Report. HW 808013. 1987-04-27. SUPPLEMENTAL_

INVESTIGATION. PDF

8-08-013

MALCOLM PIRNIE

MALCOLM PIRNIE, INC.
ENVIRONMENTAL ENGINEERS, SCIENTISTS & PLANNERS

April 23, 1987

Glen R. Bailey, Esq.
Senior Attorney
Division of Environmental Enforcement
New York State Department
of Environmental Conservation
600 Delaware Avenue
Buffalo, New York 14202-1073

Dear Sir:

Enclosed are four (4) copies of our Report on Supplemental Field Investigations at the I. Shulman & Son site in Elmira, New York.

The report has been reviewed by our client and his attorney and is submitted per their instructions.

We have drafted a Compliance Schedule which will be reviewed by our client and submitted for your review at our upcoming meeting.

Please do not hesitate to call if you have any questions.

Very truly yours,

MALCOLM PIRNIE, INC.

Richard W. Klippel, P.E.
Project Manager

RWK/mmp

cc: John Ianotti - NYSDEC
Jack Quinn, Esq. - ORNQC
Irving R. Rinde, Esq.

Enclosure

0801-03-1

Report

DRAFT

SUPPLEMENTAL FIELD INVESTIGATION

I. Shulman and Son Company, Inc.
Elmira, New York

April 1987

MALCOLM PIRNIE

ENVIRONMENTAL ENGINEERS, SCIENTISTS & PLANNERS

MALCOLM PIRNIE

MALCOLM PIRNIE, INC.
ENVIRONMENTAL ENGINEERS, SCIENTISTS & PLANNERS

April 16, 1987

Irving R. Rinde, Esq.
458 East Church Street
Elmira, New York 14901

Re: I. Shulman & Son Co., Inc.

Dear Mr. Rinde:

Enclosed is a draft copy of the Supplemental Field Investigation Report for the I. Shulman & Son site in Elmira, New York. As agreed upon by Paul Werthman (MPI) and Jack Bailey (NYSDEC), the report must be submitted to the NYSDEC by April 24, 1987. This revises Mr. Bailey's letter of March 19, 1987. This would be followed by a meeting on May 6 to discuss the report (the meeting time and place are not yet confirmed).

The schedule requested by Mr. Bailey in his March 19, 1987 letter will be presented and discussed at the May 6, 1987 meeting. We will forward you a copy in advance for your review.

Regarding the draft report, we would appreciate your comments by Wednesday April 22, 1987 to allow us to revise the report and submit it to the State by April 24, 1987. Please call Mr. Thomas A. Barba or me with your comments.

By copy of this letter, Mr. Jack Quinn (O'Shea, Reynolds, Napier, Quinn and Cummings) is also requested to comment by April 22, 1987.

Very truly yours,

MALCOLM PIRNIE, INC.

Richard W. Klippel, P.E.
Project Manager

RWK/mmp

Enclosure

cc: J. Quinn - ORNQ&C
P. Werthman - MPI/Letter Only

0801-03-1

890 SEVENTH NORTH ST. LIVERPOOL, NEW YORK 13088 315-457-4105 TELEX 137364

TABLE OF CONTENTS

		PAGE
SECTION 1	INTRODUCTION	
1.0	Site Location and History	1-1
1.1	Summary of Previous Investigations	1-1
1.2	Purpose of Supplemental Investigations	1-8
SECTION 2	PROJECT SCOPE OF WORK	
2.0	Sewer Investigation	2-1
2.1	Soil and Oil Sampling	2-1
2.2	Installation of Monitoring Wells	2-1
2.3	Groundwater Sampling	2-2
SECTION 3	RESULTS OF SUPPLEMENTAL INVESTIGATIONS	
3.0	Sewer Investigation	3-1
3.1	Soil and Oil Samples	3-1
3.2	Hydrogeologic Investigation	3-4
3.2.1	Site Hydrogeology	3-4
3.2.2	Groundwater Flow	3-7
3.2.3	Groundwater Sampling	3-9
SECTION 4	CONCLUSIONS AND RECOMMENDATIONS	
4.1	Conclusions	4-1
4.2	Recommendations	4-2

LIST OF TABLES

Table 1-1	Results of PCB Analysis of Test Pit, Area Drain and Oil Samples	1-2
Table 1-2	Heavy Metals Analytical Results For Test Pit Samples	1-4
Table 1-3	Heavy Metals Analytical Results For Area Drain	1-5
Table 1-4	Priority Pollutants Detected at Area Drain	1-6
Table 2-1	Well Construction Details, Water Levels & Permeability Testing Results	2-3
Table 3-1	Results of PCB Analysis of Monitoring Well, New Test Pit, and Oil Samples	3-2
Table 3-2	Results of Volatile Organic Analysis of Monitoring Well Samples	3-10
Table 3-3	Results of Metals Analysis of Monitoring Well Samples	3-11

TABLE OF CONTENTS
(Continued)

PAGE

LIST OF FIGURES

Figure 1-1	Test Pit and Monitoring Well Locations	1-7
Figure 3-1	Sewer Location Diagram	3-3
Figure 3-2	Site Geology	3-5
Figure 3-3	Fence Diagram	3-6
Figure 3-4	Configuration of the Water Table Surface	3-8

LIST OF APPENDICES

Appendix A	Boring Log For MW-1D
Appendix B	Proposed Sewer Sampling Plan
Appendix C	Boring Logs For MW-1S Through MW-4S
Appendix D	Results of Slug Tests

SECTION 1
INTRODUCTION

1.0 SITE LOCATION AND HISTORY

I. Shulman and Son Company, Inc. (Shulman) owns and operates a ferrous and non-ferrous metal salvaging facility comprising 24 acres located at One Shulman Plaza in the City of Elmira, Chemung County, New York.

Metal salvaging operations have been performed on the site for approximately twenty years. In 1982, a shipment of drained transformers was received by Shulman for processing. The transformers were dismantled on-site and sold as scrap. It is suspected by the New York State Department of Environmental Conservation (NYSDEC) that these transformers were contaminated with "PCB" oil which was spilled onto the surface of the site during the dismantling operations. Consequently, the NYSDEC and Shulman have entered into a Consent Agreement which has resulted in the performance of a series of site investigations.

1.1 SUMMARY OF PREVIOUS INVESTIGATIONS

In 1984, a field investigation was performed by Malcolm Pirnie, Inc. The investigation included soil sampling of fourteen test pits, sampling of sediment from a site surface drainage inlet (no water was present), and sampling of a pool of oil. All the samples were analyzed for PCBs, cadmium, chromium, copper, iron, lead, nickel, selenium and zinc. Additionally, the sediment sample was analyzed for all "priority pollutant" compounds except asbestos, acrolein and acrylonitrile. Sample locations are shown on Figure 1-1 and analytical results are presented on Tables 1-1 through 1-4.

Based on the results of the investigation, site capping was proposed as a conceptual remedial design. The purposes of the cap would be to: reduce the possibility of direct contact with PCB-contaminated surface soils; reduce or eliminate the runoff of PCB-contaminated sediment, and; reduce groundwater recharge.

TABLE 1-1
(Page 1 of 2)

RESULTS OF PCB ANAYSIS OF TEST PIT, AREA DRAIN AND OIL SAMPLES
I. SHULMAN & SON COMPANY

Test Pit No.	Depth of Sample (inches)	PCB's as Aroclor (ug/g-dry weight) 1242	1248	1254	1260	TOTAL PCB
1	0- 6	ND	ND	15.0	ND	15.0
1	6-12	ND	ND	120.0	ND	120.0
1	12-18	ND	ND	24.0	ND	24.0
1	18-24	ND	ND	1.1	ND	1.1
2	0- 6	ND	31.0	ND	33.0	64.0
2	6-12	ND	34.0	ND	62.0	96.0
2	12-18	ND	12.0	ND	12.0	24.0
2	18-24	ND	2.3	ND	3.1	5.4
3	0- 6	16.0	ND	ND	8.9	24.9
3	6-12	15.0	ND	ND	11.0	26.0
3	12-18	30.0	ND	ND	17.0	47.0
3	18-24	36.0	ND	ND	27.0	63.0
4	0- 6	ND	ND	ND	69.0	69.0
4	6-12	ND	ND	ND	27.0	27.0
4	12-18	ND	ND	ND	3.4	3.4
4	18-24	ND	ND	ND	3.0	3.0
5	0- 6	ND	ND	ND	7.3	7.3
5	6-12	ND	ND	ND	1.7	1.7
5	12-18	ND	ND	ND	6.1	6.1
5	18-24	ND	ND	ND	LT 2.0	LT 2.0
6	0- 6	13.0	ND	ND	7.5	21.0
6	6-12	4.3	ND	ND	7.6	12.0
6	12-18	2.8	ND	ND	3.9	6.7
6	18-24	4.3	ND	ND	4.3	8.6
7	0- 6	ND	ND	ND	11.0	11.0
7	6-12	ND	ND	ND	3.4	3.4
7	12-18	ND	ND	ND	0.7	0.7
7	18-24	ND	ND	ND	0.28	0.28

TABLE 1-1
(Page 2 of 2)

RESULTS OF PCB ANAYSIS OF TEST PIT, AREA DRAIN AND OIL SAMPLES
I. SHULMAN & SON COMPANY

Test Pit No.	Depth of Sample (inches)	PCB's as Aroclor (ug/g-dry weight) 1242	1248	1254	1260	TOTAL PCB
8	0- 6	11	ND	ND	34.0	45.0
8	6-12	ND	ND	ND	2.8	2.8
8	12-18	ND	ND	ND	5.5	5.5
8	18-24	ND	ND	ND	4.6	4.6
9	0- 6	ND	ND	ND	1.6	1.6
9	6-12	ND	ND	ND	0.23	0.23
9	12-18	LT 0.2	ND	ND	ND	LT 0.2
9	18-24	ND	ND	ND	LT 0.3	LT 0.3
10	0- 6	ND	ND	ND	15.0	15.0
10	6-12	ND	ND	ND	8.1	8.1
10	12-18	5.0	ND	ND	6.0	11.0
10	18-24	17.0	ND	ND	14.0	31.0
11	0- 6	9.8	ND	ND	5.8	16.0
11	6-12	5.0	ND	ND	4.9	9.9
11	12-18	5.0	ND	ND	9.0	16.0
11	18-24	ND	ND	ND	3.0	3.0
12	0- 6	16.0	ND	ND	6.3	22.0
12	6-12	6.9	ND	ND	1.7	8.6
12	12-18	ND	ND	ND	0.93	0.93
12	18-24	ND	ND	ND	2.3	2.3
13	0- 6	LT 0.2	ND	ND	ND	LT 0.2
13	6-12	LT 0.4	ND	ND	ND	LT 0.4
13	12-18	LT 0.2	ND	ND	ND	LT 0.2
13	18-24	LT 0.4	ND	ND	ND	LT 0.4
14	0- 6	ND	ND	ND	4.5	4.5
14	6-12	24.0	ND	ND	10.0	34.0
14	12-18	22.0	ND	ND	18.0	40.0
14	18-24	25.0	ND	ND	13.0	38.0
Area Drain	-	ND	ND	ND	72.0	72.0
Oil (mg/kg)	-	16.0	ND	ND	5.0	21.0

TABLE 1-2

HEAVY METALS ANALYTICAL RESULTS FOR TEST PIT SAMPLES*

Sample Location	Total Cadmium	Total Chromium	Total Copper	Total Iron	Total Lead	Total Nickel	Total Zinc	Total Selenium
Test Pit 1 and 2	14	148	1,570	124,000	1,700	200	2,150	LT 0.6
Test Pit 3 and 4	19	79	2,280	95,700	1,180	85	2,070	LT 0.6
Test Pit 5 and 6	5.8	96	2,350	100,000	1,170	102	1,080	LT 0.6
Test Pit 7 and 8	5.4	49	19,900	61,000	778	49	94	LT 0.6
Test Pit 9 and 10	4.0	59	502	67,200	1,020	35	4,130	LT 0.6
Test Pit 11	25	136	1,480	82,800	4,050	121	3,240	LT 0.6
Test Pit 12	4.8	42	3,180	56,100	592	37	1,960	LT 0.6
Test Pit 13	LT 0.5	21	783	75,900	63	28	1,080	LT 0.6
Test Pit 14	27	173	7,900	101	2,160	154	8,830	LT 0.6

* All results expressed as ug/g dry weight

TABLE 1-3

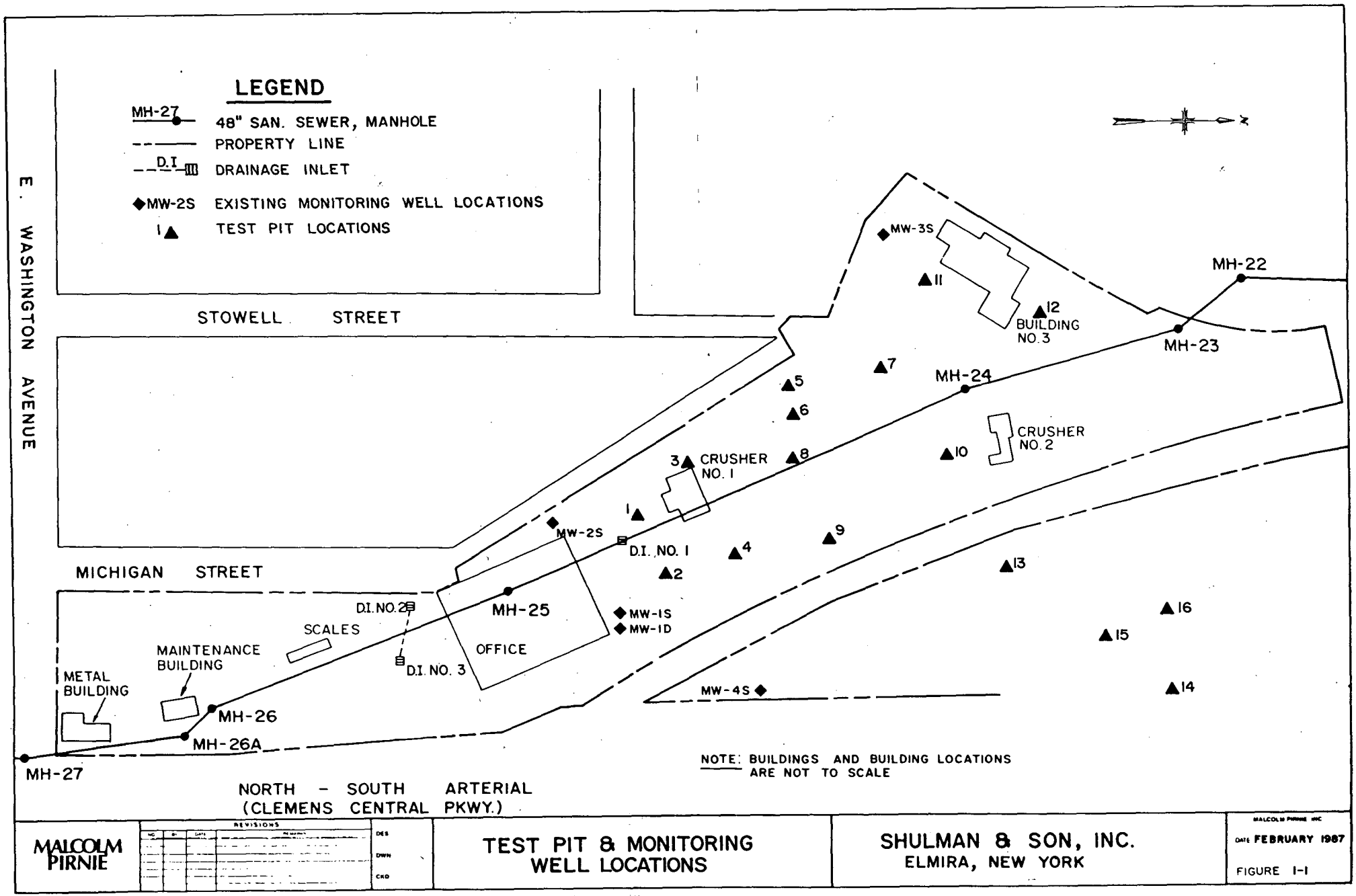
HEAVY METALS ANALYTICAL RESULTS FOR AREA DRAIN

Compound	Concentration (ug/g - dry weight)
Total Antimony	1.4
Total Arsenic	LT 0.5
Total Beryllium	LT 0.5
Total Cadmium	14
Total Chromium	121
Total Copper	1530
Total Lead	1620
Total Mercury	0.7
Total Nickel	111
Total Selenium	LT 0.5
Total Silver	3.5
Total Thallium	LT 0.5
Total Zinc	2250

TABLE 1-4

PRIORITY POLLUTANTS DETECTED AT AREA DRAIN

Compound	Area Drain - ug/g - dry weight
Chrysene	1.9
Phenanthrene	3.4
Pyrene	2.1
Total Cyanide	1.7
Total Phenolics	0.70


LEGEND
MH-27 48" SAN. SEWER, MANHOLE
PROPERTY LINE
D.I. DRAINAGE INLET
MW-2S EXISTING MONITORING WELL LOCATIONS
1 TEST PIT LOCATIONS
E. WASHINGTON AVENUE
STOWELL STREET
MICHIGAN STREET
NORTH - SOUTH ARTERIAL
(CLEMENS CENTRAL PKWY.)
MW-3S
MH-22
MH-23
MH-24
MH-25
MH-26
MH-26A
MH-27
BUILDING NO. 3
CRUSHER NO. 1
CRUSHER NO. 2
MW-2S
D.I. NO. 1
D.I. NO. 2
D.I. NO. 3
MW-1S
MW-1D
MW-4S
SCALES
MAINTENANCE BUILDING
METAL BUILDING
OFFICE
NOTE: BUILDINGS AND BUILDING LOCATIONS ARE NOT TO SCALE
MALCOLM PIRNIE
REVISIONS
DES
DWN
CKD
TEST PIT & MONITORING WELL LOCATIONS
SHULMAN & SON, INC.
ELMIRA, NEW YORK
DATE FEBRUARY 1987
FIGURE 1-1

1.2 PURPOSE OF SUPPLEMENTAL INVESTIGATIONS

Although site capping would eliminate certain exposure pathways, the data indicated that other potential migration pathways might remain, including: vertical migration through the subsurface soils to groundwater, and; off-site migration through the transport of contaminated sediments to the area drain and connecting sewer. Accordingly, the intent of this supplemental investigation, as stated in the Conceptual Remedial Plan and Supplemental Field Investigation Program (October 1986) was to:

a. Establish the existing groundwater quality and potential for vertical migration of PCBs through the subsurface soils to groundwater.

b. Evaluate off-site migration of PCB via contaminated sediments in the sewer.

c. Establish a long term monitoring program.

The supplemental scope of work is described in Section 2.

SECTION 2
PROJECT SCOPE OF WORK

2.0 SEWER INVESTIGATION

The first step in the sewer investigation was to collect sewer maps from the City of Elmira Engineering Department and from Shulman. Subsequently, some dye-testing (as described in Section 3.0) was performed on-site to confirm the destination of the sewer.

2.1 SOIL AND OIL SAMPLING

Two soil samples were collected from new test pits near Area "F". The sample locations are shown as test pits "15" and "16" on Figure 1-1. The samples were scraped from the sidewalls of the test pits at six-inch depth intervals and stored individually in clean glass containers with Teflon caps. The samples were analyzed for PCBs by EPA Method 8080.

An oil sample was collected from the oil pit in Area "C" (Figure 1-1). The sample was a composite of five sampling points. The oil sample was analyzed for PCBs by EPA Method 8080.

2.2 INSTALLATION OF MONITORING WELLS

Subsequent to the initial Malcolm Pirnie investigation (1984), a groundwater monitoring well was installed by Rochester Drilling (1985) at location MW-1D (Figure 1-1). The boring was completed at 27 feet in glaciofluvial outwash sand and gravel deposits. Fill material, consisting mainly of sand and gravel, was encountered from the surface to almost 7 feet deep. The fill was underlain by an 8 foot layer of saturated black organic silt. Below the silt was a 6-foot layer of clay, overlying the sand and gravel outwash deposit. The boring log is included in Appendix A.

During the supplemental investigation, four shallow monitoring wells (MW-1S through MW-4S) were installed. The locations are shown on Figure 1-1.

Each hole was bored using a 6¼-inch hollow stem auger. Split-spoon soil samples were obtained at five-foot intervals or at noticeable changes in stratigraphy. Split-spoon samples were

visually identified in the field by a Malcolm Pirnie hydrogeologist. Samples were placed in glass jars, labelled, and archived until the end of the project.

All drilling equipment was steam cleaned between bore holes, and the split spoons were decontaminated between samples by washing with soapy water and rinsing with acetone and then distilled water.

Each well was constructed with 2-inch inside diameter (I.D.), 5-foot long stainless steel screens with 2-inch I.D. black iron risers. The well annulus in the screening interval was backfilled with well-sorted medium sand. The screened interval was isolated from overlying zones with approximately four feet of bentonite pellets. Cement-bentonite grout was used to backfill the remainder of the well annulus to the surface and to provide a surface cap. Each well was equipped with a locking protective steel casing. Development was performed at the time of installation by bailing until groundwater freely entered each well. After the wells were developed, in-place bailer permeability tests were performed to determine the horizontal hydraulic conductivity of the soils in the screened portion of the wells. After installation, the casings were surveyed to determine the elevation of the wells relative to a referenced datum. Table 2-1 presents well specifications, water level elevations and the results of slug tests.

2.3 GROUNDWATER SAMPLING

Groundwater samples were collected from the shallow and deep downgradient wells (MW-1S and MW-1D), and from the shallow upgradient well (MW-3S)) to determine the groundwater quality. Samples were collected using a Teflon bailer. The bailer was washed with soapy water and rinsed with clean water, acetone, and distilled water between wells.

Samples were stored in glass containers with Teflon-lined caps, as appropriate. Necessary sample preservation was conducted in the field and the samples were chilled to 4°C during storage and transport to the laboratory. Samples were

TABLE 2-1

WELL CONSTRUCTION DETAILS, WATER LEVELS
AND PERMEABILITY TESTING RESULTS

WELL	ELEVATION GROUND LEVEL	ELEVATION MEASURING. POINT	TOP SCREEN	BOTTOM SCREEN	WATER LEVEL 11/24/86	WATER LEVEL 12/5/86	HYDRAULIC CONDUCTIVITY
1S	857.0	858.8	847.5	842.5	849.1	849.5	9×10^{-4}
1D	857.1	859.5	837	832	848.1	848.6	[1]
2S	857.2	859.5	850	845	855.7	855.9	4×10^{-4}
3S	856.3	858.5	849	844	853.8	854.6	4×10^{-4}
4S	862.0	863.1	850	845	847.9	848.4	[2]

[1] Too high to measure with slug test method.
[2] Screen unsaturated, slug test method not applicable.

transferred under chain-of-custody to the laboratory. The samples were analyzed for PCBs, priority pollutant volatile organics (EPA 601/602 GC Scans) and priority pollutant metals.

SECTION 3
RESULTS OF SUPPLEMENTAL INVESTIGATIONS

3.0 SEWER INVESTIGATION

During the first step of the investigation, sewer maps were collected from Shulman and from the City of Elmira Engineering Department.

The Shulman map prepared by licensed land surveyors shows one main sewer line traversing the property from the northeast to the southwest corner. There are five manholes along this sewer in the study area; then it empties into the City sewer at a manhole on the corner of East Washington Avenue and Clemens Central parkway (Figure 3-1). The location of this sewer line is confirmed on Map E-3-27 at the City of Elmira Engineering Department. It is know as the "Reformatory Sewer". The City map shows the same six manholes (MH23, 24, 25, 26, 26A, 27) that the Shulman map shows. Additionally, the City map shows four sewer connections. Between Manhole 26 and Manhole 25 there is a 6" tile sanitary line, an 8" cast iron sanitary line, and a 6" tile storm line all tied directly to the main sewer line. Between Manhole 25 and Manhole 24, there is an 8" tile storm sewer connection. The two storm lines correspond to surface drainage inlets which are known to exist on the property. However, the source of the two sanitary lines in unknown, since they do not appear to be near any existing buildings. There are no other known sewers on the Shulman property.

During the field investigation, dye was introduced to drainage inlet "DI #1". The dye was later observed at manhole "MH-27". During the dye-testing, it was observed that there was no sediment accumulated in either DI #1 or MH-26. A proposed plan for further sewer sampling is included in Appendix B.

3.1 SOIL AND OIL SAMPLES

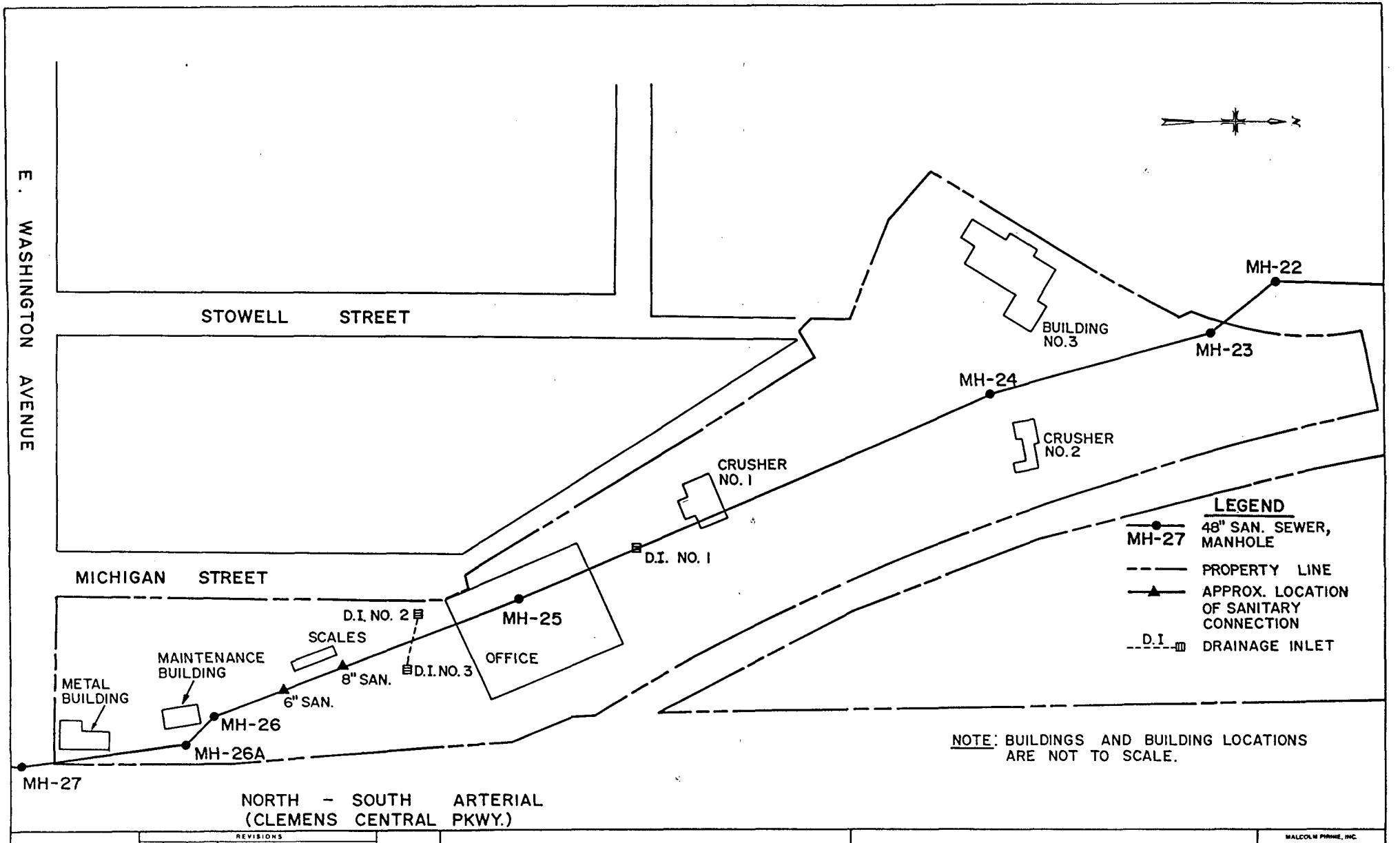
Results of the analysis of soil and oil samples for PCBs are presented in Table 3-1. No PCBs were found in soil samples TP-15

TABLE 3-1

SHULMAN & SONS
RESULTS OF PCB ANALYSIS OF MONITORING WELL,
NEW TEST PIT, AND OIL SAMPLES

SAMPLE I.D.	CODE	PCB CONCENTRATION 1221	1016	1242	1248	1254	1260	TOTAL
Shallow Downgradient MW-1S 11/24/86 (Water Sample)	32886041	ND	ND	ND	ND	ND	ND	LT 0.05*
Shallow Upgradient MW-3S 11/24/86 (Water Sample)	32886042	ND	ND	0.07*	ND	ND	ND	0.07*
Deep Downgradient MW-1D 11/24/86 (Water Sample)	32886043	ND	ND	ND	ND	ND	ND	LT 0.05*
TP-15, S-1 0.0 - 0.5' BLS 11/24/86 (Soil Sample)	32886044	ND	ND	ND	ND	ND	ND	LT 2 **
TP-15, S-2 0.5 - 1.0' BLS 11/24/86 (Soil Sample)	32886045	ND	ND	ND	ND	ND	ND	LT 2 **
TP-15, S-3 1.0 - 1.5' BLS 11/24/86 (Soil Sample)	32886046	ND	ND	ND	ND	ND	ND	LT 2 **
TP-15, S-4 1.5 - 2.0' BLS 11/24/86 (Soil Sample)	32886047	ND	ND	ND	ND	ND	ND	LT 2 **
TP-15, S-5 2.0 - 2.5' BLS 11/24/86 (Soil Sample)	32886048	ND	ND	ND	ND	ND	ND	LT 2 **
TP-16, S-1 0.0 - 0.5' BLS 11/24/86 (Soil Sample)	32886049	ND	ND	ND	ND	ND	ND	LT 2 **
TP-16, S-2 0.5 - 1.0' BLS 11/24/86 (Soil Sample)	32886050	ND	ND	ND	ND	ND	ND	LT 2 **
TP-16, S-3 1.0 - 1.5' BLS 11/24/86 (Soil Sample)	32886051	ND	ND	ND	ND	ND	ND	LT 2 **
TP-16, S-4 1.5 - 2.0' BLS 11/24/86 (Soil Sample)	32886052	ND	ND	ND	ND	ND	ND	LT 2 **
Oil Pit Composité from 5 Sampling Points 11/24/86 (Oil Sample)	32886052	ND	ND	16	ND	ND	ND	16 ppm

* Results expressed as ug/l.
** Results expressed as mg/kg.
ND Not detected.



MALCOLM PIRNIE

REVISIONS

DES.

DWN.

CKD.

SEWER LOCATION DIAGRAM

SHULMAN & SON, INC.
ELMIRA, NEW YORK

MALCOLM PIRNIE, INC.
DATE JANUARY 1987
SHEET OF
FIGURE 3-1

and TP-16. Aroclor 1242 was measured in the oil sample at a level of 16 ppm.

3.2 HYDROGEOLOGIC INVESTIGATION

3.2.1 Site Hydrogeology

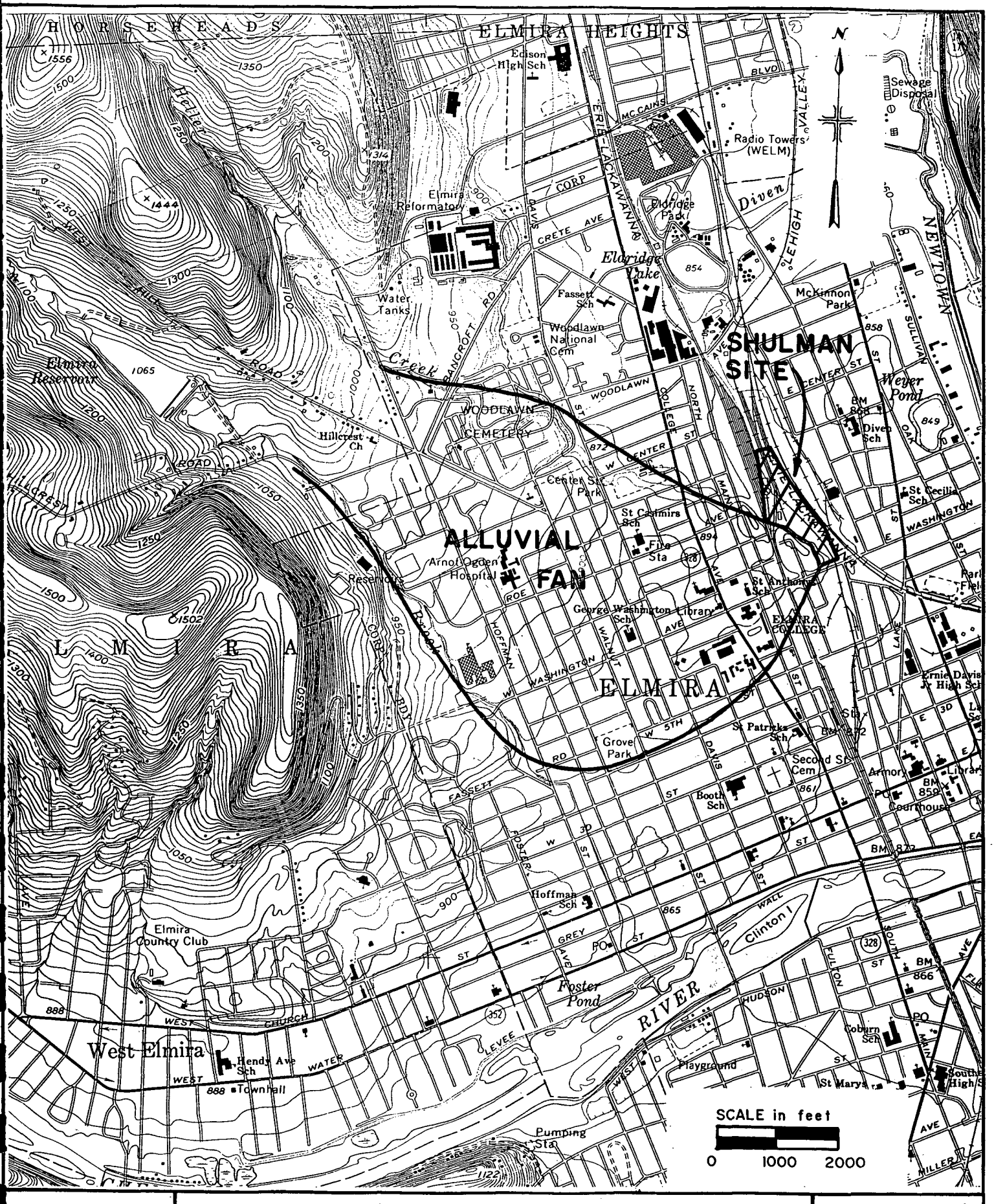
The Shulman site is situated at the western edge of the valley floor of Newtown Creek in the City of Elmira. The western boundary of the site corresponds to the eastern edge of an alluvial fan which occupies the former valley of Heller Creek (Figure 3-2). The edge of the fan is represented by the distinct rise in topography at the western property boundary.

Figure 3-3 presents a fence diagram utilizing boring information collected during the study. There appears to be two hydrogeologic zones beneath the site; an upper shallow water table zone and a lower semi-confined groundwater zone.

The upper zone consists of the following units:

- Surficial fill consisting of a variety of materials as detailed in the boring logs (Appendix C).
- Recent alluvial fan materials at the western edge of the property as encountered in boring MW-2S.
- Mixed deposits including peat underlain by glaciolacustrine silty clays and glacial lodgement till. The significant points regarding these lower glacial deposits are their fine-grained nature and their low hydraulic conductivity relative to underlying glacial outwash deposits. These deposits by virtue of their physical characteristics serve as a semi-confining layer in restricting the rate of shallow groundwater flow downward to the lower groundwater zone.

The lower groundwater zone consists of glaciofluvial outwash sand and gravel deposits which comprise a major aquifer within the valley. The upper limit of the zone is formed by the fine-grained glacial deposits described above.



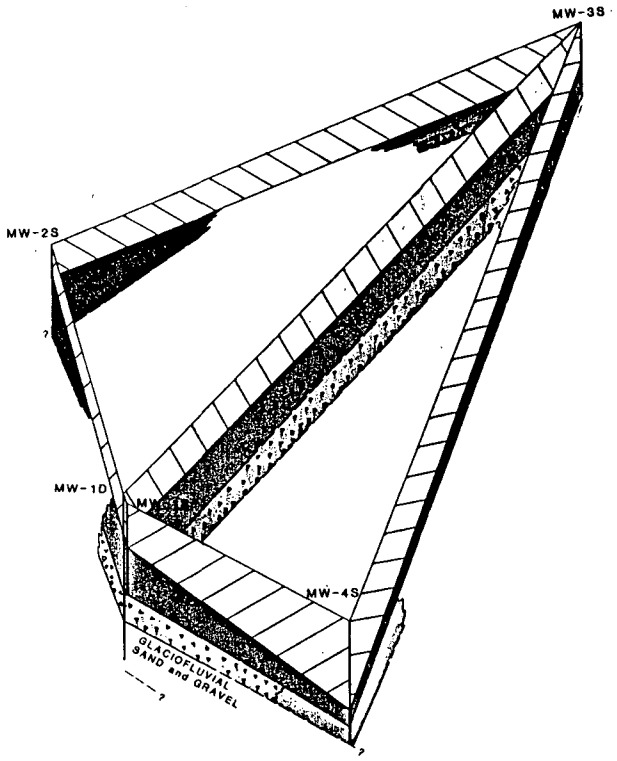
MALCOLM PIRNIE

SITE GEOLOGY

MALCOLM PIRNIE, INC.

MARCH 1987

FIGURE 3-2



N

SCALE

10 feet vert.

50 feet horiz.

LEGEND

MW-1S	Shallow Groundwater Monitoring Well Location and Designation
MW-1D	Deep Groundwater Monitoring Well Location and Designation
	Fill
	Alluvial Fan Grayish Green CLAY, some Silt, Sand and Gravel
	Peat
	Glaciolacustrine Fine Silts and Clay Medium Gray Clay some Silt, Sand and Gravel Trace Shell Fragments
	Glacial Till Gray Clay, some Silt, Sand and Gravel, No Shell Fragments

MALCOLM PIRNIE

REVISIONS

NO	BY	DATE	REMARKS

DES .....
DWN .....
CKD .....

SHULMAN and SON, INC.

ELMIRA, NEW YORK

FENCE DIAGRAM

MALCOLM PIRNIE, INC.

DATE January 1987

SHEET ..... OF .....

FIGURE 3-3

3.2.2 Groundwater Flow

The configuration of the water table within the upper groundwater zone is presented on Figure 3-4. The direction of shallow groundwater flow towards the center of the valley to the east is controlled primarily by topography. The steep hydraulic gradient in the western portion of the site is due to shallow groundwater discharging from the sloping alluvial fan deposits into the flat-lying fill, peat and glacial deposits on the valley floor. The water table gradient is shown on Figure 3-4 to decrease (between MW-1 and MW-4) towards the valley center and away from the edge of the alluvial fan.

Slug tests conducted on three shallow monitoring wells resulted in an average horizontal saturated hydraulic conductivity of 6×10^{-4} cm/sec in the upper water table zone (slug test results in Appendix D). In order to estimate horizontal seepage velocities in the water table zone, an effective porosity of 0.1 is assumed. The seepage velocity is calculated in the western portion of the site under a horizontal hydraulic gradient of about 0.03 and in the eastern portion of the site under a gradient of about 0.006. The horizontal seepage velocities are calculated to be:

- Western Portion of Site

  Horizontal hydraulic conductivity (k) = 4×10^{-4} cm/sec

  Horizontal hydraulic gradient (i) = 0.03

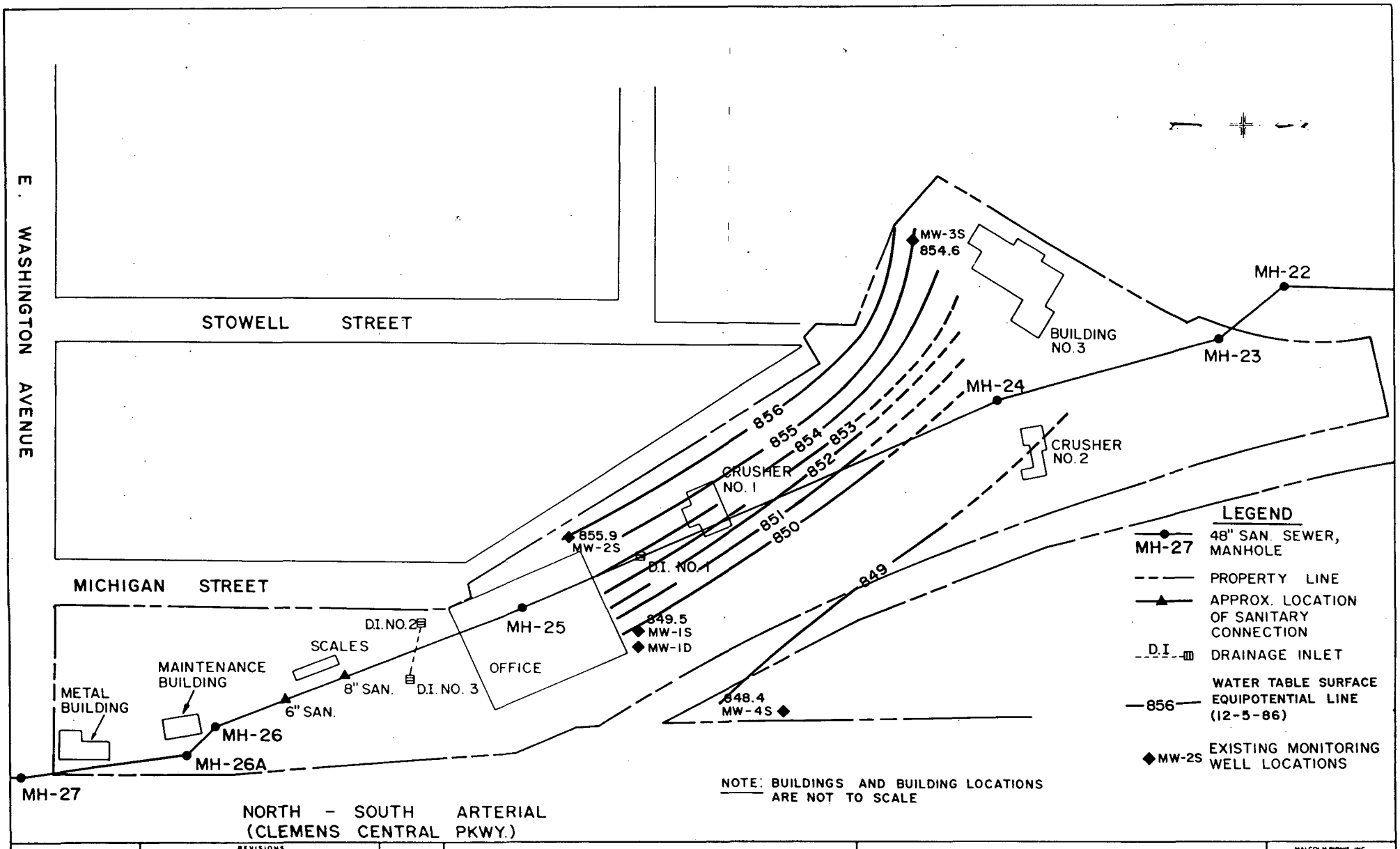
  Effective porosity (n_e) = 0.1

  V_s = seepage velocity

$$V_s = \frac{ki}{n_e} = \frac{(4 \times 10^{-4} \text{ cm/sec})(0.03)}{0.1}$$

$$= 1.2 \times 10^{-4} \text{ cm/sec}$$

$$= 120 \text{ ft/yr.}$$



MALCOLM PIRNIE	REVISIONS NO. BY DATE REMARKS; DES DWN CKD	CONFIGURATION OF THE WATER TABLE SURFACE	SHULMAN & SON, INC. ELMIRA, NEW YORK
MALCOLM PIRNIE, INC DATE FEBRUARY 1987 FIGURE 3-4			

o Eastern Portion of Site

$k = 4 \times 10^{-4}$ cm/sec

$i = 0.006$

$n_e = 0.1$

$$V_s = \frac{ki}{n_e} = \frac{4 \times 1^{-4} \text{ cm/sec})(0.006)}{0.1}$$

$$= 2.4 \times 10^{-5} \text{ cm/sec}$$
$$= 25 \text{ ft/yr.}$$

Groundwater elevations in MW-1S and MW-1D show a downward hydraulic gradient between the upper and lower groundwater zones. The gradient is calculated to be approximately 0.16.

3.2.3 Groundwater Sampling

Groundwater samples were obtained from monitoring wells MW-1S (shallow, downgradient), MW-1D (deep, downgradient) and MW-3S (shallow, upgradient). Results of the analysis are presented on Tables 3-1, 3-2 and 3-3. Arochlor 1242 was found in the sample from MW-3S at a level of 0.07 ug/l. No detectable concentrations of organics, other than trace levels of toluene, were found in any sample. Various metals were found in all the samples. The metals values which exceeded Class GA groundwater standards were arsenic (MW-3S), cadmium (MW-1S) and lead (MW-1S, MW-3S). There were no metals concentrations which exceeded groundwater standards in the deep well (MW-1D).

TABLE 3-2

SHULMAN & SONS
RESULTS OF VOLATILE ORGANIC ANALYSIS OF
MONITORING WELL SAMPLES

Parameter	Shallow Down Gradient MW-1S 11/24/86	Shallow Up Gradient MW-3S 11/24/86	Deep Down Gradient MW-1D 11/24/86
EPA 601:			
Chloromethane	LT 1	LT 1	LT 1
Bromomethane	LT 1	LT 1	LT 1
Dichlorodifluoromethane	LT 1	LT 1	LT 1
Vinyl chloride	LT 1	LT 1	LT 1
Chloroethane	LT 1	LT 1	LT 1
Methylene chloride	LT 5	LT 5	LT 5
Trichlorofluoromethane	LT 1	LT 1	LT 1
1,1-Dichloroethylene	LT 1	LT 1	LT 1
1,1-Dichloroethane	LT 1	LT 1	LT 1
t-1,2-Dichloroethylene	LT 1	LT 1	LT 1
Chloroform	LT 5	LT 5	LT 5
1,2-Dichloroethane	LT 1	LT 1	LT 1
1,1,1-Trichloroethane	LT 1	LT 1	LT 1
Carbon tetrachloride	LT 1	LT 1	LT 1
Bromodichloromethane	LT 1	LT 1	LT 1
1,2-Dichloropropane	LT 1	LT 1	LT 1
t-1,3-Dichloropropylene	LT 1	LT 1	LT 1
Trichloroethylene	LT 1	LT 1	LT 1
Dibromochloroemethane	LT 1	LT 1	LT 1
1,1,2-Trichloroethane	LT 1	LT 1	LT 1
c-1,3-Dichloropropylene	LT 1	LT 1	LT 1
1,1,2,2-Tetrachloroethane	LT 1	LT 1	LT 1
Tetrachloroethylene	LT 1	LT 1	LT 1
Bromoform	LT 1	LT 1	LT 1
2-Chloroethylvinyl ether	LT 1	LT 1	LT 1
EPA 602 (including Xylenes):			
Benzene	LT 1	LT 1	LT 1
Toluene	Trace	Trace	Trace
Ethylbenzene	LT 1	LT 1	LT 1
Xylenes	LT 1	LT 1	LT 1
Halogenated Aromatics (601/602):			
Chlorobenzene	LT 1	LT 1	LT 1
1,2-Dichlorobenzene	LT 1	LT 1	LT 1
1,3-Dichlorobenzene	LT 1	LT 1	LT 1
1,4-Dichlorobenzene	LT 1	LT 1	LT 1

All results are expressed as ppb.

TABLE 3-3

SHULMAN & SONS
RESULTS OF METALS ANALYSIS OF
MONITORING WELL SAMPLES

PARAMETER	WELL MW-1S		WELL MW-1D	WELL MW-3S
Arsenic	0.013	25 ppb	0.004	0.026
Beryllium	0.005	11 or 1100 → hardness ≤ 75 ppm	LT 0.005	LT 0.005
Cadmium	0.022	5 ppb	0.007	LT 0.005
Chromium	0.07	50	0.06	LT 0.05
Copper	0.39	hardness dependent	0.04	0.02
Mercury	0.0009	.07	LT 0.0004 ?	LT 0.0004 ?
Nickel	0.09	100	0.04	LT 0.03
Lead	0.4	25	LT 0.1 ?	0.1
Antimony	0.6	3	LT 0.4 ?	0.6
Selenium	LT 0.001	10	LT 0.001	LT 0.001
Thallium	LT 0.3	—	LT 0.3	LT 0.3
Silver	LT 0.03	50	LT 0.03	LT 0.03
Zinc	0.81	—	0.12	0.24

All results are expressed in ppm.

Cn° 200 ppb

SECTION 4
CONCLUSIONS AND RECOMMENDATIONS

4.1 CONCLUSIONS

a. Previous and follow-up investigations have found the following levels of PCBs in soils from test pits.

- Levels above 50 mg/kg — Test Pits 1, 2, 3 & 4
- Levels between 2 and 50 mg/kg — Test Pits 5, 6, 7, 8, 10, 11, 12 & 14
- Levels below 2 mg/kg — Test Pits 9, 13, 15 & 16

Maximum concentrations, in general, are found in the upper 12" of soil and decline dramatically in the next foot of depth. Only test pits #3, #10 and #14 do not exhibit this trend. Most of the PCB contamination appears to be confined to the upper foot of the soil.

b. Analyses of groundwater samples from 2 shallow wells (MW-1S and MW-3S) showed PCB levels of less than 0.05 ug/l and 0.07 ug/l, respectively. The concentration in an upgradient well (MW-3S) was slightly higher than that in the downgradient well (MW-1S). Thus, it would appear that the PCB's at the Shulman site are not mobile in the subsurface environment and are not significantly impacting groundwater quality.

c. Analysis of groundwater from the deep well (MW-1D) downgradient from the south portion of the site showed a PCB value below the detection level of 0.05 ug/l.

d. Analyses of the shallow and deep groundwater sample for volatile organic compounds showed only an undefinable trace of toluene at less than 1 ug/l.

e. Analyses of groundwater from the shallow wells also showed levels of arsenic, cadmium and lead at concentrations in excess of the Class GA Groundwater standards. Cadmium and lead, as well as copper concentrations, increase in a downgradient direction,

while arsenic is highest in the upgradient well and decreases across the site. In general, the concentrations of metals in the shallow groundwater are very low when compared to the concentrations found in the soil in the earlier investigations.

f. Groundwater infiltrating into the sewer beneath the site could, therefore, be anticipated to be relatively clean and the presence of contaminants would not be measurable in the water in the sewer.

g. Geologic data gathered during the investigation was insufficient to establish the continuity of a confining layer beneath the entire site, however, the lack of a detectable PCB level in the deep well leads one to the conclusion that contaminant migration via the groundwater route may be minimal or non-existant.

h. Analyses of the area surface drain sediment showed high levels of PCBs and metals and small but detectable concentrations of 3 organic priority pollutants.

i. The surface water migration route represents the greatest opportunity for contaminant migration from the site.

j. PCB's at or near the surface of the ground may migrate from the site via personnel and/or vehicles passing over the contamination and could conceivably be carried from the site on windblown dirt and dust.

4.2 RECOMMENDATIONS

a. It is recommended that further work be carried out at the Shulman site to identify the possible routes of surface water contaminant migration. This work would commence with the sewer sampling work described in the work plan in Appendix B. The need for further work would be dependent upon the results of that investigation.

b. Since the major routes of contaminant migration would be via surface water and site traffic, it is recommended that the Owner proceed with remediation and

detailed in the earlier recommendations. This would include paving of the high PCB areas shown in Figure #1 and covering those areas with levels between 2 and 50 ug/l with clean topsoil. Such measures would immediately reduce the erosion of contaminated soil and would also greatly reduce the infiltration of rainwater, thereby, reducing any existing downward migration of contaminants in the ground. At the same time, such remedial construction would tend to compliment any possible continuing efforts to reduce contaminant migration from the site.

c. This Report should be submitted to the NYSDEC for their review and comments. After approval by the NYSDEC, the Owner should authorize the Engineer to perform the sewer sampling work as describe.

d. After approval by the NYSDEC, the Owner should authorize the Engineer to prepare detailed plans for grading, paving and drawings of the areas identified for remediation.

Respectfully submitted,

MALCOLM PIRNIE, INC.

R. W. Klippel, P.E.
Project Manager

MALCOLM PIRNIE, INC.

Paul H. Werthman, P.E.
Senior Project Manager

Prepared By:

T.A. Barba
M.S. Cullen
R.J. Kulibert
M.D. Wilder

Appendices

APPENDIX A

BORINGS LOG FOR MW-1D

DATE: 8-27-85	LOCATION: 1 SHULMAN PLAZA, ELMIRA, N.Y.
DRILLING CONTRACTOR: ROCHESTER DRILLING	INSPECTOR: MCO
DRILLING METHOD: HOLLOW STEM AUGER	SAMPLING METHOD: 2" I.D. SPLIT SPOON STANDARD PENETRATION TEST
ELEVATION:	DATUM: WELL MW-1

SAMPLE No.	SAMPLE depth	blows per 6"		DEPTH	STRATA	SOIL DESCRIPTION (density, color, SOIL, admixtures, moisture, other notes, ORIGIN)	WELL CONST.	REMARKS
S-1	0'-2'	15	29			GM Dense, brown, SAND, some gravel, some silt, dry FILL		
		19	17					
S-2	6'-7'	15	15	5		GM Dense, brown, SAND and GRAVEL some silt, dry changing at 6.8 ft. to		
		26	2			OL Loose, black, SILT, some wood some plant fragments, moist organic.		
S-3	10'-12'	2	2	10				
		2	3			changing at 15.5 to		
S-4	15'-17'	1	1	15		CH, soft, grey, CLAY, some shells, little plant fragments, moist		
		1	3			becoming very soft, wet grading at 21.0' to		
S-5	20'-22'	WOH	WOH	20		SW, loose, grey, MEDIUM SAND, wet, well sorted, GLACIO-FLUVIAL		
		3	4			grading at 24.8' into		
S-6	25'-27'	8	12	25		GP medium dense, grey, GRAVEL and MEDIUM to COARSE SAND, wet, GLACIO-FLUVIAL		
		9	9			Boring completed at 27.0'.		
				30				
				35				

NOTES: Classification and Description based on visual inspection by M.P.I. inspector. Well Installation: 5.5 ft. of 2" I.D. wire-wound stainless steel screen (0.007" slot), 20.5 ft. of 2" I.D. black iron riser to surface; 6 ft. of 6" I.D. protective steel casing with locking cap over stick-up. Backfilled from 27 ft. to 17.5 ft. with well-sorted, medium sand; to 16.8 ft. with bentonite pellets; and to surface with cement grout. Well point at 25 ft.

MALCOLM

APPENDIX B

PROPOSED SEWER SAMPLING PLAN

PROPOSED SEWER SAMPLING PLAN

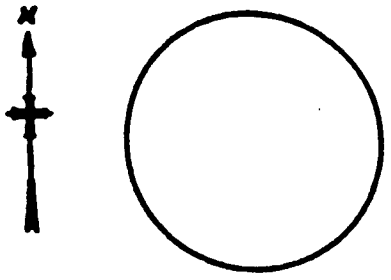
A field survey will be performed to document the location, destination and condition (regarding sediment accumulation) of the sewer. The survey will include manhole inspections, dye-testing and sediment sample collection, as follows:

1. Beginning at Manhole 27 and proceeding to Manhole 23 (Figure 1), each of the six manholes and three drainage inlets will be opened and inspected. The following information will be recorded on the attached manhole inspection log:
    a. approximate location of manhole (paced off from previous manhole),
    b. size and description of sewer and any cross-connections,
    c. depth to bottom of sewer, and
    d. estimate of volume of sediment present (or note if none is present).
2. At each manhole or drainage inlet where sediment is present, a sample of the sediment will be collected. Due to the configuration and condition of the sewer manholes, entrance is not feasible, thus the samples will be collected using an Ekman dredge. The sample will be placed in a glass jar with teflon-lined cap and preserved at 4°C. The sample jars will be properly labeled and chain-of-custody records will be filled out. The samples will be analyzed for PCB's according to EPA Method 8080.
3. Dye will be introduced into manhole 23 and visually tracked through each manhole until its arrival at Manhole 27. Starting time and arrival time at each manhole will be noted to document the testing.

4. Dye will be introduced separately into each of the three drainage inlets (beginning with the most downstream location) and tracked to the next downstream manhole.
5. The source of the 6 inch and 8 inch sanitary lines will be located, if possible. If found, dye will be introduced and tracked to Manhole 27. Starting and arrival times will be documented.

MANHOLE NO. ____

STREET _____

MANHOLE LOCATION ①	MANHOLE PLAN VIEW ②
	

DATE	COMMENTS ③		TIME	SAMPLE DESCRIPTION COLOR, TEXTURE, ETC.

① Location of MH to be shown w/respect to existing telephone poles, edge of driveways, etc. A house number should appear in the description.

② Information required - depth to all inverts, relative location of all influent and effluent pipe, diameter and material of pipe.

③ Examples - Weather, odors from manhole, detection of unsafe condition, volume (depth) of sediment present.

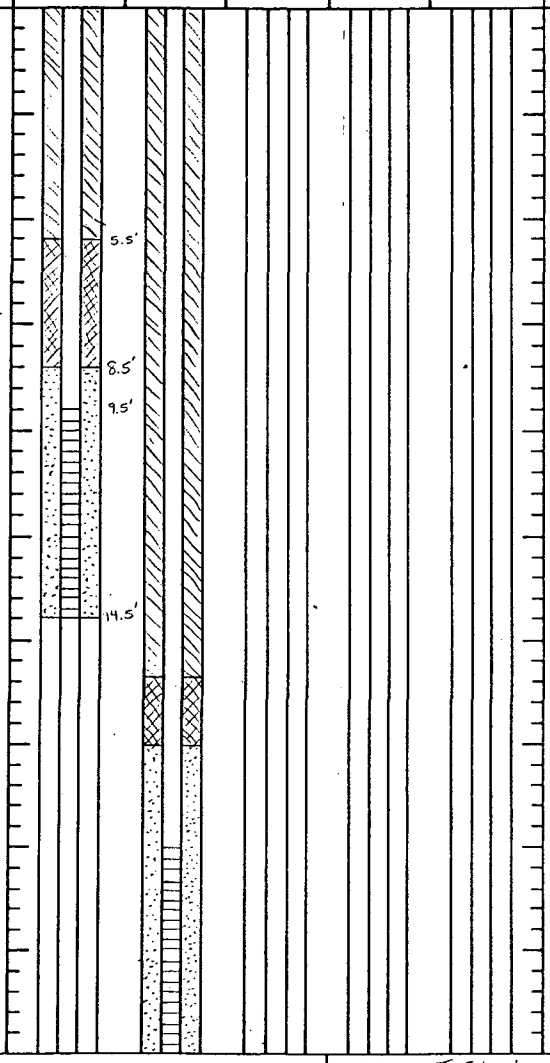
MALCOLM PIRNIE

APPENDIX C

BORING LOGS FOR MW-1S THROUGH MW-4S

DEPTH (FEET)	SAMPLES	SAMPLE NO.	SAMPLER BLOWS/FT.	SOIL or ROCK DESCRIPTION	UNIFIED SOIL CLASS
0		S1	15	Dense, brown SAND, some gravel, some silt, dry FILL	GM
			29		
			19		
			17		
5		S2	15	Dense, brown SAND and GRAVEL some silt, dry; changing @ 6.8 feet	GM
			15		
			26		
			2	loose, black SILT, some wood, some plant fragments, moist, organic	OL
10		S3	2		
			2		
			2		
			3		
15			1		
			1	soft, gray CLAY, some shells, little plant fragments, moist	CH
			1		
			3		
20			WOH	becoming very soft, wet	
			WOH	grading @ 21 feet	
			3	loose, gray, medium SAND, wet, well sorted, GLACIO-FLUVIAL	SW
			4		

MONITOR CONSTRUCTION DETAILS



PERMEABILITY (cm/sec)	DOWN HOLE PROBE ANALYSES: Temp. (°C)	Conductance (umho/cm)	pH (S.U.)	HNU (ppm)	NOTES
9×10^{-4}					

Surface Elevation 857.0 Classified By K. Owen

Date Installed MW-1S (9-19-86) MW-1D (8-27-85) MPI Inspector K. Owen / R. Kulibert

Driller Rochester Drilling Co.

Method 6 1/4 - inch Hollow Stem Auger

NOTE: DATA ON THIS SUMMARY SHEET COMPOSITED FROM DRILLER'S LOGS & MPI COLLECTED DATA & FIELD OBSERVATIONS

PROJECT: I. Shulman and Son, Inc.

MALCOLM PIRNIE

GROUNDWATER MONITOR SUMMARY SHEET

LOCATION NO. MW-1

SHEET 1 OF 2

DEPTH (FEET)	ELEVATION (MSL)	SAMPLES	SAMPLE NO.	SAMPLER BLOWS/FT.	SOIL or ROCK DESCRIPTION	UNIFIED SOIL CLASS	MONITOR CONSTRUCTION DETAILS	PERMEABILITY (cm/sec)	DOWN HOLE PROBE ANALYSES: Temp. (°C)	DOWN HOLE PROBE ANALYSES: Conductance (umho/cm)	DOWN HOLE PROBE ANALYSES: pH (S.U.)	HNU (ppm)	NOTES
			S6	8			MW-1D						
				12									
				9	grading @ 26.8								
				9	medium-dense, gray GRAVEL and medium to coarse SAND, wet, GLACIO-FLUVIAL	GP							
30													

Surface Elevation 857.0 Classified By K. Owen

Date Installed MW-1D (8-27-85) MPI Inspector K. Owen / R. Kulibert

Driller Rochester Drilling Co.

Method [redacted]

NOTE: DATA ON THIS SUMMARY SHEET COMPOSITED FROM DRILLER'S LOGS & MPI COLLECTED DATA & [redacted]

PROJECT: I. Shulman & Son, Inc.

MALCOLM PIRNIE

GROUNDWATER MONITOR SUMMARY SHEET

LOCATION NO. MW-1

SHEET 2 OF 2

DEPTH (FEET)	ELEVATION (MSL)	SAMPLES	SAMPLE NO.	SAMPLER BLOWS/FT.	SOIL or ROCK DESCRIPTION	UNIFIED SOIL CLASS
			S1	5	black-brown FILL, c/o fine-medium gravel and cinders, oxidized, moist	
				4		
				4		
				3		
5			S2	4	gray-green gravelly, sandy, silty CLAY, (FILL) reworked. oxidized, moist, apparently	
				6		
				7		
				8		
			S3	7	gray-green gravelly sandy silty CLAY (FILL?)	
				9		
				10		
				15		
10			S4	9	gray-green gravelly, sandy, silty CLAY, increasing density, moist but lower apparent moisture content than above.	
				15		
				20		
				22		
15					Note: Origin of material encountered may be from post-glacial alluvial fan	

MONITOR CONSTRUCTION DETAILS: MW-2S

3.5'
5.9'
7'
12'

PERMEABILITY (cm/sec)	DOWN HOLE PROBE ANALYSES: Temp. (°C)	Conductance (umho/cm)	pH (S.U.)	VOC (ppm)	NOTES
4×10^{-4}					

Surface Elevation 857.2 Classified By RJK

Date Installed 11/19-20/86 MPI Inspector RJK

Driller Rochester Drilling Co

Method 6 1/4-inch hollow-stem auger

NOTE: DATA ON THIS SUMMARY SHEET COMPOSITED FROM DRILLER'S LOGS & MPI COLLECTED DATA & FIELD OBSERVATIONS

PROJECT: Ishlman & Son, Inc

MALCOLM PIRNIE

GROUNDWATER MONITOR SUMMARY SHEET

LOCATION NO. MW-2

SHEET 1 OF 1

DEPTH (FEET)	ELEVATION (MSL)	SAMPLES	SAMPLE NO.	SAMPLER BLOWS/FT.	SOIL or ROCK DESCRIPTION	UNIFIED SOIL CLASS	MONITOR CONSTRUCTION DETAILS	PERMEABILITY (cm/sec)	DOWN HOLE PROBE ANALYSES: Temp. (°C)	DOWN HOLE PROBE ANALYSES: Conductance (umho/cm)	DOWN HOLE PROBE ANALYSES: pH (S.U.)	HNU (ppm)	NOTES
			S1	9	dk brown to tan, gray-olive and black FILL c/o silt, gravel, fine to coarse sand, trace clay, wet 0-0.5 feet, dry below	FILL	MW-3S						
				22									
				34									
				17									
5			S2	9	reddish, brown and black FILL c/o silt, fine to coarse sand, gravel to 4cm., cobbles, wet								
				10									
				6									
				13									
					FILL to 6.8								
			S3	2	brown, red and black organic SILT, roots and wood, some clay, trace of fine sand								
				2									
				3									
				4									
10			S4	2	brown, red and black organic SILT, and PEAT, some clay, trace v.f. sand, organic content increasing moist - wet								
				2									
				2									
				3									
			S5	6									
				7	PEAT as above to 11.8 feet								
				10									
					med gray CLAY, little coarse gravel (TILL ?)								
15													

Surface Elevation _____ Classified By MDW

Date Installed 9/18-19/86 MPI Inspector MDW

Driller Rochester Drilling Co, Inc.

Method [redacted]/4 - [redacted] hollow stem augers

NOTE: DATA ON THIS SUMMARY SHEET COMPOSITED FROM DRILLER'S LOGS & MPI COLLECTED DATA & FIELD OBSERVATIONS

PROJECT: I. Shulman & Son, Inc.

MALCOLM PIRNIE

GROUNDWATER MONITOR SUMMARY SHEET

LOCATION NO. MW-3

SH [redacted] 1

DEPTH (FEET)	ELEVATION (MSL.)	SAMPLES	SAMPLE NO.	SAMPLER BLOWS/FT.	SOIL or ROCK DESCRIPTION	UNIFIED SOIL CLASS
0			S-1	4	brown-black organic FILL, c/o peat, silt, sand, gravel, glass and cinders	
				7		
				12		
				33		
5			S-2	14	brown, silty, sandy FILL, oxidized, gray shale gravel and cobbles, dry	
				20		
				85		
				19		
					remnants of coal pile (no sample)	
10			S-3	15	gray-green silty gravelly FILL, shale cobbles, dry	
				7		
				5		
				9		
			S-4	3	black FILL c/o cinders, coal, wood sand and gravel sized, moist to wet	
				4		
				2		
				3		
15			S-5	WOR	gray-green silty PEAT and silty CLAY with shale gravel, moist wet; zone of black organic silt and peat	
				2		
				4		
				6		
			S-6	9	gray gravelly sandy silty CLAY (TILL) saturated	
				14		
				17		
				19		
20						

MONITOR CONSTRUCTION DETAILS: MW-4S

PERMEABILITY (cm/sec)

DOWN HOLE PROBE ANALYSES: Temp. (°C) | Conductance (umho/cm) | pH (S.U.)

HNU (ppm)

NOTES

Surface Elevation 862.0 Classified By RJK

Date Installed 9/20/86 MPI Inspector RJK

Driller Rochester Drilling Co, Inc.

Method 6¼-inch hollow-stem auger

NOTE: DATA ON THIS SUMMARY SHEET COMPOSITED FROM DRILLER'S LOGS & MPI COLLECTED DATA & FIELD OBSERVATIONS

PROJECT: I. Shulman & Son, Inc.

MALCOLM PIRNIE

GROUNDWATER MONITOR SUMMARY SHEET

LOCATION NO. MW-4

SHEET 1 OF 1

APPENDIX D

RESULTS OF SLUG TESTS

SHULMAN
WELL MW-1S

(A)

$H = 7'$ $\quad t_1 = 3$ sec

$L_w = 7'$ $\quad Y_t = 1.02$

$L_e = 5'$ $\quad Y_0 = 1.51$

$r_c = 0.083$ $\quad C = 1.7$

$r_w = 0.25$

$\ln(Re/r_w) = 2.4$

$$K = \frac{r_c^2 \ln(Re/r_w)}{2Le} \frac{1}{t} \ln\left(\frac{Y_0}{Y_t}\right)$$

$$= \frac{(.083)^2(2.4)}{10} \frac{1}{3} \ln\left(\frac{1.51}{1.02}\right)$$

$= 2 \times 10^{-4}$ ft/sec

$= 7 \times 10^{-3}$ cm/sec

(B) $t = 7$ sec

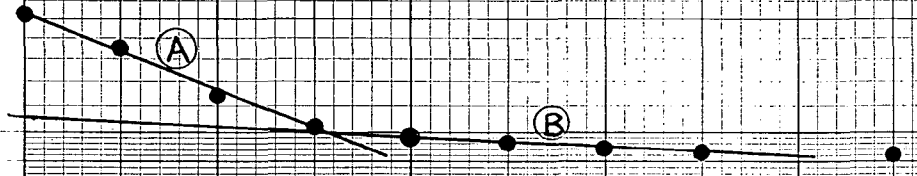
$Y_t = 0.93'$

$Y_0 = 1.05$

$$K = \frac{(.083)^2(2.4)}{10} \frac{1}{7} \ln\left(\frac{1.05}{0.93}\right)$$

$= 3 \times 10^{-5}$ ft/sec

$= 9 \times 10^{-4}$ cm/sec



SHULMAN
WELL MW-2S

$H = 11'$ $\quad t = 23$ sec

$L_e = 5'$ $\quad Y_t = 2.10'$

$L_w = 11'$ $\quad Y_o = 2.47'$

$r_w = 0.25'$ $\quad C = 1.7$

$\ln(R_e/r_w) = 2.7$

$$K = \frac{r_c^2 \ln(R_e/r_w)}{2L_e} \frac{1}{t} \ln\left(\frac{Y_o}{Y_t}\right)$$

$$= \frac{(.083)^2 (2.7)}{10} \frac{1}{23} \ln\left(\frac{2.47}{2.10}\right)$$

$$= 1 \times 10^{-5} \text{ ft/sec}$$

$$= 4 \times 10^{-4} \text{ cm/sec}$$

SHULMAN
WELL MW-3S

$H = 10'$ $\quad t = 24 sec$

$L_w = 10'$ $\quad Y_t = 2.81$

$L_e = 5'$ $\quad Y_o = 3.3$

$r_w = 0.25$ $\quad C = 1.7$

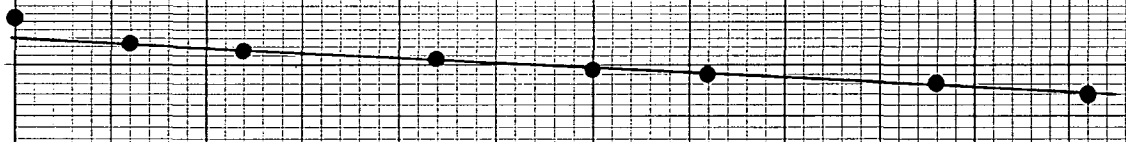
$\ln(R_e/r_w) = 2.6$

$$K = \frac{r_c^2 \ln(R_e/r_w)}{2L_e} \frac{1}{t} \ln\left(\frac{Y_o}{Y_t}\right)$$

$$= \frac{(.083)^2 (2.6)}{10} \frac{1}{24} \ln\left(\frac{3.3}{2.81}\right)$$

$$= 1 \times 10^{-5} ft/sec$$

$$= 4 \times 10^{-4} cm/sec$$



10 20 30

46 5490

KEUFFEL & ESSER CO. MADE IN U.S.A.