0.04 | 9.5000 | 0.16 |
| 10.0000 | -0.04 | 10.0000 | 0.16 |
| 12.0000 | -0.03 | 12.0000 | 0.12 |
| 14.0000 | -0.03 | 14.0000 | 0.12 |

Run #3

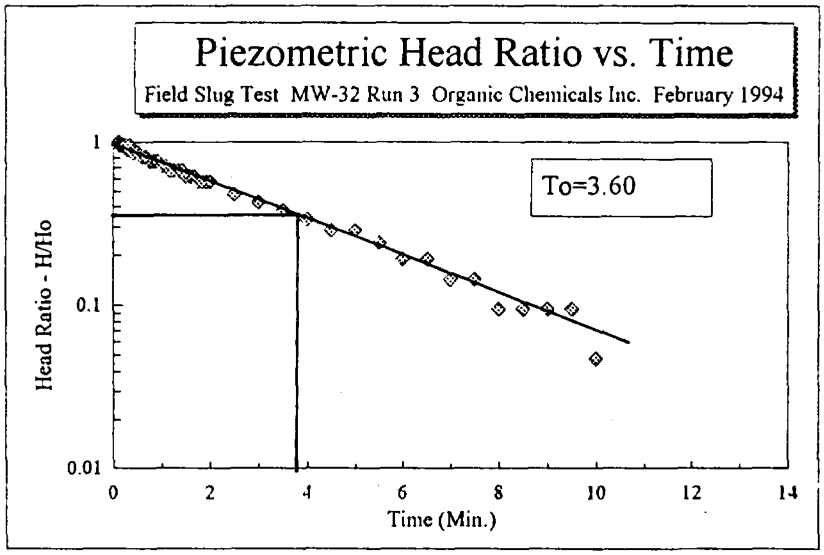
| Elapsed Time | Value | Time | H/H0 |
|---|---|---|---|
| 0.0500 | 0.15 | 0.0500 | 0.75 |
| 0.0666 | 0.20 | 0.0666 | 1.00 |
| 0.0833 | 0.20 | 0.0833 | 1.00 |
| 0.1000 | 0.20 | 0.1000 | 1.00 |
| 0.1166 | 0.20 | 0.1166 | 1.00 |
| 0.1333 | 0.20 | 0.1333 | 1.00 |
| 0.1500 | 0.19 | 0.1500 | 0.95 |
| 0.1666 | 0.19 | 0.1666 | 0.95 |
| 0.1833 | 0.19 | 0.1833 | 0.95 |
| 0.2000 | 0.19 | 0.2000 | 0.95 |
| 0.2166 | 0.19 | 0.2166 | 0.95 |
| 0.2333 | 0.19 | 0.2333 | 0.95 |
| 0.2500 | 0.19 | 0.2500 | 0.95 |
| 0.2666 | 0.19 | 0.2666 | 0.95 |
| 0.2833 | 0.18 | 0.2833 | 0.90 |
| 0.3000 | 0.18 | 0.3000 | 0.90 |
| 0.3166 | 0.18 | 0.3166 | 0.90 |
| 0.3333 | 0.18 | 0.3333 | 0.90 |
| 0.4167 | 0.18 | 0.4167 | 0.90 |
| 0.5000 | 0.17 | 0.5000 | 0.85 |
| 0.5833 | 0.17 | 0.5833 | 0.85 |
| 0.6667 | 0.16 | 0.6667 | 0.80 |
| 0.7500 | 0.16 | 0.7500 | 0.80 |
| 0.8333 | 0.16 | 0.8333 | 0.80 |
| 0.9167 | 0.15 | 0.9167 | 0.75 |
| 1.0000 | 0.15 | 1.0000 | 0.75 |
| 1.0833 | 0.15 | 1.0833 | 0.75 |
| 1.1667 | 0.14 | 1.1667 | 0.70 |
| 1.2500 | 0.14 | 1.2500 | 0.70 |
| 1.3333 | 0.14 | 1.3333 | 0.70 |
| 1.4166 | 0.13 | 1.4166 | 0.65 |
| 1.5000 | 0.13 | 1.5000 | 0.65 |
| 1.5833 | 0.13 | 1.5833 | 0.65 |
| 1.6667 | 0.13 | 1.6667 | 0.65 |
| 1.7500 | 0.12 | 1.7500 | [illegible] |
| 1.8333 | 0.12 | 1.8333 | 0.60 |
| 1.9167 | 0.12 | 1.9167 | 0.60 |
| 2.0000 | 0.12 | 2.0000 | 0.60 |
| 2.5000 | 0.10 | 2.5000 | 0.50 |
| 3.0000 | 0.09 | 3.0000 | 0.45 |
| 3.5000 | 0.08 | 3.5000 | 0.40 |
| 4.0000 | 0.08 | 4.0000 | 0.40 |
| 4.5000 | 0.07 | 4.5000 | 0.35 |
| 5.0000 | 0.06 | 5.0000 | 0.30 |
| 5.5000 | 0.06 | 5.5000 | 0.30 |
| 6.0000 | 0.05 | 6.0000 | 0.25 |
| 6.5000 | 0.05 | 6.5000 | 0.25 |
| 7.0000 | 0.04 | 7.0000 | 0.20 |
| 7.5000 | 0.04 | 7.5000 | 0.20 |
| 8.0000 | 0.04 | 8.0000 | 0.20 |
| 8.5000 | 0.04 | 8.5000 | 0.20 |
| 9.0000 | 0.03 | 9.0000 | 0.15 |
| 9.5000 | 0.03 | 9.5000 | 0.15 |
| 10.0000 | 0.03 | 10.0000 | 0.15 |
| 12.0000 | 0.02 | 12.0000 | 0.10 |
| 14.0000 | 0.02 | 14.0000 | 0.10 |


Piezometric Head Ratio vs. Time

Field Slug Test MW-32 Run 1 Organic Chemicals Inc. February 1994


Piezometric Head Ratio vs. Time

Field Slug Test MW-32 Run 2 Organic Chemicals Inc. February 1994


Piezometric Head Ratio vs. Time

Field Slug Test MW-32 Run 3 Organic Chemicals Inc. February 1994

## Hydraulic Conductivity Determined From Slug Test
## Organic Chemicals Inc.

Well #: MW-03
Test Date: February 1994

| Run # | Radius of Well (inches) r | Length of Screen (inches) L | Radius of Borehole (inches) R | Basic Time Lag (min.) T | Hydraulic Conductivity (ft/day) K | Hydraulic Conductivity (cm/sec) K |
|---|---|---|---|---|---|---|
| 1 | 1 | 54 | 4 | 0.125 | 23 | 8.13E-03 |
| 2 | 1 | 54 | 4 | 0.125 | 23 | 8.13E-03 |
| 3 | 1 | 54 | 4 | 0.21 | 13.7 | 4.84E-03 |
| | | | Geometric Mean = | | 19.4 | 6.84E-03 |

Run #1

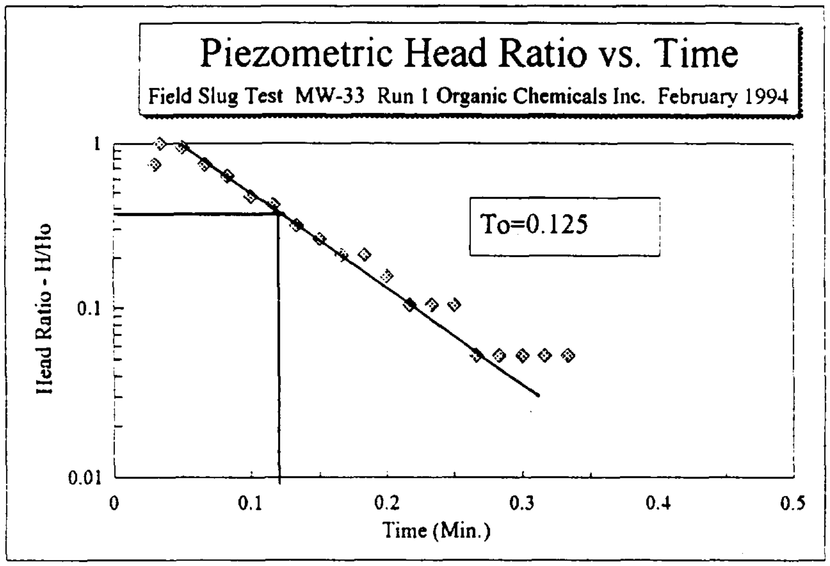
| Elapsed Time | Value | Time | H/H0 |
|---|---|---|---|
| 0.0300 | -0.14 | 0.0300 | 0.74 |
| 0.0333 | -0.19 | 0.0333 | 1.00 |
| 0.0500 | -0.18 | 0.0500 | 0.95 |
| 0.0666 | -0.14 | 0.0666 | 0.74 |
| 0.0833 | -0.12 | 0.0833 | 0.63 |
| 0.1000 | -0.09 | 0.1000 | 0.47 |
| 0.1166 | -0.08 | 0.1166 | 0.42 |
| 0.1333 | -0.06 | 0.1333 | 0.32 |
| 0.1500 | -0.05 | 0.1500 | 0.26 |
| 0.1666 | -0.04 | 0.1666 | 0.21 |
| 0.1833 | -0.04 | 0.1833 | 0.21 |
| 0.2000 | -0.03 | 0.2000 | 0.16 |
| 0.2166 | -0.02 | 0.2166 | 0.11 |
| 0.2333 | -0.02 | 0.2333 | 0.11 |
| 0.2500 | -0.02 | 0.2500 | 0.11 |
| 0.2666 | -0.01 | 0.2666 | 0.05 |
| 0.2833 | -0.01 | 0.2833 | 0.05 |
| 0.3000 | -0.01 | 0.3000 | 0.05 |
| 0.3166 | -0.01 | 0.3166 | 0.05 |
| 0.3333 | -0.01 | 0.3333 | 0.05 |
| 0.4167 | 0.00 | 0.4167 | 0.00 |

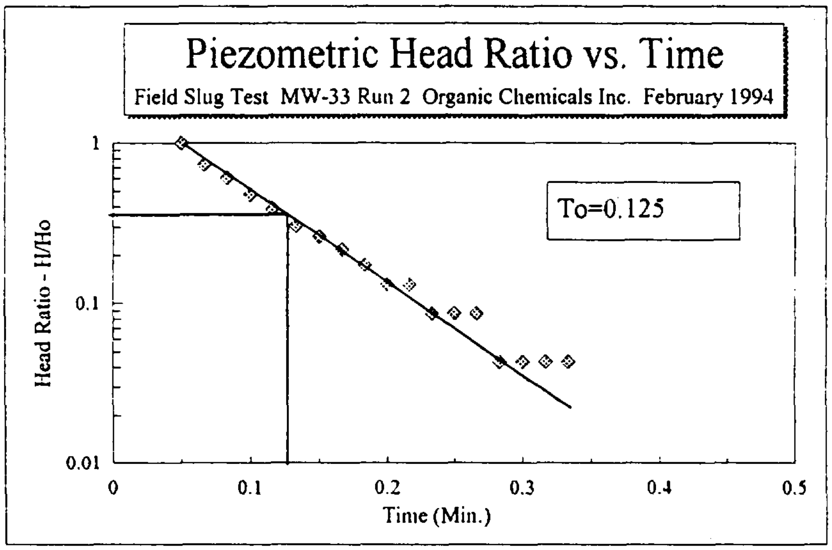
Run #2

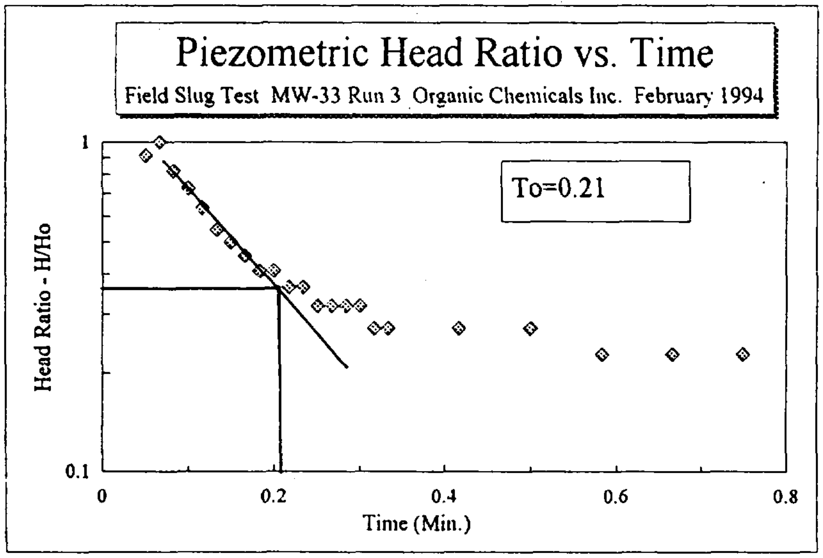
| Elapsed Time | Value | Time | H/H0 |
|---|---|---|---|
| 0.0500 | -0.23 | 0.0500 | 1.00 |
| 0.0666 | -0.17 | 0.0666 | 0.74 |
| 0.0833 | -0.14 | 0.0833 | 0.61 |
| 0.1000 | -0.11 | 0.1000 | 0.48 |
| 0.1166 | -0.09 | 0.1166 | 0.39 |
| 0.1333 | -0.07 | 0.1333 | 0.30 |
| 0.1500 | -0.06 | 0.1500 | 0.26 |
| 0.1666 | -0.05 | 0.1666 | 0.22 |
| 0.1833 | -0.04 | 0.1833 | 0.17 |
| 0.2000 | -0.03 | 0.2000 | 0.13 |
| 0.2166 | -0.03 | 0.2166 | 0.13 |
| 0.2333 | -0.02 | 0.2333 | 0.09 |
| 0.2500 | -0.02 | 0.2500 | 0.09 |
| 0.2666 | -0.02 | 0.2666 | 0.09 |
| 0.2833 | -0.01 | 0.2833 | 0.04 |
| 0.3000 | -0.01 | 0.3000 | 0.04 |
| 0.3166 | -0.01 | 0.3166 | 0.04 |
| 0.3333 | -0.01 | 0.3333 | 0.04 |
| 0.4167 | 0.00 | 0.4167 | 0.00 |

Run #3

| Elapsed Time | Value | Time | H/H0 |
|---|---|---|---|
| 0.05 | -0.20 | 0.05 | 0.91 |
| 0.07 | -0.22 | 0.07 | 1.00 |
| 0.08 | -0.18 | 0.08 | 0.82 |
| 0.10 | -0.16 | 0.10 | 0.73 |
| 0.12 | -0.14 | 0.12 | 0.64 |
| 0.13 | -0.12 | 0.13 | 0.55 |
| 0.15 | -0.11 | 0.15 | 0.50 |
| 0.17 | -0.10 | 0.17 | 0.45 |
| 0.18 | -0.09 | 0.18 | 0.41 |
| 0.20 | -0.09 | 0.20 | 0.41 |
| 0.22 | -0.08 | 0.22 | 0.36 |
| 0.23 | -0.08 | 0.23 | 0.36 |
| 0.25 | -0.07 | 0.25 | 0.32 |
| 0.27 | -0.07 | 0.27 | 0.32 |
| 0.28 | -0.07 | 0.28 | 0.32 |
| 0.30 | -0.07 | 0.30 | 0.32 |
| 0.32 | -0.06 | 0.32 | 0.27 |
| 0.33 | -0.06 | 0.33 | 0.27 |
| 0.42 | -0.06 | 0.42 | 0.27 |
| 0.50 | -0.06 | 0.50 | 0.27 |
| 0.58 | -0.05 | 0.58 | 0.23 |
| 0.67 | -0.05 | 0.67 | 0.23 |
| 0.75 | -0.05 | 0.75 | 0.23 |


Piezometric Head Ratio vs. Time
Field Slug Test MW-33 Run 1 Organic Chemicals Inc. February 1994
To=0.125
Head Ratio - H/Ho
1
0.1
0.01
0
0.1
0.2
0.3
0.4
0.5
Time (Min.)


Piezometric Head Ratio vs. Time
Field Slug Test MW-33 Run 2 Organic Chemicals Inc. February 1994
To=0.125
Head Ratio - H/Ho
1
0.1
0.01
0
0.1
0.2
0.3
0.4
0.5
Time (Min.)


Piezometric Head Ratio vs. Time
Field Slug Test MW-33 Run 3 Organic Chemicals Inc. February 1994
To=0.21
Head Ratio - H/Ho
1
0.1
0
0.2
0.4
0.6
0.8
Time (Min.)

Hydraulic Conductivity Determined From Slug Test
Organic Chemicals Inc.

Well # : MW-34
Test Date: February 1994

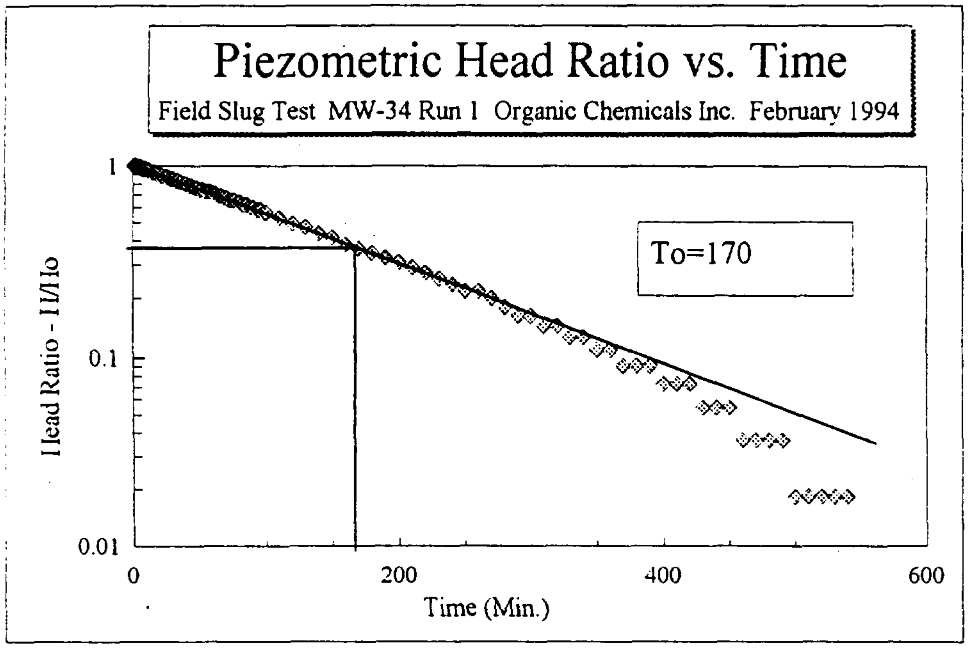
| Run # | Radius of Well (inches) r | Length of Screen (inches) L | Radius of Borehole (inches) R | Basic Time Lag (min.) T | Hydraulic Conductivity (ft/day) K | Hydraulic Conductivity (cm/sec) K |
|---|---|---|---|---|---|---|
| 1 | 1 | 54 | 2 | 170 | 0.025 | 6.97E-06 |

Run #1

| Time | Value | H/H0 |
|---|---|---|
| 0.6667 | 0.55 | 1.00 |
| 0.7500 | 0.55 | 1.00 |
| 0.8333 | 0.55 | 1.00 |
| 0.9167 | 0.55 | 1.00 |
| 1.0000 | 0.55 | 1.00 |
| 1.0833 | 0.55 | 1.00 |
| 1.1667 | 0.55 | 1.00 |
| 1.2500 | 0.55 | 1.00 |
| 1.3333 | 0.55 | 1.00 |
| 1.4166 | 0.55 | 1.00 |
| 1.5000 | 0.55 | 1.00 |
| 1.5833 | 0.55 | 1.00 |
| 1.6667 | 0.55 | 1.00 |
| 1.7500 | 0.55 | 1.00 |
| 1.8333 | 0.55 | 1.00 |
| 1.9167 | 0.55 | 1.00 |
| 2.0000 | 0.55 | 1.00 |
| 2.5000 | 0.55 | 1.00 |
| 3.0000 | 0.55 | 1.00 |
| 3.5000 | 0.54 | 0.98 |
| 4.0000 | 0.54 | 0.98 |
| 4.5000 | 0.54 | 0.98 |
| 5.0000 | 0.54 | 0.98 |
| 5.5000 | 0.54 | 0.98 |
| 6.0000 | 0.54 | 0.98 |
| 6.5000 | 0.54 | 0.98 |
| 7.0000 | 0.53 | 0.96 |
| 7.5000 | 0.53 | 0.96 |
| 8.0000 | 0.53 | 0.96 |
| 8.5000 | 0.53 | 0.96 |
| 9.0000 | 0.53 | 0.96 |
| 9.5000 | 0.53 | 0.96 |
| 10.0000 | 0.53 | 0.96 |
| 12.0000 | 0.52 | 0.95 |
| 14.0000 | 0.51 | 0.93 |
| 16.0000 | 0.51 | 0.93 |
| 18.0000 | 0.50 | 0.91 |
| 20.0000 | 0.49 | 0.89 |
| 22.0000 | 0.49 | 0.89 |
| 24.0000 | 0.48 | 0.87 |
| 26.0000 | 0.48 | 0.87 |
| 28.0000 | 0.47 | 0.85 |
| 30.0000 | 0.47 | 0.85 |
| 32.0000 | 0.46 | 0.84 |
| 34.0000 | 0.46 | 0.84 |
| 36.0000 | 0.45 | 0.82 |
| 38.0000 | 0.44 | 0.80 |
| 40.0000 | 0.44 | 0.80 |
| 42.0000 | 0.43 | 0.78 |
| 44.0000 | 0.43 | 0.78 |
| 46.0000 | 0.42 | 0.76 |
| 48.0000 | 0.42 | 0.76 |
| 50.0000 | 0.41 | 0.75 |
| 52.0000 | 0.41 | 0.75 |
| 54.0000 | 0.40 | 0.73 |
| 56.0000 | 0.40 | 0.73 |
| 58.0000 | 0.40 | 0.73 |
| 60.0000 | 0.39 | 0.71 |
| 62.0000 | 0.39 | 0.71 |
| 64.0000 | 0.38 | 0.69 |

Run #1con't

| Time | Value | H/H0 |
|---|---|---|
| 66.0000 | 0.38 | 0.69 |
| 68.0000 | 0.37 | 0.67 |
| 70.0000 | 0.37 | 0.67 |
| 72.0000 | 0.36 | 0.65 |
| 74.0000 | 0.36 | 0.65 |
| 76.0000 | 0.36 | 0.65 |
| 78.0000 | 0.35 | 0.64 |
| 80.0000 | 0.35 | 0.64 |
| 82.0000 | 0.34 | 0.62 |
| 84.0000 | 0.34 | 0.62 |
| 86.0000 | 0.34 | 0.62 |
| 88.0000 | 0.33 | 0.60 |
| 90.0000 | 0.33 | 0.60 |
| 92.0000 | 0.32 | 0.58 |
| 94.0000 | 0.32 | 0.58 |
| 96.0000 | 0.32 | 0.58 |
| 98.0000 | 0.31 | 0.56 |
| 100.0000 | 0.31 | 0.56 |
| 110.0000 | 0.29 | 0.53 |
| 120.0000 | 0.27 | 0.49 |
| 130.0000 | 0.26 | 0.47 |
| 140.0000 | 0.24 | 0.44 |
| 150.0000 | 0.23 | 0.42 |
| 160.0000 | 0.21 | 0.38 |
| 170.0000 | 0.20 | 0.36 |
| 180.0000 | 0.19 | 0.35 |
| 190.0000 | 0.18 | 0.33 |
| 200.0000 | 0.17 | 0.31 |
| 210.0000 | 0.16 | 0.29 |
| 220.0000 | 0.15 | 0.27 |
| 230.0000 | 0.14 | 0.25 |
| 240.0000 | 0.13 | 0.24 |
| 250.0000 | 0.12 | 0.22 |
| 260.0000 | 0.12 | 0.22 |
| 270.0000 | 0.11 | 0.20 |
| 280.0000 | 0.10 | 0.18 |
| 290.0000 | 0.09 | 0.16 |
| 300.0000 | 0.09 | 0.16 |
| 310.0000 | 0.08 | 0.15 |
| 320.0000 | 0.08 | 0.15 |
| 330.0000 | 0.07 | 0.13 |
| 340.0000 | 0.07 | 0.13 |
| 350.0000 | 0.06 | 0.11 |
| 360.0000 | 0.06 | 0.11 |
| 370.0000 | 0.05 | 0.09 |
| 380.0000 | 0.05 | 0.09 |
| 390.0000 | 0.05 | 0.09 |
| 400.0000 | 0.04 | 0.07 |
| 410.0000 | 0.04 | 0.07 |
| 420.0000 | 0.04 | 0.07 |
| 430.0000 | 0.03 | 0.05 |
| 440.0000 | 0.03 | 0.05 |
| 450.0000 | 0.03 | 0.05 |
| 460.0000 | 0.02 | 0.04 |
| 470.0000 | 0.02 | 0.04 |
| 480.0000 | 0.02 | 0.04 |
| 490.0000 | 0.02 | 0.04 |
| 500.0000 | 0.01 | 0.02 |
| 510.0000 | 0.01 | 0.02 |
| 520.0000 | 0.01 | 0.02 |
| 530.0000 | 0.01 | 0.02 |
| 540.0000 | 0.01 | 0.02 |
| 550.0000 | 0.00 | 0.00 |



Piezometric Head Ratio vs. Time

Field Slug Test MW-34 Run 1 Organic Chemicals Inc. February 1994

## Hydraulic Conductivity Determined From Slug Test

Organic Chemicals Inc.

Well #: MW-36

Test Date: February 1994

| Run # | Radius of Well (inches) r | Length of Screen (inches) L | Radius of Borehole (inches) R | Basic Time Lag (inches) T | Hydraulic Conductivity (ft/day) K | Hydraulic Conductivity (cm/sec) K |
|---|---|---|---|---|---|---|
| 1 | 1 | 54 | 2 | 875 | 0.00502 | 1.77E-06 |

Run #1

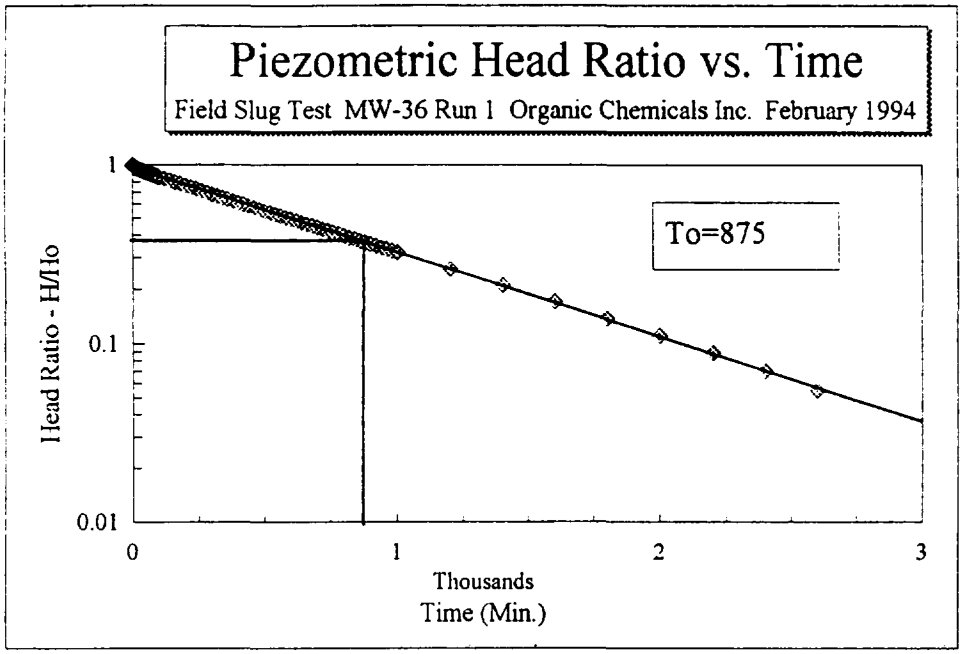
| Time | Value | H/H0 |
|---|---|---|
| 0.1100 | -5.028 | 1.00 |
| 0.1133 | -5.022 | 1.00 |
| 0.1166 | -4.978 | 0.99 |
| 0.1200 | -4.966 | 0.99 |
| 0.1233 | -4.975 | 0.99 |
| 0.1266 | -4.972 | 0.99 |
| 0.1300 | -4.972 | 0.99 |
| 0.1333 | -4.941 | 0.98 |
| 0.1366 | -4.960 | 0.99 |
| 0.1400 | -4.978 | 0.99 |
| 0.1433 | -4.978 | 0.99 |
| 0.1466 | -4.972 | 0.99 |
| 0.1500 | -4.966 | 0.99 |
| 0.1533 | -4.978 | 0.99 |
| 0.1566 | -4.985 | 0.99 |
| 0.1600 | -4.972 | 0.99 |
| 0.1633 | -4.978 | 0.99 |
| 0.1666 | -4.975 | 0.99 |
| 0.1700 | -4.981 | 0.99 |
| 0.1733 | -4.969 | 0.99 |
| 0.1766 | -4.985 | 0.99 |
| 0.1800 | -4.975 | 0.99 |
| 0.1833 | -4.978 | 0.99 |
| 0.1866 | -4.985 | 0.99 |
| 0.1900 | -4.975 | 0.99 |
| 0.1933 | -4.978 | 0.99 |
| 0.1966 | -4.981 | 0.99 |
| 0.2000 | -4.975 | 0.99 |
| 0.2033 | -4.978 | 0.99 |
| 0.2066 | -4.981 | 0.99 |
| 0.2100 | -4.981 | 0.99 |
| 0.2133 | -4.981 | 0.99 |
| 0.2166 | -4.988 | 0.99 |
| 0.2200 | -4.981 | 0.99 |
| 0.2233 | -4.985 | 0.99 |
| 0.2266 | -4.988 | 0.99 |
| 0.2300 | -4.985 | 0.99 |
| 0.2333 | -4.985 | 0.99 |
| 0.2366 | -4.985 | 0.99 |
| 0.2400 | -4.985 | 0.99 |
| 0.2433 | -4.985 | 0.99 |
| 0.2466 | -4.985 | 0.99 |
| 0.2500 | -4.985 | 0.99 |
| 0.2533 | -4.985 | 0.99 |
| 0.2566 | -4.988 | 0.99 |
| 0.2600 | -4.985 | 0.99 |
| 0.2633 | -4.985 | 0.99 |
| 0.2666 | -4.988 | 0.99 |
| 0.2700 | -4.985 | 0.99 |
| 0.2733 | -4.988 | 0.99 |
| 0.2766 | -4.988 | 0.99 |
| 0.2800 | -4.985 | 0.99 |
| 0.2833 | -4.988 | 0.99 |
| 0.2866 | -4.988 | 0.99 |
| 0.2900 | -4.988 | 0.99 |
| 0.2933 | -4.988 | 0.99 |
| 0.2966 | -4.988 | 0.99 |
| 0.3000 | -4.988 | 0.99 |
| 0.3033 | -4.988 | 0.99 |
| 0.3066 | -4.988 | 0.99 |
| 0.3100 | -4.988 | 0.99 |
| 0.3133 | -4.988 | 0.99 |
| 0.3166 | -4.991 | 0.99 |
| 0.3200 | -4.988 | 0.99 |
| 0.3233 | -4.988 | 0.99 |
| 0.3266 | -4.988 | 0.99 |
| 0.3300 | -4.988 | 0.99 |
| 0.3333 | -4.991 | 0.99 |
| 0.3500 | -4.991 | 0.99 |
| 0.3666 | -4.991 | 0.99 |
| 0.3833 | -4.991 | 0.99 |
| 0.4000 | -4.985 | 0.99 |
| 0.4166 | -4.944 | 0.98 |
| 0.4333 | -4.941 | 0.98 |
| 0.4500 | -4.953 | 0.99 |
| 0.4666 | -4.922 | 0.98 |
| 0.4833 | -4.944 | 0.98 |
| 0.5000 | -4.944 | 0.98 |
| 0.5166 | -4.913 | 0.98 |
| 0.5333 | -4.916 | 0.98 |
| 0.5500 | -4.910 | 0.98 |
| 0.5666 | -4.919 | 0.98 |
| 0.5833 | -4.919 | 0.98 |

Run #1 con't

| Time | Value | H/H0 |
|---|---|---|
| 0.6000 | -4.922 | 0.98 |
| 0.6166 | -4.922 | 0.98 |
| 0.6333 | -4.922 | 0.98 |
| 0.6500 | -4.922 | 0.98 |
| 0.6666 | -4.922 | 0.98 |
| 0.6833 | -4.922 | 0.98 |
| 0.7000 | -4.922 | 0.98 |
| 0.7166 | -4.922 | 0.98 |
| 0.7333 | -4.922 | 0.98 |
| 0.7500 | -4.922 | 0.98 |
| 0.7666 | -4.922 | 0.98 |
| 0.7833 | -4.922 | 0.98 |
| 0.8000 | -4.925 | 0.98 |
| 0.8166 | -4.922 | 0.98 |
| 0.8333 | -4.922 | 0.98 |
| 0.8500 | -4.922 | 0.98 |
| 0.8666 | -4.922 | 0.98 |
| 0.8833 | -4.922 | 0.98 |
| 0.9000 | -4.922 | 0.98 |
| 0.9166 | -4.922 | 0.98 |
| 0.9333 | -4.922 | 0.98 |
| 0.9500 | -4.922 | 0.98 |
| 0.9666 | -4.922 | 0.98 |
| 0.9833 | -4.922 | 0.98 |
| 1.0000 | -4.922 | 0.98 |
| 1.2000 | -4.919 | 0.98 |
| 1.4000 | -4.916 | 0.98 |
| 1.6000 | -4.913 | 0.98 |
| 1.8000 | -4.910 | 0.98 |
| 2.0000 | -4.906 | 0.98 |
| 2.2000 | -4.906 | 0.98 |
| 2.4000 | -4.903 | 0.98 |
| 2.6000 | -4.900 | 0.97 |
| 2.8000 | -4.897 | 0.97 |
| 3.0000 | -4.894 | 0.97 |
| 3.2000 | -4.891 | 0.97 |
| 3.4000 | -4.888 | 0.97 |
| 3.6000 | -4.884 | 0.97 |
| 3.8000 | -4.881 | 0.97 |
| 4.0000 | -4.881 | 0.97 |
| 4.2000 | -4.878 | 0.97 |
| 4.4000 | -4.875 | 0.97 |
| 4.6000 | -4.872 | 0.97 |
| 4.8000 | -4.872 | 0.97 |
| 5.0000 | -4.869 | 0.97 |
| 5.2000 | -4.866 | 0.97 |
| 5.4000 | -4.863 | 0.97 |
| 5.6000 | -4.863 | 0.97 |
| 5.8000 | -4.859 | 0.97 |
| 6.0000 | -4.859 | 0.97 |
| 6.2000 | -4.856 | 0.97 |
| 6.4000 | -4.853 | 0.97 |
| 6.6000 | -4.853 | 0.97 |
| 6.8000 | -4.850 | 0.96 |
| 7.0000 | -4.847 | 0.96 |
| 7.2000 | -4.844 | 0.96 |
| 7.4000 | -4.844 | 0.96 |
| 7.6000 | -4.841 | 0.96 |
| 7.8000 | -4.841 | 0.96 |
| 8.0000 | -4.837 | 0.96 |
| 8.2000 | -4.837 | 0.96 |
| 8.4000 | -4.834 | 0.96 |
| 8.6000 | -4.834 | 0.96 |
| 8.8000 | -4.831 | 0.96 |
| 9.0000 | -4.831 | 0.96 |
| 9.2000 | -4.828 | 0.96 |
| 9.4000 | -4.825 | 0.96 |
| 9.6000 | -4.825 | 0.96 |
| 9.8000 | -4.822 | 0.96 |
| 10.0000 | -4.822 | 0.96 |
| 12.0000 | -4.806 | 0.96 |
| 14.0000 | -4.790 | 0.95 |
| 16.0000 | -4.778 | 0.95 |
| 18.0000 | -4.762 | 0.95 |
| 20.0000 | -4.747 | 0.94 |
| 22.0000 | -4.734 | 0.94 |
| 24.0000 | -4.721 | 0.94 |
| 26.0000 | -4.706 | 0.94 |
| 28.0000 | -4.690 | 0.93 |
| 30.0000 | -4.678 | 0.93 |
| 32.0000 | -4.665 | 0.93 |
| 34.0000 | -4.653 | 0.93 |
| 36.0000 | -4.643 | 0.92 |
| 38.0000 | -4.628 | 0.92 |

Run #1 con't

| Time | Value | H/H0 |
|---|---|---|
| 40.0000 | -4.615 | 0.92 |
| 42.0000 | -4.606 | 0.92 |
| 44.0000 | -4.590 | 0.91 |
| 46.0000 | -4.581 | 0.91 |
| 48.0000 | -4.565 | 0.91 |
| 50.0000 | -4.552 | 0.91 |
| 52.0000 | -4.540 | 0.90 |
| 54.0000 | -4.534 | 0.90 |
| 56.0000 | -4.521 | 0.90 |
| 58.0000 | -4.509 | 0.90 |
| 60.0000 | -4.493 | 0.89 |
| 62.0000 | -4.484 | 0.89 |
| 64.0000 | -4.474 | 0.89 |
| 66.0000 | -4.462 | 0.89 |
| 68.0000 | -4.452 | 0.89 |
| 70.0000 | -4.443 | 0.88 |
| 72.0000 | -4.430 | 0.88 |
| 74.0000 | -4.418 | 0.88 |
| 76.0000 | -4.408 | 0.88 |
| 78.0000 | -4.396 | 0.87 |
| 80.0000 | -4.386 | 0.87 |
| 82.0000 | -4.374 | 0.87 |
| 84.0000 | -4.365 | 0.87 |
| 86.0000 | -4.355 | 0.87 |
| 88.0000 | -4.343 | 0.86 |
| 90.0000 | -4.333 | 0.86 |
| 92.0000 | -4.321 | 0.86 |
| 94.0000 | -4.311 | 0.86 |
| 96.0000 | -4.302 | 0.86 |
| 98.0000 | -4.293 | 0.85 |
| 100.0000 | -4.280 | 0.85 |
| 120.0000 | -4.183 | 0.83 |
| 140.0000 | -4.089 | 0.81 |
| 160.0000 | -3.995 | 0.79 |
| 180.0000 | -3.907 | 0.78 |
| 200.0000 | -3.820 | 0.76 |
| 220.0000 | -3.735 | 0.74 |
| 240.0000 | 3.654 | 0.73 |
| 260.0000 | -3.572 | 0.71 |
| 280.0000 | -3.491 | 0.69 |
| 300.0000 | -3.416 | 0.68 |
| 320.0000 | -3.341 | 0.66 |
| 340.0000 | -3.269 | 0.65 |
| 360.0000 | -3.200 | 0.64 |
| 380.0000 | -3.131 | 0.62 |
| 400.0000 | -3.062 | 0.61 |
| 420.0000 | -3.002 | 0.60 |
| 440.0000 | -2.934 | 0.58 |
| 460.0000 | -2.874 | 0.57 |
| 480.0000 | -2.811 | 0.56 |
| 500.0000 | -2.749 | 0.55 |
| 520.0000 | -2.689 | 0.53 |
| 540.0000 | -2.636 | 0.52 |
| 560.0000 | -2.580 | 0.51 |
| 580.0000 | -2.523 | 0.50 |
| 600.0000 | -2.476 | 0.49 |
| 620.0000 | -2.417 | 0.48 |
| 640.0000 | -2.367 | 0.47 |
| 660.0000 | -2.314 | 0.46 |
| 680.0000 | -2.270 | 0.45 |
| 700.0000 | -2.220 | 0.44 |
| 720.0000 | -2.173 | 0.43 |
| 740.0000 | -2.126 | 0.42 |
| 760.0000 | -2.082 | 0.41 |
| 780.0000 | -2.038 | 0.41 |
| 800.0000 | -1.994 | 0.40 |
| 820.0000 | -1.953 | 0.39 |
| 840.0000 | -1.913 | 0.38 |
| 860.0000 | -1.872 | 0.37 |
| 880.0000 | -1.838 | 0.37 |
| 900.0000 | -1.797 | 0.36 |
| 920.0000 | -1.759 | 0.35 |
| 940.0000 | -1.722 | 0.34 |
| 960.0000 | -1.687 | 0.34 |
| 980.0000 | -1.650 | 0.33 |
| 1000.0000 | -1.618 | 0.32 |
| 1200.0000 | -1.302 | 0.26 |
| 1400.0000 | -1.052 | 0.21 |
| 1600.0000 | -0.854 | 0.17 |
| 1800.0000 | -0.688 | 0.14 |
| 2000.0000 | -0.554 | 0.11 |
| 2200.0000 | -0.447 | 0.09 |
| 2400.0000 | -0.353 | 0.07 |
| 2600.0000 | -0.275 | 0.05 |



Piezometric Head Ratio vs. Time

Field Slug Test MW-36 Run 1 Organic Chemicals Inc. February 1994

## Hydraulic Conductivity Determined From Slug Test
## Organic Chemicals Inc.

Well # : MW-40
Test Date : February 1994

| Run # | Radius of Well (inches) r | Length of Screen (inches) L | Radius of Borehole (inches) R | Basic Time Lag (inches) T | Hydraulic Conductivity (ft/day) K | Hydraulic Conductivity (cm/sec) K |
|---|---|---|---|---|---|---|
| 1 | 1 | 54 | 2 | 0.65 | 5.75 | 2.03E-03 |
| 2 | 1 | 54 | 2 | 0.6 | 6.13 | 2.16E-03 |
| | | | | Geometric Mean = | 5.94 | 2.09E-03 |

Run #1

| Time | Value | H/H0 |
|---|---|---|
| 0.1000 | -3.998 | 0.973 |
| 0.1033 | -4.111 | 1.000 |
| 0.1066 | -4.243 | 1.032 |
| 0.1100 | -3.867 | 0.941 |
| 0.1133 | -3.908 | 0.951 |
| 0.1166 | -3.923 | 0.954 |
| 0.1200 | -3.989 | 0.970 |
| 0.1233 | -3.810 | 0.927 |
| 0.1266 | -3.873 | 0.942 |
| 0.1300 | -3.848 | 0.936 |
| 0.1333 | -3.807 | 0.926 |
| 0.1366 | -3.804 | 0.925 |
| 0.1400 | -3.763 | 0.915 |
| 0.1433 | -3.729 | 0.907 |
| 0.1466 | -3.688 | 0.897 |
| 0.1500 | -3.660 | 0.890 |
| 0.1533 | -3.638 | 0.885 |
| 0.1566 | -3.616 | 0.880 |
| 0.1600 | -3.576 | 0.870 |
| 0.1633 | -3.566 | 0.867 |
| 0.1666 | -3.532 | 0.859 |
| 0.1700 | -3.497 | 0.851 |
| 0.1733 | -3.491 | 0.849 |
| 0.1766 | -3.457 | 0.841 |
| 0.1800 | -3.435 | 0.836 |
| 0.1833 | -3.397 | 0.826 |
| 0.1866 | -3.375 | 0.821 |
| 0.1900 | -3.360 | 0.817 |
| 0.1933 | -3.334 | 0.811 |
| 0.1966 | -3.303 | 0.803 |
| 0.2000 | -3.291 | 0.801 |

Run #2

| Time | Value | H/H0 |
|---|---|---|
| 0.0833 | -3.989 | 0.914 |
| 0.0866 | -4.261 | 0.976 |
| 0.0900 | -4.311 | 0.988 |
| 0.0933 | -4.365 | 1.000 |
| 0.0966 | -4.299 | 0.985 |
| 0.1000 | -4.296 | 0.984 |
| 0.1033 | -4.305 | 0.986 |
| 0.1066 | -4.296 | 0.984 |
| 0.1100 | -4.252 | 0.974 |
| 0.1133 | -4.211 | 0.965 |
| 0.1166 | -4.167 | 0.955 |
| 0.1200 | -4.142 | 0.949 |
| 0.1233 | -4.101 | 0.940 |
| 0.1266 | -4.092 | 0.937 |
| 0.1300 | -4.080 | 0.935 |
| 0.1333 | -4.064 | 0.931 |
| 0.1366 | -4.036 | 0.925 |
| 0.1400 | -3.995 | 0.915 |
| 0.1433 | -3.976 | 0.911 |
| 0.1466 | -3.945 | 0.904 |
| 0.1500 | -3.917 | 0.897 |
| 0.1533 | -3.895 | 0.892 |
| 0.1566 | -3.854 | 0.883 |
| 0.1600 | -3.845 | 0.881 |
| 0.1633 | -3.810 | 0.873 |
| 0.1666 | -3.801 | 0.871 |
| 0.1700 | -3.754 | 0.860 |
| 0.1733 | -3.741 | 0.857 |
| 0.1766 | -3.716 | 0.851 |
| 0.1800 | -3.694 | 0.846 |
| 0.1833 | -3.666 | 0.840 |

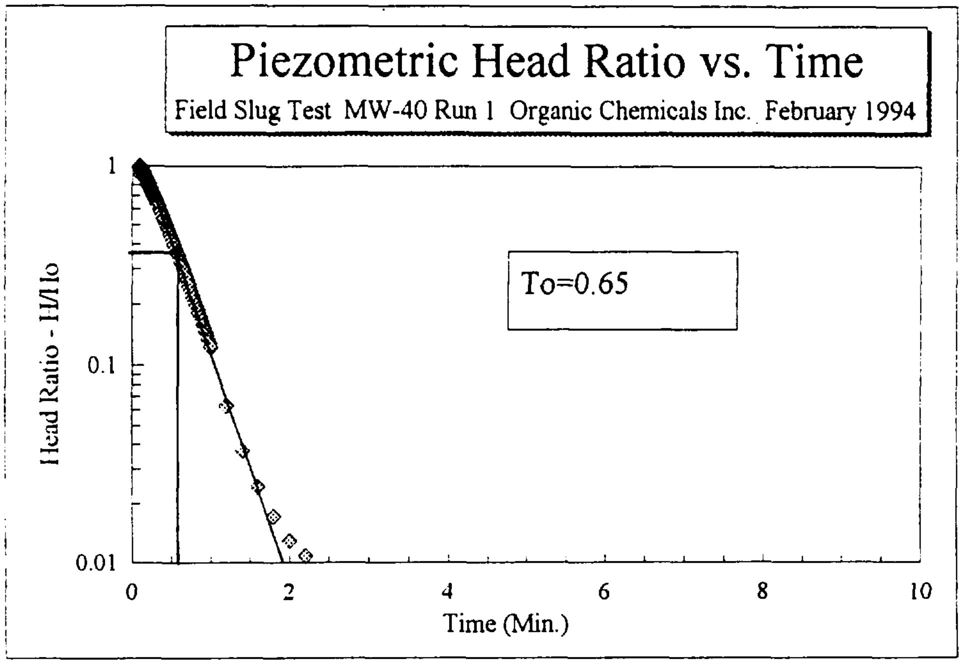
| | | | | | |
|---|---|---|---|---|---|
| 0.2033 | -3.259 | 0.793 | 0.1866 | -3.644 | 0.835 |
| 0.2066 | -3.234 | 0.787 | 0.1900 | -3.610 | 0.827 |
| 0.2100 | -3.212 | 0.781 | 0.1933 | -3.585 | 0.821 |
| 0.2133 | -3.184 | 0.775 | 0.1966 | -3.560 | 0.816 |
| 0.2166 | -3.175 | 0.772 | 0.2000 | -3.544 | 0.812 |
| 0.2200 | -3.147 | 0.766 | 0.2033 | -3.528 | 0.808 |
| 0.2233 | -3.122 | 0.759 | 0.2066 | -3.494 | 0.800 |
| 0.2266 | -3.096 | 0.753 | 0.2100 | -3.472 | 0.795 |
| 0.2300 | -3.078 | 0.749 | 0.2133 | -3.450 | 0.790 |
| 0.2333 | -3.050 | 0.742 | 0.2166 | -3.431 | 0.786 |
| 0.2366 | -3.028 | 0.737 | 0.2200 | -3.409 | 0.781 |
| 0.2400 | -3.009 | 0.732 | 0.2233 | -3.381 | 0.775 |
| 0.2433 | -2.987 | 0.727 | 0.2266 | -3.359 | 0.770 |
| 0.2466 | -2.962 | 0.721 | 0.2300 | -3.337 | 0.764 |
| 0.2500 | -2.940 | 0.715 | 0.2333 | -3.315 | 0.759 |
| 0.2533 | -2.918 | 0.710 | 0.2366 | -3.294 | 0.755 |
| 0.2566 | -2.896 | 0.704 | 0.2400 | -3.272 | 0.750 |
| 0.2600 | -2.874 | 0.699 | 0.2433 | -3.250 | 0.745 |
| 0.2633 | -2.855 | 0.694 | 0.2466 | -3.231 | 0.740 |
| 0.2666 | -2.833 | 0.689 | 0.2500 | -3.209 | 0.735 |
| 0.2700 | -2.815 | 0.685 | 0.2533 | -3.187 | 0.730 |
| 0.2733 | -2.793 | 0.679 | 0.2566 | -3.165 | 0.725 |
| 0.2766 | -2.771 | 0.674 | 0.2600 | -3.146 | 0.721 |
| 0.2800 | -2.752 | 0.669 | 0.2633 | -3.125 | 0.716 |
| 0.2833 | -2.733 | 0.665 | 0.2666 | -3.103 | 0.711 |
| 0.2866 | -2.711 | 0.659 | 0.2700 | -3.084 | 0.707 |
| 0.2900 | -2.693 | 0.655 | 0.2733 | -3.062 | 0.701 |
| 0.2933 | -2.674 | 0.650 | 0.2766 | -3.043 | 0.697 |
| 0.2966 | -2.652 | 0.645 | 0.2800 | -3.021 | 0.692 |
| 0.3000 | -2.633 | 0.640 | 0.2833 | -3.002 | 0.688 |
| 0.3033 | -2.614 | 0.636 | 0.2866 | -2.980 | 0.683 |
| 0.3066 | -2.595 | 0.631 | 0.2900 | -2.962 | 0.679 |
| 0.3100 | -2.577 | 0.627 | 0.2933 | -2.943 | 0.674 |
| 0.3133 | -2.558 | 0.622 | 0.2966 | -2.924 | 0.670 |
| 0.3166 | -2.539 | 0.618 | 0.3000 | -2.905 | 0.666 |
| 0.3200 | -2.520 | 0.613 | 0.3033 | -2.883 | 0.660 |
| 0.3233 | -2.502 | 0.609 | 0.3066 | -2.865 | 0.656 |
| 0.3266 | -2.483 | 0.604 | 0.3100 | -2.846 | 0.652 |
| 0.3300 | -2.464 | 0.599 | 0.3133 | -2.827 | 0.648 |
| 0.3333 | -2.448 | 0.595 | 0.3166 | -2.808 | 0.643 |
| 0.3500 | -2.348 | 0.571 | 0.3200 | -2.789 | 0.639 |
| 0.3666 | -2.254 | 0.548 | 0.3233 | -2.771 | 0.635 |
| 0.3833 | -2.167 | 0.527 | 0.3266 | -2.752 | 0.630 |
| 0.4000 | -2.076 | 0.505 | 0.3300 | -2.733 | 0.626 |
| 0.4166 | -1.994 | 0.485 | 0.3333 | -2.717 | 0.622 |
| 0.4333 | -1.910 | 0.465 | 0.3500 | -2.617 | 0.600 |

| | | |
|---|---|---|
| 0.4500 | -1.831 | 0.445 |
| 0.4666 | -1.756 | 0.427 |
| 0.4833 | -1.684 | 0.410 |
| 0.5000 | -1.615 | 0.393 |
| 0.5166 | -1.546 | 0.376 |
| 0.5333 | -1.484 | 0.361 |
| 0.5500 | -1.421 | 0.346 |
| 0.5666 | -1.362 | 0.331 |
| 0.5833 | -1.302 | 0.317 |
| 0.6000 | -1.246 | 0.303 |
| 0.6166 | -1.193 | 0.290 |
| 0.6333 | -1.139 | 0.277 |
| 0.6500 | -1.089 | 0.265 |
| 0.6666 | -1.039 | 0.253 |
| 0.6833 | -0.995 | 0.242 |
| 0.7000 | -0.951 | 0.231 |
| 0.7166 | -0.908 | 0.221 |
| 0.7333 | -0.867 | 0.211 |
| 0.7500 | -0.829 | 0.202 |
| 0.7666 | -0.792 | 0.193 |
| 0.7833 | -0.757 | 0.184 |
| 0.8000 | -0.723 | 0.176 |
| 0.8166 | -0.689 | 0.168 |
| 0.8333 | -0.657 | 0.160 |
| 0.8500 | -0.626 | 0.152 |
| 0.8666 | -0.601 | 0.146 |
| 0.8833 | -0.573 | 0.139 |
| 0.9000 | -0.548 | 0.133 |
| 0.9166 | -0.523 | 0.127 |
| 0.9333 | -0.498 | 0.121 |
| 0.9500 | -0.476 | 0.116 |
| 0.9666 | -0.454 | 0.110 |
| 0.9833 | -0.432 | 0.105 |
| 1.0000 | -0.410 | 0.100 |
| 1.2000 | -0.210 | 0.051 |
| 1.4000 | -0.125 | 0.030 |
| 1.6000 | -0.084 | 0.020 |
| 1.8000 | -0.062 | 0.015 |
| 2.0000 | -0.053 | 0.013 |
| 2.2000 | -0.047 | 0.011 |
| 2.4000 | -0.040 | 0.010 |
| 2.6000 | -0.040 | 0.010 |
| 2.8000 | -0.034 | 0.008 |
| 3.0000 | -0.031 | 0.008 |
| 3.2000 | -0.031 | 0.008 |
| 3.4000 | -0.028 | 0.007 |

| | | |
|---|---|---|
| 0.3666 | -2.523 | 0.578 |
| 0.3833 | -2.429 | 0.556 |
| 0.4000 | -2.342 | 0.537 |
| 0.4166 | -2.254 | 0.516 |
| 0.4333 | -2.170 | 0.497 |
| 0.4500 | -2.091 | 0.479 |
| 0.4666 | -2.010 | 0.460 |
| 0.4833 | -1.935 | 0.443 |
| 0.5000 | -1.860 | 0.426 |
| 0.5166 | -1.791 | 0.410 |
| 0.5333 | -1.722 | 0.395 |
| 0.5500 | -1.653 | 0.379 |
| 0.5666 | -1.590 | 0.364 |
| 0.5833 | -1.525 | 0.349 |
| 0.6000 | -1.465 | 0.336 |
| 0.6166 | -1.409 | 0.323 |
| 0.6333 | -1.355 | 0.310 |
| 0.6500 | -1.299 | 0.298 |
| 0.6666 | -1.246 | 0.285 |
| 0.6833 | -1.199 | 0.275 |
| 0.7000 | -1.149 | 0.263 |
| 0.7166 | -1.102 | 0.252 |
| 0.7333 | -1.058 | 0.242 |
| 0.7500 | -1.014 | 0.232 |
| 0.7666 | -0.970 | 0.222 |
| 0.7833 | -0.933 | 0.214 |
| 0.8000 | -0.892 | 0.204 |
| 0.8166 | -0.857 | 0.196 |
| 0.8333 | -0.820 | 0.188 |
| 0.8500 | -0.785 | 0.180 |
| 0.8666 | -0.751 | 0.172 |
| 0.8833 | -0.720 | 0.165 |
| 0.9000 | -0.685 | 0.157 |
| 0.9166 | -0.660 | 0.151 |
| 0.9333 | -0.635 | 0.145 |
| 0.9500 | -0.607 | 0.139 |
| 0.9666 | -0.579 | 0.133 |
| 0.9833 | -0.557 | 0.128 |
| 1.0000 | -0.532 | 0.122 |
| 1.2000 | -0.275 | 0.063 |
| 1.4000 | -0.162 | 0.037 |
| 1.6000 | -0.106 | 0.024 |
| 1.8000 | -0.075 | 0.017 |
| 2.0000 | -0.056 | 0.013 |
| 2.2000 | -0.047 | 0.011 |
| 2.4000 | -0.040 | 0.009 |

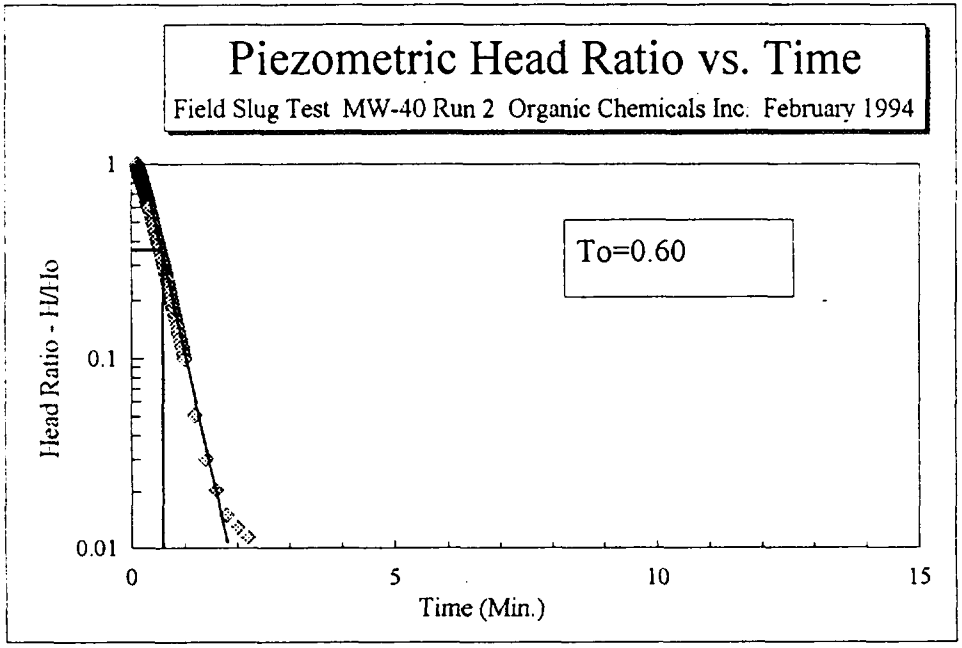
| | | |
|---|---|---|
| 3.6000 | -0.025 | 0.006 |
| 3.8000 | -0.028 | 0.007 |
| 4.0000 | -0.025 | 0.006 |
| 4.2000 | -0.022 | 0.005 |
| 4.4000 | -0.025 | 0.006 |
| 4.6000 | -0.022 | 0.005 |
| 4.8000 | -0.022 | 0.005 |
| 5.0000 | -0.018 | 0.004 |
| 5.2000 | -0.022 | 0.005 |
| 5.4000 | -0.022 | 0.005 |
| 5.6000 | -0.018 | 0.004 |
| 5.8000 | -0.022 | 0.005 |
| 6.0000 | -0.022 | 0.005 |
| 6.2000 | -0.018 | 0.004 |
| 6.4000 | -0.018 | 0.004 |
| 6.6000 | -0.018 | 0.004 |
| 6.8000 | -0.018 | 0.004 |
| 7.0000 | -0.015 | 0.004 |
| 7.2000 | -0.018 | 0.004 |
| 7.4000 | -0.015 | 0.004 |
| 7.6000 | -0.018 | 0.004 |
| 7.8000 | -0.015 | 0.004 |
| 8.0000 | -0.015 | 0.004 |
| 8.2000 | -0.015 | 0.004 |
| 8.4000 | -0.015 | 0.004 |
| 8.6000 | -0.015 | 0.004 |
| 8.8000 | -0.015 | 0.004 |
| 9.0000 | -0.015 | 0.004 |
| 9.2000 | -0.015 | 0.004 |
| 9.4000 | -0.012 | 0.003 |
| 9.6000 | -0.015 | 0.004 |
| 9.8000 | -0.012 | 0.003 |
| 10.0000 | -0.012 | 0.003 |
| 12.0000 | -0.012 | 0.003 |
| 14.0000 | -0.012 | 0.003 |

| | | |
|---|---|---|
| 2.6000 | -0.037 | 0.008 |
| 2.8000 | -0.034 | 0.008 |
| 3.0000 | -0.034 | 0.008 |
| 3.2000 | -0.031 | 0.007 |
| 3.4000 | -0.031 | 0.007 |
| 3.6000 | -0.028 | 0.006 |
| 3.8000 | -0.028 | 0.006 |
| 4.0000 | -0.028 | 0.006 |
| 4.2000 | -0.025 | 0.006 |
| 4.4000 | -0.025 | 0.006 |
| 4.6000 | -0.028 | 0.006 |
| 4.8000 | -0.028 | 0.006 |
| 5.0000 | -0.025 | 0.006 |
| 5.2000 | -0.025 | 0.006 |
| 5.4000 | -0.025 | 0.006 |
| 5.6000 | -0.021 | 0.005 |
| 5.8000 | -0.021 | 0.005 |
| 6.0000 | -0.021 | 0.005 |
| 6.2000 | -0.021 | 0.005 |
| 6.4000 | -0.018 | 0.004 |
| 6.6000 | -0.018 | 0.004 |
| 6.8000 | -0.018 | 0.004 |
| 7.0000 | -0.018 | 0.004 |
| 7.2000 | -0.018 | 0.004 |
| 7.4000 | -0.018 | 0.004 |
| 7.6000 | -0.018 | 0.004 |
| 7.8000 | -0.018 | 0.004 |
| 8.0000 | -0.018 | 0.004 |



Piezometric Head Ratio vs. Time

Field Slug Test MW-40 Run 1 Organic Chemicals Inc. February 1994



Piezometric Head Ratio vs. Time

Field Slug Test MW-40 Run 2 Organic Chemicals Inc. February 1994

# Hydraulic Conductivity Determined From Slug Test
# Organic Chemicals Inc.

Well #: MW-41

Test Date: February 1994

| Run # | Radius of Well (inches) r | Length of Screen (inches) L | Radius of Borehole (inches) R | Basic Time Lag (min.) T | Hydraulic Conductivity (ft/day) K | Hydraulic Conductivity (cm/sec) K |
|---|---|---|---|---|---|---|
| 1 | 1 | 54 | 2 | 0.7 | 6.17 | 2.18E-03 |
| 2 | 1 | 54 | 2 | 0.65 | 6.65 | 2.35E-03 |
| | | | | Geometric Mean = | 6.41 | 2.26E-03 |

Run #1

| Time | Value | H/H0 |
|---|---|---|
| 0.0733 | -4.095 | 0.983 |
| 0.0766 | -4.164 | 0.999 |
| 0.0800 | -4.167 | 1.000 |
| 0.0833 | -4.145 | 0.995 |
| 0.0866 | -4.127 | 0.990 |
| 0.0900 | -4.127 | 0.990 |
| 0.0933 | -3.788 | 0.909 |
| 0.0966 | -3.826 | 0.918 |
| 0.1000 | -3.823 | 0.917 |
| 0.1033 | -3.823 | 0.917 |
| 0.1066 | -3.826 | 0.918 |
| 0.1100 | -3.782 | 0.908 |
| 0.1133 | -3.760 | 0.902 |
| 0.1166 | -3.757 | 0.902 |
| 0.1200 | -3.748 | 0.899 |
| 0.1233 | -3.704 | 0.889 |
| 0.1266 | -3.676 | 0.882 |
| 0.1300 | -3.644 | 0.874 |
| 0.1333 | -3.629 | 0.871 |
| 0.1366 | -3.607 | 0.866 |
| 0.1400 | -3.591 | 0.862 |
| 0.1433 | -3.560 | 0.854 |
| 0.1466 | -3.529 | 0.847 |
| 0.1500 | -3.516 | 0.844 |
| 0.1533 | -3.500 | 0.840 |
| 0.1566 | -3.472 | 0.833 |
| 0.1600 | -3.447 | 0.827 |
| 0.1633 | -3.425 | 0.822 |
| 0.1666 | -3.400 | 0.816 |
| 0.1700 | -3.378 | 0.811 |
| 0.1733 | -3.359 | 0.806 |

Run #2

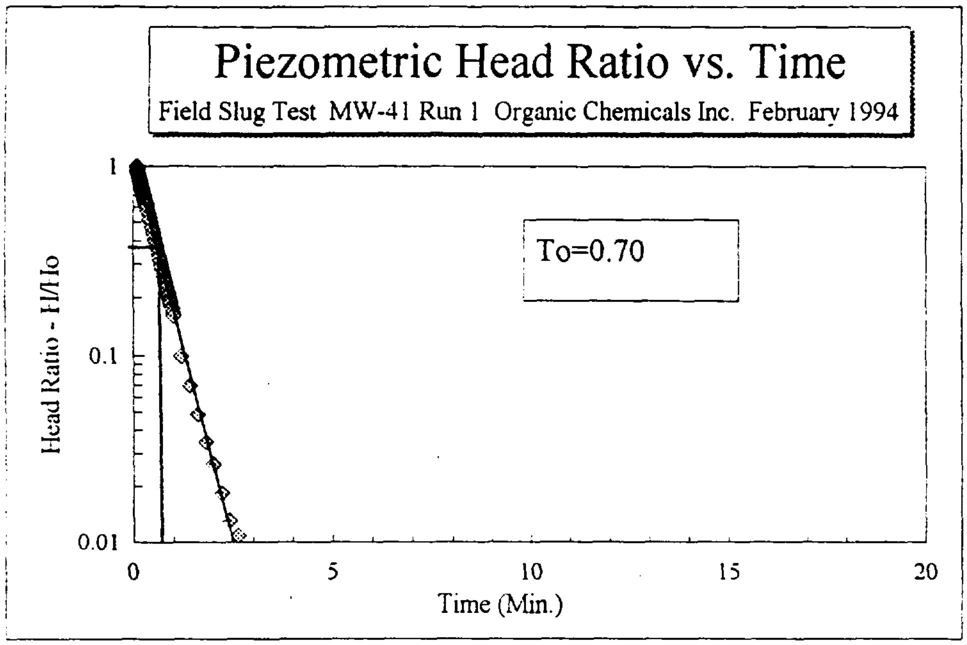
| Time | Value | H/H0 |
|---|---|---|
| 0.0766 | -4.008 | 0.943 |
| 0.0800 | -4.155 | 0.978 |
| 0.0833 | -4.249 | 1.000 |
| 0.0866 | -4.242 | 0.998 |
| 0.0900 | -4.221 | 0.993 |
| 0.0933 | -4.227 | 0.995 |
| 0.0966 | -4.130 | 0.972 |
| 0.1000 | -4.152 | 0.977 |
| 0.1033 | -4.067 | 0.957 |
| 0.1066 | -3.945 | 0.928 |
| 0.1100 | -3.911 | 0.920 |
| 0.1133 | -3.889 | 0.915 |
| 0.1166 | -3.914 | 0.921 |
| 0.1200 | -3.907 | 0.920 |
| 0.1233 | -3.848 | 0.906 |
| 0.1266 | -3.823 | 0.900 |
| 0.1300 | -3.782 | 0.890 |
| 0.1333 | -3.767 | 0.887 |
| 0.1366 | -3.751 | 0.883 |
| 0.1400 | -3.729 | 0.878 |
| 0.1433 | -3.707 | 0.872 |
| 0.1466 | -3.676 | 0.865 |
| 0.1500 | -3.648 | 0.859 |
| 0.1533 | -3.632 | 0.855 |
| 0.1566 | -3.613 | 0.850 |
| 0.1600 | -3.579 | 0.842 |
| 0.1633 | -3.554 | 0.836 |
| 0.1666 | -3.541 | 0.833 |
| 0.1700 | -3.516 | 0.827 |
| 0.1733 | -3.488 | 0.821 |
| 0.1766 | -3.469 | 0.816 |

| | | | | | |
|---|---|---|---|---|---|
| 0.1766 | -3.337 | 0.801 | 0.1800 | -3.447 | 0.811 |
| 0.1800 | -3.319 | 0.796 | 0.1833 | -3.428 | 0.807 |
| 0.1833 | -3.300 | 0.792 | 0.1866 | -3.406 | 0.802 |
| 0.1866 | -3.278 | 0.787 | 0.1900 | -3.384 | 0.796 |
| 0.1900 | -3.256 | 0.781 | 0.1933 | -3.363 | 0.791 |
| 0.1933 | -3.234 | 0.776 | 0.1966 | -3.341 | 0.786 |
| 0.1966 | -3.215 | 0.772 | 0.2000 | -3.319 | 0.781 |
| 0.2000 | -3.193 | 0.766 | 0.2033 | -3.294 | 0.775 |
| 0.2033 | -3.175 | 0.762 | 0.2066 | -3.275 | 0.771 |
| 0.2066 | -3.153 | 0.757 | 0.2100 | -3.256 | 0.766 |
| 0.2100 | -3.134 | 0.752 | 0.2133 | -3.237 | 0.762 |
| 0.2133 | -3.115 | 0.748 | 0.2166 | -3.215 | 0.757 |
| 0.2166 | -3.093 | 0.742 | 0.2200 | -3.193 | 0.751 |
| 0.2200 | -3.074 | 0.738 | 0.2233 | -3.172 | 0.747 |
| 0.2233 | -3.053 | 0.733 | 0.2266 | -3.153 | 0.742 |
| 0.2266 | -3.037 | 0.729 | 0.2300 | -3.131 | 0.737 |
| 0.2300 | -3.018 | 0.724 | 0.2333 | -3.112 | 0.732 |
| 0.2333 | -2.999 | 0.720 | 0.2366 | -3.090 | 0.727 |
| 0.2366 | -2.977 | 0.714 | 0.2400 | -3.074 | 0.723 |
| 0.2400 | -2.959 | 0.710 | 0.2433 | -3.056 | 0.719 |
| 0.2433 | -2.940 | 0.706 | 0.2466 | -3.037 | 0.715 |
| 0.2466 | -2.921 | 0.701 | 0.2500 | -3.015 | 0.710 |
| 0.2500 | -2.902 | 0.696 | 0.2533 | -2.996 | 0.705 |
| 0.2533 | -2.887 | 0.693 | 0.2566 | -2.977 | 0.701 |
| 0.2566 | -2.868 | 0.688 | 0.2600 | -2.962 | 0.697 |
| 0.2600 | -2.849 | 0.684 | 0.2633 | -2.946 | 0.693 |
| 0.2633 | -2.833 | 0.680 | 0.2666 | -2.924 | 0.688 |
| 0.2666 | -2.818 | 0.676 | 0.2700 | -2.909 | 0.685 |
| 0.2700 | -2.799 | 0.672 | 0.2733 | -2.890 | 0.680 |
| 0.2733 | -2.783 | 0.668 | 0.2766 | -2.871 | 0.676 |
| 0.2766 | -2.764 | 0.663 | 0.2800 | -2.855 | 0.672 |
| 0.2800 | -2.749 | 0.660 | 0.2833 | -2.840 | 0.668 |
| 0.2833 | -2.733 | 0.656 | 0.2866 | -2.824 | 0.665 |
| 0.2866 | -2.714 | 0.651 | 0.2900 | -2.805 | 0.660 |
| 0.2900 | -2.696 | 0.647 | 0.2933 | -2.790 | 0.657 |
| 0.2933 | -2.680 | 0.643 | 0.2966 | -2.771 | 0.652 |
| 0.2966 | -2.664 | 0.639 | 0.3000 | -2.752 | 0.648 |
| 0.3000 | -2.649 | 0.636 | 0.3033 | -2.736 | 0.644 |
| 0.3033 | -2.630 | 0.631 | 0.3066 | -2.718 | 0.640 |
| 0.3066 | -2.614 | 0.627 | 0.3100 | -2.702 | 0.636 |
| 0.3100 | -2.599 | 0.624 | 0.3133 | -2.686 | 0.632 |
| 0.3133 | -2.583 | 0.620 | 0.3166 | -2.667 | 0.628 |
| 0.3166 | -2.567 | 0.616 | 0.3200 | -2.652 | 0.624 |
| 0.3200 | -2.548 | 0.611 | 0.3233 | -2.633 | 0.620 |
| 0.3233 | -2.536 | 0.609 | 0.3266 | -2.617 | 0.616 |
| 0.3266 | -2.520 | 0.605 | 0.3300 | -2.602 | 0.612 |

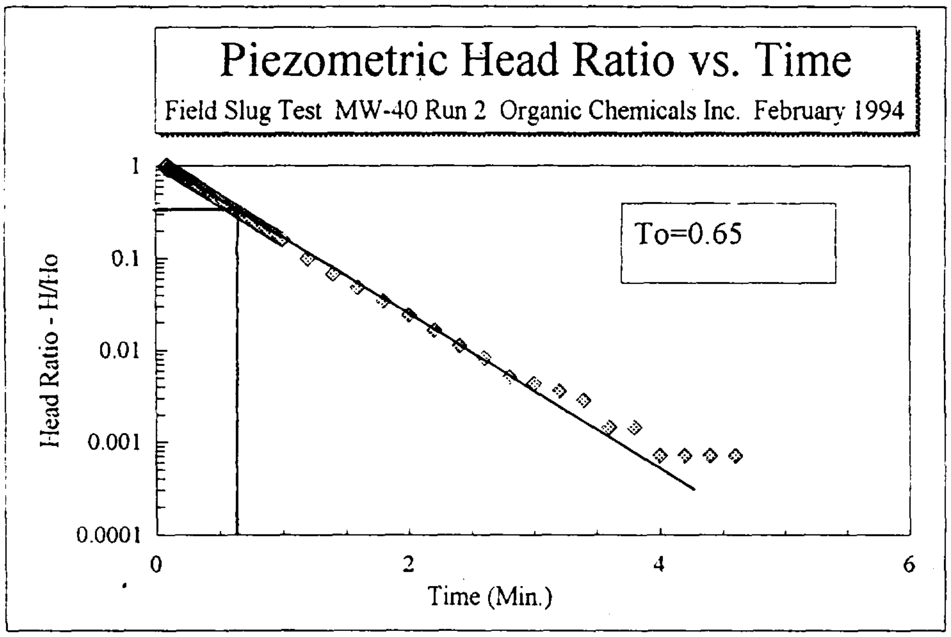
| | | | | | |
|---|---|---|---|---|---|
| 0.3300 | -2.505 | 0.601 | 0.3333 | -2.586 | 0.609 |
| 0.3333 | -2.489 | 0.597 | 0.3500 | -2.498 | 0.588 |
| 0.3500 | -2.401 | 0.576 | 0.3666 | -2.417 | 0.569 |
| 0.3666 | -2.320 | 0.557 | 0.3833 | -2.336 | 0.550 |
| 0.3833 | -2.245 | 0.539 | 0.4000 | -2.257 | 0.531 |
| 0.4000 | -2.166 | 0.520 | 0.4166 | -2.182 | 0.514 |
| 0.4166 | -2.094 | 0.503 | 0.4333 | -2.107 | 0.496 |
| 0.4333 | -2.022 | 0.485 | 0.4500 | -2.032 | 0.478 |
| 0.4500 | -1.957 | 0.470 | 0.4666 | -1.966 | 0.463 |
| 0.4666 | -1.891 | 0.454 | 0.4833 | -1.903 | 0.448 |
| 0.4833 | -1.831 | 0.439 | 0.5000 | -1.841 | 0.433 |
| 0.5000 | -1.769 | 0.425 | 0.5166 | -1.775 | 0.418 |
| 0.5166 | -1.712 | 0.411 | 0.5333 | -1.719 | 0.405 |
| 0.5333 | -1.653 | 0.397 | 0.5500 | -1.665 | 0.392 |
| 0.5500 | -1.600 | 0.384 | 0.5666 | -1.612 | 0.379 |
| 0.5666 | -1.546 | 0.371 | 0.5833 | -1.559 | 0.367 |
| 0.5833 | -1.496 | 0.359 | 0.6000 | -1.506 | 0.354 |
| 0.6000 | -1.446 | 0.347 | 0.6166 | -1.456 | 0.343 |
| 0.6166 | -1.399 | 0.336 | 0.6333 | -1.409 | 0.332 |
| 0.6333 | -1.355 | 0.325 | 0.6500 | -1.362 | 0.321 |
| 0.6500 | -1.312 | 0.315 | 0.6666 | -1.318 | 0.310 |
| 0.6666 | -1.268 | 0.304 | 0.6833 | -1.274 | 0.300 |
| 0.6833 | -1.227 | 0.294 | 0.7000 | -1.233 | 0.290 |
| 0.7000 | -1.186 | 0.285 | 0.7166 | -1.196 | 0.281 |
| 0.7166 | -1.149 | 0.276 | 0.7333 | -1.155 | 0.272 |
| 0.7333 | -1.111 | 0.267 | 0.7500 | -1.117 | 0.263 |
| 0.7500 | -1.074 | 0.258 | 0.7666 | -1.086 | 0.256 |
| 0.7666 | -1.039 | 0.249 | 0.7833 | -1.052 | 0.248 |
| 0.7833 | -1.005 | 0.241 | 0.8000 | -1.020 | 0.240 |
| 0.8000 | -0.973 | 0.234 | 0.8166 | -0.989 | 0.233 |
| 0.8166 | -0.945 | 0.227 | 0.8333 | -0.955 | 0.225 |
| 0.8333 | -0.914 | 0.219 | 0.8500 | -0.923 | 0.217 |
| 0.8500 | -0.886 | 0.213 | 0.8666 | -0.898 | 0.211 |
| 0.8666 | -0.857 | 0.206 | 0.8833 | -0.870 | 0.205 |
| 0.8833 | -0.829 | 0.199 | 0.9000 | -0.842 | 0.198 |
| 0.9000 | -0.804 | 0.193 | 0.9166 | -0.814 | 0.192 |
| 0.9166 | -0.779 | 0.187 | 0.9333 | -0.789 | 0.186 |
| 0.9333 | -0.754 | 0.181 | 0.9500 | -0.764 | 0.180 |
| 0.9500 | -0.729 | 0.175 | 0.9666 | -0.742 | 0.175 |
| 0.9666 | -0.704 | 0.169 | 0.9833 | -0.710 | 0.167 |
| 0.9833 | -0.682 | 0.164 | 1.0000 | -0.688 | 0.162 |
| 1.0000 | -0.663 | 0.159 | 1.2000 | -0.419 | 0.099 |
| 1.2000 | -0.410 | 0.098 | 1.4000 | -0.294 | 0.069 |
| 1.4000 | -0.281 | 0.067 | 1.6000 | -0.206 | 0.048 |
| 1.6000 | -0.200 | 0.048 | 1.8000 | -0.147 | 0.035 |
| 1.8000 | -0.140 | 0.034 | 2.0000 | -0.112 | 0.026 |

|  |  |  |
|---|---|---|
| 2.0000 | -0.100 | 0.024 |
| 2.2000 | -0.068 | 0.016 |
| 2.4000 | -0.046 | 0.011 |
| 2.6000 | -0.034 | 0.008 |
| 2.8000 | -0.021 | 0.005 |
| 3.0000 | -0.018 | 0.004 |
| 3.2000 | -0.015 | 0.004 |
| 3.4000 | -0.012 | 0.003 |
| 3.6000 | -0.006 | 0.001 |
| 3.8000 | -0.006 | 0.001 |
| 4.0000 | -0.003 | 0.001 |
| 4.2000 | -0.003 | 0.001 |
| 4.4000 | -0.003 | 0.001 |
| 4.6000 | -0.003 | 0.001 |
| 4.8000 | 0.000 | 0.000 |
| 5.0000 | 0.000 | 0.000 |

|  |  |  |
|---|---|---|
| 2.2000 | -0.078 | 0.018 |
| 2.4000 | -0.056 | 0.013 |
| 2.6000 | -0.046 | 0.011 |
| 2.8000 | -0.040 | 0.009 |
| 3.0000 | -0.025 | 0.006 |
| 3.2000 | -0.025 | 0.006 |
| 3.4000 | -0.025 | 0.006 |
| 3.6000 | -0.021 | 0.005 |
| 3.8000 | -0.021 | 0.005 |
| 4.0000 | -0.015 | 0.004 |
| 4.2000 | -0.012 | 0.003 |
| 4.4000 | -0.009 | 0.002 |
| 4.6000 | -0.015 | 0.004 |
| 4.8000 | -0.012 | 0.003 |
| 5.0000 | -0.012 | 0.003 |
| 5.2000 | -0.012 | 0.003 |
| 5.4000 | -0.003 | 0.001 |
| 5.6000 | -0.009 | 0.002 |
| 5.8000 | -0.009 | 0.002 |
| 6.0000 | -0.006 | 0.001 |
| 6.2000 | -0.009 | 0.002 |
| 6.4000 | -0.009 | 0.002 |
| 6.6000 | -0.009 | 0.002 |
| 6.8000 | -0.009 | 0.002 |
| 7.0000 | -0.009 | 0.002 |
| 7.2000 | -0.003 | 0.001 |
| 7.4000 | -0.009 | 0.002 |
| 7.6000 | -0.006 | 0.001 |
| 7.8000 | -0.006 | 0.001 |
| 8.0000 | -0.006 | 0.001 |
| 8.2000 | -0.003 | 0.001 |
| 8.4000 | -0.003 | 0.001 |
| 8.6000 | -0.009 | 0.002 |
| 8.8000 | -0.009 | 0.002 |
| 9.0000 | -0.006 | 0.001 |
| 9.2000 | -0.009 | 0.002 |
| 9.4000 | -0.006 | 0.001 |
| 9.6000 | -0.006 | 0.001 |
| 9.8000 | -0.006 | 0.001 |
| 10.0000 | -0.009 | 0.002 |
| 12.0000 | -0.006 | 0.001 |
| 14.0000 | -0.006 | 0.001 |
| 16.0000 | -0.009 | 0.002 |
| 18.0000 | -0.009 | 0.002 |


Piezometric Head Ratio vs. Time

Field Slug Test MW-41 Run 1 Organic Chemicals Inc. February 1994


Piezometric Head Ratio vs. Time

Field Slug Test MW-40 Run 2 Organic Chemicals Inc. February 1994

## Hydraulic Conductivity Determined From Slug Test
## Organic Chemicals Inc.

Well #: D3
Test Date: February 1994

| Run # | Radius of Well (inches) r | Length of Screen (inches) L | Radius of Borehole (inches) R | Basic Time Lag (min.) T | Hydraulic Conductivity (ft/day) K | Hydraulic Conductivity (cm/sec) K |
|---|---|---|---|---|---|---|
| 1 | 1 | 54 | 4 | 0.01 | 288.2 | 0.102 |
| 2 | 1 | 54 | 4 | 0.032 | 90.1 | 0.0318 |
| 3 | 1 | 54 | 4 | 0.026 | 110.5 | 0.039 |
|  |  |  | Geometric Mean = |  | 142.1 | 0.0502 |

Run-1

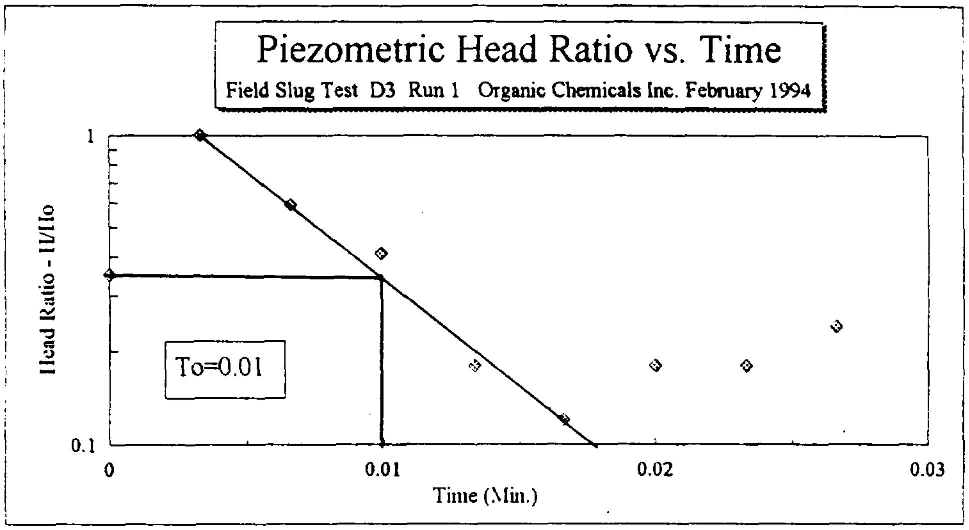
| Time (Min.) | H(t) (ft.) | Time (cont.) (Min.) | H(t) (ft.) |
|---|---|---|---|
| 0 | -0.060 | 0.0333 | -0.090 |
| 0.0033 | -0.170 | 0.0500 | 0.000 |
| 0.0066 | -0.100 | 0.0666 | 0.000 |
| 0.0099 | -0.070 | 0.0833 | 0.000 |
| 0.0133 | -0.030 | 0.1000 | 0.000 |
| 0.0166 | -0.020 |  |  |
| 0.0200 | 0.010 |  |  |
| 0.0233 | 0.010 |  |  |
| 0.0266 | -0.040 |  |  |
| 0.0300 | -0.080 |  |  |

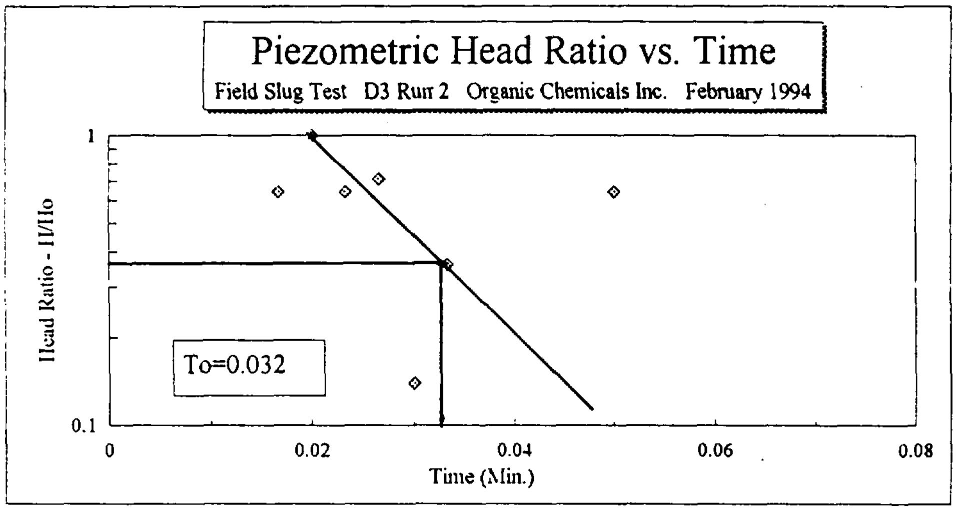
Run-2

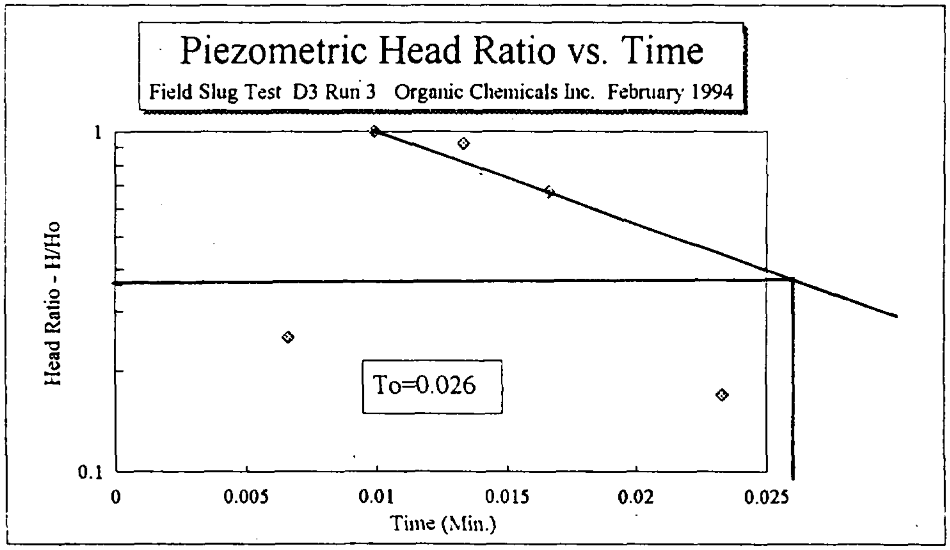
| Time (min.) | H (t) (ft.) | Time (cont.) (min.) | H (t) (ft.) |
|---|---|---|---|
| 0.0000 | 0.000 | 0.0333 | -0.050 |
| 0.0033 | 0.000 | 0.0500 | -0.090 |
| 0.0066 | 0.000 | 0.0666 | 0.000 |
| 0.0099 | 0.000 | 0.0833 | 0.010 |
| 0.0133 | 0.000 | 0.1000 | 0.000 |
| 0.0166 | -0.090 | 0.1166 | 0.000 |
| 0.0200 | -0.140 | 0.1333 | 0.000 |
| 0.0233 | -0.090 | 0.1500 | 0.000 |
| 0.0266 | -0.100 |  |  |
| 0.0300 | -0.020 |  |  |

Run-3

| Time (min.) | H'(t) (ft.) | Time (cont.) (min.) | H'(t) (ft.) |
|---|---|---|---|
| 0.0000 | 0.00 | 0.0300 | -0.10 |
| 0.0033 | 0.00 | 0.0333 | -0.09 |
| 0.0066 | -0.03 | 0.0500 | 0.00 |
| 0.0099 | -0.12 | 0.0666 | 0.00 |
| 0.0133 | -0.11 | 0.0833 | 0.00 |
| 0.0166 | -0.08 |  |  |
| 0.0200 | 0.01 |  |  |
| 0.0233 | -0.02 |  |  |
| 0.0266 | -0.08 |  |  |
| 0.0300 | -0.10 |  |  |


Piezometric Head Ratio vs. Time
Field Slug Test D3 Run 1 Organic Chemicals Inc. February 1994
Head Ratio - H/Ho
1
0.1
0
0.01
0.02
0.03
Time (Min.)
To=0.01


Piezometric Head Ratio vs. Time
Field Slug Test D3 Run 2 Organic Chemicals Inc. February 1994
Head Ratio - H/Ho
1
0.1
0
0.02
0.04
0.06
0.08
Time (Min.)
To=0.032


Piezometric Head Ratio vs. Time
Field Slug Test D3 Run 3 Organic Chemicals Inc. February 1994
Head Ratio - H/Ho
1
0.1
0
0.005
0.01
0.015
0.02
0.025
Time (Min.)
To=0.026

## Hydraulic Conductivity Determined From Slug Test
Organic Chemicals Inc.

Well #: D5
Test Date: February 1994

| Run # | Radius of Well (inches) r | Length of Screen (inches) L | Radius of Borehole (inches) R | Basic Time Lag (min.) T | Hydraulic Conductivity (ft/day) K | Hydraulic Conductivity (cm/sec) K |
|---|---|---|---|---|---|---|
| 1 | 1 | 54 | 4 | 1 | 2.9 | 1.02E-03 |
| 2 | 1 | 54 | 4 | 1.05 | 2.74 | 9.69E-04 |
| 3 | 1 | 54 | 4 | 4.4 | 0.653 | 2.31E-04 |
| | | | Geometric Mean = | | 1.73 | 6.11E-04 |

Run 3

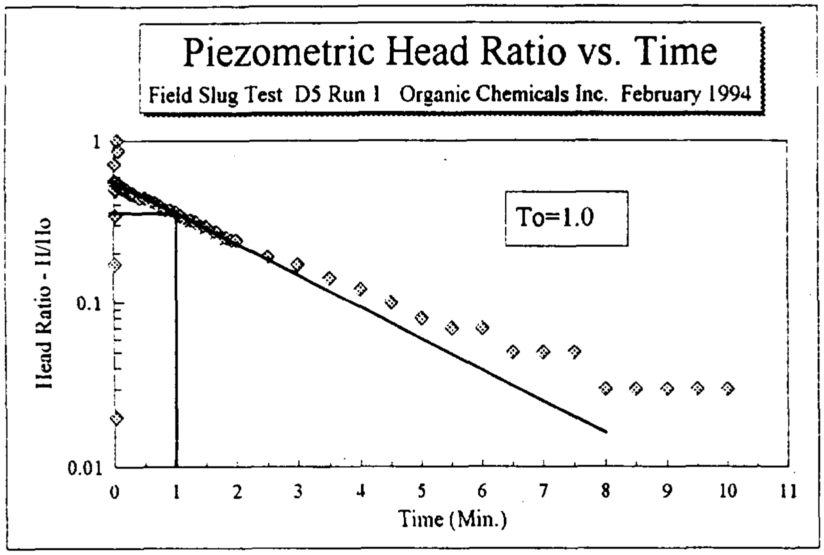
| Elapsed Time | Value | Time | H.H0 |
|---|---|---|---|
| 0.0000 | 0.00 | 0.0000 | 0.00 |
| 0.0033 | 0.00 | 0.0033 | 0.00 |
| 0.0066 | 0.00 | 0.0066 | 0.00 |
| 0.0099 | -0.42 | 0.0099 | 0.71 |
| 0.0133 | -0.33 | 0.0133 | 0.56 |
| 0.0166 | -0.10 | 0.0166 | 0.17 |
| 0.0200 | -0.01 | 0.0200 | 0.02 |
| 0.0233 | -0.20 | 0.0233 | 0.34 |
| 0.0266 | -0.32 | 0.0266 | 0.54 |
| 0.0300 | -0.29 | 0.0300 | 0.49 |
| 0.0333 | -0.30 | 0.0333 | 0.51 |
| 0.0500 | -0.59 | 0.0500 | 1.00 |
| 0.0666 | -0.51 | 0.0666 | 0.86 |
| 0.0833 | -0.31 | 0.0833 | 0.53 |
| 0.1000 | -0.31 | 0.1000 | 0.53 |
| 0.1166 | -0.30 | 0.1166 | 0.51 |
| 0.1333 | -0.30 | 0.1333 | 0.51 |
| 0.1500 | -0.30 | 0.1500 | 0.51 |
| 0.1666 | -0.30 | 0.1666 | 0.51 |
| 0.1833 | -0.29 | 0.1833 | 0.49 |
| 0.2000 | -0.29 | 0.2000 | 0.49 |
| 0.2166 | -0.29 | 0.2166 | 0.49 |
| 0.2333 | -0.29 | 0.2333 | 0.49 |
| 0.2500 | -0.28 | 0.2500 | 0.47 |
| 0.2666 | -0.28 | 0.2666 | 0.47 |
| 0.2833 | -0.28 | 0.2833 | 0.47 |
| 0.3000 | -0.28 | 0.3000 | 0.47 |
| 0.3166 | -0.28 | 0.3166 | 0.47 |
| 0.3333 | -0.27 | 0.3333 | 0.46 |
| 0.4167 | -0.26 | 0.4167 | 0.44 |
| 0.5000 | -0.26 | 0.5000 | 0.44 |
| 0.5833 | -0.25 | 0.5833 | 0.42 |
| 0.6667 | -0.24 | 0.6667 | 0.41 |
| 0.7500 | -0.23 | 0.7500 | 0.39 |
| 0.8333 | -0.22 | 0.8333 | 0.37 |
| 0.9167 | -0.22 | 0.9167 | 0.37 |
| 1.0000 | -0.21 | 1.0000 | 0.36 |
| 1.0833 | -0.20 | 1.0833 | 0.34 |
| 1.1667 | -0.19 | 1.1667 | 0.32 |
| 1.2500 | -0.19 | 1.2500 | 0.32 |
| 1.3333 | -0.18 | 1.3333 | 0.31 |
| 1.4166 | -0.17 | 1.4166 | 0.29 |
| 1.5000 | -0.17 | 1.5000 | 0.29 |
| 1.5833 | -0.16 | 1.5833 | 0.27 |
| 1.6667 | -0.16 | 1.6667 | 0.27 |
| 1.7500 | -0.15 | 1.7500 | 0.25 |
| 1.8333 | -0.15 | 1.8333 | 0.25 |
| 1.9167 | -0.14 | 1.9167 | 0.24 |
| 2.0000 | -0.14 | 2.0000 | 0.24 |
| 2.5000 | -0.11 | 2.5000 | 0.19 |
| 3.0000 | -0.10 | 3.0000 | 0.17 |
| 3.5000 | -0.08 | 3.5000 | 0.14 |
| 4.0000 | -0.07 | 4.0000 | 0.12 |
| 4.5000 | -0.06 | 4.5000 | 0.10 |
| 5.0000 | -0.05 | 5.0000 | 0.08 |
| 5.5000 | -0.04 | 5.5000 | 0.07 |
| 6.0000 | -0.04 | 6.0000 | 0.07 |
| 6.5000 | -0.03 | 6.5000 | 0.05 |
| 7.0000 | -0.03 | 7.0000 | 0.05 |
| 7.5000 | -0.03 | 7.5000 | 0.05 |
| 8.0000 | -0.02 | 8.0000 | 0.03 |
| 8.5000 | -0.02 | 8.5000 | 0.03 |
| 9.0000 | -0.02 | 9.0000 | 0.03 |
| 9.5000 | -0.02 | 9.5000 | 0.03 |
| 10.0000 | -0.02 | 10.0000 | 0.03 |
| 12.0000 | -0.02 | 12.0000 | 0.03 |
| 14.0000 | -0.01 | 14.0000 | 0.02 |
| 16.0000 | -0.01 | 16.0000 | 0.02 |
| 18.0000 | -0.01 | 18.0000 | 0.02 |
| 20.0000 | -0.01 | 20.0000 | 0.02 |
| 22.0000 | -0.01 | 22.0000 | 0.02 |
| 24.0000 | -0.01 | 24.0000 | 0.02 |
| 26.0000 | -0.01 | 26.0000 | 0.02 |
| 28.0000 | -0.01 | 28.0000 | 0.02 |
| 30.0000 | -0.01 | 30.0000 | 0.02 |

Run 2

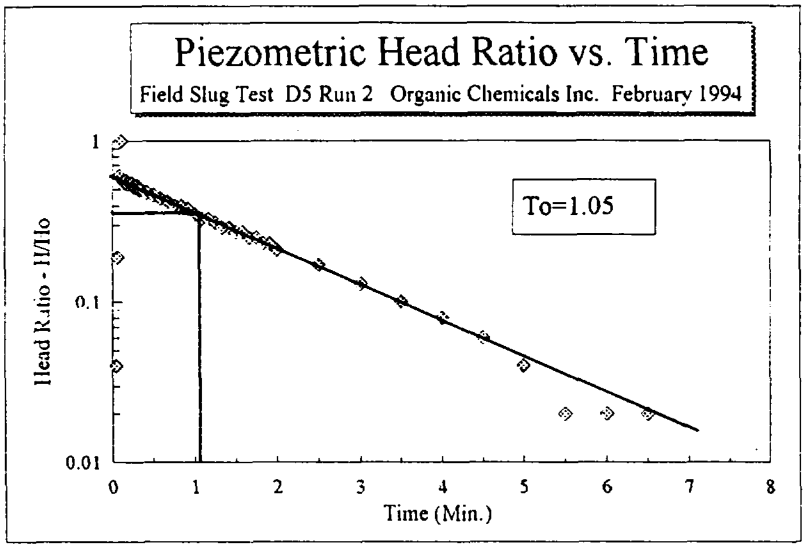
| Elapsed Time | Value | Time | H/H0 |
|---|---|---|---|
| 0.0300 | 0.00 | 0.0300 | 0.00 |
| 0.0333 | 0.00 | 0.0333 | 0.00 |
| 0.0500 | 0.02 | 0.0500 | 0.04 |
| 0.0666 | 0.09 | 0.0666 | 0.19 |
| 0.0833 | 0.29 | 0.0833 | 0.60 |
| 0.1000 | 0.48 | 0.1000 | 1.00 |
| 0.1166 | 0.26 | 0.1166 | 0.54 |
| 0.1333 | 0.27 | 0.1333 | 0.56 |
| 0.1500 | 0.27 | 0.1500 | 0.56 |
| 0.1666 | 0.27 | 0.1666 | 0.56 |
| 0.1833 | 0.26 | 0.1833 | 0.54 |
| 0.2000 | 0.26 | 0.2000 | 0.54 |
| 0.2166 | 0.26 | 0.2166 | 0.54 |
| 0.2333 | 0.26 | 0.2333 | 0.54 |
| 0.2500 | 0.25 | 0.2500 | 0.52 |
| 0.2666 | 0.25 | 0.2666 | 0.52 |
| 0.2833 | 0.25 | 0.2833 | 0.52 |
| 0.3000 | 0.25 | 0.3000 | 0.52 |
| 0.3166 | 0.24 | 0.3166 | 0.50 |
| 0.3333 | 0.24 | 0.3333 | 0.50 |
| 0.4167 | 0.23 | 0.4167 | 0.48 |
| 0.5000 | 0.22 | 0.5000 | 0.46 |
| 0.5833 | 0.21 | 0.5833 | 0.44 |
| 0.6667 | 0.20 | 0.6667 | 0.42 |
| 0.7500 | 0.19 | 0.7500 | 0.40 |
| 0.8333 | 0.19 | 0.8333 | -0.40 |
| 0.9167 | 0.18 | 0.9167 | 0.38 |
| 1.0000 | 0.17 | 1.0000 | 0.35 |
| 1.0833 | 0.16 | 1.0833 | 0.33 |
| 1.1667 | 0.16 | 1.1667 | 0.33 |
| 1.2500 | 0.15 | 1.2500 | 0.31 |
| 1.3333 | 0.14 | 1.3333 | 0.29 |
| 1.4166 | 0.14 | 1.4166 | 0.29 |
| 1.5000 | 0.13 | 1.5000 | 0.27 |
| 1.5833 | 0.13 | 1.5833 | 0.27 |
| 1.6667 | 0.12 | 1.6667 | 0.25 |
| 1.7500 | 0.12 | 1.7500 | 0.25 |
| 1.8333 | 0.11 | 1.8333 | 0.23 |
| 1.9167 | 0.11 | 1.9167 | 0.23 |
| 2.0000 | 0.10 | 2.0000 | 0.21 |
| 2.5000 | 0.08 | 2.5000 | 0.17 |
| 3.0000 | 0.06 | 3.0000 | 0.13 |
| 3.5000 | 0.05 | 3.5000 | 0.10 |
| 4.0000 | 0.04 | 4.0000 | 0.08 |
| 4.5000 | 0.03 | 4.5000 | 0.06 |
| 5.0000 | 0.02 | 5.0000 | 0.04 |
| 5.5000 | 0.01 | 5.5000 | 0.02 |
| 6.0000 | 0.01 | 6.0000 | 0.02 |
| 6.5000 | 0.01 | 6.5000 | 0.02 |
| 7.0000 | 0.00 | 7.0000 | 0.00 |

Run 1

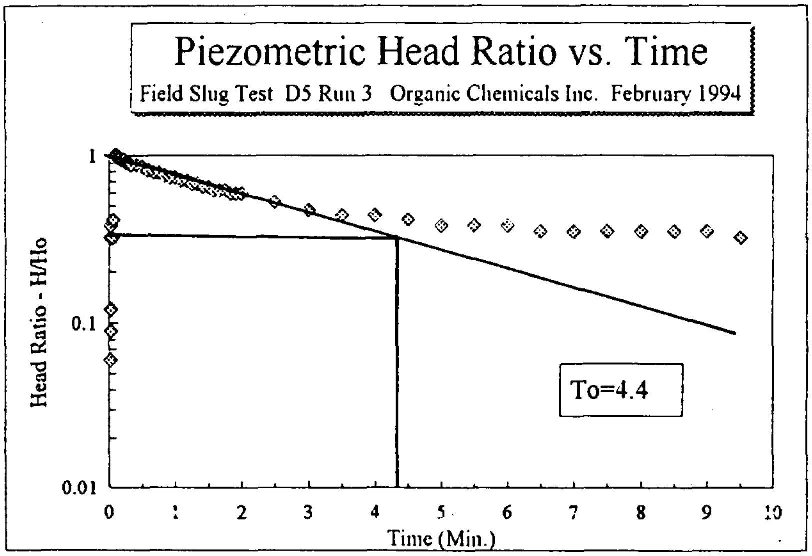
| Elapsed Time | Value | Time | H/H0 |
|---|---|---|---|
| 0.0166 | 0.00 | 0.0166 | 0.00 |
| 0.0200 | -0.02 | 0.0200 | 0.06 |
| 0.0233 | -0.11 | 0.0233 | 0.32 |
| 0.0266 | 0.04 | 0.0266 | 0.12 |
| 0.0300 | -0.13 | 0.0300 | 0.38 |
| 0.0333 | -0.03 | 0.0333 | 0.09 |
| 0.0500 | 0.11 | 0.0500 | 0.32 |
| 0.0666 | -0.14 | 0.0666 | 0.41 |
| 0.0833 | -0.34 | 0.0833 | 1.00 |
| 0.1000 | -0.34 | 0.1000 | 1.00 |
| 0.1166 | -0.34 | 0.1166 | 1.00 |
| 0.1333 | -0.33 | 0.1333 | 0.97 |
| 0.1500 | -0.33 | 0.1500 | 0.97 |
| 0.1666 | -0.33 | 0.1666 | 0.97 |
| 0.1833 | -0.32 | 0.1833 | 0.94 |
| 0.2000 | -0.32 | 0.2000 | 0.94 |
| 0.2166 | -0.32 | 0.2166 | 0.94 |
| 0.2333 | -0.32 | 0.2333 | 0.94 |
| 0.2500 | -0.31 | 0.2500 | 0.91 |
| 0.2666 | -0.31 | 0.2666 | 0.91 |
| 0.2833 | -0.31 | 0.2833 | 0.91 |
| 0.3000 | -0.31 | 0.3000 | 0.91 |
| 0.3166 | -0.30 | 0.3166 | 0.88 |
| 0.3333 | -0.30 | 0.3333 | 0.88 |
| 0.4167 | -0.30 | 0.4167 | 0.88 |
| 0.5000 | -0.29 | 0.5000 | 0.85 |
| 0.5833 | -0.28 | 0.5833 | 0.82 |
| 0.6667 | -0.27 | 0.6667 | 0.79 |
| 0.7500 | -0.27 | 0.7500 | 0.79 |
| 0.8333 | -0.26 | 0.8333 | 0.76 |
| 0.9167 | -0.25 | 0.9167 | 0.74 |
| 1.0000 | -0.25 | 1.0000 | 0.74 |
| 1.0833 | -0.21 | 1.0833 | 0.71 |
| 1.1667 | [illegible] | [illegible] | 0.71 |
| 1.2500 | -0.23 | 1.2500 | 0.68 |
| 1.3333 | -0.23 | 1.3333 | 0.68 |
| 1.4166 | -0.22 | 1.4166 | 0.65 |
| 1.5000 | -0.22 | 1.5000 | 0.65 |
| 1.5833 | -0.21 | 1.5833 | 0.62 |
| 1.6667 | -0.21 | 1.6667 | 0.62 |
| 1.7500 | -0.21 | 1.7500 | 0.62 |
| 1.8333 | -0.20 | 1.8333 | 0.59 |
| 1.9167 | -0.20 | 1.9167 | 0.59 |
| 2.0000 | -0.20 | 2.0000 | 0.59 |
| 2.5000 | -0.18 | 2.5000 | 0.53 |
| 3.0000 | -0.16 | 3.0000 | 0.47 |
| 3.5000 | -0.15 | 3.5000 | 0.44 |
| 4.0000 | -0.15 | 4.0000 | 0.44 |
| 4.5000 | -0.14 | 4.5000 | 0.41 |
| 5.0000 | -0.13 | 5.0000 | 0.38 |
| 5.5000 | -0.13 | 5.5000 | 0.38 |
| 6.0000 | -0.13 | 6.0000 | 0.38 |
| 6.5000 | -0.12 | 6.5000 | 0.35 |
| 7.0000 | -0.12 | 7.0000 | 0.35 |
| 7.5000 | -0.12 | 7.5000 | 0.35 |
| 8.0000 | -0.12 | 8.0000 | 0.35 |
| 8.5000 | -0.12 | 8.5000 | 0.35 |
| 9.0000 | -0.12 | 9.0000 | 0.35 |
| 9.5000 | -0.11 | 9.5000 | 0.32 |
| 10.0000 | -0.11 | 10.0000 | 0.32 |
| 12.0000 | -0.11 | 12.0000 | 0.32 |
| 14.0000 | -0.11 | 14.0000 | 0.32 |
| 16.0000 | -0.11 | 16.0000 | 0.32 |
| 18.0000 | -0.11 | 18.0000 | 0.32 |
| 20.0000 | -0.11 | 20.0000 | 0.32 |
| 22.0000 | -0.11 | 22.0000 | 0.32 |
| 24.0000 | -0.11 | 24.0000 | 0.32 |
| 26.0000 | -0.11 | 26.0000 | 0.32 |
| 28.0000 | -0.11 | 28.0000 | 0.32 |


Piezometric Head Ratio vs. Time

Field Slug Test D5 Run 1 Organic Chemicals Inc. February 1994


Piezometric Head Ratio vs. Time

Field Slug Test D5 Run 2 Organic Chemicals Inc. February 1994


Piezometric Head Ratio vs. Time

Field Slug Test D5 Run 3 Organic Chemicals Inc. February 1994

# APPENDIX K

# GROUNDWATER CONTAMINANT ISOPLETH ASSUMPTIONS

# APPENDIX K

# GROUNDWATER CONTAMINANT ISOPLETH ASSUMPTIONS

The 1989 and 1993 groundwater conditions were represented on Figures 4-1, 4-2, 4-5 and 4-6, respectively, using contaminant isopleths. Contaminant isopleths were drawn using SURFER, Version 4.14, by Golden Software, Inc., Golden, Colorado. The following data-specific assumptions were made to draw the contaminant isopleths:

1) total chlorinated VOCs were contoured in Figures 4-1 and 4-5; total VOCs were contoured in Figures 4-2 and 4-6;
2) VOCs at each well location were assumed to be equal to the average of round 1 and 2 data;
3) contours are based solely on data collected from UGS monitoring wells, and;
4) data qualified "j" were assumed to be positive "hits".

The following model-specific assumptions were made to draw the contaminant isopleth contours:

1) the kriging data interpolation method was employed;
2) a grid density of 50 x 50 was employed;
3) topographic contour levels of 10 (figures 4-1 and 4-5 only), 100, 1,000 and 10,000 ug/L were employed, and;
4) contour lines were "smoothed".

Additional assumptions were made to the data set in order to create the contaminant isopleth contours. In instances where two UGS wells occured at the same location, the groundwater concentrations from both wells and both sampling rounds were averaged. For example, in the case of the the groundwater concentration used to represent Phase 1 total VOCs at MW-1/MW-2, (i.e., 41,603 ug/L, see Figure 4-2), the following values were averaged: 15,310 ug/L, 44,057 ug/L, 91,900 ug/L, and 15,146 ug/L. Monitoring wells MW-14, MW-15, MW-16, MW-32, and MW-33 were assumed to have been impacted by sources other than the OCI site, and therefore were not used to draw contaminant isopleths.

Chloromethane (320 ug/L) detected in MW-25 during phase 2, round 1 sampling was assumed not to represent true conditions. At MW-25, chloromethane was the only contaminant detected in round 1 sampling, and there were no contaminants detected in round 2 sampling. Additional information regarding the occurence of chloromethane was discussed in Section 4.2.1.

Volinated chlorinated hydrocarbons were determined by determining the sum of the following compounds: chloroform, chlorobenzene, 1,1-dichloroethene, 1,1-dichloroethane, 1,2-dichloroethene (total), 1,2-dichloropropane, methylene chloride, tetrachloroethene, trichloroethene, 1,1,1-trichloroethane, 1,1,2-trichloroethane, vinyl chloride.

Using these assumptions and the input data presented in Tables K-1, K-2, K-3, and K-4, the contaminant isopleths presented in Figures 4-1, 4-2, 4-5, and 4-6, were generated.

Table K-1. Input Data for Phase I (1989) Groundwater Contaminant Isopleth Contours.

| Easting (feet) | Northing (feet) | Average Phase I RI Groundwater VOC Concentrations (UG/L) | Monitoring Well Location |
|---|---|---|---|
| 11958 | 9273 | 41603 | MW-1/MW-2 |
| 11820 | 8909 | 7.5 | MW-3 |
| 11710 | 9355 | 142 | MW-4 |
| 11899 | 9812 | 91 | MW-5 |
| 12126 | 9781 | 12 | MW-6 |
| 11302 | 8272 | 6 | MW-7 |
| 10908 | 9097 | 9 | MW-8 |
| 10955 | 9733 | 3.5 | MW-9 |
| 11320 | 11503 | 0 | MW-10 |
| 12212 | 10512 | 15 | MW-11 |
| 10112 | 9450 | 3.5 | MW-13 |
| 12547 | 8915 | 4 | MW-17 |
| 11941 | 8935 | 4 | MW-21 |
| 12065 | 9197 | 242 | MW-22 |
| 12252 | 9452 | 4 | MW-23 |

Table K-2. Input Data for Phase II (1993) Groundwater Contaminant Isopleth Contours.

| Easting (feet) | Northing (feet) | Average Phase II RI Groundwater VOC Concentrations (UG/L) | Monitoring Well Location |
|---|---|---|---|
| 11958 | 9286 | 766.5 | MW-1/MW-2 |
| 11820 | 8909 | 0 | MW-3 |
| 11899 | 9812 | 27 | MW-5 |
| 11302 | 8272 | 0 | MW-7 |
| 10908 | 9097 | 2 | MW-8 |
| 10955 | 9733 | 4.5 | MW-9 |
| 11320 | 11503 | 1.5 | MW-10 |
| 10112 | 9450 | 0 | MW-13 |
| 12547 | 8915 | 0.5 | MW-17 |
| 11941 | 8935 | 2.5 | MW-21 |
| 12065 | 9197 | 114.5 | MW-22 |
| 12072 | 9996 | 48.5 | MW-24 |
| 12398 | 9369 | 0 | MW-25 |
| 12254 | 9455 | 7.8 | MW-26/MW-23 |
| 11700 | 9319 | 1370.5 | MW-27/MW-4 |
| 12128 | 9775 | 13.8 | MW-28/MW-6 |
| 12217 | 10505 | 5 | MW-29/MW-11 |
| 11638 | 10415 | 0 | MW-30 |
| 11732 | 11116 | 6 | MW-31 |

Table K-3. Input Data for Phase I (1989) Volatile Chlorinated Organic Groundwater Contaminant Isopleth Contours.

| Easting (feet) | Northing (feet) | Average Phase I RI Groundwater VOC Concentrations (UG/L) | Monitoring Well Location |
|---|---|---|---|
| 11958 | 9273 | 18667 | MW-1/MW-2 |
| 11820 | 8909 | 7.5 | MW-3 |
| 11710 | 9355 | 25.5 | MW-4 |
| 11899 | 9812 | 17 | MW-5 |
| 12126 | 9781 | 8.5 | MW-6 |
| 11302 | 8272 | 6 | MW-7 |
| 10908 | 9097 | 9.5 | MW-8 |
| 10955 | 9733 | 3.5 | MW-9 |
| 11320 | 11503 | 0 | MW-10 |
| 12212 | 10512 | 12 | MW-11 |
| 10112 | 9450 | 3.5 | MW-13 |
| 12547 | 8915 | 4 | MW-17 |
| 11941 | 8935 | 4.5 | MW-21 |
| 12065 | 9197 | 212.5 | MW-22 |
| 12252 | 9452 | 4 | MW-23 |

Table K-4. Input Data for Phase II (1993) Volatile Chlorinated Organic Groundwater Contaminant Isopleth Contours.

| Easting (feet) | Northing (feet) | Average Phase II RI Groundwater VOC Concentrations (UG/L) | Monitoring Well Location |
|---|---|---|---|
| 11958 | 9286 | 370 | MW-1/MW-2 |
| 11820 | 8909 | 0.5 | MW-3 |
| 11899 | 9812 | 3.5 | MW-5 |
| 11302 | 8272 | 0 | MW-7 |
| 10908 | 9097 | 0.5 | MW-8 |
| 10955 | 9733 | 1.5 | MW-9 |
| 11320 | 11503 | 1.5 | MW-10 |
| 10112 | 9450 | 0 | MW-13 |
| 12547 | 8915 | 0 | MW-17 |
| 11941 | 8935 | 0.5 | MW-21 |
| 12065 | 9197 | 205 | MW-22 |
| 12072 | 9996 | 4 | MW-24 |
| 12398 | 9369 | 0 | MW-25 |
| 12254 | 9455 | 3 | MW-26/MW-23 |
| 11700 | 9319 | 321 | MW-27/MW-4 |
| 12128 | 9775 | 0 | MW-28/MW-6 |
| 12217 | 10505 | 3 | MW-29/MW-11 |
| 11638 | 10415 | 0 | MW-30 |
| 11732 | 11116 | 0 | MW-31 |

# APPENDIX L

# BACKGROUND SOIL CONCENTRATION CALCULATIONS

# Background Inorganic Concentrations in Site Soils

## PURPOSE:

This documentation outlines the procedures for determining background metals concentrations of soils found at OCI. All samples were reviewed for qualifying as background samples appear in Tables I and II. Table I lists surface soil samples (0-2 ft) by soil type(s). Table II lists subsurface soil samples (>2 ft) also by the soil type(s) found within a 2 ft sampling interval.

## CONDITIONS FOR BACKGROUND:

In order for a sample to qualify as a background, the sample must meet the following conditions: TIC levels for volatiles must be less than 100 and for semivolatiles, less than 5000.

Qualifying soil samples are then categorized based on their primary constituents. Soil types were grouped under one of three categories; gravel, sand/silt, and clay. The categories include:

| Gravel | Sand | Clay |
|---|---|---|
| Gravel* | Sand | Clay |
| Sandy gravel | Silty sand | Sandy clay* |
| Silty gravel* | Clayey sand | Silty clay |
| | Silt* | Gravelly clay* |
| | Clayey silt | |
| | Silty cinder* | |

Note: Soil types labeled (*) did not have samples which were qualified as backgrounds but are to be considered a part of the category under which it appears.

## STATISTICAL ANALYSIS:

Four samples were selected from each class to satisfy the minimum number of samples required by the MDNR (1) (see attached sheets). A statistical analysis of the metals concentrations for each category determined a mean, standard deviation, and coefficient of variance (c.v) for each target metal. The data is provided on Tables III-V. Note that for non-detected metals (those not shaded), the reportedconcentrations were divided in half.

For metals with a c.v.>0.50, the samples were screened for outliers. For gravel (Table III), cadmium was found to have c.v.=0.58. However, SS-35 will not be considered an outlier since all values for cadmium were non-detects. For sand (Table IV), potassium has a c.v.=0.59. Rather than labeling SB-46J an outlier, the MDNR guidelines recommend that the background concentration for potassium in sand be defaulted to the potassium concentration in gravel, thereby using a more conservative estimate.

Background concentrations are taken to be the sum of the mean and 3 times the standard deviation.

References: 1. MDNR, April 1994, "Guidance Document for Verification of Soil Remediation", pp. 5-8.

Table I

| Sample | Interval | Soil Type |
|---|---|---|
| SB-38A | 0-2 | Clayey Sand |
| SB-12 | 0-2 | Clayey sand |
| SB-14 | 0-2 | Clayey sand |
| SB-25 | 0-2 | Clayey sand |
| SB-26 | 0-2 | Clayey sand |
| SB-33 | 0-2 | Clayey sand |
| SB-36 | 0-2 | Clayey sand |
| SB-37 | 0-2 | Clayey sand |
| SB-38 | 0-2 | Clayey sand |
| SB-42 | 0-2 | Clayey sand |
| SB-44 | 0-2 | Clayey sand |
| SB-45 | 0-2 | Clayey sand |
| SB-48 | 0-2 | Clayey sand |
| SB-49 | 0-2 | Clayey sand |
| SB-52 | 0-2 | Clayey sand |
| SB-55 | 0-2 | Clayey sand |
| SB-56 | 0-2 | Clayey sand |
| SB-57 | 0-2 | Clayey sand |
| SB-58 | 0-2 | Clayey sand |
| SB-59 | 0-2 | Clayey sand |
| MW-33 | 0-2 | Clayey sand |

| Sample | Interval | Soil Type |
|---|---|---|
| SB-15 | 0-2 | Clayey silt |
| SB-18 | 0-2 | Clayey silt |
| SB-60 | 0-2 | Clayey silt |

| Sample | Interval | Soil Type |
|---|---|---|
| SS-31 | 0-2 | Gravelly silt |
| SS-40 | 0-2 | Gravelly silt |
| SS-59 | 0-2 | Gravelly silt |
| SS-61 | 0-2 | Gravelly silt |
| SS-67 | 0-2 | Gravelly silt |
| SS-68 | 0-2 | Gravelly silt |
| SS-75 | 0-2 | Gravelly silt |
| SS-81 | 0-2 | Gravelly silt |
| SS-94 | 0-2 | Gravelly silt |
| SS-97 | 0-2 | Gravelly silt |
| SS-103 | 0-2 | Gravelly silt |

| *Sample* | *Interval* | *Soil Type* |
|---|---|---|
| SS-41 | 0-2 | Sand |
| SS-78 | 0-2 | Sand |
| SS-85 | 0-2 | Sand |
| SS-105 | 0-2 | Sand |
| MW-32 | 0-2 | Sand |
| MW-35 | 0-2 | Sand |

| Sample | Interval | Soil Type |
|---|---|---|
| SS-33 | 0-2 | Sandy silt |
| SS-43 | 0-2 | Sandy silt |
| SS-51 | 0-2 | Sandy silt |
| SS-53 | 0-2 | Sandy silt |
| SS-62 | 0-2 | Sandy silt |
| SS-66 | 0-2 | Sandy silt |
| SS-76 | 0-2 | Sandy silt |
| SS-87 | 0-2 | Sandy silt |
| SS-88 | 0-2 | Sandy silt |
| SS-99 | 0-2 | Sandy silt |
| SS-109 | 0-2 | Sandy silt |
| SB-24 | 0-2 | Sandy silt |
| MW-29 | 0-2 | Sandy silt |
| MW-37 | 0-2 | Sandy silt |
| MW-40 | 0-2 | Sandy silt |

| Sample | Interval | Soil Type |
|---|---|---|
| SS-60 | 0-2 | Silt |
| SS-98 | 0-2 | Silt |

| Sample | Interval | Soil Type |
|---|---|---|
| SS-93 | 0-2 | Sandy clay |
| SB-34 | 0-2 | Sandy clay |

| Sample | Interval | Soil Type |
|---|---|---|
| SB-30 | 0-2 | Clayey sand/gravelly sand |

| Sample | Interval | Soil Type |
|---|---|---|
| SB-13 | 0-2 | Clayey silt/gravelly sand |
| SB-20 | 0-2 | Clayey silt/gravelly sand |
| SB-22 | 0-2 | Clayey silt/gravelly sand |
| MW-31 | 0-2 | Clayey silt gravelly sand |

| Sample | Interval | Soil Type |
|---|---|---|
| SB-27 | 0-2 | Sandy clay gravelly sand |
| SB-28 | 0-2 | Sandy clay/gravelly sand |

| Sample | Interval | Soil Type |
|---|---|---|
| SB-53 | 0-2 | Silty clay/sandy gravel |

| Sample | Interval | Soil Type |
|---|---|---|
| MW-36A | 0-2 | Silty Sand |
| MW-37A | 0-2 | Silty Sand |
| MW-34A | 0-2 | Silty Sand |
| SS-32 | 0-2 | Silty sand |
| SS-38 | 0-2 | Silty sand |
| SS-45 | 0-2 | Silty sand |
| SS-74 | 0-2 | Silty sand |
| SS-77 | 0-2 | Silty sand |
| SS-79 | 0-2 | Silty sand |
| SS-95 | 0-2 | Silty sand |
| SS-96 | 0-2 | Silty sand |
| SS-121 | 0-2 | Silty sand |
| SB-41 | 0-2 | Silty sand |
| MW-24 | 0-2 | Silty sand |
| MW-25 | 0-2 | Silty sand |
| MW-28 | 0-2 | Silty sand |
| MW-34 | 0-2 | Silty sand |
| MW-36 | 0-2 | Silty sand |

| Sample | Interval | Soil Type |
|---|---|---|
| SS-106 | 0-2 | Silty gravel |
| MW-26 | 0-2 | Silty gravel |

| Sample | Interval | Soil Type |
|---|---|---|
| MW-30 | 0-2 | Silty clay |
| MW-39 | 0-2 | Silty clay |

| Sample | Interval | Soil Type |
|---|---|---|
| SS-44 | 0-2 | Silty cinder |
| SS-52 | 0-2 | Silty cinder |
| SS-65 | 0-2 | Silty cinder |
| SS-110 | 0-2 | Silty cinder |

| Sample | Interval | Soil Type |
|---|---|---|
| SB-11 | 0-2 | Silty clay/sand |

| Sample | Interval | Soil Type |
|---|---|---|
| SB-16 | 0-2 | Silty clay/clay |

| Sample | Interval | Soil Type |
|---|---|---|
| SB-35 | 0-2 | Clayey sand/sand |
| SB-54 | 0-2 | Clayey sand/sand |

| Sample | Interval | Soil Type |
|---|---|---|
| SS-47 | 0-2 | Gravelly sand |
| SS-48 | 0-2 | Gravelly sand |
| SS-50 | 0-2 | Gravelly sand |
| SS-55 | 0-2 | Gravelly sand |
| SS-56 | 0-2 | Gravelly sand |
| SS-63 | 0-2 | Gravelly sand |
| SS-64 | 0-2 | Gravelly sand |
| SS-69 | 0-2 | Gravelly sand |
| SS-71 | 0-2 | Gravelly sand |
| SS-72 | 0-2 | Gravelly sand |
| SS-73 | 0-2 | Gravelly sand |
| SS-82 | 0-2 | Gravelly sand |
| SS-91 | 0-2 | Gravelly sand |
| SS-92 | 0-2 | Gravelly sand |
| SS-102 | 0-2 | Gravelly sand |
| SS-107 | 0-2 | Gravelly sand |
| SS-108 | 0-2 | Gravelly sand |
| SS-112 | 0-2 | Gravelly sand |
| SS-113 | 0-2 | Gravelly sand |
| SS-114 | 0-2 | Gravelly sand |
| SS-116 | 0-2 | Gravelly sand |
| SS-117 | 0-2 | Gravelly sand |
| SS-118 | 0-2 | Gravelly sand |
| SS-119 | 0-2 | Gravelly sand |
| SS-120 | 0-2 | Gravelly sand |
| SS-122 | 0-2 | Gravelly sand |
| SS-124 | 0-2 | Gravelly sand |
| SS-125 | 0-2 | Gravelly sand |
| SB-17 | 0-2 | Gravelly sand |
| SB-19 | 0-2 | Gravelly sand |
| SB-21 | 0-2 | Gravelly sand |
| SB-23 | 0-2 | Gravelly sand |
| SB-31 | 0-2 | Gravelly sand. |
| SB-32 | 0-2 | Gravelly sand |
| SB-39 | 0-2 | Gravelly sand |
| SB-40 | 0-2 | Gravelly sand |
| SB-43 | 0-2 | Gravelly sand |
| SB-46 | 0-2 | Gravelly sand |
| SB-47 | 0-2 | Gravelly sand |
| SB-50 | 0-2 | Gravelly sand |
| SB-51 | 0-2 | Gravelly sand |
| MW-27 | 0-2 | Gravelly sand |
| MW-42 | 0-2 | Gravelly sand |

| Sample | Interval | Soil Type |
|---|---|---|
| SB-27A | 0-2 | Sandy Gravel |
| SB-28A | 0-2 | Sandy Gravel |
| SB-39A | 0-2 | Sandy Gravel |
| SB-40A | 0-2 | Sandy Gravel |
| SB-46A | 0-2 | Sandy Gravel |
| SS-27 | 0-2 | Sandy Gravel |
| SS-28 | 0-2 | Sandy Gravel |
| SS-29 | 0-2 | Sandy Gravel |
| SS-30 | 0-2 | Sandy Gravel |
| SS-34 | 0-2 | Sandy Gravel |
| SS-35 | 0-2 | Sandy Gravel |
| SS-36 | 0-2 | Sandy Gravel |
| SS-37 | 0-2 | Sandy Gravel |
| SS-42 | 0-2 | Sandy Gravel |
| SS-46 | 0-2 | Sandy Gravel |
| SS-49 | 0-2 | Sandy Gravel |
| SS-54 | 0-2 | Sandy Gravel |
| SS-57 | 0-2 | Sandy Gravel |
| SS-58 | 0-2 | Sandy Gravel |
| SS-70 | 0-2 | Sandy Gravel |
| SS-80 | 0-2 | Sandy Gravel |
| SS-83 | 0-2 | Sandy Gravel |
| SS-89 | 0-2 | Sandy gravel |
| SS-90 | 0-2 | Sandy gravel |
| SS-100 | 0-2 | Sandy gravel |
| SS-101 | 0-2 | Sandy gravel |
| SS-104 | 0-2 | Sandy gravel |
| SS-111 | 0-2 | Sandy gravel |
| SS-115 | 0-2 | Sandy gravel |
| SS-123 | 0-2 | Sandy gravel |
| SB-29 | 0-2 | Sandy gravel |
| MW-38 | 0-2 | Sandy gravel |

## Table II

| Sample | Interval | Soil Type |
|---|---|---|
| SB-11K | 20-22 | Clay |
| SB-22F | 10-12 | Clay |
| SB-23J | 18-20 | Clay |
| SB-36Q | 32-34 | Clay |
| SB-44Q | 32-34 | Clay |
| SB-60S | 36-38 | Clay |
| D-2Q | 32-34 | Clay |

| Sample | Interval | Soil Type |
|---|---|---|
| SB-56B | 2-4 | Clayey sand |
| SB-57C | 4-6 | Clayey sand |
| SB-58B | 2-4 | Clayey sand |
| SB-59C | 4-6 | Clayey sand |
| SB-59D | 6-8 | Clayey sand |

| Sample | Interval | Soil Type |
|---|---|---|
| SB-15B | 2-4 | Clayey silt |
| SB-31M | 24-26 | Clayey silt |
| SB-39F | 10-12 | Clayey silt |
| SB-40I | 16-18 | Clayey silt |

| Sample | Interval | Soil Type |
|---|---|---|
| SB-44M | 24-26 | Gravel |

| Sample | Interval | Soil Type |
|---|---|---|
| SB-57Q | 32-34 | Sand/Clay |

| Sample | Interval | Soil Type |
|---|---|---|
| SB-34H | 14-16 | Silty clay |
| SB-39G | 12-14 | Silty clay |
| SB-41N | 26-28 | Silty clay |
| SB-50O | 28-30 | Silty clay |
| MW-34P | 30-32 | Silty clay |
| MW-35N | 26-28 | Silty clay |
| MW-38G | 12-14 | Silty clay |
| MW-39K | 20-22 | Silty clay |
| MW-42O | 28-30 | Silty clay |

| Sample | Interval | Soil Type |
|---|---|---|
| SB-41K | 20-22 | Silty sand |
| SB-53L | 22-24 | Silty sand |

| Sample | Interval | Soil Type |
|---|---|---|
| SB-25I | 16-18 | Silty clay/clay |
| SB-48T | 38-40 | Silty clay/clay |

| Sample | Interval | Soil Type |
|---|---|---|
| SB-42O | 28-30 | Sand/silty clay |

| Sample | Interval | Soil Type |
|---|---|---|
| SB-53R | 34-36 | Silty sand/silt |

| Sample | Interval | Soil Type |
|---|---|---|
| SB-38J | 18-20 | Sandy gravel/sand/gravelly sand |

| Sample | Interval | Soil Type |
|---|---|---|
| SB-55B | 2-4 | Clayey sand/gravelly sand |
| SB-56D | 6-8 | Clayey sand/gravelly sand |
| SB-58C | 4-6 | Clayey sand/gravelly sand |
| SB-59B | 2-4 | Clayey sand/gravelly sand |

| Sample | Interval | Soil Type |
|---|---|---|
| SB-27D | 6-8 | Gravelly sand/clayey silt |

| Sample | Interval | Soil Type |
|---|---|---|
| SB-17H | 14-16 | Gravelly sand/silty clay |
| SB-28E | 8-10 | Gravelly sand/silty clay |

| Sample | Interval | Soil Type |
|---|---|---|
| SB-41H | 14-16 | Gravelly sand/silty sand |

| Sample | Interval | Soil Type |
|---|---|---|
| MW-40E | 8-10 | Sandy gravel/gravelly sand |

| Sample | Interval | Soil Type |
|---|---|---|
| SB-43M | 24-26 | Sandy gravel/silty clay |

| Sample | Interval | Soil Type |
|---|---|---|
| SB-11C | 4-6 | Sand |
| SB-35J | 18-20 | Sand |
| SB-37N | 26-28 | Sand |
| SB-46I | 16-18 | Sand |
| SB-46J | 18-20 | Sand |
| SB-49C | 4-6 | Sand |
| SB-49D | 6-8 | Sand |
| SB-52M | 24-26 | Sand |
| SB-52P | 30-32 | Sand |
| SB-54B | 2-4 | Sand |
| SB-54C | 4-6 | Sand |
| SB-54D | 6-8 | Sand |
| D-2M | 24-26 | Sand |
| D-5O | 28-30 | Sand |
| MW-36K | 20-22 | Sand |

| Sample | Interval | Soil Type |
|---|---|---|
| MW-36S | 36-38 | Silty sand/silty clay |

| Sample | Interval | Soil Type |
|---|---|---|
| SB-26H | 14-16 | Sandy gravel/clay |
| SB-30I | 16-18 | Sandy gravel/clay |
| SB-33I | 16-18 | Sandy gravel/clay |

| Sample | Interval | Soil Type |
|---|---|---|
| SB-51M | 24-26 | Silty clay/silt |

| Sample | Interval | Soil Type |
|---|---|---|
| SB-30E | 8-10 | Sand/gravelly sand |

| Sample | Interval | Soil Type |
|---|---|---|
| MW-33D | 6-8 | Sand/sandy clay |

| Sample | Interval | Soil Type |
|---|---|---|
| SB-49B | 2-4 | Clayey sand/sand |

| Sample | Interval | Soil Type |
|---|---|---|
| SB-32L | 22-24 | Gravelly clay/clay |

| Sample | Interval | Soil Type |
|---|---|---|
| SB-13B | 2-4 | Gravelly sand |
| SB-13H | 14-16 | Gravelly sand |
| SB-13I | 16-18 | Gravelly sand |
| SB-15E | 8-10 | Gravelly sand |
| SB-16H | 14-16 | Gravelly sand |
| SB-16I | 16-18 | Gravelly sand |
| SB-17D | 6-8 | Gravelly sand |
| SB-18G | 12-14 | Gravelly sand |
| SB-18H | 14-16 | Gravelly sand |
| SB-19E | 8-10 | Gravelly sand |
| SB-20K | 20-22 | Gravelly sand |
| SB-21C | 4-6 | Gravelly sand |
| SB-21G | 12-14 | Gravelly sand |
| SB-22B | 2-4 | Gravelly sand |
| SB-23E | 8-10 | Gravelly sand |
| SB-23G | 12-14 | Gravelly sand |
| SB-25C | 4-6 | Gravelly sand |
| SB-27C | 4-6 | Gravelly sand |
| SB-28C | 4-6 | Gravelly sand |
| SB-34D | 6-8 | Gravelly sand |
| SB-45H | 14-16 | Gravelly sand |
| SB-47H | 14-16 | Gravelly sand |
| SB-50H | 14-16 | Gravelly sand |
| SB-51G | 12-14 | Gravelly sand |
| SB-55C | 4-6 | Gravelly sand |
| SB-55D | 6-8 | Gravelly sand |
| SB-58D | 6-8 | Gravelly sand |
| SB-60O | 28-30 | Gravelly sand |
| MW-40F | 10-12 | Gravelly sand |

| Sample | Interval | Soil Type |
|---|---|---|
| SB-18K | 20-22 | Gravelly sand/clay |
| SB-19D | 6-8 | Gravelly sand/clay |
| SB-19H | 14-16 | Gravelly sand/clay |
| SB-38K | 20-22 | Gravelly sand/clay |
| D-4N | 26-28 | Gravelly sand/clay |
| MW-40H | 14-16 | Gravelly sand/clay |

| Sample | Interval | Soil Type |
|---|---|---|
| SB-45N | 26-28 | Gravelly sand/sand |

| Sample | Interval | Soil Type |
|---|---|---|
| SB-36N | 26-28 | Gravel/sandy clay |

| Sample | Interval | Soil Type |
|---|---|---|
| SB-11J | 18-20 | Sandy Gravel |
| SB-26D | 6-8 | Sandy gravel |
| SB-32E | 8-10 | Sandy gravel |
| SB-33H | 14-16 | Sandy gravel |
| SB-40G | 12-14 | Sandy gravel |
| SB-43H | 14-16 | Sandy gravel |
| SB-48M | 24-26 | Sandy gravel |
| D-4F | 10-12 | Sandy gravel |
| MW-34H | 14-16 | Sandy gravel |
| MW-35K | 20-22 | Sandy gravel |
| MW-38D | 6-8 | Sandy gravel |
| MW-39E | 8-10 | Sandy gravel |
| MW-39F | 10-12 | Sandy gravel |
| MW-42G | 12-14 | Sandy gravel |

Table III

Soil Type: Gravel

| OCI Sample No.: | SS-35 | SS-54 | SS-101 | SS-111 | Mean | Std. Dev. | 3*Std.Dev. | Co. Var. | BACKGROUND |
|---|---|---|---|---|---|---|---|---|---|
| Aluminum | 3180 | 4760 | 3910 | 3530 | 3845.00 | 587.98 | 1763.95 | 0.15 | 5609.0 |
| Antimony | 2.75 | 2.8 | 2.6 | 2.5 | 2.66 | 0.12 | 0.36 | 0.04 | 3.0 |
| Arsenic | 1.7 | 2.9 | 3 | 2.4 | 2.50 | 0.51 | 1.54 | 0.21 | 4.0 |
| Barium | 14 | 22.8 | 25.6 | 16.7 | 19.78 | 4.63 | 13.90 | 0.23 | 33.7 |
| Beryllium | 0.11 | 0.125 | 0.115 | 0.11 | 0.12 | 0.01 | 0.02 | 0.05 | 0.13 |
| Cadmium | 0.44 | 0.125 | 0.115 | 0.11 | 0.20 | 0.14 | 0.42 | 0.71 | 0.62 |
| Calcium | 50000 | 71300 | 56400 | 116000 | 73425.00 | 25766.88 | 77300.63 | 0.35 | 150725.6 |
| Chromium | 11.1 | 10.6 | 9.7 | 8.9 | 10.08 | 0.84 | 2.53 | 0.08 | 12.6 |
| Cobalt | 3 | 3.1 | 2.9 | 2.4 | 2.85 | 0.27 | 0.81 | 0.09 | 3.7 |
| Copper | 9.1 | 20.2 | 11.5 | 9.8 | 12.65 | 4.45 | 13.34 | 0.35 | 26.0 |
| Iron | 6370 | 12400 | 9610 | 6490 | 8717.50 | 2491.48 | 7474.44 | 0.29 | 16191.9 |
| Lead | 18.2 | 24.3 | 41.6 | 24.4 | 27.13 | 8.73 | 26.18 | 0.32 | 53.3 |
| Magnesium | 15700 | 12200 | 29400 | 19800 | 19275.00 | 6434.82 | 19304.45 | 0.33 | 38579.5 |
| Manganese | 175 | 309 | 237 | 165 | 221.50 | 57.56 | 172.67 | 0.26 | 394.2 |
| Mercury | 0.055 | 0.06 | 0.055 | 0.055 | 0.06 | 0.00 | 0.01 | 0.04 | 0.06 |
| Nickel | 5.8 | 5.5 | 5.2 | 6.2 | 5.68 | 0.37 | 1.11 | 0.07 | 6.8 |
| Potassium | 203 | 560 | 496 | 689 | 487.00 | 178.09 | 534.28 | 0.37 | 1021.3 |
| Selenium | 0.33 | 0.245 | 0.225 | 0.215 | 0.25 | 0.05 | 0.14 | 0.18 | 0.39 |
| Silver | 0.33 | 0.245 | 0.225 | 0.215 | 0.25 | 0.05 | 0.14 | 0.18 | 0.39 |
| Sodium | 91.3 | 92 | 152 | 118 | 113.33 | 24.79 | 74.36 | 0.22 | 187.7 |
| Thallium | 0.11 | 0.125 | 0.115 | 0.11 | 0.12 | 0.01 | 0.02 | 0.05 | 0.13 |
| Vanadium | 9.9 | 18.4 | 13 | 12.8 | 13.53 | 3.07 | 9.21 | 0.23 | 22.7 |
| Zinc | 36.1 | 34.6 | 52.4 | 34.7 | 39.45 | 7.50 | 22.50 | 0.19 | 62.0 |
| Cyanide | 0.275 | 0.305 | 0.285 | 0.27 | 0.28 | 0.01 | 0.04 | 0.05 | 0.32 |

## Table IV

Soil Type: Sand

| OCI Sample No.: | SB-19A | SB-46J | SB-19D | MW-36S | Mean | Std. Dev. | 3*Std.Dev. | Co. Var. | Background |
|---|---|---|---|---|---|---|---|---|---|
| **Aluminum** | 3660 | 5760 | 4650 | 2440 | 4127.50 | 1225.18 | 3675.54 | 0.30 | 7803.04 |
| **Antimony** | 1.9 | 1.75 | 1.9 | 2.05 | 1.90 | 0.11 | 0.32 | 0.06 | 2.22 |
| **Arsenic** | 3.2 | 3.8 | 2.5 | 1.9 | 2.85 | 0.72 | 2.15 | 0.25 | 5.00 |
| **Barium** | 26.4 | 41.8 | 32.7 | 17.9 | 29.70 | 8.74 | 26.22 | 0.29 | 55.92 |
| **Beryllium** | 0.14 | 0.27 | 0.25 | 0.3 | 0.24 | 0.06 | 0.18 | 0.25 | 0.42 |
| **Cadmium** | 0.18 | 0.165 | 0.18 | 0.195 | 0.18 | 0.01 | 0.03 | 0.06 | 0.21 |
| **Calcium** | 32700 | 49800 | 18900 | 47500 | 37225.00 | 12449.77 | 37349.32 | 0.33 | 74574.32 |
| **Chromium** | 12.7 | 13.7 | 8.4 | 5.7 | 10.13 | 3.24 | 9.72 | 0.32 | 19.84 |
| **Cobalt** | 3.7 | 4.7 | 4 | 1.8 | 3.55 | 1.07 | 3.22 | 0.30 | 6.77 |
| **Copper** | 12 | 10.6 | 6.9 | 5.5 | 8.75 | 2.64 | 7.93 | 0.30 | 16.68 |
| **Iron** | 7860 | 10300 | 8950 | 5160 | 8067.50 | 1888.09 | 5664.26 | 0.23 | 13731.76 |
| **Lead** | 8.9 | 7.1 | 9.1 | 3.4 | 7.13 | 2.29 | 6.86 | 0.32 | 13.99 |
| **Magnesium** | 13200 | 20700 | 7810 | 20200 | 15477.50 | 5328.09 | 15984.26 | 0.34 | 31461.76 |
| **Manganese** | 230 | 221 | 171 | 135 | 189.25 | 38.55 | 115.65 | 0.20 | 304.90 |
| **Mercury** | 0.025 | 0.08 | 0.08 | 0.08 | 0.07 | 0.02 | 0.07 | 0.36 | 0.14 |
| **Nickel** | 9.3 | 13.4 | 8.1 | 5.1 | 8.98 | 2.98 | 8.93 | 0.33 | 17.91 |
| **Potassium** | 403 | 1350 | 495 | 421 | 667.25 | 395.69 | 1187.07 | 0.59 | 1854.32 |
| **Selenium** | 0.32 | 0.36 | 0.345 | 0.37 | 0.35 | 0.02 | 0.06 | 0.05 | 0.41 |
| **Silver** | 0.4 | 0.37 | 0.4 | 0.435 | 0.40 | 0.02 | 0.07 | 0.06 | 0.47 |
| **Sodium** | 60.9 | 126 | 167 | 115 | 117.23 | 37.86 | 113.57 | 0.32 | 230.79 |
| **Thallium** | 0.25 | 0.28 | 0.275 | 0.29 | 0.27 | 0.01 | 0.04 | 0.05 | 0.32 |
| **Vanadium** | 14.7 | 13.2 | 14 | 10 | 12.98 | 1.80 | 5.39 | 0.14 | 18.37 |
| **Zinc** | 23.3 | 21 | 30 | 11.4 | 21.43 | 6.67 | 20.00 | 0.31 | 41.42 |
| **Cyanide** | 0.255 | 0.27 | 0.28 | 0.3 | 0.28 | 0.02 | 0.05 | 0.06 | 0.33 |

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Table V

Soil Type: Clay

| OCI Sample No.: | SB-50O | MW-36S | SB-38K | SB-24H | Mean | Std. Dev. | 3*Std.Dev. | Co. Var. | BACKGROUND |
|---|---|---|---|---|---|---|---|---|---|
| Aluminum | 7300 | 2440 | 10100 | 8190 | 9145.00 | 955.00 | 2865.00 | 0.10 | 12010.00 |
| Antimony | 2.1 | 2.05 | 1.9 | 2 | 1.95 | 0.05 | 0.15 | 0.03 | 2.10 |
| Arsenic | 5.1 | 1.9 | 3.8 | 3.7 | 3.75 | 0.05 | 0.15 | 0.01 | 3.90 |
| Barium | 69.9 | 17.9 | 68.5 | 63.2 | 65.85 | 2.65 | 7.95 | 0.04 | 73.80 |
| Beryllium | 0.38 | 0.3 | 0.39 | 0.5 | 0.45 | 0.06 | 0.17 | 0.12 | 0.61 |
| Cadmium | 0.16 | 0.195 | 0.18 | 0.19 | 0.19 | 0.00 | 0.01 | 0.03 | 0.20 |
| Calcium | 56300 | 47500 | 81400 | 79600 | 80500.00 | 900.00 | 2700.00 | 0.01 | 83200.00 |
| Chromium | 12.7 | 5.7 | 17.3 | 15.6 | 16.45 | 0.85 | 2.55 | 0.05 | 19.00 |
| Cobalt | 6.8 | 1.8 | 8.2 | 7.4 | 7.80 | 0.40 | 1.20 | 0.05 | 9.00 |
| Copper | 13.4 | 5.5 | 15.6 | 14 | 14.80 | 0.80 | 2.40 | 0.05 | 17.20 |
| Iron | 14100 | 5160 | 16400 | 14300 | 15350.00 | 1050.00 | 3150.00 | 0.07 | 18500.00 |
| Lead | 5.9 | 3.4 | 7.6 | 7.8 | 7.70 | 0.10 | 0.30 | 0.01 | 8.00 |
| Magnesium | 19800 | 20200 | 33200 | 32800 | 33000.00 | 200.00 | 600.00 | 0.01 | 33600.00 |
| Manganese | 254 | 135 | 329 | 320 | 324.50 | 4.50 | 13.50 | 0.01 | 338.00 |
| Mercury | 0.03 | 0.08 | 0.03 | 0.08 | 0.06 | 0.03 | 0.08 | 0.45 | 0.13 |
| Nickel | 15.6 | 5.1 | 19.7 | 17.4 | 18.55 | 1.15 | 3.45 | 0.06 | 22.00 |
| Potassium | 1790 | 421 | 2080 | 1660 | 1870.00 | 210.00 | 630.00 | 0.11 | 2500.00 |
| Selenium | 0.325 | 0.37 | 0.365 | 0.36 | 0.36 | 0.00 | 0.01 | 0.01 | 0.37 |
| Silver | 0.375 | 0.435 | 0.405 | 0.425 | 0.42 | 0.01 | 0.03 | 0.02 | 0.45 |
| Sodium | 172 | 115 | 193 | 204 | 198.50 | 5.50 | 16.50 | 0.03 | 215.00 |
| Thallium | 0.3 | 0.29 | 0.155 | 0.285 | 0.22 | 0.07 | 0.20 | 0.30 | 0.42 |
| Vanadium | 16.2 | 10 | 23.7 | 20.6 | 22.15 | 1.55 | 4.65 | 0.07 | 26.80 |
| Zinc | 30.8 | 11.4 | 37.9 | 33.5 | 35.70 | 2.20 | 6.60 | 0.06 | 42.30 |
| Cyanide | 0.29 | 0.3 | 0.275 | 0.275 | 0.28 | 0.00 | 0.00 | 0.00 | 0.28 |

DNR

# MICHIGAN DEPARTMENT OF NATURAL RESOURCES

# GUIDANCE DOCUMENT FOR VERIFICATION OF SOIL REMEDIATION

## EXECUTIVE SUMMARY

The document provides guidance for sampling soils to verify that soil contamination has been remediated to Type A or Type B criteria in accordance with Act 307 P.A. 1982, as amended. This document is not designed to either guide investigations to determine whether a release has occurred or the nature and extent of an identified release, nor to guide due diligence by a potential property owner.

Soil sampling and analyses to verify that site remediation is complete can result in two basic errors.

- Declaring a site clean when it is contaminated
- Declaring a site contaminated when it is clean

A soil sampling plan submitted to the DNR must minimize these errors. The guidance document presents acceptable methods for verifying soil remediation. It contains guidance on soil sampling protocols and documentation necessary to characterize and verify cleanup of contaminated soils. The document provides recommended procedures for establishing soil background concentrations, sampling grids, chemical constituent evaluations, statistical comparisons, verifying excavation and in-situ and ex-situ remedies, evaluating treated soils, and soil characterization. The recommended procedures are not *absolutes*. Other methods are available to verify soil remediation. The Department of Natural Resources will evaluate other sampling and statistical strategies on a case-by-case basis.

The guidance document is divided into two parts:

Part 1 contains guidance for small site cleanup verification (less than 10,890 square feet--<.25 acre). It is a "biased" sampling strategy recommending soil sampling from areas most likely to contain contamination.

Part 2 contains guidance for soil characterization and cleanup verification of medium and large sites (greater than 10,890 square feet-->.25 acre). It is a statistical random sampling strategy that minimizes biases in sampling.

Both sampling strategies require discrete soil samples. Compositing samples for cleanup verification is not accepted without prior DNR approval.

The guidance document contains verification checklists and reporting sections. The reporting sections should be carefully followed in reporting sampling rationale.

**Reader's Note:** Questions regarding this guidance document should be directed to Department staff you are currently working with for your project or site.

# ATTACHMENTS--DNR GUIDANCE DOCUMENT

# VERIFICATION OF SOIL REMEDIATION

*attachment #* *attachment* *page #*

# TABLE OF CONTENTS–DNR GUIDANCE DOCUMENT
# VERIFICATION OF SOIL REMEDIATION

# DNR--GUIDANCE DOCUMENT, PART 1

# SMALL SITE SOIL CLEANUP VERIFICATION (LESS THAN 10,890 SQUARE FEET)

Part 1 of this document is a guide for a biased sampling strategy to verify that soil contamination has been remediated at small sites. Soil sampling and analyses to verify that a site remediation is complete can result in two basic errors.

- Declaring a site clean when it is contaminated
- Declaring a site contaminated when it is clean

A soil sampling plan submitted to the DNR must minimize these errors. Part 1 presents a biased sampling method of verifying soil remediation at small sites. The biased sampling approach specified in this guidance recommends soils sampling from areas most likely to still exceed cleanup criteria. The location of the soil sample points relies on a site specific analysis of the released or contaminant distribution and the soil types encountered. The remediation is verified using a point by point comparison of sample values with the appropriate cleanup criteria. If the cleanup criteria are exceeded at any sampled point, the biased sampling methodology may require additional remediation at that point until the criteria are met. Verification of cleanup utilizing the biased approach should generally require fewer samples to demonstrate attainment than by using the unbiased approach. DNR will evaluate other sampling and statistical strategies on a case-by-case basis.

Any biased sampling plan, whether presented in the guidance document or some other geostatistical approach, requires professional judgment. Therefore, documentation and the rationale used to select sample locations is extremely important. The report section (page 9) of this guidance document should be carefully followed.

Compositing samples for verifying soil remediation is not acceptable without prior DNR approval. When verifying a soil remediation is complete, contaminant concentrations will be low. Compositing may result in the contaminant concentrations not being representative of what remains in the soil. If concentrations are low, compositing may dilute the concentrations of a contaminant to below its threshold detection limit. Additionally, if contamination is indicated in a composited sample, the location of the contamination remains unknown.

Part 1 is divided into four main sections: Verifying Excavation Remedies, Verifying In-Situ and Ex-Situ Soil Remedies, Background Soil Samples, and Reports. The excavation and in-situ remediations require different strategies for verification. Guidance is presented for statistically determining background concentrations of compounds/contaminants. Guidance for reporting all appropriate information is presented to facilitate remediation approval.

# VERIFYING EXCAVATION REMEDIES

Verifying that contaminated soil is remediated by means of excavation requires samples from the excavation bottom and sidewalls. Tables and formulas presented provide the minimum number of samples necessary to verify cleanup for various size excavations. The biased approach specified in this guidance recommends soil sampling from areas most likely to still exceed cleanup criteria. The location of the sample collection points relies on site specific analysis of the release or contaminant distribution and the soil types encountered in the excavation. The minimum number of excavation floor and sidewall samples required to demonstrate verification using a point by point comparison with the cleanup criteria are specified. If the cleanup criteria are exceeded at any point, this verification methodology may require additional excavation at that point until the criteria are attained.

Sampling and analyzing the locations most likely to have contaminants can minimize the number of samples needed to verify remediation is complete. Since professional judgment and site specific knowledge are required for selecting sampling locations, the rationale used to select these locations must be documented in the verification report.

## SAMPLE LOCATIONS

Using a biased sampling approach, samples must be collected where they will most likely encounter contamination which could exceed the cleanup criteria. This will minimize the number of samples needed to verify a site is remediated. A sampling strategy that uses bias to choose sample locations is recommended. While it is inappropriate for this guidance document to dictate exact locations for sample collection in this strategy, site specific information (e.g., the location of leaks in an underground storage tank or its piping) from the remedial investigation concerning the release and soil conditions should be used along with professional judgment and the general guidance provided here to select appropriate soil sampling locations.

**EXAMPLE**: It would be incorrect to sample the north side of an excavation pit as extensively as the south side when the leak was confirmed on the south side of the tank.

Because a site must be remediated to a certain degree before approval can be considered, an analysis of data generated by prior investigation should yield information for the verification analysis. The field personnel present during remediation should be sufficiently familiar with the conditions on site to implement an appropriate verification strategy. A soil verification strategy should incorporate all pertinent biases of a site which may include, but are not limited to, those listed below.

- preferential pathways of contaminant migration
- source areas
- stained soils
- other site specific "clues" (e.g., fractures in clays)
- changes in soil characteristics (e.g., sand/clay interfaces)
- soil types and characteristics

## NUMBER OF SAMPLES

The following tables are used to determine the minimum number of samples necessary from the floor and sidewalls of an excavation no greater than 0.25 acres using a biased sampling approach. If the area of the excavation floor exceeds 10,890 square feet, use Part 2 of this guidance document. A site may have an appropriate number of samples collected for verification, but, if the samples are not collected from the appropriate locations (discussed previously) and adequately reported, remediation may not be considered adequate. All sample locations must be accurately located, described, and reported. It should be noted that "excavation" as used here refers only to that area excavated for remediation purposes and being verified to meet Type A/Type B cleanup criteria.

### *Number of Excavation Floor Samples*

Determine the minimum number of excavation floor samples from the table below.

### TABLE 1

### Excavation Floor Samples

| *Area of Floor (sq ft)* | *Number of Samples* |
|---|---|
| < 500 | 2 |
| 500 < 1,000 | 3 |
| 1,000 < 1,500 | 4 |
| 1,500 < 2,500 | 5 |
| 2,500 < 4,000 | 6 |
| 4,000 < 6,000 | 7 |
| 6,000 < 8,500 | 8 |
| 8,500 <10,890 | 9 |

### *Number of Excavation Sidewall Samples*

Sidewall samples are required to verify that the horizontal extent of contamination has been remediated. Use Table 2 to determine the minimum number of required sidewall samples. In no case is less than one sample on each sidewall (i.e., four) acceptable. In the case of irregularly shaped excavations, where four walls are not readily discernible, divide the total wall area into four segments of approximately equal size. Sidewall samples should be located in accordance with "biases" outlined earlier in Part 1.

## TABLE 2

## Excavation Sidewall Samples

| *Total Area of Sidewalls (sq ft)* | *Number of Samples* |
|---|---|
| < 500 | 4 |
| 500 < 1,000 | 5 |
| 1,000 < 1,500 | 6 |
| 1,500 < 2,000 | 7 |
| 2,000 < 3,000 | 8 |
| 3,000 < 4,000 | 9 |
| > 4,000 | 1 sample per 45 lineal feet of sidewall |

## VERIFYING IN-SITU AND EX-SITU SOIL REMEDIES

The effectiveness of in-situ soil remedies must be verified by three-dimensional random soil sampling. Refer to Attachment 2 for approved statistical sampling strategies. Certain ex-situ remedies, such as bio-piles or above-ground vapor extraction, may be amenable to statistical sampling strategies or batch sampling. Any proposed sampling strategy for in-situ or ex-situ remedies should be pre-approved by the DNR.

# BACKGROUND SOIL SAMPLES

## ESTABLISHING SOIL BACKGROUND

Establishing soil background, as required by Act 307 PA 1982, as amended, Michigan Environmental Response Act (MERA), can be accomplished by utilizing Operational Memorandum #15 or using the following guidance.

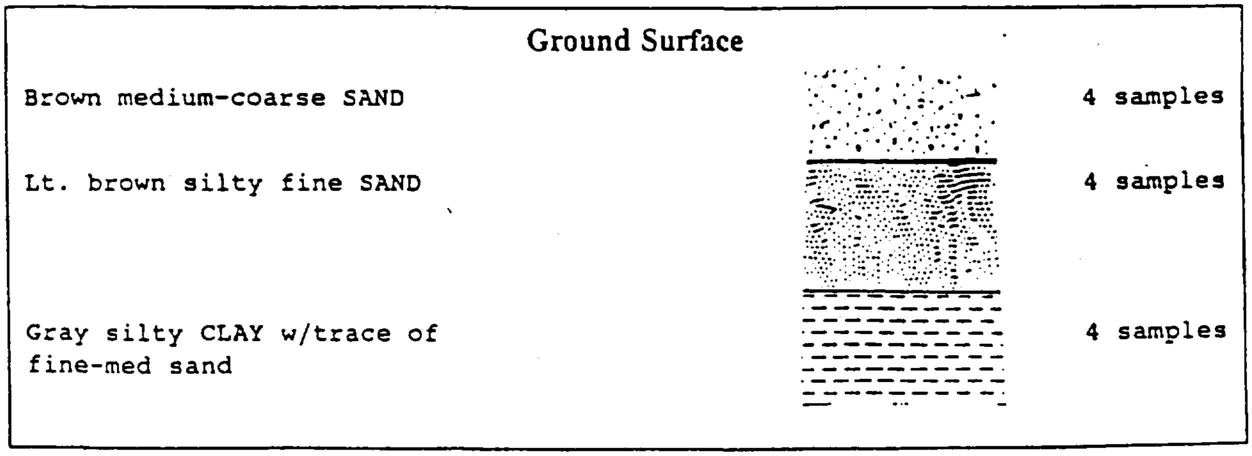
Background should be established for site specific waste constituents, specific chemicals used in various processes, facility operations, or remedial investigation results. Sample analyses may include metals, organic constituents, or other site specific waste constituents. Analyses should be in accordance with Act 307 P.A. 1982, as amended.

Many factors can play a part in the background concentrations of a chemical in soil.

**EXAMPLE**: The geologic origin (e.g., the parent rock) of glacial drift may have been high in copper, lead, or other metals that may be potential contaminants. Additionally, the hydrogeologic situation can alter the quantity of these elements. Groundwater recharge areas (e.g., highlands) are frequently leached of metals while groundwater discharge areas (e.g., swamps, floodplain) are the recipients of leached metals. Thus, sites in low areas will usually have higher background concentrations than upland areas. Other conditions, such as precipitation and atmospheric fallout from widely dispersed human and natural activities, also affect soil concentrations.

A minimum of four samples must be used to establish "background" in soils. This will help account for natural constituent occurrences and inherent variability within each distinctive soil horizon. Background samples must be collected in an area which has not been impacted by environmental contamination from the site and representative of natural background conditions. Based on waste type, contaminant mobility, operation practices, and soil type (sand, silty sand, clay), an estimate of contamination depth should be made and background samples taken at comparable depths for the particular soil type. Multiple soil horizons should have "background" established separately (e.g., minimum of four samples per each soil unit).

**EXAMPLE**:



# STATISTICAL ANALYSIS FOR ESTABLISHING BACKGROUND CONCENTRATIONS

The recommended statistical method for establishing background concentrations at small sites is (1) establishing the upper limit of background concentration of a constituent at the mean plus 3 standard deviations or (2) other statistical methods submitted to DNR for approval.

1. *Mean Plus 3 Standard Deviation Approach*

   Calculate the "upper limit" of background concentration by using the following 5 step process.

   A. Calculate the background mean ($\bar{X}_b$) by dividing the sum of the total background readings by the total number of background readings:

   $$\bar{X}_b = \frac{X_1 + X_2 + \ldots X_n}{n}$$

   B. Calculate the background variance ($S_b^2$) by taking the sum of the squares of each reading minus the mean and dividing by the degrees of freedom (the total number of background samples minus one):

   $$S_b^2 = \frac{(X_1 - \bar{X}_b)^2 + (X_2 - \bar{X}_b)^2 \ldots (X_n - \bar{X}_b)^2}{n-1}$$

   NOTE: Any sample populations less than ($n<30$ samples) must use $n - 1$ for degrees of freedom.

   C. Calculate the background standard deviation ($S_b$) by taking the square root of the variance:

   $$S_b = \sqrt{S_b^2}$$

D. The Coefficient of Variation Test (CV) where

$$CV = \frac{S_b}{\overline{X}_b}$$

is used to evaluate data distribution. The background data should generally have a CV of less than 0.5 for granular soils, less than 0.75 for cohesive soils, or an explanation accounting for higher CV values. The maximum reccommended CV is 1.00. If the data distribution exceeds a CV of 1.00, then a thorough evaluation will need to be made to account for this variability (e.g., lab QA/QC, typographical errors, soil classification, sample location, data not normally distributed etc.). If the CV exceeds 1.0 and there is sufficient evidence to suggest a data point does not accurately represent background conditions or if QA/QC problems exist which invalidate that data point, the outlier data may be dropped or additional samples collected and analyzed to ensure a sufficient representative data population (n) is achieved. A high concentration in and of itself is not sufficient justification to exclude the data point.

E. Use the $\overline{X}_b + 3*S_b$ of "background" data as the maximum allowable limit or upper limit. Where $3*S_b$ equals three times the standard deviation and $X_b$ equals the background mean (this statistical method only requires one sample per station). Compare each sample point to the calculated maximum allowable limit or upper limit analyzed from background data.

**EXAMPLE:** Four soil samples from a site were analyzed for background concentrations for lead. Concentrations of lead from the sample analyses returned from the lab were 56, 25, 18, and 35 ppb. Now, the investigator wants to examine the data set to discover whether the 56 ppb sample is an outlier:

$$\overline{X}_b \ mean = \frac{56+25+18+35}{4} = 33.5$$

$$S_b^2 = \frac{[56-33.5]^2+[25-33.5]^2+[18-33.5]^2+[35-33.5]^2}{3} = 273.67$$

$$S_b = (standard\ deviation) = \sqrt{S_b^2} = 16.5$$

$$CV = \frac{16.5}{33.5} = 0.49$$

Because 0.49 is less than 0.5, no further evaluation of the background data set is necessary.

Therefore, the background upper limit value for this site is

$$background\ upper\ limit = \overline{X}_b + (3*S_b) = 33.5 + (3*16.5) = 83.0\ ppb$$

If a value is found to be an outlier which is not representative of background conditions, it may be replaced by another sample that is not an outlier to maintain at least four samples for background determination.

2. *Other statistical procedures for establishing background.* Refer to a statistical reference book or U.S. EPA's Interim Final Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities (April 1989) and Addendum (July 1992).

## PROCEDURES FOR NON-DETECT VALUES

The following provides some guidelines in incorporating non-detectable sample results into the procedure to calculate background concentrations.

1. If less than 50% of the background data is below the detection limit (DL), use ½ of the detection limit as the value.

2. If more than 50% of the background data is below the detection limit, use one of the following procedures.

   - Alternate "0" and the detection limit (DL) resulting in a net value of ½ the detection limit, with a variance.

     | EXAMPLE: | Actual Value | Substitute Value |
     |---|---|---|
     | | <DL | DL |
     | | <DL | 0 |
     | | <DL | DL |
     | | <DL | 0 |

   - The Continuity Correction procedure with the t-test, Cohen's method, or other approved methods.

# REPORT FOR SMALL SITE VERIFICATION

Soil cleanup verification reports for small sites must identify the number and location of samples and justify the sample location selected (why and how). The verification report must include the following.

1. MAP(s) and CROSS SECTIONS

   Provide a scaled map of the floor and walls of an excavation (the vertical and horizontal area treated for "in-situ" remediations) with sample locations identified. The cross section should depict the stratigraphy, fractures, soil types, discolorations, unusual characteristics, odor, etc.

2. SAMPLE LOCATION RATIONALE

   A. Background sample location
   B. Verification sample locations
   C. Sample depths
   D. Sample collection procedures
   E. Describe biases and rationale used for collecting each sample (e.g., clay fractures, discolored soil, location of leak in tank)

3. DATA ANALYSES

   A. Analytical parameters
   B. Analytical methods used
   C. Method detection limits
   D. Laboratory Quality Assurance/Quality Control

4. STATISTICAL ANALYSES

   A. Calculation of background concentrations
   B. Coefficient of variance calculations
   C. Lab results
   D. Narrative explanation of background concentrations

# DNR--GUIDANCE DOCUMENT, PART 2

## MEDIUM AND LARGE SITE SOIL CLEANUP VERIFICATION (GREATER THAN 10,890 SQUARE FEET)

Part 2 describes statistical random sampling strategies to verify the remediation of medium and large sites greater than 0.25 acres in size. The strategies employ the use of gridding to facilitate the unbiased selection of sampling points and accepted statistical tools for evaluating the resultant data. The strategies provide a 95% confidence level of determining any hot spot concentrations on a site. It contains guidance on sampling protocol and necessary documentation for clean closures. Part 2 also discusses how to establish grid intervals, set grids, sample grids, statistically evaluate the data, use grids to guide additional remedial activities, disposal options, reporting, and a certification checklist. It also provides guidance on the sampling of ex-situ remedial processes (e.g., thermal desorption).

The term 'clean closure' means that the site has been restored to either Type A or Type B levels. Type A is defined in Act 307 P.A. 1982, as amended, which references non-detect or background levels. Type B is defined in Act 307 P.A. 1982, as amended, which references risk-based or background levels. Waste, soil, other environmental media, and/or debris removed should be classified as hazardous or non-hazardous to determine disposal options and handling requirements (i.e., solid waste under Act 641 P.A. 1978, as amended; hazardous waste under Act 64 P.A. 1979, as amended; land ban restrictions under 40 CFR Part 268).

All cleanup verification evaluations must consider the spatial arrangements of sample values (patterned vs totally random) and the impacts on the present and future uses of the site. Because Type B cleanups are based on residual risk, the distribution of that risk, now and in the future, must be determined. These procedures are not *absolutes*. Other sampling approaches may be developed and submitted for DNR approval.

Three of the statistical sampling strategies most commonly used for evaluating remedial sites and wastes are described in Attachment 2. For further discussion on sampling strategies and sample collection methods, see "Test Methods for Evaluating Solid Waste," SW-846 Volume II: Field Methods, November 1986, Third Edition, US EPA.

Compositing samples for verifying soil remediation is not acceptable without prior DNR approval. When verifying a soil remediation is complete, contaminant concentrations will be low. Compositing may result in the contaminant concentrations not being representative of what remains in the soil. If concentrations are low, compositing may dilute the concentrations of a contaminant to below its threshold detection limit. Additionally, if contamination is indicated in a composited sample, the location of the contamination remains unknown.

## ESTABLISHING GRID INTERVALS

When obtaining samples to verify that soil or wastes have been adequately remediated, it is important to insure that the analytical results obtained will provide an accurate representation of the entire area or volume under consideration. The location and number of samples to be taken at a particular remediation site depends on many factors: the level of confidence desired, the spatial and temporal variability of the media to be sampled, and the costs involved. An important objective in any sampling program is to obtain the most accurate data possible while minimizing the associated costs. One method to accomplish this goal is to use statistically valid sampling strategies. The appropriate sample number can be estimated and the sampling locations can be chosen without bias.

Such strategies employ the use of gridding to facilitate the unbiased selection of sampling points and accepted statistical tools for evaluating the resultant data. Statistical theory allows for the sampling of a subset of the grid points to achieve a reliable characterization of the entire remedial area or waste. Subsections describe ways to use sampling grids and statistical tools to evaluate areas of remediation.

The following equations and tables provide a simple basis to establish a grid system to facilitate unbiased selection of sampling points and sample coverage proportional to the area being verified.

1. *Basic Strategies.* A grid system should be established over the area being remediated. Grid point representation should be proportional to the size of the area. For excavation, both the sidewalls and bottom areas would be included in the determination of the area size. It is recommended that one of the following equations be used to determine grid intervals for stationing:

*small site: see Part 1*

$$\text{medium site: } \frac{\sqrt{A/\pi}}{4} = GI$$

$$\text{large site: } \sqrt{\frac{A\pi}{SF}} = GI$$

where: A = area to be grid (square feet)
GI = grid interval
SF = Size Factor, length of area to be grid (unitless)

It appears that there are logical size ranges of sites to which the grid equations apply:

A) small: up to 0.25 acre

B) medium: 0.25 - 3.0 acres

C) large: 3.0 acres and greater

To simplify this application, use the following chart based on an average size range of sites (1 acre = 43,560 square feet). The approximate grid ranges are provided as a quick check on numbers generated for specific sites using the above formulas.

| *Site Acreage** | *Square Feet** | *≈ Grid Interval Ranges* |
|---|---|---|
| up to 0.25 (small) | up to 10,890 | See Part 1 |
| 0.25-3.00 (medium) | 10,890-130,680 | 15-50 feet |
| 3.0 and over (large) | 130,680 + | 30 feet plus |

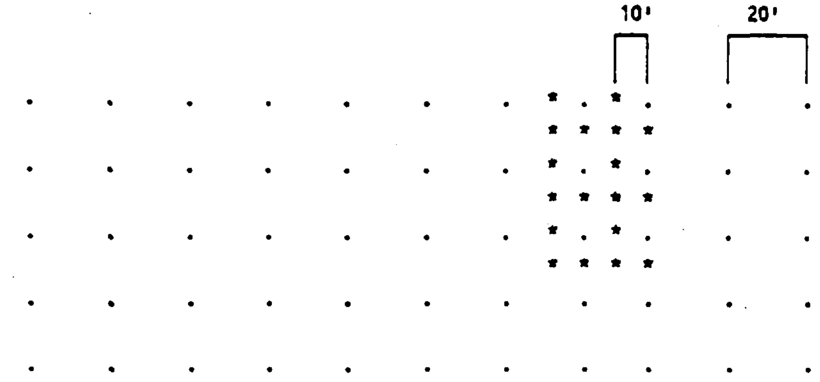
* Site acreage, square footage, is total area of sidewalls and base of excavation.

2. *Setting the Grid.* After the grid interval is calculated, it is recommended that a scaled grid overlay be made to superimpose on a map of the remediated area (this area includes both sidewalls and base). Some specified point (usually the southwest corner) should be designated as the 0,0 coordinate. The grid can then be adjusted to maximize sampling coverage. Some grid adjustment may be necessary for unusually shaped areas. Grid adjustment may also be needed to accommodate a minimum of at least one sample from each sidewall.

### 3. ***Variations on Basic Strategy.***

A. Subgridding. It may be warranted to apply grids with different intervals within the remediated area so that a proportional sampling can be focused on suspect areas (such as sumps, tank leak areas, etc.).

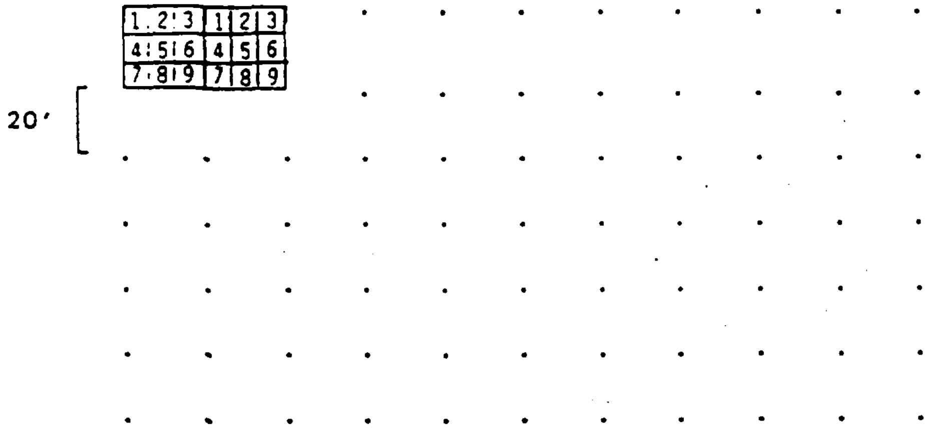
**EXAMPLE:**



. Area I Sample Station, 80′ x 200′, GI = 20′
* Area II (subset of I) Sample Station, 30′ x 50′, GI = 10′

B. Further Randomization. Sites that may have a patterned distribution of waste or contamination due to time sequence of filling, production sequences, or physical site conditions (i.e., furrows) may require a further randomization of sampling. In such cases, the following grid cell sampling format may be selected instead of at grid point stations. Each grid cell to be sampled must be divided into nine equal sized "subcells." Next, a random number table is used to select in which of the subcells the sample will be taken. The random number table is used again to select which subcell for the next cell and so on.

**EXAMPLE:**



Area = 120′ x 200′, GI = 20′

In the example above, a sampling grid has been set up with grid point stations 20 feet apart using the appropriate formula. Two cells which have been selected at random have been divided into nine subcells each. Subcell #4 was chosen randomly in one cell and subcell #2 in the other cell. This process is continued for all of the cells selected at random for sampling. Samples are then taken in each randomly chosen subcell.

C. **Three dimensional gridding: In-Situ and Ex-Situ Remediations.**

In-situ and ex-situ remediations involving soils and/or wastes with a significant vertical component should be evaluated in three dimensions (volume evaluation). Examples of such remediations would be in-situ soil vapor extraction or ex-situ bioremediation involving several cubic feet of soil and/or waste. A grid is superimposed on the remediation area as described in the previous sections and a vertical component is added at each node. The vertical sampling increments would be site specific and require prior approval from the DNR.

## SAMPLING OF GRID

Sampling of grids may include all of the grid stations or a phased subset of the total stations. The subset of grid stations is created by assigning coordinates to all the nodes and randomly selecting nodes using a random number generator or a random number table (refer to Attachment 2). A minimum of 10 samples or 25%, whichever is larger, of the total grid stations should be sampled and analyzed initially to allow a large enough data pool for statistical analysis. It is advisable that extra samples also be taken and kept under proper chain of custody and storage procedures at the time of initial sampling. If the statistical analysis indicates that more samples are needed, an additional sample trip to the field may have been avoided. A method for calculating the sample size requirements is presented in Attachment 2 (Lamda relationship).

## ESTABLISHING SOIL BACKGROUND

Establishing soil background, as required by Act 307 PA 1982, as amended, Michigan Environmental Response Act (MERA), can be accomplished by utilizing Operational Memorandum #15 or using the following guidance.

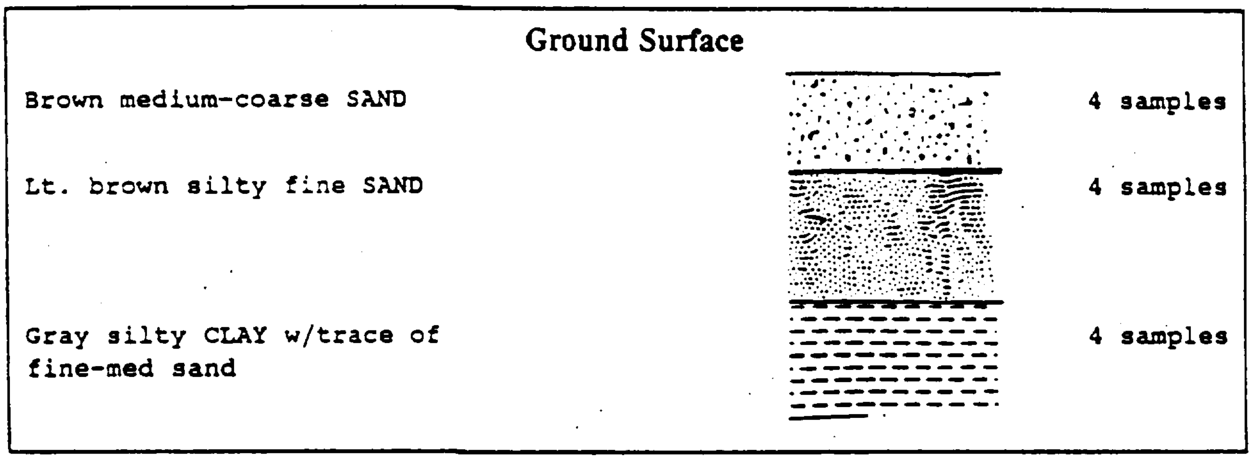
Background should be established for site specific waste constituents, specific chemicals used in various processes, facility operations, or remedial investigation results. Sample analyses may include metals, organic constituents, or other site specific waste constituents. Analyses should be in accordance with Act 307 P.A. 1982, as amended.

Many factors can play a part in the background concentrations of a chemical in soil.

**EXAMPLE**: The geologic origin (e.g., the parent rock) of glacial drift may have been high in copper, lead, or other metals that may be potential contaminants. Additionally, the hydrogeologic situation can alter the quantity of these elements. Groundwater recharge areas (e.g., highlands) are frequently leached of metals while groundwater discharge areas (e.g., swamps, floodplain) are the recipients of leached metals. Thus, sites in low areas will usually have higher background concentrations than upland areas. Other conditions, such as precipitation and atmospheric fallout from widely dispersed human and natural activities, also affect soil concentrations.

A minimum of four samples must be used to establish "background" in soils. This will help account for natural constituent occurrences and inherent variability within each distinctive soil horizon. Background samples must be collected in an area which has not been impacted by environmental contamination from the site and representative of natural background conditions. Based on waste type, contaminant mobility, operation practices, and soil type (sand, silty sand, clay), an estimate of contamination depth should be made and background samples taken at comparable depths for the particular soil type. Multiple soil horizons should have "background" established separately (e.g., minimum of four samples per each soil unit).

**EXAMPLE:**



## STATISTICAL ANALYSIS FOR ESTABLISHING BACKGROUND CONCENTRATIONS

The recommended statistical method(s) for establishing background concentrations at medium and large sites are (1) establishing the upper limit of background concentration of a constituent at the mean plus 3 standard deviations, (2) tolerance limit, (3) t-tests, and (4) other statistical methods submitted to the DNR for approval.

1. *Mean Plus 3 Standard Deviation Approach.*

   Calculate the "upper limit" of background concentration by using the following 5 step process.

   A. Calculate the background mean ($\bar{X}_b$) by dividing the sum of the total background readings by the total number of background readings:

$$\bar{X}_b = \frac{X_1 + X_2 + \ldots X_n}{n}$$

   B. Calculate the background variance ($S_b^2$) by taking the sum of the squares of each reading minus the mean and dividing by the degrees of freedom (the total number of background samples minus one):

$$S_b^2 = \frac{(X_1-\overline{X}_b)^2+(X_2-\overline{X}_b)^2 \ldots (X_n-\overline{X}_b)^2}{n-1}$$

**NOTE:** **Any sample populations less than (n<30 samples) must use n - 1 for degrees of freedom.**

C. Calculate the background standard deviation ($S_b$) by taking the square root of the variance:

$$S_b = \sqrt{S_b^2}$$

D. The Coefficient of Variation Test (CV) where

$$CV = \frac{S_b}{\overline{X}_b}$$

is used to evaluate data distribution. The background data should generally have a CV of less than 0.5 for granular soils, less than 0.75 for cohesive soils, or an explanation accounting for higher CV values. The maximum recommended CV is 1.00. If the data distribution exceeds a CV of 1.00, then a thorough evaluation will need to be made to account for this variability (e.g., lab QA/QC, typographical errors, soil classification, sample location, data not normally distributed etc.). If the CV exceeds 1.0 and there is sufficient evidence to suggest a data point does not accurately represent background conditions or if QA/QC problems exist which invalidate that data point, the outlier data may be dropped or additional samples collected and analyzed to ensure a sufficient representative data population (n) is achieved. A high concentration in and of itself is not sufficient justification to exclude the data point.

E. Use the $\overline{X}_b + 3*S_b$ of "background" data as the maximum allowable limit or upper limit. Where $3*S_b$ equals three times the standard deviation and $X_b$ equals the background mean (this statistical method only requires one sample per station). Compare each sample point to the calculated maximum allowable limit or upper limit analyzed from background data.

**EXAMPLE:** Four sand samples from a site were analyzed for background concentrations for lead. Concentrations of lead from the sample analyses returned from the lab were 56, 25, 18, and 35 ppb. Now, the investigator wants to examine the data set to discover whether the 56 ppb sample is an outlier:

$$\overline{X}_b \ mean = \frac{56+25+18+35}{4} = 33.5$$

$$S_b^2 = \frac{[56-33.5]^2+[25-33.5]^2+[18-33.5]^2+[35-33.5]^2}{3} = 273.67$$

$$S_b = (standard\ deviation) = \sqrt{S_b^2} = 16.5$$

$$CV = \frac{16.5}{33.5} = 0.49$$

Because 0.49 is less than 0.5, no further evaluation of the background data set is necessary.

Therefore, the background upper limit value for this site is

$$background\ upper\ limit = \overline{X}_b + (3*S_b) = 33.5 + (3*16.5) = 83.0\ ppb$$

If a value is found to be an outlier which is not representative of background conditions, it may be replaced by another sample that is not an outlier to maintain at least four samples for background determination.

2. *Tolerance Limit.* This statistical procedure is a fairly sensitive program for environmental purposes. It minimizes false positive and is simple to perform. **A minimum background data base of n=8** (optimum n=16) is needed for this method. Other suggested criteria follow:

   A. The Coefficient of Variation Test (CV) to evaluate data distribution. See this Guidance Document, Part 2, Statistical Comparisons, #1.D. (the Coefficient of Variation Test....).

   B. Using the mean ($\overline{X}_b$) and standard deviation ($S_b$), construct the one-sided upper tolerance limit (TL) by taking the mean plus a tolerance coefficient (K) at the 95% probability level for a 95% coverage (for K values, see Attachment 3) times the standard deviation as follows:

$$TL = \overline{X}_b + KS_b$$

3. *t-tests.* Any t-test should be "approved" by DNR prior to use since there are a number of variations. The Gosset Student t-test (1908) or Cochran's Approximation to the Behren's-Fisher Student's t-test as referenced in the 40 CFR Part 264, Appendix IV are recommended. Note that these statistical comparison methods require that two or more discrete samples be taken at each sampling station.

4. *Other statistical procedures for establishing background.* Refer to a statistical reference book or U.S. EPA's Interim Final Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities (April 1989) and Addendum (July 1992).

## PROCEDURES FOR NON-DETECT VALUES

The following provides some guidelines in incorporating non-detectable sample results into the procedure to calculate background concentrations.

1. If less than 50% of the background data is below the detection limit (DL), use ½ of the detection limit as the value.

2. If more than 50% of the background data is below the detection limit, use one of the following procedures.

    - Alternate "0" and the detection limit (DL) resulting in a net value of ½ the detection limit, with a variance.

**EXAMPLE:**

| Actual Value | Substitute Value |
|---|---|
| <DL | DL |
| <DL | 0 |
| <DL | DL |
| <DL | 0 |

    - The Continuity Correction procedure with the t-test, Cohen's method, or other approved methods.

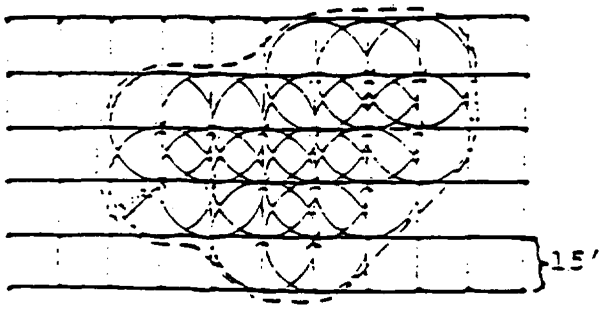
## STATISTICAL EVALUATION OF DATA

A detailed description of an acceptable approach for evaluating the data generated by statistically based random sampling strategies such as those described in the foregoing sections is provided in Attachment 2 (page 27). The 95% upper confidence limit (UCL) of the mean is calculated for each constituent of concern and compared to the regulatory threshold (RT) (i.e., cleanup criterion, eg., Type A or B). If the UCL is less than the RT and an adequate number of samples have been collected and spatially evaluated, the remediation is deemed complete. Attachment 2 also provides a step wise procedure for determining whether an adequate number of samples have been collected, based on the analytical data derived from the initial and subsequent rounds of samples. **All evaluations must consider the spatial correlation of sample values** (e.g., highest concentrations in the same area), present and future uses of the site, residual risk, and distribution of that risk now and in the future. Other acceptable methods for UCL and sample size calculations can be found in U.S. EPA SW-846, Third Edition, Section 9.1.1.3.

## GRID APPROACH TO ADDITIONAL REMEDIATION

1. *Two-Dimensional Node Sampling Excavation Grid.* Verification sampling as described above will at times indicate that remediation is incomplete. Excavation of contaminated areas should be based on the established grid system interval (as recommended in this Guidance Document, Part 2). Where a subset of grid points has indicated that the entire area exceeds the cleanup, the nodes adjacent to the sampled nodes that are causing the exceedance should be sampled, and this process repeated until the "Hot spots" requiring removal have been defined. The radius of excavation around the contaminated sample point(s) is equal to the grid interval (GI=r). Excavation depth is to the deepest point of contamination or to the depth where acceptable levels are anticipated. After excavation, the impacted point(s) must be resampled at their new elevations to verify that the area meets the selected cleanup criteria. If continued contamination is detected, the excavation format is repeated until a satisfactory result is obtained.

**EXAMPLE:**



GL = 150
A = 11,250
GI = 14.9

. Sample Station
x Contaminated Station
r = GI = 15 feet

Remediation of contaminated soil by excavation will be in accordance with Act 307 P.A. 1982, as amended. The proposed remedial action plan must be approved by the DNR.

2. *Two-Dimensional Subcell Sampling Excavation Grid.* Use this Guidance Document, Part 2. The radius of excavation around a contaminated point may need to be adjusted to greater than the GI distance. This adjustment is due to the variable distances between sampling points.

3. *Three-Dimensional Cleanup Verification.* If sampling and statistical analysis using this Guidance Document indicate that Act 307 cleanup criteria have not been met, additional remediation will be required. The sampling protocol and strategies described in Attachment 2 and in SW-846, Third Edition, Volume II, Part III, Chapter 9, are acceptable. All sampling strategies, detection levels, and sampling pathways must be in accordance with Act 307 P.A. 1982, as amended. If any portion of the soil mass in question appears to be causing the material to fail, it may be identified through hot spot sampling and selectively removed. Subsequent sampling must be done to confirm that the remaining material meets Act 307 P.A. 1982, as amended.

4. *Batch Sampling for ex-situ treatment processes.* If ex-situ treatment processes of contaminated soil or waste is used in the remediation, a sampling program for the process stream needs to be developed. The basis of this program is to get representative samples over time versus a spatial approach (Attachment 2, Sampling Process Streams).

## DISPOSAL OPTIONS

Soils remediated to Act 307 P.A. 1982, as amended, standards (Type A and/or Type B) are no longer considered a waste per Act 64 P.A. of 1979, as amended, and RCRA regulations. Disposal of excavated waste, soil, other environmental media, and/or debris must be in accordance with all applicable Federal, State, and local regulations.

## REPORT FOR MEDIUM AND LARGE SITES VERIFICATION

Soil cleanup verification reports for medium and large sites must identify the number and location of samples and justify the sample location selected (why and how). The verification report must include the following.

1. MAP(S) AND CROSS SECTIONS
   Provide a scaled map of the floor and walls of the excavation (the vertical and horizontal area treated for "in-situ" remediations) with sample grid and sample locations identified. Appropriate cross section should depict the stratigraphy, fractures, soil types, and final depth and elevations of the excavation.

2. SAMPLE LOCATION RATIONALE
   a. Properly labelled and easily identified sampling grid stations (map) including background stations
   b. Sample Depths
   c. Sample Collection Procedures
   d. Results of all tests to determine clean closure (charts, tables, lab sheets, field notes, well logs, boring logs)

3. DATA ANALYSES
   a. Analytical parameters
   b. Analytical methods used
   c. Method detection limits
   d. Laboratory Quality Assurance/Quality Control

4. STATISTICAL ANALYSES
   a. Explanation and calculation of background concentrations
   b. Statistical comparisons on sampling results compared to background (this should include full computations on background and statistical analysis)
   c. Lab results

5. Additional information to support closure (e.g, residual risks, spatial correlation of sample values, present and future land uses)

## RCRA CLEAN CLOSURE CERTIFICATION CHECKLIST

Attachment 4 is a guide that indicates the information that a facility should provide to certify that their activities meet the conditions for a clean closure under the Act 64/RCRA regulations.

# ATTACHMENT 1

## GUIDE TO SAMPLE BIAS

Many factors can play a part in the concentrations of contaminants. The following contains some of the factors impacting chemical concentrations and locations.

### CHEMICAL TRANSFORMATIONS

Many organic chemicals may undergo aerobic and anaerobic degradation. A description of these processes is beyond the scope of this document. The subject is approached here, however, to be sure that samplers are aware that the chemical(s) spilled may not be the only chemical(s) in the soil after a transformation has occurred. These occurrences should be documented in the remedial investigation. The full scan of chemicals from the remedial investigation requiring cleanup should be analyzed when doing a closure. Analyses should be done for all chemicals that have been identified as breakdown products of the chemicals found on site.

The professional literature contains many articles on this subject (Cline and Brown, 1989; Borden and Bedient, 1987; Wilson and Wilson, 1985). The interested reader is directed to these articles.

### *Organic Carbon Content of Soil*

The organic carbon content of soils is a key factor in the ability of any soil to adsorb contaminants. For a variety of reasons (Lindsay, 1979), an increase in organic carbon content leads to an increase in the adsorption of several classes of chemicals.

> **Where to sample:** Areas of the excavation that appear to have excess organic carbon (e.g. peat, muck, darker soils) should be preferentially sampled.

### *Medium Sand or Larger Grains*

Medium to larger grain size sand has from 20 to 40 percent porosity. Most sands in Michigan are composed of quartz, limestone, and small amounts of metamorphic rock fragments. These soils have a low capacity for adsorbing metals or hydrophilic (soluble) organic chemicals. Hydrophobic (insoluble) organic chemicals with low molecular weight will adsorb to this soil in small amounts. Hydrophobic chemicals with high molecular weight will adsorb in moderate amounts (Cline & Brown, 1989). These soils have a low capacity to hold contaminants in the grain interstices due to low capillary action. Contaminants that are held in these soils adhere to the grains themselves in dry soils and are forced into the smaller pore spaces in wet soils (Schwille, 1988).

> **Where to sample:** Samples should be placed at regular intervals along the base and sidewalls of the excavation being sure that samples are located where the source was removed. In these soils, the capillary force is low enough to ignore its effects in transporting contaminants lateral to gravity. Therefore, sidewall samples should be located near the excavation floor. This is especially true for low surface tension products such as gasoline.
>
> The limestone sand grains can act as a buffer to contaminants that cause pH changes (e.g., steel mill pickling acids). For these types of contaminants, the sampler should be on the lookout for intra-granular precipitates. These can appear as grain surface staining or make the soil appear clumpy or aggregated. Soils containing precipitates should be sampled.

### *Fine Sand and Silt*

These soils have strong capillary action due to the small inter-granular distances. A determination of the fluid surface tension of the spilled product is helpful. High surface tension aids in the ability of a substance to overcome gravity by capillary action. As before, higher molecular weight products can be expected to adsorb to the grains to a greater degree. This allows a product to move lateral to gravity and, to a degree, upward from the leak location. Low surface tension products, such as TCE (trichloroethene), are more likely to go straight down than oils in these kinds of soils. However, the hydraulic head (i.e., the amount of product in the original spill) must be substantial to force a dense non-aqueous phase liquid through a media with a hydraulic conductivity less than 1 x $10^{-3}$ cm/sec (Schwille, 1988).

> **Where to sample:** Interfaces between fine sand layers with larger grains above should be sampled. When high surface tension contaminants are suspected, silt layers should be sampled.

### *Clays*

Clay soils are very different from the sands and silts. Clays possess a net negative charge. This causes heavy metal cations (e.g., $Cr^{+6}$, $Cd^{+2}$, $Pb^{+2}$) to adsorb to the clay surface. In fact, this is true for any positive ionizable substance. Clays also have a much greater secondary porosity than primary (primary porosity is the space between the soil particles; secondary porosity is the space between fractures, bedding planes, and soil structures). As a result, spills in clay soils tend to follow preferred pathways. Clays will often show signs of shrinkage cracks or fractures that will allow contaminants to migrate in what would otherwise be considered a "tight" soil in a lab analysis of permeability. Signs of fracturing include "patterned" mottling. This is where the Fe (and also Mn) will be oxidized to a red, yellow, or reddish brown color along the crack while the matrix remains the reduced blue/gray color (Lindsay, 1979).

> **Where to sample:** It is very important to take clay soil samples from fractures. The fractures are the avenue of travel for contaminants in clay soils. Clay soils may also have sand lenses which should always be sampled. Sand lenses in clays tend to collect fluids. As such, they may harbor contaminants.

### *Bedrock*

Excavations in bedrock present difficult problems. Unlike clay, some bedrock formations have substantial primary porosity as well as secondary porosity. In Michigan, these are sandstones, conglomerates, and brecciated/coarse grained limestones. Examples of bedrock in Michigan with low primary porosity are fine grained limestones, shale, and crystalline metamorphic rocks (e.g., gneiss). If the sampler is unaware of the type of bedrock that is in an excavation, a geologist must be consulted.

> **Where to sample:** Excavations in areas of bedrock with significant primary porosity must be sampled in both the fractures and the matrix. Bedrock without primary porosity should have sampling predominantly in the fractures as in the clay situation. Weathered zones in bedrock will hold contaminants better than unweathered zones. This is due to the increased number of adsorption sites available in weathered rock.

# ATTACHMENT 2

## SAMPLING PROTOCOL FOR CHARACTERIZING WASTE/TREATMENT LEVELS:

## STRATEGIES FOR EVALUATING TREATED SOILS AND WASTE MATERIALS

When obtaining samples to characterize a treated soil or waste material, it is important to insure that the analytical results obtained will provide an accurate estimation of the nature of the entire area/volume under consideration. The location and number of samples to be taken at a particular site depends on many factors: the degree of accuracy desired, the spatial and temporal variability of the media to be sampled, and the costs involved. An important objective in any sampling program is to obtain the most accurate data possible while minimizing the associated costs. One method to accomplish this goal is to use statistically valid sampling strategies. The appropriate sample number can be estimated and the sampling locations can be chosen without bias.

Attachment 2 provides information on the methods used to obtain accurate data while minimizing the costs. The attachments include a discussion of three statistical sampling strategies and methods to determine the appropriate grid size for the area under investigation. If several areas on a site are under investigation, it may be advisable to grid them separately. This is especially true if information does not exist to indicate that the areas contain similar constituents or that they were placed at the same time period.

Information is also supplied on the statistical evaluation of the resultant analytical data. A minimum of 10 samples or 25%, whichever is greater, of the total grid stations should be sampled and analyzed initially to allow a large enough data pool for the statistical analysis. Extra samples should be taken and kept under proper chain of custody and handling procedures at the time of initial sampling. If the statistical analysis indicates that two or three more samples are needed, an additional trip to the field may not be necessary. This may also avoid the need to reestablish the grid pattern at a later date.

For further discussion on sampling strategies and sample collection methods, see "Test Methods for Evaluating Solid Waste," SW-846 Volume II: Field Methods, November 1986, Third Edition, US EPA.

# STATISTICAL SAMPLING STRATEGIES

Statistical sampling strategies can often produce increased data accuracy while eliminating sampler bias. Random sampling is based on the theory of random chance probabilities in order to choose the most representative sample. Knowledge of the waste distribution is not necessary. The error in data accuracy of a random sampling scheme can be objectively measured since the probability of choosing each sampling point is known. A random numbers table (attached) or a random numbers generator should be used to select the sampling locations eliminating bias by the sample collector.

Several statistical sampling strategies are available to produce an unbiased, representative sampling program. The principles behind three of these and the situations for which they are best suited are provided below. To achieve true random sampling, composite sampling is not acceptable.

1. *Simple Random* is a method that requires little or no prior knowledge of material distribution. It relies on random chance probability theory--where each sampling location has an equal and known probability of being selected. In this way, sampling error can be accurately estimated. Usually, the area of interest is sectioned into a two or three dimensional grid pattern and random coordinates are chosen for sampling.

2. *Systematic random* is an extension of simple random sampling that may produce a more efficient sampling survey. It can be more efficient by reducing the sampling error while maintaining the sample number, or by reducing the number of samples needed to achieve a specified sampling error, or by reducing the cost of collection. This method also requires little or no knowledge about the waste distribution, but bias and imprecision can be introduced if unseen trends or cycles exist. Two methods used to select sample locations under this method follow.

    A) randomly selecting a transect or transects and sampling at preselected intervals.

    B) preselecting both the transect or transects and the sampling interval and starting from a randomly selected point.

3. *Stratified random sampling* requires some knowledge about the waste distribution. When stratification is known or suspected, sampling efficiency can be improved by dividing the material into strata that are more homogeneous than the total area. Simple random sampling techniques can then be used to sample each stratum independently. Each stratum is divided into a grid pattern and the sampling points are selected randomly. If the area is vertically stratified, the sampling points in each stratum are selected randomly and then selected depths are sampled. If the area is horizontally stratified, the sampling points within each stratum are selected randomly, but the total depth is sampled. An analysis of variance (ANOVA) should be done on the analytical results to determine if the strata differ significantly. This is done to assure that the use of stratified random sampling was statistically valid. When the volume of the strata differ or the number of samples within each strata differs, the results must be weighed appropriately to avoid bias.

# RANDOM NUMBERS TABLE

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 03 | 47 | 43 | 73 | 86 | 36 | 96 | 47 | 36 | 61 | 46 | 98 | 63 | 71 | 62 |
| 97 | 74 | 24 | 67 | 62 | 42 | 81 | 14 | 57 | 20 | 42 | 53 | 32 | 37 | 32 |
| 16 | 76 | 62 | 27 | 66 | 56 | 50 | 26 | 71 | 07 | 32 | 90 | 79 | 78 | 53 |
| 12 | 56 | 85 | 99 | 26 | 96 | 96 | 68 | 27 | 31 | 05 | 03 | 72 | 93 | 15 |
| 55 | 59 | 56 | 35 | 64 | 38 | 54 | 82 | 46 | 22 | 31 | 62 | 43 | 09 | 90 |
| 16 | 22 | 77 | 94 | 39 | 49 | 54 | 43 | 54 | 82 | 17 | 37 | 93 | 23 | 78 |
| 84 | 42 | 17 | 53 | 31 | 57 | 24 | 55 | 06 | 88 | 77 | 04 | 74 | 47 | 67 |
| 63 | 01 | 63 | 78 | 59 | 16 | 95 | 55 | 67 | 19 | 98 | 10 | 50 | 71 | 75 |
| 33 | 21 | 12 | 34 | 29 | 78 | 64 | 56 | 07 | 82 | 52 | 42 | 07 | 44 | 38 |
| 57 | 60 | 86 | 32 | 44 | 09 | 47 | 27 | 96 | 54 | 49 | 17 | 46 | 09 | 62 |
| 18 | 18 | 07 | 92 | 46 | 44 | 17 | 16 | 58 | 09 | 79 | 83 | 86 | 19 | 62 |
| 26 | 62 | 38 | 97 | 75 | 84 | 16 | 07 | 44 | 99 | 83 | 11 | 46 | 32 | 24 |
| 23 | 42 | 40 | 64 | 74 | 82 | 97 | 77 | 77 | 81 | 07 | 45 | 32 | 14 | 08 |
| 52 | 36 | 28 | 19 | 95 | 50 | 92 | 26 | 11 | 97 | 00 | 56 | 76 | 31 | 38 |
| 37 | 85 | 94 | 35 | 12 | 83 | 39 | 50 | 08 | 30 | 42 | 34 | 07 | 96 | 88 |
| 70 | 29 | 17 | 12 | 13 | 40 | 33 | 20 | 38 | 26 | 13 | 89 | 51 | 03 | 74 |
| 56 | 62 | 18 | 37 | 35 | 96 | 83 | 50 | 87 | 75 | 97 | 12 | 25 | 93 | 47 |
| 99 | 49 | 57 | 22 | 77 | 88 | 42 | 95 | 45 | 72 | 16 | 64 | 36 | 16 | 00 |
| 16 | 08 | 15 | 04 | 72 | 33 | 27 | 14 | 34 | 09 | 45 | 59 | 34 | 68 | 49 |
| 31 | 16 | 93 | 32 | 43 | 50 | 27 | 89 | 87 | 19 | 20 | 15 | 37 | 00 | 49 |

## HOW TO USE THE RANDOM NUMBERS TABLE

1. If sampling containerized material, segregate the containers according to type based on available information. Number containers of the same type consecutively starting from 01. If sampling surface waters or piles, divide the area into a two or three dimensional grid and number the grid locations.

2. Determine the number of samples you need to take. For regulatory or research purposes, a large sample size may be needed (such as one sample for every five containers or grid points). Using a random scheme will generate more statistically valid data.

3. Using the random numbers table, choose any number as a starting point.

4. From this number, go in any direction until you have selected the predetermined number of samples with no repetitions. Numbers larger than the population size are ineligible.

## SAMPLING GRIDS

1. A grid system should be established over the specified area (sidewalls and base). Grid point representation should be proportioned to the size of the area. It is recommended that one of the following equations be used to determine grid intervals for stationing.

small site $$\frac{\sqrt{A/\pi}}{2}=GI$$

medium site $$\frac{\sqrt{A/\pi}}{4}=GI$$

large site $$\sqrt{\frac{A\pi}{SF}}=GI$$

where: A = area to be grid (sq. ft.)
GI = grid interval
SF = Size Factor, length of area to be grid (unitless)

It appears that there are logical size ranges of sites to which the three equations apply:

A) small: up to 0.25 acre

B) medium: 0.25 - 3.0 acres, and

C) large: 3.0 acres and greater

To simplify this application, use the following chart based on an average size range of sites (1 acre = 43,560 square feet). The approximate grid ranges are provided as a quick check on numbers generated for specific sites using the above formulas.

| *Site Acreage** | *Square Feet** | *≈ Grid Interval Ranges* |
|---|---|---|
| up to 0.25 (small) | up to 10,890 | See Part 1 |
| 0.25-3.00 (medium) | 10,890-130,680 | 15-50 feet |
| 3.0 and over (large) | 130,680 + | 30 feet plus |

* Site acreage, square footage, is total area of sidewalls and base of excavation.

2. After the grid interval is calculated, it is recommended that a scaled grid overlay be made to superimpose on the area under consideration. Some specified point (usually the southwest corner) should be designated as the 0,0 coordinate. The grid can then be adjusted to maximize sampling coverage. Some grid adjustment may be necessary for unusually shaped areas.

# STATISTICAL EVALUATION
# WASTE/TREATMENT CHARACTERIZATION SAMPLINGS

Following is a step by step description of the approach used to calculate confidence limits based on the analytical data derived from the preliminary samples.

1. Calculate a preliminary estimate of X

$$\bar{X}=\frac{\sum_{i=1}^{n} Xi}{n}$$

where: n = number of measurements
X = variable concentration
Xi = individual measurements

2. Calculate a preliminary estimate of the variance ($S^2$) and the standard deviation (S). Standard deviation is a function of both sampling variability and measurement variability.

$$S^2=\frac{\sum_{i=1}^{n} Xi^2-\frac{\left(\sum_{i=1}^{n} Xi\right)^2}{n}}{n-1}$$

$$S=\sqrt{S^2}$$

3. Calculate the standard error of the mean (Sx). Standard error is inversely proportional to the square root of the number of samples (increasing n from 4 to 16 reduces Sx by 50%).

$$Sx=\frac{S}{\sqrt{n}}$$

4. Since the concern is only whether the upper limit of a confidence interval is below or above the regulatory threshold, the lower confidence limit (LCL) need not be considered. The upper confidence limit (UCL) can be calculated using the one-tailed (one-sided) t values with n-1 degrees of freedom derived from a table of the Student's t distribution. Where only small sized statistical samples are involved (n<30), the normal or Gaussian distribution is not accurate, and the t distribution must be used.

5. The 95% UCL is calculated by using the following formula and substituting the values determined above plus the appropriate t value obtained from the t table.

$$UCL = \overline{x}+[t0.95(n-1)]Sx$$

The term in brackets indicates a one-tailed t-test at n-1 degrees of freedom. See the t-distribution table in Attachment 2.

The UCL number resulting from this formula will indicate with a 95% probability that it is either above or below the regulatory threshold (RT) developed for the constituent being subjected to the test. If a compound does not have a specified RT, then the UCL is compared to whatever concentration is of concern (i.e., a clean up level, action level, etc). Other confidence levels can be used, based on the specific sampling situation.

If the preliminary data indicate that more samples are needed to make a hazard determination, the Lambda ($\lambda$) relationship should be used. A step by step approach to calculating the appropriate sample size follows:

1. The appropriate number of samples to be collected can be estimated by use of the Lambda ($\lambda$) relationship and then consulting a table of values and their corresponding sample size number.

$$\lambda = \frac{RT-\bar{X}}{S}$$

   The lower the calculated value, the more samples are required to maintain a certain level of confidence. Also, as $\overline{X}$ approaches RT, $\lambda$ becomes smaller, and therefore a greater sample size is indicated for a certain level of confidence.

2. To obtain the appropriate sample size from the table of values, use the single sided value for $\alpha$ to test at the desired significance level (for 5%, $\alpha = 0.05$).

3. Randomly collect any additional samples that may be needed using the same grid and random numbers sequence as the first sampling. All field and laboratory procedures should be kept as consistent as possible to lower the amount of variability in the data.

4. Use all data values to calculate new $\overline{X}$, S, and Sx.

5. If the new $\bar{X} \geq RT$, then the contaminant is present at an unacceptable concentration and the study would be complete.

6. If $\bar{X} < RT$ and $\bar{X} > S^2$, calculate C (the criterion for determining if contamination is present at hazardous concentration). If $\bar{X} = S^2$ or $\bar{X} < S^2$, the data must be transformed prior to calculating C.

   Using the new data, C is calculated by the formula:

$$C = \frac{RT-\bar{X}}{Sx}$$

7. Compare the calculated C value to the two-tailed t value for the level of significance desired. The two-tailed t-value is used because both the possibility that C is > t or that C is < t must be checked.

   Use t0.95 and df (degrees of freedom) = n-1.

8. If C > t value, the contaminant is present at unacceptable concentrations and the study would be over. If C < t value, re-estimate the total number of additional samples to be collected by deriving a new $\lambda$. Use the newly calculated values of $\bar{X}$ and S.

9. If this new number of samples is not more than 20% greater than the last set collected, there is little chance that additional samples would decrease Sx and result in the material being considered unacceptable. Therefore, the study would be complete.

# EXAMPLE

## CALCULATION OF CONFIDENCE LIMITS AND LAMDA CALCULATION

*Problem 1: STATISTICAL SAMPLING*

A metal plating factory has been discharging process wastewaters into a large nearby swampy area for several years. This swampy area drains into a small river. The discharged wastewaters are known to be contaminated with very low levels of cadmium and chromium (i.e., the levels in the wastewater are below the facilities NPDES permit limitations). However, it has been suspected that the sediments in this swampy area may contain high levels of cadmium and chromium. Three preliminary sediment samples were taken with a Ponar dredge and analyzed to determine whether or not these sediments were contaminated with hazardous levels of these two metals. In 40 CFR 261.24, it states that a waste is hazardous under the characteristic of EP toxicity if it contains cadmium at a level $\geq 1.0$ mg/ℓ or chromium at a level $\geq 5.0$ mg/ℓ. The analysis of the three preliminary samples indicated a mean cadmium concentration of 0.37 mg/ℓ (3 samples at 0.25, 0.51, and 0.35 mg/ℓ) and a mean chromium concentration of 4.66 mg/ℓ (3 samples at 4.93, 4.21, and 4.84 mg/ℓ). Based on this analytical data, the cadmium level is well below the regulatory threshold (RT), but the chromium level closely approaches its RT. Because large legal or monetary losses may be incurred if the sediments are declared hazardous, the analytical data must be sound and a high degree of confidence is necessary in any decision made.

QUESTIONS: Given the above scenario, answer the following questions and calculate the appropriate answers.

1. Based on the chromium data supplied

   *Calculate* $S^2$, $S$, $S\bar{x}$

   Calculate the 95% UCL

   With what degree of confidence can it be stated that the chromium concentration does not exceed the RT?

2. If more samples are deemed necessary, determine how many

   Calculate the $\lambda$ value

   Calculate the appropriate number of additional samples using $\alpha = 0.05$ and $\beta = 0.05$

## PROBLEM 1 ANSWER SHEET

Given three samples with chromium concentrations of 4.93, 4.21, and 4.84 mg/ℓ and

$$\overline{X} = 4.66\ mg/\ell$$

(1a) Calculate $S^2$

$$S^2 = \frac{\sum_{i=1}^{n} X_i^2 - (\sum_{i=1}^{n} X_i)^2/n}{n-1}$$

$$= \frac{4.93^2+4.21^2+4.84^2-(4.93+4.21+4.84)^2/3}{2}$$

$$= 0.15$$

Calculate S

$$S = \sqrt{S^2} = \sqrt{0.15} = 0.39$$

Calculate $S_{\overline{X}}$

$$S_x = \frac{S}{\sqrt{n}} = \frac{0.39}{\sqrt{3}} = 0.23$$

(1b) Calculate the 95% UCL

$$95\%\ UCL = \overline{X} + [t0.95(n-1)]S_{\overline{X}}$$

$$= 4.66 + (2.920)\ (0.23)$$
$$= 5.33$$

(1c)

$$90\%\ UCL = \overline{X} + [t0.90(n-1)]S_{\overline{X}}$$

$$= 4.66 + (1.886)(0.23)$$
$$= 5.09$$

$$80\%\ UCL = \overline{X} + [t0.80(n-1)]S_{\overline{X}}$$

$$= 4.66 + (1.061)(0.23)$$
$$= 4.90$$

The preceding two calculations indicate that it can be stated with somewhere between 80% and 90% confidence that the chromium concentration does not exceed the RT. This degree of confidence may not be sufficient to meet the needs of the sampling plan. Therefore, more samples may need to be taken.

2a. Calculate the $\lambda$ value

$$\lambda = \frac{RT - \overline{X}}{S} = \frac{5.0 - 4.66}{0.39} = 0.87$$

2b. Calculate the number of additional samples

Using Attachment 2, *Number of Observations for T Test of Mean*, page 34 of this Guidance Document, using a single-sided test with $\alpha$=0.05 and $\beta$=0.05, approximately 15 to 17 total samples need to be collected. Therefore, based on the three preliminary samples that were collected, an additional 13 samples need to be taken.

# Cumulative t Distribution

| | | | | | p | | | | |
|---|---|---|---|---|---|---|---|---|---|
| one-tailed | | 0.550 | 0.750 | 0.080 | 0.900 | 0.950 | 0.975 | 0.990 | 0.995 |
| two-tailed | | 0.100 | 0.500 | 0.600 | 0.800 | 0.900 | 0.950 | 0.980 | 0.990 |
| | 1 | 0.158 | 1.000 | 1.376 | 3.078 | 6.314 | 12.706 | 31.821 | 63.657 |
| | 2 | 0.142 | 0.816 | 1.061 | 1.886 | 2.920 | 4.303 | 6.925 | 9.925 |
| | 3 | 0.137 | 0.765 | 0.978 | 1.638 | 2.353 | 3.182 | 4.541 | 5.841 |
| | 4 | 0.134 | 0.741 | 0.941 | 1.533 | 2.132 | 2.776 | 3.747 | 4.604 |
| | 5 | 0.132 | 0.727 | 0.920 | 1.476 | 2.015 | 2.571 | 3.365 | 4.032 |
| | 6 | 0.131 | 0.718 | 0.906 | 1.440 | 1.943 | 2.447 | 3.143 | 3.707 |
| | 7 | 0.130 | 0.711 | 0.896 | 1.415 | 1.895 | 2.365 | 2.998 | 3.499 |
| | 8 | 0.130 | 0.706 | 0.889 | 1.397 | 1.860 | 2.306 | 2.896 | 3.355 |
| | 9 | 0.129 | 0.703 | 0.883 | 1.383 | 1.833 | 2.262 | 2.821 | 3.250 |
| | 10 | 0.129 | 0.700 | 0.879 | 1.372 | 1.812 | 2.228 | 2.764 | 3.169 |
| | 11 | 0.129 | 0.697 | 0.876 | 1.363 | 1.796 | 2.201 | 2.718 | 3.106 |
| | 12 | 0.128 | 0.695 | 0.873 | 1.356 | 1.782 | 2.179 | 2.681 | 3.055 |
| | 13 | 0.128 | 0.694 | 0.870 | 1.350 | 1.771 | 2.160 | 2.650 | 3.012 |
| | 14 | 0.128 | 0.692 | 0.868 | 1.345 | 1.761 | 2.145 | 2.624 | 2.977 |
| | 15 | 0.128 | 0.691 | 0.866 | 1.341 | 1.753 | 2.131 | 2.602 | 2.947 |
| | 16 | 0.128 | 0.690 | 0.865 | 1.337 | 1.746 | 2.120 | 2.583 | 2.921 |
| | 17 | 0.128 | 0.689 | 0.863 | 1.333 | 1.740 | 2.110 | 2.567 | 2.898 |
| | 18 | 0.127 | 0.688 | 0.862 | 1.330 | 1.734 | 2.101 | 2.552 | 2.878 |
| df | 19 | 0.127 | 0.688 | 0.861 | 1.328 | 1.729 | 2.093 | 2.539 | 2.861 |
| (n-1) | 20 | 0.127 | 0.687 | 0.860 | 1.325 | 1.725 | 2.086 | 2.528 | 2.845 |
| | 21 | 0.127 | 0.686 | 0.859 | 1.323 | 1.721 | 2.080 | 2.518 | 2.831 |
| | 22 | 0.127 | 0.686 | 0.858 | 1.321 | 1.717 | 2.074 | 2.508 | 2.819 |
| | 23 | 0.127 | 0.685 | 0.858 | 1.319 | 1.714 | 2.069 | 2.500 | 2.807 |
| | 24 | 0.127 | 0.685 | 0.857 | 1.318 | 1.711 | 2.064 | 2.492 | 2.797 |
| | 25 | 0.127 | 0.684 | 0.856 | 1.316 | 1.708 | 2.060 | 2.485 | 2.787 |
| | 26 | 0.127 | 0.684 | 0.856 | 1.315 | 1.706 | 2.056 | 2.479 | 2.779 |
| | 27 | 0.127 | 0.684 | 0.855 | 1.314 | 1.703 | 2.052 | 2.473 | 2.771 |
| | 28 | 0.127 | 0.683 | 0.855 | 1.313 | 1.701 | 2.048 | 2.467 | 2.763 |
| | 29 | 0.127 | 0.683 | 0.854 | 1.311 | 1.699 | 2.045 | 2.462 | 2.756 |
| | 30 | 0.127 | 0.683 | 0.854 | 1.310 | 1.697 | 2.042 | 2.457 | 2.750 |
| | 40 | 0.126 | 0.681 | 0.851 | 1.303 | 1.684 | 2.021 | 2.423 | 2.704 |
| | 60 | 0.126 | 0.679 | 0.848 | 1.296 | 1.671 | 2.000 | 2.390 | 2.660 |
| | 120 | 0.126 | 0.677 | 0.845 | 1.289 | 1.658 | 1.980 | 2.358 | 2.617 |
| | | 0.126 | 0.674 | 0.842 | 1.282 | 1.645 | 1.960 | 2.326 | 2.576 |

NOTE: For one-tailed distributions $\alpha/2 = 1-p$
For two-tailed distributions $\alpha = 1-p$

## NUMBER OF OBSERVATIONS FOR T TEST OF MEAN

### Level for t Test

| Single-sided<br>Double-sided | $\alpha$ = 0.005<br>= 0.01 | | | | | $\alpha$ = 0.01<br>= 0.02 | | | | | $\alpha$ = 0.025<br>= 0.05 | | | | | $\alpha$ = 0.05<br>= 0.1 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $\lambda$ | $\beta$= 0.01 | 0.05 | 0.1 | 0.2 | 0.5 | 0.01 | 0.05 | 0.1 | 0.2 | 0.5 | 0.01 | 0.05 | 0.1 | 0.2 | 0.5 | 0.01 | 0.05 | 0.1 | 0.2 | 0.5 |
| 0.05 | | | | | | | | | | | | | | | | | | | | |
| 0.10 | | | | | | | | | | | | | | | | | | | | |
| 0.15 | | | | | | | | | | | | | | | | | | | | 122 |
| 0.20 | | | | | | | | | | 139 | | | | | 99 | | | | | 70 |
| 0.25 | | | | | 110 | | | | | 90 | | | | 128 | 64 | | | 139 | 101 | 45 |
| 0.30 | | | | 134 | 78 | | | | 115 | 63 | | | 119 | 90 | 45 | | 122 | 97 | 71 | 32 |
| 0.35 | | | 125 | 99 | 58 | | | 109 | 85 | 47 | | 109 | 88 | 67 | 34 | | 90 | 72 | 52 | 24 |
| 0.40 | | 115 | 97 | 77 | 45 | | 101 | 85 | 66 | 37 | 117 | 84 | 68 | 51 | 26 | 101 | 70 | 55 | 40 | 19 |
| 0.45 | | 92 | 77 | 62 | 37 | 110 | 81 | 68 | 53 | 30 | 93 | 67 | 54 | 41 | 21 | 80 | 55 | 44 | 33 | 15 |
| 0.50 | 100 | 75 | 63 | 51 | 30 | 90 | 66 | 55 | 43 | 25 | 76 | 54 | 44 | 34 | 18 | 65 | 45 | 36 | 27 | 13 |
| 0.55 | 83 | 63 | 53 | 42 | 26 | 75 | 55 | 46 | 36 | 21 | 63 | 45 | 37 | 28 | 15 | 54 | 38 | 30 | 22 | 11 |
| 0.60 | 71 | 53 | 45 | 36 | 22 | 63 | 47 | 39 | 31 | 18 | 53 | 38 | 32 | 24 | 13 | 46 | 32 | 26 | 19 | 9 |
| 0.65 | 61 | 46 | 39 | 31 | 20 | 55 | 41 | 34 | 27 | 16 | 46 | 33 | 27 | 21 | 12 | 39 | 28 | 22 | 17 | 8 |
| 0.70 | 53 | 40 | 34 | 28 | 17 | 47 | 35 | 30 | 24 | 14 | 40 | 29 | 24 | 19 | 10 | 34 | 24 | 19 | 15 | 8 |
| 0.75 | 47 | 36 | 30 | 25 | 16 | 42 | 31 | 27 | 21 | 13 | 35 | 26 | 21 | 16 | 9 | 30 | 21 | 17 | 13 | 7 |
| 0.80 | 41 | 32 | 27 | 22 | 14 | 37 | 28 | 24 | 19 | 12 | 31 | 22 | 19 | 15 | 9 | 27 | 19 | 15 | 12 | 6 |
| 0.85 | 37 | 29 | 24 | 20 | 13 | 33 | 25 | 21 | 17 | 11 | 28 | 21 | 17 | 13 | 8 | 24 | 17 | 14 | 11 | 6 |
| 0.90 | 34 | 26 | 22 | 18 | 12 | 29 | 23 | 19 | 16 | 10 | 25 | 19 | 16 | 12 | 7 | 21 | 15 | 13 | 10 | 5 |
| 0.95 | 31 | 24 | 20 | 17 | 11 | 27 | 21 | 18 | 14 | 9 | 23 | 17 | 14 | 11 | 7 | 19 | 14 | 11 | 9 | 5 |
| 1.00 | 28 | 22 | 19 | 16 | 10 | 25 | 19 | 16 | 13 | 9 | 21 | 16 | 13 | 10 | 6 | 18 | 13 | 11 | 8 | 5 |
| 1.1 | 24 | 19 | 16 | 14 | 9 | 21 | 16 | 14 | 12 | 8 | 18 | 13 | 11 | 9 | 6 | 15 | 11 | 9 | 7 | |
| 1.2 | 21 | 16 | 14 | 12 | 8 | 18 | 14 | 12 | 10 | 7 | 15 | 12 | 10 | 8 | 5 | 13 | 10 | 8 | 6 | |
| 1.3 | 18 | 15 | 13 | 11 | 8 | 16 | 13 | 11 | 9 | 6 | 14 | 10 | 9 | 7 | | 11 | 8 | 7 | 6 | |
| 1.4 | 16 | 13 | 12 | 10 | 8 | 14 | 11 | 10 | 9 | 6 | 12 | 9 | 8 | 7 | | 10 | 8 | 7 | 5 | |
| 1.5 | 15 | 12 | 11 | 9 | 7 | 13 | 10 | 9 | 8 | 6 | 11 | 8 | 7 | 6 | | 9 | 7 | 6 | | |
| 1.6 | 13 | 11 | 10 | 8 | 6 | 12 | 10 | 9 | 7 | 5 | 10 | 8 | 7 | 6 | | 8 | 6 | 6 | | |
| 1.7 | 12 | 10 | 9 | 8 | 6 | 11 | 9 | 8 | 7 | | 9 | 7 | 6 | 5 | | 8 | 6 | 5 | | |
| 1.8 | 12 | 10 | 9 | 8 | 6 | 10 | 8 | 7 | 7 | | 8 | 7 | 6 | | | 7 | 6 | | | |
| 1.9 | 11 | 9 | 8 | 7 | 6 | 10 | 8 | 7 | 6 | | 8 | 6 | 6 | | | 7 | 5 | | | |
| 2.0 | 10 | 8 | 8 | 7 | 5 | 9 | 7 | 7 | 6 | | 7 | 6 | 5 | | | 6 | | | | |
| 2.1 | 10 | 8 | 7 | 7 | | 8 | 7 | 6 | 6 | | 7 | 6 | | | | 6 | | | | |
| 2.2 | 9 | 8 | 7 | 6 | | 8 | 7 | 6 | 5 | | 7 | 6 | | | | 6 | | | | |
| 2.3 | 9 | 7 | 7 | 6 | | 8 | 6 | 6 | | | 6 | 5 | | | | 5 | | | | |
| 2.4 | 8 | 7 | 7 | 6 | | 7 | 6 | 6 | | | 6 | | | | | | | | | |
| 2.5 | 8 | 7 | 6 | 6 | | 7 | 6 | 6 | | | 6 | | | | | | | | | |
| 3.0 | 7 | 6 | 6 | 5 | | 6 | 5 | 5 | | | 5 | | | | | | | | | |
| 3.5 | 6 | 5 | 5 | | | 5 | | | | | | | | | | | | | | |
| 4.0 | 6 | | | | | | | | | | | | | | | | | | | |

99% confidence

95% confidence

# SAMPLING PROCESS STREAMS

Although sampling is generally thought to occur on a pile of material or over an area of treated soil, other schemes are possible. The most common instance is when the material is to be sampled at the point of generation. This is the preferred method, since it is most representative of the material under study. The lack of exposure to elements that might cause chemical degradation and/or leaching will result in material most indicative of actual conditions.

A sampling point along the material conveyor that can be fairly easily and safely reached should be chosen. It should be in an area where the entire belt can be accessed for sampling. Under this scenario, a temporal, rather than a spatial, approach needs to be used.

Time stratum should be established over the course of the process day. Ideally, the entire active time of the line should be included in the sampling scheme. Once time strata are chosen, the random numbers table can be used to establish sampling times. For a four hour period, a point somewhere on the table would be chosen and every number greater than 0 but less than 240 would be selected until the number of samples for that strata were obtained. The number would relate to time in minutes. This would be added to the starting time for that strata to determine the time of sampling.

If the time strata chosen are of unequal lengths, the number of samples chosen from any one strata should reflect the percentage contribution that strata makes to the time frame as a whole. For example, if for a 24 hour operating time, strata 1 is 4 hours and strata 2 is 8 hours, strata 2 should have twice as many samples as strata 1.

When the appropriate sampling time arrives, the material from the conveyor belt point that had been identified would be removed. This material should be well mixed and a subsample taken for inclusion in the jar for lab analysis. An example of the use of this protocol is attached.

# RANDOM TIME WASTE SAMPLING EXAMPLE

| | Sampling Point | Random Minute | Time |
|---|---|---|---|
| Stratum #1 | | | |
| 6:00 to 8:00 hours | 1 | 28 | 6:28 |
| | 2 | 62 | 7:02 |
| | 3 | 99 | 7:39 |
| | 4 | 112 | 7:52 |
| Stratum #2 | | | |
| 8:00 to 20:00 hours | 1 | 11 | 8:11 |
| | 2 | 107 | 9:47 |
| | 3 | 156 | 10:36 |
| | 4 | 173 | 10:53 |
| | 5 | 296 | 12:56 |
| | 6 | 313 | 13:13 |
| | 7 | 398 | 14:38 |
| | 8 | 497 | 16:17 |
| | 9 | 555 | 17:15 |
| | 10 | 600 | 18:00 |
| | 11 | 637 | 18:37 |
| | 12 | 706 | 19:46 |
| Stratum #3 | | | |
| 20:00 to 22:00 hours | 1 | 13 | 20:13 |
| | 2 | 52 | 20:52 |
| | 3 | 88 | 21:28 |
| | 4 | 108 | 21:48 |
| Stratum #4 | | | |
| 22:00 to 6:00 hours | 1 | 48 | 22:48 |
| | 2 | 113 | 23:53 |
| | 3 | 153 | 24:33 |
| | 4 | 189 | 1:09 |
| | 5 | 227 | 1:47 |
| | 6 | 290 | 2:49 |
| | 7 | 314 | 3:14 |
| | 8 | 474 | 5:44 |

ATTACHMENT 3

# TOLERANCE FACTORS (K)

## TOLERANCE FACTORS (K) FOR ONE-SIDED NORMAL TOLERANCE INTERVALS WITH PROBABILITY LEVEL (CONFIDENCE FACTOR) Y = 0.95 AND COVERAGE P = 95%

| *n* | *K* | *n* | *K* |
|---|---|---|---|
| 3 | 7.655 | 75 | 1.972 |
| 4 | 5.145 | 100 | 1.924 |
| 5 | 4.202 | 125 | 1.891 |
| 6 | 3.707 | 150 | 1.868 |
| 7 | 3.399 | 175 | 1.850 |
| 8 | 3.188 | 200 | 1.836 |
| 9 | 3.031 | 225 | 1.824 |
| 10 | 2.911 | 250 | 1.814 |
| 11 | 2.815 | 275 | 1.806 |
| 12 | 2.736 | 300 | 1.799 |
| 13 | 2.670 | 325 | 1.792 |
| 14 | 2.614 | 350 | 1.787 |
| 15 | 2.566 | 375 | 1.782 |
| 16 | 2.523 | 400 | 1.777 |
| 17 | 2.486 | 425 | 1.773 |
| 18 | 2.453 | 450 | 1.769 |
| 19 | 2.423 | 475 | 1.766 |
| 20 | 2.396 | 500 | 1.763 |
| 21 | 2.371 | 525 | 1.760 |
| 22 | 2.350 | 550 | 1.757 |
| 23 | 2.329 | 575 | 1.754 |
| 24 | 2.309 | 600 | 1.752 |
| 25 | 2.292 | 625 | 1.750 |
| 30 | 2.220 | 650 | 1.748 |
| 35 | 2.166 | 675 | 1.746 |
| 40 | 2.126 | 700 | 1.744 |
| 45 | 2.092 | 725 | 1.742 |
| 50 | 2.065 | 750 | 1.740 |
| 55 | 2.036 | 775 | 1.739 |
| 60 | 2.017 | 800 | 1.737 |
| 65 | 2.000 | 825 | 0.736 |
| 70 | 1.986 | 850 | 1.734 |
|  |  | 875 | 1.733 |
|  |  | 900 | 1.732 |
|  |  | 925 | 1.731 |
|  |  | 950 | 1.729 |
|  |  | 975 | 1.728 |
|  |  | 1,000 | 1.727 |

SOURCE: FOR SAMPLE SIZES ≤ 50: Lieberman, Gerald F. 1958. "Tables for One-sided Statistical Tolerance Limits." *Industrial Quality Control*. Vol. XIV, No. 10.

FOR SAMPLE SIZES ≥ 50: K values were calculated from large sample approximation.

NTIS Document PB-89-151-047

## ATTACHMENT 4

# WASTE MANAGEMENT DIVISION'S
# CLEAN CLOSURE CERTIFICATION CHECKLIST

This checklist was developed to review RCRA clean closures. Due to direct reference to 40 CFR, Part 264, Subpart G, by Act 64, Rule 613; Act 64 closures should also be evaluated by this checklist.

Documentation supporting the owners/operators and the independent registered professional engineer's certification can be requested under 40 CFR, 264.115 and 265.115 (as of October 29, 1986). The owner/operator must submit at least four copies of certification documentation.

The checklist identifies items recommended to properly evaluate a closure certification. These items are not "absolutes." Other information or substitutions may be provided which technically justify and certify a "clean closure."

This checklist can be used for land disposal, storage, and treatment facilities. Several of the items would not be required for storage and/or treatment facilities where testing was minimal. Items 1 through 5 would be required for all closures. Items 6 through 11 would be optional for storage and/or treatment facilities, dependent on extent of testing required. Land disposal facilities would require all items listed.

1. Manifests (or some type of manifest/waste removal summary) of where and how much waste was shipped.

2. Certification statement is needed by the owner/operator AND an independent registered engineer. All independent registered professional engineer certificates must have an original stamp on at least one copy.

3. Summary of decontamination procedures (pressure wash, Steam clean, etc.) and how the resultant waste water was disposed.

4. Summary analysis (include conditions of haul roads, time table, soil and groundwater results, weather conditions, runoff controls, equipment decontamination, etc.).

5. Results of all tests used to determine clean closure (charts, tables, lab sheets).

6. Statistical comparisons on sampling results compared to cleanup criteria (this should include full computations on background and statistical analysis).

7. Sampling and analysis procedures (specify references).

8. Final depth and elevations of excavations of wastes and soils.

9. Properly labelled and easily identified sampling locations and grid stations (map) including background stations.

10. Groundwater data (and statistical evaluation) used to determine if groundwater degradation has occurred (usually four sets of replicate analysis compared to sampling event after closure activities). Monitor well construction details and sampling and analysis procedures may be required if documentation is not in the file.

11. Summary of final restoration of excavated area...
information on fill material used and/or future land use outline. If clean closure cannot be achieved (e.g., contaminated soils to water table and groundwater results show contamination). This summary item should be used to address the need for any post closure program and/or corrective action.

12. A copy of all field notes pertaining to these closure activities.

13. A copy of the approved closure plan and letter of closure plan approval.

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# APPENDIX M

# USACE CONE PENETROMETER STUDY

US Army Corps of Engineers

MISCELLANEOUS PAPER GL-92-38

# USE OF THE SITE CHARACTERIZATION AND ANALYSIS PENETROMETER SYSTEM AT GRANDVILLE, MICHIGAN SUPERFUND SITE

by

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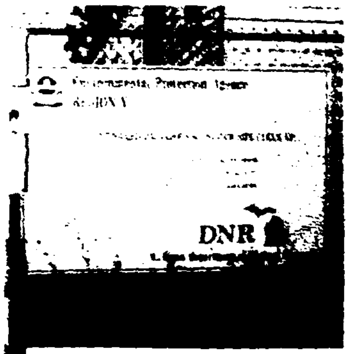

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Final Report

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Prepared for US Environmental Protection Agency, Region V
Chicago, Illinois 60604
and
US Army Toxic and Hazardous Materials Agency
Aberdeen Proving Ground, Maryland 21010-5401

GEOTECHNICAL LABORATORY

# REPORT DOCUMENTATION PAGE

*Form Approved*
*OMB No. 0704-0188*

**1. AGENCY USE ONLY** *(Leave blank)*

**2. REPORT DATE**
December 1992

**3. REPORT TYPE AND DATES COVERED**
Final report

**4. TITLE AND SUBTITLE**
Use of Site Characterization and Analysis Penetrometer System at Grandville, Michigan, Superfund Site

**5. FUNDING NUMBERS**

**6. AUTHOR(S)**
Michael K. Sharp, Raju Kala, Jeff Powell

**7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)**
See reverse.

**8. PERFORMING ORGANIZATION REPORT NUMBER**
Miscellaneous Paper GL-92-38

**9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)**
See reverse.

**10. SPONSORING/MONITORING AGENCY REPORT NUMBER**

**11. SUPPLEMENTARY NOTES**
This report is available from the National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161.

**12a. DISTRIBUTION/AVAILABILITY STATEMENT**
Approved for public release; distribution is unlimited

**12b. DISTRIBUTION CODE**

**13. ABSTRACT** *(Maximum 200 words)*

This report documents the results of an investigation at the Organic Chemical, Inc. site in Grandville, Michigan. This site is on the National Priority List for cleanup, and is being overseen by the Environmental Protection Agency, Chicago, Region V office. The site was investigated utilizing the Site Characterization and Analysis Penetrometer System, with a fiber optic fluorimeter sensor. This sensor allows the detection of hydrocarbon contaminants in the subsurface. A total of fifty pushes were completed at the site to an average depth of approximately 15 ft, covering approximately 80 acres. A hydrocarbon contaminant plume was located at the site extending from the OCI facility in a northerly direction. This matches the flow of the groundwater in the area as it moves toward the Grand River. The plume was successfully bounded on the North, South, and West sides. The plume boundary on the East side could not be established due to property constraints. The concentrations of contaminants in certain areas of the site exceeded 5000 ppm.

**14. SUBJECT TERMS**
Cone penetrometer
Fiber optic fluorescence
Geophysics

**15. NUMBER OF PAGES**
99

**16. PRICE CODE**

**17. SECURITY CLASSIFICATION OF REPORT**
UNCLASSIFIED

**18. SECURITY CLASSIFICATION OF THIS PAGE**
UNCLASSIFIED

**19. SECURITY CLASSIFICATION OF ABSTRACT**

**20. LIMITATION OF ABSTRACT**

NSN 7540-01-280-5500

Standard Form 298 (Rev 2-89)
Prescribed by ANSI Std Z39-18
298-102

7. Continued.

USAE Waterways Experiment Station
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9. Continued.

US Environmental Protection Agency, Region V
Chicago, Illinois 60604

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Aberdeen Proving Ground, Maryland 21010-5401

# Preface

The Earthquake Engineering and Geosciences Division (EEGD), Geotechnical Laboratory (GL), Waterways Experiment Station (WES), was tasked by the Environmental Protection Agency (EPA) and the United States Army Toxic and Hazardous Materials Agency (USATHAMA) to perform an investigation at an EPA superfund site in Grandville, Michigan. The immediate site is owned by Organic Chemicals, Inc., and encompasses approximately 5 acres, with the total anticipated area of contamination encompassing approximately 80 acres. The EPA wished to evaluate and demonstrate the ability of the Site Characterization and Analysis Penetrometer System (SCAPS) to detect and delineate hydrocarbon contaminants at the site. Coordination with the EPA was provided by Mr. Tom Williams, and with USATHAMA by Mr. Wayne Sisk. The investigation was conducted from 8 July to 24 July 1992.

The field work was conducted by Messrs. Michael K. Sharp, Raju Kala, Karl F. Konecny, and Don Harris of the GL, and Messr. Jeff Powell of the Instrumentation Services Division (ISD), WES.

Report preparation was done by Messrs. Michael K. Sharp and Raju Kala, GL, and Jeff Powell, ISD.

The project was under the direct supervision of Mr. Joseph R. Curro, Jr., Chief, Engineering Geophysics Branch, Mr. Mark Vispi, Chief, In Site Evaluation Branch, Dr. A. G. Franklin, Chief, EEGD, and Dr. W. F. Marcuson III, Director, GL.

At the time of publication of this report, Director of WES was Dr. Robert W. Whalin. Commander was COL Leonard G. Hassell, EN.

## CONTENTS

# CONVERSION FACTOR, NON-SI TO SI (METRIC)
# UNITS OF MEASUREMENT

Non-SI units of measurement used in this report can be converted to SI (metric) units as follows:

| Multiply | By | To Obtain |
|---|---|---|
| acres | 4,046.873 | square metres |
| Fahrenheit degrees | 5/9 | Celsius degrees or Kelvins |
| feet | 0.3048 | metres |
| gallons | 3.785412 | cubic decimetres |
| gamma | 1.0 | nanotesla |
| inches | 2.54 | centimetres |
| miles (US statute) | 1.609347 | kilometres |
| pounds (mass) | 4.448222 | newtons |
| tons (short ton) | 907.2 | kilograms |

* To obtain Celcius (C) temperature readings from Fahrenheit (F) readings, use the following formula: C=(5/9)(F-32). To obtain Kelvin (K) readings, use: K=(5/9)(F-32)+273.15.

# USE OF THE SITE CHARACTERIZATION AND ANALYSIS PENETROMETER SYSTEM AT GRANDVILLE, MICHIGAN, SUPERFUND SITE

## PART I: INTRODUCTION

### Background

1. The Earthquake Engineering and Geosciences Division was tasked by the U. S. Environmental Protection Agency (EPA) and the U. S. Army Toxic and Hazardous Materials Agency (USATHAMA) to perform an investigation at a site in Grandville, MI (Figure 1). The site is owned by Organic Chemicals Inc. (OCI) and is on the National Priority List as a Superfund Site. The facility, through the years, has served many roles, first being an oil refinery and later being converted to an industrial chemical recovery/disposal operation. The plant is now closed pending cleanup activity. The EPA was interested in the ability of the Site Characterization and Analysis Penetrometer System (SCAPS) to detect and delineate hydrocarbon contaminants in the subsurface.

2. Previous work performed at the site includes three investigations done using soil borings and monitoring wells by three different contractors (Black and Veatch Engineers-Architects, Prein and Newhof Engineers-Planners, and Materials Testing Consultants). Both soil and liquid samples were taken and analyzed in the laboratory. In addition, a limited amount of trenching and soil gas surveying was performed at the site. A geophysical electromagnetic survey was also performed. The laboratory results obtained from the samples taken indicate several compounds in the subsurface including benzene, toluene, xylene, styrene, methylene chloride, chlorobenzene, chloroform, acetone, benzoic acid and many others. A complete listing of chemical compounds discovered is contained in a report at the EPA Region V office.

### Purpose

3. In addition to the many types of industrial chemicals discovered through laboratory analysis, the EPA wanted to determine whether or not hydrocarbons typical of fuels were also present in the subsurface and if so to what extent. The boring program had indicated that hydrocarbons might be present as evidenced by the color and odor of many samples collected. Due to the complex nature of the conditions at the site, the EPA was having difficulty assimilating the data into a clear representation of site conditions. The objective of the SCAPS work at the site was to develop a data set that could be directly compared to results

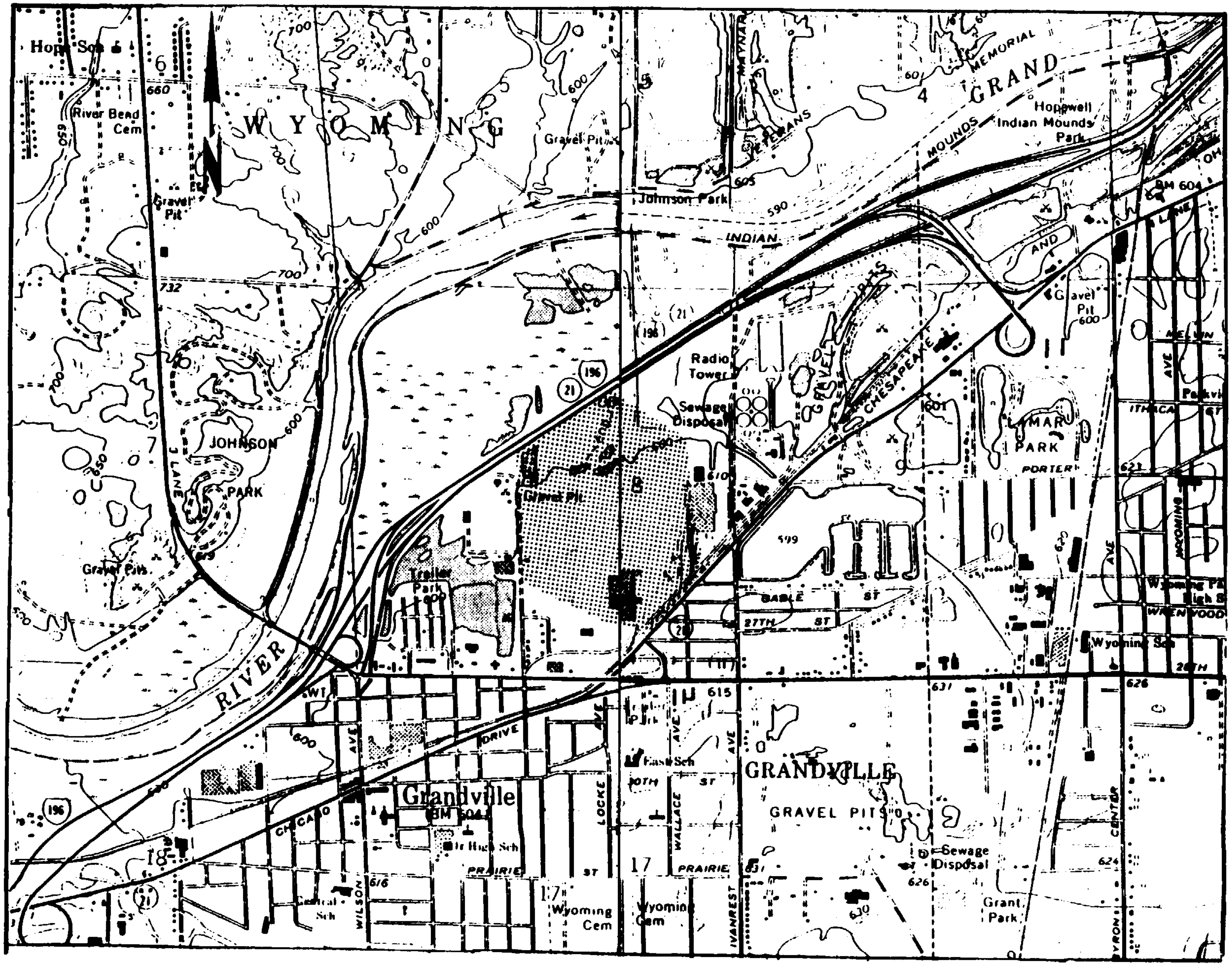


Figure 1. Site map showing the area investigated at Grandville, Michigan.

from wells and soils borings and to develop data on the areal and vertical extent of hydrocarbon contamination in the soil above and below the water table. The work of locating the hydrocarbon contamination was done using a cone penetrometer equipped with a fiber optic fluorometer.

# PART II: SITE DESCRIPTION

## Geology

4. The site investigated lies in Kent county in the west central part of the Lower Peninsula of Michigan. The bedrock in Kent county consists of the edges of bowlike formations that fill the Michigan Basin. The oldest rock is Marshall Sandstone, which underlies all of the county and is the uppermost bedrock in the southwestern part. Overlapping the Marshall Sandstone in the central and southeastern parts of the county is the Michigan Formation, which is primarily limestone, gypsum, and dolomite interbedded with shale and sandstone. To the northeast, these rocks are progressively overlapped by Bayport Limestone, Parma Sandstone, and finally by the coal-bearing Saginaw Formation in the furthest northeast part of the county. Overlying these rock formations is a mass of glacial drift that was deposited during the Wisconsin glacial period. The county is situated in an area where the Michigan and Saginaw lobes of the Wisconsin ice sheet met. Consequently, a very complex and strongly developed interlobate morainic system developed. The deposits of glacial drift range from less than 10 feet to several hundred feet in thickness within the county. The drift ranges from coarse gravel to fine lacustrine clay. It is the parent material in which many of the soils in the county formed. The present surface features are, for the most part, the results of glacial action. The landscape is an undulating plain in which valleys have been cut. Outwash material was deposited in the valleys by glacial meltwater streams. Three major physiographic regions are recognized in the county. The one that affects the area of investigation consists of a number of outwash plains and lake plains in nearly level valleys having rather definite boundaries. The glacial drift is typically thinnest in these areas, and the bedrock is within a few feet of the surface along the lower reaches of Buck and Plaster Creeks, near Wyoming and Grandville. The elevation in most of Kent county is 750 to 850 feet above sea level. The major outwash channels and plains, however, range from 600 to 750 feet in elevation. The Grand River has an elevation of about 617 feet where it enters the county and of 592 feet where it leaves the county. The water table slopes from 600 ft to 587 ft MSL between the site and the nearby Grand River.

5. The parent material of the soils of Kent county were deposited by glaciers or by glacial meltwater. Some of these materials have been reworked and redeposited by the subsequent action of water and wind. Although the parent materials are of common glacial origin, their properties vary greatly, sometimes within small areas, depending on how the materials were deposited. The dominant parent materials in Kent county were deposited as glacial till, outwash deposits, lacustrine deposits, alluvium, and organic material. The glacial till in Kent

county is calcareous loam, clay loam, or fine sandy loam. From this information and the information obtained from boring logs, it can be determined that there is a substantial clay layer underlying the site. This clay layer occurs at various elevations throughout the site, but tends to occur at lower elevations towards the Grand River. To maintain the integrity of this clay layer, no pushes were made to elevations that would puncture or damage the layer.

## General

6. The site once served as an old gravel pit and can be divided in general into two sections. The southern half of the site, where the OCI facility is located, does not appear to have had as much gravel removed as the northern half. The northern half does have a lower surface elevation than the southern half which is in areas as much as 10 ft higher. The northern half of the site has also undergone extensive filling operations in an attempt to raise the surface elevation. The current landowner described the fill material as various types of construction debris. This includes large pieces of concrete, metal pipes, culverts, bricks, blocks, etc. This debris filling operation was not known to WES before the SCAPS work began, and presented quite a problem to the cone penetrometer trying to push through such material. This resulted in many broken probes and rods, greatly hampering progress.

7. The site in general presented a challenge to the cone penetrometer trying to force the push rod through rather large gravels. Four out of six probes on hand were damaged trying to push through the gravel layers. This necessitated the use of a dummy probe in many of the probe locations. The dummy probe is a non-instrumented mechanical device slightly smaller than the instrumented probe used to make a pilot hole. Once the pilot hole was made to the depth required, the instrumented probe was used to collect fluorescence data. This technique does not allow the collection of soils data (cone tip resistance and sleeve friction) for soil classification purposes, but does permit the collection of fluorescence data. Since the main objective of the project was to collect fluorescence data, this technique did not hamper the project.

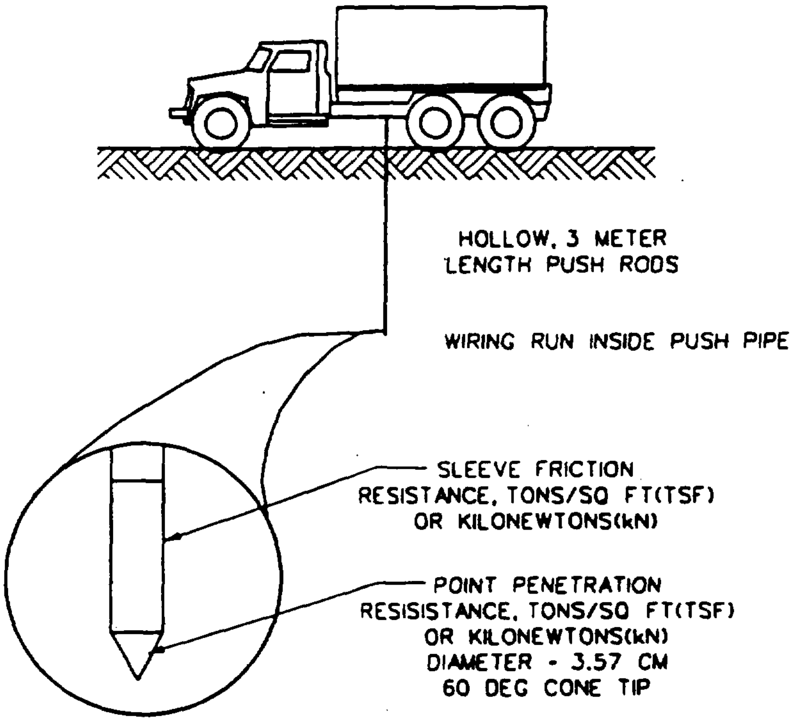
## PART III: EQUIPMENT AND METHODS

### General

8. The Site Characterization and Analysis Penetrometer System (SCAPS), includes a suite of surface geophysical equipment, survey and mapping equipment, special penetrometers with sensors for contaminant detection, and soil and pore fluid penetrometer samplers. The experimental penetrometer system is mounted in a specially-engineered truck (Figure 2) designed with protected work spaces to allow access to toxic and hazardous sites while minimizing exposure of the work crew. The SCAPS "screening" penetrometers are equipped with sensors that can determine certain physical and chemical characteristics of the soil as the penetrometer tip is forced through the soil. SCAPS includes sensors that can determine the strength, electrical resistivity, and spectral properties, in this case the fluorescence, of soils. All sensors read out in real time, and a computer-based data collection and analysis system permits a display and partial interpretation of data in the instrument compartment on the penetrometer truck. The data analysis system also allows processing of various types of surface geophysical and mapping data collected on site, and integration of data into a unified data base. Fluid and soil samples can be collected using devices such as the commercial "stab type" groundwater and soil samplers that are designed for use with penetrometers. The SCAPS system is also equipped to seal each penetrometer hole with grout as the probe is withdrawn from the hole and the geotechnical investigation proceeds across a site. The SCAPS unit is built so that surfaces and compartments exposed to waste can be thoroughly and completely decontaminated. Post processing of the data to provide a 3-D visualization of site conditions is presently done with a computer work station that can be used at WES or brought to the installation. SCAPS is designed to save time and costs and to minimize exposure of the crew while sensor data or samples are collected. Penetrometer units available commercially do not have this combination of capabilities.

### Site Mapping

9. The locations of penetrometer push points were determined by establishing a grid over the site. The OCI site covers approximately five acres while the total area of investigation covers approximately eighty acres. A grid was established on 300 ft centers (Figure 3) with each location to be surveyed for northing, easting, and elevation. The survey points are based on a local coordinate system provided by EPA, that tied into work performed during the drilling operations. A local Corps District was used for surveying the grid. Additional surveying was performed by the WES crew utilizing a total station



<u>BASIC CONFIGURATION OF SCAPS TRUCK</u>

MOUNTED ON ALL WHEEL DRIVE TRUCK (MODIFIED M814 MILITARY CHASSIS)
HYDRAULICALLY POWERED PUSH APPARATUS 178-kN PUSH
WEIGHT APPROXIMATELY 21,000 KG
COMPUTER AIDED DATA ACQUISITION
MEASUREMENTS OF PENETRATION RESISTANCE
AT 1-INCH (2.5 CM) INTERVALS
ENCLOSED AIR-CONDITIONED WORKSPACE

Figure 2. Experimental penetrometer system and configuration.

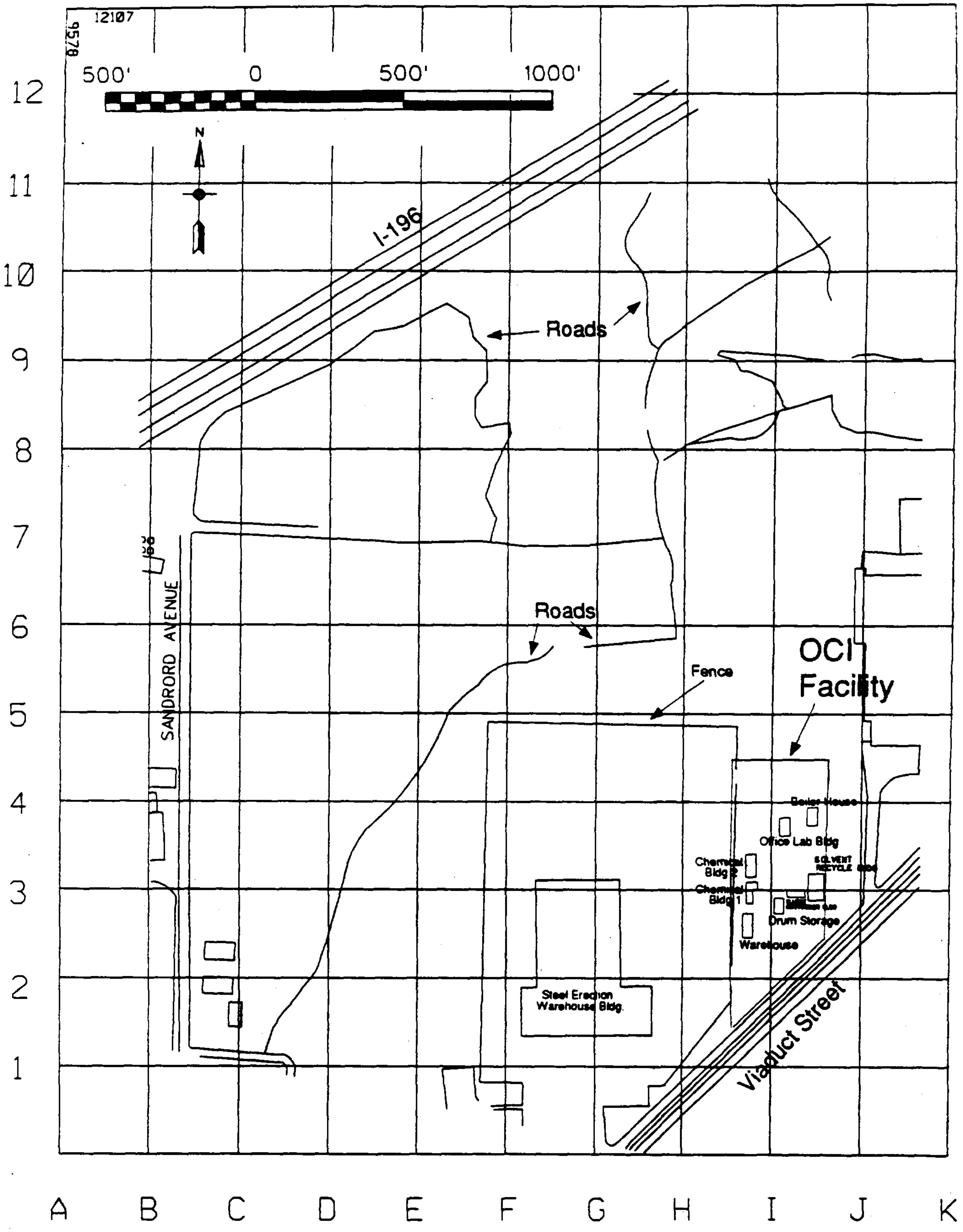


**Figure 3.** Detail of OCI site and surrounding area showing survey grid established to guide push locations.

electronic distance measuring system (EDM). This additional surveying included points that could not be reached with the push truck due to physical constraints, points investigated between the original 300 ft grid, and points located outside the grid.

## Geophysical Investigations

10. Geophysical site surveys were undertaken primarily to determine if there was metallic debris in the area where the penetrometer unit would be operating. The geophysical investigations were simply scans of the area before pushing began to insure that no damage would occur to the probe and that no pipes, barrels, or other such objects would be punctured. The geophysical technique used at the OCI site in conjunction with the SCAPS truck consisted of electromagnetic induction. This technique was selected because of its ease of use, real-time data analysis, and reliability of metal detection to a maximum depth of twenty feet.

11. The electromagnetic induction devices are used to measure the earth's apparent ground conductivity. The responses from the equipment are directly proportional to conductivity and inversely proportional to resistivity. The basic operation utilizes a transmitter coil (Tx) energized with an alternating current at an audio frequency and a receiver coil (Rx) located a short distance away. The time varying magnetic field arises from the alternating current in the transmitter coil inducing currents in the earth. These currents generate a secondary magnetic field which is sensed, together with the primary field, by the receiver coil. In general, this secondary magnetic field is a complicated function of the intercoil spacing, the operating frequency, and the ground conductivity. Under certain constraints, called the low induction condition, the secondary magnetic field is a very simple function of these variables. Under these constraints, the ratio of the secondary to the primary field is linearly proportional to the terrain conductivity. The apparent conductivity indicated by the instruments depends on measurement of the secondary to primary field ratio and assumes low induction conditions. The units of conductivity are the mho (Siemen) per meter or, more conveniently, the millimho per meter.

12. There are two components of the induced magnetic field measured by the instrument. The first is the quadrature-phase component which gives the ground conductivity measurement. The second is the inphase component, which is used primarily for calibration purposes; however, the inphase component is significantly more sensitive to large metallic objects and hence very useful when looking for buried metal containers. Experiments have indicated that the Geonics EM-31 can detect a single 45 gal oil drum at a depth of about 12 ft (3.7m) using

the inphase component of the meter.

13. The instrument has an intercoil spacing of 12 ft (3.7m) and has an effective depth of exploration of approximately 20 ft (6 m). The EM-31 meter reading is a weighted average of the earth's conductivity as a function of depth. A thorough investigation to a depth of 13 ft (4 m) is possible, but below that depth the effect of conductive anomalies becomes more difficult to distinguish as their depth increases. The instrument can be operated in both a horizontal and vertical orientation which changes the effective depth of exploration. The instrument is normally carried such that the transmitter and receiver coils are oriented vertically, which gives the maximum penetration depth. It can be used in either a discrete or continuous-read mode.

## Grouting Methods

14. The SCAPS unit is equipped to seal the penetrometer holes using either a liquid (chemical) grout or conventional Portland cement-based grout. The chemical grout system is designed to inject a two-component grout through tubes running down the center of the penetrometer rod and seal the penetrometer hole as the rod is withdrawn. The system uses two high-pressure, positive-displacement pumps feeding into a pressure/volume regulating system that can control the amount of each component dispensed. The chemical grout injection system can handle acrylate, urethane or silicate grouts. The SCAPS equipment also includes a conventional cement/bentonite grout mixer and a low-pressure progressive cavity pump for tremie grouting of penetrometer holes. All holes at the OCI site were grouted utilizing the conventional cement/bentonite grout either poured or tremied into the hole.

## Site Characterization Methods

15. The major component of the SCAPS system is a 20-ton, all-wheel-drive penetrometer truck that was designed specifically for operations at hazardous waste sites, an overall view of the system is shown in Figure 4. The truck carries a hydraulic power unit and controls to operate the push apparatus, separated push and data acquisition work spaces, a shock-isolated floor for the penetrometer instrumentation, easily decontaminated stainless steel van body, and other personnel protection features. A specially designed trailer is used to carry the grouting pumps, water tank, and a closed-loop steam cleaner to clean the penetrometer rods and tools as they are withdrawn from the soil.

16. The electronics package includes WES-designed and built signal-conditioning hardware and test equipment capable of providing on-site calibrations of

Figure 4. Photograph of penetrometer truck and grouting trailer.

contaminant detectors and load cells used to make penetration resistance measurements. Data acquisition and initial data processing are carried out with an on-board computer with a matching computer used for data management and file integration. The second computer affords redundancy in the event of a computer failure. A view of the data collection compartment of the truck is shown in Figure 5.

## Soil Strength and Type Determination

17. A sectional view of a penetrometer equipped to measure soil strength is shown in Figure 6. The point load cell is loaded in compression as the cone tip is advanced. The friction sleeve load cell is in the form of a hollow cylinder and strain gauged on the inside surface of the cylinder. The cell surrounds the tip load cell and is also loaded in compression when soil friction acts on the friction sleeve which jackets the front of the probe. The design employed in this soil strength unit allows the tip penetration resistance and sleeve friction measurement to be made independently and continuously.

18. Two calibration procedures are used with the cone employed in this investigation so that separate calibration curves can be developed for the two load cells. The point resistance load cell is calibrated by cycling the load from zero load to approximately 7272 Kgf (equivalent to 16,000 psi) and back to zero load several times. The cell is then loaded to selected load increments and back to zero. The load cell output is read for each load increment applied and the zero load condition at the beginning and end of each loading increment. The load increments are increased until the compressive force reaches the maximum capacity of the cell. The friction sleeve load cell is calibrated in a similar way. Figures 7 and 8 show typical calibration curves obtained for a strain-gaged penetrometer instrument. Each load cell is calibrated independently but the output of each cell is measured as the calibration proceeds so that any influence of one cell on the output of the other can be determined. Typically neither cell shows any influence on the other. Calibration test responses are generally within 0.5% of the applied load. Load cell calibrations can be done in the field, but are generally completed prior to field deployment.

19. Due to the nature of the site (gravels and construction debris) and the many broken probes, no soils data was collected at the site for any of the probes. Therefore no soils classification information is presented in this report. The depth of penetrometer pushes, selected to extend to the clay layer, was determined from the boring logs in the area rather than from the penetrometer soils information.

Figure 5. View of data collection and processing section of penetrometer truck.

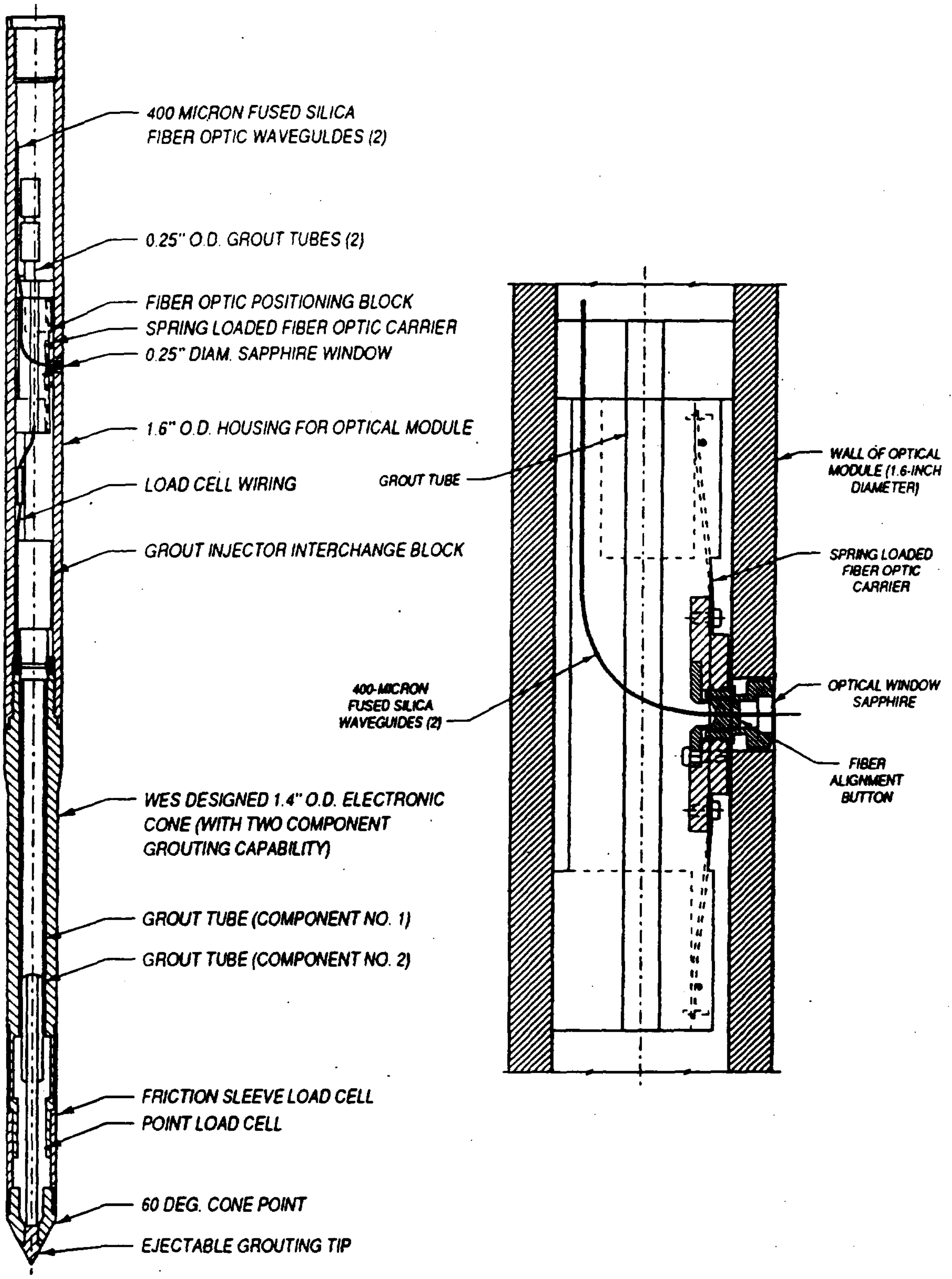


Figure 6. Cross sectional view of penetrometer showing cone, sleeve, and fiber optic components, with close-up of fiber optic window.

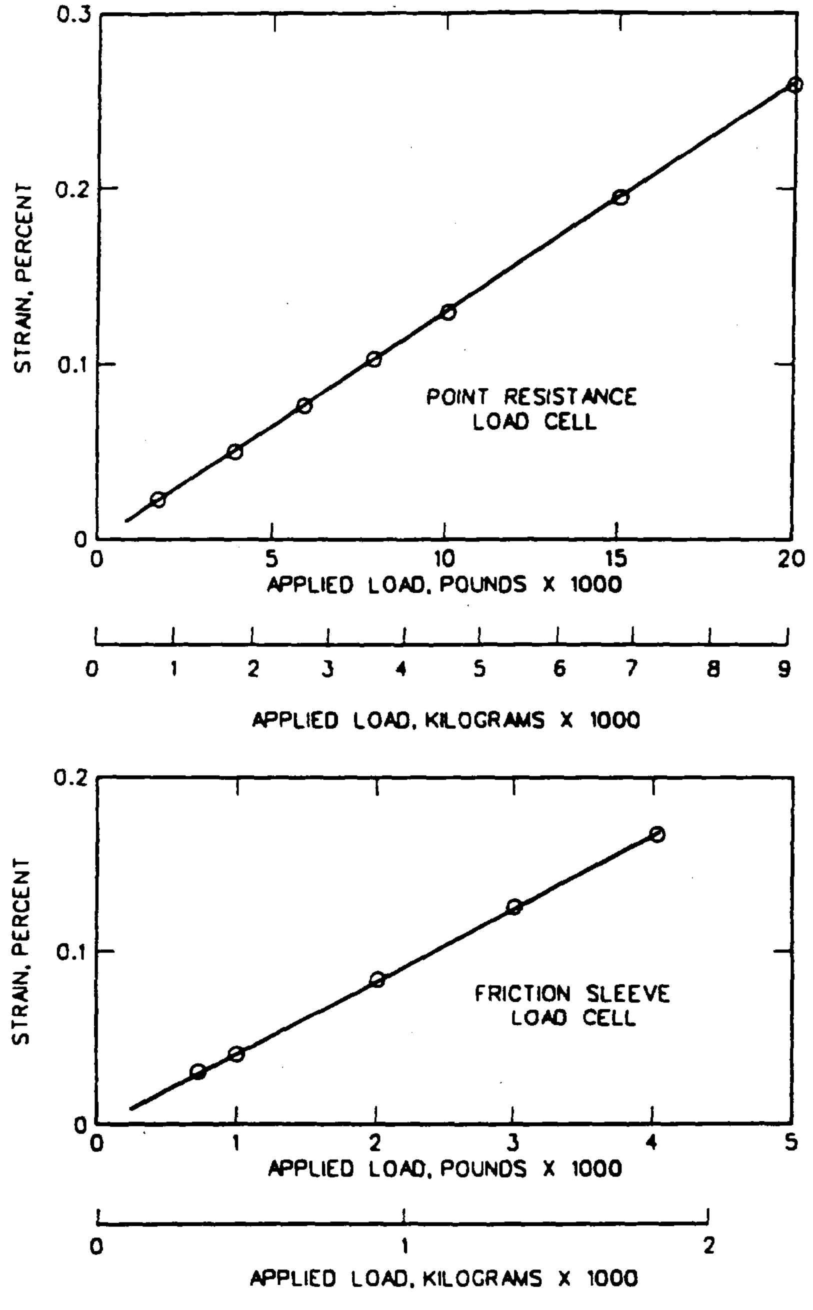


Figure 7 and 8. Calibration curves for point resistance and sleeve friction.

## Soil Fluorescence Measurement Methods

20. The in situ fluorometer is described in detail in the U. S. Patent Office (1992). Lieberman, Inman and Theriault (1989) had used a fluorometer for measuring POL fluorescence in seawater, and the fluorescence has been documented as a useful approach in tracking hydrocarbon pollutants. A schematic of the system is presented in Figure 9. In making a measurement, the exciting radiation is produced by firing a pulsed nitrogen laser (emitting wavelengths at 337 nm). The laser light is coupled into two fibers, a timing circuit fiber and the downhole sample irradiation fiber. The light in the timing circuit fiber is used to set the timing window on the detector. The major part of the laser pulse is coupled into a 400-micron optical fiber that passes down the center of the penetrometer rod. The fiber ends at a 6.35-mm sapphire window that passes the light onto the soil surface adjacent to the window. The fluorescence signal that is a response to the ultra-violet excitation is collected by a second 400-micron fiber and is carried back up through the penetrometer rod to a polychromator. In the polychromator the fluorescent signal is dispersed and the energy distribution at the wavelengths of interest is measured using a linear photodiode array. This system is much faster than a scanning spectrofluorometer. Readout of an entire emission spectrum requires only 15 msec. The rapidity of the readout makes it practical to "stack" or add successive pulses and increase the sensitivity of the unit. Time resolve fluorometry is also possible although this may require holding the window in one position for several minutes.

21. The response of the fluorometer is directly related to the concentration of aromatic compounds in the soil. Fluorescence of any aromatic compounds with basic or acid functional groups is usually pH dependent. Ionized aromatic compounds will fluoresce at different wavelengths and at different intensities from the same compounds in a nonionized state. Fluorescing compounds adsorbed on solid surfaces will typically fluoresce with greater intensity than the same compounds in solution. Decomposition or weathering phenomena also change the fluorescence of fuels. Generally the aromatic (ring) compounds that fluoresce are concentrated in the weathering process because the lighter hydrocarbons volatilize and the longer straight-chain hydrocarbons are more easily decomposed by microbial activity.

22. Each fluorescence spectrum consists of photon counts measured at 1024 points (over a wavelength range of 300 to 800 nm) for every 2-cm (0.8-in.) layer of soil investigated. The present data processing system records all spectral intensity measurements and makes corrections for instrument drift during measurement. The corrected data are screened to develop the photon counts for the peak of interest and the background. A file containing the single equivalent

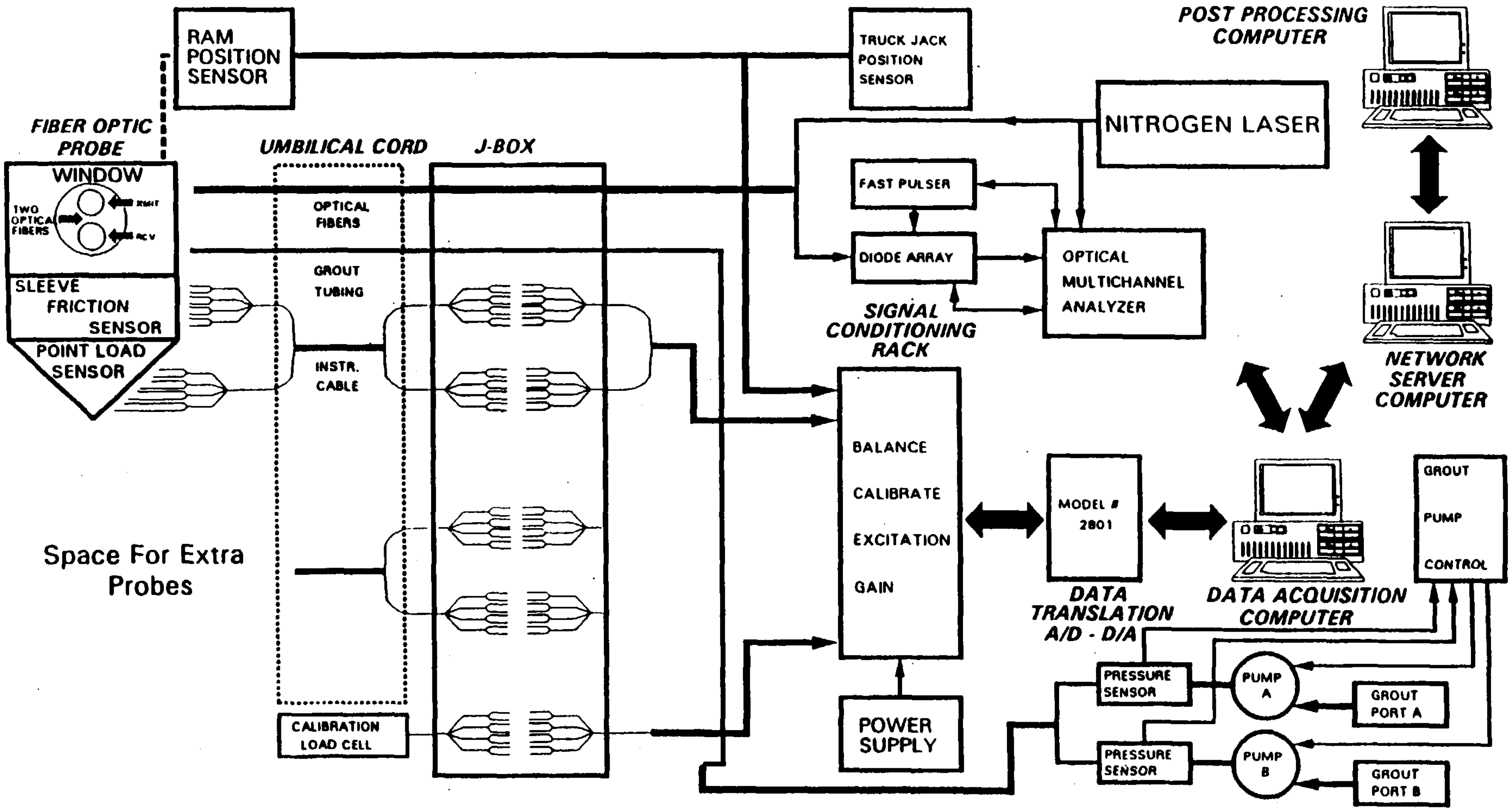


Figure 9. Flowchart of fiber optic system.

normalized counts, the map coordinates, and the depth below a surveyed datum is prepared from the spectral data. The final data file is transformed into a 3-dimensional gridded file and is displayed using a visualization program.

## Method of Converting Counts to Probable Contaminant Concentrations

23. Prior to arrival of the SCAPS truck a WES crew visited the OCI site and obtained soil samples at two locations. These samples were collected in areas that were known to contain hydrocarbon contaminants or known to be free of hydrocarbon contaminants based on earlier trenching activity conducted by the EPA. The samples were returned to WES and analyzed in the laboratory for total oil and grease (O&G), total recoverable petroleums and hydrocarbons (TRPH), and total polynuclear aromatics (TPNA). The same samples were investigated with the fiber optic fluorescence system to determine the counts associated with each. The samples were then mixed to form ratios of "clean" to "dirty" at ratios of 25:75, 50:50, and 75:25, respectively. The new samples were then analyzed as described above to produce a set of points for each test. The results of the lab analysis and fluorescence data is presented in Table 1. A plot of O&G, TRPH, and TPNA concentrations of contaminants in ppm versus intensity counts (Figure 10) was then created. The intensity counts axis is a ratio of counts obtained from firing on the soil samples (Table 1) over counts obtained from firing on the rhodamine standard. A best fit line was forced through the data to give three equations. These equations represent a technique to convert counts from the fiber optic system, into predicted concentrations of ppm based on the data collected at the OCI site. The equation used to convert all the counts to ppm in this report is based on the TRPH data. The O&G data should give values that are high because of the inclusion of the greases which do not fluoresce. The TPNA data should give values that are low because it only includes the aromatics. Therefore, the TRPH data is best representative of the soil fluorometer data.

**Table 1. Results of calibration testing for the OCI site.**

| | Dirty | 75% Dirty 25% Clean | 50% Dirty 50% Clean | 25% Dirty 75% Clean | Clean |
|---|---|---|---|---|---|
| Fluorescence Counts | 1115 | 731 | 402 | 170 | 45 |
| Laboratory O&G, ppm | 4500 | 3100 | 1600 | 800 | 230 |
| Laboratory TRPH, ppm | 3900 | 2600 | 1200 | 600 | 45 |
| Laboratory TPNA, ppm | 1.4 | 1.0 | 0.6 | 0.06 | 0 |

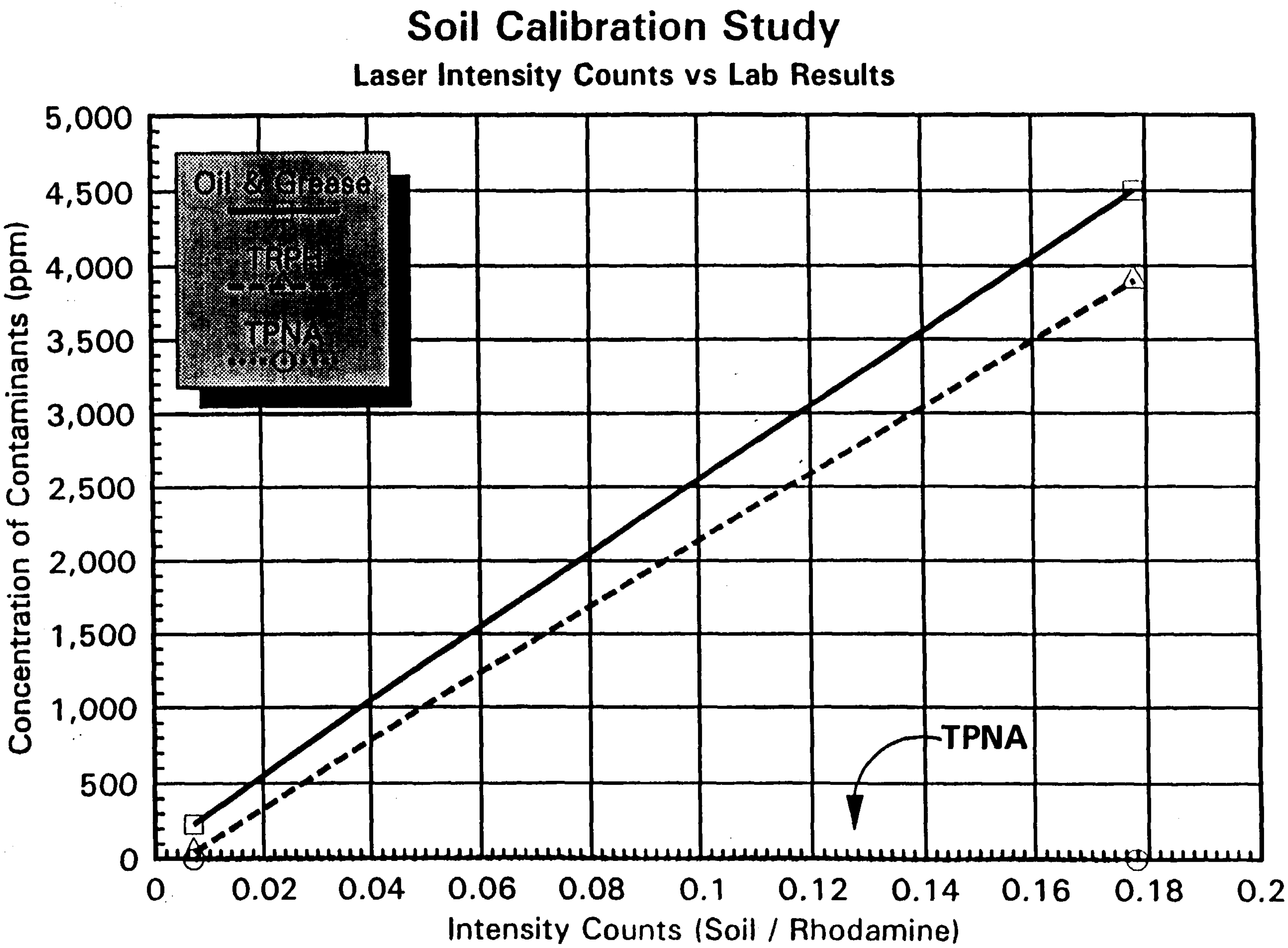


Figure 10. Calibration curves established for the OCI site showing counts versus ppm for three different laboratory test.

## Data Acquisition

24. The data acquisition system and the post processing system each have a separate control computer. The two computers are linked by a network so that data can be exchanged during and after the penetration testing. During the penetration test the data acquisition computer controls all systems and stores the data on a hard disk. The major block of data is generated by the soil fluorometer system in the optical multichannel analyzer (OMA). The OMA is a separate computer that is controlled by the data acquisition computer through a general purpose interface bus. The data acquisition is also interfaced directly with; the amplifier/filter components for the measurement of strain on the cone tip and sleeve and a variable potentiometer that reads out the position of the hydraulic rams (data used to calculate the depth of the penetrometer tip). After the completion of each push, the data are transferred via the network link from the data acquisition computer to the post processing computer where two dimensional plots of the data can be produced. In addition to this, the data are continuously displayed in the form of two dimensional plots on the computer screen during each push.

## Data Visualization

25. Penetrometer data were interpreted on-site with the help of 3-dimensional visualization software (Interactive Volume Modeling, IVM) developed by Dynamic Graphics, Inc. on a Silicon Graphics workstation. The IVM program accepts scattered data files in ASCII format and creates a uniform 3-dimensional grid. Smooth extrapolation and interpretation for points is used to create grid values within and near the existing data. A lateral clipping plane is created to clip extrapolated data outside the bounds of the original data. The basic data controls the location of each known value but the aspect of the final 3-dimensional shapes produced from a data set can be altered by varying the weighting on the 3-dimensional grid derived from the original data. Typically the weighting values for the derived grid are selected by examining 3-dimensional volume plots and observing which spacing combination produces a plot that most closely agrees with the original data points. The software is referred to as "modeling" by the vendor. In the opinion of the authors, these are interpolation and extrapolation processes rather then modeling of a physic to science based process.

26. A completed 3-dimensional visualization model is presented as a series of surfaces that represent specific values of the variable under study. The plot of the surfaces can be presented as a series of drawings of the site or as a

computer-generated video that shows the soil volume with the data boundaries presented in varying colors. The IVM software can rotate the volume so that the limits of the parameter can be observed from all sides. Subprograms are available that allow the volume model to be sliced at various points so that the variation of the parameter can be observed inside the projected volume. All data collected at the OCI site was processed in this manner each day to help in directing the next day's probe siting.

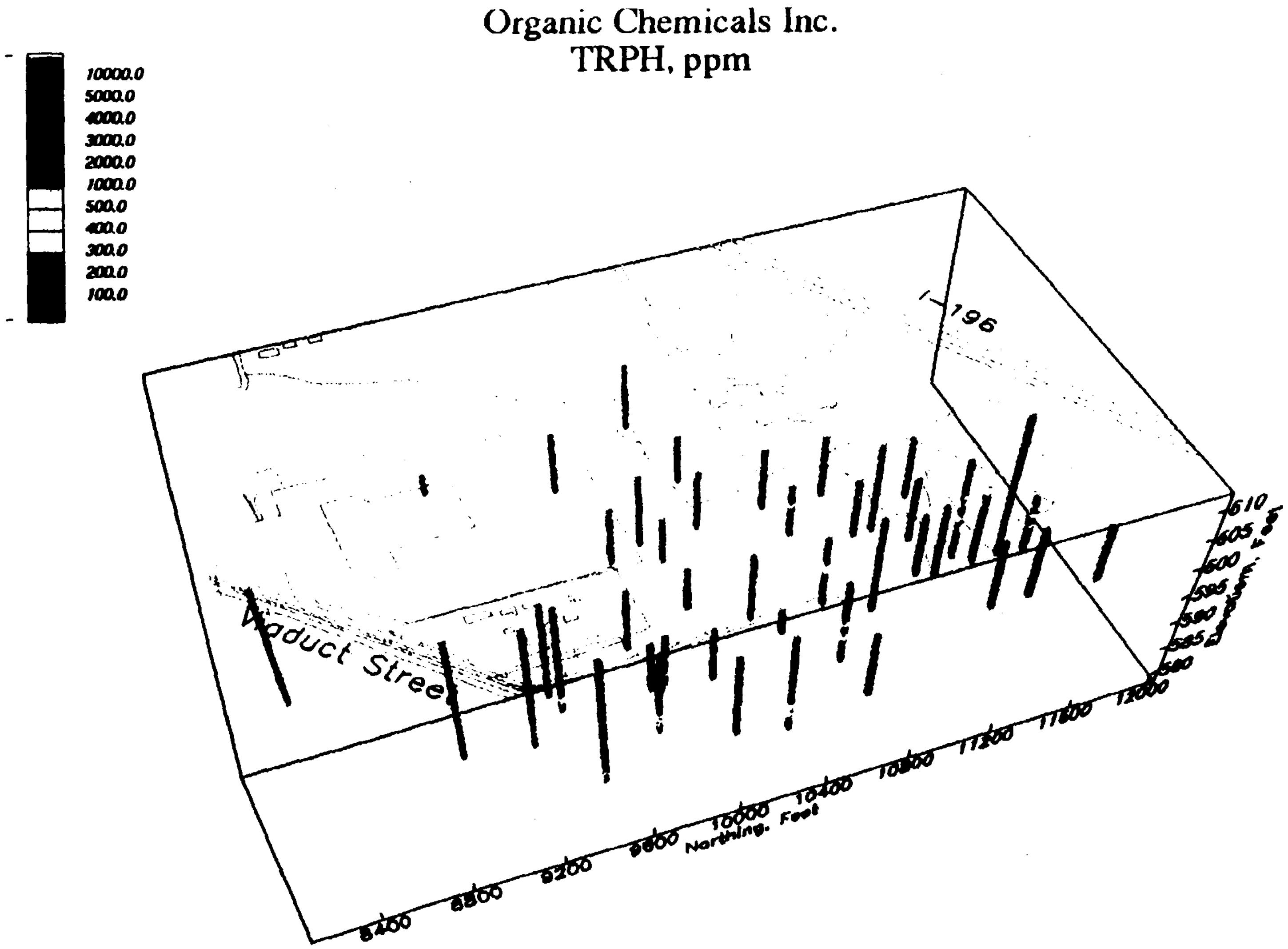


Figure 12. Three dimensional representation of site showing all probes presented as green rectangles, with the data color coded to reveal varying concentrations as varying colors.

# PART IV: RESULTS AND DISCUSSION

## General

27. The location of each probe conducted at the OCI site is shown in Figure 11. The results for each probe are presented as a series of panels in two dimensional form and as a three dimensional volume representation. The two dimensional figures each contain four panels presenting the fluorescence data. As previously discussed, due to the use of pilot holes, geotechnical data were not collected for any probe.

28. The four panels represent the fluorescence data collected at the site. The first panel is a plot of fluorescence intensity single equivalent normalized counts. At each depth of data collection (every 2 cm) the fluorescence intensity returned from the soil being sampled is recorded in terms of counts. Low counts referring to very little fluorescence and high counts referring to high fluorescence. The counts are then normalized by adjusting them to the calibration data recorded at the start and end of every push. In addition the counts are referenced to a standard (Rhodamine calibration of 10,000 counts) so that every probe regardless of the site conditions can be compared one to another. The panel shows the minimum resolution of the SCAPS fluorescence system, which is approximately 100 single equivalent normalized counts. Values below this range are attributable to resolution difficulties and can not be considered representative of conditions in the sub-surface.

29. The second and third panels convert fluorescence intensity single equivalent normalized counts into predicted parts per million (TRPH). Panel two presenting the data on a linear scale and panel three on a logarithmic scale. This data is based on the conversion technique as discussed in paragraph 22. The fourth panel is the wavelength that corresponds to the counts.

30. On each of the two dimensional figures presenting the results of a single probe (four panels), a legend is located at the bottom containing information about the probe. The values that appear for North, East, and Elevation are referenced to a local coordinate system. In the lower left corner of the legend is located the probe name. The probe name is a WES naming convention that is tied to the initial grid established by the surveyors. For example, "OCIC70" is the name identifying cone penetrometer push at the OCI site at location C7 on the grid (Figure 11).

31. The data are also presented in the form of three dimensional volumetric models representing sub-surface conditions. The field data are analyzed by

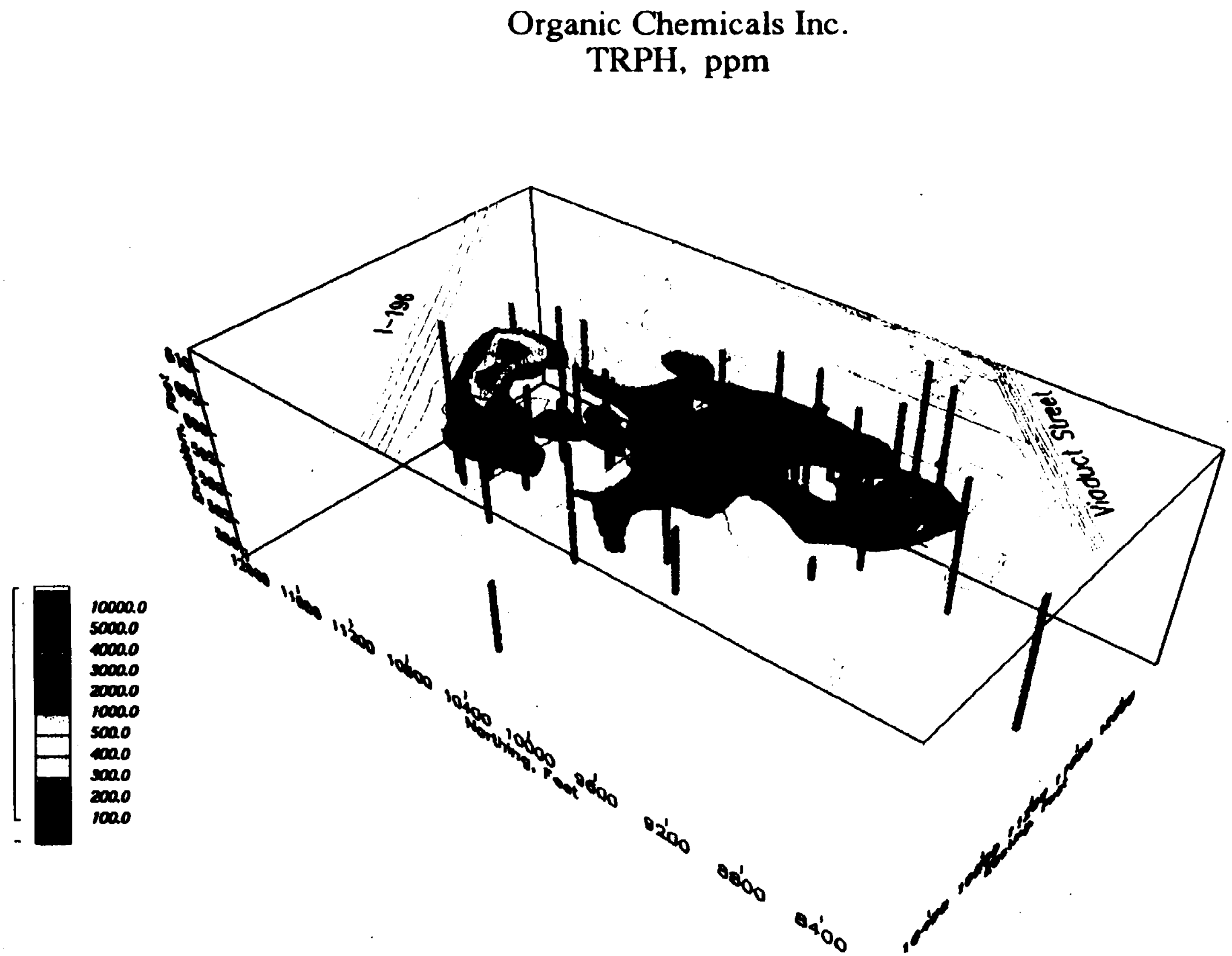


Figure 13. Volumetric representation of data looking southwest to northeast showing all concentrations of 100 ppm and greater.

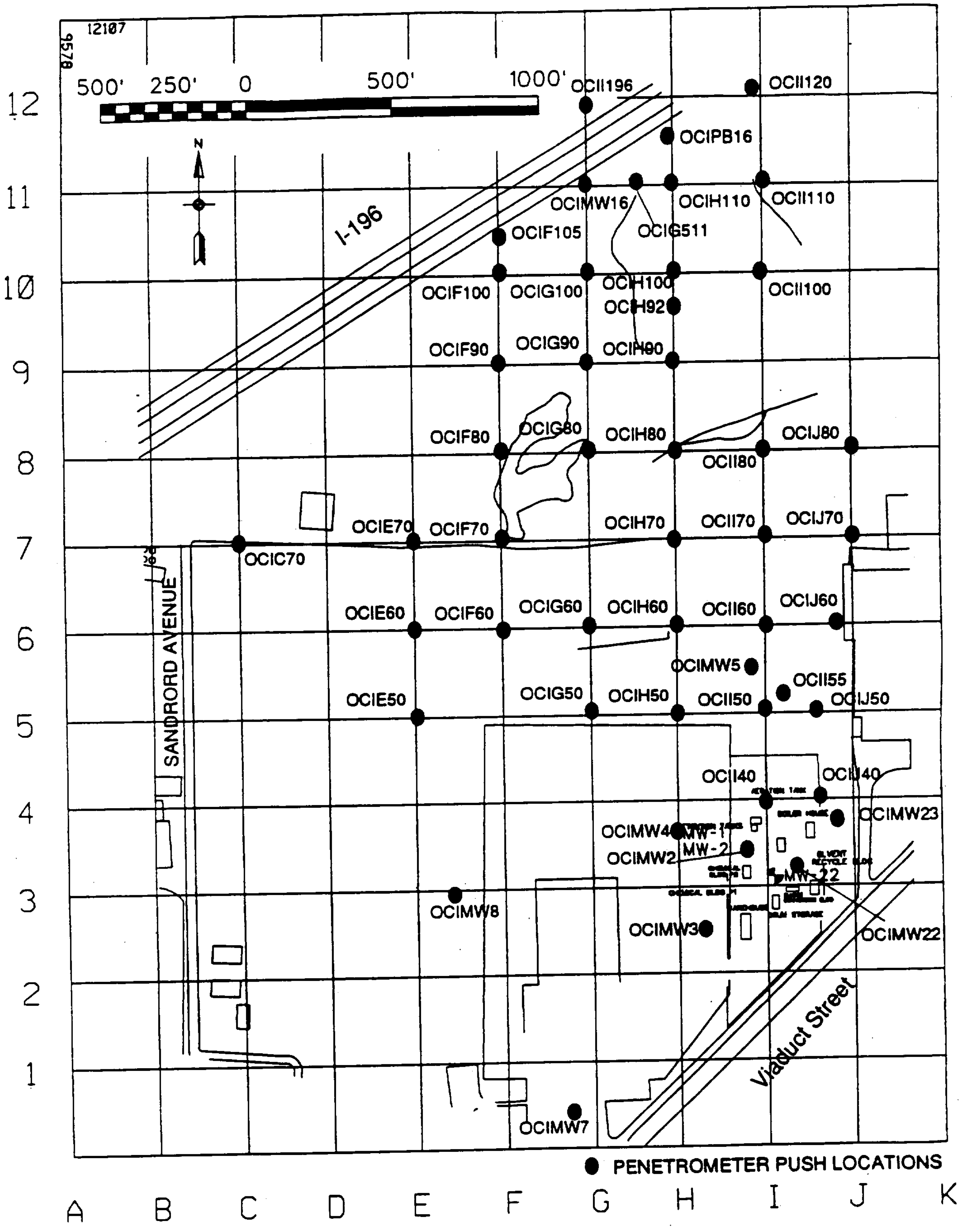


Figure 11. Detail of OCI site and surrounding area showing the locations of all penetrometer pushes at the site.

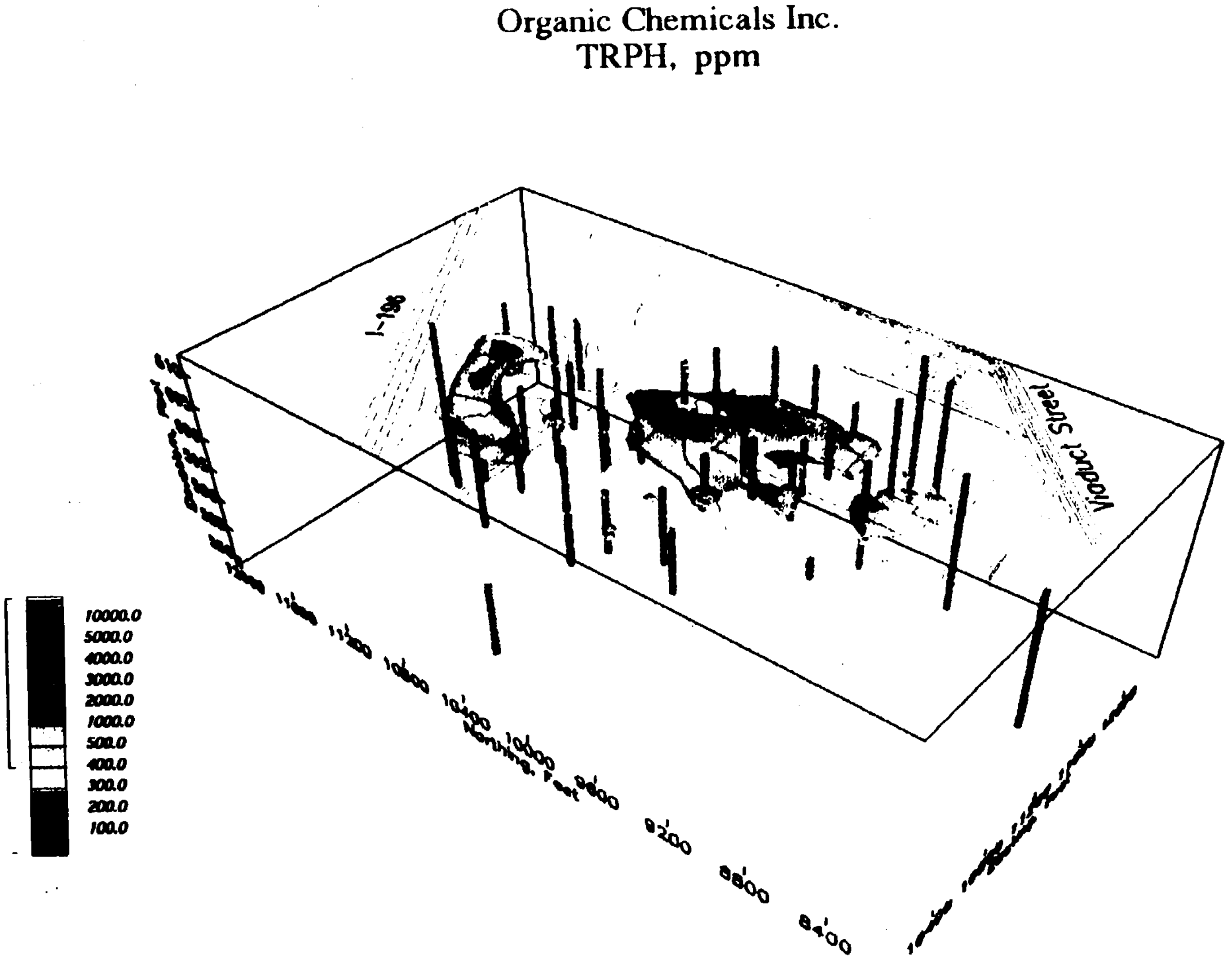


Figure 14. Volumetric representation of data looking southwest to northeast showing all concentrations of 400 ppm and greater.

sophisticated three dimensional data interpolation algorithms. The gridded data are then formed into a three dimensional volumetric image of the subsurface soil conditions or of the body of contaminated soil. Varying properties of the material (contaminant concentrations) are displayed as different color zones. The image can easily and rapidly be manipulated in a number of ways to allow viewing the object from all angles. The location of all data points used to create the gridded data are displayed on the figure. Due to the large data set collected (every 2 cm) the posted data appear as a solid line. A two-dimensional plan map of the site investigated can be added to the figure to aid in feature locations. In the lower left corner of the figure is a legend presenting the color zones and corresponding values represented.

## Fluorescence Data

32. The two dimensional panel plots of the fluorescence data from each individual probe conducted at the site are presented in Appendix A, and are summarized in Table II. Figures 12 through 22 are the volumetric representations of the data. Figure 12 is a view of the site looking east to west, that shows each probe location. The probe locations have been presented as elongated rectangles that have been color coded, with the legend located in the upper left corner of the plot. From a simple presentation like this, one can see the locations of contaminants extending from the south to north end of the site. The probes extended from Viaduct Street at the south end to Interstate-196 at the north end of the site. The east west boundaries were established by the property boundaries of adjacent landowners. A total of 49 probes were completed at the site.

33. A more detailed presentation of the data is given in the remaining figures. Figures 13 through 16 are all views of the site looking from southwest to northeast. Figure 13 shows all the data obtained at the site with TRPH concentrations of 100 ppm and above. Figure 14 shows the data with concentrations of 400 ppm and above, Figure 15 with concentrations of 1000 ppm and above, and Figure 16 with concentrations of 5000 ppm and above. These figures all show that the contaminants are spread out from the OCI site (where the buildings and tanks are located) northward toward the Interstate.

Organic Chemicals Inc.
TRPH, ppm

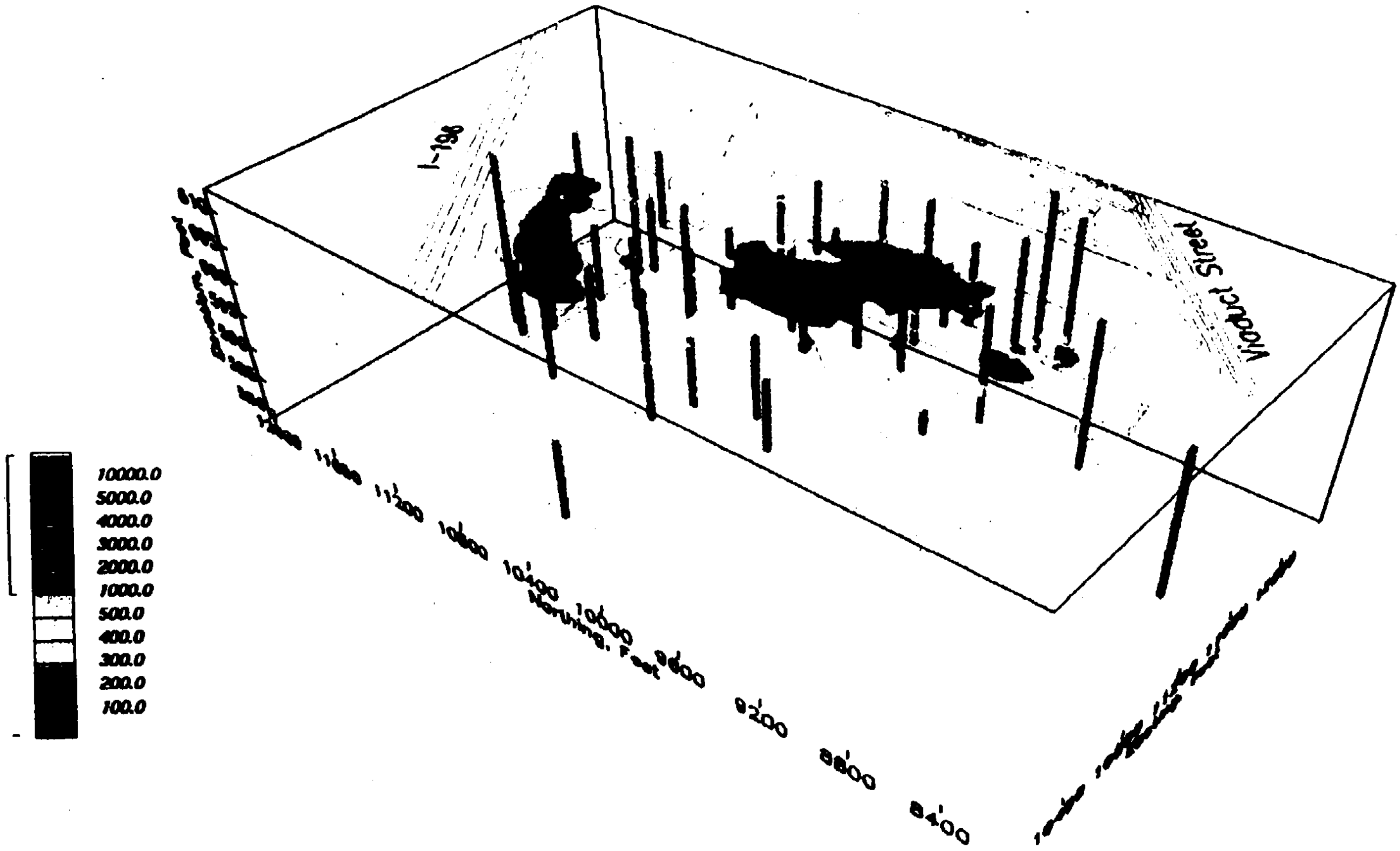


Figure 15. Volumetric representation of data looking southwest to northeast showing all concentrations of 1000 ppm and greater.

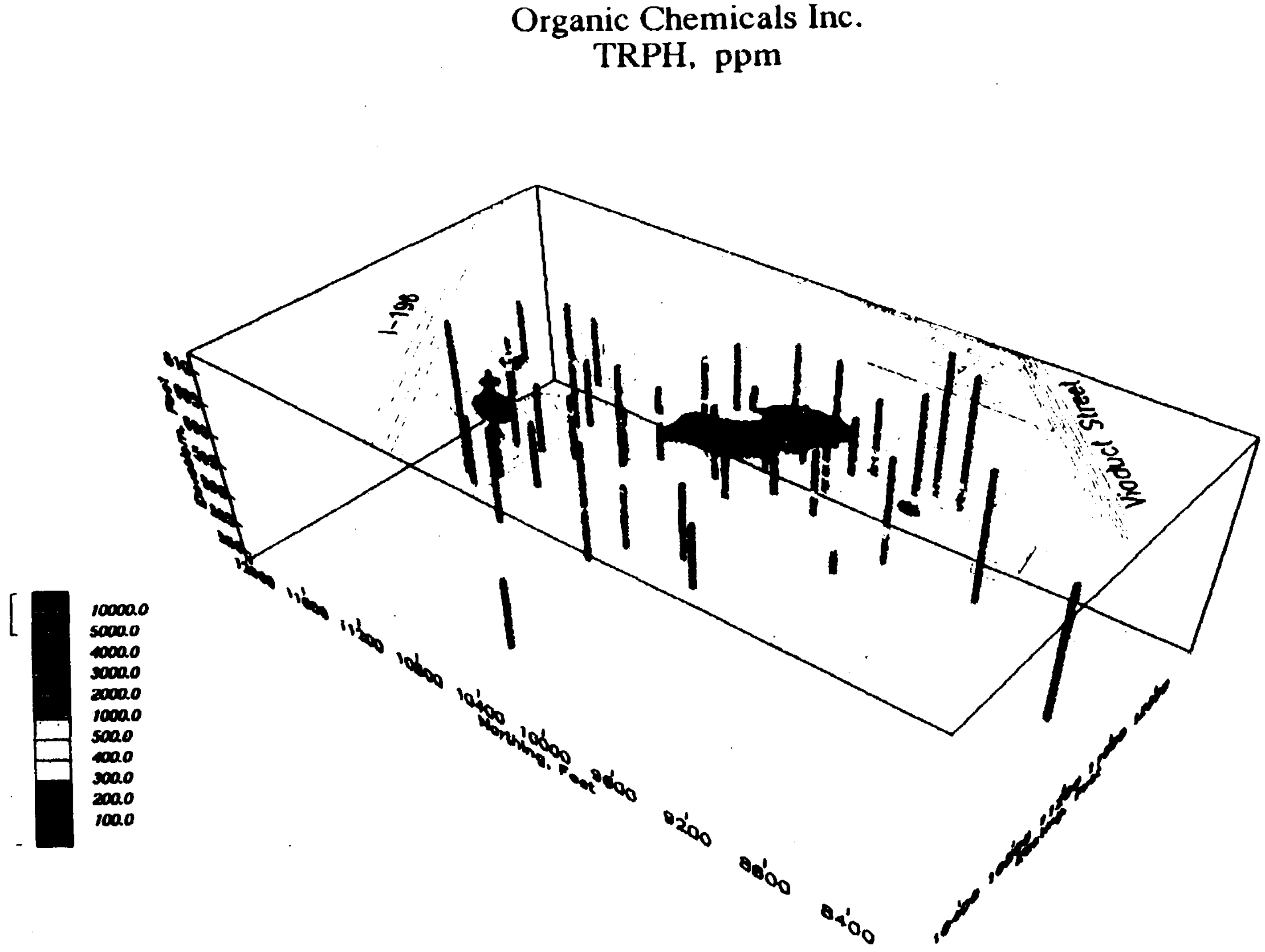


Figure 16. Volumetric representation of data looking southwest to northeast showing all concentrations of 5000 ppm and greater.

Table II. Summary of probes at OCI site

| PROBE NAME | PROBE LOCATION | ELEV INVESTIGATED ABOVE MSL | PRODUCT ENCOUNTERED AT ELEV ABOVE MSL |
|---|---|---|---|
| OCIC70 | C7 on survey grid | 600.1 - 587 | none |
| OCIE50 | E5 on survey grid | 606.2 - 595 | none |
| OCIE60 | E6 on survey grid | 602.9 - 594 | none |
| OCIE70 | E7 on survey grid | 600.2 - 591 | none |
| OCIF60 | F6 on survey grid | 603.6 - 590 | none |
| OCIF70 | F7 on survey grid | 600.3 - 588 | 598, 594 - 590 |
| OCIF80 | F8 on survey grid | 602.5 - 591 | none |
| OCIF90 | F9 on survey grid | 602.1 - 590 | none |
| OCIF100 | F10 on survey grid | 597.8 - 580 | none |
| OCIF105 | Between F10 & F11 on survey grid | 597.8 - 585 | none |
| OCIG50 | G5 on survey grid | 608.8 - 598.5 | 605 - 603 |
| OCIG60 | G6 on survey grid | 603.9 - 594 | 597 - 594 |
| OCIG80 | G8 on survey grid | 603.8 - 594 | 602 - 598 |
| OCIG90 | G9 on survey grid | 600.3 - 590 | 599.7, 598 - 597 |
| OCIG100 | G10 on survey grid | 600.3 - 588 | 589 - 588 |
| OCIG511 | Between G11 & H11 on survey grid | 600 - 583 | 598 - 596, 594 |
| OCIH50 | H5 on survey grid | 602.7 - 591 | 596 - 593 |
| OCIH60 | H6 on survey grid | 603.7 - 595.5 | 599, 595.5 |
| OCIH70 | H7 on survey grid | 603 - 591 | 601-599, 597-592 |
| OCIH80 | H8 on survey grid | 602.4 - 589 | 597 - 589 |
| OCIH90 | H9 on survey grid | 601.7 - 585 | none |
| OCIH92 | Between H9 & H10 on survey grid | 601.7 - 589 | none |
| OCIH100 | H10 on survey grid | 601.7 - 588 | 600-597, 594, 591.5 |
| OCIH110 | H11 on survey grid | 602.3 - 590 | none |
| OCII40 | I4 on survey grid | 610.3 - 592 | 607, 596 - 592 |
| OCII50 | I5 on survey grid | 601 - 593 | 599.5, 593.5 |
| OCII55 | Between I5 and J5 on survey grid | 601 - 594 | 596 - 594.5 |
| OCII60 | I6 on survey grid | 600.1 - 591 | 600, 598.5, 597-591 |
| OCII70 | I7 on survey grid | 600.6 - 596.5 | 597.25 |

| PROBE NAME | PROBE LOCATION | ELEV INVESTIGATED ABOVE MSL | PRODUCT ENCOUNTERED AT ELEV ABOVE MSL |
|---|---|---|---|
| OCII80 | I8 on survey grid | 602.3 - 591 | 602-600, 595.5-591 |
| OCII100 | I10 on survey grid | 603 - 590 | none |
| OCII110 | I11 on survey grid | 603.4 - 590 | none |
| OCII120 | I12 on survey grid | 600.8 - 589 | none |
| OCIJ40 | J4 on survey grid | 607.5 - 601 | none |
| OCIJ50 | J5 on survey grid | 603 - 591 | 601-600, 598-592 |
| OCIJ60 | J6 on survey grid | 604.4 - 591 | 598, 596-591 |
| OCIJ70 | J7 on survey grid | 604.7 - 589 | 596.5 - 591 |
| OCIJ80 | J8 on survey grid | 602.3 - 590 | 595 - 591 |
| OCIMW2 | Near chemical bldg #2, and MW-2 | 610.3 - 599 | none |
| OCIMW3 | West of warehouse, and MW-3 | 606 - 584 | none |
| OCIMW4 | Between H3 and H4 on survey grid | 604.3 - 590 | 600, 595.5-591.5 |
| OCIMW5 | Between I5 and I6 on survey grid | 599.1 - 590 | 596 - 592 |
| OCIMW7 | Near G1 on survey gird, and MW-7 | 606.6 - 585 | none |
| OCIMW8 | Between E3 and F3 on survey grid | 608.1 - 603.5 | none |
| OCIMW16 | G11 on survey grid | 600 - 580 | 600 - 585 |
| OCIMW22 | Between I3 and J3 on survey grid | 614.2 - 592 | 606-603, 597-593 |
| OCIMW23 | Near boiler house, and MW-23 | 611.2 - 589 | 593 - 589 |
| OCIPB16 | Between H11 and H12 on survey grid | 600.8 - 588 | 600 - 592 |
| OCI196 | Near G12 on survey grid | 605.5 - 578 | none |

34. The volumetric representation of the data has been rotated upward to present top views as shown in Figure 17 - 20. Figure 17 is the data having a concentration of 100 ppm and greater, Figure 18 is a view of concentrations 400 ppm and greater, Figure 19 is a view of concentrations 1000 ppm and greater, Figure 20 is a view of concentrations 5000 ppm and greater. In the left top corner of Figure 17 is a small diagram indicating the volume of the contaminant

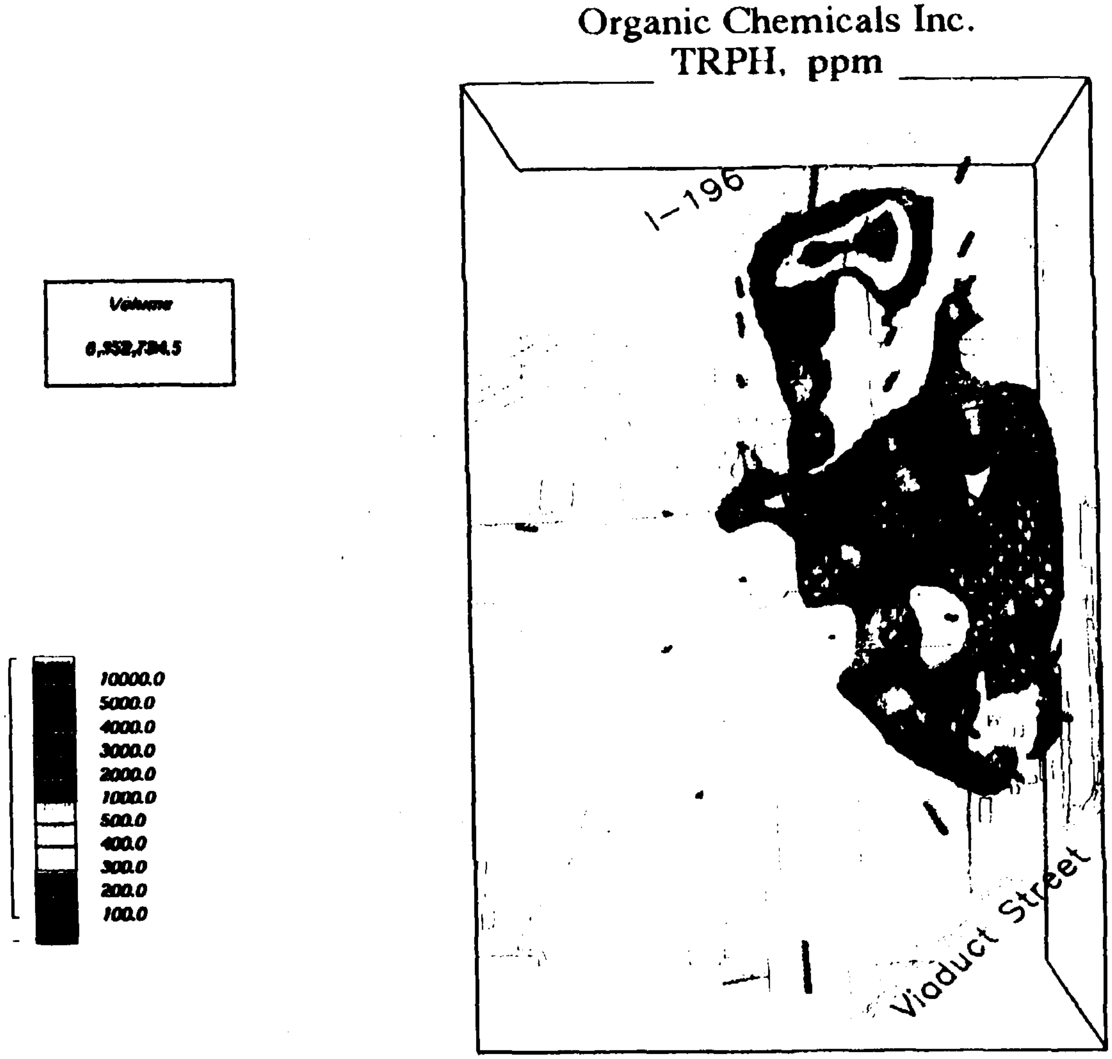


Figure 17. Volumetric representation of data, top view, showing all concentrations of 100 ppm and greater.

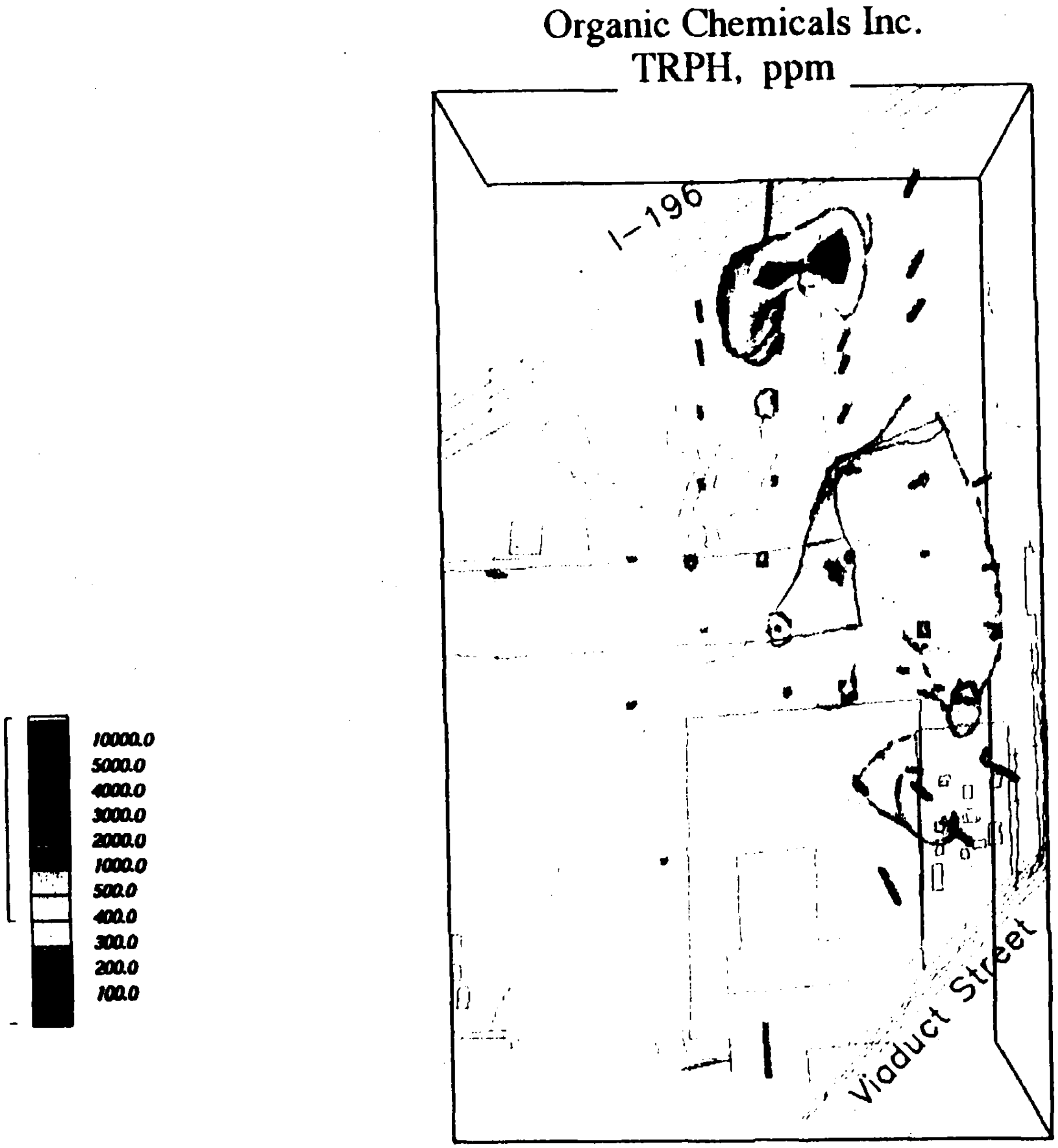


**Figure 18.** Volumetric representation of data, top view, concentrations of 400 ppm and greater.

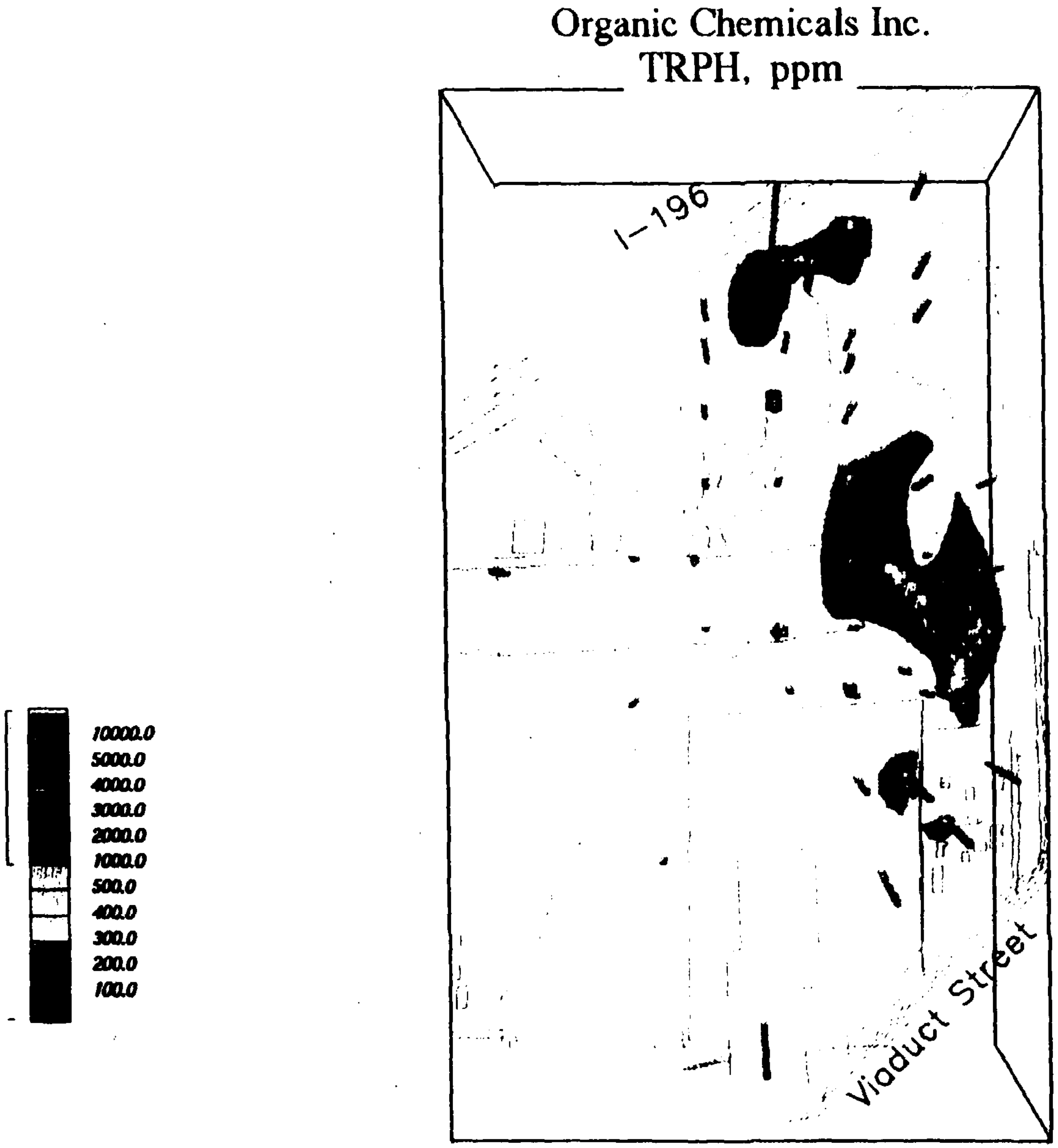


**Figure 19.** Volumetric representation of data, top view, concentrations of 1000 ppm and greater.

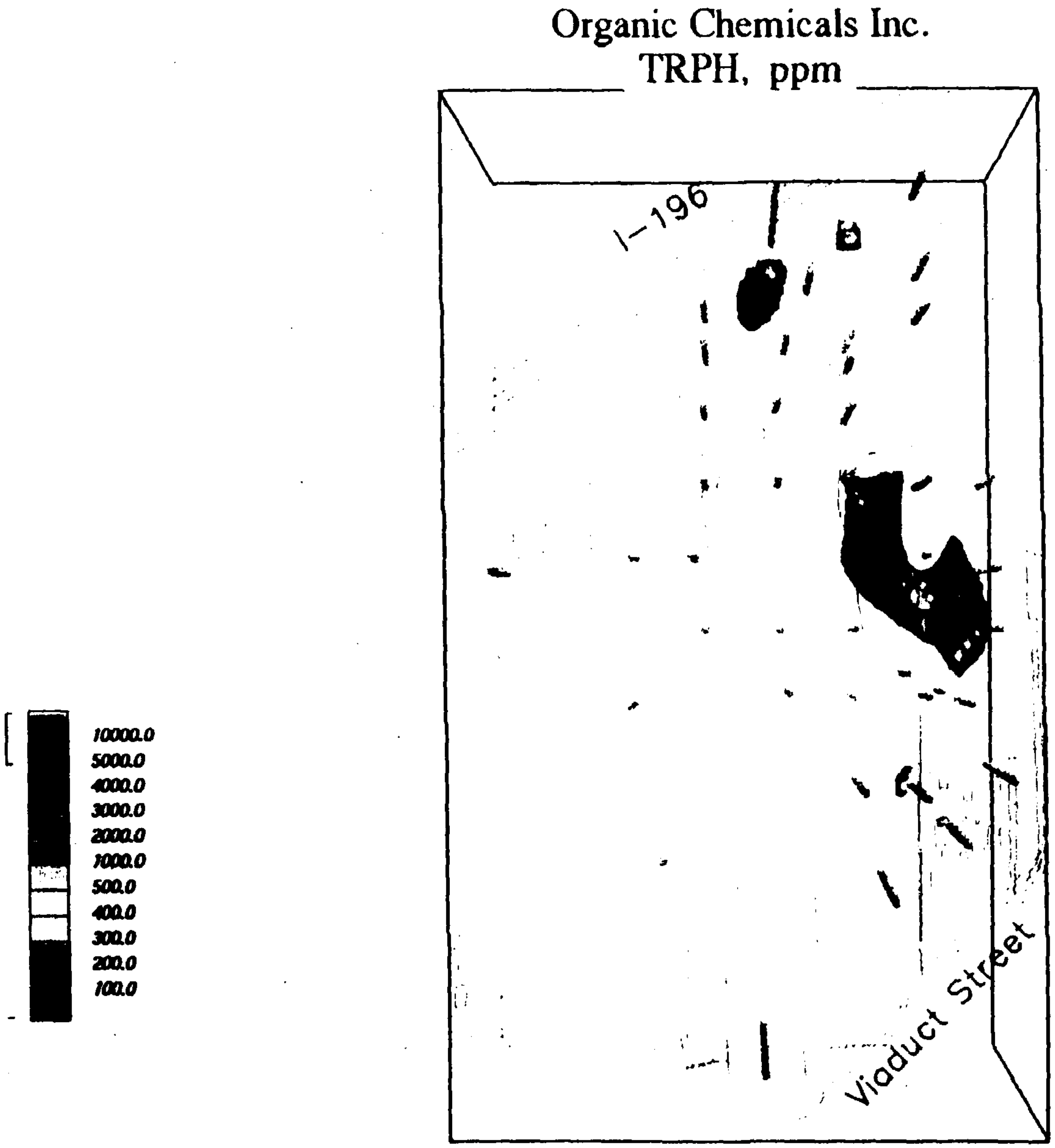


Figure 20. Volumetric representation of data, top view, concentrations of 5000 ppm and greater.

plume. The volume is 6,352,734.5 cubic feet of material for concentratins of 100 ppm and greater.

35. Figures 21 and 22 are views of the data looking east to west. Both figures show concentrations of 100 ppm and greater. Figure 22 is a view of the data where a cut has been made into the center of the data to reveal the higher concentrations.

36. Appendix B contains two top views of the contaminant plume that has been superimposed on top of the aerial photograph of the site. Figure B1 contains the data with concentrations of 100 ppm and greater, Figure B2 the concentrations with 5000 ppm and greater. This presentation gives an excellent view of where the contaminant plume has spread over the site.

37. A final attempt has been made to correlate the findings from the cone penetrometer with actual laboratory data. The soil samples collected prior to arrival of the cone truck, that were used to produce the data in Table 1 and Figure 10, were collected very close to the location between I5 and J5 on the survey grid. A push was made in this area, shown in Appendix A as Figure A28, therefore the data from the penetrometer and the laboratory analysis can be compared. Two samples were taken and analyzed, one at a depth of 1 ft and a second at a depth of 6 feet. From the laboratory analysis, Table 1 (the 1 ft sample is labeled clean, the 6 ft sample is labeled dirty), the concentrations are 3900 ppm TRPH at 6 ft and 45 ppm TRPH at 1 ft. The O&G concentrations are 4500 ppm at 6 ft and 230 ppm at 1 ft. From Figure A28, at a depth of 1 ft the concentration is less than 100 ppm (does not plot), and at a depth of 6 ft the concentration is approximately 4500 ppm.

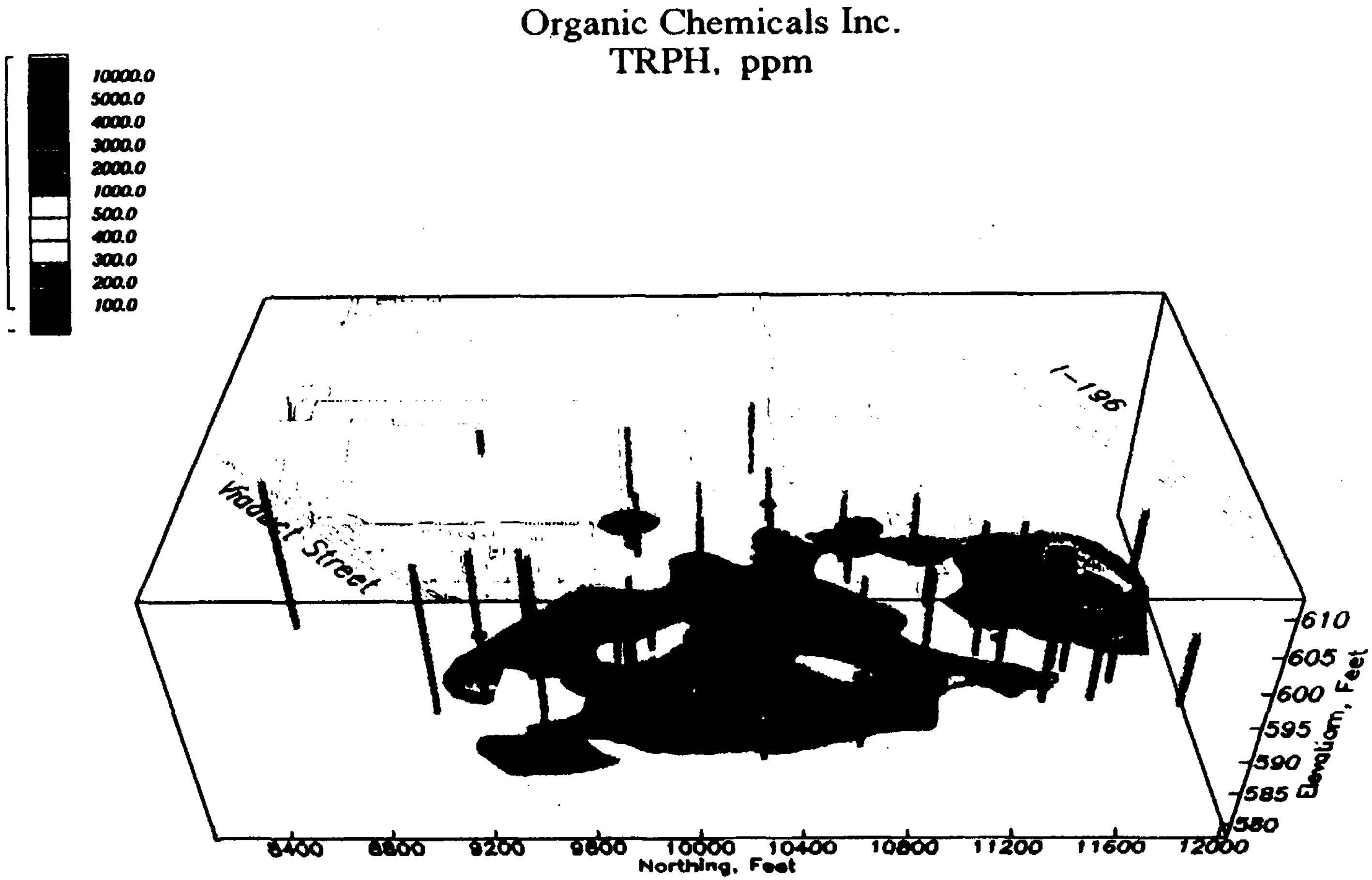


Figure 21. Volumetric representation of data looking east to west showing all concentrations of 100 ppm and greater.

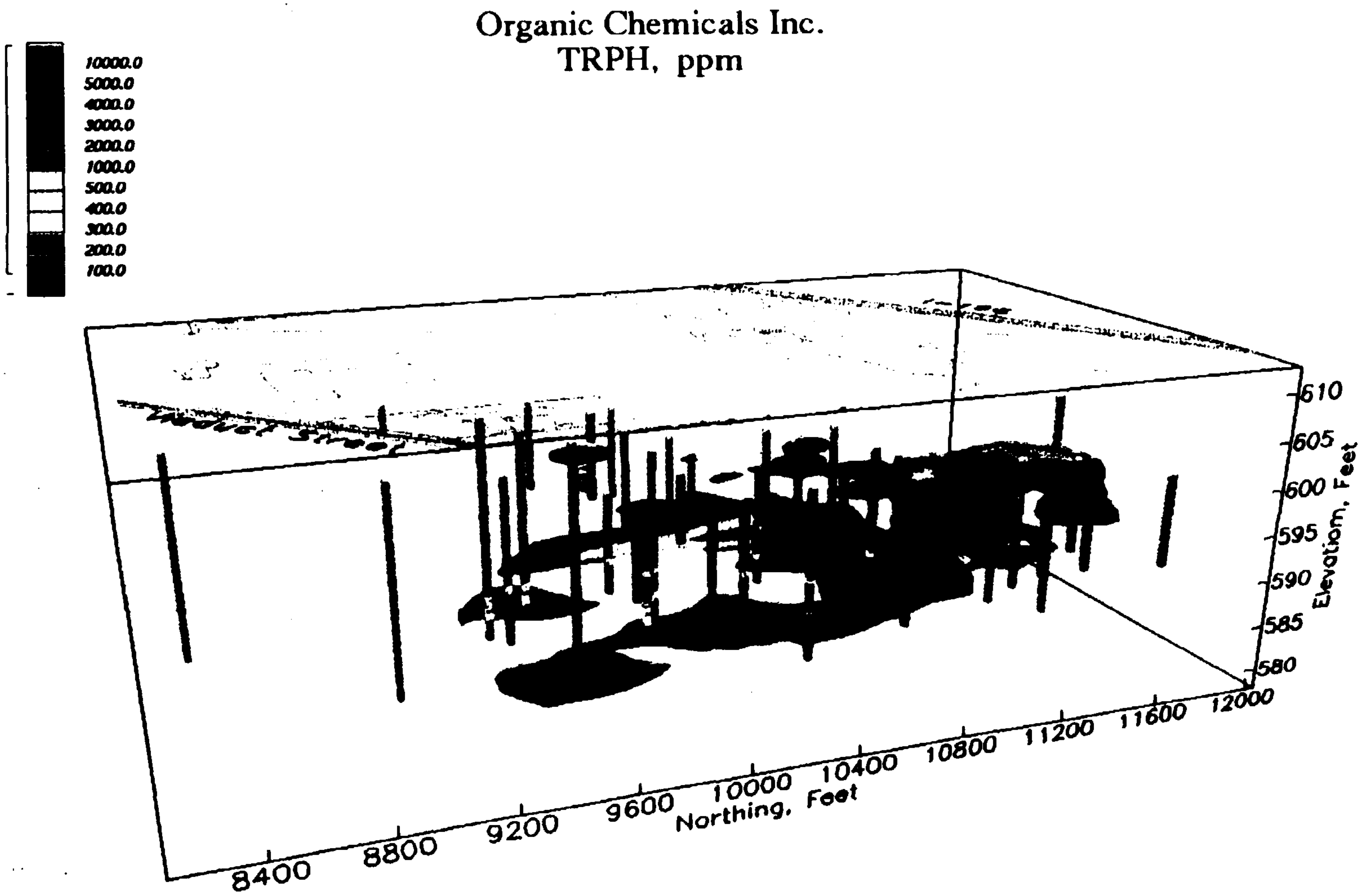
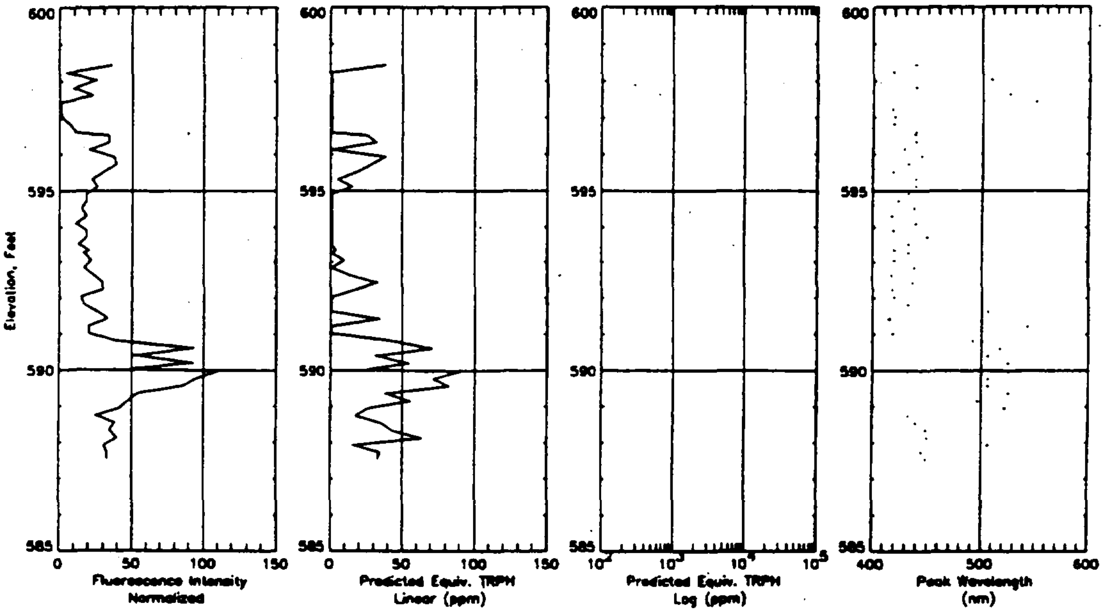


**Figure 22.** Volumetric representation of data looking east to west showing all concentrations of 100 ppm and greater, with a section sliced away to reveal higher concentrations inside the plume.

# PART V: CONCLUSIONS

38. Summarizing the results of the probes conducted at the OCI site, several things are apparent. First, the plume was successfully mapped and delineated on all sides except for the east side. Property access did not allow pushing any further east, however the plume does appear to extend farther in that direction than was mapped. The plume boundaries were successfully delineated on the north, south, and west sides. The plume does not appear to have spread north of the interstate, but rather is located to the area south of that location. Second, it is entirely possible that there are two seperate rather than one long continuous plume. This fact is clearly seen in Figure 17. One plume appears to be associated with the contaminants from the OCI site, extending from that location north for approximately 1600 ft. The second plume appears to be associated with a sludge pond located at approximate location G11 on the grid (very near MW-16). This pond was approximately 35 to 40 feet in diameter and contained a very thick, black tar like substance. Third, the contaminants are caught up in and travelling through the thick gravel layers located at varying depths around the site. Although the soil classification data was not collected, the locations of contaminants correlated extremely well with the sounds that could be heard as the cone was "crunching" through the gravel layers. Fourth, the direction the plume has travelled from the OCI facility is in the same direction as the groundwater gradient.

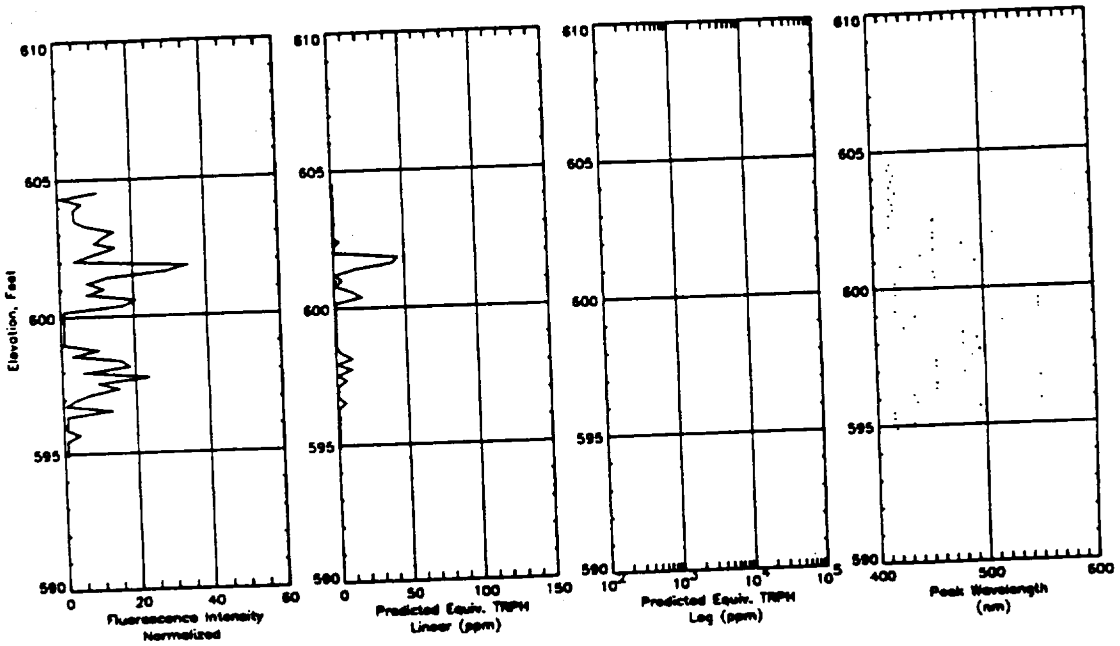
# Appendix A. Two dimensional plots of fluorescence data



Probe = OCIC70
Easting(ft.) = 10209.20
Northing(ft.) = 10246.99
Elevation(ft.) = 600.10

1 foot = 0.3048 meters
1 ton/sq.ft = 0.958 bars

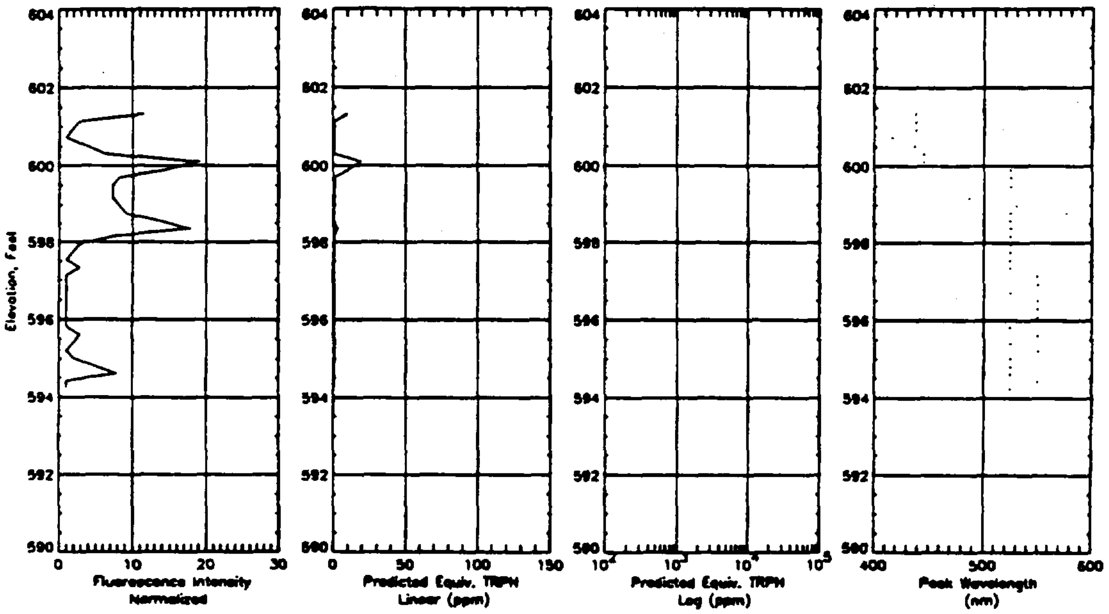
**Figure A1. Results of fluorescence probe conducted at location C7 on the survey grid.**



Probe = OCIE50
Easting(ft.) = 10779.41
Northing(ft.) = 9707.36
Elevation(ft.) = 606.19

1 foot = 0.3048 meters
1 ton/sq.ft = 0.958 bars

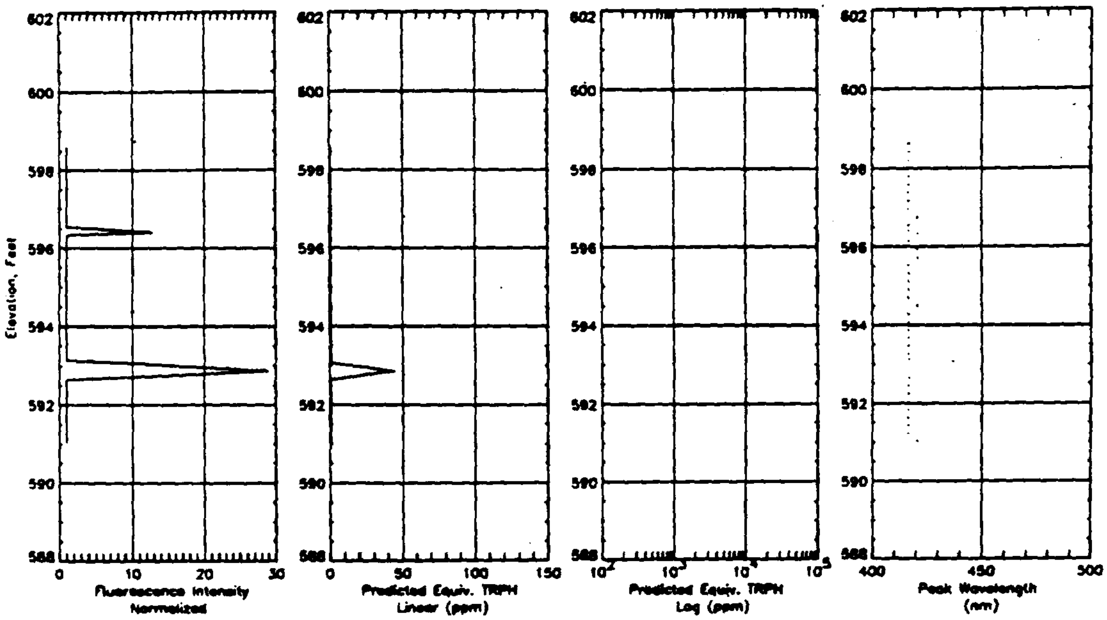
**Figure A2. Results of fluorescence probe conducted at location E5 on the survey grid.**



Probe = OCIE60
Easting(ft.) = 10779.41
Northing(ft.) = 10007.36
Elevation(ft.) = 602.94

1 foot = 0.3048 meters
1 ton/sq.ft = 0.958 bars

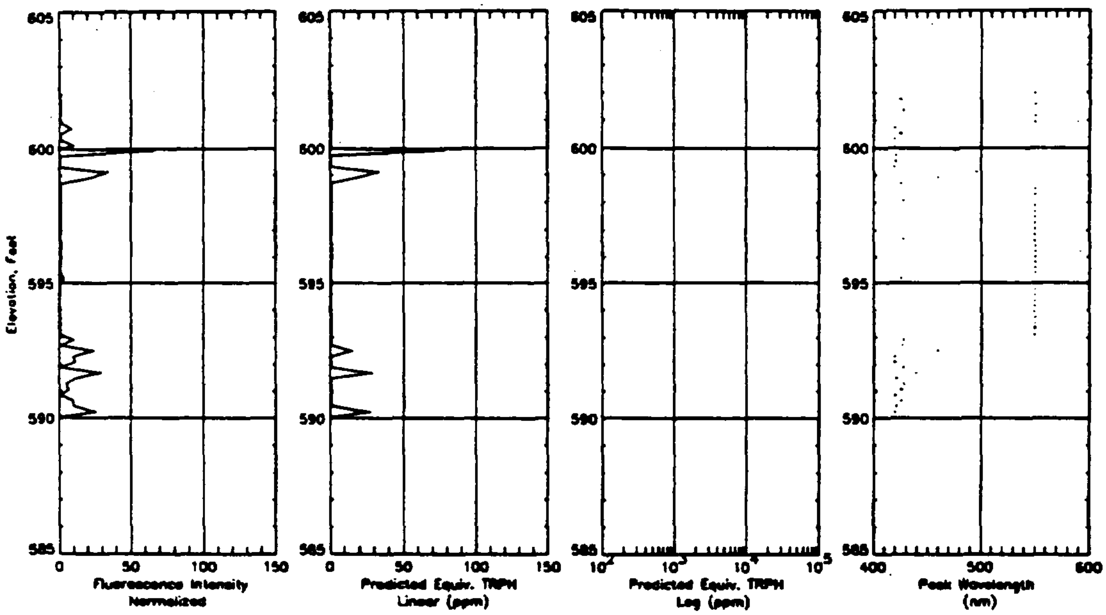
Figure A3. Results of fluorescence probe conducted at location E6 on the survey grid.



Probe = OCIE70
Easting(ft.) = 10779.41
Northing(ft.) = 10307.36
Elevation(ft.) = 600.18

1 foot = 0.3048 meters
1 ton/sq.ft = 0.958 bars

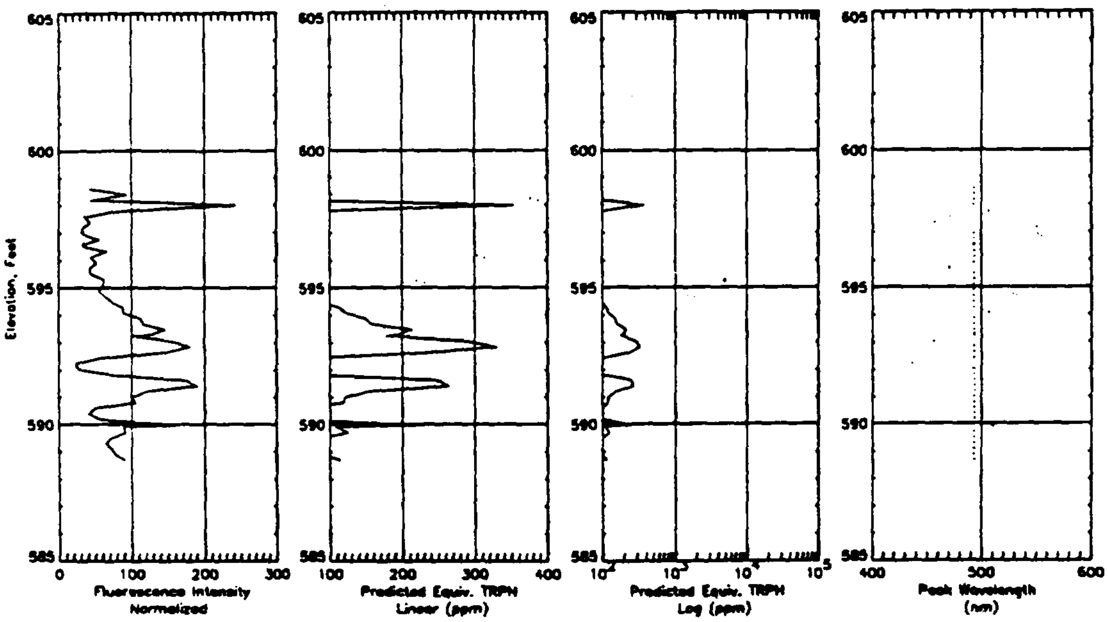
Figure A4. Results of fluorescence probe conducted at location E7 on the survey grid.



Probe = OCIF60
Easting(ft.) = 11079.41
Northing(ft.) = 10007.36
Elevation(ft.) = 603.65

1 foot = 0.3048 meters
1 ton/sq.ft = 0.958 bars

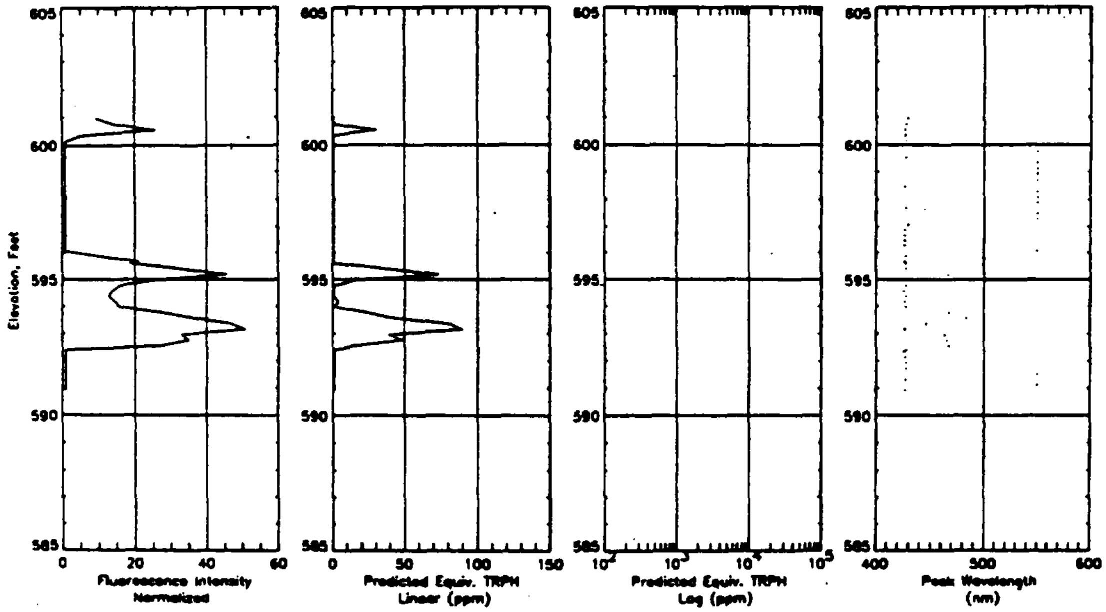
**Figure A5.** Results of fluorescence probe conducted at location F6 on the survey grid.



Probe = OCIF70
Easting(ft.) = 11029.41
Northing(ft.) = 10307.36
Elevation(ft.) = 600.28

1 foot = 0.3048 meters
1 ton/sq.ft = 0.958 bars

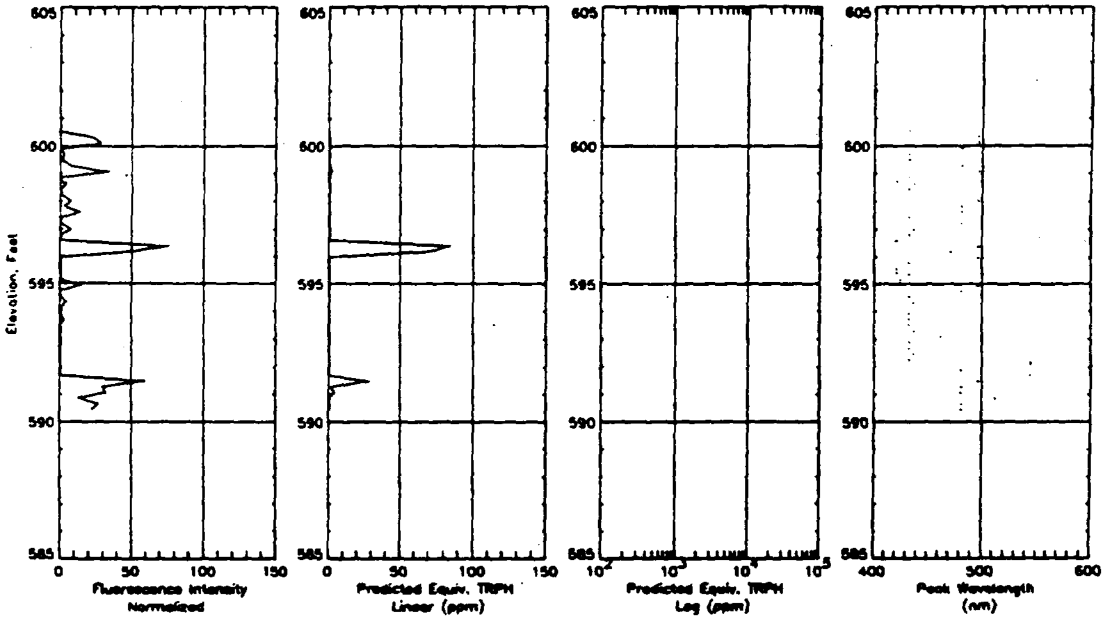
**Figure A6. Results of fluorescence probe conducted at location F7 on the survey grid.**



Probe = OCIF80
Easting(ft.) = 11079.41
Northing(ft.) = 10607.36
Elevation(ft.) = 602.52

1 foot = 0.3048 meters
1 ton/sq.ft = 0.958 bars

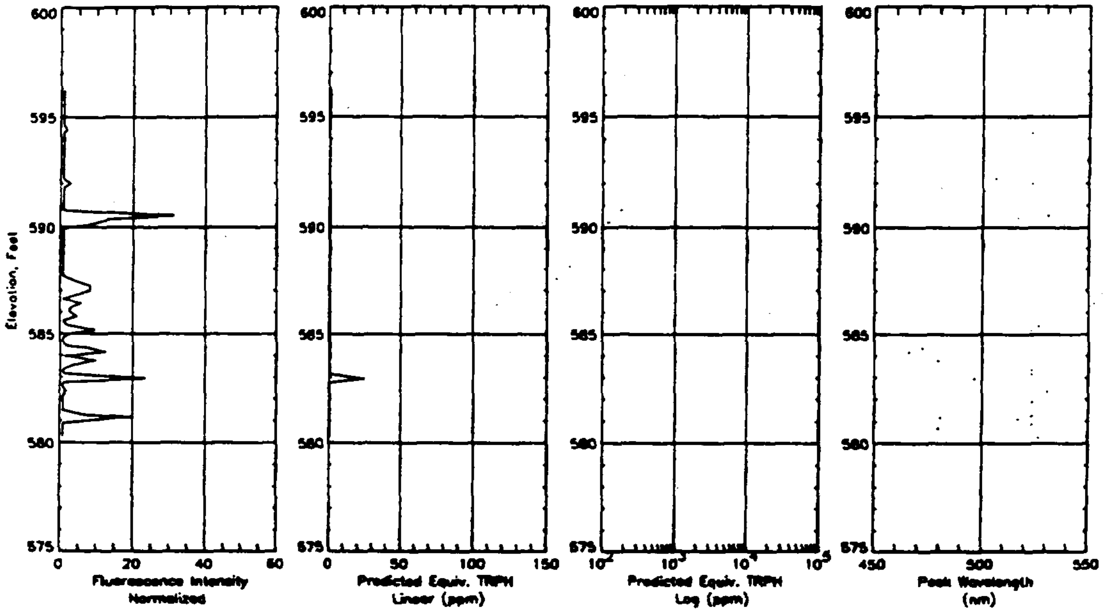
Figure A7. Results of fluorescence probe conducted at location F8 on the survey grid.



Probe = OCIF90
Easting(ft.) = 11079.41
Northing(ft.) = 10907.39
Elevation(ft.) = 602.12

1 foot = 0.3048 meters
1 ton/sq.ft = 0.958 bars

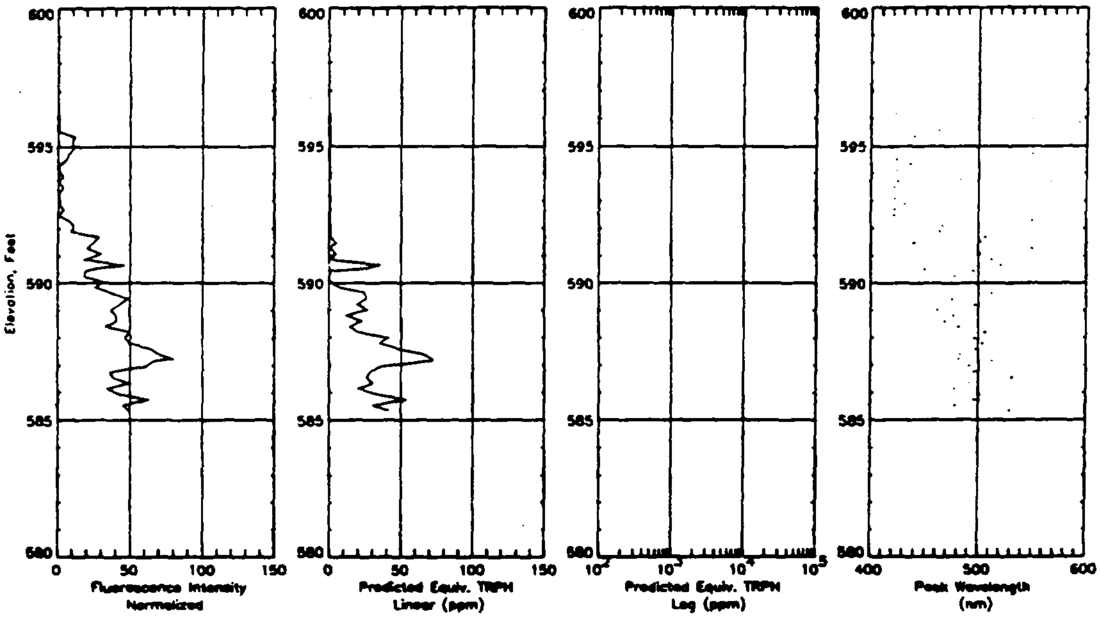
**Figure A8.** **Results of fluorescence probe conducted at location F9 on the survey grid.**



Probe = OCIF100
Easting(ft.) = 11079.41
Northing(ft.) = 11207.36
Elevation(ft.) = 597.81

1 foot = 0.3048 meters
1 ton/sq.ft = 0.958 bars

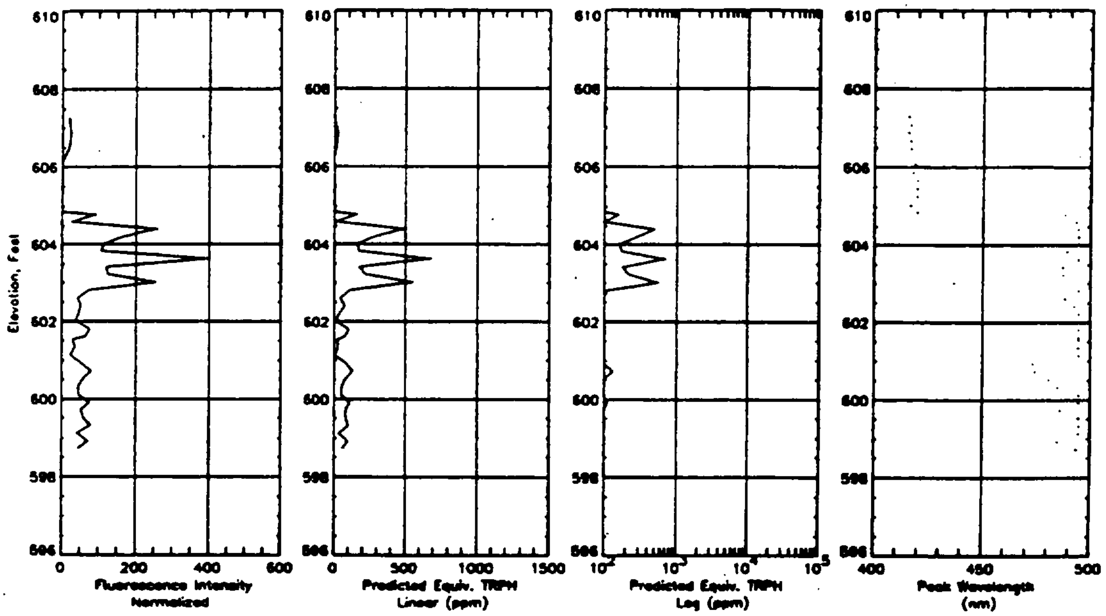
Figure A9. Results of fluorescence probe conducted at location F10 on the survey grid.



Probe = OCIF105
Easting(ft.) = 11079.41
Northing(ft.) = 11367.36
Elevation(ft.) = 597.81

1 foot = 0.3048 meters
1 ton/sq.ft = 0.958 bars

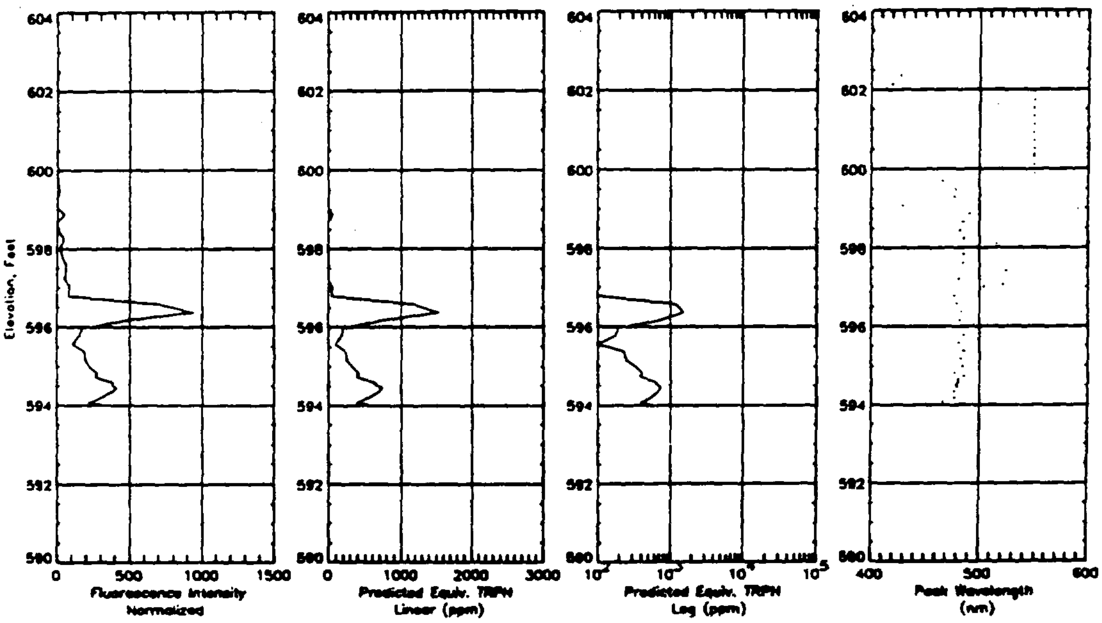
**Figure A10.** Results of fluorescence probe conducted between F10 and F11 on the survey grid.



Probe = OCIG50
Easting(ft.) = 11409.41
Northing(ft.) = 9762.36
Elevation(ft.) = 608.80

1 foot = 0.3048 meters
1 ton/sq.ft = 0.958 bars

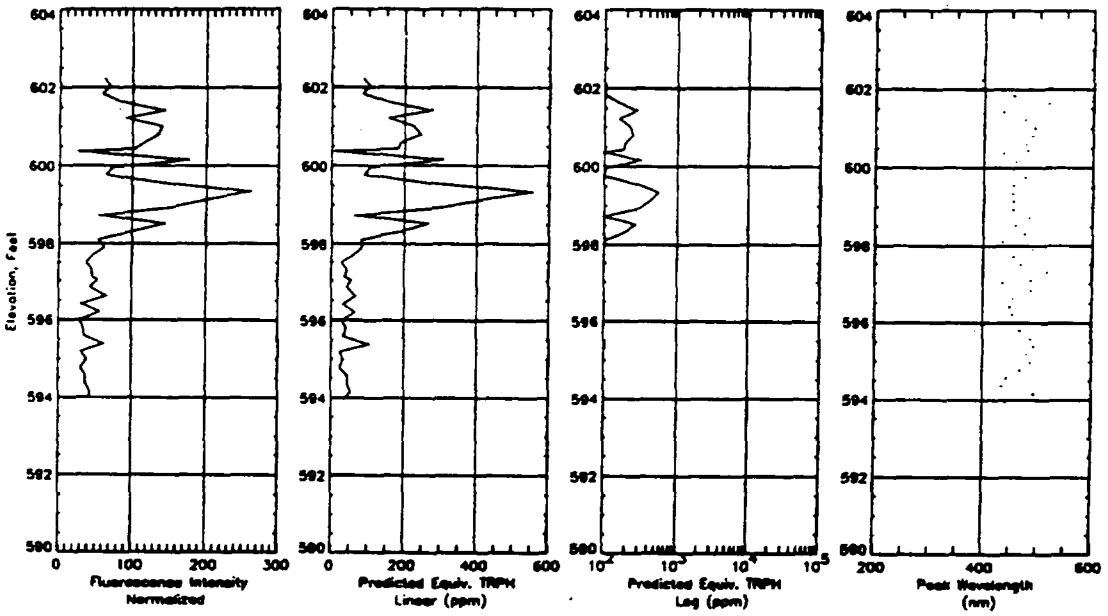
Figure A11. Results of fluorescence probe conducted at location G5 on the survey grid.



Probe = OCIG60
Easting(ft.) = 11379.41
Northing(ft.) = 10007.36
Elevation(ft.) = 603.91

1 foot = 0.3048 meters
1 ton/sq.ft = 0.958 bars

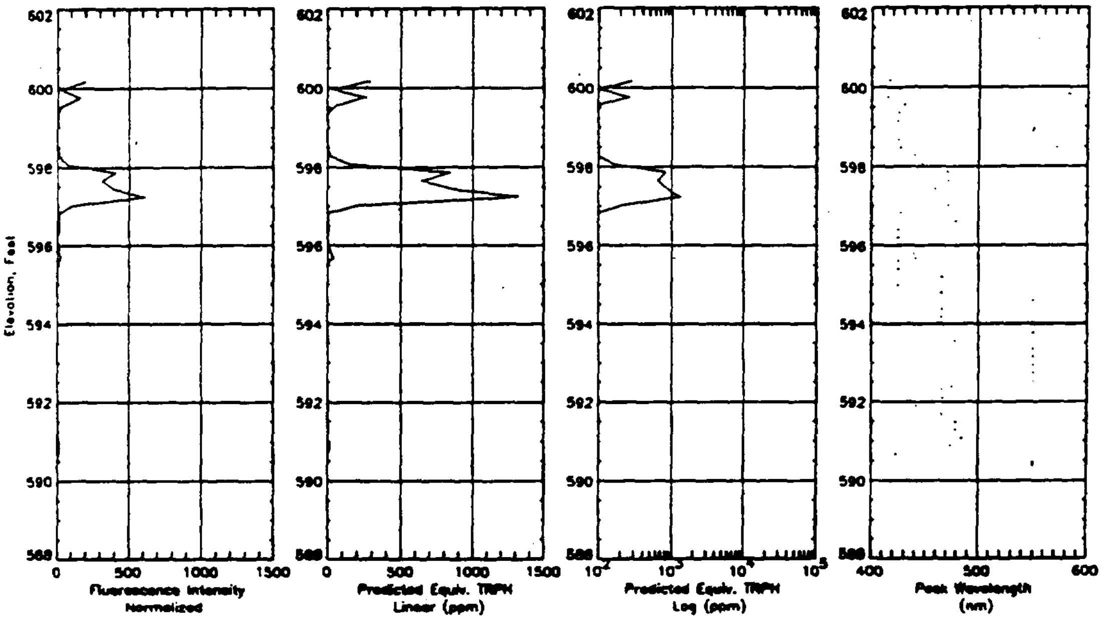
Figure A12. Results of fluorescence probe conducted at location G6 on the survey grid.



Probe = OCIG80
Easting(ft.) = 11379.41
Northing(ft.) = 10607.36
Elevation(ft.) = 603.79

1 foot = 0.3048 meters
1 ton/sq.ft = 0.958 bars

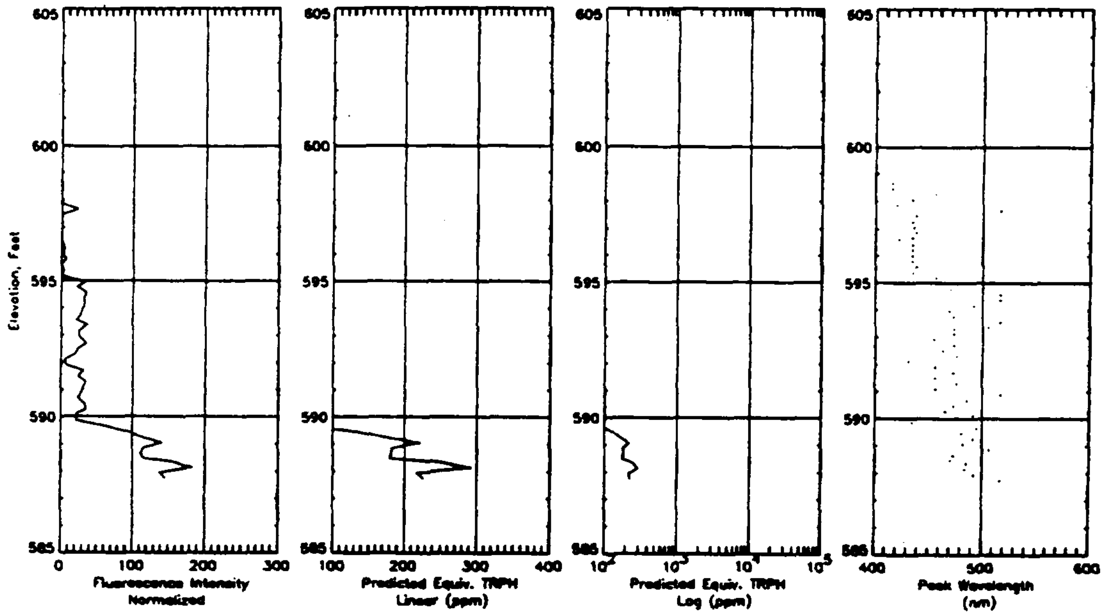
Figure A13. Results of fluorescence probe conducted at location G8 on the survey grid.



Probe = OCIG90
Easting(ft.) = 11379.41
Northing(ft.) = 10937.36
Elevation(ft.) = 600.26

1 foot = 0.3048 meters
1 ton/sq.ft = 0.958 bars

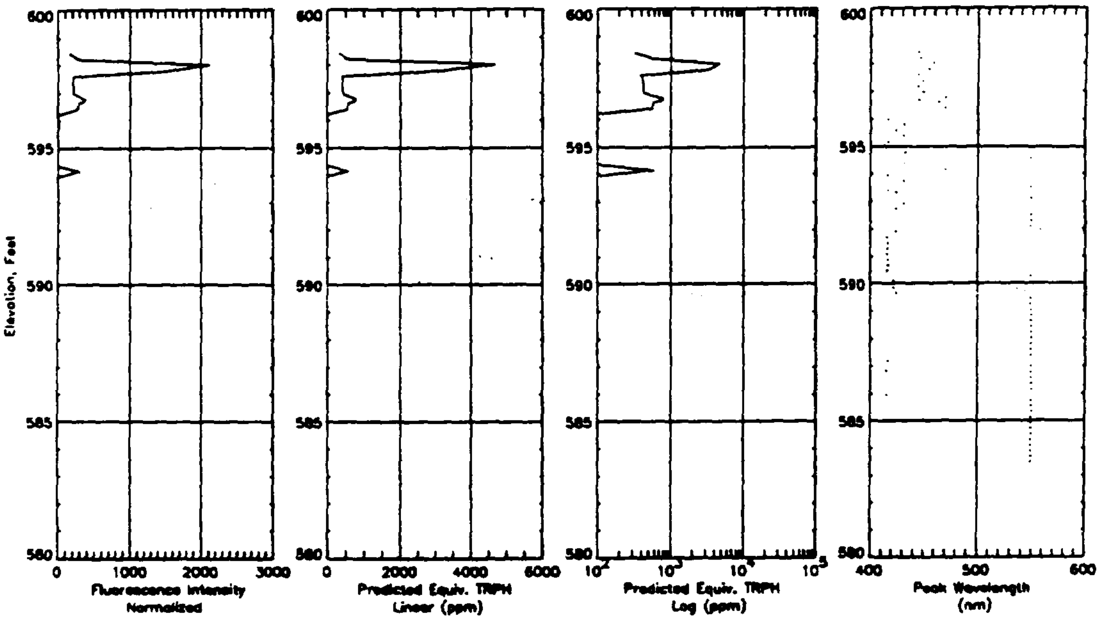
Figure A14. Results of fluorescence probe conducted at location G9 on the survey grid.



Probe = OCIG100
Easting(ft.) = 11419.41
Northing(ft.) = 11207.36
Elevation(ft.) = 600.26

1 foot = 0.3048 meters
1 ton/sq.ft = 0.958 bars

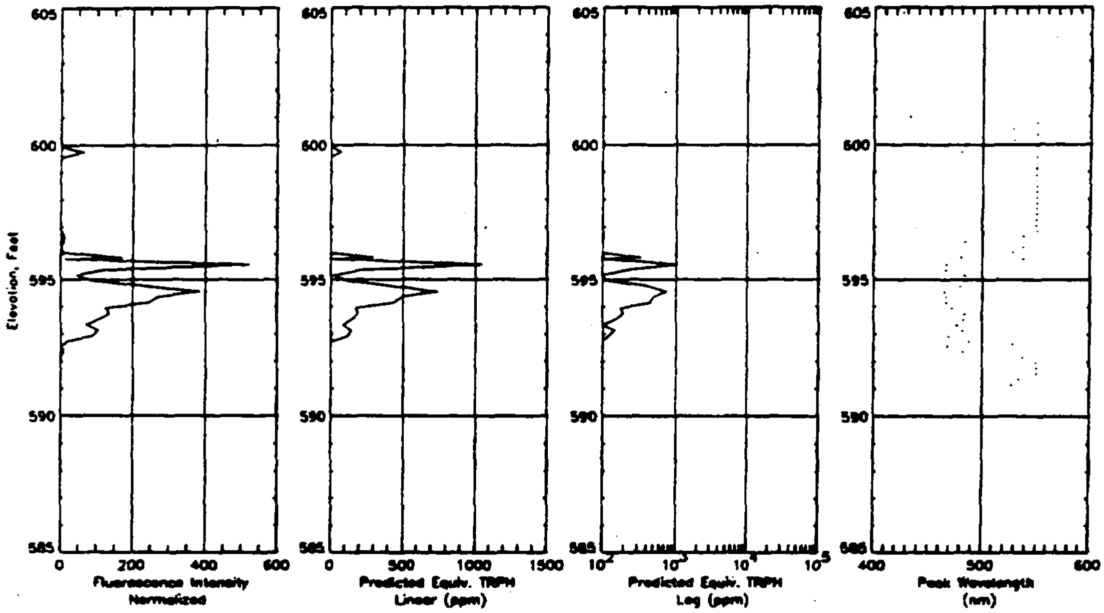
Figure A15. Results of fluorescence probe conducted at location G10 on the survey grid.



Probe = OCIG511
Easting(ft.) = 11529.41
Northing(ft.) = 11507.36
Elevation(ft.) = 600.00

1 foot = 0.3048 meters
1 ton/sq.ft = 0.958 bars

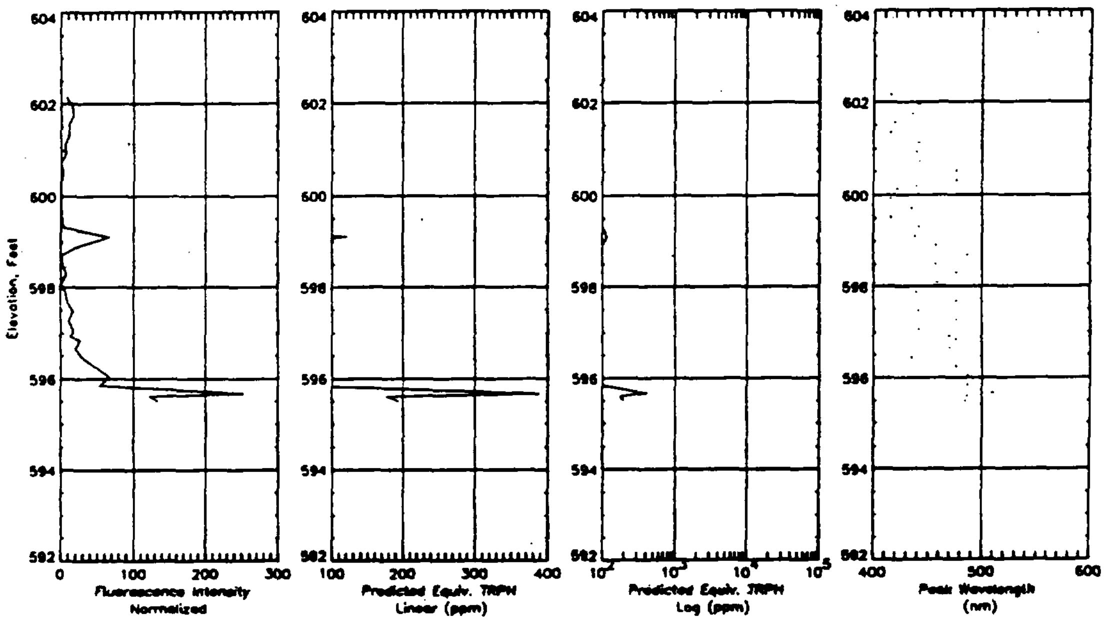
**Figure A16. Results of fluorescence probe conducted between G11 and H11 on the survey grid.**



Probe = OCIH50
Easting(ft.) = 11679.41
Northing(ft.) = 9732.36
Elevation(ft.) = 602.66

1 foot = 0.3048 meters
1 ton/sq.ft = 0.958 bars

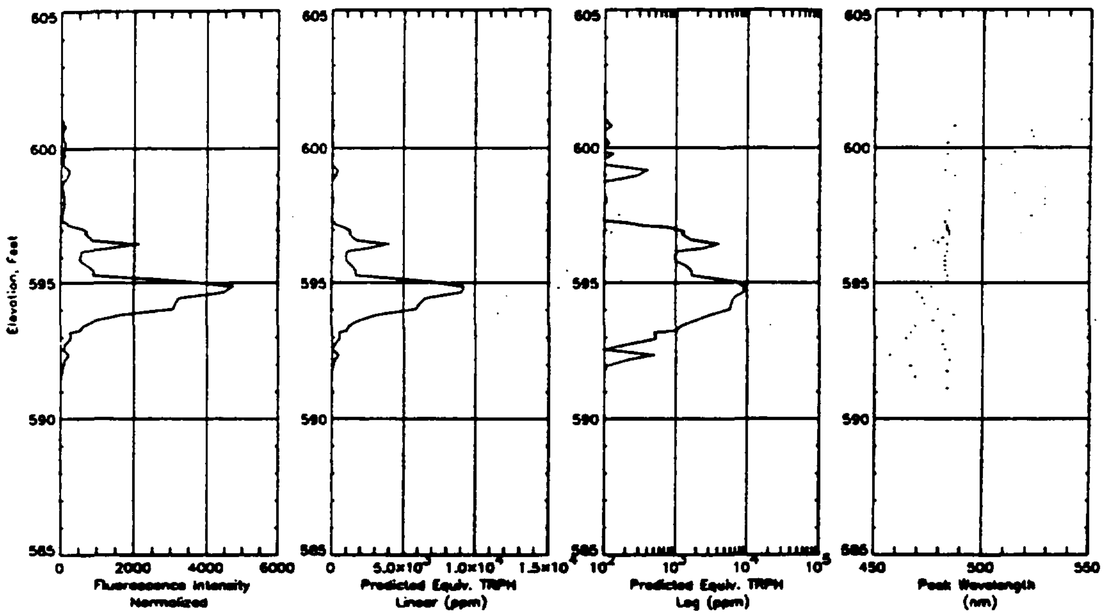
**Figure A17.** Results of fluorescence probe conducted at location H5 on the survey grid.



Probe = OCIH60
Easting(ft.) = 11679.41
Northing(ft.) = 10007.36
Elevation(ft.) = 603.68

1 foot = 0.3048 meters
1 ton/sq.ft = 0.958 bars

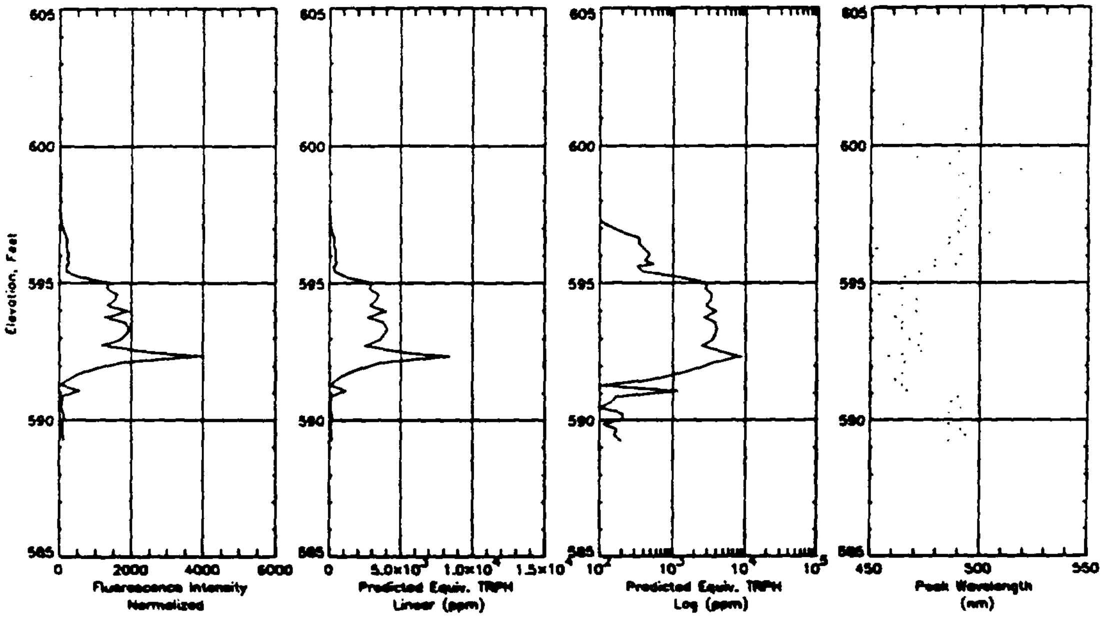
Figure A18. Results of fluorescence probe conducted at location H6 on the survey grid.



Probe = OCIH70
Easting(ft.) = 11679.41
Northing(ft.) = 10307.36
Elevation(ft.) = 603.00

1 foot = 0.3048 meters
1 ton/sq.ft = 0.958 bars

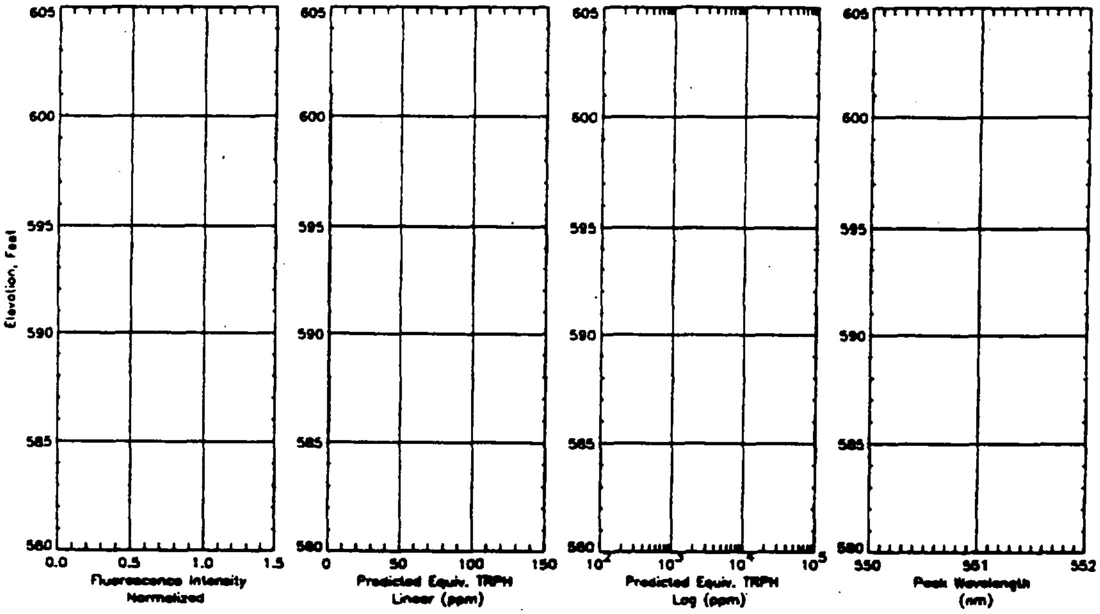
Figure A19. Results of fluorescence probe conducted at location H7 on the survey grid.



Probe = OCIH80
Easting(ft.) = 11679.41
Northing(ft.) = 10647.36
Elevation(ft.) = 602.44

1 foot = 0.3048 meters
1 ton/sq.ft = 0.958 bars

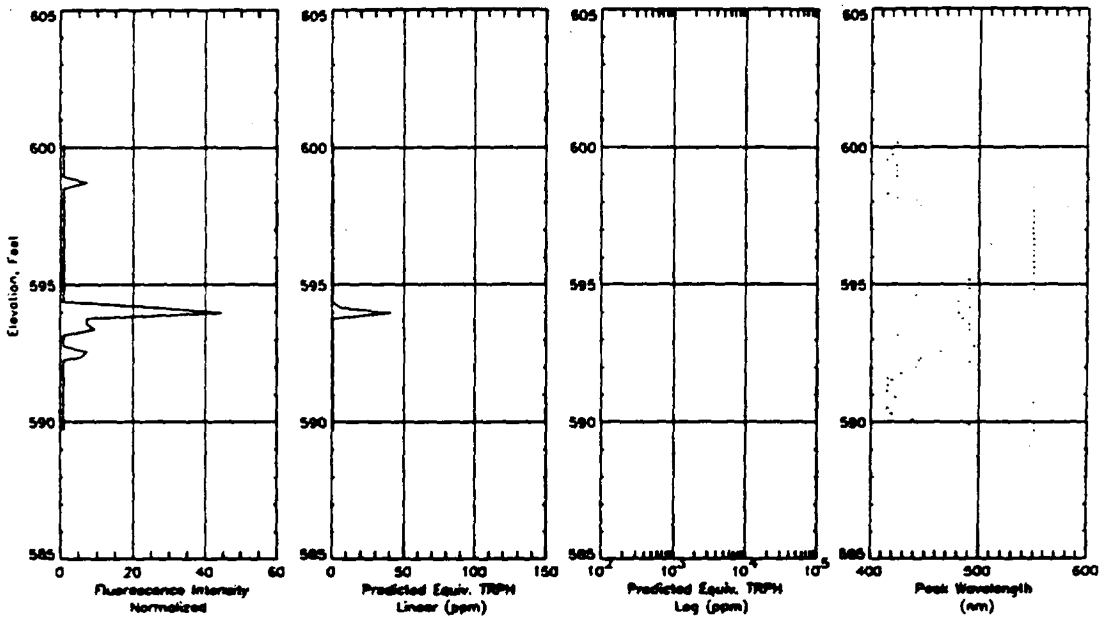
Figure A20. Results of fluorescence probe conducted at location H8 on the survey grid.



Probe = OCIH90
Easting(ft.) = 11679.41
Northing(ft.) = 10907.36
Elevation(ft.) = 601.71

1 foot = 0.3048 meters
1 ton/sq.ft = 0.958 bars

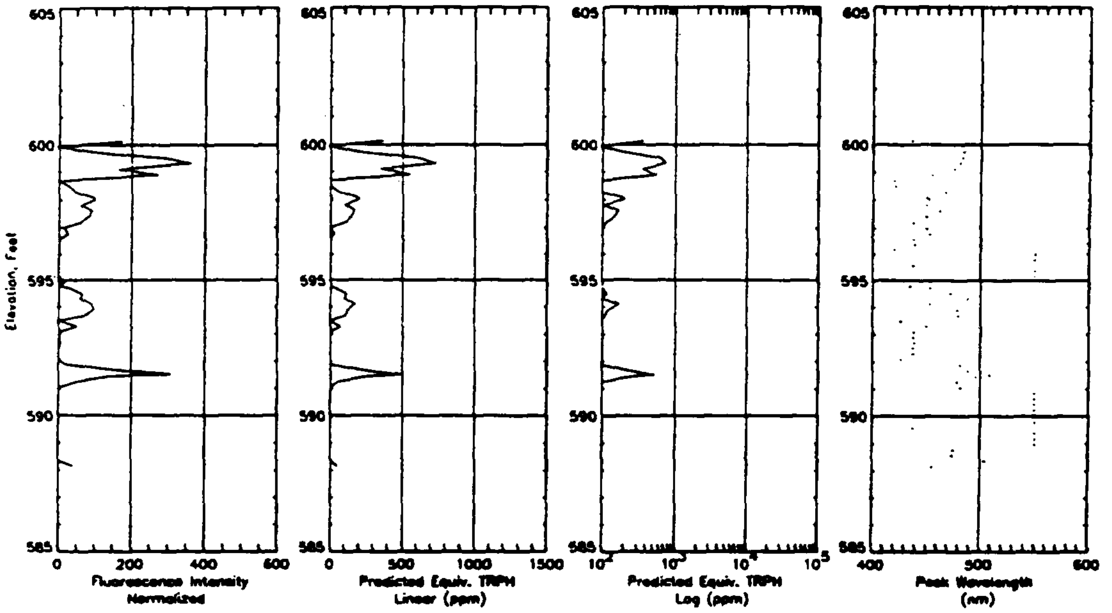
Figure A21. Results of fluorescence probe conducted at location H9 on the survey grid.



Probe = OCIH92
Easting(ft.) = 11679.41
Northing(ft.) = 11107.36
Elevation(ft.) = 601.71

1 foot = 0.3048 meters
1 ton/sq.ft = 0.958 bars

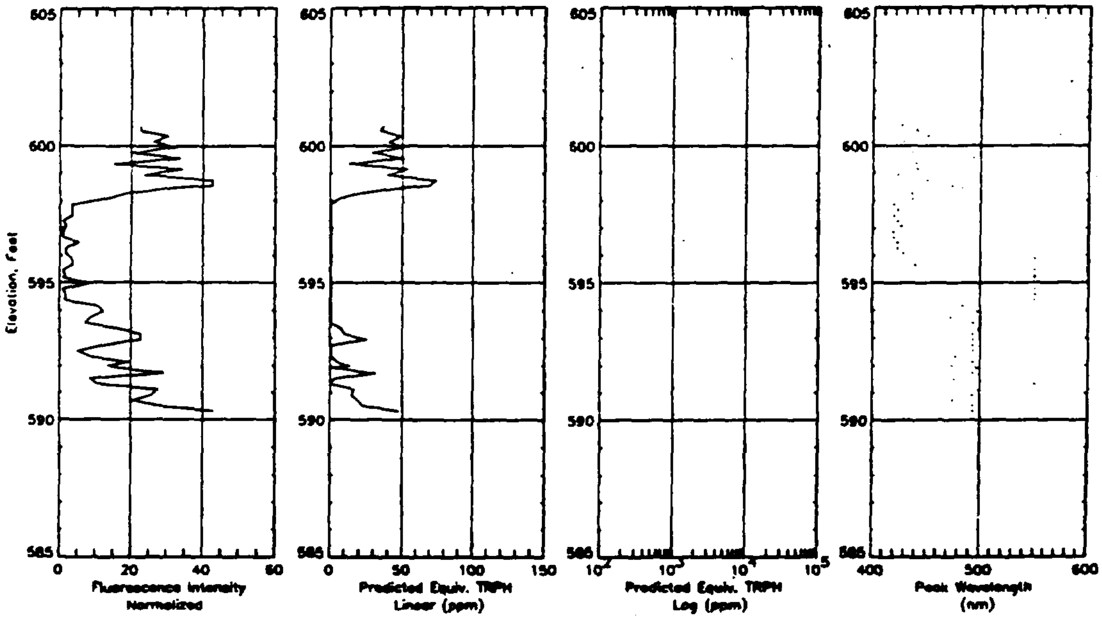
Figure A22. Results of fluorescence probe conducted between H9 and H10 on the survey grid.



Probe = OCIH100
Easting(ft.) = 11679.41
Northing(ft.) = 11207.41
Elevation(ft.) = 601.71

1 foot = 0.3048 meters
1 ton/sq.ft = 0.958 bars

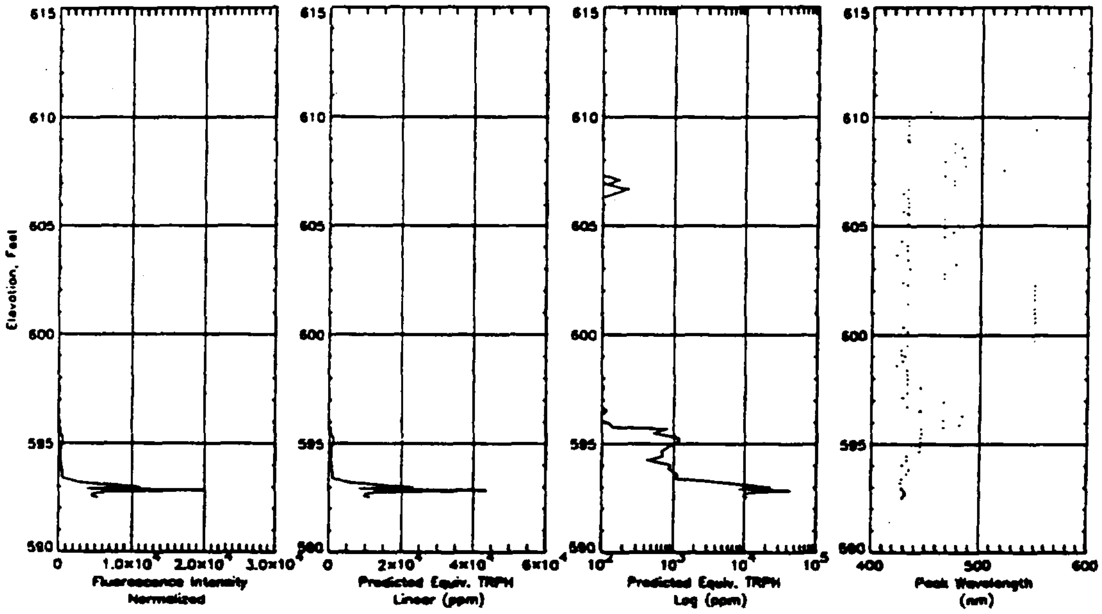
Figure A23. Results of fluorescence probe conducted at location H10 on the survey grid.



Probe = OCIH110
Easting(ft.) = 11679.41
Northing(ft.) = 11207.36
Elevation(ft.) = 602.27

1 foot = 0.3048 meters
1 ton/sq.ft = 0.958 bars

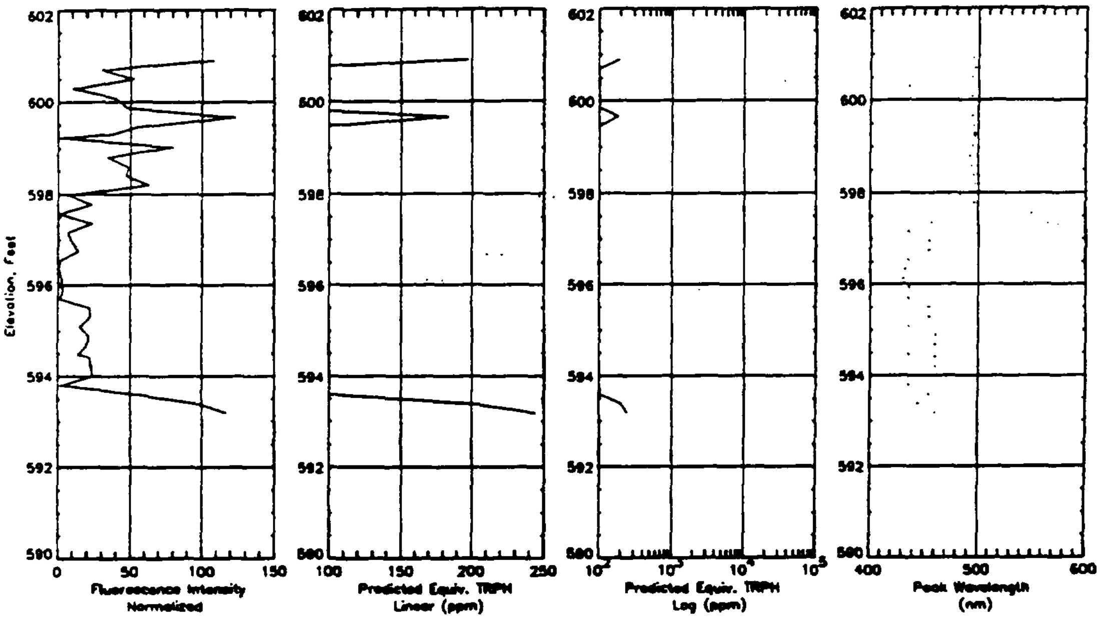
Figure A24. Results of fluorescence probe conducted at location H11 on the survey grid.



Probe = OCII40
Easting(ft.) = 11929.41
Northing(ft.) = 9357.36
Elevation(ft.) = 610.30

1 foot = 0.3048 meters
1 ton/sq.ft = 0.958 bars

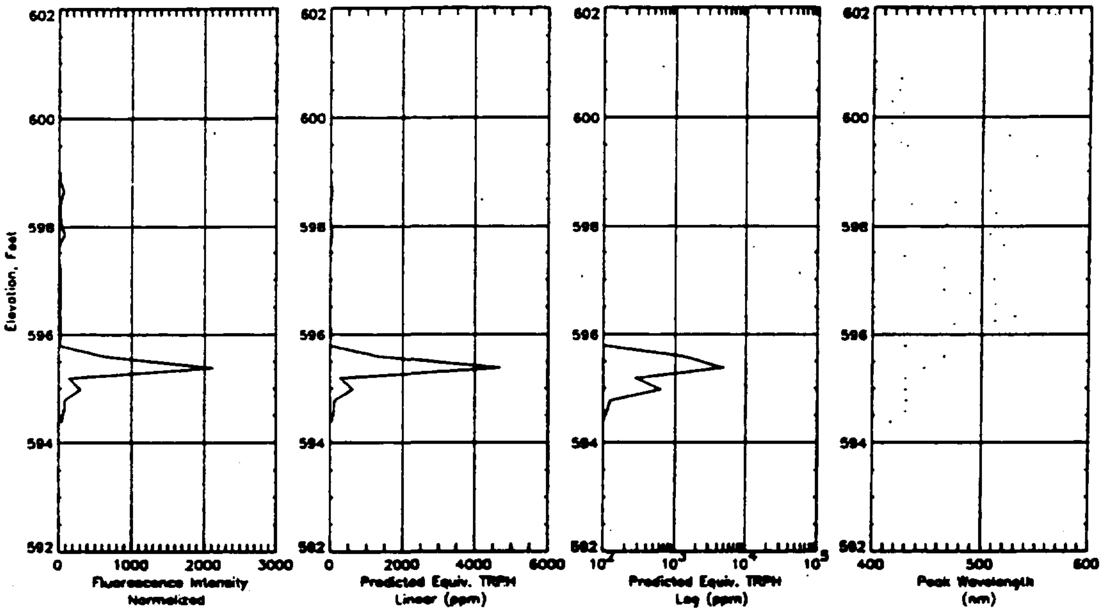
Figure A26. Results of fluorescence probe conducted at location I4 on the survey grid.



Probe = OCI150
Easting(ft.) = 11979.41
Northing(ft.) = 9732.36
Elevation(ft.) = 601.00

1 foot = 0.3048 meters
1 ton/sq.ft = 0.958 bars

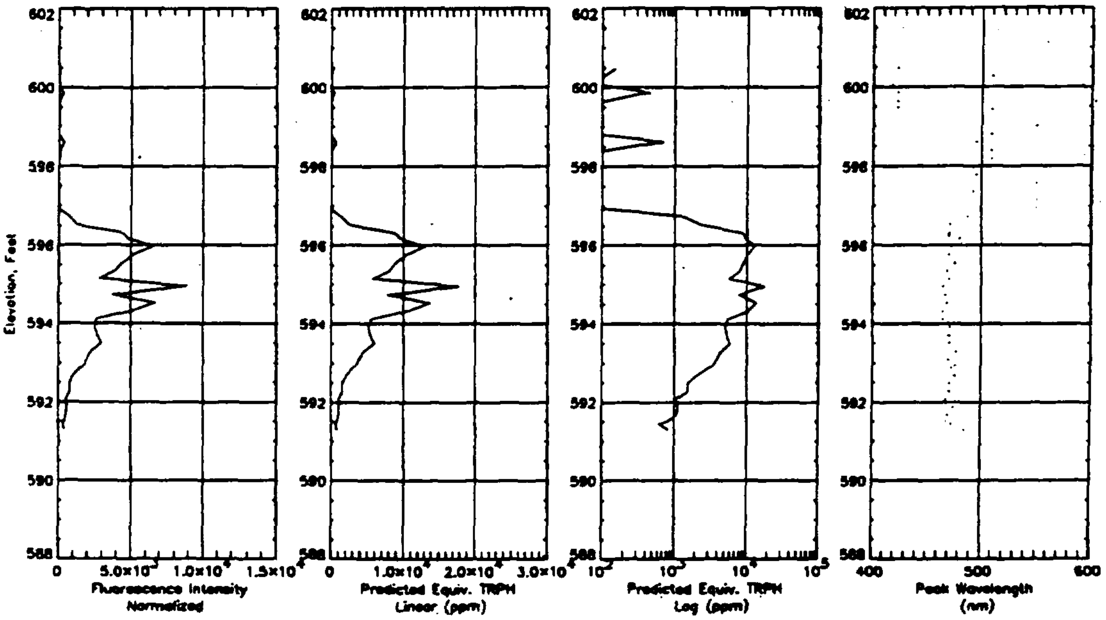
Figure A27. Results of fluorescence probe conducted at location I5 on the survey grid.



Probe = OCI155
Easting(ft.) = 12029.41
Northing(ft.) = 9757.36
Elevation(ft.) = 601.00

1 foot = 0.3048 meters
1 ton/sq.ft = 0.958 bars

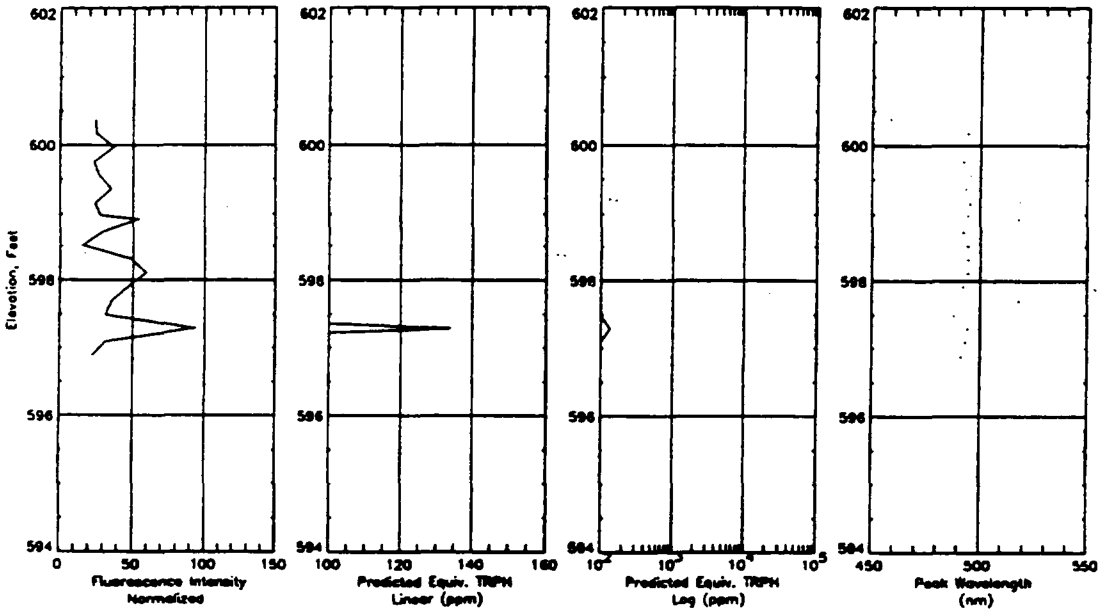
Figure A28. Results of fluorescence probe conducted between I5 and J5 on the survey grid.



Probe = OCII60
Easting(ft.) = 11979.41
Northing(ft.) = 10007.36
Elevation(ft.) = 600.89

1 foot = 0.3048 meters
1 ton/sq.ft = 0.958 bars

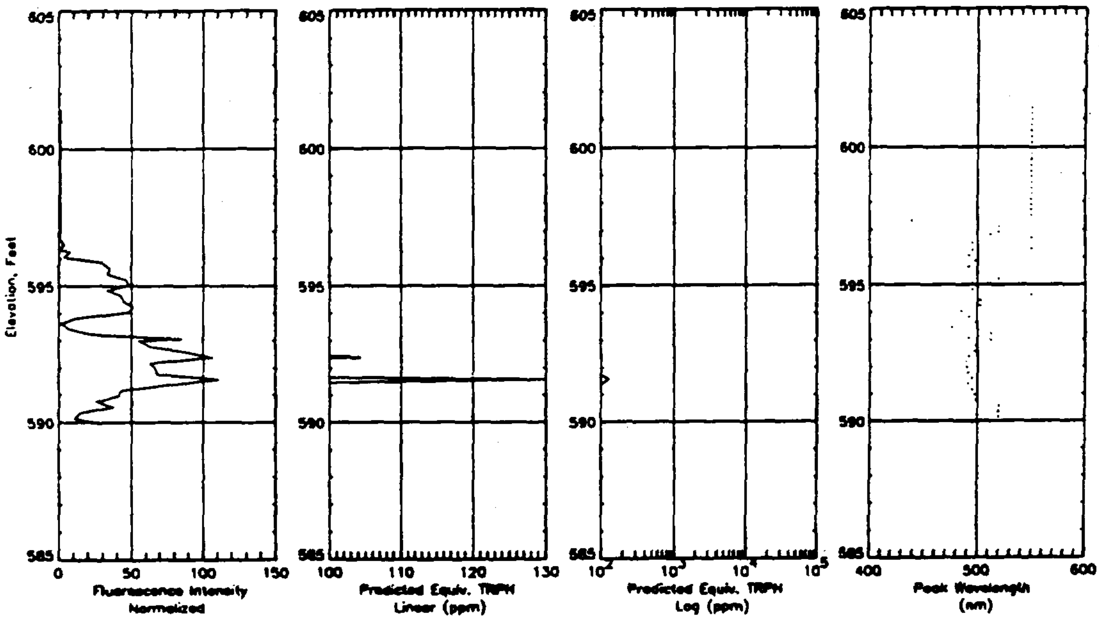
Figure A29. Results of fluorescence probe conducted at location I6 on the survey grid.



Probe = OCII70
Easting(ft.) = 11979.41
Northing(ft.) = 10307.36
Elevation(ft.) = 600.66

1 foot = 0.3048 meters
1 ton/sq.ft = 0.958 bars

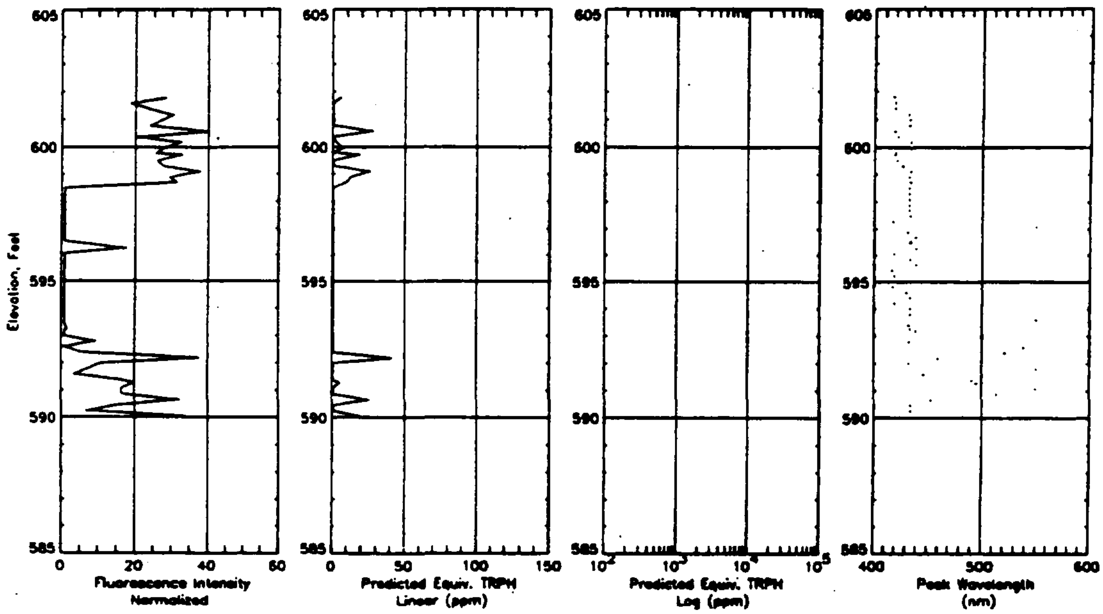
Figure A30. Results of fluorescence probe conducted at location I7 on the survey grid.



Probe = OCI1100
Easting(ft.) = 11979.41
Northing(ft.) = 11322.36
Elevation(ft.) = 603.04

1 foot = 0.3048 meters
1 ton/sq.ft = 0.958 bars

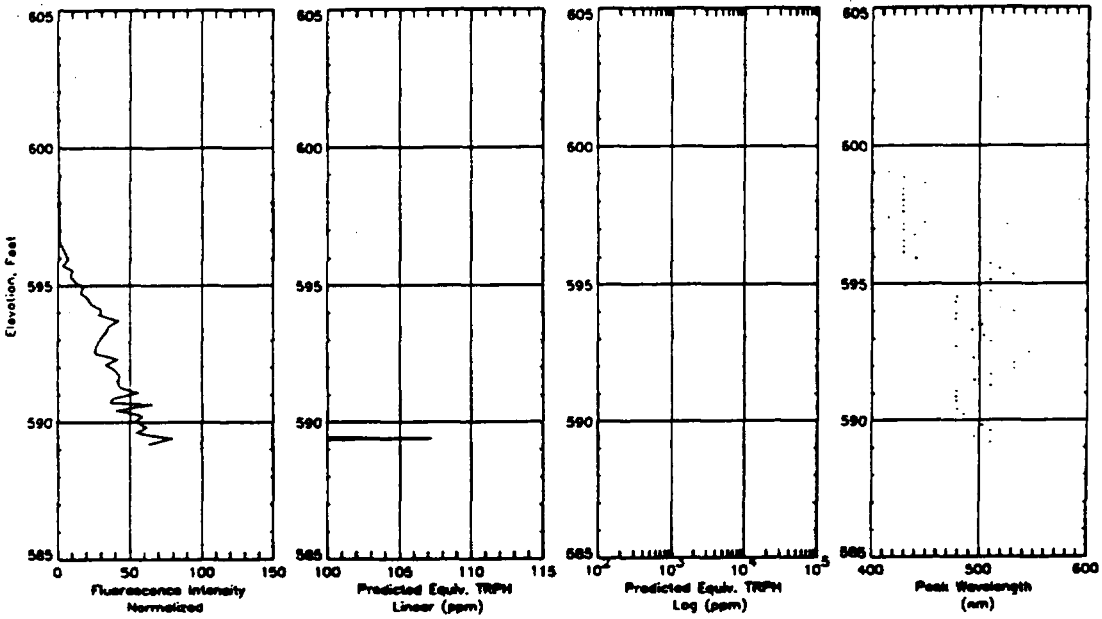
**Figure A32.** Results of fluorescence probe conducted at location I10 on the survey grid.



Probe = OCII110
Easting(ft.) = 11979.41
Northing(ft.) = 11507.36
Elevation(ft.) = 603.43

1 foot = 0.3048 meters
1 ton/sq.ft = 0.958 bars

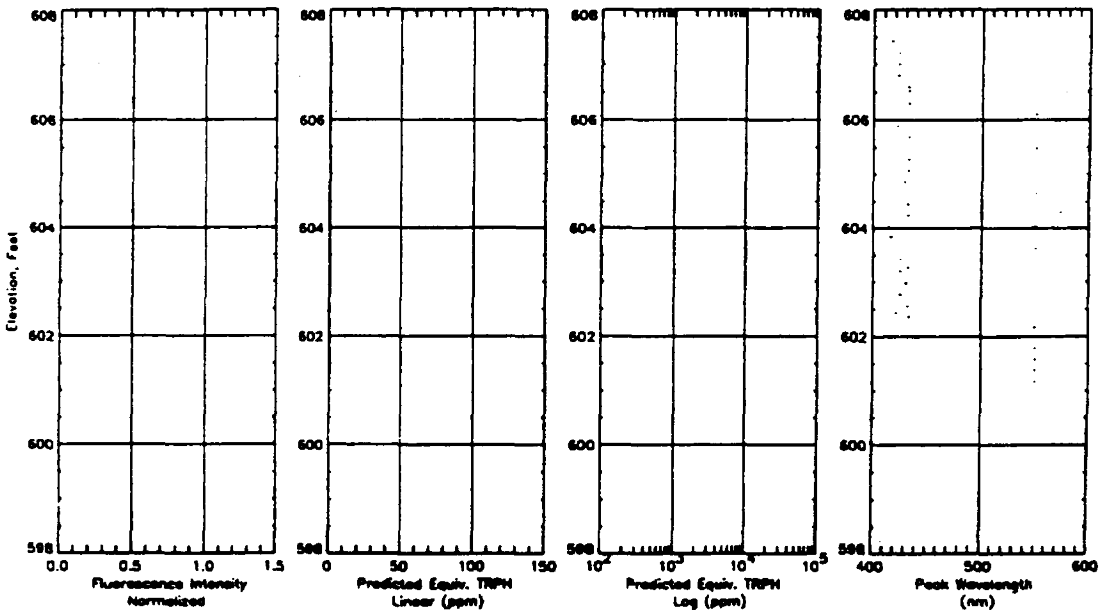
Figure A33. Results of fluorescence probe conducted at location I11 on the survey grid.



Probe = OCII120
Easting(ft.) = 11979.41
Northing(ft.) = 11857.36
Elevation(ft.) = 600.80

1 foot = 0.3048 meters
1 ton/sq.ft = 0.958 bars

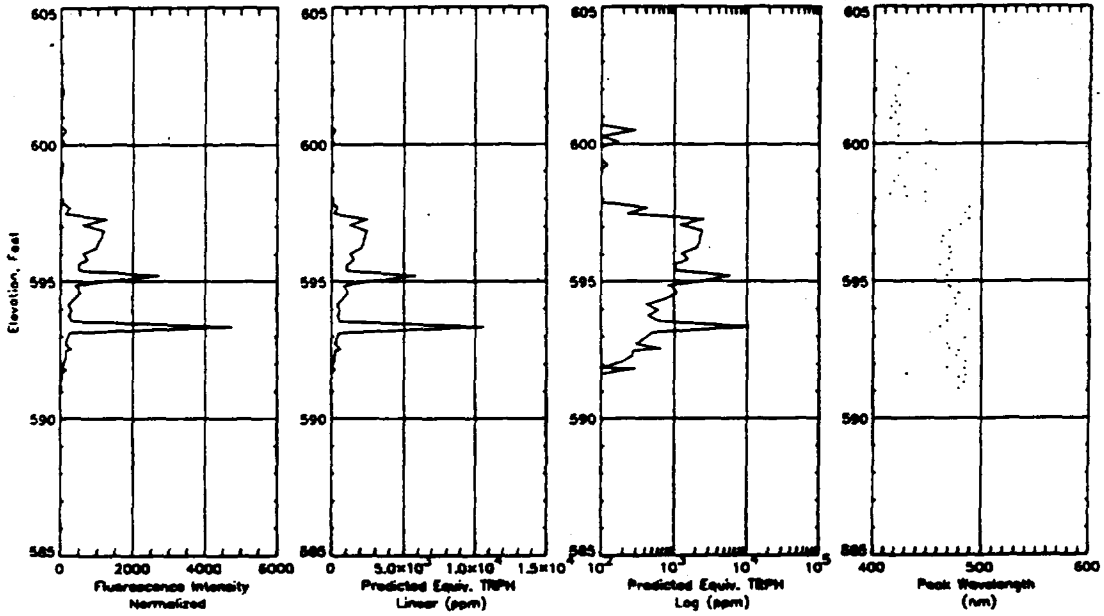
Figure A34. Results of fluorescence probe conducted at location I12 on the survey grid.



Probe = OCIJ40
Easting(ft.) = 12149.41
Northing(ft.) = 9407.36
Elevation(ft.) = 607.50

1 foot = 0.3048 meters
1 ton/sq.ft = 0.958 bars

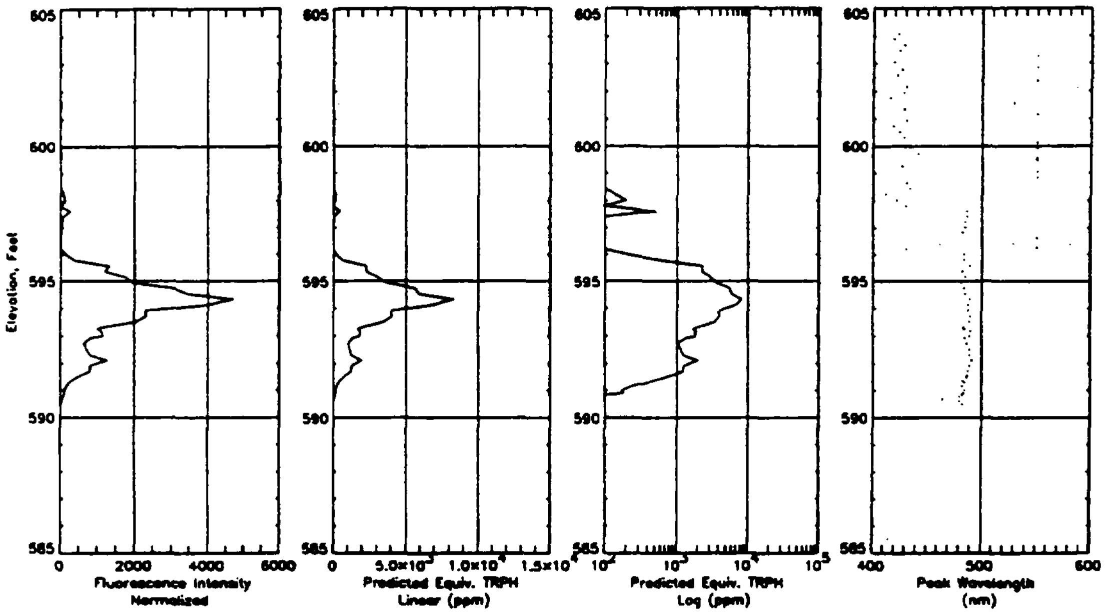
**Figure A35.** Results of fluorescence probe conducted at location J4 on the survey grid.



Probe = OCIJ50
Easting(ft.) = 12139.41
Northing(ft.) = 9707.36
Elevation(ft.) = 603.04

1 foot = 0.3048 meters
1 ton/sq.ft = 0.958 bars

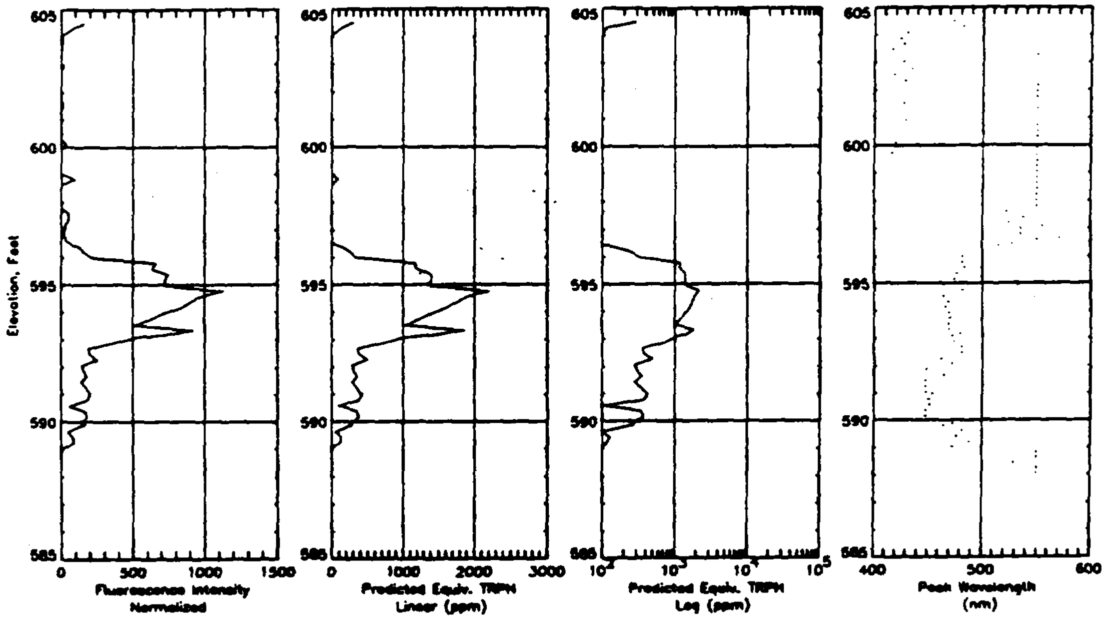
Figure A36. Results of fluorescence probe conducted at location J5 on the survey grid.



Probe = OCIJ60
Easting(ft.) = 12243.91
Northing(ft.) = 10007.36
Elevation(ft.) = 604.36

1 foot = 0.3048 meters
1 ton/sq.ft = 0.958 bars

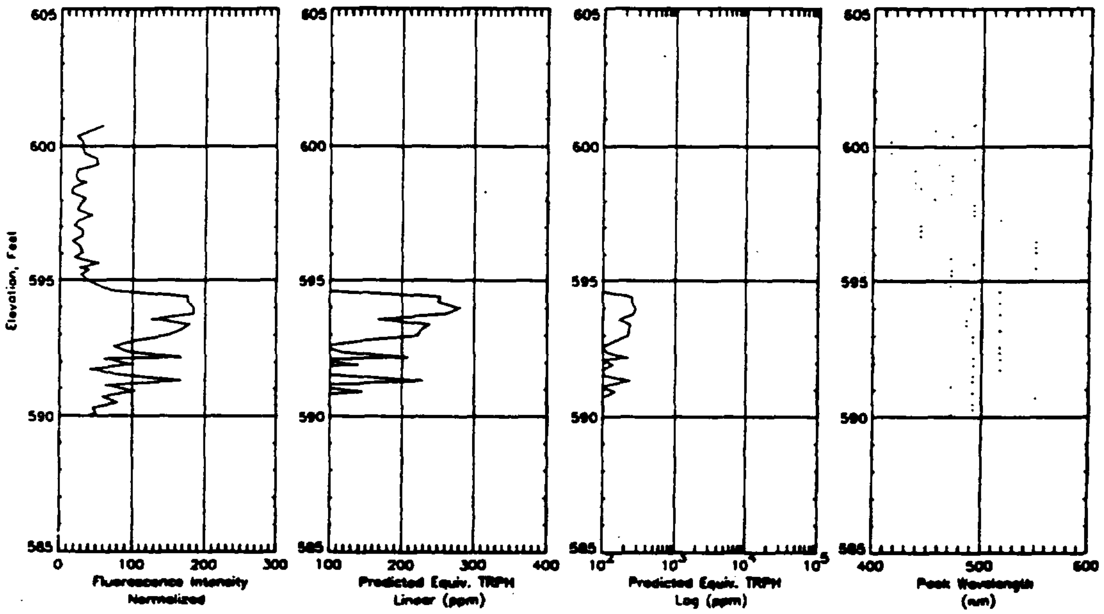
Figure A37. Results of fluorescence probe conducted at location J6 on the survey grid.



Probe = OCIJ70
Easting(ft.) = 12239.41
Northing(ft.) = 10246.36
Elevation(ft.) = 604.77

1 foot = 0.3048 meters
1 ton/sq.ft = 0.958 bars

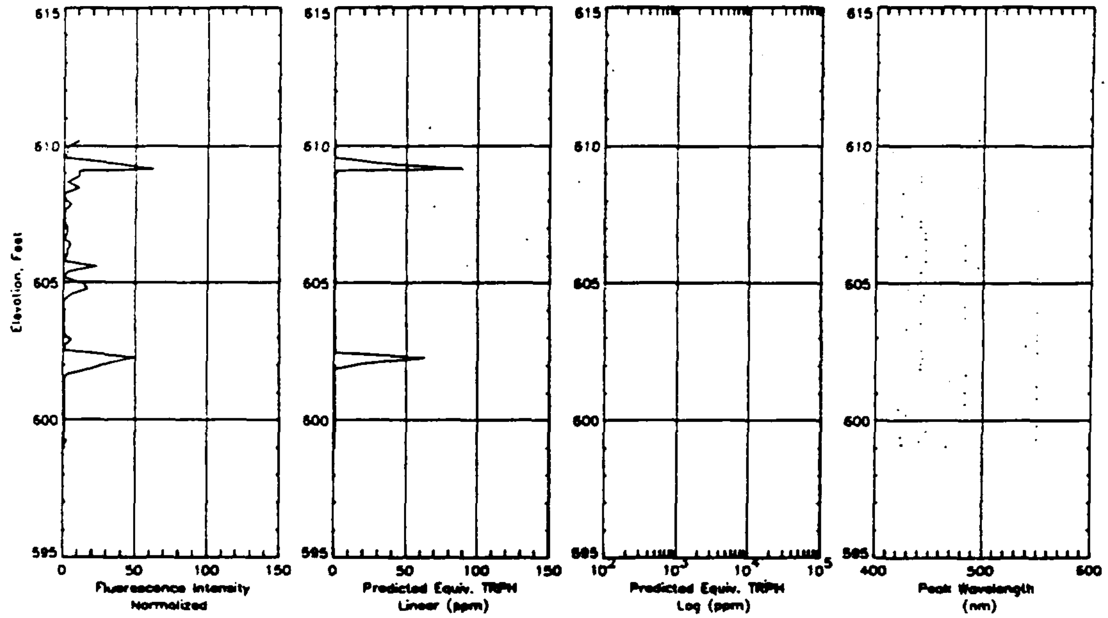
Figure A38. Results of fluorescence probe conducted at location J7 on the survey grid.



Probe = OCIJ80
Easting(ft.) = 12239.41
Northing(ft.) = 10607.36
Elevation(ft.) = 602.27

1 foot = 0.3048 meters
1 ton/sq.ft = 0.958 bars

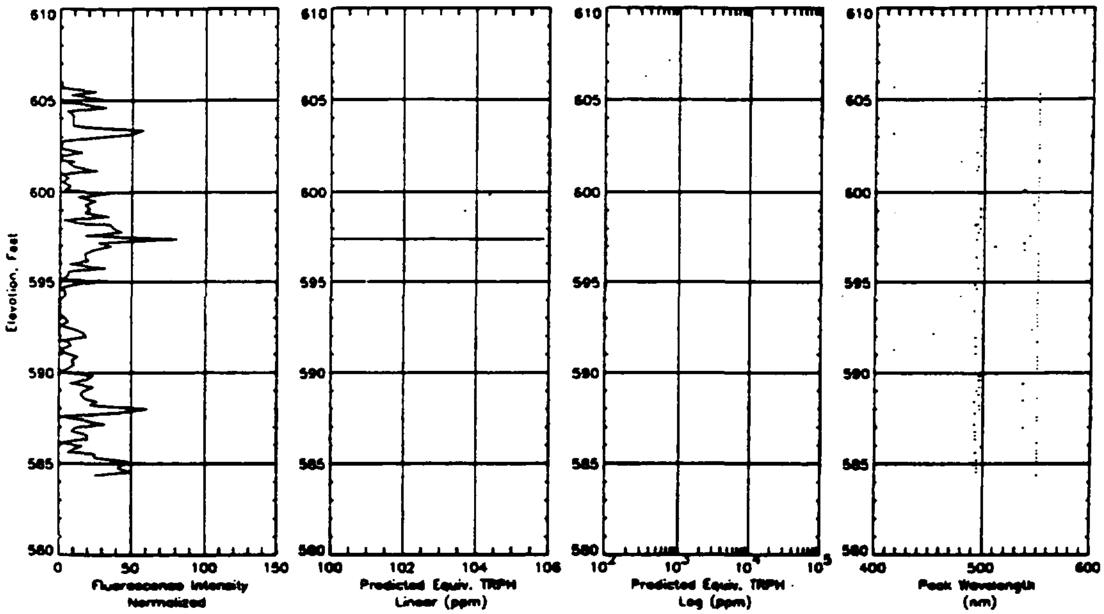
Figure A39. Results of fluorescence probe conducted at location J8 on the survey grid.



Probe = OCIMW2
Easting(ft.) = 11963.30
Northing(ft.) = 9273.21
Elevation(ft.) = 610.30

1 foot = 0.3048 meters
1 ton/sq.ft = 0.958 bars

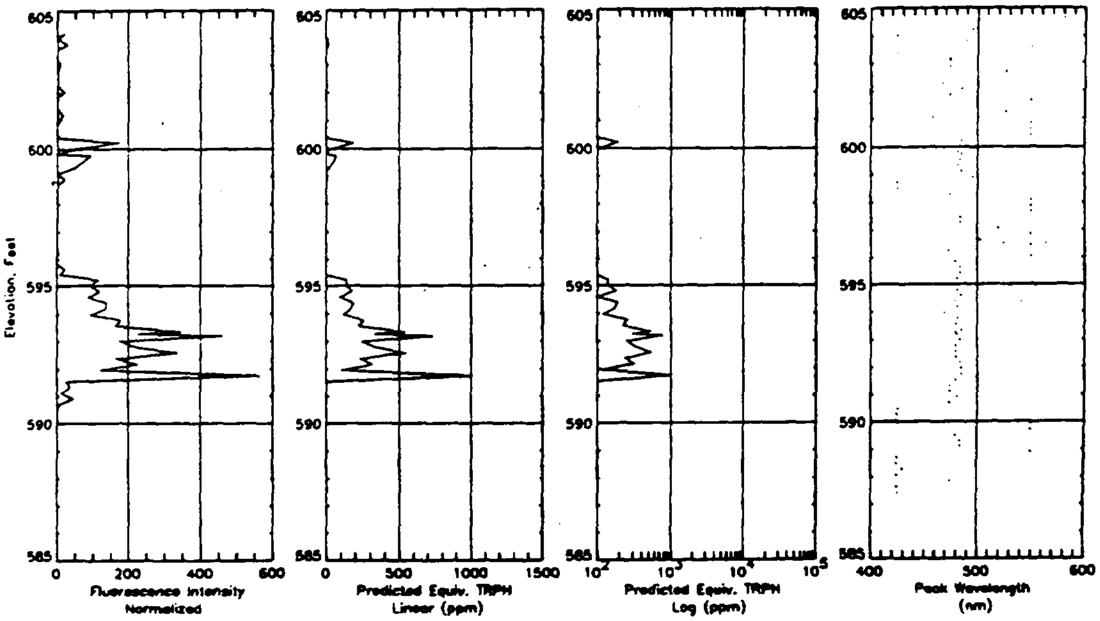
Figure A40. Results of fluorescence probe conducted near Chemical Building #2 (MW-2) on the survey grid.



robe = OCIMW3
Easting(ft.) = 11820.25
Northing(ft.) = 8934.44
Elevation(ft.) = 606.00

1 foot = 0.3048 meters
1 ton/sq.ft = 0.958 bars

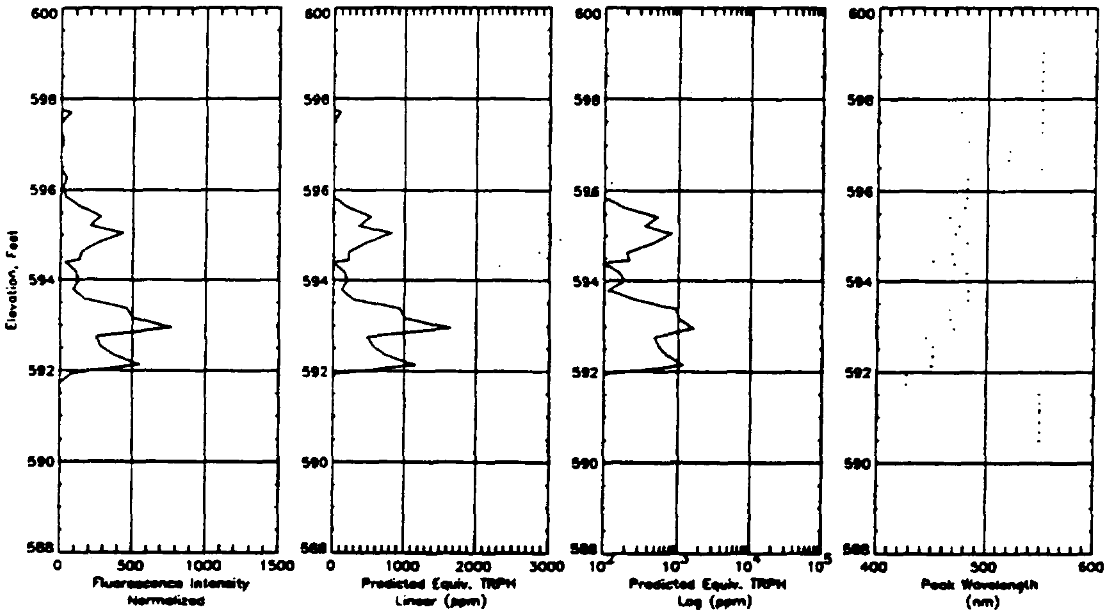
**Figure A41. Results of fluorescence probe conducted west of Warehouse (MW-3) on the survey grid.**



Probe = OCIMW4
Easting(ft.) = 11710.81
Northing(ft.) = 9355.65
Elevation(ft.) = 604.30

1 foot = 0.3048 meters
1 ton/sq.ft = 0.958 bars

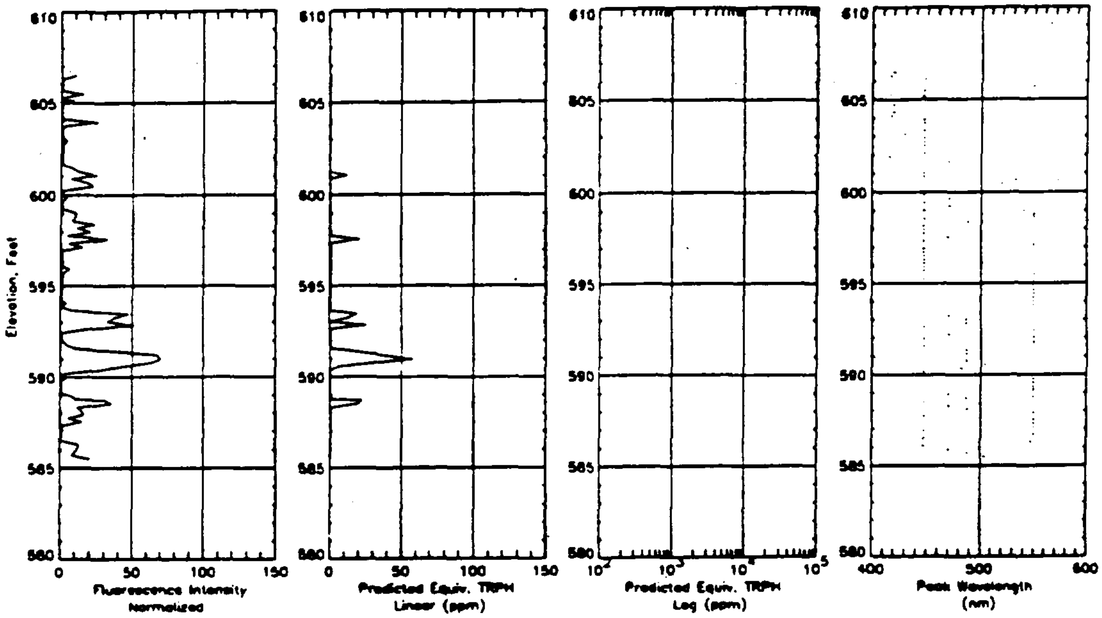
Figure A42. Results of fluorescence probe conducted between H3 and H4 (MW-4) on the survey grid.



Probe = OCIMW5
Easting(ft.) = 11899.76
Northing(ft.) = 9822.47
Elevation(ft.) = 599.10

1 foot = 0.3048 meters
1 ton/sq.ft = 0.958 bars

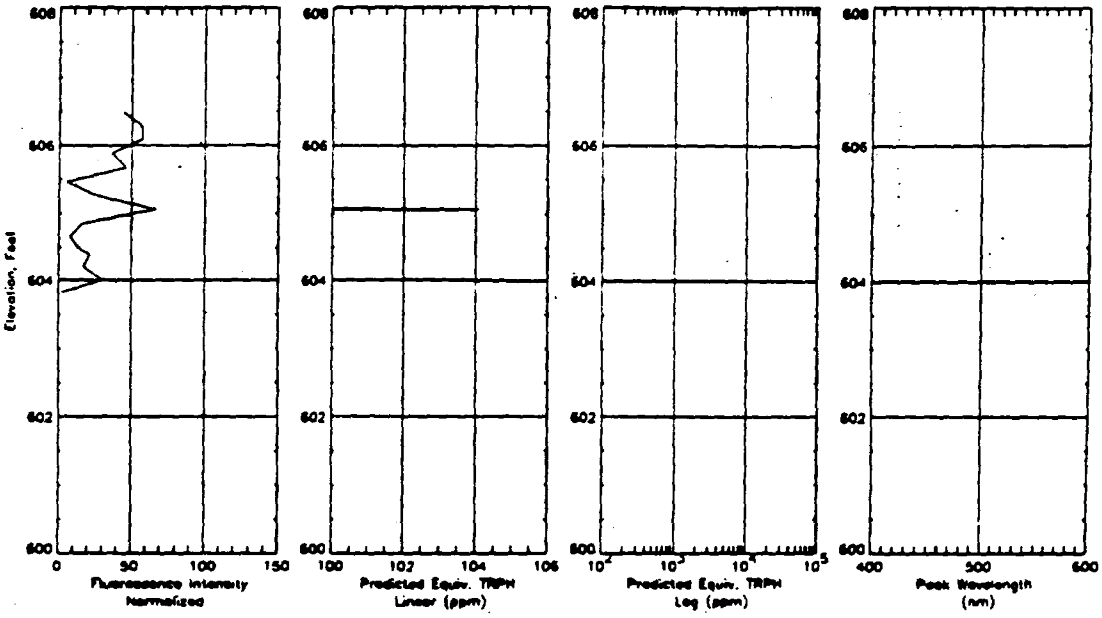
Figure A43. Results of fluorescence probe conducted between I5 and I6 (MW-5) on the survey grid.



robe = OCIMW7
Easting(ft.) = 11302.34
Northing(ft.) = 8277.15
Elevation(ft.) = 606.60

1 foot = 0.3048 meters
1 ton/sq.ft = 0.958 bars

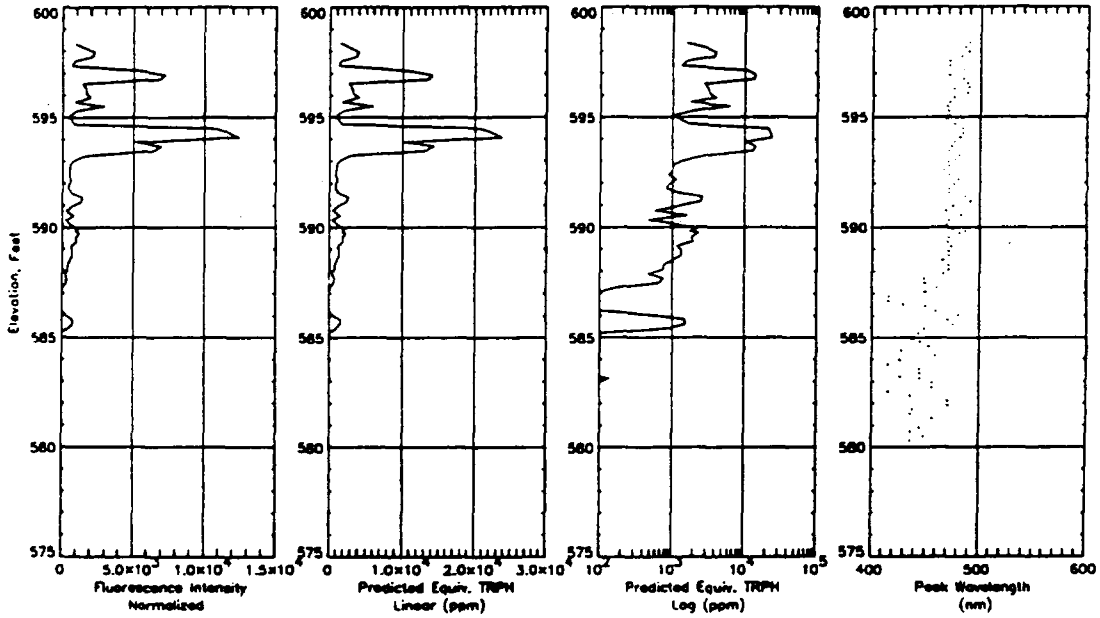
Figure A44. Results of fluorescence probe conducted near G1 (MW-7) on the survey grid.



Probe = OCIMW8
Easting(ft.) = 10908.01
Northing(ft.) = 9102.00
Elevation(ft.) = 608.10

1 foot = 0.3048 meters
1 ton/sq.ft = 0.958 bars

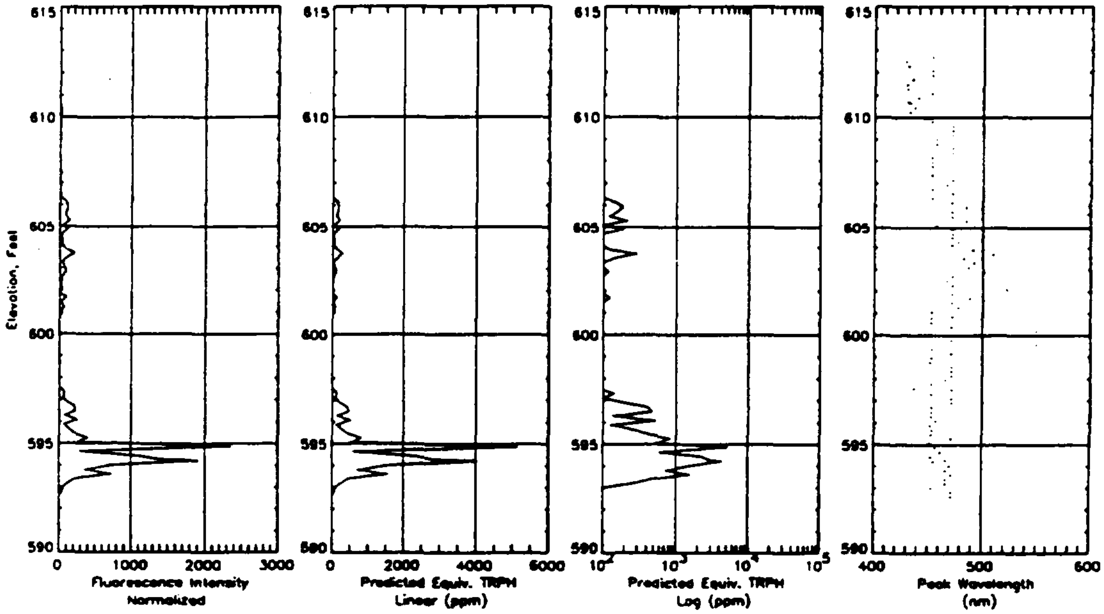
Figure A45. Results of fluorescence probe conducted between E3 and F3 (MW-8) on the survey grid.



Probe = OCIMW16
Easting(ft.) = 11379.41
Northing(ft.) = 11497.36
Elevation(ft.) = 600.00

1 foot = 0.3048 meters
1 ton/sq.ft = 0.958 bars

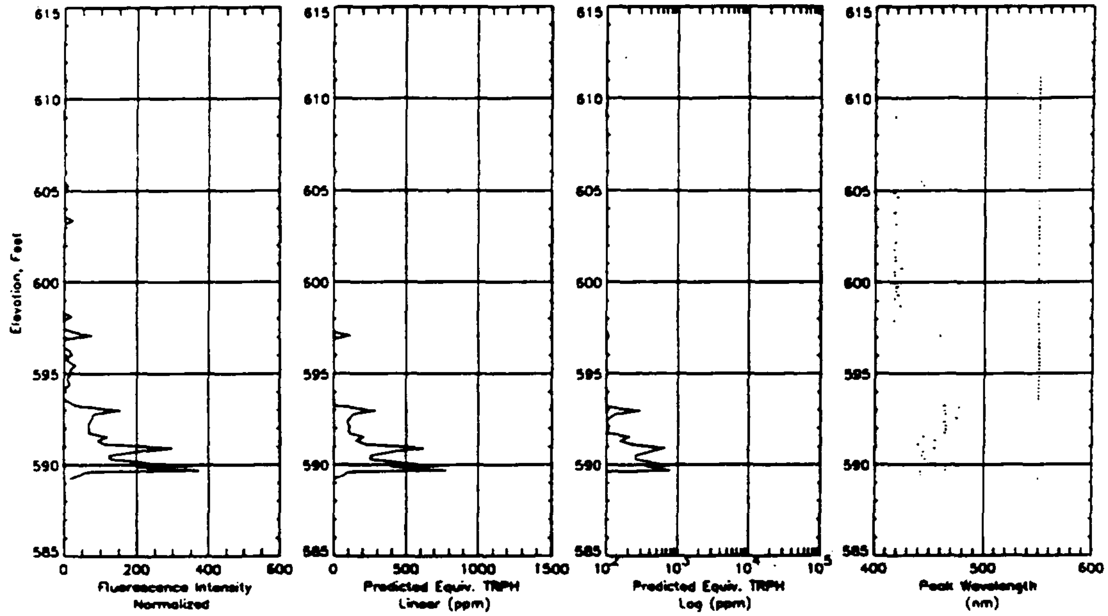
Figure A46. Results of fluorescence probe conducted at location G11 (MW-16) on the survey grid.



robe = OCIMW22
Easting(ft.) = 12065.84
Northing(ft.) = 9197.34
Elevation(ft.) = 614.20

1 foot = 0.3048 meters
1 ton/sq.ft = 0.958 bars

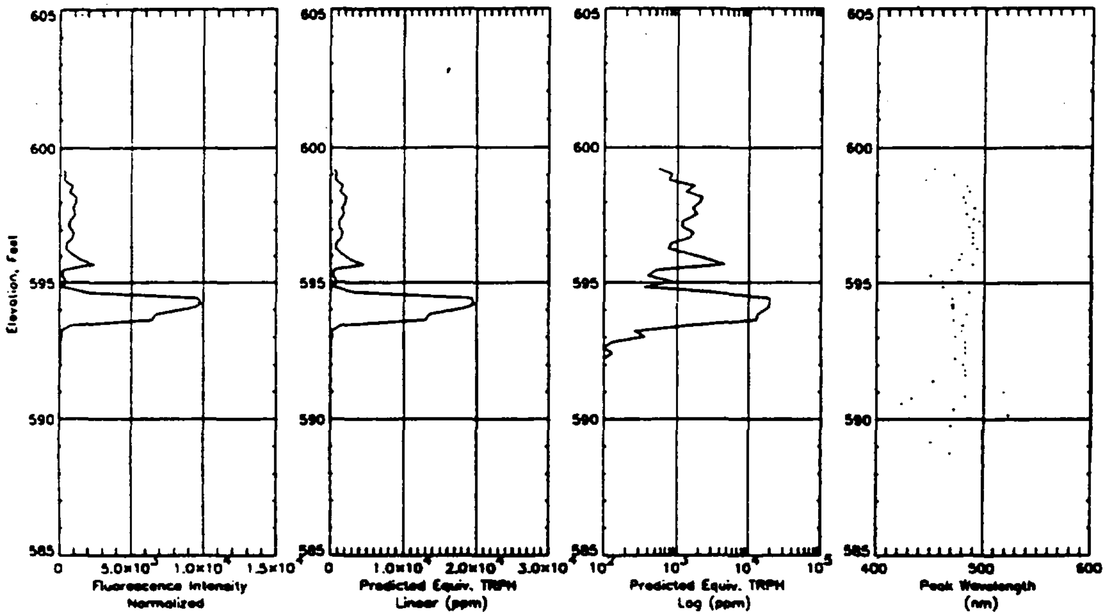
Figure A47. Results of fluorescence probe conducted between I3 and J3 (MW-22) on the survey grid.



robe = OCIMW23
Easting(ft.) = 12252.61
Northing(ft.) = 9432.44
Elevation(ft.) = 611.20

1 foot = 0.3048 meters
1 ton/sq.ft = 0.958 bars

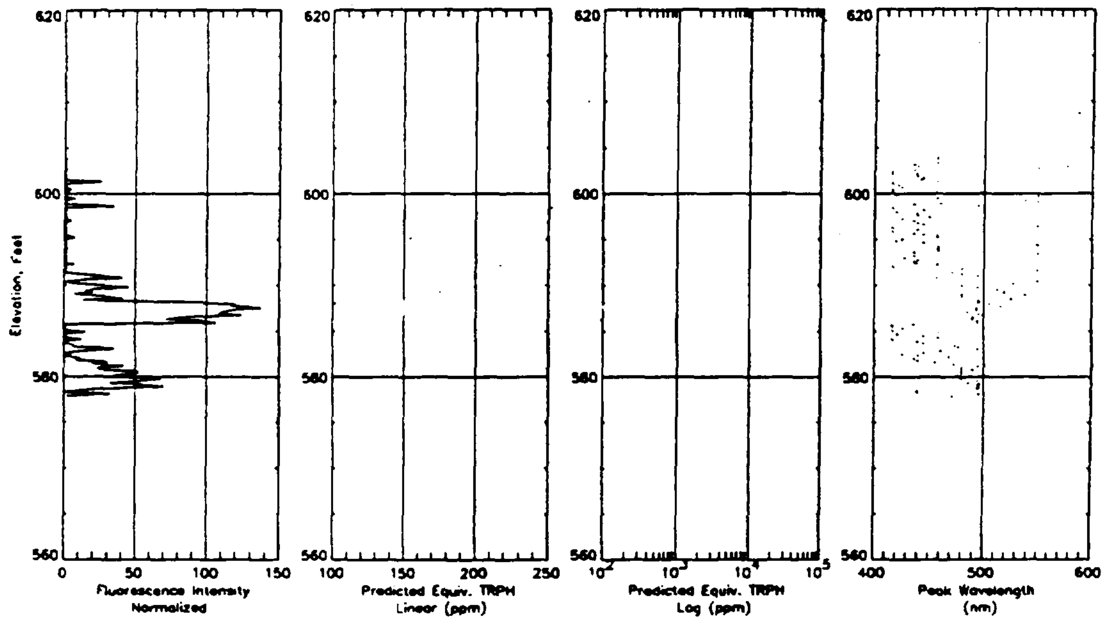
Figure A48. Results of fluorescence probe conducted near Boiler House (MW-23) on the survey grid.



Probe = OCIPB16
Easting(ft.) = 11679.41
Northing(ft.) = 11657.36
Elevation(ft.) = 600.80

1 foot = 0.3048 meters
1 ton/sq.ft = 0.958 bars

Figure A49. Results of fluorescence probe conducted between H11 and H12 (near Prein & Newhoff boring #16) on the survey grid.



robe = OCII196
Easting(ft.) = 11379.41
Northing(ft.) = 11757.36
Elevation(ft.) = 605.50

1 foot = 0.3048 meters
1 ton/sq.ft = 0.958 bars

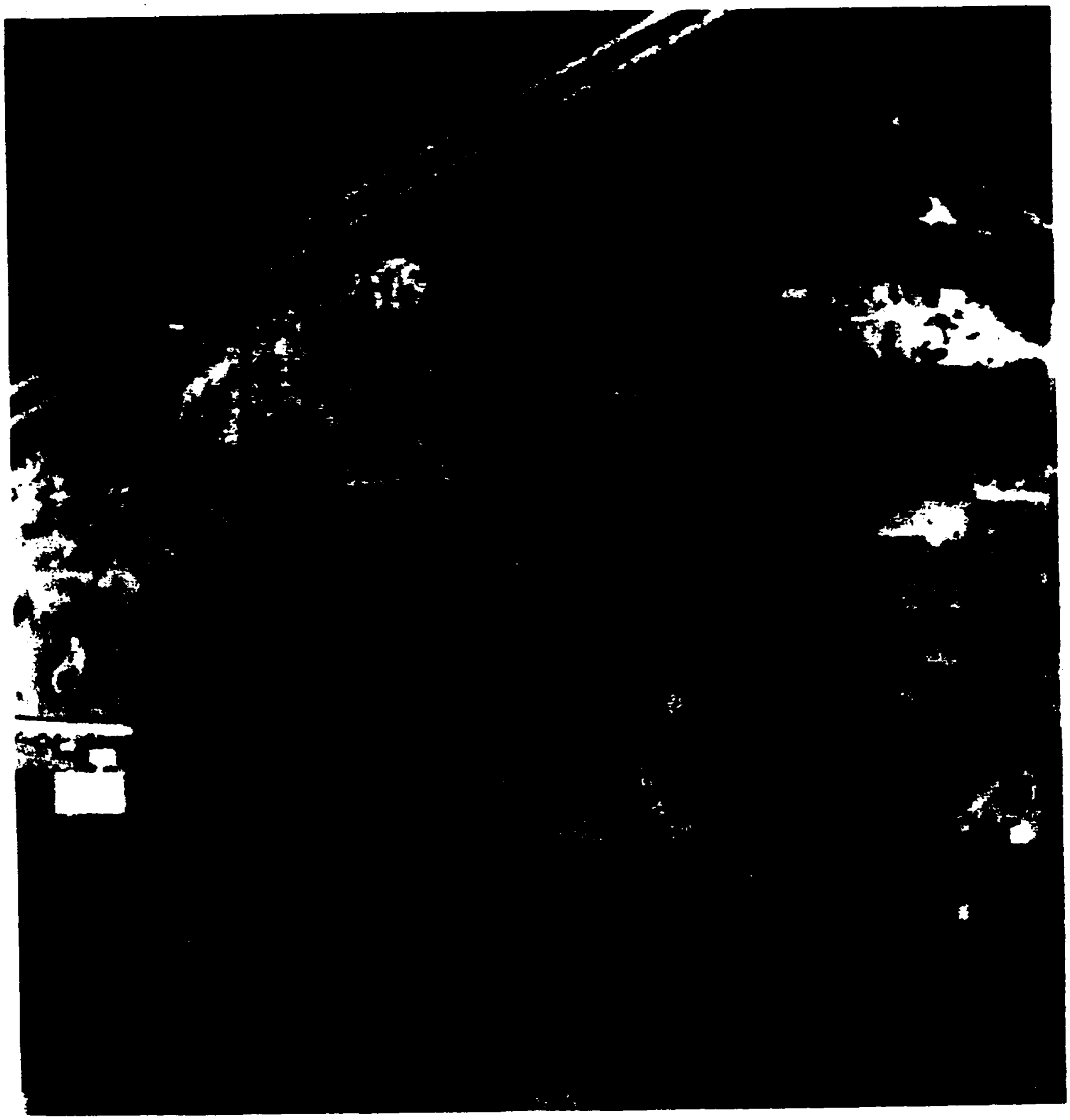
Figure A50. Results of fluorescence probe conducted across Interstate 196 (near G12).

# Appendix B: Aerial photographs with plume superimposed.

**Waterways Experiment Station Cataloging-in-Publication Data**

Sharp, Michael K.
Use of the site characterization and analysis penetrometer system at Grandville, Michigan Superfund site / by Michael K. Sharp, Raju Kala and Jeff Powell ; prepared for US Environmental Protection Agency, Region V [and] US Army Toxic and Hazardous Materials Agency.
99 p. : ill.; 28 cm. -- (Miscellaneous paper; GL-92-38)
Includes bibliographical references.
1. Environmental impact analysis -- Michigan -- Grandville -- Measurement -- Instruments. 2. Penetrometer -- Environmental aspects. 3. Soil surveys -- Michigan -- Grandville -- Geophysical methods -- Environmental aspects. 4. Pollution -- Michigan -- Grandville -- Measurement -- Instruments. I. Kala, Raju. II. Powell, Jeff F. III. United States. Environmental Protection Agency. Region V. IV. U.S. Army Toxic and Hazardous Materials Agency. V. U.S. Army Engineer Waterways Experiment Station. VI. Title. VII. Series: Miscellaneous paper (U.S. Army Engineer Waterways Experiment Station); GL-92-38.
TA7 W34m no.GL-92-38

# Organic Chemicals Inc.
# 4000 TRPH and Above



Scale 1"≅ 400'

N

▨ Above 4000 ppm
Volume - 717,289.4 ft³
Elevation range 588.9' - 596.8'

U.S. ARMY ENGINEER WATERWAYS EXPERIMENT STATION

Figure B2. Aerial photograph with contaminant plume superimposed, concentrations of 5000 ppm and greater

# Organic Chemicals Inc.
# 100 TRPH and Above

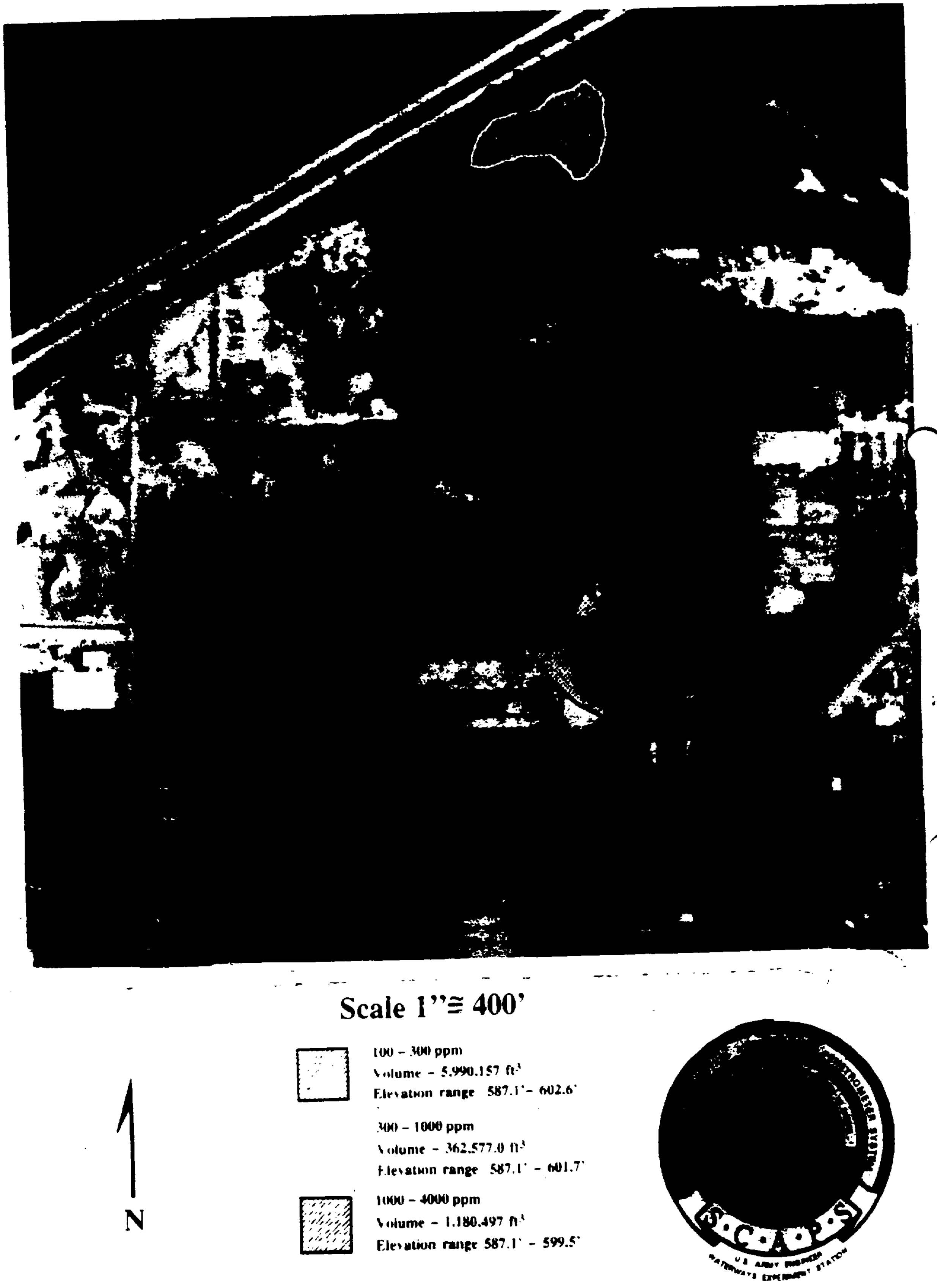


Figure B1 Aerial photograph with contaminant plume superimposed, concentrations of 100 ppm and greater

# APPENDIX N

# TENTATIVELY IDENTIFIED COMPOUND RISK EVALUATION

# Appendix N

Assumptions in the following list are used to determine what compound will accurately estimate the toxicity of a tentatively identified compound (TIC).

The following compounds are considered non-toxic or ignored:

- Unknown compounds.
- Unknown floroalkanes.
- Unknown organics for which the number of carbon atoms cannot be estimated.
- Unknown siloxanes.
- Aldol.
- Argon.
- Blank contaminants.
- Carbon dioxide.
- Laboratory artifacts.

Compounds possess the toxic effects of their tentative identifications.

Alkanes containing one to eight ($C_1$ to $C_8$) carbon atoms whose tentative identifications are not in the U.S. Environmental Protection Agency (USEPA) toxic databases have the same toxic effects as:

- Chemically similar compounds.
- N-Hexane.

Alkanes containing nine to sixteen ($C_9$ to $C_{16}$) carbon atoms whose tentative identifications are not in the USEPA toxic databases have the same toxic effects as:

- Chemically similar compounds.
- Methyl cyclohexane.

Alkanes, alkenes, cyclics and aromatics containing more than sixteen ($>C_{16}$) carbon atoms whose tentative identifications are not in the USEPA toxic databases have the same toxic effects as:

- Chemical similar compounds.
- To be non-toxic.

Alkenes, cyclic hydrocarbons, and other unsaturated compounds containing one to sixteen carbon atoms whose tentative identifications are not in the USEPA toxic databases have the same toxic effects as:

- Chemically similar compounds.
- Methyl cyclohexane.

TICs and unknown carboxylic acids that are not in the USEPA toxic databases have the same toxic effects as:

- Chemically similar compounds.
- Benzoic acid.

TICs and unknown ketones that are not in the USEPA toxic databases have the same toxic effects as:

- Chemically similar compounds.
- Methyl isobutyl ketone if they contain eight or less ($\leq C_8$) carbon atoms.
- Acetophenone, if they contain more than eight ($> C_8$) carbon atoms.

TICs and unknown alcohols that are not in the USEPA toxic databases have the same effects as:

- Chemically similar compounds.
- Propylene glycol.

TICs and unknown esters that are not in the USEPA toxic databases have the same toxic effects as:

- Chemically similar compounds.
- Methylacetate if they contain eight or less ($\leq C_8$) carbon atoms.
- Butyl benzyl phthalate if they contain more than eight ($> C_8$) carbon atoms.

TICs and unknown organics containing nitrogen that are not in the USEPA toxic databases have the same toxic effects as:

- Chemically similar compounds.
- Diphenylamine.

TICs and unknown polyaromatic hydrocarbons that are not in the USEPA toxic databases have the same toxic effects as:

- Chemically similar compounds.
- Acenaphthene.

TICs and unknown aldehydes that are not in the USEPA toxic databases have the same toxic effects as:

- Chemically similar compounds.
- Benzaldehyde.

TICs and unknown compounds containing chlorine that are not in the USEPA toxic databases have the same toxic effects as:

- Chemically similar compounds.
- Trichlorofluoro methanes.

## Table N-1
## Volatile Tentatively Identified Compounds
## Organic Chemicals, Inc.

| Tentatively Identified Compounds | | | | Compound Used to Provide Estimated Risk Values | | | |
|---|---|---|---|---|---|---|---|
| CAS Number | Compound Name | # of Carbon Molecules | Molecular Weight | CAS Number | Compound Name | # of Carbon Molecules | Molecular Weight |
| 75694 | Trichloroflurومethane | 1 | 137.37 | 75694 | Trichloroflurومethane | 1 | 137.37 |
| 75070 | Acetaldehyde | 2 | 44.05 | 75070 | Acetaldehyde | 2 | 44.05 |
| 75078 | Acetonitrile | 2 | 41.05 | 75078 | Acetonitrile | 2 | 41.05 |
| 107040 | 1-Bromo-2chloroethane | 2 | 143.41 | 75003 | Bromoethene | 2 | 106.95 |
| 354234 | 1,2-Dichloro-1,1,2 trifluroethane | 2 | 152.92 | 107062 | 1,2-Dichloroethane | 2 | 98.96 |
| 64175 | Ethanol | 2 | 46.07 | 107211 | Ethylene glycol | 2 | 62.07 |
| 115106 | Oxybis-methane | 2 | 46.07 | 67561 | Methanol | 1 | 32.04 |
| 79209 | Acetic acid-methy ester | 3 | 74.08 | 79209 | Methyl acetate | 3 | 74.08 |
| 109875 | Dimethoxy methane | 3 | 76.10 | 109864 | 2-Methoxy ethanol | 3 | 76.10 |
| 420564 | Flurotrimethyl silane | 3 | 92.19 | 110543 | n-Hexane | 6 | 86.18 |
| 1066406 | Trimethyl silanol | 3 | 90.17 | 57556 | Propylene glycol | 3 | 76.10 |
| 10688788 | Ethyl oxirane | 4 | 72.11 | 108101 | Methylisobutyl ketone | 6 | 100.16 |
| 1825612 | Methoxytrimethyl silane | 4 | 104.22 | | Assumed to be non-toxic | | |
| 109999 | Tetrohydro furan | 4 | 72.11 | 110009 | Furan | 4 | 68.08 |
| 110021 | Thiophene | 4 | 84.142 | 505293 | 1,4-Dithiane | 4 | 120.24 |
| 119196496 | Ethyl cyclopropane | 5 | 70.14 | 108872 | Methyl cyclohexane | 7 | 98.19 |
| | Unknown hydrocarbon | 5 | 70.14 | 108872 | Methyl cyclohexane | 7 | 98.19 |
| 294313030 | 2H-Thiopyrane-3(6H)-one | 5 | 130.17 | 505293 | 1,4 Dithiane | 4 | 120.24 |
| 71432 | Benzene | 6 | 78.11 | 71432 | Benzene | 6 | 78.11 |
| 542187 | Chlorocyclo hexane | 6 | 118.16 | 109693 | 1-Chlorobutane | 4 | 92.57 |
| 110827 | Cyclohexane | 6 | 84.16 | 108872 | Methyl cyclohexane | 7 | 98.19 |
| 110543 | Hexane | 6 | 86.18 | 110543 | n-Hexane | 6 | 86.18 |
| | Hexamethyl cyclotrisiloxane | 6 | 222.46 | | Assumed to be non-toxic | | |
| | 2,3,4-Trimethyl hexane | 6 | 92.23 | 110543 | n-Hexane | 6 | 86.18 |

Table N-1 (Continued)
Volatile Tentatively Identified Compounds
Organic Chemicals, Inc.

| Tentatively Identified Compounds | | | | Compound Used to Provide Estimated Risk Values | | | |
|---|---|---|---|---|---|---|---|
| CAS Number | Compound Name | # of Carbon Molecules | Molecular Weight | CAS Number | Compound Name | # of Carbon Molecules | Molecular Weight |
| 103651 | Propyl benzene | 9 | 120.20 | 99828 | Cumene (isopropyl benzene) | 9 | 120.20 |
| 526738 | 1,2,3-Trimethy benzene | 9 | 120.20 | 95636 | 1,2,4-Trimethyl benzene | 9 | 120.20 |
| 95636 | 1,2,4-Trimethyl benzene | 9 | 120.20 | 95636 | 1,2,4-Trimethyl benzene | 9 | 120.20 |
| 108678 | 1,3,5-Trimethyl benzene | 9 | 120.20 | 108678 | 1,3,5-Trimethyl benzene | 9 | 120.20 |
| | Trimethyl cyclohexane | 9 | 126.24 | 108872 | Methyl cyclohexane | 7 | 98.19 |
| 3073663 | 1,1,3-Trimethyl cyclohexane | 9 | 126.24 | 108872 | Methyl cyclohexane | 7 | 98.19 |
| 921471 | 2,3,4-Trimethylhexane | 9 | 128.26 | 108872 | Methyl cyclohexane | 7 | 98.19 |
| | Unknown akyl benzene | 9 | 120.20 | 99828 | Cumene (isopropyl benzene) | 9 | 120.20 |
| | Unknown hydrocarbon | 9 | 118.18 | 108872 | Methyl cyclohexane | 7 | 98.19 |
| | Unknown hydrocarbon | 9 | 120.20 | 108872 | Methyl cyclohexane | 7 | 98.19 |
| | Unknown hydrocarbon | 9 | 124.23 | 108872 | Methyl cyclohexane | 7 | 98.19 |
| | Unknown hydrocarbon | 9 | 126.24 | 108872 | Methyl cyclohexane | 7 | 98.19 |
| | Unknown hydrocarbon | 9 | 128.26 | 108872 | Methyl cyclohexane | 7 | 98.19 |
| | Decahydro naphthalene | 10 | 138.25 | 110543 | n-Hexane | 6 | 86.17 |
| | Decamethyl cyclopenta siloxane | 10 | 370.77 | | Assumed to be non toxic | | |
| | 1,4-Diethyl benzene | 10 | 134.22 | 135988 | sec-butyl benzene | 10 | 134.22 |
| | Dihydromethyl indene isomer | 10 | 131.20 | 91203 | Naphthalene | 10 | 128.17 |
| | 1,1-Dimethylethyl benzene | 10 | 134.22 | 135988 | Sec-butyl benzene | 10 | 134.22 |
| | Dimethylethyl cyclohexane | 10 | 140.27 | 108872 | Methyl cyclohexane | 7 | 98.19 |
| | Dimethyl octane | 10 | 142.29 | 108872 | Methyl cyclohexane | 7 | 98.19 |
| | Ethylmethyl heptane | 10 | 142.29 | 108872 | Methyl cyclohexane | 7 | 98.19 |
| | 2-Ethyl-1,4-dimethyl benzene | 10 | 134.22 | 135988 | Sec-butyl benzene | 10 | 134.22 |
| | Isopropyldimethyl cyclopentane | 10 | 140.27 | 10887 | Methyl cyclohexane | 7 | 98.19 |
| | Methylpropyl benzene | 10 | 134.22 | 135988 | Sec-butyl benzene | 10 | 134.22 |

Table N-1 (Continued)
Volatile Tentatively Identified Compounds
Organic Chemicals, Inc.

| Tentatively Identified Compounds | | | | Compound Used to Provide Estimated Risk Values | | | |
|---|---|---|---|---|---|---|---|
| CAS Number | Compound Name | # of Carbon Molecules | Molecular Weight | CAS Number | Compound Name | # of Carbon Molecules | Molecular Weight |
| | Methyl (Methyl propyl) cyclopentane | 10 | 140.27 | 108872 | Methyl cyclohexane | 7 | 98.19 |
| | Methyl propyl cyclohexane | 10 | 140.27 | 108872 | Methyl cyclohexane | 7 | 98.19 |
| 91203 | Naphthalene | 10 | 128.17 | 91203 | Naphthalene | 10 | 128.17 |
| | Unknown akyl benzene | 10 | 134.22 | 135988 | Sec-butyl benzene | 10 | 134.22 |
| | Unknown hydrocarbon | 10 | 132.21 | 108872 | Methyl cyclohexane | 7 | 98.19 |
| | Unknown hydrocarbon | 10 | 134.22 | 108872 | Methyl cyclohexane | 7 | 98.19 |
| | Unknown hydrocarbon | 10 | 138.25 | 108872 | Methyl cyclohexane | 7 | 98.19 |
| | Unknown hydrocarbon | 10 | 140.27 | 108872 | Methyl cyclohexane | 7 | 98.19 |
| | Unknown hydrocarbon | 10 | 142.29 | 108872 | Methyl cyclohexane | 7 | 98.19 |
| | Unknown ketone | 10 | 152.24 | 108941 | Cyclohexanone | 6 | 98.15 |
| 51284298 | 1,2-Dimethylpropyl cyclohexane | 11 | 154.30 | 108872 | Methyl cyclohexane | 7 | 98.19 |
| | Unknown hydrocarbon | 11 | 142.20 | 108872 | Methyl cyclohexane | 7 | 98.19 |
| | Unknown hydrocarbon | 11 | 146.23 | 108872 | Methyl cyclohexane | 7 | 98.19 |
| | Unknown hydrocarbon | 11 | 148.25 | 108872 | Methyl cyclohexane | 7 | 98.19 |
| | Unknown hydrocarbon | 11 | 152.28 | 108872 | Methyl cyclohexane | 7 | 98.19 |
| | Unknown hydrocarbon | 11 | 154.30 | 108872 | Methyl cyclohexane | 7 | 98.19 |
| | Unknown hydrocarbon | 11 | 156.31 | 108872 | Methyl cyclohexane | 7 | 98.19 |
| 112021421 | Undecane | 11 | 156.31 | 108872 | Methyl cyclohexane | 7 | 98.19 |
| | Butyl cyclooctane | 12 | 168.20 | 108872 | Methyl cyclohexane | 7 | 98.19 |
| | Unknown hydrocarbon | 12 | 156.23 | 108872 | Methyl cyclohexane | 7 | 98.19 |
| | Unknown hydrocarbon | 12 | 162.28 | 108872 | Methyl cyclohexane | 7 | 98.19 |
| | Unknown hydrocarbon | 12 | 166.31 | 108872 | Methyl cyclohexane | 7 | 98.19 |
| | Unknown hydrocarbon | 12 | 168.20 | 108872 | Methyl cyclohexane | 7 | 98.19 |
| | Unknown hydrocarbon | 14 | 198.39 | 108872 | Methyl cyclohexane | 7 | 98.19 |

## Table N-2
## Semi-volatile Tentatively Identified Compounds
## Organic Chemicals, Inc.

| Tentatively Identified Compounds | | | | Compound Used to Provide Estimated Risk Values | | | |
|---|---|---|---|---|---|---|---|
| CAS Number | Compound Name | # of Carbon Molecules | Molecular Weight | CAS Number | Compound Name | # of Carbon Molecules | Molecular Weight |
| 594047 | Dichloroiodo methane | 1 | 210.83 | 75274 | Bromodichloromethane | 1 | 209.82 |
| | tetrachloroethane | 2 | 167.85 | 79345 | 1,1,2,2 Tetrachloroethane | 2 | 167.85 |
| 79345 | 1,1,2,2 Tetrachloroethane | 2 | 167.85 | 79345 | 1,1,2,2 Tetrachloroethane | 2 | 167.85 |
| 109875 | Dimethoxy methane | 3 | 76.10 | 109864 | 2-Methoxy ethanol | 3 | 76.10 |
| 68122 | N,N-Dimethyl formamide | 3 | 73.10 | 79061 | Acrylamide | 3 | 71.08 |
| | Trichloro porpene | 3 | 145.42 | 96195 | 1,2,3-Trichloropropene | 3 | 145.42 |
| 2233003 | 3,3,3-Trichloro propene | 3 | 145.42 | 96195 | 1,2,3-Trichloropropene | 3 | 145.42 |
| | Aldo | 4 | 88.11 | | Assumed to be non-toxic | | |
| 111466 | 2,2'-Oxybis ethanol | 4 | 106.12 | 109864 | 2-Methoxy ethanol | 3 | 76.10 |
| 111353 | 3-Ethoxy-1-propanol | 5 | 104.15 | 109864 | 2-Methoxy ethanol | 3 | 76.10 |
| | Methoxy butanol | 5 | 104.15 | 109864 | 2-Methoxy ethanol | 3 | 76.10 |
| 53778737 | 1-Methoxy-2-butanol | 5 | 104.15 | 109864 | 2-Methoxy ethanol | 3 | 76.10 |
| | Methoxy ethoxy ethanol | 5 | 120.15 | 109864 | 2-Methoxy ethanol | 3 | 76.10 |
| 20324327 | 1-(2-Methoxy-1-methyl)2 propanal | 5 | 104.15 | 109864 | 2-Methoxy ehtanol | 3 | 76.10 |
| 872504 | Methyl Pyrrolidinone | 5 | 99.13 | 105602 | Caprolactam | 6 | 113.16 |
| 872504 | 1-Methyl-2-Pyrrolidinone | 5 | 99.13 | 105602 | Caprolactam | 6 | 113.16 |
| 625310 | 4-Penten-2-ol | 5 | 86.13 | 57556 | Propylene glycol | 3 | 76.10 |
| 60322 | 6-Amino hexanoic acid | 6 | 131.18 | 64186 | Formic acid | 1 | 46.03 |
| | Butoxy ethanol | 6 | 118.18 | 109864 | 2-Methoxyethanol | 3 | 76.10 |
| 105602 | Caprolactam | 6 | 113.16 | 105602 | Caprolactam | 6 | 113.16 |
| 108907 | Chlorobenzene | 6 | 112.56 | 108907 | Chlorobenzene | 6 | 112.56 |
| 542187 | Chlorocyclohexane | 6 | 118.61 | 109693 | 1-Chlorobutane | 4 | 92.57 |
| | Alkane | 6 | 86.18 | 110543 | n-Hexane | 6 | 86.18 |
| | Alkene | 6 | 84.16 | 108872 | Methyl cyclohexane | 7 | 98.19 |

Table N-2 (Continued)
Semi-volatile Tentatively Identified Compounds
Organic Chemicals, Inc.

| Tentatively Identified Compounds | | | | Compound Used to Provide Estimated Risk Values | | | |
|---|---|---|---|---|---|---|---|
| CAS Number | Compound Name | # of Carbon Molecules | Molecular Weight | CAS Number | Compound Name | # of Carbon Molecules | Molecular Weight |
| | Carbon compound | 6 | 158.11 | 57556 | Propylene glycol | 3 | 76.10 |
| | Carbon compound | 6 | 100.16 | 108101 | Methyl-isobutyl ketone | 6 | 76.10 |
| | Cyclohexanediol | 6 | 116.16 | 57556 | Propylene glycol | 3 | 76.10 |
| 931179 | 1,2-Cyclohexanediol | 6 | 116.16 | 57556 | Propylene glycol | 3 | 76.10 |
| 108930 | Cyclohexanol | 6 | 100.16 | 57556 | Propylene glycol | 3 | 76.10 |
| | Cyclohexenol | 6 | 98.15 | 57556 | Propylene glycol | 3 | 76.10 |
| 4065810 | 1-Cyclohexen-l-ol | 6 | 98.15 | 57556 | Propylene glycol | 3 | 76.10 |
| 822673 | 2-Cyclohexen-l-ol | 6 | 98.15 | 57556 | Propylene glycol | 3 | 76.10 |
| | 3-cyclohexen-l-ol | 6 | 98.15 | 57556 | Propylene glycol | 3 | 76.10 |
| | Cyclohexenone | 6 | 96.13 | 108101 | Methyl-isobutyl ketone | 6 | 100.16 |
| 930687 | 2-cyclohexen-l-one | 6 | 96.13 | 108101 | Methyl-isobutyl ketone | 6 | 100.16 |
| 4584638 | 1,4-Dione-2,5-cyclohexadiene | 6 | 108.10 | 108941 | Cyclohexanone | 6 | 98.15 |
| | Fluorophenol | 6 | 112.10 | 108952 | Phenol | 6 | 93.11 |
| | Hexamethyl cyclotrisiloxane | 6 | 222.46 | | Assumed to be non-toxic | | |
| 123422 | 4-Hydroxy-4-methyl-2-pentanone | 6 | 116.16 | 108101 | Methyl-isobutyl ketone | 6 | 100.16 |
| 760214 | 3-Methylene pentane | 6 | 84.16 | 108872 | Methyl cyclohexane | 7 | 98.19 |
| 141797 | 4-Methyl (3-penten-2-one) | 6 | 98.15 | 108101 | Methyl-isobutyl ketone | 6 | 100.16 |
| | Phenol | 6 | 94.11 | 108952 | Phenol | 6 | 93.11 |
| 2415-72-7 | Propyl cyclopropane | 6 | 84.16 | 108872 | Methyl cyclohexane | 7 | 98.19 |
| | Tetrachloro phenyl | 6 | 215.89 | 95943 | 1,2,4,5-Tetrachlorobenzene | 6 | 215.89 |
| | Thienyl ethanone | 6 | 126.18 | 23564058 | Thiophanate-methyl | 6 | 146.21 |
| 78422 | Tris(2-ethyl)phosporic acid | 6 | 182.16 | 1832548 | Isopropyl methyl phosphoric acid | 4 | 138.10 |
| 100527 | Benzaldehyde | 7 | 106.12 | 100527 | Benzaldehyde | 7 | 106.12 |
| 100516 | Benzene methanol | 7 | 108.14 | 100516 | Benzyl alcohol | 7 | 108.14 |

## Table N-2 (Continued)
## Semi-volatile Tentatively Identified Compounds
## Organic Chemicals, Inc.

| Tentatively Identified Compounds | | | | Compound Used to Provide Estimated Risk Values | | | |
|---|---|---|---|---|---|---|---|
| CAS Number | Compound Name | # of Carbon Molecules | Molecular Weight | CAS Number | Compound Name | # of Carbon Molecules | Molecular Weight |
| 65850 | Benzoic acid | 7 | 122.12 | 65850 | Benzoic acid | 7 | 122.12 |
| | Chloromethyl benzene | 7 | 126.59 | 95498 | O-chlorotoluene | 7 | 126.59 |
| | Carbon compound | 7 | 148.20 | 111762 | Ethylene glycol, monobutylether | 6 | 118.17 |
| | Hydrocarbon | 7 | 96.17 | 108872 | Methyl cyclohexane | 7 | 98.19 |
| | Carbon isomer | 7 | 98.19 | 108872 | Methyl cyclohexane | 7 | 98.19 |
| 69727 | 2-Hydroxy benzoic acid | 7 | 138.12 | 65850 | Benzoic acid | 7 | 122.12 |
| 36 | Methyl benzene | 7 | 92.14 | 108883 | Toluene | 7 | 92.14 |
| | Methyl benzoic acid | 8 | 136.15 | 65850 | Benzoic acid | 7 | 122.12 |
| 5343964 | 3-Methyl-2-butanol acetate | 7 | 146.19 | 111762 | Ethylene glycol, monobutylether | 6 | 118.17 |
| 453636 | 2-Methyl hexanoic acid | 7 | 130.19 | 64186 | Formic acid | 1 | 46.03 |
| 108883 | Toluene | 7 | 92.14 | 108883 | Toluene | 7 | 92.14 |
| 4305264 | 6-Acetyloxy-2-hexanone | 8 | 158.20 | 108101 | Methyl-isobutyl ketone | 6 | 100.16 |
| 532285 | Alpha benzene acetonitrile | 8 | 117.15 | 107131 | Acrylonitrile | 3 | 53.06 |
| 619409 | 4-Amino-methyl benzoic acid | 8 | 151.17 | 86306 | N-Nitrosodiphenyl amine | 12 | 198.22 |
| | 1,2 Benzene dicarboxilic acid | 8 | 166.13 | 100210 | p-Phthalic acid | 8 | 166.13 |
| | Benzo thiaphene | 8 | 134.20 | 23564058 | Methyl thiophanate | 6 | 146.21 |
| | 2-Bis(1-methyl ethyl) ethanol | 8 | 130.23 | 57556 | Propylene glycol | 3 | 76.10 |
| | Akyl benzene | 8 | 106.17 | 100414 | Ethyl benzene | 8 | 100.17 |
| | Carbon compound | 8 | 104.15 | 108872 | Methyl cyclohexane | 7 | 98.19 |
| | Alkane | 8 | 114.15 | 108872 | Methyl cyclohexane | 7 | 98.19 |
| | Hydrocarbon | 8 | 106.17 | 108872 | Methyl cyclohexane | 7 | 98.19 |
| | Hydrocarbon | 8 | 108.18 | 108872 | Methyl cyclohexane | 7 | 98.19 |
| | Ketone | 8 | 146.76 | 108101 | Methyl-isobutyl ketone | 6 | 100.16 |
| | Dimethyl benzene | 8 | 106.17 | 95476 | m-xylene | 8 | 106.17 |

### Table N-2 (Continued)
### Semi-volatile Tentatively Identified Compounds
### Organic Chemicals, Inc.

| Tentatively Identified Compounds | | | | Compound Used to Provide Estimated Risk Values | | | |
|---|---|---|---|---|---|---|---|
| CAS Number | Compound Name | # of Carbon Molecules | Molecular Weight | CAS Number | Compound Name | # of Carbon Molecules | Molecular Weight |
| 108383 | 1,3-Dimethyl benzene | 8 | 106.17 | 95476 | m-Xylene | 8 | 106.17 |
| 23586643 | 1,1'-(3-3-Dimethyl)benzene | 8 | 108.18 | 95476 | m-Xylene | 8 | 106.17 |
| | Dimethylphenol | 8 | 138.17 | 108952 | Phenol | 6 | 93.11 |
| 1743619 | 4-Ethenyl-1,4-D...cyclohexene | 8 | 110.20 | 108872 | Methyl cyclohexane | 7 | 98.19 |
| 100414 | Ethyl benzene | 8 | 106.17 | 100414 | Ethly benzene | 8 | 106.17 |
| 149575 | 2-Ethyl hexanoic acid | 8 | 144.21 | 64186 | Formic acid | 1 | 46.03 |
| 6321148 | 3-Hydroxy-3,5-dimethyl 1-2-hexanone | 8 | 144.21 | 108101 | Methyl-isobutyl ketone | 6 | 100.16 |
| | Isobenzofuranone | 8 | 134.13 | 110009 | Furan | 4 | 68.08 |
| | Methyl heptanone | 8 | 146.76 | 108101 | Methyl-isobutyl ketone | 6 | 100.16 |
| | 4 Methyl-2-benzo thialzolamine | 8 | 164.23 | 21564170 | 2(Thiocyanomethylthio)-benzo thiazole | 9 | 233.36 |
| | 5 Methyl-3-(1-methyl)cyclohexanone | 8 | 124.18 | 108941 | Cyclohexanone | 6 | 98.15 |
| 4337659 | Mono(2-ethyl)-hexanedioc acid | 8 | 174.20 | 64186 | Formic acid | 1 | 46.03 |
| 124072 | Octanoic acid | 8 | 144.21 | 64186 | Formic acid | 1 | 46.03 |
| 628682 | 2,2'-Oxybis-ethanol diacetyl | 8 | 190.20 | 111762 | Ethylene glycol, mono butyl ether | 6 | 118.18 |
| | Xylene | 8 | 106.17 | 108323 | O-Xylene | 8 | 106.17 |
| | C3 Alkyl benzene isomer | 9 | 120.20 | 99828 | Cumene (isopropyl benzene) | 9 | 120.20 |
| | C9,H20 Alkane | 9 | 128.26 | 108872 | Methyl cyclohexane | 7 | 98.19 |
| | C9,H10 Hydrocarbon | 9 | 118.18 | 108872 | Methyl cyclohexane | 7 | 98.19 |
| | C9,H12 Hydrocarbon | 9 | 120.20 | 108872 | Methyl cyclohexane | 7 | 98.19 |
| | C9,H18 Hydrocarbon | 9 | 126.24 | 108872 | Methyl cyclohexane | 7 | 98.19 |
| | C9,H85 Hydrocarbon | 9 | 148.23 | 505293 | 1,4-Dithiane | 4 | 120.24 |
| 54965081 | 2,3 Dihydro-2-methyl benzofuran | 9 | 134.18 | 108941 | Cyclohexanone | 6 | 98.15 |
| | Ethenyl methyl benzene | 9 | 118.18 | 25013154 | Methyl styrene | 9 | 118.18 |
| | Ethyl methyl benzene | 9 | 120.20 | 25013154 | Methyl styrene | 9 | 118.18 |

### Table N-2 (Continued)
### Semi-volatile Tentatively Identified Compounds
### Organic Chemicals, Inc.

| Tentatively Identified Compounds | | | | Compound Used to Provide Estimated Risk Values | | | |
|---|---|---|---|---|---|---|---|
| CAS Number | Compound Name | # of Carbon Molecules | Molecular Weight | CAS Number | Compound Name | # of Carbon Molecules | Molecular Weight |
| 611143 | 1-Ethyl-2-methyl benzene | 9 | 120.20 | 25013154 | Methyl styrene | 9 | 118.18 |
| 620144 | 1-Ethyl-3-methyl benzene | 9 | 120.20 | 25013154 | Methyl styrene | 9 | 118.18 |
| 622968 | 1-Ethyl-4-methyl benzene | 9 | 120.20 | 25013154 | Methyl styrene | 9 | 118.18 |
| | Ethyl methyl cyclohexane | 9 | 126.24 | 108872 | Methyl cyclohexane | 7 | 98.19 |
| 91645 | 2H-1 Benzopyran-2-one | 9 | 148.16 | 98862 | Acetophenone | 8 | 120.15 |
| | Methyl benzeneatic acid | 9 | 150.18 | 100210 | p-Phthalic acid | 8 | 166.13 |
| | Methyl benzo[]thiophene | 9 | 148.33 | 505293 | 1,4-Dithiane | 4 | 120.24 |
| | Methyl ethenyl benzene | 9 | 118.18 | 25013154 | Methyl styrene | 9 | 118.18 |
| 98839 | 1-Methyl ethenyl benzene | 9 | 118.18 | 25013154 | Methyl styrene | 9 | 118.18 |
| | Methyl ethyl benzene | 9 | 120.20 | 25013154 | Methyl styrene | 9 | 118.18 |
| 98828 | 1-Methylethyl benzene | 9 | 120.20 | 250135 | Methyl styrene | 9 | 118.18 |
| | Methyl phenyl ethanone | 9 | 134.18 | 98862 | Acetophenone | 8 | 120.15 |
| 111842 | Nonane | 9 | 128.26 | 108872 | Methyl cyclohexane | 7 | 98.19 |
| 112050 | Nonanoic acid | 9 | 158.24 | 64186 | Formic acid | 1 | 46.03 |
| 103651 | Propyl benzene | 9 | 120.20 | 99828 | Cumene (isopropyl benzene) | 9 | 120.20 |
| | Trimethyl benzene | 9 | 120.20 | 95636 | 1,2,4-Trimethyl benzene | 9 | 120.20 |
| 108678 | 1,3,5 Trimethyl benzene | 9 | 120.20 | 108678 | 1,3,5 Trimethyl benzene | 9 | 120.20 |
| 4130421 | 2,6 Bis (1,1 dimethyl) phenol | 10 | 154.25 | 108952 | Phenol | 6 | 93.11 |
| | C4 Akyl benzene | 10 | 134.22 | 135988 | Sec-butyl benzene | 10 | 134.22 |
| | C10,H12 Hydrocarbon | 10 | 132.21 | 108872 | Methyl cyclohexane | 7 | 98.19 |
| | C10,H14 Hydrocarbon | 10 | 134.22 | 108872 | Methyl cyclohexane | 7 | 98.19 |
| | C10,H18 Hydrocarbon | 10 | 138.25 | 108872 | Methyl cyclohexane | 7 | 98.19 |
| | C10,H22 Hydrocarbon | 10 | 142.29 | 108872 | Methyl cyclohexane | 7 | 98.19 |
| | C10,H20 Isomer | 10 | 140.27 | 108872 | Methyl cyclohexane | 7 | 98.19 |

Table N-2 Continued)
Semi-volatile Tentatively Identified Compounds
Organic Chemicals, Inc.

| Tentatively Identified Compounds | | | | Compound Used to Provide Estimated Risk Values | | | |
|---|---|---|---|---|---|---|---|
| CAS Number | Compound Name | # of Carbon Molecules | Molecular Weight | CAS Number | Compound Name | # of Carbon Molecules | Molecular Weight |
| | C10,H16 Ketone | 10 | 152.24 | 108941 | Cyclohexanone | 6 | 98.15 |
| | Decamethyl cyclopenta siloxane | 10 | 370.77 | | Assumed to be non-toxic | | |
| | Decanoic acid | 10 | 172.27 | 64186 | Formic acid | 1 | 46.03 |
| | Diethyl benzene | 10 | 134.22 | 135988 | Sec-butyl benzene | 10 | 134.22 |
| 105055 | 1,4-Diethyl benzene | 10 | 134.22 | 135988 | Sec-butyl benzene | 10 | 134.22 |
| | Dihydro methyl indene | 10 | 132.21 | 91203 | Naphthalene | 10 | 128.17 |
| | Dimethylethyl benzene | 10 | 134.22 | 135988 | Sec-butyl benzene | 10 | 134.22 |
| 15869893 | 2,5 Dimethyl Octane | 10 | 142.29 | 108872 | Methyl cyclohexane | 7 | 98.19 |
| 3637012 | 1-(3,4 Dimethyl phenyl)ethanone | 10 | 148.21 | 98862 | Acetophenone | 8 | 120.15 |
| | Ethenyl-dimethyl benzene | 10 | 132.21 | 95636 | 1,2,4-Trimethyl benzene | 9 | 120.12 |
| 933982 | 1-ethyl-2,3-dimethyl benzene | 10 | 134.22 | 135988 | Sec-butyl benzene | 10 | 134.22 |
| 874419 | 1-ethyl-2,4-dimethyl benzene | 10 | 134.22 | 135988 | Sec-butyl benzene | 10 | 134.22 |
| 1758889 | 2-ethyl-1,4-dimethyl benzene | 10 | 134.22 | 135988 | Sec-butyl benzene | 10 | 134.22 |
| 61142696 | 1-ethyl-2,4-dimethyl cyclohexane | 10 | 140.27 | 108872 | Methyl cyclohexane | 7 | 98.19 |
| 7045672 | 2-ethyl-1,3-dimethyl cyclohexane | 10 | 140.27 | 108872 | Methyl cyclohexane | 7 | 98.19 |
| 6754661 | 2,4,6,7,8,8-5(1H)-Azulenone | 10 | 142.16 | 108941 | Cyclohexanone | 6 | 98.15 |
| 25155151 | Methyl (1-methylethyl)benzene | 10 | 134.22 | 135988 | Sec-butyl benzene | 10 | 134.22 |
| 527844 | 1-Methyl-2-(1-methylethyl)benzene | 10 | 134.22 | 135988 | Sec-butyl benzene | 10 | 134.22 |
| | 1-Methyl-3-(1-methylethyl)benzene | 10 | 134.22 | 135988 | Sec-butyl benzene | 10 | 134.22 |
| | 2-Methyl(1-methylethyl)benzene | 10 | 134.22 | 135988 | Sec-butyl benzene | 10 | 134.22 |
| | Methyl propyl benzene | 10 | 134.22 | 135988 | Sec-butyl benzene | 10 | 134.22 |
| 1074437 | 1-Methyl-3-propyl benzene | 10 | 134.22 | 135988 | Sec-butyl benzene | 10 | 134.22 |
| 4291809 | 1-Methyl-3-propyl cyclohexane | 10 | 140.27 | 108872 | Methyl cyclohexane | 7 | 98.19 |
| 122576 | 4-phenyl-3-butene-2-one | 10 | 146.18 | 98862 | Acetophenone | 8 | 120.15 |

## Table N-2 (Continued)
## Semi-volatile Tentatively Identified Compounds
## Organic Chemicals, Inc.

| Tentatively Identified Compounds | | | | Compound Used to Provide Estimated Risk Values | | | |
|---|---|---|---|---|---|---|---|
| CAS Number | Compound Name | # of Carbon Molecules | Molecular Weight | CAS Number | Compound Name | # of Carbon Molecules | Molecular Weight |
| 119642 | Tetrahydro naphthalene | 10 | 132.21 | 91203 | Naphthalene | 10 | 128.17 |
| | Tetramethyl benzene | 10 | 134.22 | 135988 | Sec-butyl benzene | 10 | 134.22 |
| 488233 | 1,2,3,4 Tetramethyl benzene | 10 | 134.22 | 135988 | Sec-butyl benzene | 10 | 134.22 |
| 95932 | 1,2,4,5 Tetramethyl benzene | 10 | 134.22 | 135988 | Sec-butyl benzene | 10 | 134.22 |
| 13877935 | 4-Bicyclo(7,2,0)undec-4-ene | 11 | 150.26 | 77736 | Dicyclopentadiene | 10 | 132.21 |
| | C11,H24 Alkane | 11 | 156.31 | 108872 | Methyl cyclohexane | 7 | 98.19 |
| | C11,H16 Alkene | 11 | 148.25 | 108872 | Methyl cyclohexane | 7 | 98.19 |
| | C11,H10 Hydrocarbon | 11 | 142.20 | 108872 | Methyl cyclohexane | 7 | 98.19 |
| | C11,H14 Hydrocarbon | 11 | 146.23 | 108872 | Methyl cyclohexane | 7 | 98.19 |
| | C11,H16 Hydrocarbon | 11 | 148.25 | 108872 | Methyl cyclohexane | 7 | 98.19 |
| | C11,H20 Hydrocarbon | 11 | 152.28 | 108872 | Methyl cyclohexane | 7 | 98.19 |
| | C11,H24 Hydrocarbon | 11 | 156.31 | 108872 | Methyl cyclohexane | 7 | 98.19 |
| | C11,H16 Hydrocarbon isomer | 11 | 148.25 | 108872 | Methyl cyclohexane | 7 | 98.19 |
| | C11,H16 Isomer | 11 | 148.25 | 108872 | Methyl cyclohexane | 7 | 98.19 |
| | Dihydro-dimethyl-1H Indene | 11 | 146.23 | 91203 | Naphthalene | 10 | 128.17 |
| | Dimethylethyl-methyl benzene | 11 | 148.25 | 135988 | Sec-butyl benzene | 10 | 134.22 |
| 4132723 | 1,4 Dimethyl-2-(1-Methylethyl)benzene | 11 | 148.25 | 135988 | Sec-butyl benzene | 10 | 134.22 |
| | Dimethyl methylethyl benzene | 11 | 148.25 | 135988 | Sec-butyl benzene | 10 | 134.22 |
| 4706892 | 2,4 Dimethyl-1-(1-methylethyl)benzene | 11 | 148.25 | 135988 | Sec-butyl benzene | 10 | 134.22 |
| 17302271 | 2,5 Dimethylnonane | 11 | 156.31 | 108872 | Methyl cyclohexane | 7 | 98.19 |
| 2049958 | 1,1 Dimethyl propyl benzene | 11 | 148.25 | 135988 | Sec-butyl benzene | 10 | 134.22 |
| | Ethyl-trimethyl-benzene | 11 | 148.25 | 135988 | Sec-butyl benzene | 10 | 134.22 |
| 54120626 | Ethyl-1,2,4-trimethyl benzene | 11 | 148.25 | 135988 | Sec-butyl benzene | 10 | 134.22 |
| | Ethylidene-1H indene | 11 | 142.20 | 91203 | Naphthalene | 10 | 128.17 |

Table N-2 (Continued)

Semi-volatile Tentatively Identified Compounds

Organic Chemicals, Inc.

| Tentatively Identified Compounds | | | | Compound Used to Provide Estimated Risk Values | | | |
|---|---|---|---|---|---|---|---|
| CAS Number | Compound Name | # of Carbon Molecules | Molecular Weight | CAS Number | Compound Name | # of Carbon Molecules | Molecular Weight |
| | Methyl naphthalene | 11 | 142.20 | 91203 | Naphthalene | 10 | 128.17 |
| 90120 | 1-Methyl naphthalene | 11 | 142.20 | 91203 | Naphthalene | 10 | 128.17 |
| | Methyl-butenyl-benzene | 11 | 146.23 | 135988 | Sec-butyl benzene | 10 | 134.22 |
| 4292926 | Pentyl cyclohexane | 11 | 154.30 | 108872 | Methyl cyclohexane | 7 | 98.19 |
| 1120214 | Unedecane | 11 | 156.31 | 108872 | Methyl cyclohexane | 7 | 98.19 |
| 103333 | Azobenzene | 12 | 182.23 | 103333 | Azobenzene | 12 | 182.23 |
| 120401 | N,N Bis (2-hydroxy docecanamide) | 12 | 231.34 | 79061 | Acrylamide | 3 | 71.08 |
| | C12,H26 Alkane | 12 | 170.34 | 108872 | Methyl cyclohexane | 7 | 98.19 |
| | C12,H24 Alkene | 12 | 168.32 | 108872 | Methyl cyclohexane | 7 | 98.19 |
| | C12,H12 Hydrocarbon | 12 | 156.23 | 108872 | Methyl cyclohexane | 7 | 98.19 |
| | C12,H16 Hydrocarbon | 12 | 160.26 | 108872 | Methyl cyclohexane | 7 | 98.19 |
| | C12,H24 Hydrocarbon | 12 | 168.32 | 108872 | Methyl cyclohexane | 7 | 98.19 |
| 294622 | Cyclo dodecane | 12 | 168.32 | 108872 | Methyl cyclohexane | 7 | 98.19 |
| 132650 | Dibenzothiophene | 12 | 184.27 | 505293 | 1,4 Dithiane | 4 | 120.24 |
| | diethyl-methyl benzamide | 12 | 191.27 | 79061 | Acrylamide | 3 | 71.08 |
| 134623 | N,N diethyl-3-methyl benzamide | 12 | 191.27 | 79061 | Acrylamide | 3 | 71.08 |
| 3910358 | 2,3 Dihydro-1,1,3-trimethyl-1H-indene | 12 | 162.28 | 92524 | 1,1 Biphenyl | 12 | 154.21 |
| | 1,1'-(3,3-Dimethyl-1-butoyl)benzene | 12 | 160.26 | 135988 | Sec-butyl benzene | 10 | 134.22 |
| 23586643 | 1,1'-(3,3-Dimethyl-1-butenol)benzene | 12 | 176.26 | 100516 | Benzyl alcohol | 7 | 108.14 |
| | Dimethyl naphthalene | 12 | 156.23 | 91203 | Naphthalene | 10 | 128.17 |
| 573988 | 1,2-Dimethyl naphthalene | 12 | 156.23 | 91203 | Naphthalene | 10 | 128.17 |
| 575417 | 1,3-Dimethyl naphthalene | 12 | 156.23 | 91203 | Naphthalene | 10 | 128.17 |
| 571584 | 1,4-Dimethyl naphthalene | 12 | 156.23 | 91203 | Naphthalene | 10 | 128.17 |
| 575371 | 1,7-Dimethyl naphthalene | 12 | 156.23 | 91203 | Naphthalene | 10 | 128.17 |

## Table N-2 (Continued)
## Semi-volatile Tentatively Identified Compounds
## Organic Chemicals, Inc.

| Tentatively Identified Compounds | | | | Compound Used to Provide Estimated Risk Values | | | |
|---|---|---|---|---|---|---|---|
| CAS Number | Compound Name | # of Carbon Molecules | Molecular Weight | CAS Number | Compound Name | # of Carbon Molecules | Molecular Weight |
| 569415 | 1,8 Dimethyl naphthalene | 12 | 156.23 | 91203 | Naphthalene | 10 | 128.17 |
| 882337 | Diphenyl disulfide | 12 | 216.33 | 505293 | 1,4-Dithiane | 4 | 120.24 |
| 112403 | Dodecane | 12 | 170.34 | 108872 | Methyl cyclohexane | 7 | 98.19 |
| 143077 | Dodecanoic acid | 12 | 200.32 | 64186 | Formic acid | 1 | 46.03 |
| | Ethyl naphthalene | 12 | 156.23 | 91203 | Naphthalene | 10 | 128.17 |
| 2440224 | 2-(2H-benzotriazol)phenol | 12 | 211.22 | 1563662 | Carbo furan | 12 | 221.26 |
| 4292197 | 1-Iodo decane | 12 | 296.24 | 593602 | Bromomethane | 1 | 94.94 |
| | Methylcycopentyl-benzene | 12 | 160.26 | 108883 | Toluene | 7 | 92.14 |
| 1336363 | PCBs | 12 | | 1336363 | Polychlorinated biphenyls | 12 | |
| 4645152 | 1,1'-Oxybiscyclohexane | 12 | 182.31 | 85687 | Butyl benzyl phthalate | 19 | 312.37 |
| 80079 | 1,1'-Sulfonyl bis (4-benzene) | 12 | 218.28 | 2104645 | Ethyl-p-nitrophenyl phenyl phosphoro. | 14 | 307.31 |
| | Tetrachloro biphenyl | 12 | 291.99 | 1336363 | Polychlorinated biphenyls | 12 | |
| | Tetrachloro-1,1'-biphenyl | 12 | 291.99 | 1336363 | Polychlorinated biphenyls | 12 | |
| | Tetrahydro-dimetyl naphthalene | 12 | 160.26 | 91203 | Naphthalene | 10 | 128.17 |
| | Trichloro biphenyl | 12 | 257.55 | 1336363 | Polychlorinated biphenyls | 12 | |
| | Trichloro-1,1'-biphenyl | 12 | 257.55 | 1336363 | Polychlorinated biphenyls | 12 | |
| | Tetrahydro-naphth[]oxirane | 12 | 172.23 | 1563662 | Carbo furan | 12 | 221.26 |
| 119619 | Benzophenone | 13 | 182.22 | 98862 | Acetophenone | 8 | 120.15 |
| | Butyl-trimethyl cyclohexane | 13 | 182.35 | 108872 | Methyl cyclohexane | 7 | 98.19 |
| | C13,H28 Alkane | 13 | 184.37 | 108872 | Methyl cyclohexane | 7 | 98.19 |
| | C13,H12 Hydrocarbon | 13 | 168.24 | 108872 | Methyl cyclohexane | 7 | 98.19 |
| | C13,H14 Hydrocarbon | 13 | 170.26 | 108872 | Methyl cyclohexane | 7 | 98.19 |
| | C13,H18 Hydrocarbon | 13 | 174.29 | 108872 | Methyl cyclohexane | 7 | 98.19 |
| | C13,H20 Hydrocarbon | 13 | 176.30 | 108872 | Methyl cyclohexane | 7 | 98.19 |

Table N-2 (Continued)
Semi-volatile Tentatively Identified Compounds
Organic Chemicals, Inc.

| Tentatively Identified Compounds | | | | Compound Used to Provide Estimated Risk Values | | | |
|---|---|---|---|---|---|---|---|
| CAS Number | Compound Name | # of Carbon Molecules | Molecular Weight | CAS Number | Compound Name | # of Carbon Molecules | Molecular Weight |
| | C13,H26 Hydrocarbon | 13 | 182.35 | 108872 | Methyl cyclohexane | 7 | 98.19 |
| | C13,H28 Hydrocarbon | 13 | 184.37 | 108872 | Methyl cyclohexane | 7 | 98.19 |
| | C1,H10 S | 13 | 198.29 | 505293 | 1,4 Dithiane | 4 | 120.25 |
| 1142150 | 1-Methoxy-4-(2-phenyl)benzene | 13 | 184.24 | 92524 | 1,1 Biphenyl | 12 | 154.21 |
| | Methyl dibenzo thiophene | 13 | 198.29 | 505293 | 1,4-Dithiane | 4 | 120.25 |
| 629505 | Tridecane | 13 | 184.37 | 108872 | Methyl cyclohexane | 7 | 98.19 |
| | Trimethyl naphthalene | 13 | 170.26 | 91203 | Naphthalene | 10 | 128.17 |
| 2245387 | 1,6,7-Trimethyl naphthalene | 13 | 170.26 | 91203 | Naphthalene | 10 | 128.17 |
| | Anthracenedione | 14 | 208.22 | 120127 | Anthracene | 14 | 178.23 |
| | Bis(-dimethyl ethyl)phenol | 14 | 206.33 | 135988 | Sec-butyl benzene | 10 | 134.22 |
| | C14,H30 Alkane | 14 | 198.39 | 108872 | Methyl cyclohexane | 7 | 98.19 |
| | C14,H12 Hydrocarbon | 14 | 180.25 | 108872 | Methyl cyclohexane | 7 | 98.19 |
| | C14,H14 Hydrocarbon | 14 | 182.27 | 108872 | Methyl cyclohexane | 7 | 98.19 |
| | C14,H30 Hydrocarbon | 14 | 198.39 | 108872 | Methyl cyclohexane | 7 | 98.19 |
| | C14,H13 N Compound | 14 | 195.26 | 108918 | Cyclohexylanine | 6 | 99.18 |
| 295170 | Cyclotetradecane | 14 | 196.38 | 108872 | Methyl cyclohexane | 7 | 98.19 |
| | Dimethyl biphenyl | 14 | 182.27 | 92524 | 1,1 Biphenyl | 12 | 154.21 |
| 28973979 | 1,6,10-Dodecatriene,7,11-Dimethyl | 14 | 192.35 | 108872 | Methyl cyclohexane | 7 | 98.19 |
| 72599 | DDE | 14 | 320.05 | 72599 | DDE | 14 | 320.05 |
| 86282 | Ethylcarbazole | 14 | 195.26 | 86748 | Carbazole | 12 | 167.21 |
| | Methyl Fluorene | 14 | 180.25 | 86737 | Fluorene | 13 | 166.22 |
| 26730143 | 7-Methyl tridecane | 14 | 198.39 | 108872 | Methyl cyclohexane | 7 | 98.19 |
| 2057490 | 4-(3-Phenyl propyl)pyridine | 14 | 197.28 | 110861 | Pyridine | 5 | 79.10 |
| 629594 | Tetradecane | 14 | 198.39 | 108872 | Methyl cyclohexane | 7 | 98.19 |

Table N-2 (Continued)
Semi-volatile Tentatively Identified Compounds
Organic Chemicals, Inc.

| Tentatively Identified Compounds | | | | Compound Used to Provide Estimated Risk Values | | | |
|---|---|---|---|---|---|---|---|
| CAS Number | Compound Name | # of Carbon Molecules | Molecular Weight | CAS Number | Compound Name | # of Carbon Molecules | Molecular Weight |
| 544638 | Tetradecanoic acid | 14 | 228.38 | 64186 | Formic acid | 1 | 46.03 |
| | Tetra decene | 14 | 196.38 | 108872 | Methyl cyclohexane | 7 | 98.19 |
| | Dimethyl dibenzo()thiophene | 14 | 213.32 | 505293 | 1,4 Dithiane | 4 | 120.25 |
| | Benzo(b)naphtho(1,2-d)thiophene | 15 | 222.31 | 505293 | 1,4 Dithiane | 4 | 120.24 |
| | Benzonaphthothiophene | 15 | 222.31 | 505293 | 1,4 Dithiane | 4 | 120.24 |
| | Carboxylic acid-1-phenanthrene | 15 | 222.24 | 65850 | Benzoic acid | 7 | 122.12 |
| 87445 | Caryophyyllene | 15 | 204.36 | 108872 | Methyl cyclohexane | 7 | 98.19 |
| | C15,H32 Alkane | 15 | 212.42 | 108872 | Methyl cyclohexane | 7 | 98.19 |
| | C15,H12 Hydrocarbon | 15 | 192.26 | 108872 | Methyl cyclohexane | 7 | 98.19 |
| | C15,H32 Hydrocarbon | 15 | 212.42 | 108872 | Methyl cyclohexane | 7 | 98.19 |
| | C15,H24 Isomer | 15 | 204.36 | 108872 | Methyl cyclohexane | 7 | 98.19 |
| 56292661 | 2,5-Dimethyltridecane | 15 | 212.42 | 108872 | Methyl cyclohexane | 7 | 98.19 |
| | Methyl anthracene | 15 | 192.26 | 120127 | Anthracene | 14 | 178.23 |
| | (Methyl ethylidone)bis phenol | 15 | 226.28 | 100516 | Benzyl alcohol | 7 | 108.14 |
| 832644 | 4-Methyl phenanthrene | 15 | 192.26 | 129000 | Pyrene | 16 | 202.26 |
| 1560958 | 2-Methyl tetradecane | 15 | 212.42 | 108872 | Methyl cyclohexane | 7 | 98.19 |
| | 1-Phenanthrene carboxylic acid | 15 | 222.24 | 65850 | Benzoic acid | 7 | 122.12 |
| 629629 | Pentadecane | 15 | 212.42 | 108872 | Methyl cyclohexane | 7 | 98.19 |
| 74645980 | 2,7,10-Trimethyldodecane | 15 | 212.42 | 108872 | Methyl cyclohexane | 7 | 98.19 |
| 205436 | Benzonaphthothiophene | 16 | 234.32 | 505293 | 1,4 Dithiane | 4 | 120.24 |
| 85609 | 4,4'Butylidene bis (2 phenol) | 16 | 242.32 | 100516 | Benzylalcohol | 7 | 108.14 |
| | 1,1'-(1,3-butadiene)phenyl benzene | 16 | 206.29 | 92524 | 1,1 Bipheynl | 12 | 154.21 |
| | Carboxy-octahydro phenanthrene | 16 | 230.35 | 85687 | Butyl benzyl phthalate | 19 | 312.37 |
| | C16,H34 Alkane | 16 | 226.45 | 108872 | Methyl cyclohexane | 7 | 98.19 |

### Table N-2 (Continued)
### Semi-volatile Tentatively Identified Compounds
### Organic Chemicals, Inc.

| Tentatively Identified Compounds | | | | Compound Used to Provide Estimated Risk Values | | | |
|---|---|---|---|---|---|---|---|
| CAS Number | Compound Name | # of Carbon Molecules | Molecular Weight | CAS Number | Compound Name | # of Carbon Molecules | Molecular Weight |
| | C16,H32 Alkene | 16 | 224.43 | 108872 | Methyl cyclohexane | 7 | 98.19 |
| | C16,H14 Hydrocarbon | 16 | 206.29 | 108872 | Methyl cyclohexane | 7 | 98.19 |
| | C16,H34 Hydrocarbon | 16 | 226.45 | 108872 | Methyl cyclohexane | 7 | 98.19 |
| | C16,H32 O2 Acid | 16 | 256.43 | 64186 | Formic acid | 1 | 46.03 |
| 295658 | Cyclo hexadecane | 16 | 224.43 | 108872 | Methyl cyclohexane | 7 | 98.19 |
| | Dimethyl phenanthrene | 16 | 206.29 | 129000 | Pyrene | 16 | 202.26 |
| 3674666 | 2,5 Dimethyl penanthrene | 16 | 206.29 | 129000 | Pyrene | 16 | 202.26 |
| 544763 | Hexadecane | 16 | 226.45 | 108872 | Methyl cyclohexane | 7 | 98.19 |
| 57103 | Hexadecanoic acid | 16 | 256.43 | 64186 | Formic acid | 1 | 46.03 |
| 36653824 | 1-Hexadecanol | 16 | 242.45 | 57556 | Propylene glycol | 3 | 76.1 |
| 2091294 | 9-Hexadecenoic acid | 16 | 254.41 | 64186 | Formic acid | 1 | 46.03 |
| 55045108 | 6 Propyl tridecane | 16 | 226.45 | 108872 | Methyl cyclohexane | 7 | 98.19 |
| 1889674 | 1,1'-(1,1,2,2-Tetramethyl)phenyl benzene | 16 | 212.34 | 92524 | 1,1 Biphenyl | 12 | 154.21 |
| | Benzo Fluorene | 17 | 216.28 | 86737 | Fluorene | 13 | 166.22 |
| | Benzo(a)fluorene | 17 | 216.28 | 86737 | Fluorene | 13 | 166.22 |
| | Benzo(b)fluorene | 17 | 216.28 | 86737 | Fluorene | 13 | 166.22 |
| | C17,H36 Alkane | 17 | 240.48 | | Assumed to be non-toxic | | |
| 238846 | 11H-Benz(a)fluorene | 17 | 218.30 | 86737 | Fluorene | 13 | 166.22 |
| 82053 | 7H-Benz(de)anthracen-7-one | 17 | 234.30 | 56553 | Benz(a)anthracene | 18 | 228.29 |
| 238846 | 11H-Benzo(a)fluorene | 17 | 218.30 | 86737 | Fluorene | 13 | 166.22 |
| 243174 | 11H-Benzo(b)fluorene | 17 | 218.30 | 86737 | Fluorene | 13 | 166.22 |
| 629787 | Heptadecane | 17 | 240.48 | | Assumed to be non-toxic | | |
| | Methyl benzo naphthothiophene | 17 | 248.35 | 505293 | 1,4 Dithiane | 4 | 120.24 |
| | Methyl pyrene | 17 | 216.28 | 129000 | Pyrene | 16 | 202.26 |

## Table N-2 (Continued)
## Semi-volatile Tentatively Identified Compounds
## Organic Chemicals, Inc.

| Tentatively Identified Compounds | | | | Compound Used to Provide Estimated Risk Values | | | |
|---|---|---|---|---|---|---|---|
| CAS Number | Compound Name | # of Carbon Molecules | Molecular Weight | CAS Number | Compound Name | # of Carbon Molecules | Molecular Weight |
| 2381217 | 1-methyl pyrene | 17 | 216.28 | 129000 | Pyrene | 16 | 202.26 |
| 3442782 | 2-methyl pyrene | 17 | 216.28 | 129000 | Pyrene | 16 | 202.26 |
| 538238 | 1,2,3 propane octanoic acid | 17 | 270.46 | 64186 | Formic acid | 1 | 46.03 |
| | 3,12,17-trione and rostane | 17 | 274.36 | | Assumed to be non-toxic | | |
| | Benzanthracenone | 18 | 244.29 | 56553 | Benz(a)anthracene | 18 | 228.29 |
| 159197 | Benzo(c)phenathrene | 18 | 228.24 | 218019 | Chrysene | 18 | 228.29 |
| | C18,H38 Alkane | 18 | 254.50 | | Assumed to be non-toxic | | |
| | C18,H20 Hydrocarbon | 18 | 236.36 | | Assumed to be non-toxic | | |
| | C18,H20 Phenyl Alkene | 18 | 236.36 | | Assumed to be non-toxic | | |
| | Dichloroterphenyl | 18 | 299.20 | | Polychlor terphenyls (PCTs) | | |
| 64401214 | 1,3 Dimethyl pyrene | 18 | 230.31 | 12900 | Pyrene | 16 | 202.26 |
| 21164954 | 7,9 Dimethyl hexadecane | 18 | 254.50 | | Assumed to be non-toxic | | |
| 1090137 | 5,12 Naphthacenedione | 18 | 228.29 | 56553 | Benz(a)anthracene | 18 | 228.29 |
| 593453 | Octadecane | 18 | 254.50 | | Assumed to be non-toxic | | |
| 57114 | Octadecanoic acid | 18 | 284.48 | 64186 | Formic acid | 1 | 46.03 |
| 35365594 | 9-Octadecyne | 18 | 252.49 | | Assumed to be non-toxic | | |
| | Trichloroter phenyl | 18 | 333.65 | | PCTs | | |
| 791286 | Triphenyl phosphine oxide | 18 | 278.29 | 7803512 | Phosphine | | 34.00 |
| | Triphenyl stannane | 18 | 350.01 | 108883 | Toluene | 7 | 92.14 |
| | C19,H40 Alkane | 19 | 268.53 | | Assumed to be non-toxic | | |
| | Cyclo hexane derivative + C13 | 19 | 266.51 | | Assumed to be non-toxic | | |
| 54105678 | 2,6-dimethyl heptadecane | 19 | 268.53 | | Assumed to be non-toxic | | |
| 629925 | Nonadecane | 19 | 268.53 | | Assumed to be non-toxic | | |
| 101019 | N,N',N"-Triphenyl quanidine | 19 | 287.35 | 505293 | 1,4 Dithiane | 4 | 120.24 |

## Table N-2 (Continued)
## Semi-volatile Tentatively Identified Compounds
## Organic Chemicals, Inc.

| Tentatively Identified Compounds | | | | Compound Used to Provide Estimated Risk Values | | | |
|---|---|---|---|---|---|---|---|
| CAS Number | Compound Name | # of Carbon Molecules | Molecular Weight | CAS Number | Compound Name | # of Carbon Molecules | Molecular Weight |
| 18344371 | 2,6,10,14 Tetramethylpentadecane | 19 | 268.53 | | Assumed to be non-toxic | | |
| | Benzo pyrene | 20 | 252.32 | 50328 | Benzo(a)pyrene | 20 | 252.32 |
| 192972 | Benzo(e)pyrene | 20 | 252.32 | 50328 | Benzo(a)pyrene | 20 | 252.32 |
| | Benzofluoranthene | 20 | 252.32 | 207089 | Benzo(k)fluoranthene | 20 | 252.32 |
| | C20,H42 Alkane | 20 | 282.56 | | Assumed to be non-toxic | | |
| | C20,H42 Hydrocarbon | 20 | 282.56 | | Assumed to be non-toxic | | |
| | C20,H17 N05 Isomer | 20 | 351.36 | 105602 | Caprolactam | 6 | 113.16 |
| 198550 | Perylene | 20 | 252.32 | 50328 | Benzo(a)pyrene | 20 | 252.32 |
| 1235741 | Carboxylic acid-1-phenanthracene | 21 | 298.34 | 65850 | Benzoic acid | 7 | 108.14 |
| | C21,H44 Alkane | 21 | 296.58 | | Assumed to be non-toxic | | |
| 76631 | Triphenyl-2-propene stannane | 21 | 391.08 | 108883 | Toluene | 7 | 92.14 |
| 18344371 | 2,6,10,14 Tetramethyl-heptadecane | 21 | 296.58 | | Assumed to be non-toxic | | |
| | C22,H46 Alkane | 22 | 310.61 | | Assumed to be non-toxic | | |
| | C22,H44 O2 Acid ester | 22 | 340.59 | 85687 | Butyl benzylphthalate | 19 | 312.67 |
| 123795 | Dioctyl ester hexanedioic acid | 22 | 366.54 | 85687 | Butyl benzylphthalate | 19 | 312.67 |
| 629970 | Docosane | 22 | 310.61 | | Assumed to be non-toxic | | |
| 646139 | 2 Methyl propyl octadecanoic acid | 22 | 340.59 | 64186 | Formic acid | 1 | 46.03 |
| | C23,H48 Alkane | 23 | 324.64 | | Assumed to be non-toxic | | |
| | C24,H50 Alkane | 24 | 338.66 | | Assumed to be non-toxic | | |
| 535904 | Tetraphenyl Stannane | 24 | 497.11 | 108883 | Toluene | 7 | 92.14 |
| 629992 | Pentacosane | 25 | 352.69 | | Assumed to be non-toxic | | |
| | C26,H54 Alkane | 26 | 366.72 | | Assumed to be non-toxic | | |
| | C27,H56 Alkane | 27 | 380.45 | | Assumed to be non-toxic | | |
| | C27,H35 NO2 | 27 | 405.58 | 1563662 | Carbo furan | | 221.26 |

### Table N-2 (Continued)
### Semi-volatile Tentatively Identified Compounds
### Organic Chemicals, Inc.

| Tentatively Identified Compounds | | | | Compound Used to Provide Estimated Risk Values | | | |
|---|---|---|---|---|---|---|---|
| CAS Number | Compound Name | # of Carbon Molecules | Molecular Weight | CAS Number | Compound Name | # of Carbon Molecules | Molecular Weight |
| 630024 | Octacosane | 28 | 394.77 | | Assumed to be non-toxic | | |
| | C29,H60 Alkane | 29 | 408.80 | | Assumed to be non-toxic | | |

# APPENDIX O

# ECOLOGICAL CONTAMINANTS OF POTENTIAL CONCERN PROFILES

# APPENDIX O

***ACETONE.*** Acetone, Chemical Abstract Service Registry No. 67-64-1 is an aliphatic ketone also known as 2-propanone and dimethyl ketone. Acetone is a colorless, highly volatile, flammable liquid with an aromatic odor (NIOSH, 1978). Acetone is miscible with water, alcohol, ether, and most oils (Merck 1976).

Acetone is produced in large quantities and may be released to the environment as stack emissions, fugitive emissions, and in wastewater in its production and use as a chemical intermediate and solvent. Acetone is a product of the photooxidation of some alkanes and alkenes that are found in urban air and it is also released from volcanoes and in forest fires. It is a metabolic product released by plants and animals (Howard 1990).

If released on soil, acetone will both volatilize and leach into the ground and probably biodegrade. If released into water, it will probably biodegrade and be lost due to volatilization. It has an estimated half-life of 20 hours from a model river. Bioconcentration in aquatic organisms and adsorption sediment should not be significant. In the atmosphere, acetone will be lost by photolysis and reaction with photochemically produced hydroxyl radicals. Estimated half-lives from these combined processes averages 22 days. The general public is exposed to acetone in the atmosphere from sources such as auto exhaust, solvents, tobacco smoke, and fireplaces, as well as from dermal contact with consumer products such as solvents. In addition, there will be exposure by ingestion of food that may naturally contain acetone, such as onions, apples, grapes, and tomatoes, or exposure from contaminated drinking water. (Howard 1990)

Acetone is a compound that occurs normally in small amounts in human blood and urine, is a component of human breath and is of metabolic origin (NIOSH 1978).

A 90 day oral gavage study with groups of albino rats at levels of 0, 100, 500, or 2500 mg/kg/day resulted in an increase in kidney-to-body and brain weight ratios for both sexes in the 2500 mg/kg group. Liver weight and liver-to-body weight ratios were also elevated for the 2500 mg/kg group. Females revealed a significant increase in kidney and liver weights at the 500 mg/kg/day exposure level. The NOEL for this study is 100 mg/kg/day. Based on this study, U.S.EPA has established a reference dose (RfD) of 0.1 mg/kg/day (IRIS 1994).

***POLYNUCLEAR AROMATIC HYDROCARBONS.*** Polynuclear aromatic hydrocarbons are a class of organic compounds that are formed during the incomplete combustion or pyrolysis of organic material containing carbon and hydrogen (USEPA 1984f). Polynuclear aromatic hydrocarbons are found in petroleum-derived products, asphalts, coal tar, creosote oils, and coal tar pitches formed by the distillation of coal tar. Polynuclear aromatic hydrocarbons characteristics are: Multiringed organic compounds usually with densities greater than water; low solubility in water; high partition coefficients, which explains their affinity for organic matter (high affinity for soil over water); low vapor pressure; and slow biological degradation half-lives, which explains their persistence in soil and other media.

Polynuclear aromatic hydrocarbons are a class of compounds that are formed during the incomplete combustion or pyrolysis of organic materials containing carbon and hydrogen (USEPA 1984f).

Polynuclear aromatic hydrocarbons are released to the environment through natural and man-made sources with emissions largely to the atmosphere. Natural sources include emissions from volcanoes and forest fires. Man-made sources provide a much greater release volume than natural sources; the largest single source is the burning of wood in homes. Automobile and truck emissions are also major sources of polynuclear aromatic hydrocarbons. On a local scale, hazardous waste sites can be a concentrated source of polynuclear aromatic hydrocarbons. Polynuclear aromatic hydrocarbons can enter surface water through atmospheric deposition and from discharges of industrial effluents, municipal wastewater, and improper disposal of used motor oil.

In air, polynuclear aromatic hydrocarbons are found sorbed to particulates and as gases (ATSDR 1989b). Benzo(a)anthracene, chrysene, benzo(a)pyrene and benzo (g,h,i)perylene should exist predominantly in the particulate sorbed phase in the atmosphere whereas naphthalene, fluoranthene, and pyrene should exist in the vapor phase in the atmosphere (USEPA 1984f). Particulate-bound polynuclear aromatic hydrocarbon can be transported long distances and are removed from the atmosphere through precipitation and dry deposition (ATSDR, 1989b). The removal of polynuclear aromatic hydrocarbons from the atmosphere can occur through photochemical reactions; chemical reactions with hydroxy radicals, ozone and nitrogen oxides; and physical removal mechanisms. The polynuclear aromatic hydrocarbons that exist in the vapor phase in the atmosphere are likely to be removed primarily through direct or indirect photochemical reactions (USEPA 1984f).

Three mechanisms that may be responsible for the removal of polynuclear aromatic hydrocarbons from aquatic media are volatilization, photochemical reactions and microbial degradation. Polynuclear aromatic hydrocarbons are transported from surface waters by volatilization and sorption to settling particles. The compounds are transformed in surface waters by photooxidation, chemical oxidation and microbial metabolism. In soils and sediments, microbial metabolism is the major process for degradation of polynuclear aromatic hydrocarbons (ATSDR 1989b).

The predominant mechanism for the removal of polynuclear aromatic hydrocarbons from soils is likely to be microbial degradation. Based on the assumption that microbial degradation is greater in soils than in aquatic systems, the half-life of polynuclear aromatic hydrocarbons in soils could range from less than a day to a few years. Considering the soil sorption coefficient and water solubilities, these compounds are not expected to have high mobility in soils. Therefore, significant leaching of these compounds into groundwater is not expected, particularly from soils with higher organic carbon content (USEPA 1984f).

Biological effects of PAHs on terrestrial vegetation have been reviewed by several authors as presented in Eisler (1987). In general, these authorities agreed on several points. First, plants and vegetables can absorb PAHs from soil through their roots, and translocate them to other plant parts such as developing shoots. Second, above-ground parts of vegetables, especially the outer shell or skin, contained more PAHs than underground parts, and this was attributed to airborne deposition and subsequent adsorption. Third, PAH-induced phytotoxic effects were rare; however, the data base on this subject is small. Fourth, most higher plants can catabolize benzo(a)pyrene, and possibly other PAHs, but metabolic pathways have not been clearly defined. Finally, the biomagnification potential of vegetation in terrestrial and aquatic food PAHs in both field and laboratory experiments.

Eisler refers to two articles regarding PAHs and avian wildlife, and both concerned mallards (Anas platyrhynchos). In one study, Patton and Dieter (1980), as cited by Eisler (1987), fed mallards diets that contained 4,000 mg PAHs/kg (mostly as napthlenes, napthenes, and phenanthrene) for a period of 7 months. No mortality or visible signs of toxicity were evident during exposure; however, liver weight increased 25% and blood flow to liver increased 30%, when compared to controls. In the second study, Hoffman and Gay (1981), as cited by Eisler (1987), measured embryotoxicity of various PAHs applied externally, in a comparatively innocuous synthetic petroleum mixture, to the surface of mallard eggs. For benzo(a)pyrene, 0.002 ug/egg did not affect mallard survival, but did cause embryonic growth and an increased incidence of abnormal survivors. At 0.01 ug benzo(a)pyrene/egg, 60% died in 18 days; at 0.05 ug/egg, 75% were dead within 3 days of treatment. Embryos may contain microsomal enzymes that can metabolize PAHs to more highly toxic intermediates than can adults, and avian embryos may have a greater capacity to metabolize PAHs in this manner than do mammalian embryos and fetuses (as quoted in Hoffman and Gay 1981, as cited by Eisler 1987); this observation warrants additional research. Several investigators have suggested that the presence of PAHs in petroleum, including benzo(a)pyrene, chrysene, and 7,12-dimethylbenz(a)anthracene, significantly enhances the overall embryotoxicity in avian species, and that the relatively small percent of the aromatic hydrocarbons contributed by PAHs in petroleum may confer much of the adverse biological effects reported after eggs have been exposed to microliter quantities of polluting oils (Hoffman and Gay 1981; Albers 1983, as cited by Eisler 1987).

Numerous PAH compounds are distinct in their ability to produce tumors in skin and in most epithelial tissues of practically all animal species tested; malignancies were often induced by acute exposures to microgram quantities. In some cases, the latency period can be as short as 4 to 8 weeks, with the tumors resembling human carcinomas. Certain carcinogen PAHs are capable of passage across skin, lungs, and intestine, and can enter the rat fetus, for example, following intragastric or intravenous administration to pregnant dams. In most cases, the process of carcinogenesis occurs over a period of many months in experimental animals, and many years in man. The tissue affected is determined by the route of administration and species under investigation. Thus, 7,12-dimelthylbenz(a)anthracene is a potent carcinogen for the mammary gland of young female rats after oral or intravenous administration; dietary benzo(a)pyrene leads to leukemia, lung adenoma, and stomach tumors in mice; and both PAH compounds can induce hepatomas in skin of male mice when injected shortly after birth. Acute and chronic exposure to various carcinogenic PAHs have resulted in destruction of hematopoietic and lymphoid tissues, ovotoxicity, antispermatogonic effects, adrenal necrosis, changes in the intestinal and respiratory epithelia, and other effects. For the most part, however, tissue damage occurs at dose levels that would also be expected to induce carcinomas, and thus the threat of malignancy predominates in evaluating PAH toxicity. There is a scarcity of data available on the toxilogical properties of PAHs which are not demonstrably carcinogenic to mammals.

Target organs for PAH toxic action are diverse, due partly to extensive distribution in the body and also to selective attack by these chemicals on proliferating cells. Damage to the hematopoietic and lymphoid system in experimental animals is a particularly common observation. Application of carcinogenic PAHs to mouse skin leads to destruction of sebaceous glands and to hyperplasia, hyperkeratosis, and ulceration. Tumors are induced in application of a large dose, or by the single application of certain noncarcinogenic agents (promotion).

Investigators agree that unsubstituted aromatic PAHs with less than 4 condensed rings have not shown tumorigenic activity; that many, but not all, 4-,5-, and 6-ring PAH compounds are carcinogenic; and that only a few unsubstituted hydrocarbons with 7 rings or greater are tumorigenic or carcinogenic. Many PAH compounds containing 4 and 5 rings, and some containing 6 or more rings, provoke local tumors after repeated application to the dorsal skin of mice; the tumor incidence exhibited a significant dose-response relationship (Grimmer et al. 1985 as cited in Eisler 1987). Among unsubstituted PAHs containing a nonaromatic ring, e.g., chloranthrene and acepthanthacene, all active carcinogens retained an intact phenantrene segment. The addition of alkyl substitutents in certain positions in ring system of a fully aromatic PAH will often confer carcinogenic activity or dramatically enhance existing carcinogenic potency. For example, monomethyl substitution of benz(a)anthracene can lead to strong carcinogenicity in mice, with potency depending on the position substitution in the order $7 > 6 > 8 = 12 > 9$;

a further enhancement of carcinogenic activity is produced by appropriate dimethyl substitution, with 7,12-dimethylbenzene(a)anthracene among the most potent PAH carcinogens known. Alkyl substitution of partially aromatic condensed ring systems may also add considerable carcinogenic activity, as is the case with 3-methylchlolanthrene. With alkyl substituted longer than methyl, carcinogenicity levels decrease, possibly due to a decrease in transport through cell membranes.

A good correlation exists between skin tumor initiating activities of various benzo(a)pyrene metabolites, and their mutagenic activity in mammalian cell mutagenesis systems (Slaga et al. 1978 as cited in Eisler 1987), although variations in chromosome number and structure may accompany tumors induced by various carcinogenic PAHs in rats, mice, and hamsters (Bayer 1978; EPA 1980 as cite in Eisler 1987). Active PAH metabolites, e.g., dihydrodiols or diol epoxides, can produce sister chromatid exchanges in Chinese hamster ovary cell (Bayer 1978; EPA 1980; Pal 1984 as cited in Eisler 1987). When exchanges were induced by the diol epoxide, a close relationship exists between the frequency of sister chromatid exchanges and the levels of deoxyribnucleoside-diol-epoxide adduct formation. In general, noncarcinogenic PAHs were not mutagenic.

Laboratory studies with mice have shown that many carcinogenic PAHs adversely affect the immune system, thus directly impacting an organism's general health, although noncarcinogenic analogues had no imunosuppressive effect; further, the more carcinogenic the PAH, the greater the immunosuppression (Ward et al. 1985 as cited in Eisler 1987).

Numerous studies show that unsubstituted PAHs do not accumulate in mammalian adipose tissues despite their high lipid solubility, probably because they tend to be rapidly and extensively metabolized (EPA 1980; Lee and Grant 1981 as cited by Eisler 1987).

Many chemicals are known to modify the action of carcinogenic PAHs in experimental animals, including other PAHs that are weakly carcinogenic or noncarcinogenic. The effects of these modifiers on PAH metabolism appear to fall into three major categories: those which alter the metabolism appear to fall into three major categories: those which alter the metabolism of the carcinogen, causing decreased activation or increased detoxification; those which scavenge active molecular species of carcinogens to prevent their reaching critical target sites in the cell; and those which exhibit competitive antagonism (DiGiovanni and Slaga 1981as cited by Eisler 1987). For example, benz(a)anthracene, a weak carcinogen, when applied simultaneously with benz (a)anthracene, a weak carcinogen, when applied simultaneously with dibenz(a,h)anthracene, inhibited the carcinogenic action of the latter in mouse skin; a similar case is made for benzo(e)pyrene or dibenz(a,c)anthracene applied to mouse skin shortly prior to initiation with 7,12-dimethylbenz(a)antracene, or 3-methylcholanthrene (DiGiovanni and Slaga 1981as cited by Eisler 1987). Benxo(a)pyrene, a known carcinogen, interacts synergistically with cyclopenta(cd)pyrene, a moderately strong carcinogen found in automobile exhausts, according to results of mouse skin carcinogenicity studies (Rogan et al. 1983 as cited by Eisler 1987). Other PAH combinations were cocarcinogenic, such as benxo(e)pyrene to the skins of mice (DiGiovanni and Slaga 1981as cited by Eisler 1987). Effective inhibitors of PAH-induced tumor development include selenium, vitamin E, ascorbic acid, butylated hydroxytoluene, and hydroxyanisole (EPA 1980 as cited by Eisler 1987). In addition, protective effects against PAH-induced tumor formation have been reported for various naturally occurring compounds such as flavones, retenoids, and vitamin A (EPA 1980 as cited by Eisler 1987). Until these interaction effects are clarified, the results of single substance laboratory studies may be extremely difficult to apply to field situations of suspected PAH contamination. Additional work is also needed on PAH dose-response relationships, testing relevant environmental PAHs for carcinogenicity, and elucidating effects of PAH mixtures on tumer formation (Grimmer 1983 as cited by Eisler 1987).

Eisler (1987) presents toxicity values for several PAHs. Acute oral LD50's for benzo(a)pyrene and phenanthrene were 50 and 700 mg/kg (body weight) respectively. Carcinogenic effects were observed for chronic oral doses (mg/kg body weight) with benzo(a)pyrene (0.002), dibenz(a,h)anthracene (0.006), benz(a)anthracene (2.), benzo(b)fluoranthene (40.0), indeno (1,2,3-cd) pyrene (72.0) and chrysene (99.0). Carcinogenic effects were also observed in mice for topical external application (mg) of benzo(a)pyrene (0.001), benzo(g,h,i)perylene (0.8), and benzo(a)anthracene.

**Chlordane.** Chlordane has been released in the past into the environment primarily from its application as an insecticide. The amount of chlordane used annually in the U.S. prior to 1983 was estimated in 1985 to be greater than 3.6 million pounds. Between July 1, 1983 and April 14, 1988, the only approved use for chlordane in the U.S. was for underground termite control. As of April 14, 1988, however, all commercial use of chlordane is a mixture of at least 50 compounds; the major constituents of the mixture are cis- and transchlordane, heptachlor, cis- and trans-nonachlor, α, β, and γ-chlordene, 3a,4,5,5a,6-exo-hexachloro-1a,2,3,3a,5a,5b-hexahydro-1,4-methano-1H-cyclobuta(cd)pentalene, and 2,4,4,5,6,6,7,8-octahydro-2,3,3a4,5,7a-hexahydro-1,4-methano-1H-indene[11]. If released to soil, chlordane may persists for long periods of time. Under field conditions, the mean degradation rate has been observed to range from 4.05-28.33%/yr with a mean half-life of 3.3 years. Chlordane is expected to be generally immobile or only slighly mobile in soil based on field tests, soil column leaching tests and estimated Koc estimation; however, its detection in various ground water in NJ and elsewhere indicated that movement to groundwater can occur. Soil volatility tests, have found that chlordane can volatilize significantly from soil surfaces on which it has been sprayed, particularly moist soil surfaces; however, shallow incorporation into soil will greatly restrict volatile losses. Although sufficient biodegradation data are not available, it has been suggested that chlordane is very slowsly biotransformed in the environment which is consistent with the long persistence periods observed under field conditions. If released to water, chlordane is not expected to undergo significant hydrolysis, oxidation or direct photolysis. The volatilization half-life from a river one meter deep flowing 1 m/sec with a wind velocity of 3 m/sec is estimated to be 7.3-7.9 hrs. at 23 $^0$ C for the $\gamma$- and trans-isomers, respectively, and 43 hrs for technical chlordane; the volatilization half-lives from a representative environmental pond, river and lake are estimated to be 18-26, 3.6-5.2 and 14.4-20.6 days, respectively. However, adsorption to sediment signigicanlty attenuates the importance of volatilization. Adsorption to sediment is expected to be a major fate process based on soil adsorption data, estimated Koc values (24,600-15,500), and extensive sediment monitoring data. Bioconcentration is expected to be important based on experimental BCF values which are generally above 3,200. Sensitized photolysis in the water column may be possible. The presence of chlordane in sediment core samples suggests that chlordane may be very persistent in the adsorbed state in the aquatic environment. The observation that 85% of the chlordane originally present in a sealed glass jar under sunlight and artificial lifgt in a river die-away test remained at the end of two weeks and persisted at that level through week 8 of the experiment; this indicates that chlordane will be very persistent in aquatic environments. If released to the atmosphere, it will be expected to be predominantly in the vapor phase. Chlordane will react in the vapor-phase with photochemically produced hydroxyl radicals at an estimated half-life rate of 6.2 hr. suggesting that this reaction is the dominant chemical removal process. The detection of chlordane in remote atmosphere (Pacific and Atlantic Oceans; the Arctic) indicates that long range transport occurs. It has been estimated that 96% of the airborn reservoir of chlordane exists in the sorbed state which may explain why its long range transport possible without chemical transformation. The detection of chlordane in rainwater and its observed dry deposition at various rural locations indicated that physical removal via wet and dry deposition occurs in the environment. Major general population esposure to chlordane can occur through oral consumption of contaminated food and inhalation of contaminated air. Occupation exposure by dermal and inhalation routes related to the use of chlordane as an insecticide may be significan (Howard, 1990).

A NOAEL of 0.055 mg/kg-day (1 ppm) was developed from a dietary study with Charles River Fischer rats. A LOAEL of 0.273 mg/kg-day was also reported with regional liver hypertrophy as the effect for females (IRIS 1994).

***BARIUM*.** Barium, CASRN 7440-39-3, is a silvery white metallic element which oxidizes very easily. It is one of the less expensive metals that have the distinctive properties of absorbing gases. It belongs to the alkaline earth group, resembling calcium chemically. The most important compounds are the peroxide, chloride, sulfate, carbonate, nitrate, and chlorate. Naturally occurring barium is a mixture of seven stable isotopes (CRC, 1984).

Traces of barium are very widely distributed. No data exist concerning its presence or its amount in dust; the content of barium will probably be proportionally related to the calcium content.

Barium is extremely reactive, decomposes in water, and readily forms insoluble carbonate and sulfate salts. Barium is generally present in solution in surface or groundwater only in trace amounts. Large amounts will not dissolve because natural waters usually contain sulfate, and the solubility of barium sulfate is generally low. Barium is not soluble at more than a few parts per million in water that contains sulfate at more than a few parts per million. However, barium sulfate may become considerably more soluble in the presence of chloride and other anions. Monitoring programs show that it is rare to find barium in drinking water at concentrations greater than 1 mg/liter. Atmospheric transport of barium, in the form of particulates, can occur. Bioaccumulation is not an important process for barium (Clement, 1985).

There are no reports of carcinogenicity, mutagenicity, or teratogenicity associated with exposure to barium or its compounds. Insoluble forms of barium, particularly barium sulfate, are not toxic by ingestion or inhalation because only minimal amounts are absorbed. Accidental ingestion of soluble barium salts have resulted in gastroenteritis, muscular paralysis, and ventricular fibrillation and extra systoles. There are no adequate animal data available for determining the chronic effects of low level exposure to barium by ingestion. Adequate data for characterization of toxicity to wildlife and domestic animals are not available (Clement, 1985).

The LOAEL identified in the Perry et al study (5.1 mg/kg/day) has been used in the derivation of the oral RfD without an additional 10-fold uncertainty factor for the lack of a NOAEL. The oral reference dose is 5x10$^{-2}$ mg/kg/day with an uncertainty factor of 100 (IRIS 1994).

***BERYLLIUM.*** Beryllium, Chemical Abstract Service Registry No. 7440-41-7 is a metal that is also known as glucinium. It is one of the lightest of metals, is widely distributed geographically, and has found wide application in industry. Some features that has contributed to its wide use in industry are that it is a stable lightweight metal with a high melting point, it has a high strength to weight ratio, and it imparts resistance to corrosion, vibration, and shock when alloyed with other metals.

Beryllium usually exists in nature as a compound. Bextrandixe and beryl ores are used commercially for obtaining beryllium. Beryllium is also found in coal and gasoline (ATSDR, 1987a). Common forms of beryllium are beryllium oxide, fluoride, and hydroxide.

Although beryllium is a naturally occurring substance, the major source of its emission to air is the combustion of coal and fuel oil, which releases particulates and fly ash containing beryllium into the atmosphere. The average concentration of beryllium in coal is 1.8 - 2.2 micrograms per gram. Fuel oil can contain 0.08 ppm beryllium. The beryllium released from coal combustion is likely to be in the form of beryllium oxide. Beryllium oxide is relatively insoluble and would not be mobilized in soil or surface water at normal pH ranges. It is believed that most environmental beryllium is present in an insoluble form. This is substantiated by empirical data which indicate that even in polluted rivers, dissolved beryllium levels are very low. In most type of soils, beryllium is expected to be tightly absorbed because it displaces divalent cations which share common absorption sites. Removal of beryllium from the atmosphere results from wet and dry deposition. No evidence was found that any environmental process results in the volatilization of beryllium into the atmosphere from water or soil (ATSDR, 1987a).

Schroeder and Mitchner (1975 as cited in IRIS 1994) orally administered beryllium (as beryllium sulfate) to rats at dose level of 0 and 0.54 mg/kg/day. The exposure was for a lifetime, after which the rats were observed for changes in the heart, kidney, liver, and spleen. There were no effects of treatment on these organs nor on the number of tumors, the lifespan, urinalysis, serum glucose, cholesterol, and uric acid. Two other studies (Schroeder and Mitchner, 1975 and Morgareidge et al. 1975 as cited in IRIS 1994) indicates higher dose levels may be NOEL (IRIS 1994).

Based on the above studies, U.S. EPA established an oral reference dose of 5 x $10^{-3}$ mg/beryllium/kg/day with an uncertainty factor of 100 (IRIS 1994).

A reference dose for inhalation toxicity is not available at this time from USEPA IRIS. Several studies on the inhalation toxicity of beryllium are, however, noteworthy. Hardy and Tabershaw (1946 as cited in IRIS 1994) noted that decreased longevity following inhalation exposure to beryllium compounds in human is related to the pulmonary effects. Short-term human and animal exposures to high levels of beryllium leads to development of inflammation or reddening and swelling of the lungs (similar to pneumonia). Long-term exposure at much lower levels have been reported to cause berylliosis, which is a noncancerous growth in the lung of humans. A skin allergy has been shown to develop when beryllium comes in contact with the skin. (ATSDR, 1987a)

Several studies were performed that associated the increases in the rate of mortality due to cancer to exposure to beryllium (Wagoner et al. 1980, Bayliss and Wagoner 1977; Mancuso, 1970, 1979, 1980 as cited in IRIS 1994). When the number of expected deaths was adjusted for smoking, the increased incidence was no longer significant (IRIS 1994).

Despite the inadequate studies performed for human subjects, there does exist sufficient animal studies to justify classifying beryllium B2; probable human carcinogen. Based on the evidence for induction of tumors by a variety of beryllium compounds in male and female monkeys and in several strains of rats of both sexes ,via inhalation and intratracheal instillation, and the induction of osteosarcomas in rabbits by intravenous or intramedullary injection in multiple studies, an oral slope factor of 4.3 mg/kg/day has been assigned by U.S. EPA (IRIS 1994).

Despite limitations in the human studies, human data was used to establish an inhalation slope factor of 8.4 mg/kg/day. Humans are most likely to be exposed by inhalation to beryllium oxide, rather than other beryllium salts. Animal studies by inhalation of beryllium oxide have utilized intratracheal instillation, rather than general inhalation exposure. (IRIS 1994)

Based on a study with fifty-two weanling Long-Evans rats, each sex received 0 or 5 ppm beryllium in drinking water. Exposure was for the lifetime of the animals. A NOEL was observed for 5 ppm or 0.54 mg/kg/day. A body weight of 0.325 kg was used for the rats. There is no LOAEL for beryllium (IRIS 1994).

***Cadmium.*** Cadmium, Chemical Abstract Service Registry No. 7440-43-9 is a silver-blue-white metal. Pure metallic cadmium is not common in the environment. It is most often encountered in combination with other elements such as oxygen, chlorine, or sulfur. Metallic cadmium has a low melting point for metals ($321^0$C) and is insoluble in water. (ATSDR 1987d)

Cadmium enter the environment to a limited extent from the natural weathering of minerals, but to a much greater degree from pollutant sources such as discarded metal-containing products, phosphate fertilizers, and fuel combustion (ATSDR 1987d).

Although overall natural sources of cadmium are relatively low, the metal is widely distributed in the Earth's crust and is commonly found at detectable levels in soil, surface water, and groundwater (ATSDR 1987d).

Atmospheric cadmium is in the form of very small particulate matter, produced by combustion of fuel containing cadmium. This material is subject to dry deposition and rainwash, so that cadmium levels in the atmosphere are generally less than 3 ng/m$^3$ near specific cadmium emitting industries. Cadmium in surface water is usually present at less than 1 ng/L; industrial contaminations can result in concentrations up to 10 ng/L. There is some concern that soil cadmium levels are increasing largely from the use of cadmium-contaminated phosphate fertilizer and land disposal of some sewage sludges containing particularly high levels of cadmium. Consumption of food represents the greatest sources of human exposure, since plants take up cadmium from the soil (ATSDR 1987d).

Combustion of coal and petroleum products tend to produce cadmium that is adsorbed to small (1 to 2 micron) particles that are persistent in the atmosphere and are easily respirable. In this form, cadmium can be transported to some distance and transferred to other environmental compartments via wet or dry deposition (ATSDR 1987d).

Compared to most other heavy metals, cadmium is relatively mobile in the aqueous environment. In natural waters, cadmium may exist as the hydrated ion; as metal-inorganic complexes with $CO_3^{-2}$, $OH^-$, $Cl^-$ or $SO_4^{-2}$; or as metal-organic complexes with humic acids. Cadmium does not form volatile compounds in the aquatic environment, nor does biological methylation occur (ATSDR 1987d).

Concentrations of cadmium in groundwater are kept low by sorption by mineral matter and clay, binding by humic substances, precipitation as cadmium sulfide in the presence of sulfide, and precipitation as the carbonate at relatively high alkalinities (ATSDR 1987d).

Cadmium may be present in soil as free cadmium compounds or in solution dissolved in soil water. It may also be held to soil mineral or organic constituents by cation exchange. High soil acidity favors release of cadmium and its uptake by plants (ATSDR 1987d). Cadmium is mobile in soil, as evidenced by the detection of this element in 100% of the groundwater samples collected from New Jersey (USEPA 1984a).

The acute $LC_{50}$ for freshwater fish and invertebrates generally ranged from 100 to 1,000 ug/liter; salmonids are much more sensitive than other organisms. Saltwater species were in general 10-fold more tolerant to the acute effects of cadmium. Chronic tests have been performed and show that cadmium has cumulative toxicity and acute-chronic ratios that range of from 66 to 431. Bioconcentration factors were generally less than 1,000 but were as high as 10,000 for some freshwater fish species (Clement, 1985).

A NOAEL of 0.01 mg/kg-day (food) was developed based on human studies invoving chronic exposures. A LOAEL was not reported (IRIS 1994).

***CHROMIUM.*** The ammonium and alkali metal salts of hexavalent chromium are generally water-soluble, but the alkaline metal salts (calcium, strontium) are sparingly soluble or insoluble in water. Hexavalent chromium rarely occurs in nature apart from man-made sources because it is readily reduced in the presence of oxidizable organic matter; however, hexavalent chromium compounds that occur most commonly in the form of chromate and dichromate are stable in many natural waters because of the low concentration of reducing matter. Except acetate and nitrate salts, the trivalent chromium compounds are generally insoluble in water. In most biological systems, chromium is present in the trivalent form. The physical or chemical forms and the mode by which chromium (III) compounds are incorporated into biological systems are poorly characterized (ATSDR, 1987b).

Chromium occurs naturally in the earth's crust. Continental dust is the primary source of natural chromium present in the environment; however, chromium is released to the environment because of human activities in much larger amounts. Chromium is primarily removed from the atmosphere by fallout and precipitation. Atmospheric chromium removed by physical processes predominantly enters surface water or soil; however, before their removal, chromium particles of aerodynamic diameter less than 20 um may remain airborne for long periods and may be transported long distances (ATSDR 1987b).

Because there are no known chromium compounds that can volatilize from water, transport of chromium from water to the atmosphere is not likely other than by transport in windblown sea sprays. Most of the chromium (III) is eventually expected to precipitate in sediments. Small amounts of chromium (III) may remain in solution as soluble complexes. Chromium (VI) will be present predominantly in soluble form. These soluble forms of chromium may be stable enough to undergo intramedia transport; however, organic matters present in water will eventually reduce chromium (VI) to chromium (III). It has been estimated that the residence time of chromium in lake water is from 4.6 to 18 years (ATSDR, 1987b).

Chromium probably occurs as insoluble $Cr_2O_3.H_2O$ in soil because the organic matter in soil is expected to convert soluble chromate to insoluble $Cr_2O_3$. Chromium in soil may be transported to the atmosphere in the aerosol form, and runoff and leaching may transport chromium from soil to surface waters and ground water. Runoff could remove both soluble and bulk precipitate with final deposition on either a different land area or a water body. Flooding of soils and the subsequent anaerobic decomposition of plant matter may increase mobilization of chromium in soils because of the formation of soluble complexes. The half-life of chromium in soils may be several years (ATSDR, 1987b).

Chromium is an essential nutrient and is accumulated in a variety of aquatic and marine biota, especially benthic organisms, to levels much higher than in ambient water. Levels in biota, however, usually are lower than levels in the sediments. Passage of chromium through the food chain can be demonstrated. The food chain appears to be a more efficient pathway for chromium uptake than direct uptake from seawater.

Water hardness, temperature, dissolved oxygen, species, and age of the test organism all modify the toxic effects of chromium on aquatic life. Cr III appears to be more acutely toxic to fish than Cr VI; the reverse is true in long term chronic exposure studies.

None of the plants normally used as food or animal feed are chromium accumulators. Chromium absorbed by plants tends to remain primarily in the roots and is poorly translocated to the leaves. There is little tendency for chromium to accumulate along food chains in the trivalent inorganic form.

A bioconcentration factor for manganese in a species of edible fish (striped bass) has been reported to be less than 10. Bioaccumulation of manganese may not occur significantly with organisms of higher tropic level (USEPA, 1984c).

Both chemical and microbiological interactions may cause speciation of manganese in soils; soil pH and oxidation-reduction potential of soil may influence the speciation process. It has been suggested that in acid water-logged soils, manganese passes freely into solution and may leach into groundwater. Also, manganese can be leached directly from waste burial sites and from other natural soils into groundwater (USEPA, 1984c).

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Manganese occurs in many minerals that are widely distributed in the earth's crust and, in trace amounts, is an essential element for both plants and animals. The many different possible manganese compounds may enter the aquatic environment from natural and industrial sources. Manganese and its compounds have moderate acute and chronic toxicity to aquatic life. Insufficient data are available to evaluate or predict the short-term and long-term effects to plants, birds, or land animals.

Manganese and its compounds range in their respective water solubilities from very soluble to insoluble. It is also highly persistent with a half-life of greater than 200 days. Manganese is expected to be found at about the same levels in fish tissue, as in the surrounding waters (Clement, 1985).

A NOAEL of 0.005 mg/kg-day was established from a human chronic ingestion study. A LOAEL was also established as 0.06 mg/kg-day based on CNS effects (IRIS 1994).