915012

Engineering Report

REMEDIAL INVESTIGATION REPORT BUFFALO COLOR AREA "D"

buffalo COLOR CORPORATION

Buffalo, New York

Allied Signal

Morristown, New Jersey

April 1989

Project: 1115-03-1

MALCOLM PIRNIE

ENVIRONMENTAL ENGINEERS, SCIENTISTS & PLANNERS

MALCOLM PIRNIE

BUFFALO COLOR CORPORATION

REMEDIAL INVESTIGATION REPORT
BUFFALO COLOR AREA "D"

ENGINEERING REPORT

APRIL 1989

MALCOLM PIRNIE, INC.

S-3515 Abbott Road
P.O. Box 1938
Buffalo, New York 14219

1115-03-1

MALCOLM PIRNIE

TABLE OF CONTENTS

MALCOLM PIRNIE

TABLE OF CONTENTS (Continued)

MALCOLM PIRNIE

TABLE OF CONTENTS (Continued)

MALCOLM PIRNIE

TABLE OF CONTENTS (Continued)

LIST OF TABLES

MALCOLM PIRNIE

TABLE OF CONTENTS (Continued)

LIST OF TABLES (Continued)

MALCOLM PIRNIE

TABLE OF CONTENTS (Continued)

LIST OF TABLES (Continued)

LIST OF FIGURES

MALCOLM PIRNIE

TABLE OF CONTENTS (Continued)

LIST OF FIGURES (Continued)

MALCOLM PIRNIE

TABLE OF CONTENTS (Continued)

LIST OF FIGURES (Continued)

LIST OF APPENDICES

1.0 EXECUTIVE SUMMARY

1.1 GENERAL

The New York State Department of Environmental Conservation (NYSDED) has listed the Iron Oxide Sludge Lagoons and the Weathering Area at the Area "D" on the New York State Registry of Inactive Hazardous Waste Disposal Sites. Subsequently, the Buffalo Color Corporation and Allied Signal, Inc. have jointly entered into an Order on Consent with NYSDEC to conduct a Remedial Investigation/Feasibility Study program at the Area "D".

During the period of May - November 1988, Malcolm Pirnie conducted the field investigation activities required by the Remedial Investigation scope of work. The purpose of this document is to present the findings of The Remedial Investigation. The elements of the Remedial Investigation addressed herein include:

- Physiography and climate data associated with the Area "D" and the surrounding area.

- Geology and hydrogeology of the site.

- Hydrologic relationship of the Area "D" with the Buffalo River.

- Site contamination characterization.

- Pathways of off-site contaminant migration.

- Public health and environmental concerns.

1.2 PHYSIOGRAPHY AND CLIMATE

In general, the Area "D" is relatively flat, with all surface run-off to the Buffalo River. Historical climatic data indicates that average annual precipitation at the site totals 35-37 inches, and the mean annual temperature is 47.4°F.

1.3 GEOLOGY AND HYDROGEOLOGY

1.3.1 Scope of Investigations

The 1988 field investigation involved the following specific tasks:

- A geophysical (EM-34-3) survey.

- Drilling and sampling of five (5) shallow and two (2) deep test borings.

- Installation of ten (10) monitoring wells, three (3) additional wells, four (4) piezometers, and one (1) replacement well within the saturated and unsaturated overburden deposits.

- Development of all existing monitoring wells, the new monitoring wells, and all piezometers.

- In-situ hydraulic conductivity testing of new well installations and all existing monitoring wells.

- Measurement of ground water and river water levels.

1.3.2 Geology

The regional geology of the Buffalo area is classified into surficial materials (recent alluvium, lacustrine sediments, and glacial deposits) and bedrock (stratified Paleozoic sedimentary rocks). The Area "D" site is underlain by five stratigraphic units (fill, alluvium, glaciolacustrine deposits, glacial till, and bedrock). Fill consists of mixtures of gravel, sand, silt, clay, demolition debris, chemical wastes, and other foreign materials, and averages 9.0 feet thick.

Alluvium underlies fill and generally consists of black to gray silty sand with traces of clay, and averages 17.8 feet thick. Glaciolacustrine deposits underlie the alluvium and consist of gray and brown-gray clayey silt and silty clay, and average 27.9 feet thick. Glacial till is the lowest surficial deposit and consists of gray and brown sandy silt, with small percentages of clay and gravel, and averages 12.0 feet thick. The bedrock beneath the site consists of hard, dark gray limestone of the Middle Devonian Onondaga Formation.

1.3.3 Hydrogeology

Three (3) hydrostratigraphic units were defined at the Area "D" site. These include: the shallow waterbearing zone, overburden aquitard, and bedrock aquiter. The Shallow Waterbearing Zone is located in the fill/alluvium deposits and yields an average hydraulic conductivity of 2.2 x 10^{-3} cm/sec and an average seepage velocity of 1.4 x 10^{-5} cm/sec. The ground water flow in this zone is primarily from the north and flows directly to the Buffalo River. The Shallow Waterbearing zone is underlain by a clay-rich confining layer (overburden aquitard). Hydraulic conductivity of this unit is only 1.2 x 10^{-6} cm/sec and flow was determined to be predominantly upward at a rate of 1.2 x 10^{-9} cm/sec. Hydraulic conductivity in the bedrock aquifer ranges from 1.4 x 10^{-2} to 1.2 cm/sec and flow probably occurs under confined conditions.

1.4 HYDROLOGY

1.4.1 Water Shed Characteristics

Physical alterations of the Buffalo River basin which have occurred since the late 1930s include development of an extensive sewage system in the upper water shed areas, and the dredging of the Buffalo River by the U.S. Army Corps of Engineers. These activities have led to relatively stagnant flow conditions within the river.

In order to alleviate stagnant flow conditions, the various industries located along the Buffalo River formed the Buffalo River Improvement Corporation (BRIC). The BRIC currently removes 10,000,000 - 20,000,000 gallons of water per day from the Buffalo Harbor and transfers this to Buffalo Color and PVS Chemicals Inc. The BRIC water is used primarily for non-contact cooling and is subsequently discharged to the Buffalo River.

1.4.2 Flood Plain

Data obtained from the Federal Emergency Management Agency (FEMA) indicates that the Area "D" site is not within the 100 year flood boundary.

1.4.3 Relationship between River and Ground Water Elevations

Data for the shallow wells in each area of the site, except for Well-7 and Well-8, demonstrate that the shallow water-bearing zone is in direct hydraulic connection with the river. Since the deep wells represent confined conditions, a relationship does not exist between these wells and the Buffalo River.

1.5 SITE CONTAMINATION CHARACTERIZATION

The characterization of site contamination was accomplished by analysis of soil, ground water, river water, stream sediments, and waste residuals. All samples were collected during the period of May - November 1988.

The results of sample collection analysis have demonstrated contamination at the Area "D" to be both widespread and variable with respect to its character and concentration. Contamination was found in the soil and/or ground water at virtually every location of the site investigated during the present RI.

On a weight basis, the principal contaminant found at the site is iron. An assortment of other heavy metals is also present at the site. A wide variety of organics was detected in both the soils and ground water at the site. These organics can be generally characterized as substituted and unsubstituted aromatics and PAHs. In addition, an oily sheen was observed in soils at a number of locations and a 6-foot layer of light non-aqueous phase liquid was found floating on ground water in the area of former tank park 910.

1.6 CONTAMINANT MIGRATION

1.6.1 Contaminant Pathways

Migration pathways for the Area "D" site, as identified during field investigations include:

- release of soluble constituents of the non-aqueous phase liquid located in the area of W-8 to ground water within the shallow overburden;
- overland runoff and mechanical transport of waste particles;
- lateral movement of contaminated ground water through the shallow overburden, with ultimate discharge to the Buffalo River; and
- mechanical erosion of the river bank along the periphery of the site resulting in the release of waste fill to the Buffalo River.

In general, the major pathways of contaminant migration from the Area "D" to the Buffalo River are via ground water and erosion of fill material. A daily loading of 1.2 lbs VOCs and 3.4 lbs SVOCs is estimated, on the basis of data collected during the present RI, to be migrating from the Area "D" to the Buffalo River via ground water. The total organic carbon loading migrating to the river via ground water is estimated to be 44.5 lbs/day.

The estimated loading of iron (17.4 lbs/day) and other metals (2.0 lbs/day) migrating to the river via ground water may be erroneously high as these estimates are based on unfiltered total metals concentration. do not agree

An estimated 575 cubic yards per year of fill material is eroding into the Buffalo River from Area "D". This is the primary pathway for off-site migration of iron (270 lbs/day) and other metals (6.2 lbs/day). A daily loading of 0.044 lbs SVOCs and 0.20 lbs EOX is also estimated to be migrating from Area "D" to the Buffalo River via mechanical erosion.

1.7 PUBLIC HEALTH AND ENVIRONMENTAL CONCERNS

There are no known potable water wells in the vicinity of the Area "D". Consequently, the most likely human exposure pathways identified at the site are ingestion, dermal contact and inhalation of contaminants in the surface soils by trespassers.

Ground water contaminants found at the site in excess of applicable standards and guidelines include volatile organics (viz., benzene, toluene, chlorobenzene, and xylene) and metals (viz., arsenic, cadmium, chromium, lead, and zinc).

Data collected in the past 20 years has indicated a substantial improvement in the environmental quality in the Buffalo River. Although the environmental quality of the Buffalo River has improved, there is some evidence that contamination found in river sediments may be a persistent problem since transport of the sediments downstream is believed to be minimal. In additon, there are a number of listed New York State inactive hazardous waste sites located on the Buffalo River that may be acting as continuous sources of contamination. However, it is not clear to what extent, if any, either Area "D" or these other sites are contributing to water and sediment contamination or are affecting river biota.

2.0 INTRODUCTION

2.1 SITE LOCATION AND DESCRIPTION

The Buffalo Color Area "D" is presently an inactive site located off South Park Avenue in the City of Buffalo, Erie County, New York (Figure 2-1). This site consists of a 19-acre peninsula surrounded on three sides by the Buffalo River and on the fourth side by a railroad yard and Buffalo Color's dye manufacturing facility. The Area "D" was last actively used by Allied Chemical Corporation for the manufacture of a variety of chemicals (principally household detergents and dye intermediates). Portions of the site were also used for temporary storage, prior to recycle, of iron oxide sludge and other metal sludges from off-site dye and dye intermediate manufacturing processes. Subsequent to Buffalo Color's purchase of the dye manufacturing plant and Area "D" site from Allied Chemical in 1977, all buildings and other above grade structures were demolished. All that presently remains that can be distinctly identified are the floor slabs and foundations of the former buildings and the waste disposal/storage areas (Figure 2-2).

The portions of the Area "D" which are of concern include:

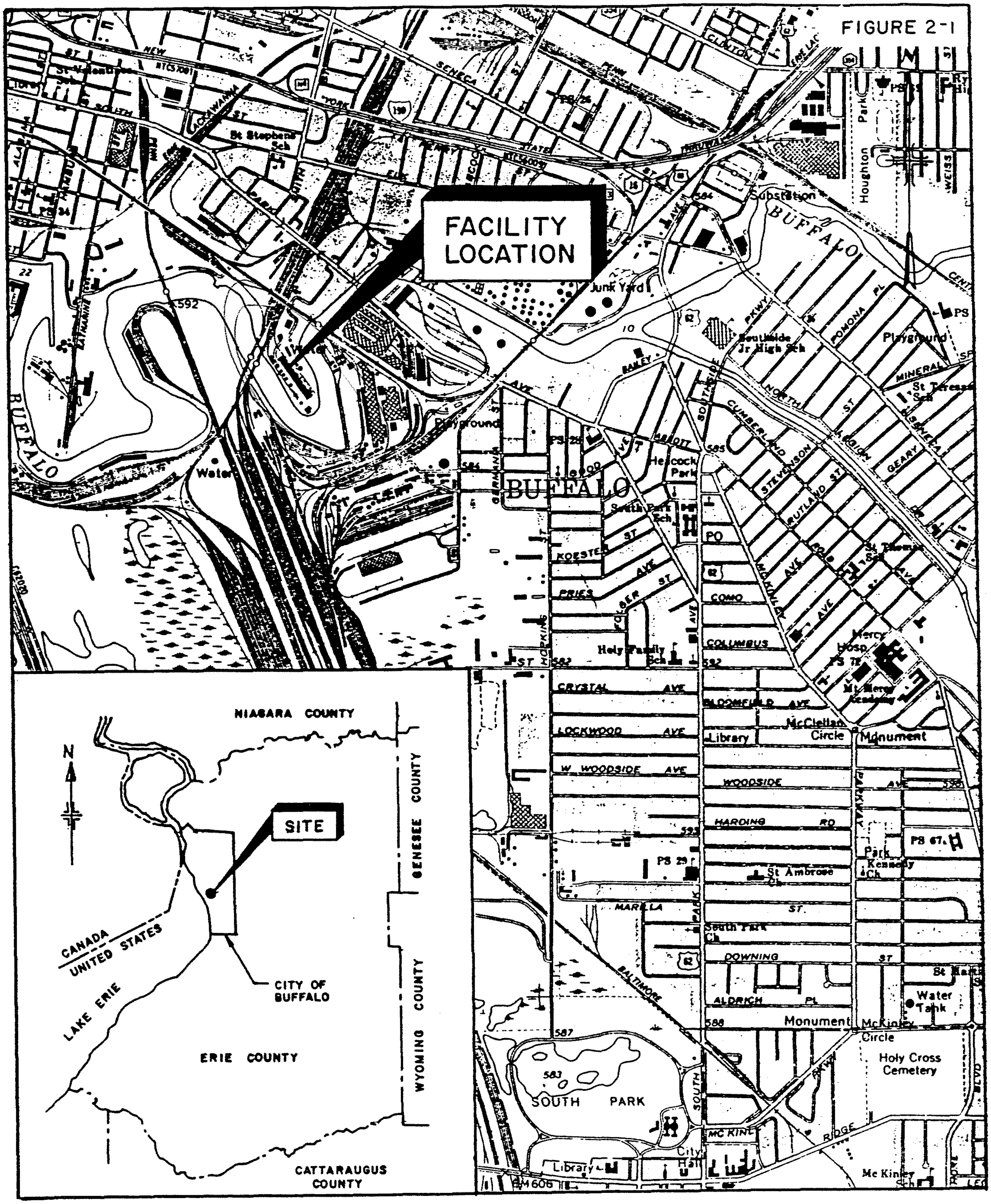
1) the "Weathering Area" located at the tip of the peninsula which was utilized for the storage of metal oxide sludges;

2) the "Iron Oxide Sludge Lagoons" which were used for storage of iron oxide sludge from the manufacture of dyes and intermediates;

3) tank farm areas used for the bulk storage of petroleum products and process chemicals; and

4) the area on the eastern side of the peninsula formerly occupied by open burning pits and later by an incinerator used for burning of organic wastes generated during dye manufacturing processes.

The "Iron Oxide Sludge Lagoons" and "Weathering Area" are currently listed in the New York State Registry of Inactive Hazardous Waste Disposal Sites, Site Nos. 915012A and 915012B, respectively.



MALCOLM PIRNIE

SOURCE: BUFFALO SE QUADRANGLE
N.Y.S.D.O.T. MAP
SCALE: 1:24000

AREA "D" RI/FS

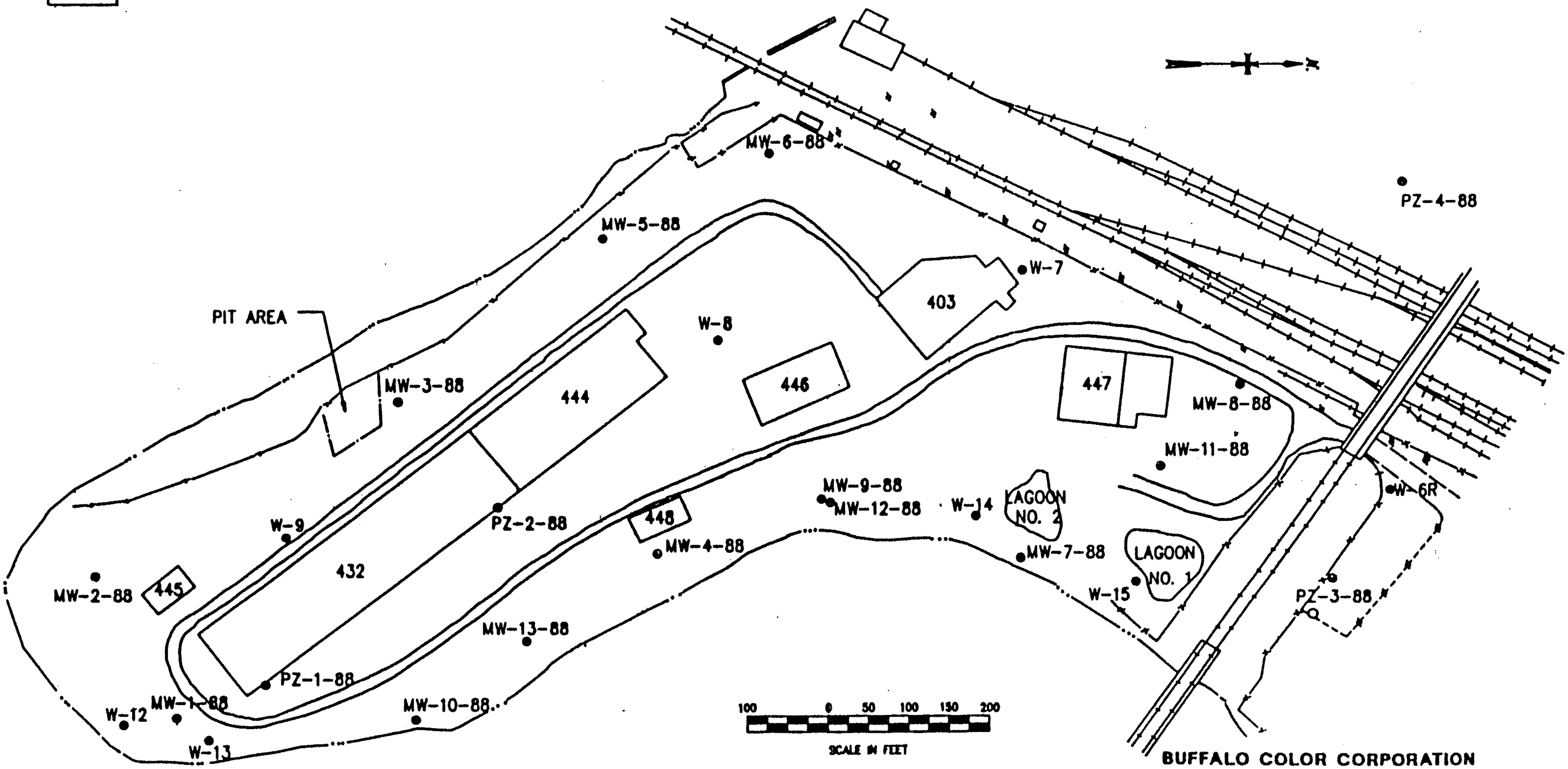
VICINITY MAP

BUFFALO COLOR CORPORATION

FIGURE 2-2

LEGEND

● MW-5-88	MONITORING WELL NO. 5 INSTALLED IN 1988
● W-9	MONITORING WELL NO. 9 INSTALLED IN 1982
⊖ PZ-2-88	PIEZOMETER NO. 2 INSTALLED IN 1988
444	LOCATION OF DEMOLISHED BUILDING 444



BUFFALO COLOR CORPORATION
BUFFALO, NEW YORK
AREA "D REMEDIAL INVESTIGATION
PRESENTLY EXISTING
SITE FEATURES

MALCOLM PIRNIE

Chronology

2.2 SITE HISTORY

2.2.1 Chronology

The 19 peninsular acres known as Area "D" were used for at least 70 years as a chemical manufacturing site. In addition, parts of the site were used for chemical waste handling. Manufacturing ended in Area "D" in 1974 and chemical waste handling ended in 1976. An attempt has been made to determine the history of the site from old records, maps, and interviews with former workers. A chronology of events is presented as Table 2-1.

2.2.2 Ownership

Area "D" was purchased in 1879 by Jacob Schoellkopf, the founder of the Buffalo Dye Plant. The use to which Area "D" was put for the first 25 years of ownership is unknown. At some point, the swamp-like area was built up to an elevation well above that of the Buffalo River.

In 1905, Schoellkopf formed the Contact Process Company which produced acids and other chemicals on the site of Area "D".

In 1917, Schoellkopf's nearby dye works on the adjacent property were expanded into the National Aniline Chemical Company. National Aniline also produced chemicals in Area "D" beginning in 1917 when the company entered into a joint operation with the U.S. Government's Edgewood Arsenal to produce Phosgene gas for use in World War I.

In 1920, National Aniline and the Contact Process Company were merged into Allied Chemical and Dye Corporation. During the next 54 years, Area "D" was used intensively for the manufacture of petroleum-based detergents and other chemicals. Three solid waste management units are known to have been operated in this period, the metal sludge weathering area, the iron sludge ponds, and the incinerator area. Allied ceased chemical manufacturing operations in Area "D" in 1974.

In 1977, Area "D" was sold to Buffalo Color Corporation which has held the area idle since then. All structures were demolished in 1984.

MALCOLM PIRNIE

TABLE 2-1

CHRONOLOGICAL HISTORY OF AREA "D"

1866 A map of the City of Buffalo shows Area "D" as swampland.

1879 Jacob Schoellkopf forms the Schoellkopf Aniline and Dye Company. Area "D" is acquired, along with other areas of the plant.

1884 Schoellkopf begins manufacture of Aniline, a fundamental raw material of dyestuffs. The process is later abandoned under pressure from the German chemical cartel which holds the patents on other necessary dye intermediates.

1885 A prospectus of Schoellkopf Aniline and Dye Company indicates that the quantity of wastes produced by the facility is "none". The land at Area "D" has been found to consist of an average of 10 feet of fill material piled atop the natural soils.

1890 The dye plant obtains its first of many patents. Schoellkopf Acid, a naphtahlene derivative is patented in both the USA and Germany.

1901 Schoellkopf Aniline patents the process for Direct Black 38. This joins an ever-increasing line of dye products. It's primary intermediate, Benzidine Sulfate, must be imported. General Chemical Company, a manufacturer of sulfuric acid, is established across Lee Street from Schoellkopf Aniline.

1905 Schoellkopf establishes the Contact Process Company at Area D. Buildings occupied the area near Building 403. The Contact Process Company produced acids and other chemicals.

1910 The Benzol Products Company is formed at Marcus Hook, Pennsylvania to produce Nitrobenzene and Aniline. Benzol becomes the principal supplier of these materials, both to the Schoellkopf Dye works and the rest of the chemical industry.

1912 The W. Beckers Aniline and Chemical Works is formed at Brooklyn, New York. The firm is soon producing 15 types of dyestuffs, based on the use of European intermediates.

1913 The number of dyes in production at Buffalo reaches 100.

1914 World War I begins in Europe, choking off the supply of German dye intermediates. The American dye industry has to find alternative sources in order to continue. The possibility of producing the intermediates which has been trade-secreted, patented, and cartelized by the Germans offers a major opportunity for the expansion of the business. By the end of the year Schoellkopf is producing Benzidene Sulfate, an intermediate for the manufacture of Direct Black 38.

TABLE 2-1

CHRONOLOGICAL HISTORY OF AREA "D" (continued)

1915 Schoellkopf and the City of Buffalo agree to trade land. The tip of the Area "D" peninsula is given up to the river to accommodate large ships at new steel plant on opposite shore. Area which later becomes the Iron Sludge ponds is reclaimed from the river by Schoellkopf. The Buffalo Dye Plant begins manufacture of H-Acid and other Naphthalene-based intermediates. Iron sludges from some of these may have been used to fill the Iron Sludge Ponds area.

1916 The number of manufactured intermediates increases, making possible the manufacture of a widening variety of dyestuffs. Some of these result in the generation of metallic byproducts. It is possible that the "weathering" of National Aniline's metal sludges prior to resale or disposal began at the new tip of the Area "D" peninsula at this point in time.

1917 National Aniline and Chemical Company Inc., is incorporated in New York, affecting a merger of three companies; Schoellkopf Aniline, W. Beckers Aniline, and the Benzol Products Company. The company, now vertically integrated, undertakes a massive building program. Among the new structures is Building 432 in Area D. By the end of the year National Aniline is producing 50 intermediates and 120 colors, more than half of the American market for all dyestuffs.

1918 National Aniline experiences a vast increase in activity and complexity as new intermediates and colors are invented and production begins in the newly-constructed buildings. America's entry into World War I removes any claim the Germans had on their patents for dyes or intermediates. National Aniline joins with the U.S. Government's Edgewood Arsenal to produce Phosgene for use in poison gas shells used by the Allies in the war. This work may have been done in Building 432.

1920 Allied Chemical and Dye Corporation is formed, uniting National Aniline, the Contact Process Company, nearby General Chemical, with three other firms.

1921 New dyes and intermediates continue to be introduced by Allied Chemical. The W. Beckers plant in Brooklyn is closed and the processes are moved to Buffalo.

1922 Manufacture of Phthalic Anhydride from the catalyzed oxidation of Naphthalene begins at Buffalo. The process produces a ton of Naphthalene-based waste for each two tons of product. Tars are taken to Area "D" and burned while liquids are sewered to the river. This is the oldest record found of a burning operation.

MALCOLM PIRNIE

TABLE 2-1

CHRONOLOGICAL HISTORY OF AREA "D" (continued)

1923 Allied Chemical moves the Aniline process from the Benzol Products Plant in Marcus Hook, Pennsylvania to the Buffalo Dye Plant. This results in a large increase in the volume of iron sludge handled at the iron sludge ponds in Area D. All of Allied's dye-related activities are now consolidated at Buffalo.

1926 Allied begins manufacture of 1-Naphthylamine resulting in additional iron waste sent to the iron sludge ponds.

1934 Allied Chemical begins production in Building 432 of the first synthetic detergents made from petroleum-based materials.

1941 Allied starts up massive spray drying operation in newly-constructed Building 444.

1945 Allied begins major expansion of detergents manufacturing capacity in Area D.

1948 Kerylbenzene production begins in newly-built Building 447 in Area D.

1953 Kerylbenzene production is converted to continuous process in Building 447.

1954 Incinerator constructed at Building 448 burns tars and solvents from processes as well as plant trash. Open burning of wastes along north-east shore of Area "D" probably ends at this time.

1963 Aniline manufacture ceases at Buffalo. The rate of iron sludge sent to the ponds in Area "D" is greatly reduced.

1967 The Buffalo River Improvement Corporation begins pumping operations. A large pumping line has been installed along the northwestern side of Area D.

1971 Allied starts up waste water treatment plant, diverting treated process waste water out of the Buffalo river and into the Buffalo Sewer Authority.

1972 As a result of an order by Erie County Air Pollution Control Allied Chemical halts waste burning at the Building 448 incinerator. Organic chemical wastes are sent to disposal vendors for landfill and incineration.

MALCOLM PIRNIE

TABLE 2-1

CHRONOLOGICAL HISTORY OF AREA "D" (continued)

March 1974	Allied ends last chemical manufacturing activity in Area "D" as spray drying operation in Building 444 is shut down.
July 1976	Allied removes the last metal sludges from the weathering area at the tip of the peninsula, shipping them to a metal recycler.
July 1 1977	Allied Chemical sells the Dye Plant to Buffalo Color Corporation.
August 23 1978	An Interagency Task Force (USEPA/NYSDEC/NYDOH) requests a list of inactive waste sites at the dye plant. Buffalo Color provides descriptions of the weathering area and the iron sludge ponds.
August 24 1979	Buffalo Color installs three monitoring wells at the weathering area and two at the iron sludge ponds.
January 17 1980	Buffalo Color sends weathering area well monitoring data to NYSDEC.
May 12 1981	Buffalo Color sends NYSDEC well monitoring data from the iron sludge ponds area.
March 25 1982	Buffalo Color consents to conduct a field investigation of the soils, ground water, and hydrogeology in Area D.
June 27 1984	Buffalo Color completes the field investigation and submits it to NYSDEC.
September 15 1984	Buffalo Color demolishes all remaining structures in Area D, leveling the entire 19 acres.
October 4 1984	Buffalo Color reports estimated quantities of materials burned in Area "D" between 1920 and 1972 to NYSDEC as part of a hazardous waste disposal questionnaire.
December 2 1987	Allied-Signal and Buffalo Color consent to jointly conduct a Remedial Investigation and Feasibility Study of Area "D" in accord with a defined project scope. NYSDEC agrees not to require significant deviations from that scope.

2.2.3 Structures

The Contact Process Company had buildings along both sets of railroad tracks which form the borders of Area "D". With the possible exception of Buildings 403 - 410, no records of these buildings have been found in the plant archives. Building 432 was built in 1917. The building may have been used in conjunction with the Edgewood Arsenal to produce Phosgene gas. It was definitely used after the 1920s for the production of Picric Acid, an unstable chemical.

Most of the structures shown in the available records were built in the 1930's and 1940's for the manufacture of detergents. It is not clear at what date the tank parks were built, but it is known that they serviced the detergents units, so it is likely that they also were built in the 1930s or 1940s.

The railroad tracks in Area "D" are at least as old as Building 432. A tabulation of structures found in the records is presented as Table 2-2.

2.2.4 Chemical Manufacturing Processes

A tabulation of what is known about the chemical processes which were carried out in Area "D" is presented as Table 2-3. Descriptions of the known processes are given as follows:

2.2.4.1 Sulfuric Acid

Sulfur is burned to form sulfur dioxide which is passed over a vanadium catalyst with air to form sulfur trioxide which is absorbed in a circulating stream of 98-99% sulfuric acid, where it unites with the small excess of water in the acid to form more sulfuric acid.

2.2.4.2 Phosgene

Phosgene is produced by the combination of carbon monoxide and chlorine gases using activated charcoal as a catalyst.

2.2.4.3 Picric Acid

Dinitrophenol is suspended in sulfuric and nitric acid and nitrated by adding sodium nitrate to form trinitrophenol.

TABLE 2-2

HISTORY OF AREA STRUCTURES

STRUCTURE	BUILT	IDLED	DEMOLISHED	KNOWN USE
B 403	1905	1976	1984	Garage, Warehouse
B 404	1905 ?		1984	Offices, Utilities
B 406	1905 ?		1969	Chemical Production
B 410	1905 ?		1984	Utilities
B 432	1917	1972	1984	Chemical Production
B 436	1917 ?	1974	1984	Offices, Shops
B 437	1917 ?		1969	Chemical Production
B 441	1937		1969	Chemical Production, Whse.
B 443	1940		1969	Utilities
B 444	1941	1976	1984	Chemical Production, Whse.
B 445	1946	1972	1984	RR Car Thawing
B 446	1945	1976	1984	Shops, Offices
B 447	1946	1970 ?	1984	Chemical Production
B 448	1953	1972	1984	Incinerator
B 450	1948	1972	1984	Utilities
B 453	1942	1972	1984	Utilities
B 454	1942	1972	1984	Utilities
TP 910	1953	1974	1984	Chemical Storage
TP 911 N	1946 ?	1972	1984	Chemical Storage
TP 911 S	1946 ?	1972	1984	Chemical Storage
TP 912	1935 ?	1974	1984	Chemical Storage
TP 913	1935 ?	1974	1984	Chemical Storage

NOTE: Structures shown have numbers which appear on maps, drawings, or plant records.

TABLE 2-3

HISTORY OF AREA D CHEMICAL MANUFACTURING

CHEMICAL PRODUCT	MANUFACTURER	DATES OF PRODUCTION	CHEMICAL HANDLED	BUILDINGS
Sulfuric Acid	Contact Process Co.	1905 - 1920	Sulfur Sulfur Dioxide Sulfur Trioxide Sulfuric Acid Lead-Lined Tanks	403 ?
Other Chemicals	Contact Process Co.	1905 - 1920	?	403 ? 406 ?
Phosgene	Edgewood Arsenal National Aniline	1917 - 1918	Carbon Monoxide Chlorine Phosgene Activated Carbon	432 ? 437 ?
Other Chemicals	National Aniline	1919 - 1920	?	432 ?
Other Chemicals	Allied Chemical	1921 - 1928	?	432 ?
Picric Acid	Allied Chemical	1929 - 1969	2,4 Dinitrophenol Sulfuric Acid Nitric Acid Sodium Nitrate 2,4,6 Trinitrophenol)	432 437 ?
Detergents	Allied Chemical	1934 - 1974	Benzene Toluene Kerosene Alkylates Aluminum Chlorine Keryl Chloride Alkyl Chloride Keryl Benzene Alkyl Benzene Keryl Toluene Alkyl Toluene Kerylbenzene Sulfonate KerylToluene Sulfonate Alkylbenzene Sulfonate Kerylbenzene Sulfonate Aluminum Chloride Aluminum Hydroxide Sulfuric Acid Sodium Hydroxide Sodium Chloride	432 444 447 TP910 TP911N TP911S TP912 TP913

2.2.4.4 Detergents

Kerosene (or alkylate) is reacted with chlorine gas to form keryl chloride (or alkylchloride) which is reacted with Benzene (or Toluene) and metallic Aluminum to from Kerylbenzene (Keryltoluene, Alkylbenzene, or Alkyltoluene). This then reacted with Sulfuric Acid to form Kerylbenzene Sulfonate (Keryltoluene Sulfonate, Alkylbenzene Sulfonate, or Alkyltoluene Sulfonate) which is dried and sold. Aluminum Chloride and Hydrogen Chloride byproducts are neutralized with Sodium Hydroxide.

2.2.5 Solid Waste Handling Units

2.2.5.1 Weathering Area (1916 - 1976)

Heavy metal sludges from a variety of processes were brought to the tip of the Area "D" peninsula and piled for "weathering". The dewatered sludges were then loaded onto trucks or railroad cars and shipped to metal recyclers. A summary of those sludge producing processes which could be found in plant records is presented in Table 2-4.

2.2.5.2 Iron Oxide Sludge Lagoons (1916-1976)

Iron-bearing solid wastes were brought through the area reclaimed from the Buffalo River at the north eastern corner of Area "D" and handled in a similar fashion to the Weathering Area operation. Iron sludge producing processes are also shown in Table 2-4.

2.2.5.3 Incinerator Area (1922 - 1972)

Burnable chemical wastes, solid and liquid, were brought to Area "D" to be burned along with wood and paper from other plant activities along the river bank between the weathering area and the iron sludge ponds. Open burning pits were operated until 1954 when an incinerator was constructed at Building 448. An estimate of the quantity of wastes handled at the incinerator based on previous reports to the NYSDEC is presented in Table 2-5.

TABLE 2-4

HISTORY OF METALLIC SLUDGE HANDLING IN AREA D

CONTAMINANT[1]	PRODUCT GENERATING CONTAMINANT[2]	ID	DATES OF PRODUCTION[3]	AVERAGE RATE OF MANUFACTURE OF PRODUCT (POUNDS/YEAR)	DRY POUNDS OF SOLID WASTE GENERATED PER 1000 LBS. OF PRODUCT: CONTAM.	NOTE 4	OTHERS	1916-1976 AREA D THROUGHPUT DRY TONS: CONTAM.	NOTE 4	OTHER
Fe_3O_4	Alpha Naphthylamine	CAS 134-32-7	1927-1968	1,320,000	626	0	150	22,623	0	5,421
	Amino H Acid	CAS 117-42-0	1916-1976	1,880,000	2,636	0	169	151,000	0	9,690
	Aniline	CAS 62-53-3	1923-1963	10,000,000	1,680	0	262	344,000	0	53,300
	Basic Blue 9	CI 52015	1916-1972	162,000	650	-	-	3,001	-	-
	Basic Violet 5	CI 50205	1924-1976	6,800	463	-	-	83	-	-
	O-Chloroaniline	ACC 12813	1961-1965	20,500	197	0	50	10	0	3
	4-Chlorometanilic Acid	CAS 98-36-2	1938-1975	35,800	1,770	45	50	1,204	31	34
	2,4-Diaminotoluene	CAS 95-80-7	1924-1968	83,400	356	27	0	668	51	0
	4-Hydroxymetanilic Acid	CAS 98-37-3	1961-1970	37,200	125	0	150	23	0	28
	O-Toluidine	CAS 95-53-4	1936-1968	2,150,000	180	0	50	6,386	0	1,773
	P-Toluidine	CAS 106-49-0	1960-1966	160,000	132	0	50	74	0	28
	6,6-Thiodimetanilic Acid	CAS 118-86-5	1931-1973	12,900	567	0	250	157	0	69
	2,4-Xylidine	CAS 95-68-1	1927-1968	151,000	200	0	50	634	0	159
$PbSO_4$	Acid Blue 1	CI 42045	1928-1975	17,000	354	24	157	145	10	64
	Acid Blue 7	CI 42080	1924-1974	30,100	255	19	10	196	15	8
	Acid Blue 34	CI 44025	1923-1975	7,300	231	29	10	45	6	2
	Acid Blue 104	CI 42735	1936-1974	16,800	186	43	78	61	14	26
	Acid Green 3	CI 42085	1923-1973	29,500	174	14	9	131	11	7
	Acid Green 9	CI 42100	1922-1974	42,300	391	46	13	438	52	15
	Acid Green 16	CI 44025	1924-1974	39,300	348	17	174	349	17	174
	Basic Green 4	CI 42000	1925-1974	251,000	723	22	104	4,536	138	653
	Food Violet 2	CI 42640	1954-1973	11,500	1,010	263	725	116	30	83
Cr_2O_3	Acid Blue 9	CI 42090	1918-1976	261,000	31	25	144	239	192	1,108
	Acid Red 207	ACC 1677	1949-1969	2,600	23	30	33	1	1	1
	Acid Violet 49	CI 42640	1922-1976	35,000	158	31	76	152	30	73
	Basic Blue 9	CI 52015	1916-1972	162,000	670	295	0	3,093	1,362	0
	Basic Blue 22	ACC 3255	1965-1974	29,500	3	0	68	1	0	10
	Basic Violet 5	CI 50205	1924-1976	6,800	1,055	0	2,027	190	0	365
	Food Blue 2	CI 42090	1930-1976	17,800	106	0	907	44	0	379
	Indole-2,3-dione	CAS 91-56-5	1941-1971	98,800	123	30	50	188	46	76
Zn_2O_3	Basic Blue 9	CI 52015	1916-1972	162,000	427	-	-	1971	-	-
	Basic Violet 5	CI 50205	1924-1976	6,800	689	-	-	124	-	-
	3,6-Diacetylamino Acridine	ACC 12471	1933-1971	600	201	0	300	2	0	3
	Diazosalicylic Acid	ACC 12148	1923-1970	5,300	117	0	300	15	0	38
	Isobutyl Beta-Naphthol	ACC 12602	1940-1973	21,000	870	0	768	301	0	266
	Phthalide	CAS 87-41-2	1961-1971	59,900	114	0	150	38	0	49
	Solvent Green 3	CI 61565	1926-1973	25,800	85	0	1,740	53	0	1,077
	Tertiary Amyl Beta Naphthol	ACC 12972	1940-1973	9,100	837	0	409	129	0	63
	1,3,3-Trimethyl-2-Methylene-Indolene	CAS 118-12-7	1961-1970	25,300	984	0	2,605	124	0	329
Cu_2S	Acid Blue 25	CI 62055	1924-1967	2,100	51	90	0	2	4	0
	Acid Blue 40	CI 62125	1941-1973	55,700	17	91	103	16	84	95
	Acid Blue 102	CI 50370	1935-1969	20,600	12	0	135	4	0	49
	1-Amino-4-Anilino-2-Methoxy Anthraquinone	ACC 12294	1946-1974	4,900	215	144	115	15	10	8
	Basic Blue 22	ACC 3255	1965-1974	29,500	3	-	- -	-	-	-
	Basic Violet 1	CI 42535	1916-1976	252,000	224	201	56	1,439	1,291	360
	[1,1'-Binaphthalene]-8,8'-Dicarboxylic Acid	CAS 117-16-8	1962-1975	19,700	724	1,788	539	100	247	74
	4,5'-dibenzamido-1,1'-imino dianthraquinone	CAS 128-89-2	1937-1969	11,900	5	0	50	1	0	10
	Direct Blue 76	ACC 5258	1942-1974	10,900	13	0	6	2	0	1
	Direct Yellow 103	ACC 5856	1961-1974	55,400	89	191	147	35	74	57
	Solantine Yellow UFE	ACC 5814	1968-1974	39,500	98	29	137	14	4	19
	Solantine Yellow 4RL	ACC 5836	1935-1963	76,100	328	195	213	362	215	235
$Ca_3(AsO_4)_2$	1-Amino Anthraquinone	CAS 82-45-1	1936-1969	103,000	214	0	150	374	0	263
	1-Nitro-2,4-Diaminobenzene	ACC 12478	1943-1970	800	230	0	150	3	0	2
$Hg(OH)_2$	Dihydroxyanthraquinone	CAS 117-12-4	1926-1970	68,600	4	0	50	6	0	77
$Co(OH)_2$	Acid Red 32	ACC 1632	1958-1974	2,900	48	125	96	1	3	2
	Solvinac Red 3BS	ACC 6612	1968-1974	1,400	105	375	52	1	2	0

RECAPITULATION

Fe_3O_4	Iron Sludges	1916-1976	Average Iron content 63.9 % Dry	529,853	82	70,505
$PbSO_4$	Lead Sludges	1922-1975	Average Lead content 56.0 % Dry	6,017	293	1,032
Cr_2O_3	Chromium Sludges	1916-1976	Average Chrome content 35.4 % Dry	3,908	1,631	2,012
Zn_2O_3	Zinc Sludges	1916-1976	Average Zinc content 44.0 % Dry	2,757	0	1,825
Cu_2S	Copper Sludges	1916-1976	Average Copper content 32.9 % Dry	1,990	1,929	908
$Ca_3(AsO_4)_2$	Arsenic Sludges	1936-1970	Average Arsenic content 22.1 % Dry	377	0	265
$Hg(OH)_2$	Mercury Sludges	1926-1970	Average Mercury content 6.2 % Dry	6	0	77
$Co(OH)_2$	Cobalt Sludges	1943-1974	Average Cobalt content 14.1 % Dry	2	5	2

Note (1) All sludges are quantified as their stoichiometric equivalent of the most common compound produced.

Note (2) ID Numbers assigned according to availability. In decreasing priority, CAS = Chemical Abstracts Service No., CI = Color Index No., ACC = Allied Chemical Corp. Produce Code Number.

Note (3) Earliest date based on search of standard processes. Latest date based on production records.

Note (4) Materials in this column are filter cel, solka floc, and activated charcoal. The "others" column contains both organic species and other inorganic compounds (especially sodium and calcium salts).

Note (5) Many of the other metals were probably also present in the iron sludges, having entered the processes as undocumented impurities in the purchased iron. A 1.0 percent effect is along the order of 5,000 tons of "other" metal sludge passing through Area D over the period studied.

MALCOLM PIRNIE

TABLE 2-5

HISTORY OF AREA "D" INCINERATION OPERATIONS

INCINERATED MATERIAL	CAS NUMBER	PERIOD	TOTAL (TONS)
Unspecified Burnables	NA	1922-1972	8,412
Aliphatic & Naphthenic Hydrocarbons	NA	1939-1972	7,000
Alcohol, Ethyl	64-17-5	1940-1972	6,060
Antimony Chloride/Nitrobenzene Tar	NA	1931-1972	6,060
Toluene	018-88-3	1922-1972	5,010
Naphthalene	91-20-3	1925-1972	5,010
1-Dodecene	112-41-4	1956-1972	3,920
Alcohol, Isopropyl	67-63-0	1922-1972	2,482
Alcohol, n-Butyl	71-36-3	1933-1972	2,270
Nitrobenzene	98-95-3	1922-1972	2,232
1,2-Dichlorobenzene	95-50-1	1924-1972	1,300
Chlorobenzene	108-90-7	1923-1972	827
Alcohol Methyl	67-56-1	1922-1972	827
Polymerized Anhydrides	NA	1939-1972	400
Alkylated Anilines	NA	1922-1972	381
Alcohol, Benzyl	100-51-6	1940-1972	356
Aniline	62-53-3	1922-1972	306
O-Cresol	108-39-4	1953-1970	237
Phenol	108-95-2	1922-1972	91
P-Toluidine	106-49-0	1940-1972	31

Adapted from Hazardous Waste Disposal Questionnaire for Buffalo Dye Plant filed with New York State Department of Environmental Conservation on October 4, 1984.

Quantities are calculated from documented burning rates in 1968-1971 times periods of manufacture of the waste-producing processes.

2.2.6 Geographical Distribution of Potential Impacts

The foregoing information has been projected onto two maps of Area "D" showing areas of potential impact from these known activities. They represent two types of potential contamination.

2.2.6.1 Heavy Metal Potentials are defined as areas:

Within 75 feet of the iron sludge lagoons.
Within 75 feet of the weathering area.
Within 50 feet of railroad lines.
Within 25 feet of roadways.
See Figure 2-3.

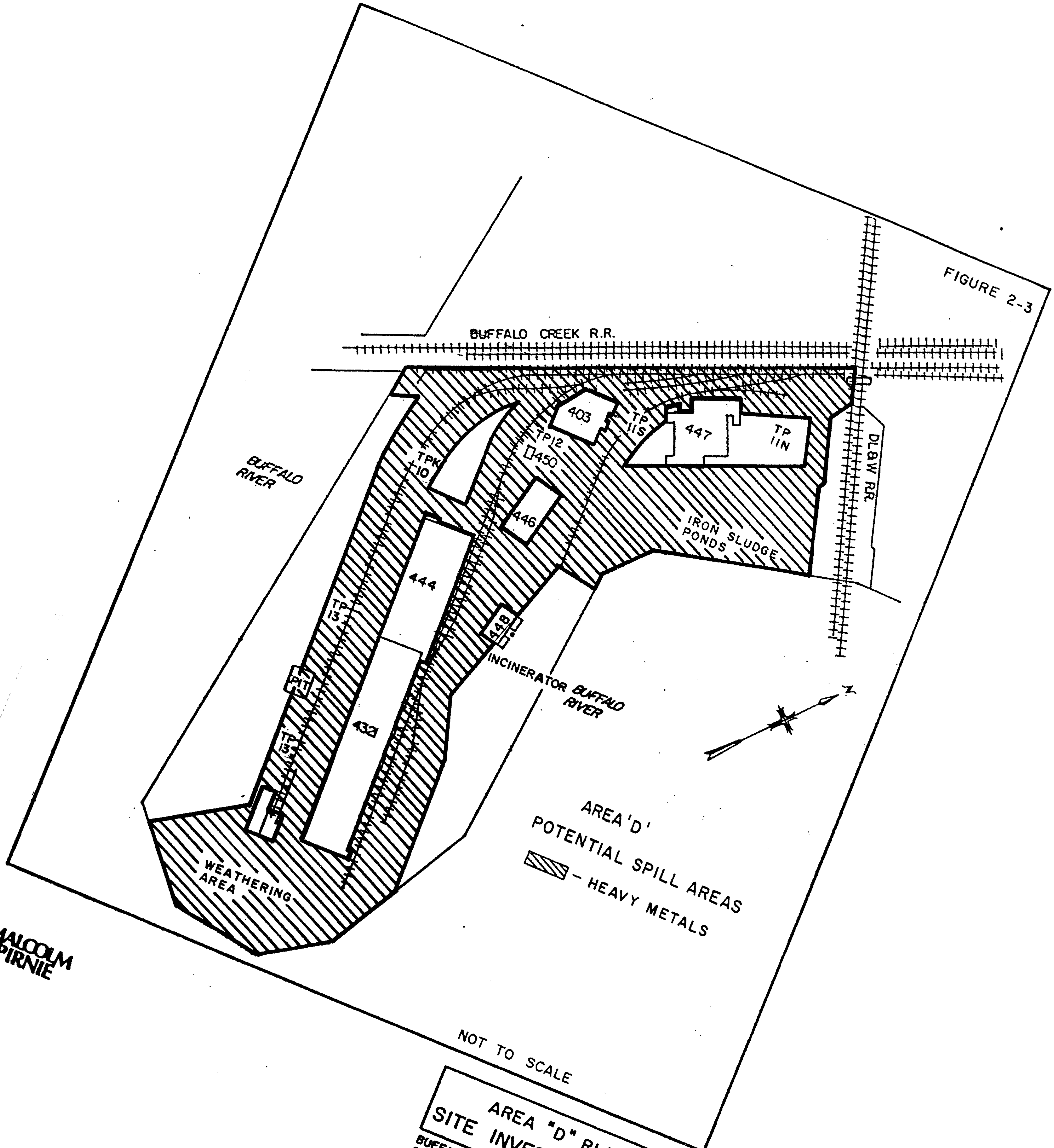
2.2.6.2 Liquid Organics Potentials are defined as areas:

Within 75 feet of the incinerator area.
Within 75 feet of tank parks.
Within 50 feet of railroad lines.
Within 25 feet of roadways.
See Figure 2-4.

2.3 PURPOSE

The New York State Department of Environmental Conservation (NYSDEC) has listed the Iron Oxide Sludge Lagoons and Weathering Area on the New York State Registry of Inactive Hazardous Waste Disposal Sites. Subsequently, the Buffalo Color Corporation and Allied Signal, Inc. have jointly entered into an Order on Consent with NYSDEC to conduct a Remedial Investigation/Feasibility Study program at the Area "D". The scope of the investigative and reporting activities to be performed is identified in the Order on Consent (Appendix A.1).

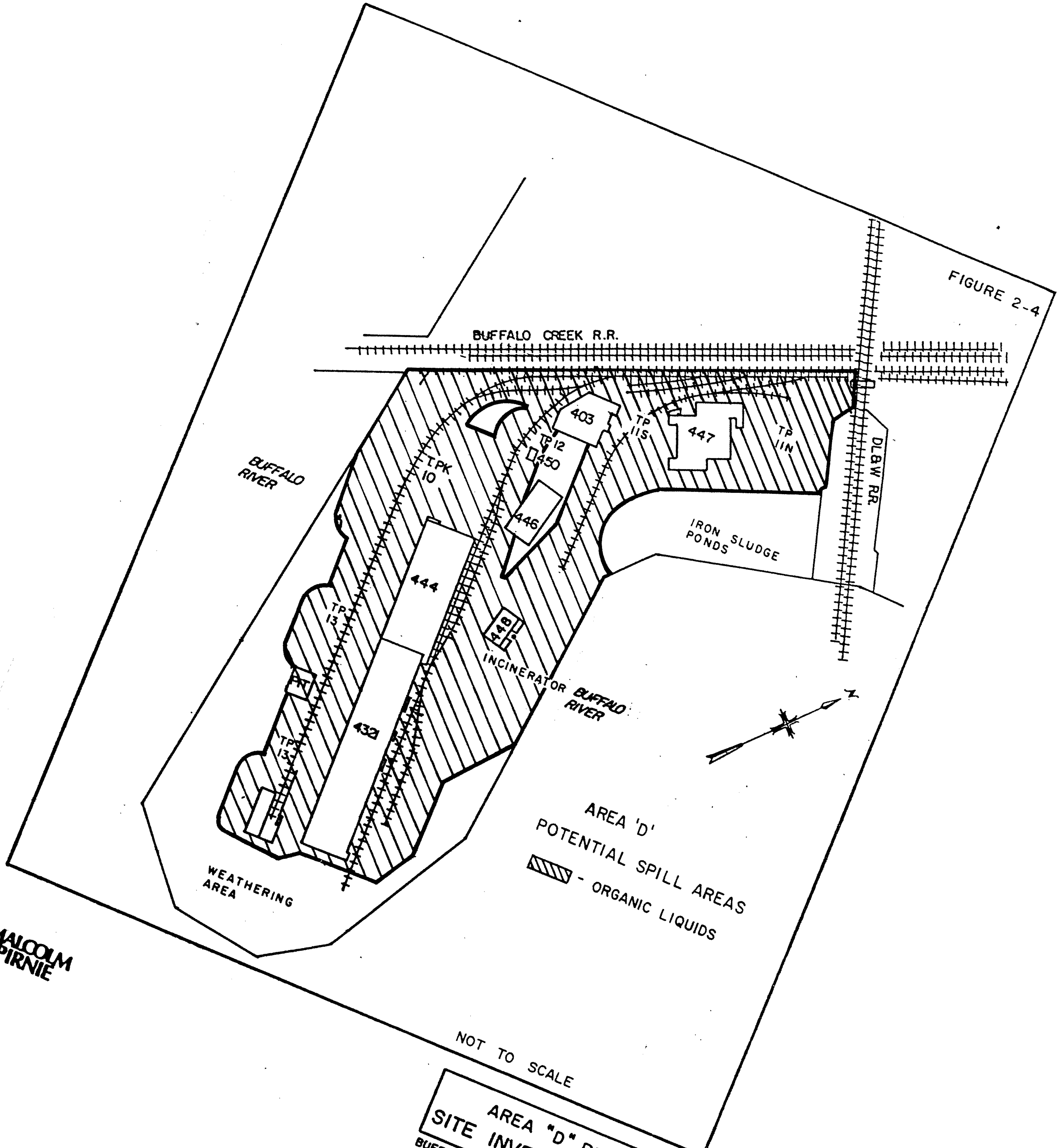
Buffalo Color and Allied Signal contracted with Malcolm Pirnie, Inc. to implement and perform the required Remedial Investigation and Feasibility Study. During the period of May-November 1988, Malcolm Pirnie conducted the field investigation activities required by the Remedial Investigation scope of work. The purpose of this document is to present the findings of the Remedial Investigation. Upon approval



AREA "D" RI/FS
SITE INVESTIGATION PLAN

BUFFALO COLOR CORPORATION

MALCOLM PIRNIE



MALCOLM PIRNIE

AREA "D" RI/FS
SITE INVESTIGATION PLAN
BUFFALO COLOR CORPORATION

and acceptance of this report by the NYSDEC, these findings will provide the basis for subsequent performance of the Feasiblity Study.

2.4 APPROACH

To implement the scope of work identified in the Order on Consent, Malcolm Pirnie prepared a Work Plan/Quality Assurance Plan (Malcolm Pirnie, 1988). This Work Plan includes a Remedial Investigation Plan which identifies all the field investigative activities and methodology, including sample collection and analysis procedures, that was employed to perform the investigation. The quality assurance/quality control procedures used to insure data validity are also identified. The Work Plan/Quality Assurance Plan is included as Appendix B.1 to this report.

During the course of the field investigative activities, a number of modifications to the scope of work and/or investigative procedures were recommended on the basis of new information discovered and/or mitigating circumstances encountered in the field. All such modifications were implemented only after the mutual agreement and formal approval by NYSDEC, Buffalo Color, and Allied Signal. A chronological accounting and documentation of all such modifications is presented in Appendix B.2.

Collectively, the documents presented in Appendices B.1 and B.2 define the specific methodology that was employed to generate the data that is presented in this document. This methodology will only be referenced and/or summarized in the text of this document as appropriate for interpretation of results and findings. The reader is referred to the Appendices for a detailed presentation of the specific investigative procedures and methods employed.

3.0 PHYSIOGRAPHY AND CLIMATE

3.1 LAND USE

A zoning map illustrating the current and potential zoning and land use at the Buffalo Color Corporation Area "D" site, and the surrounding area, is attached as Figure 3-1. As shown by this map, the site and immediate surrounding area are zoned for heavy industry. The nearest residential area is approximately 1200 feet northwest of the site.

3.2 TOPOGRAPHY

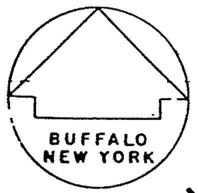
The topography of the Area "D" site, and the surrounding area, is relatively flat. The Buffalo River borders the site to the east, south and west. Along the northeast perimeter, an elevated railroad line borders the site. Along the remaining north perimeter, additional railroad lines, at grade, border the site.

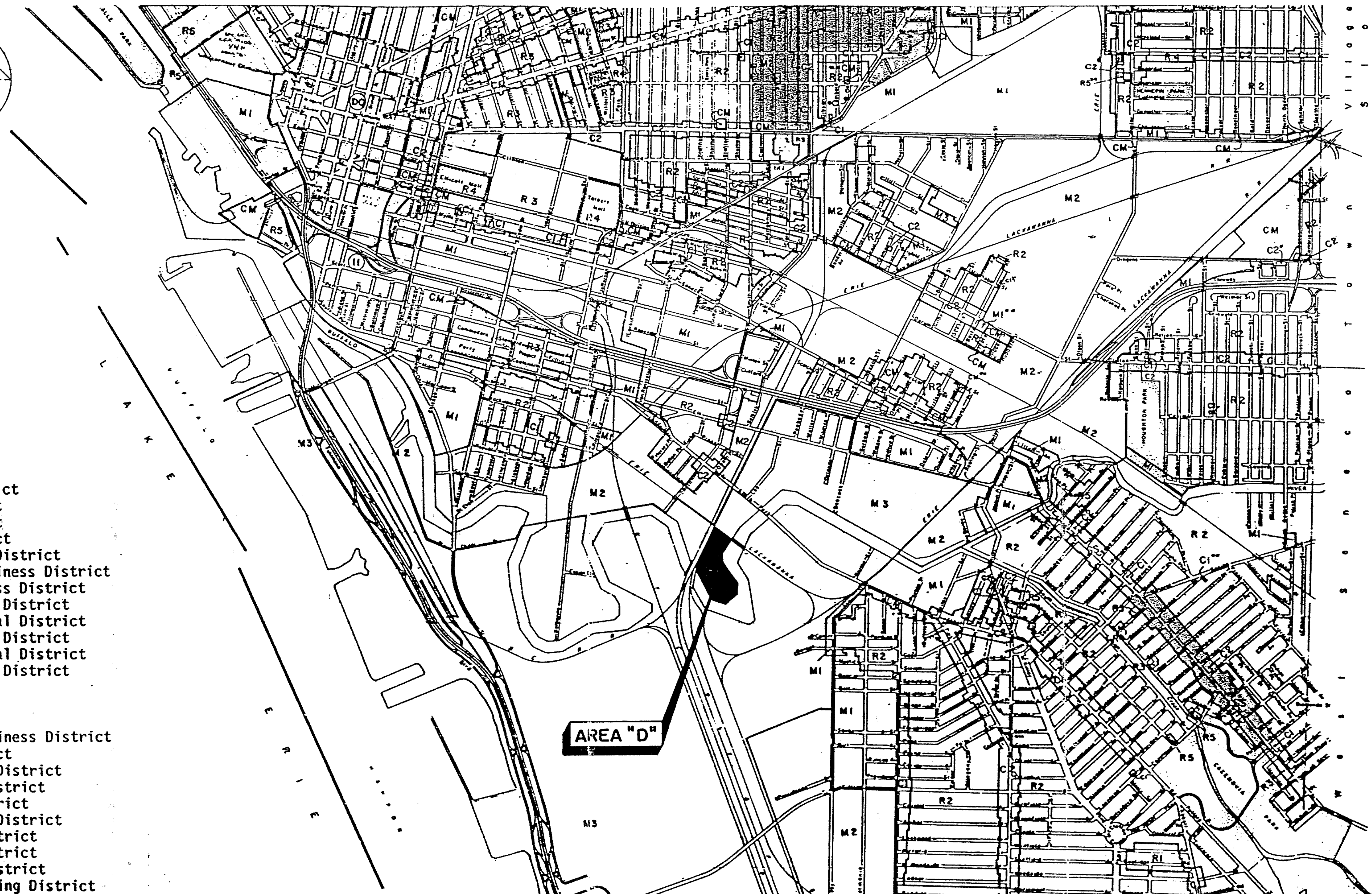
3.3 DRAINAGE

Surface run-off at the Area "D" site is entirely to the Buffalo River. The Buffalo River, only 8.1 miles in length, drains an urban and industrial water shed and flows into the Buffalo Harbor near Naval Park (Harding and Gilbert, 1968). See Section 5.1 for additional information on the Buffalo River Drainage Basin.

3.4 CLIMATIC DATA

Pertinent meteorological data for the period 1958 to 1987 from the weather observation station at the Buffalo International Airport is summarized in Table 3-1. Weather data from this station is forwarded to the national climatic data center in Asheville, North Carolina and is published monthly.





1987

CITY OF BUFFALO
ZONING MAP

"ZONING DISTRICTS

"R1" One-Family District
"R2" Dwelling District
"R3" Dwelling District
"R4" Apartment District
"R5" Apartment-Hotel District
"C1" Neighborhood Business District
"C2" Community Business District
"C3" Central Business District
"CM" General Commercial District
"M1" Light Industrial District
"M2" General Industrial District
"M3" Heavy Industrial District

SPECIAL DISTRICTS

"EB" Elmwood Ave. Business District
"AD" Allen St. District
"DA" Delaware Avenue District
"HA" Hertel Avenue District
"MS" Main Street District
"TS" Transit Station District
"PB" Porter-Busti District
"SO" Sign Overlay District
"SS" Seneca Street District
"RP" Residential Parking District
"RR" Residential Restricted District
"DO" Downtown Opportunity District
"II" Institutional-Light Industrial District

MALCOLM PIRNIE

BUFFALO COLOR CORPORATION
BUFFALO, NEW YORK
AREA "D REMEDIAL INVESTIGATION
CITY OF BUFFALO
ZONING MAP

MALCOLM PIRNIE

TABLE 3-1

BUFFALO COLOR CORPORATION
AREA "D"
SUMMARY OF CLIMATIC DATA

BUFFALO, N.Y. MONTHLY AND ANNUAL PRECIPITATION AND TEMPERATURE
FOR THE PERIOD JANUARY 1958 - DECEMBER 1987*
BUFFALO AIRPORT WEATHER STATION

PERIOD	INCHES	TEMPERATURE
January	3.10	24.7
February	2.67	24.6
March	2.76	32.5
April	2.69	43.6
May	2.89	54.9
June	2.89	64.8
July	2.90	70.4
August	3.24	68.9
September	3.08	62.5
October	3.05	51.6
November	3.32	40.0
December	3.28	29.6
Total	35.87	
Mean Annual		47.4

TABLE 3-2

MAXIMUM AND MINIMUM ANNUAL PRECIPITATION
FOR THE PERIOD JANUARY 1958 - DECEMBER 1987*

BUFFALO AIRPORT WEATHER STATION

Maximum: 53.55 (inches) 1977
Minimum: 28.55 (inches) 1962

* National Oceanic and Atmospheric Administration
National Climatic Data Center

It should be recognized that precipitation and temperature vary considerably from year to year, as shown by the range in annual precipitation presented in Table 3-2. Therefore, no single set of values is representative of year to year conditions in the Buffalo Area. Table 3-3 presents rainfall frequency for a duration of 24 hours and return periods of 1, 10, 25 and 100 years. These values were interpolated from the appropriate maps presented in Technical Paper No. 40, Rainfall Frequency Atlas of the United States.

MALCOLM PIRNIE

TABLE 3-3

BUFFALO COLOR CORPORATION
AREA "D"
CITY OF BUFFALO

RAINFALL FREQUENCY FOR DURATION OF 24 HOURS

(Years)	Precipitation (Inches)
1	2.08
10	3.56
25	4.05
100	4.78

Source: Technical Paper No. 40
Rainfall Frequency Atlas of the United States

4.0 GEOLOGY AND HYDROGEOLOGY

4.1 INVESTIGATIVE METHODOLOGY

The geologic and hydrogeologic field investigations for the Buffalo Color Corporation Remedial Investigation (RI) at the Area "D" site were conducted from May through November, 1988. The field investigations involved the following tasks:

- a geophysical survey (EM Terrain Conductivity);
- drilling and sampling of seven (7) deep test borings;
- installation of four (4) piezometers and 13 monitoring wells within shallow and deep water bearing zones;
- development of all newly-installed ground water monitoring wells and piezometers as well as existing monitoring wells;
- in-situ hydraulic conductivity testing of all wells and newly-installed piezometers;
- measurement of ground water and river water levels; and
- sampling of ground water, surface water, river sediment, and surficial soil.

The various tasks are briefly described in the following sections.

4.1.1 Geophysical Survey

An electromagnetic (EM) terrain conductivity survey was performed at the site using a Geonics EM 34-3 terrain conductivity meter with a 10-meter antenna spacing configuration as described in the Work Plan. Approximately 400 readings were recorded at 10-meter intervals on 50-foot spaced grid lines. The conductivity results are presented in Appendix C.1 and summarized in Section 4.3.1.1.

The Area "D" site is underlain by metallic objects and traversed by power transmission lines, both of which cause electrical interference thereby distorting background conductivity values. In order to establish representative regional background, conductivity readings were taken in South Park in South Buffalo, located approximately two miles south of the site. Background readings ranged from 22-26 mmhos/meter. Readings recorded at the Area "D" site ranged from 22 to 300 mmhos/meter.

4.1.2 Test Borings

Borehole drilling, backfilling, and subsurface soil logging procedures were conducted in conformance with the Work Plan. Of the seven (7) deep test borings which were to have been advanced to bedrock as identified in the Work Plan, only two (2) were actually advanced to the overburden/bedrock interface. The remaining five (5) boreholes were terminated in the upper two feet of the clay-rich confining layer. This field-based decision was determined to be necessary in order to prevent the possibility of contaminating units below the shallow water bearing zone. The criteria used to determine whether a borehole should be terminated at a shallower depth (i.e., in the confining layer) was based on the presence of odor, sheen, or visible evidence of contamination. Boreholes with apparent organic contamination are indicated on the borehole logs in Appendix C.2. Boreholes advanced to rock were: B-3-88 and B-5-88. Boreholes terminated in the confining layer included: B-1-88, B-2-88, B-4-88, B-6-88, and B-7-88. Borehole locations are shown in Figure 4-1.

4.1.3 Monitoring Well and Piezometer Installation

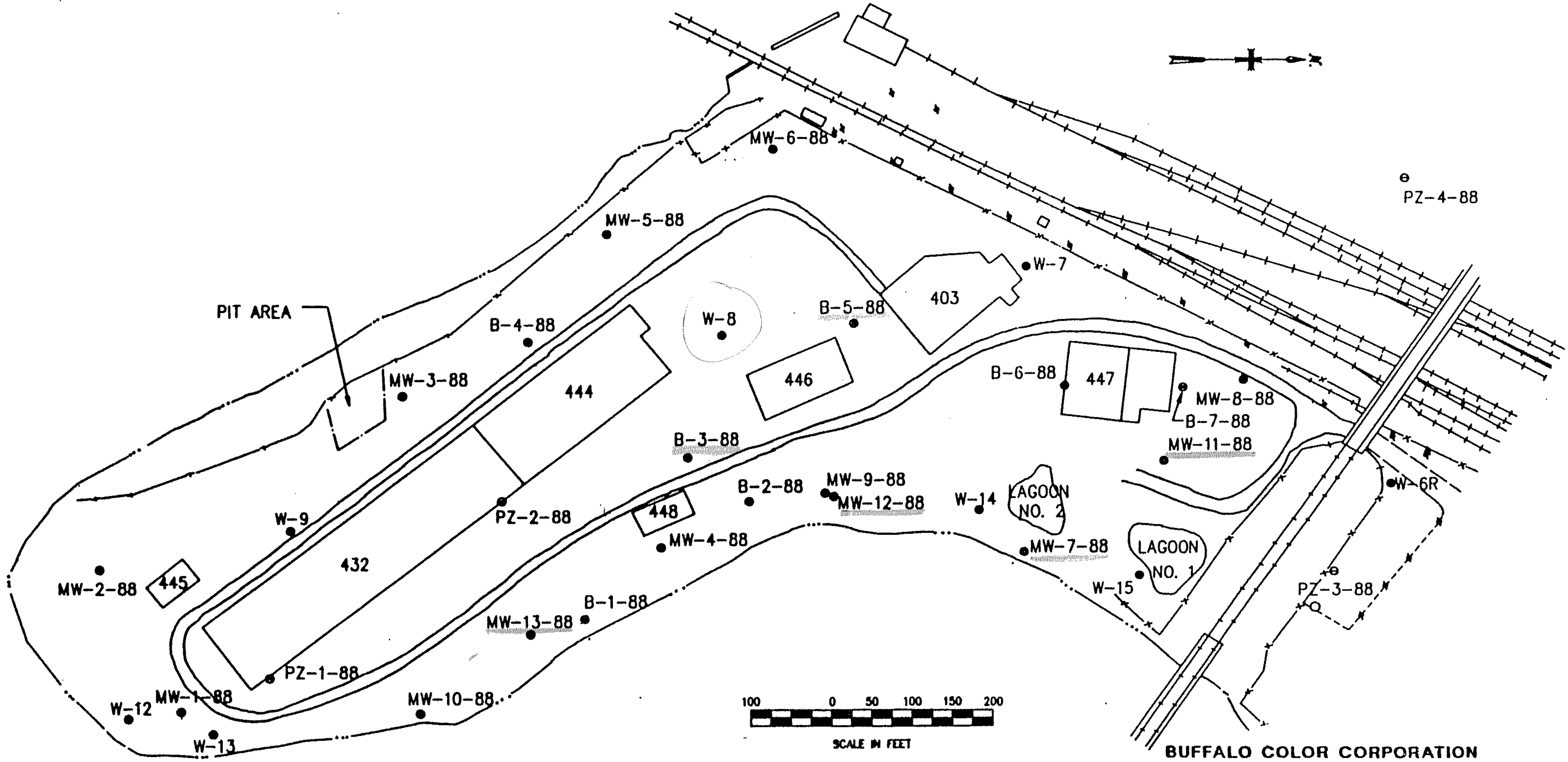
The locations of monitoring well installation MW-1-88 through MW-13-88 and piezometer installation PZ-1-88 through PZ-4-88, as well as existing monitoring wells, W-6 through W-9 and W-12 through W-15, are shown in Figure 4-1. Existing Well 6 had been damaged during previous construction activities at the site and was replaced with Well 6R. With the exception of MW-7-88, monitoring wells MW-1-88 through MW-10-88 and piezometers PZ-1-88 through PZ-4-88 were installed in accordance with the Work Plan.

A distinct odor and heavy sheen was observed in the shallow subsurface during the drilling of monitoring well MW-7-88. In order to reduce the risk of downhole contamination, a permanent 35-foot long, 8-5/8" diameter black steel casing was grouted into place approximately six (6) feet into the confining layer (see Appendix C.3). After allowing

FIGURE 4-1

LEGEND

- ● MW-5-88 — MONITORING WELL NO. 5 INSTALLED IN 1988
- ● B-4-88 — TEST BORING NO.4 COMPLETED IN 1988
- ● W-9 — MONITORING WELL NO. 9 INSTALLED IN 1982
- ϴ PZ-2-88 — PIEZOMETER NO. 2 INSTALLED IN 1988
- [444] — LOCATION OF DEMOLISHED BUILDING 444



— boring to bdrk

— screened @ top of clay layer

— casing used

MALCOLM PIRNIE

BUFFALO COLOR CORPORATION
BUFFALO, NEW YORK
AREA "D REMEDIAL INVESTIGATION

BOREHOLE/MONITORING WELL/ PIEZOMETER LOCATION MAP

the grout to set for 24 hours, the boring was advanced through the casing and the confining layer to the overburden/bedrock interface. Monitoring well installation proceeded in accordance with the Work Plan.

To supplement existing analytical, geologic, and hydrogeologic data on the shallow water bearing zone, the screened intervals of monitoring wells MW-11-88 through MW-13-88 were installed in the glaciofluvial sand and gravel which underlies the fill. Well installation procedures for these wells were in compliance with the Work Plan.

A summary of monitoring well and piezometer elevations and screened intervals is presented in Table 4-1. Borehole logs and well construction details for all newly-installed monitoring wells, piezometers, and existing monitoring wells are presented in Appendix C.2 and Appendix C.4, respectively.

4.1.4 Monitoring Well/Piezometer Development

Development of monitoring wells and piezometers was continued until discharge water turbidity values were less than 50 NTU or until at least 10 to 20 well volumes were removed and no visual improvement in turbidity values was observed. Methods included bailing, gentle surging with a bailer and bailing, and slow pumping with a peristaltic or inertia pump. Details of development procedures and a summary of monitoring well/-piezometer development data are presented in Appendix C.5 and Table 4-2, respectively.

4.1.5 Ground Water and River Level Monitoring

Water levels in all monitoring wells, piezometers and at two locations along the Buffalo River (installed river staff gauges) were measured as described in the Work Plan for both sampling rounds (June 16, 1988 and August 18, 1988) and on five additional occasions. The water levels for these specific dates are presented in Table 4-3. These data were used to: 1) establish hydraulic gradients; 2) establish ground water flow directions; and 3) provide a means of comparing ground water elevation changes to river level fluctuations.

MALCOLM PIRNIE

TABLE 4-1

BUFFALO COLOR CORPORATION

MONITORING WELL/PIEZOMETER ELEVATIONS AND SCREENED INTERVALS

WELL NO.	GROUND ELEVATION	TOP OF RISER ELEVATION	SCREENED INTERVALS BELOW GROUND SURFACE	SCREENED MATERIALS
MW-1-88	583.95	586.56	62.5 - 67.5	Till
MW-2-88	586.82	589.98	11.0 - 16.0	Fill
MW-3-88	584.53	586.76	11.0 - 16.0	Alluvium
MW-4-88	586.09	588.35	13.0 - 18.0	Alluvium
MW-5-88	587.25	589.33	11.25 - 16.25	Alluvium
MW-6-88	587.33	589.38	11.0 - 16.0	Fill
MW-7-88	588.89	592.15	59.5 - 64.5	Till
MW-8-88	586.32	588.77	11.8 - 16.8	Alluvium
MW-9-88	585.46	587.41	11.75 - 16.75	Alluvium
MW-10-88	585.49	587.63	11.5 - 16.5	Alluvium
MW-11-88	586.98	589.23	26.0 - 31.0	Alluvium
MW-12-88	585.48	587.38	18.5 - 23.5	Alluvium
MW-13-88	585.44	587.24	18.5 - 23.5	Alluvium
PZ-1-88	583.91	586.01	13.0 - 18.0	Alluvium
PZ-2-88	584.51	586.41	12.0 - 17.0	Alluvium
PZ-3-88	585.68	588.07	13.0 - 18.0	Alluvium
PZ-4-88	586.51	588.79	15.0 - 20.0	Alluvium
Well-6R	587.00	588.94	13.0 - 18.0	Alluvium
*Well-7	586.13	588.41	15.0 - 20.0	Alluvium
*Well-8	585.64	587.91	15.0 - 20.0	Alluvium
*Well-9	584.80	586.60	15.0 - 20.0	Alluvium
*Well-12	584.29	586.40	13.0 - 18.0	Alluvium
*Well-13	584.23	586.13	13.0 - 18.0	Alluvium
*Well-14	587.41	588.67	15.0 - 20.0	Fill
*Well-15	591.21	593.69	18.5 - 23.5	Fill

NOTE: * Well installed 1982, 1983

TABLE 4-2

BUFFALO COLOR CORPORATION

FIELD DEVELOPMENT DATA
FROM 6/9/88 to 6/23/88 AND 11/15/88 to 11/16/88

WELL NO.	STATIC WATER LEVEL (fmsl)	pH	TEMP. (C)	SPECIFIC CONDUCTIVITY (umhos)	TURBIDITY (NTU)	FIELD OBSERVATIONS	VOLUME REMOVED (gals.)	DEVELOPING METHOD	DATE OF DEVELOPMENT
MW-1-88	573.81	12.10	14	8,000	100	brown fine sediment, no odor or layers	35	Bailing	6-14-88
MW-2-88	573.88	6.79	14	3,000	0-3*	black, H2S odor, oily film, no layers	80	Bailing	6-10-88
MW-3-88	572.91	6.60	13	1,620	63	some silty sediment, no layers, slight odor	75	Bailing	6-13-88
MW-4-88	572.95	6.60	14	4,600	90	moderate turbid, strong mothball odor, HNU reading 3 ppm, little organic product	35	Bailing	6-22-88
MW-5-88	572.98	6.50	12	2,350	23	slightly turbid, no odors or layers	10	Bailing	6-9-88
MW-6-88	572.98	7.30	17	1,550	45	slightly turbid, brown sediment, no layers or odors	55	Bailing	6-10-88
MW-7-88	572.90	10.62	16	630	0.5*	very turbid, grey silt and clay fines	65	Bailing	6-15-88
MW-8-88	573.27	6.67	13	1,600	4	clear, slight odor, no layers	8	Bailing	6-15-88

TABLE 4-2 (Continued)

BUFFALO COLOR CORPORATION

FIELD DEVELOPMENT DATA
FROM 6/9/88 to 6/23/88 AND 11/15/88 to 11/16/88

WELL NO.	STATIC WATER LEVEL (fmsl)	pH	TEMP. (C)	SPECIFIC CONDUCTIVITY (umhos)	TURBIDITY (NTU)	FIELD OBSERVATIONS	VOLUME REMOVED (gals.)	DEVELOPING METHOD	DATE OF DEVELOPMENT
MW-9-88	573.31	6.70	14	5,200	27	slight yellow tint no odor	10	Bailing	6-14-88
MW-10-88	573.18	4.78	16	4,740	12	slight yellow tint no odor	6	Bailing	6-13-88
MW-11-88	572.30	6.46	10	3,500	>100	slightly cloudy, no odor or layers 7 ppm HNU	45	Inertia Pump	11-15-88
MW-12-88	572.40	6.54	11	6,980	>100	turbid, strong organic odor	115	Inertia Pump	11-16-88
MW-13-88	572.04	6.57	11	18,430	>100	very strong odor, dk grn-blk silt and clay, HNU reading 50 ppm	45	Bailing	11-15-88
Well 6R	577.89	8.7	15	2,860	0.9*	black color, slight odor, no layers	55	Bailing	6-23-88
Well 7	573.26	6.80	12	1,610	86	rust brown color, no odor or layers	55	Bailing	6-17-88

TABLE 4-2 (Continued)

BUFFALO COLOR CORPORATION

FIELD DEVELOPMENT DATA
FROM 6/9/88 to 6/23/88 AND 11/15/88 to 11/16/88

WELL NO.	STATIC WATER LEVEL (fmsl)	pH	TEMP. (C)	SPECIFIC CONDUCTIVITY (umhos)	TURBIDITY (NTU)	FIELD OBSERVATIONS	VOLUME REMOVED (gals.)	DEVELOPING METHOD	DATE OF DEVELOPMENT
Well 8	567.62	7.10	15	720	12	very strong kerosene odor, approx.6' NAPL, HNU reading 13 ppm	55	Bailing	6-21-88
Well 9	572.90	6.95	14	2,350	6*	black color, slight sulfide odor	55	Bailing	6-16-88
Well 12	572.50	6.15	11	1,750	90	blue color, no odors or layers, little sediment	55	Peristaltic Pump & Bailing	6-16-88
Well 13	572.53	4.90	15	2,210	35	fine to gray sediment no odor or layers	55	Bailing	6-16-88
Well 14	573.12	6.84	17	1,750	5*	black w/ oily layer on top, sulfide odor, HNU reading 1 ppm	55	Bailing	6-16-88
Well 15	571.74	9.01	15	1,840	54	clear ground water, free floating product, HNU reading 6 ppm	6	Bailing	6-23-88
PZ-1-88	572.91	6.85	14	1,820	35	slightly turbid, no odor or layers	15	Bailing	6-22-88
PZ-2-88	572.91	5.50	11	2,000	7.5	slightly turbid, brown, no layers, detergent bubbles	30	Bailing	6-15-88

TABLE 4-2 (Continued)

BUFFALO COLOR CORPORATION

FIELD DEVELOPMENT DATA
FROM 6/9/88 to 6/23/88 AND 11/15/88 to 11/16/88

WELL NO.	STATIC WATER LEVEL (fmsl)	pH	TEMP. (C)	SPECIFIC CONDUCTIVITY (umhos)	TURBIDITY (NTU)	FIELD OBSERVATIONS	VOLUME REMOVED (gals.)	DEVELOPING METHOD	DATE OF DEVELOPMENT
PZ-3-88	573.34	6.52	14	1,890	>100	turbid, black sediment, slight odor, no layers	45	Bailing	6-22-88
PZ-4-88	574.1	7.15	13	1,750	33	slightly turbid, no odor or layers	35	Bailing	6-23-88

* - NTU reading suspect due to absorption of light from black or grey color of sample.

MALCOLM PIRNIE

TABLE 4-3

BUFFALO COLOR CORPORATION

GROUND WATER AND SURFACE WATER ELEVATIONS

WELL NO.	06/22/88	07/01/88	07/05/88	07/07/88	07/19/88	07/22/88	08/16/88
MW-1-88	571.81	572.11	572.46	572.51	572.66	572.66	572.91
MW-2-88	573.73	573.63	573.58	573.53	573.46	573.43	573.25
MW-3-88	573.01	572.81	572.61	572.71	572.69	572.56	572.46
MW-4-88	572.95	573.05	572.90	572.95	572.90	572.80	572.85
MW-5-88	572.78	572.73	572.63	572.58	572.58	572.48	572.83
MW-6-88	572.88	572.78	572.63	572.63	572.68	572.53	572.68
MW-7-88	572.90	572.30	572.75	572.80	572.85	572.80	572.85
MW-8-88	572.97	573.07	572.87	572.97	572.97	572.82	573.02
MW-9-88	573.31	573.43	573.11	573.21	573.06	573.01	573.01
MW-10-88	573.13	572.93	572.83	572.83	572.83	572.56	572.83
Well 6R	577.89	577.79	577.59	577.54	577.07	577.04	576.39
Well 7	572.86	572.96	572.76	573.39	572.83	572.76	572.91
Well 8	573.37*	573.11*	573.81*	573.91*	573.81*	573.71*	573.51*
Well 9	572.90	572.75	572.50	572.65	572.65	572.60	572.50
Well 12	572.90	572.60	572.35	572.60	572.50	572.60	572.70
Well 13	572.83	572.58	572.38	572.53	572.51	572.63	572.68
Well 14	572.97	572.82	572.67	572.67	572.57	572.47	572.37
Well 15	571.74	572.74	572.59	572.54	572.49	572.44	572.39
PZ-1-88	572.91	572.71	572.56	572.66	572.64	572.71	572.76
PZ-2-88	573.24	573.04	572.84	572.94	572.89	572.89	572.84
PZ-3-88	573.34	573.22	573.12	573.00	573.17	573.04	573.17
PZ-4-88	574.10	574.04	573.94	573.89	573.74	573.69	573.74
UPSTREAM GAUGE	NA	572.64	572.51	572.64	572.41	572.39	572.66
DOWNSTREAM GAUGE	NA	572.53	572.40	572.36	572.56	572.23	572.78

* Elevation of light NAPL

Gradients ft/ft

MW4 = (.0035 ft/ft)(3.9 ft/d)

	MW4 55 ft River	MW9 40 ft River	MW 10 15'	MW 12	MW 13
✓ 6/22	.004	.016	.032		
7/1	.006	.020	.019		
7/5	.006	.015	.021		
7/7	.005	.014	.013		
7/19	.007	.016	.028		
7/22	.006	.015	.011		
✓ 8/16	.003	.008	.011		
AVG	.005	.015	.019		
	✓ .0035	✓ .012	✓ .021		

4.1.6 In-Situ Hydraulic Conductivity Testing

In-situ hydraulic conductivity testing was conducted on newly-installed wells, piezometers, and existing monitoring wells. Rising head tests were conducted on all wells and piezometers with the exception of W-8, which contained a large volume of light NAPL (free-product). For unconfined conditions where the screens straddled the water table, rising-head data were analyzed by the method described in Bouwer and Rice (1976). Where the screened interval was fully saturated, rising-head data were analyzed by the method described by Hvorslev (1951). Details of the test procedures are presented in Appendix C.6. Test results are discussed in Section 4.4.1, Hydrostratigraphy. Testing of wells that exhibit rapid recoveries was conducted using a pressure transducer and data logger to obtain more accurate results.

4.2 REGIONAL GEOLOGY AND HYDROGEOLOGY

4.2.1 Regional Geology

The surficial geology of the Buffalo area has been described by Muller (1977). The surficial materials can be classified into three units based upon depositional environments. These include Recent Alluvium, Lacustrine Sediments, and Glacial Deposits. The bedrock geology of the area has been described by Buehler and Tesmer (1963) and includes a thick succession of stratified Paleozoic sedimentary rocks which form the northern flank of the Alleghany Basin.

Recent Alluvium

The Recent Alluvium includes sand, silt, and gravel deposited along modern river and stream courses. These deposits are thin and of limited lateral extent. These sediments normally lie unconformably above the underlying Lacustrine Sediments or Glacial Deposits.

Lacustrine Sediments

The Lacustrine Sediments are comprised of silt, clay, and sand deposits formed in predecessors of the existing lakes. The ancestral lakes include, from youngest to oldest, Lake Tonawanda, Lake Iroquois, Lake Warren, and Lake Whittlesey. At Buffalo, the surficial sediments were formed in glacial Lake Warren and Lake Whittlesey. These deposits are relatively thin and consist of laminated silt, fine-to-medium sand, and clay. Remnant beach strands are commonly associated with the borders of this unit.

Glacial Deposits

Sediments of glacial origin overlie bedrock in much of the Buffalo area. An extensive ground moraine comprised of a thin silty clay to sandy till occupies much of the area. The ground moraine is marked by end moraines composed of materials of similar texture as well as sand and gravel deposits formed in ice-marginal positions or as outwash. The Buffalo and Crystal Beach end moraines border the Buffalo area to the north and south, respectively. In general, the Glacial Deposits are thin and lie unconformably atop Paleozoic bedrock.

Bedrock

The bedrock stratigraphic succession beneath Buffalo consists of rock ranging in age from Middle Devonian to Upper Silurian. The Paleozoic strata dip toward the southeast at a slope of approximately 40 feet per mile. Bedrock exposure is controlled by glacial and lacustrine erosion.

4.2.2 Regional Hydrogeology

As will be discussed in Section 4.4, ground water is not extensively utilized in the Buffalo area due to the low water-bearing characteristics in the overburden and the generally poor water quality in the bedrock.

Recharge to the overburden is principally through infiltration of precipitation, however, much of the overburden contains a high fine grain content and is, therefore, relatively impermeable. The regional direction of ground water flow is to the west and northwest toward Lake Erie, with local variations in ground water flow directions due to the influences of topography, land use, and drainage. On a regional scale, the Glaciolacustrine Deposits and the Glacial Till are considered an aquitard, thus retarding the downward migration of ground water.

4.3 SITE GEOLOGY

The current and historic investigations at the "D" Area Site have provided an extensive data base of geologic information. In general, the site is underlain by five stratigraphic units. These are: Waste/Fill, Alluvium, Glaciolacustrine Deposits, Glacial Till, and Bedrock. The Regional and Site Stratigraphy are correlated in Table 4-4. The detailed descriptions of the stratigraphic units are derived from the well logs and are presented in the following sections.

Table 4-5 summarizes the stratigraphic data base obtained from the various well and borehole installations at the site. The table presents survey data, depth and elevation of each stratigraphic unit encountered, and a summary of the stratigraphic unit thicknesses.

Cross sections of the site stratigraphy are located in Figure 4-2 and the profiles presented in Figures 4-3 through 4-7.

4.3.1 Fill Layer

The uppermost stratigraphic unit consists of fill material deposited in conjunction with the landfilling activities described in Section 2.0. The fill typically consists of mixtures of gravel, sand, silt, and clay, as well as demolition debris, cinders, ferrous wastes, chemical wastes, and other foreign materials which were placed directly on top of existing undisturbed soils (see Section 4.3.1.1). Moisture conditions within the fill vary from dry to saturated.

The thickness of the fill varies across the site from 2.0 (MW-1-88) to 24.0 (Well-15) feet and averages 9.0 feet (as shown on Figure 4-8, Isopach of Fill). The thickest fill is located beneath the two lagoons in the northeast corner of the site. Two other areas of thick fill include the northwest corner, which is associated with the installation of underground utilities, and the southwest corner, which is a topographic high.

4.3.1.1 Geophysical Survey Results

An electromagnetic (EM) terrain conductivity survey was performed in order to locate anomalous areas of high conductance within the fill

TABLE 4-4

REMEDIAL INVESTIGATION AT THE
BUFFALO COLOR CORPORATION AREA "D"

REGIONAL AND SITE STRATIGRAPHY SUMMARY TABLE

UNIT AGES	REGIONAL UNITS	SITE UNITS
Recent		Waste/Fill
	Recent Alluvium	Alluvium
Wisconsinan	Lacustrine Sediments	Glaciolacustrine Deposits
	Glacial Deposits	Glacial Till
Middle Devonian	Hamilton Group	
	Onondaga Limestone	Onondaga Limestone
Upper Silurian	Akron Dolostone	
	Bertie Formation	
	Cammillus Shale	

MALCOLM PIRNIE

TABLE 4-5
REMEDIAL INVESTIGATION AT THE
BUFFALO COLOR CORPORATION AREA "D"

STRATIGRAPHIC SUMMARY TABLE

VELL #	ELEV.	DEPTH TO ALLUVIUM (ft)	ELEV. OF ALLUVIUM	DEPTH TO CLAY (ft)	ELEV.OF CLAY	DEPTH TO TILL (ft)	ELEV.OF TILL	DEPTH TO BEDROCK (ft)	ELEV.OF BEDROCK	DEPTH TO BOTTOM (ft)	ELEV.OF BOTTOM	THICKNESS OF FILL (ft)	ALLUVIUM (ft)	CLAY (ft)	TILL (ft)
IW-1-88	583.95	2.00	581.95	23.50	560.45	52.33	531.62	68.50	515.45	68.54	515.41	2.00	21.50	28.83	16.17
IW-2-88	586.82	15.83	570.99	-	-	-	-	-	-	16.00	570.82	15.83	-	-	-
IW-3-88	584-53	8.42	576.11	-	-	-	-	-	-	18.00	566.53	8.42	-	-	-
IW-4-88	586.09	6.00	580.09	-	-	-	-	-	-	20.00	566.09	6.00	-	-	-
IW-5-88	587.25	8.00	579.25	-	-	-	-	-	-	18.00	569.25	8.00	-	-	-
IW-6-88	587.33	)18.00	)569.33	-	-	-	-	-	-	18.00	569.33	)18.00	-	-	-
IW-7-88	588.89	20.42	568.47	28.83	560.06	56.00	532.89	64.50	524.39	64.58	524.31	20.42	8.41	27.17	8.50
IW-8-88	586.32	10.50	575.82	-	-	-	-	-	-	18.00	568.32	10.50	-	-	-
IW-9-88	585.46	10.42	575.04	-	-	-	-	-	-	18.00	567.46	10.42	-	-	-
IW-10-88	585.49	4.42	581.07	-	-	-	-	-	-	18.00	567.49	4.42	-	-	-
IW-11-88	586.98	(18.00	(568.98	32.00	554.98	-	-	-	-	34.00	552.98	(18.00	-	-	-
IW-12-88	585.48	(18.00	(567.48	22.25	563.23	-	-	-	-	24.00	561.48	(18.00	-	-	-
IW-13-88	585.44	(18.00	(567.44	22.58	562.86	-	-	-	-	24.00	561.44	(18.00	-	-	-
'Z-1-88	583.91	6.00	577.91	-	-	-	-	-	-	18.00	565.91	6.00	-	-	-
'Z-2-88	584.51	4.42	580.09	-	-	-	-	-	-	17.00	567.51	4.42	-	-	-
'Z-3-88	585.68	10.00	575.68	-	-	-	-	-	-	18.00	567.68	10.00	-	-	-
'Z-4-88	586.51	2.00	584.51	-	-	-	-	-	-	20.00	566.51	2.00	-	-	-
}-1-88	585.63	6.00	579.63	24.00	561.63	-	-	-	-	26.00	559.63	6.00	18.00	-	-
}-2-88	586.24	7.00	579.24	26.25	559.99	-	-	-	-	28.00	558.24	7.00	19.25	-	-
}-3-88	586.02	8.00	578.02	25.00	561.02	52.50	533.52	65.00	521.02	65.08	520.94	8.00	17.00	27.50	12.50
}-4-88	585.33	6.08	579.25	24.00	561.33	-	-	-	-	26.00	559.33	6.08	17.92	-	-
}-5-88	585.99	6.00	579.99	23.33	562.66	51.33	534.66	62.00	523.99	62.58	523.41	6.00	17.33	28.00	10.67
}-6-88	585.92	6.75	579.17	25.33	560.59	-	-	-	-	26.00	559.92	6.75	18.58	-	-
}-7-88	586.58	6.67	579.91	28.67	557.91	-	-	-	-	30.00	556.58	6.67	22.00	-	-

MALCOLM PIRNIE

TABLE 4-5 (Continued)
REMEDIAL INVESTIGATION AT THE
BUFFALO COLOR CORPORATION AREA "D"

STRATIGRAPHIC SUMMARY TABLE

ELL #	ELEV.	DEPTH TO ALLUVIUM (ft)	ELEV. OF ALLUVIUM	DEPTH TO CLAY (ft)	ELEV.OF CLAY	DEPTH TO TILL (ft)	ELEV.OF TILL	DEPTH TO BEDROCK (ft)	ELEV.OF BEDROCK	DEPTH TO BOTTOM (ft)	ELEV.OF BOTTOM	THICKNESS OF FILL (ft)	THICKNESS OF ALLUVIUM (ft)	THICKNESS OF CLAY (ft)	THICKNESS OF TILL (ft)
lell-6R	587.00	14.00	573.00	-	-	-	-	-	-	18.00	569.00	14.00	-	-	-
lell-7	586.13	7.00	579.13	-	-	-	-	-	-	20.00	566.13	7.00	-	-	-
lell-8	585.64	2.50	582.14	-	-	-	-	-	-	20.00	565.64	2.50	-	-	-
lell-9	584.80	10.00	574.80	-	-	-	-	-	-	20.00	564.80	10.00	-	-	-
lell-12	584.29	7.00	577.29	-	-	-	-	-	-	18.00	566.29	7.00	-	-	-
lell-13	584.23	8.00	576.23	-	-	-	-	-	-	18.00	566.23	8.00	-	-	-
lell-14	587.41	)20.00	)567.41	-	-	-	-	-	-	20.00	567.41	)20.00	-	-	-
lell-15	591.21	)24.00	)567.21	-	-	-	-	-	-	24.00	567.21	)24.00	-	-	-

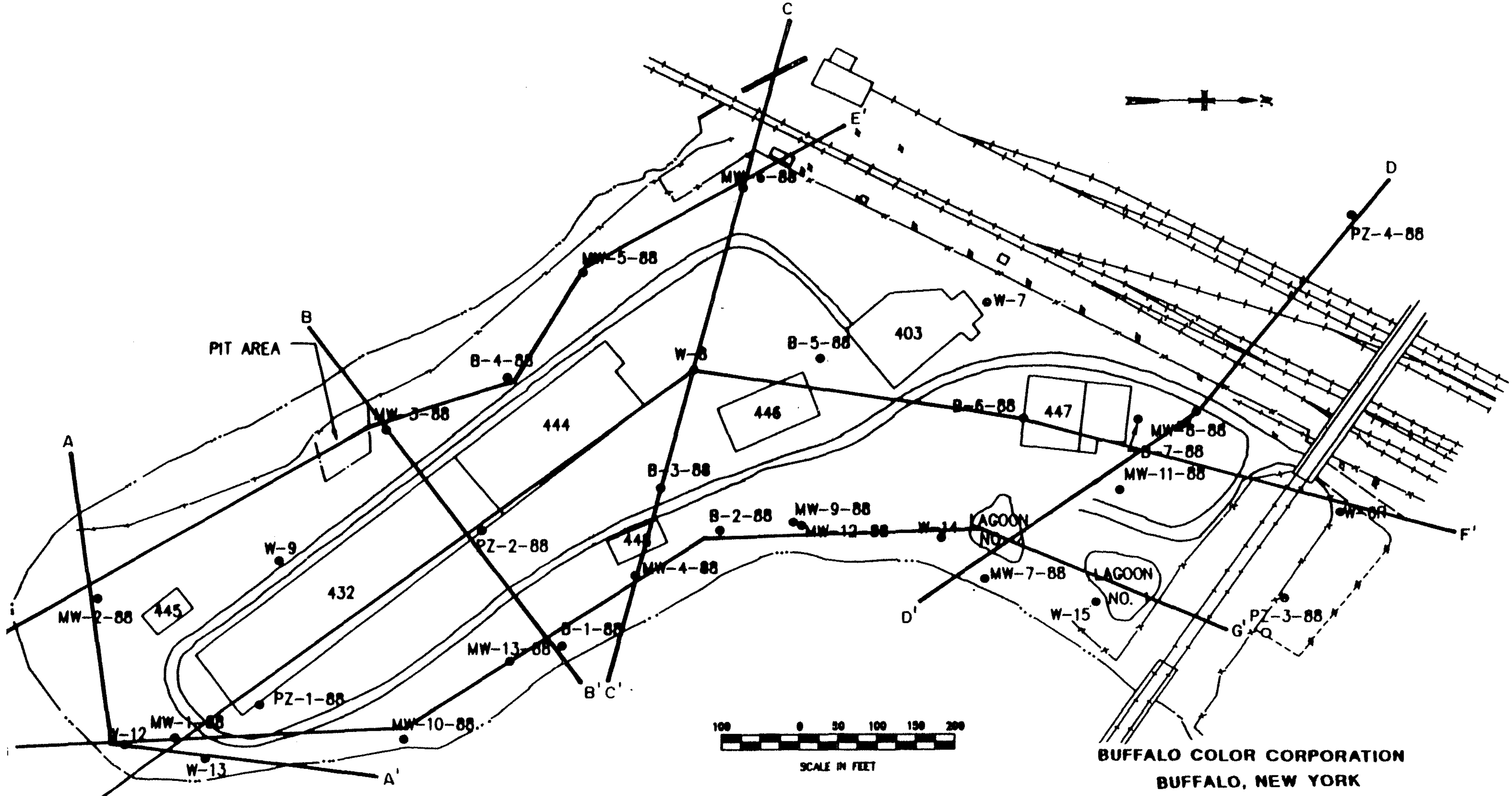
FIGURE 4-2

LEGEND

● — TEST BORING (B), MONITORING WELL (MW, W), OR PIEZOMETER (PZ)

446 — LOCATION OF DEMOLISHED BUILDING 446

A—A' — CROSS SECTION A-A' LOCATION

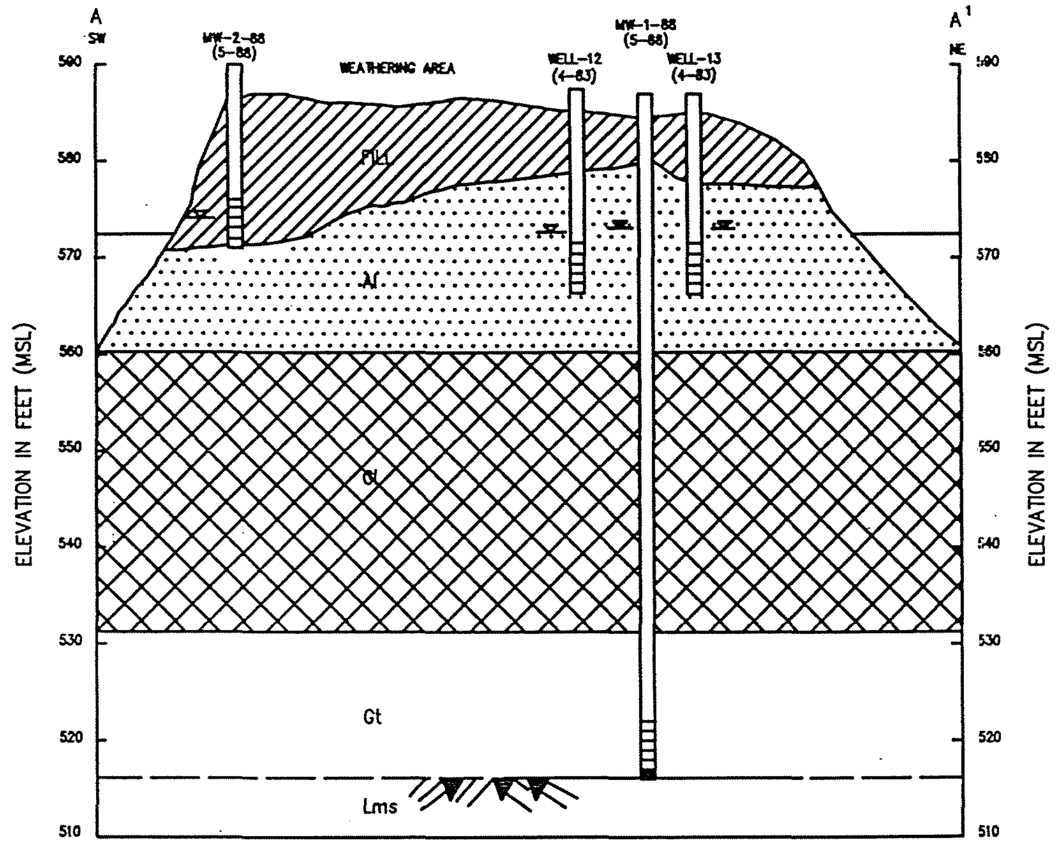


BUFFALO COLOR CORPORATION
BUFFALO, NEW YORK
AREA "D REMEDIAL INVESTIGATION

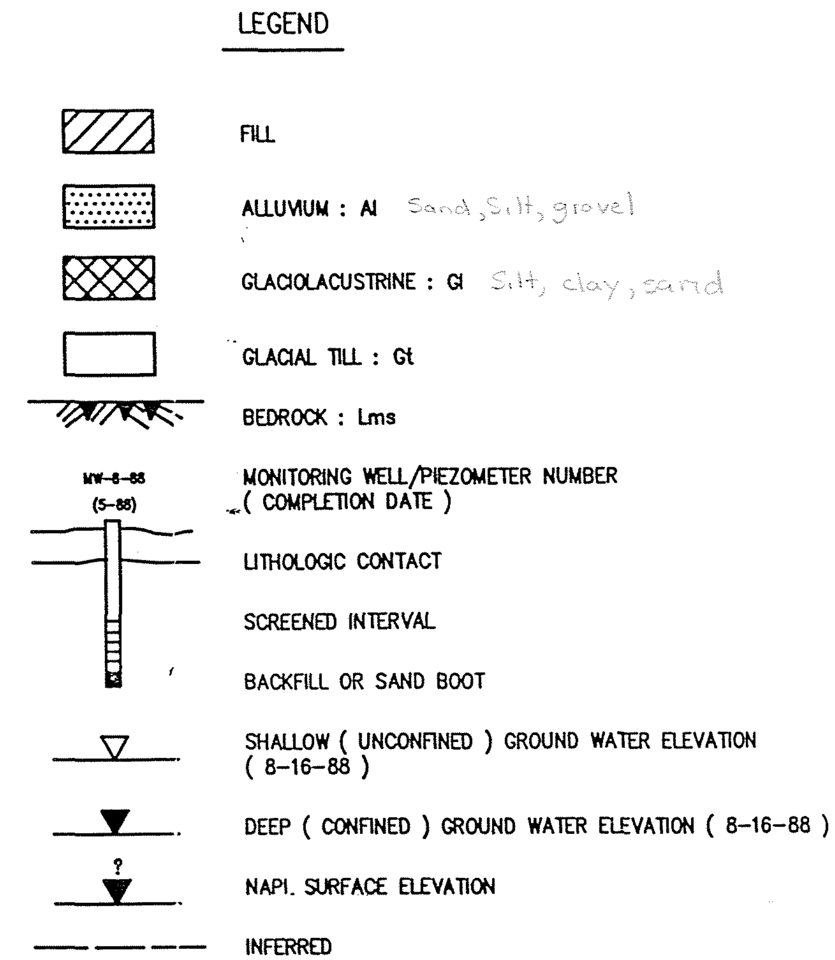
CROSS-SECTION LOCATIONS

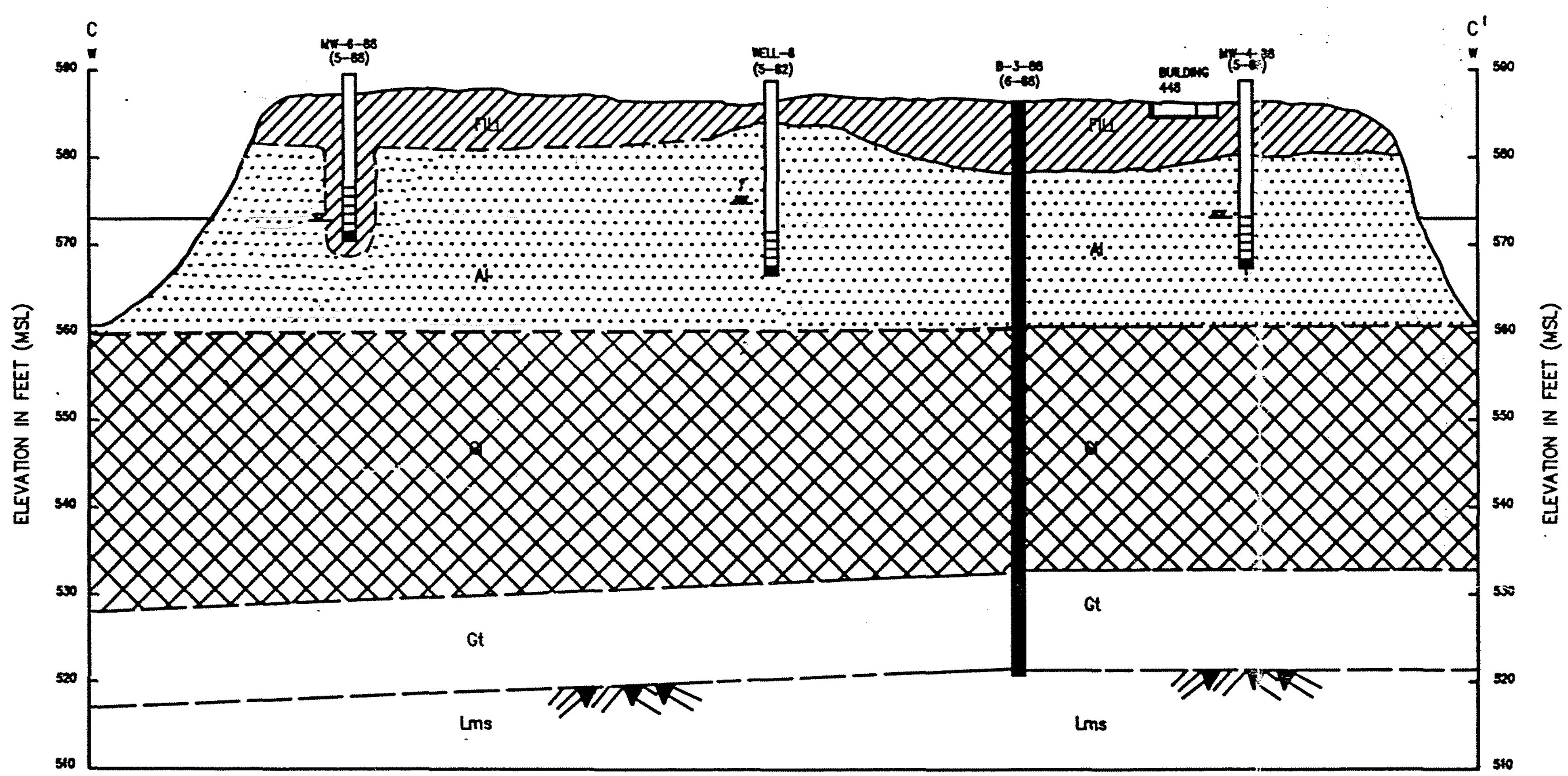
MALCOLM PIRNIE

FIGURE 4–3



SECTION A–A¹





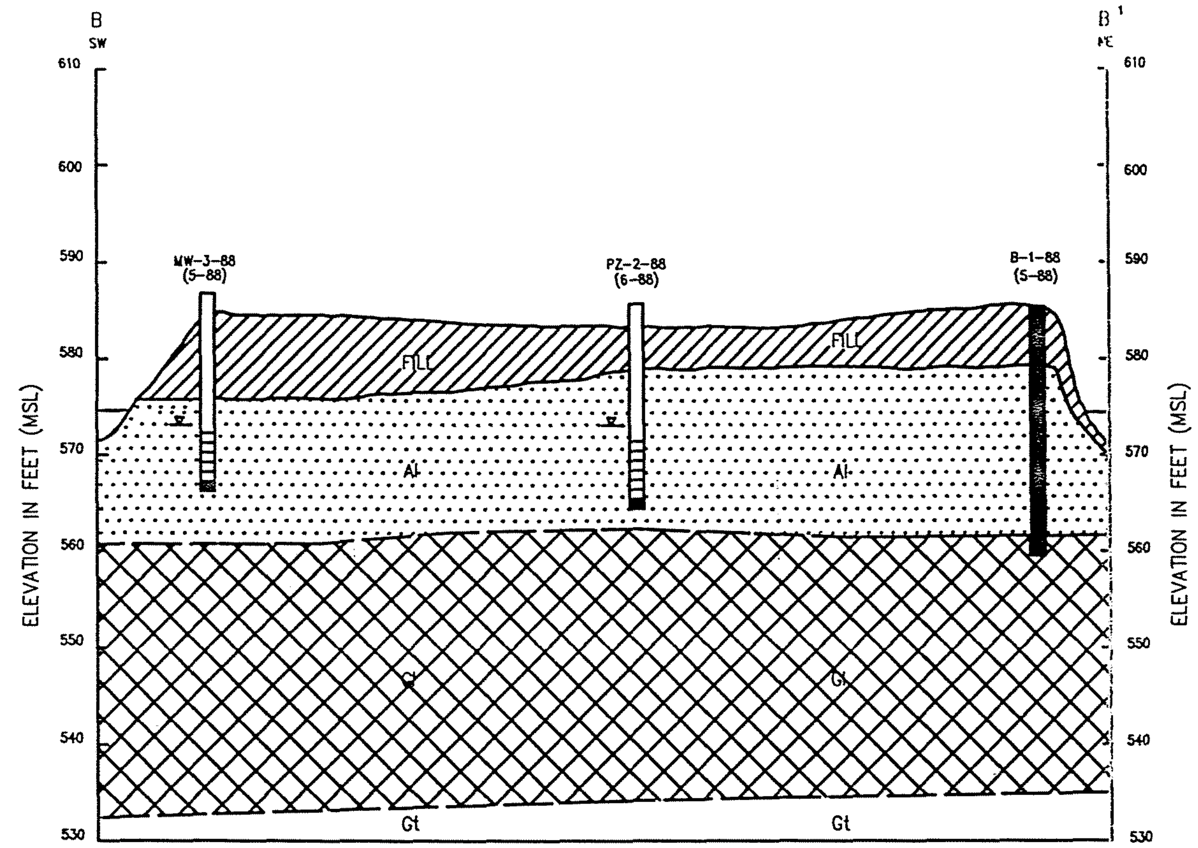
SECTION C–C¹

BUFFALO COLOR CORPORATION
BUFFALO , NEW YORK
AREA "D" REMEDIAL INVESTIGATION

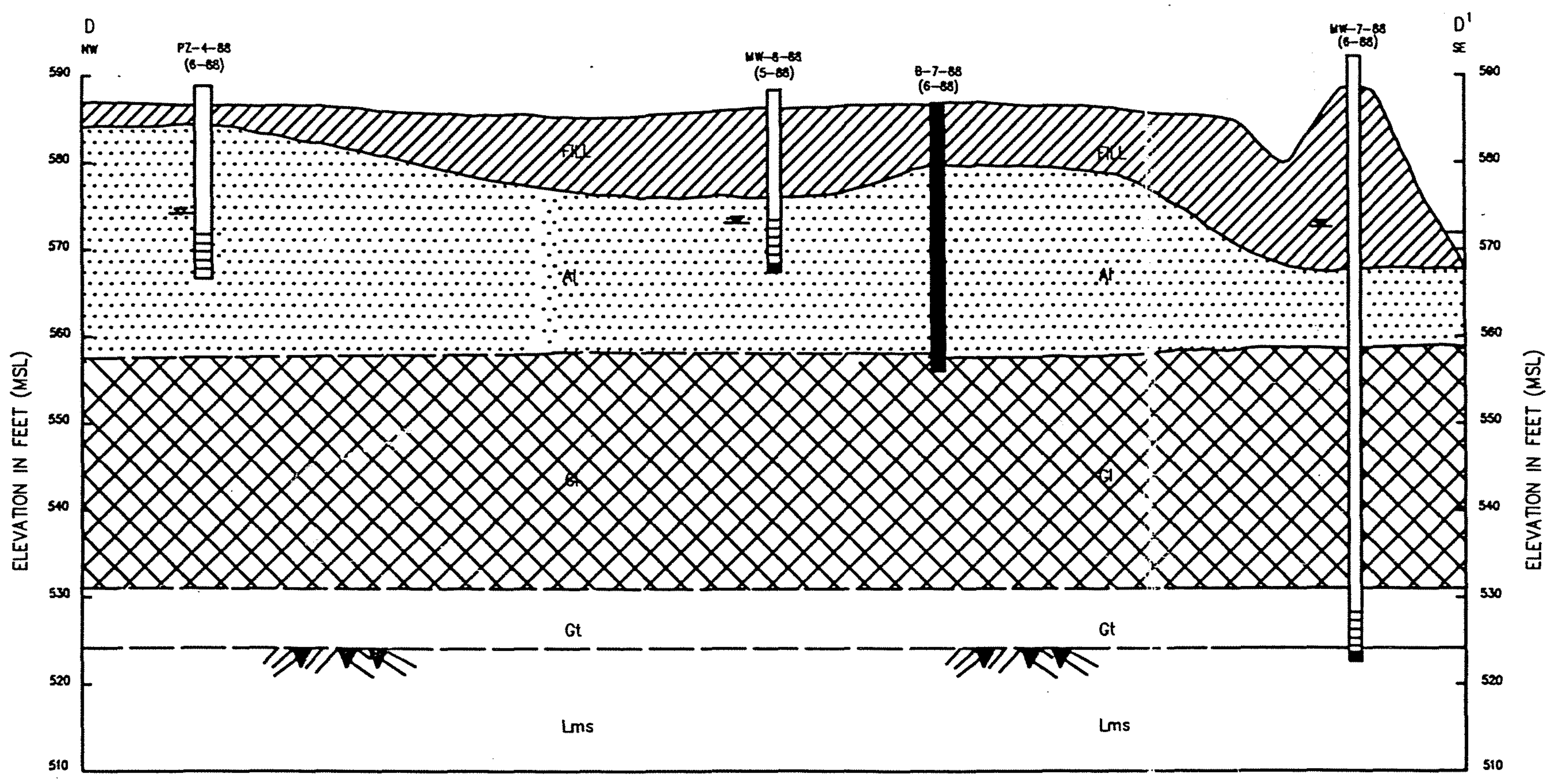
HYDROGEOLOGIC CROSS SECTIO
ALONG LINE A–A¹, C–C¹

SCALE : HORIZ. 1"=200' , VERT. 1"=20'

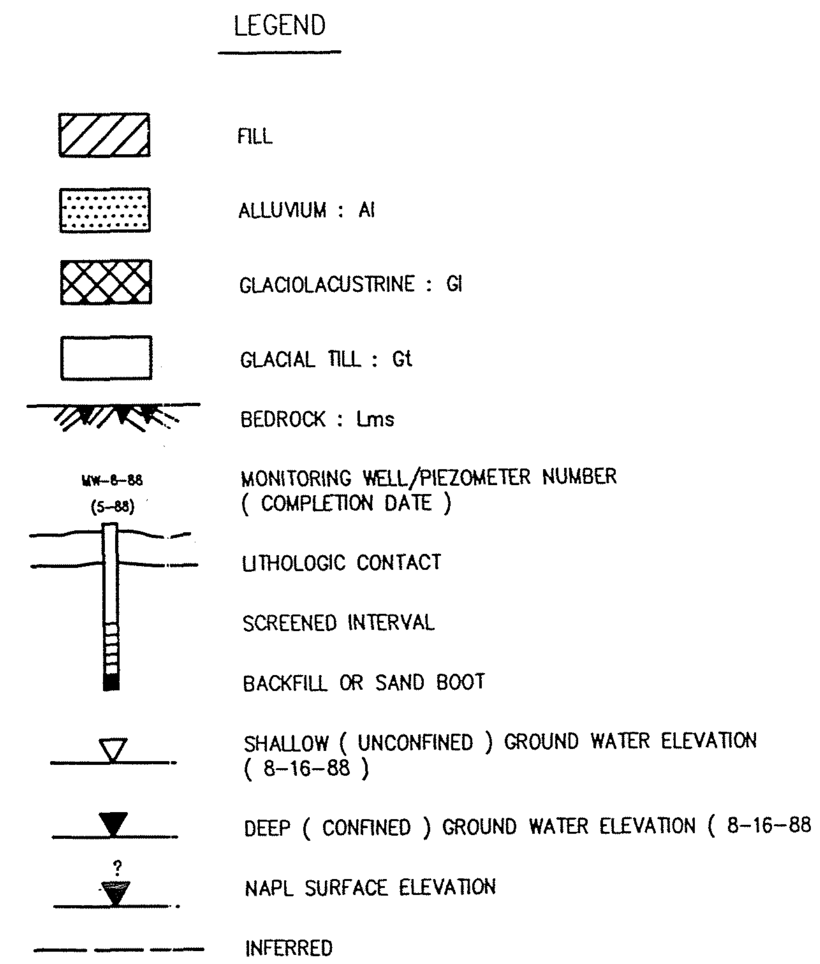
FIGURE 4-4



SECTION B-B'



SECTION D-D'

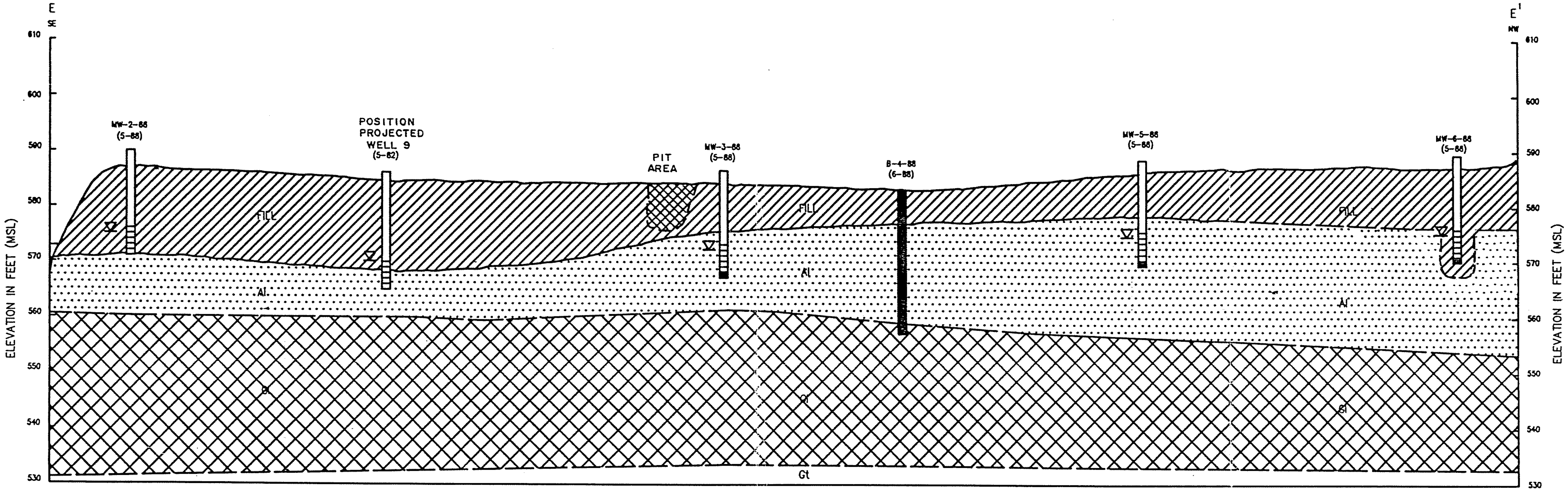


BUFFALO COLOR CORPORATION
BUFFALO , NEW YORK
AREA "D" REMEDIAL INVESTIGATION

HYDROGEOLOGIC CROSS SECTION
ALONG LINE B-B', D-D'

SCALE : HORIZ. 1"=200' , VERT. 1"=20'

FIGURE 4-5



SECTION E-E'

LEGEND

FILL

ALLUVIUM : Al

GLACIOLACUSTRINE : Gl

GLACIAL TILL : Gt

BEDROCK : Lms

MW-6-88 (5-88) MONITORING WELL/PIEZOMETER NUMBER (COMPLETION DATE)

LITHOLOGIC CONTACT

SCREENED INTERVAL

BACKFILL OR SAND BOOT

SHALLOW (UNCONFINED) GROUND WATER ELEVATION (8-16-88)

DEEP (CONFINED) GROUND WATER ELEVATION (8-16-88)

NAPL SURFACE ELEVATION

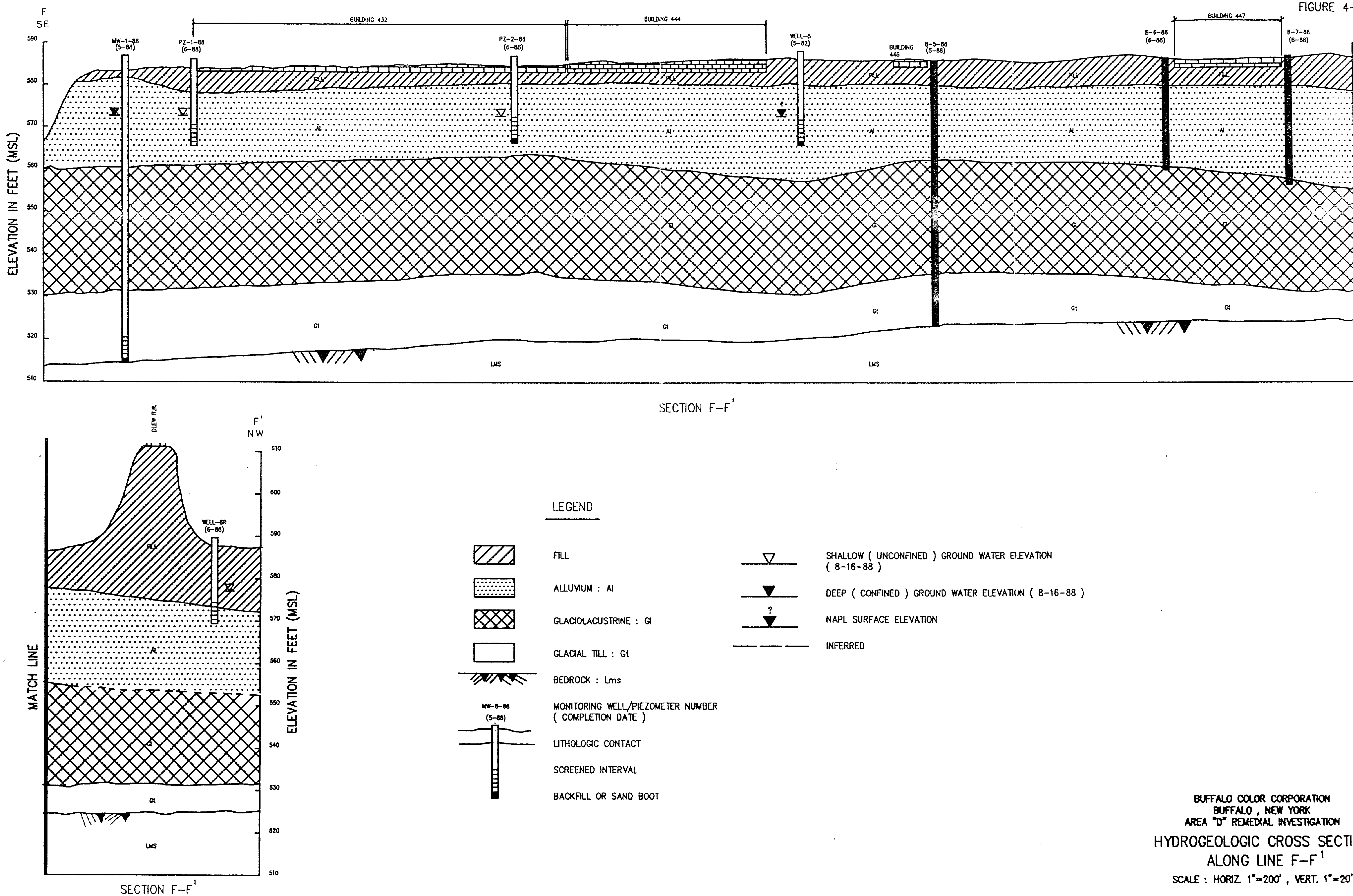
INFERRED

BUFFALO COLOR CORPORATION
BUFFALO , NEW YORK
AREA "D" REMEDIAL INVESTIGATION

HYDROGEOLOGIC CROSS SECTIO
ALONG LINE E-E'

SCALE : HORIZ. 1"=200' , VERT. 1"=20'

FIGURE 4-6

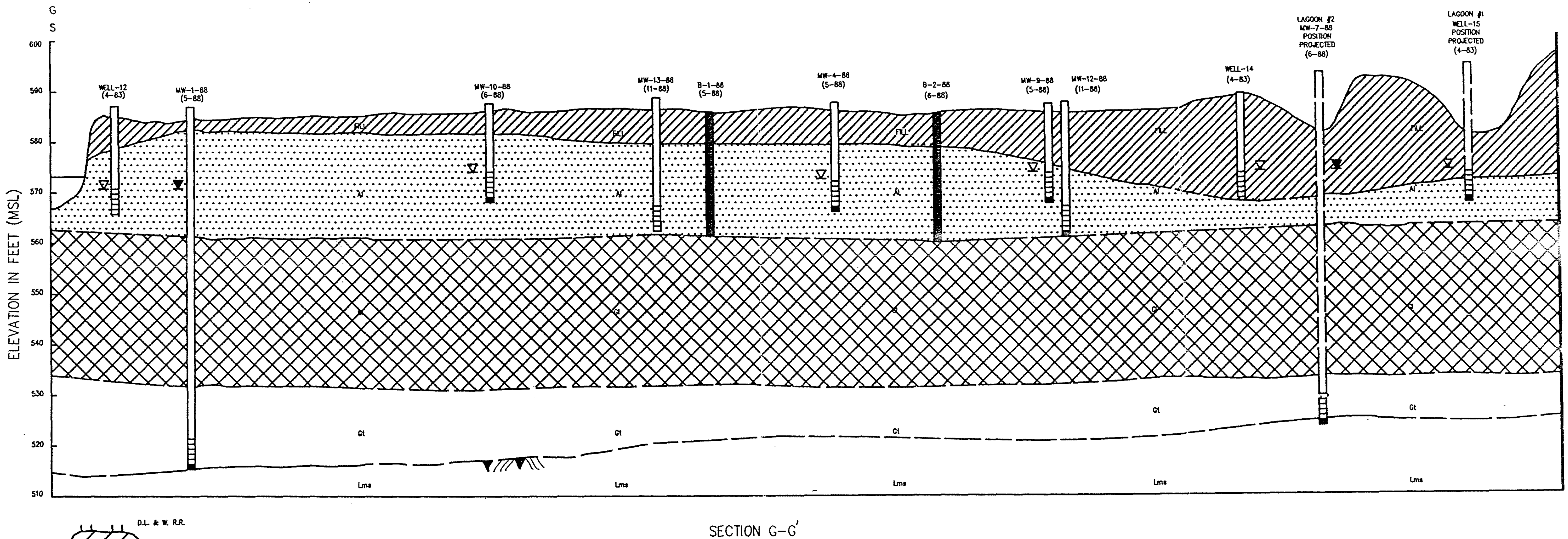


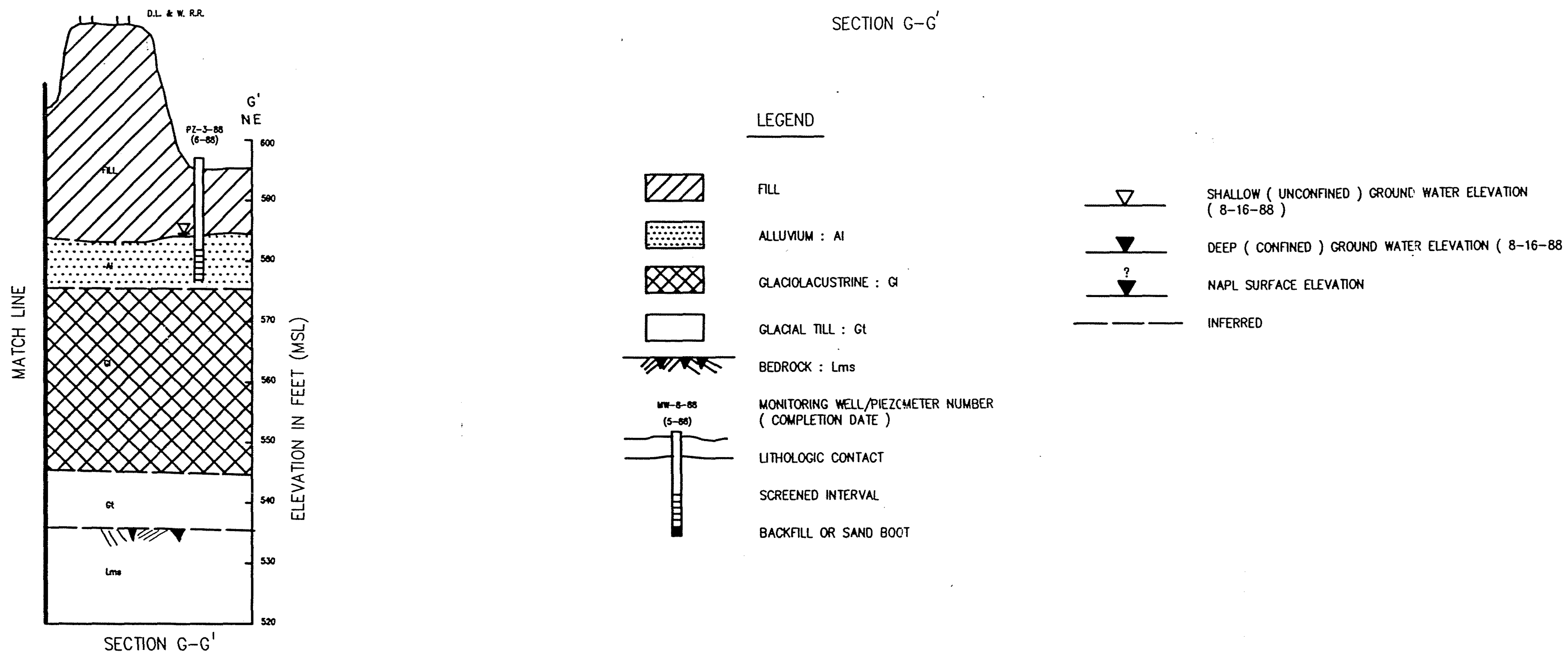
BUFFALO COLOR CORPORATION
BUFFALO , NEW YORK
AREA "D" REMEDIAL INVESTIGATION

HYDROGEOLOGIC CROSS SECTION
ALONG LINE F-F[1]

SCALE : HORIZ. 1"=200' , VERT. 1"=20'

FIGURE 4-7





BUFFALO COLOR CORPORATION
BUFFALO , NEW YORK
AREA "D" REMEDIAL INVESTIGATION

HYDROGEOLOGIC CROSS SECTION
ALONG LINE G-G[1]

SCALE : HORIZ. 1"=200' , VERT. 1"=20'

FIGURE 4-8

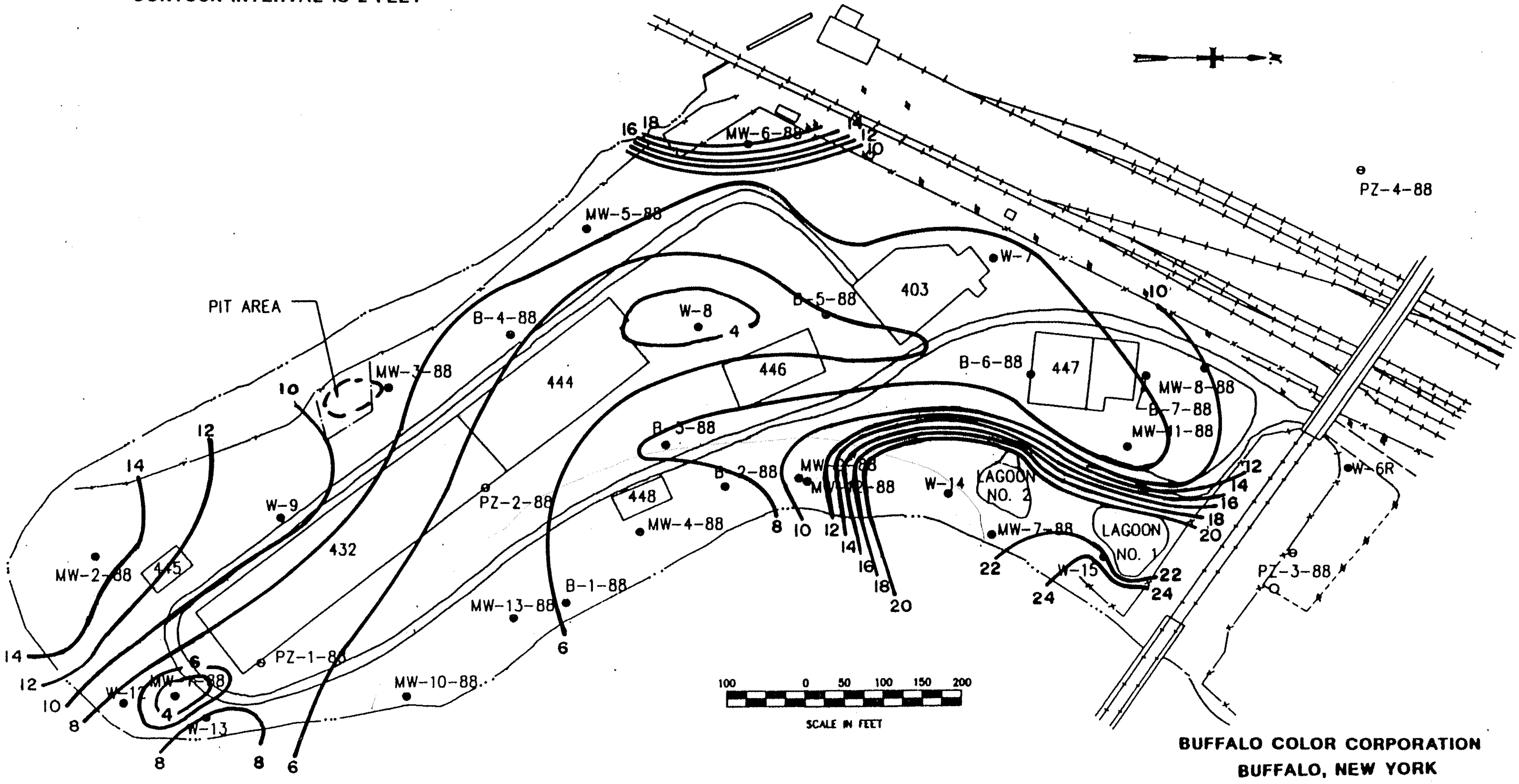
LEGEND

● — TEST BORING (B), MONITORING WELL (MW, W), OR PIEZOMETER (PZ)

446 — LOCATION OF DEMOLISHED BUILDING 446

12 — ISOPACH CONTOUR

CONTOUR INTERVAL IS 2 FEET



BUFFALO COLOR CORPORATION
BUFFALO, NEW YORK
AREA "D REMEDIAL INVESTIGATION

FILL ISOPACH

MALCOLM PIRNIE

material at the site. Typically, high values of electrical conductance imply the existence of conductive materials in the fill.

Figure 4-9 shows the computer-generated conductivity contours derived from the survey. Several highly conductive anomalies are observed at the site. The linear anomaly labelled "A" may be caused by a former underground trolley which was reported to have operated along the traverse. Another linear feature ("B") could be due to railroad spurs. The high magnitude of readings along each of these features indicates buried metallic objects.

Another area of elevated conductivity values is in the vicinity of the lagoons ("C"), where ferrous wastes were deposited. Anomaly "D" may be caused by metallic objects or materials buried in conjunction with operations at the former Incineration Building. Additional isolated high-magnitude values primarily coincide with former rail spurs, for example, anomaly "E" occurs in an area where a rail spur is partially visible.

4.3.2 Alluvium

The Waste/Fill material is underlain by Alluvium which was laid down by the Buffalo River. This unit generally consists of black to gray silty sand with a trace of clay, however, grain-size textural variations to gravelly sand or sandy silt are recognized. In general, a coarsening downward sequence is present. Two sub-units of the alluvium are observed at the site: a black, brown, and red-brown clayey silt and very fine sand unit; and a lower, generally thicker and more permeable gray sand and gravel unit. Moisture conditions within the alluvium vary from moist to saturated.

Structural contours of the top of the alluvium are presented on Figure 4-10. The upper surface of the alluvium generally slopes in three directions. Sloping toward the northwest corner is due to trenching for the installation of underground utilities. Sloping toward the southwest and northeast corners is due to erosion by the Buffalo River. The alluvium ranges in thickness up to 22.0 (B-7-88) feet and averages 17.8 feet.

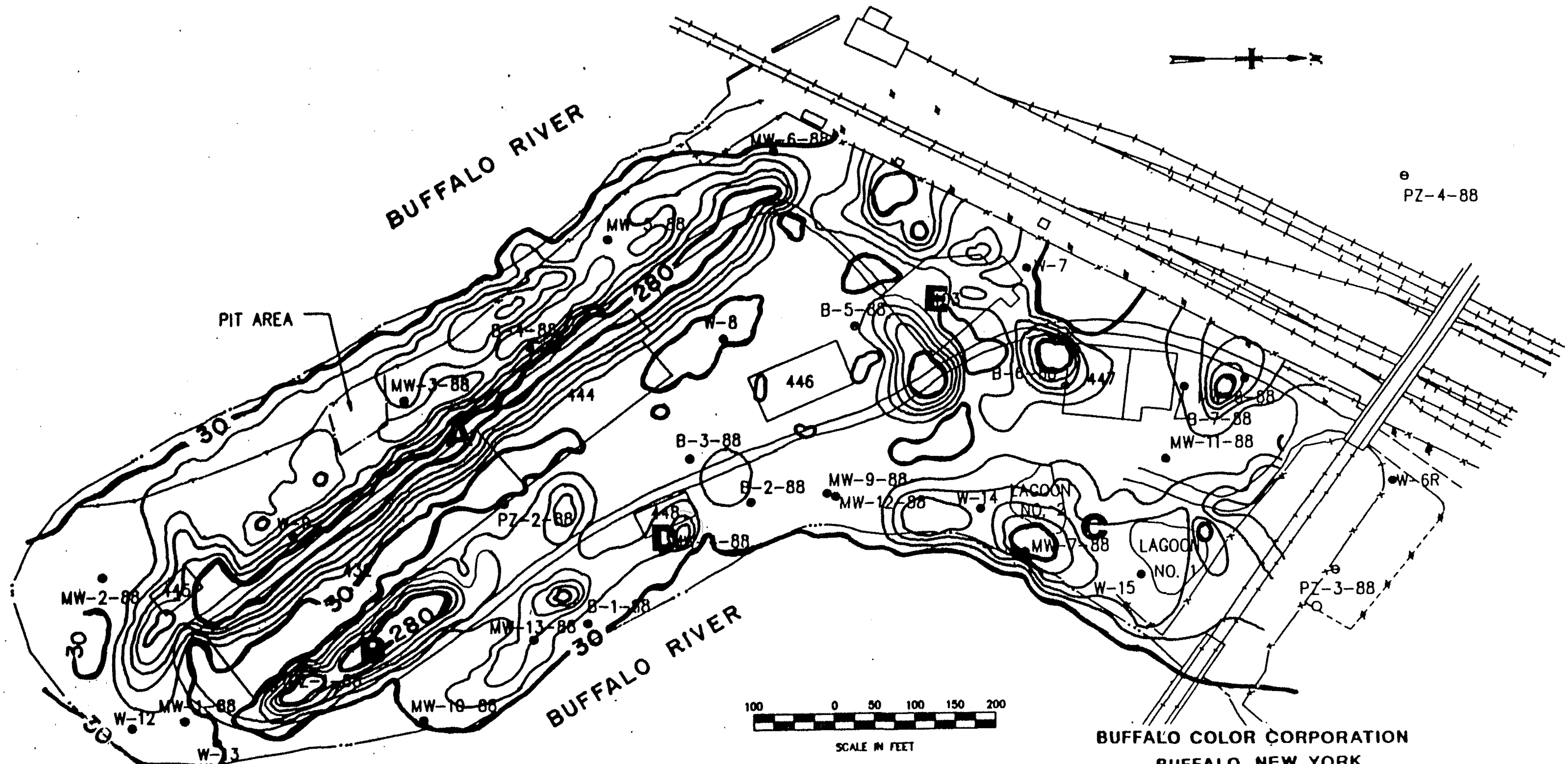
FIGURE 4-9

LEGEND

● — TEST BORING (B), MONITORING WELL (MW, W), OR PIEZOMETER (PZ)

[446] — LOCATION OF DEMOLISHED BUILDING 446

—280 — CONTOUR VALUES IN MMHOS/METER



NOTE:VALUES IN MMHOS/METER

BUFFALO COLOR CORPORATION
BUFFALO, NEW YORK
AREA "D REMEDIAL INVESTIGATION

E.M. TERRAIN CONDUCTIVITY SURVEY

CONTOUR INTERVAL=50 MMHOS/METER

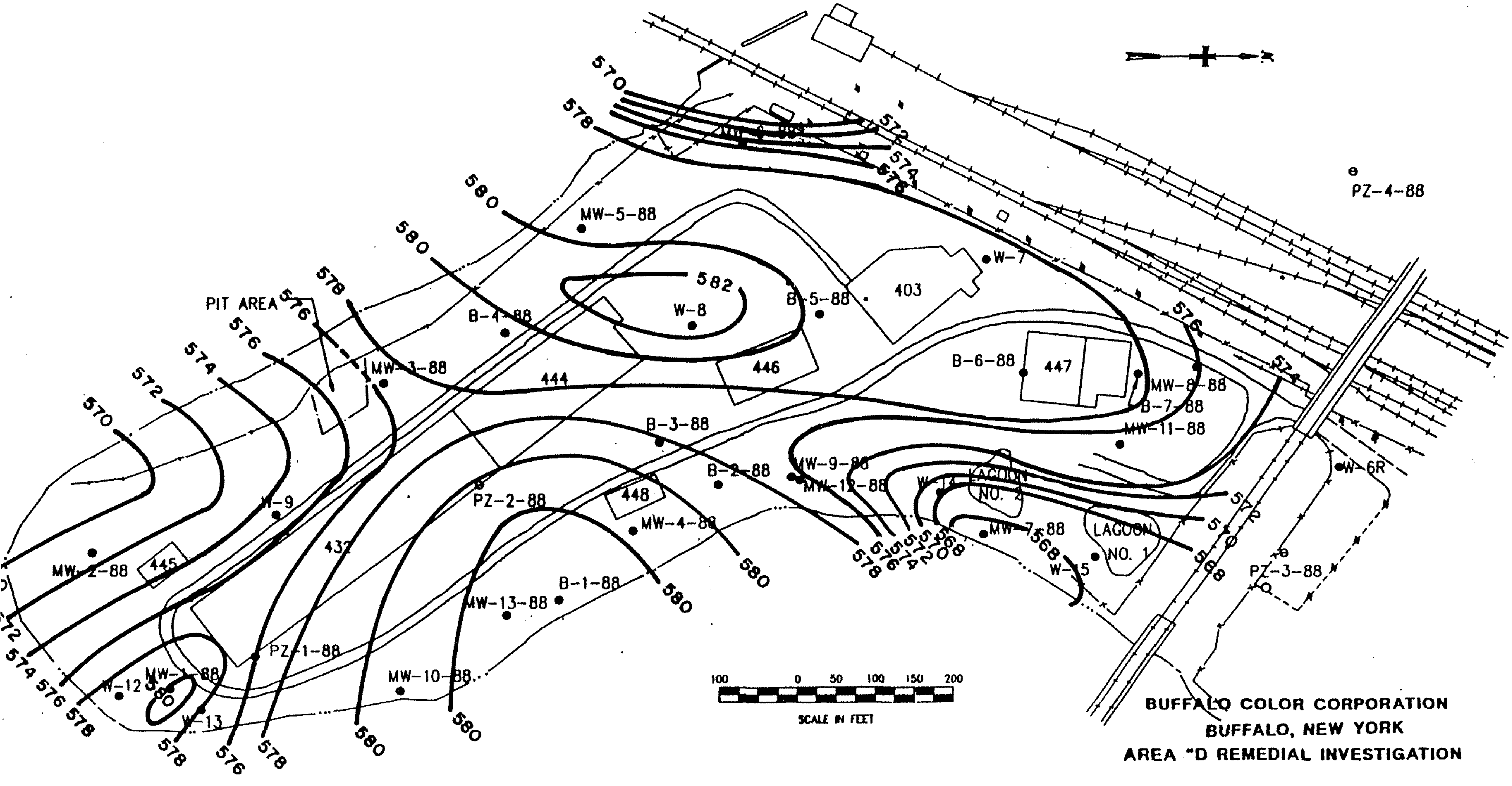
MALCOLM PIRNIE

FIGURE 4-10

LEGEND

- ● — TEST BORING (B), MONITORING WELL (MW, W), OR PIEZOMETER (PZ)
- [446] — LOCATION OF DEMOLISHED BUILDING 446
- 580 — ELEVATION (ASL) OF TOP OF ALLUVIUM

CONTOUR INTERVAL IS 2 FEET



BUFFALO COLOR CORPORATION
BUFFALO, NEW YORK
AREA "D REMEDIAL INVESTIGATION

TOP OF ALLUVIUM CONTOUR

MALCOLM PIRNIE

4.3.3 Glaciolacustrine Deposits

The alluvial deposits are typically underlain by Glaciolacustrine Deposits (clay). This unit generally consists of gray and brown-gray clayey silt and silty clay commonly varved with silt. The clay is highly plastic, firm, and texturally homogeneous. The upper surface generally slopes north and northeast toward the D.L.& W. Railroad embankment (see Figure 4-11. The clay reaches a maximum thickness of 28.8 (MW-1-88) feet on the southern boundary of the site and averages 27.9 feet. Moisture conditions within the lacustrine sediments are predominantly moist to saturated.

4.3.4 Glacial Till

A thin layer of Glacial Till (till) mantles the bedrock surface beneath the site. The till is a texturally homogeneous unit consisting of gray, gray-brown, and brown sandy silt, with small percentages of clay and gravel. A thin layer of limestone fragments (i.e. regolith) is present between the till and the bedrock surface. The till reaches a maximum thickness of 16.2 (MW-1-88) feet in the southeast portion of the site and averages 12.0 feet. Moisture conditions within the till vary from wet to saturated.

4.3.5 Bedrock

The bedrock was contacted at MW-1-88, MW-7-88, B-3-88, and B-5-88 (Table 4-5) after auger refusal. Therefore, only the upper few inches of the bedrock were observed. The bedrock beneath the site consists of hard, dark gray limestone of the Middle Devonian Onondaga Limestone (Buehler and Tesmer, 1963).

4.4 SITE HYDROGEOLOGY

4.4.1 Hydrostratigraphic Units and Hydrogeologic Properties

Hydrostratigraphic units are sequences of geologic materials that possess similar hydrogeologic properties including hydraulic conductivity, storage, and porosity. The hydrostratigraphy of the Area "D" site, as derived from an assessment of the hydraulic properties of the geologic

FIGURE 4-11

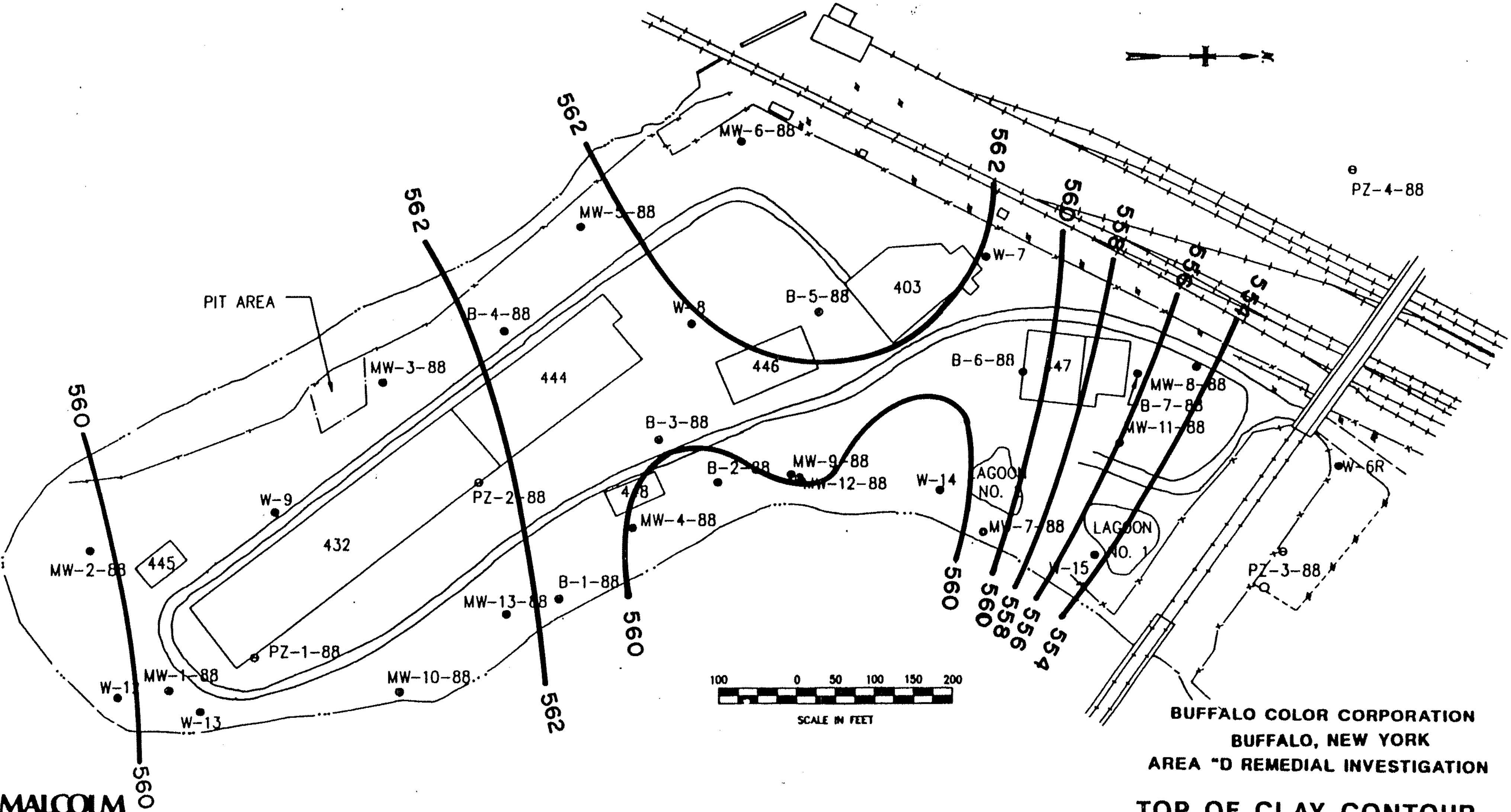
LEGEND

● — TEST BORING (B), MONITORING WELL (MW, W), OR PIEZOMETER (PZ)

446 — LOCATION OF DEMOLISHED BUILDING 446

—562— ELEVATION (ASL) OF TOP OF CLAY

CONTOUR INTERVAL IS 2 FEET



BUFFALO COLOR CORPORATION
BUFFALO, NEW YORK
AREA "D REMEDIAL INVESTIGATION

TOP OF CLAY CONTOUR

MALCOLM PIRNIE

units described in Section 4.3 is illustrated in Table 4-6. The major hydrostratigraphic units are:

1) an unconfined, shallow water-bearing zone consisting of fill material with an underlying layer of alluvial silt, sand, and gravel;

2) a confining unit (aquitard) comprised of very low permeable glaciolacustrine deposits and an underlying layer of glacial till; and

3) a bedrock aquifer.

The shallow water-bearing zone, which underlies the entire site, varies in saturated thickness from about 10.0 to 18.0 feet. Figure 4-12 shows this water-bearing zone in profile through the central portion of the site along cross-section line E-E'. The unit maintains a relatively constant thickness across most of the site. The unit thickness increases near the northern boundary of Area "D". An isopach map of this unit is presented in Figure 4-13.

The glaciolacustrine/till aquitard appears to occur as a continuous zone across all areas beneath the site. The aquitard thickness increases to the south from about 35 feet at M-7-88 to about 45 feet at MW-1-88. Confining layer isopachs are presented in Figure 4-14.

The bedrock aquifer which underlies the site at depth, dips to the south from a high of 524.6 feet (MSL) at MW-7-88 to 515.5 feet (MSL) at MW-1-88. The bedrock aquifer in this area is comprised of the Onondaga Limestone, Akron Dolomite, and the Bertie Limestone and is approximately 140 to 160 feet thick (La Sala, 1968).

Hydraulic conductivity values for each well are presented in Table 4-7. Hydraulic conductivities of the shallow water-bearing zone range from $1.4x10^{-5}$ cm/sec at W-15 to $7.4x10^{-2}$ cm/sec at MW-11-88. The hydraulic conductivity values obtained from wells screened in the lower portion of the shallow water-bearing zone (viz. directly above the confining layer) were higher than many values obtained from wells screened in the upper portion of this zone. The higher hydraulic conductivity values probably reflect the observed coarsening of grain size from surface to depth through the zone. This coarsening is expected to be associated with an increase in the permeability of the water-bearing

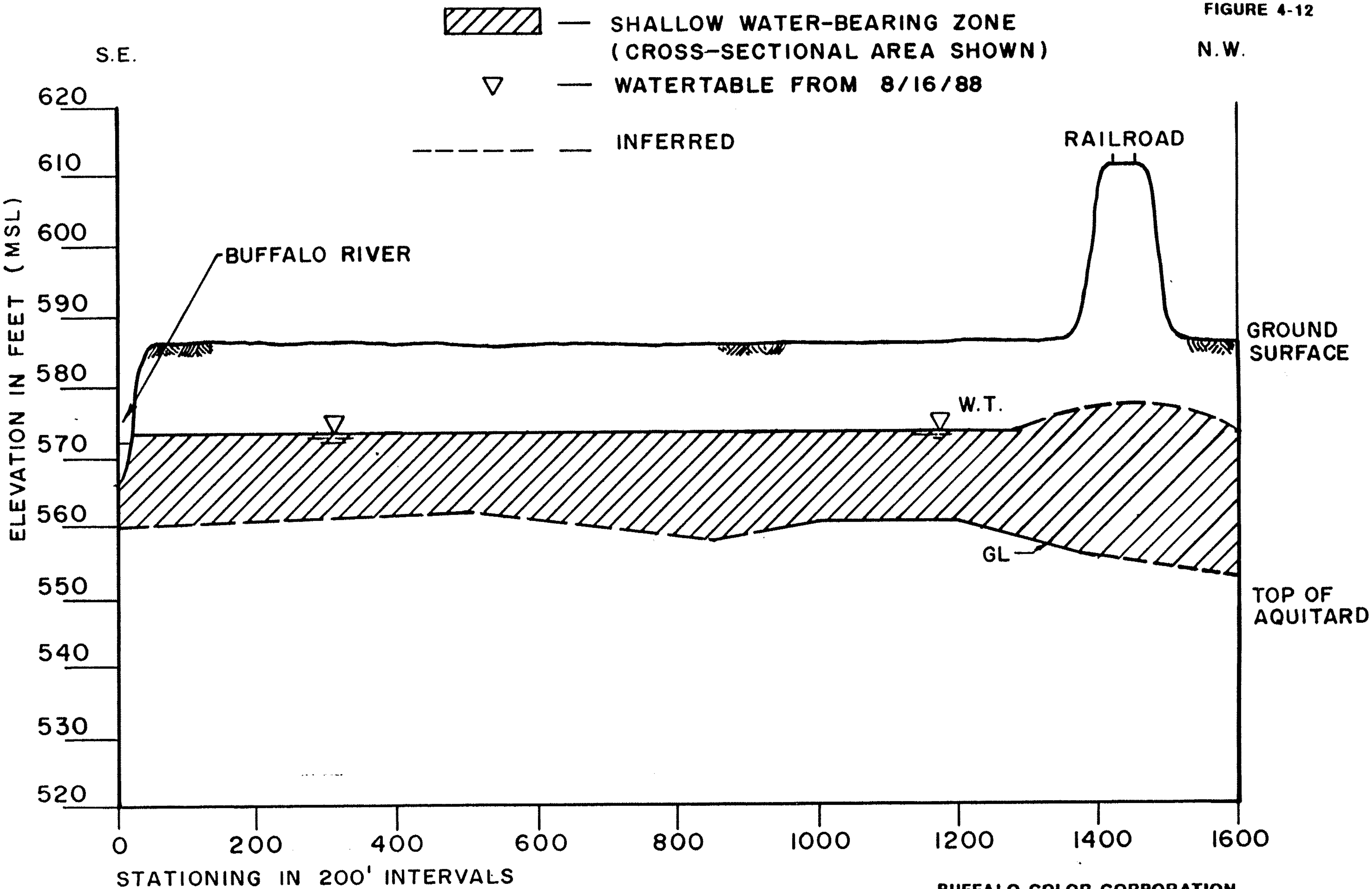
MALCOLM PIRNIE

TABLE 4-6

CORRELATION OF GEOLOGIC AND HYDROGEOLOGIC UNITS

GEOLOGIC UNIT			HYDROSTRATIGRAPHIC UNIT
Fill Deposits	:	construction debris, industrial sludge, sand and silt	Shallow Unconfined Water-Bearing Zone
Alluvial Deposits	:	sandy silt to sand and gravel	
Glaciolacustrine	:	Silty Clay	Aquitard
Glacial Till	:	Clay, silt, sand and gravel	
Bedrock	:	Limestone	Bedrock Aquifer

FIGURE 4-12



BUFFALO COLOR CORPORATION
BUFFALO, NEW YORK
AREA "D REMEDIAL INVESTIGATION

PROFILE OF THE SHALLOW SATURATED ZONE ALONG SECTION F-F'

SCALE:HORIZ. 1"=200', VERT. 1"=20'

MALCOLM PIRNIE

FIGURE 4-13

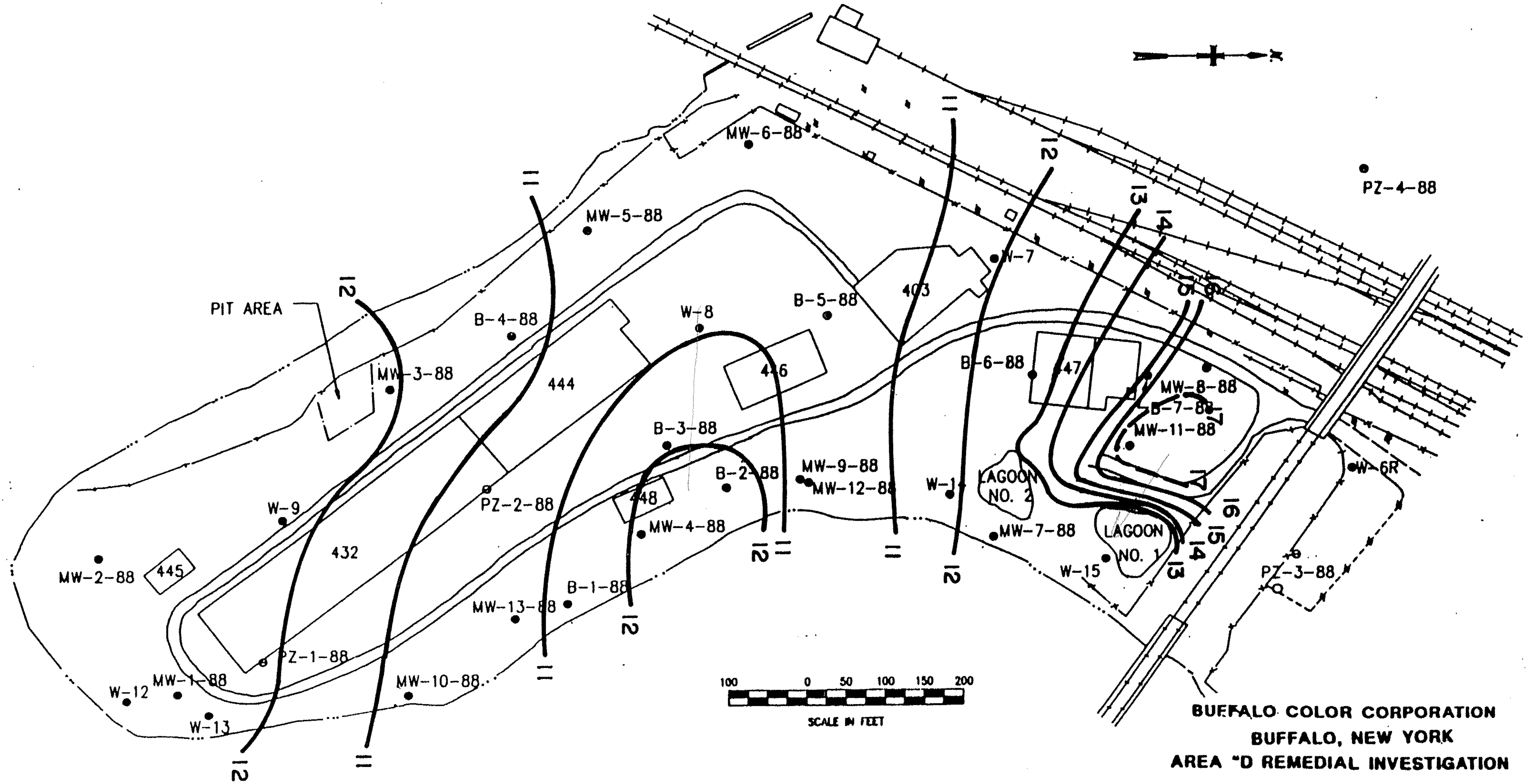
LEGEND

● — TEST BORING (B), MONITORING WELL (MW, W), OR PIEZOMETER (PZ)

[446] — LOCATION OF DEMOLISHED BUILDING 446

~12 — ISOPACH CONTOUR

CONTOUR INTERVAL IS 1 FOOT



BUFFALO COLOR CORPORATION
BUFFALO, NEW YORK
AREA "D REMEDIAL INVESTIGATION

SHALLOW AQUIFIER
ISOPACH MAP (8/18/88)

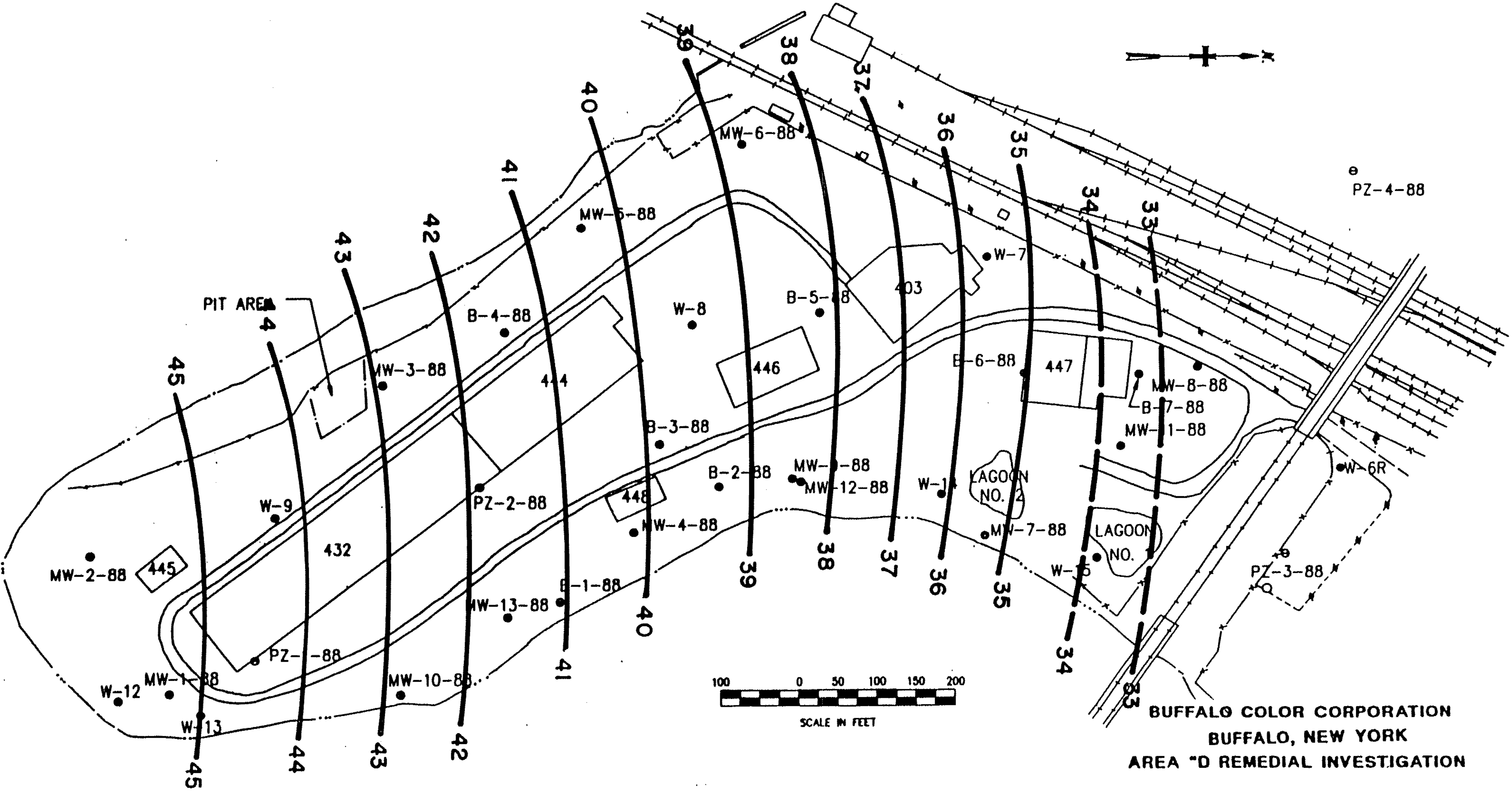
MALCOLM PIRNIE

FIGURE 4-14

LEGEND

- ● — TEST BORING (B), MONITORING WELL (MW, W), OR PIEZOMETER (PZ)
- 446 — LOCATION OF DEMOLISHED BUILDING 446
- 12 — ISOPACH CONTOUR

CONTOUR INTERVAL IS 1 FOOT



BUFFALO COLOR CORPORATION
BUFFALO, NEW YORK
AREA "D REMEDIAL INVESTIGATION

CONFINING LAYER ISOPACH

MALCOLM PIRNIE

MALCOLM PIRNIE

TABLE 4-7

SUMMARY OF SATURATED ZONE CHARACTERISTICS

WELL	DEPTH OF INTERVAL SCREENED (ft)	MATERIAL SCREENED	HYDRAULIC CONDUCTIVITY (cm/sec)
FILL MATERIAL			
MW-2-88	11.0 - 16.0	Gravelly sandy fill	2.3×10^{-2}
MW-6-88	11.0 - 16.0	Sandy silty fill	Insufficient water in well
Well 14	15.0 - 20.0	Mixed sludge, sand and gravel fill	4.13×10^{-2}
Well 15	18.5 - 23.5	Mixed sludge, silt loam fill	1.42×10^{-5}
		GEOMETRIC MEAN:	2.38×10^{-3}
UPPER ALLUVIUM DEPOSITS			
MW-3-88	11.0 - 16.0	Sand and gravel	1.58×10^{-3}
MW-4-88	13.0 - 18.0	Silt and sand	5.24×10^{-4}
MW-5-88	11.3 - 16.3	Silt loam	1.37×10^{-4}
MW-8-88	11.8 - 16.8	Fn-Med sand	3.52×10^{-3}
MW-9-88	11.8 - 16.8	Silty sand	2.40×10^{-3}
MW-10-88	11.5 - 16.5	Sandy loam	2.97×10^{-4}
PZ-1-88	13.0 - 18.0	Silty sand, little gravel	1.26×10^{-3}
PZ-2-88	12.0 - 17.0	Sandy loam	6.42×10^{-4}
PZ-3-88	13.0 - 18.0	Silty sand	4.10×10^{-4}
PZ-4-88	15.0 - 20.0	Silty sand	1.79×10^{-4}

TABLE 4-7 (Continued)

SUMMARY OF SATURATED ZONE CHARACTERISTICS

WELL	DEPTH OF INTERVAL SCREENED (ft)	MATERIAL SCREENED	HYDRAULIC CONDUCTIVITY (cm/sec)
UPPER ALLUVIUM DEPOSITS (Continued)			
Well 6R	13.0 - 18.0	Silty sand	1.04×10^{-4}
Well 8	15.0 - 20.0	Sandy loam	(1)
Well 9	15.0 - 20.0	Clayey Silt w/ sand and gravel	3.39×10^{-3}
Well 12	13.0 - 18.0	Sandy loam	3.11×10^{-3}
Well 13	13.0 - 18.0	Sandy loam	2.87×10^{-3}
		GEOMETRIC MEAN =	8.34×10^{-4}
LOWER ALLUVIUM DEPOSITS			
MW-11-88	26.0 - 31.0	Coarse sand and gravel	7.4×10^{-2}
MW-12-88	18.5 - 23.5	Fine sand, little gravel	2.9×10^{-3}
MW-13-88	18.5 - 23.5	Fine, coarse sand and gravel	7.2×10^{-4}
		GEOMETRIC MEAN =	5.4×10^{-3}
GLACIAL TILL			
MW-1-88	62.5 - 67.5	Sandy silt, trace clay, some gravel	4.7×10^{-6}
MW-7-88	59.5 - 64.5	Clayey sandy silt, little gravel	2.3×10^{-5}
		GEOMETRIC MEAN =	1.04×10^{-5}

NOTE: (1) Well not tested due to presence of light NAPL.

material. The geometric mean hydraulic conductivity for the entire thickness of the shallow water-bearing zone is 2.1×10^{-3} cm/sec.

Measured hydraulic conductivities for the glacial till have a geometric mean of 1.0×10^{-5} cm/sec. None of the monitoring wells/piezometers were screened in the glaciolacustrine unit, consequently, no field-derived hydraulic conductivity values are available for this unit. A value of 3.5×10^{-7} cm/sec is given by Lappala (1978) for a silty clay. Assuming this mean value for the hydraulic conductivity of the glaciolacustrine unit is reasonable, the mean hydraulic conductivity of the glaciolacustrine/till aquitard is estimated to be 2×10^{-6} cm/sec.

Since none of the wells were completed in bedrock, a hydraulic conductivity value for the bedrock aquifer beneath the site was not obtained. LaSala (1968) has reported hydraulic conductivity values ranging from 1.4×10^{-2} cm/sec to 1.2 cm/sec for the bedrock aquifer.

4.4.2 Ground Water Flow

4.4.2.1 Shallow Water-Bearing Zone

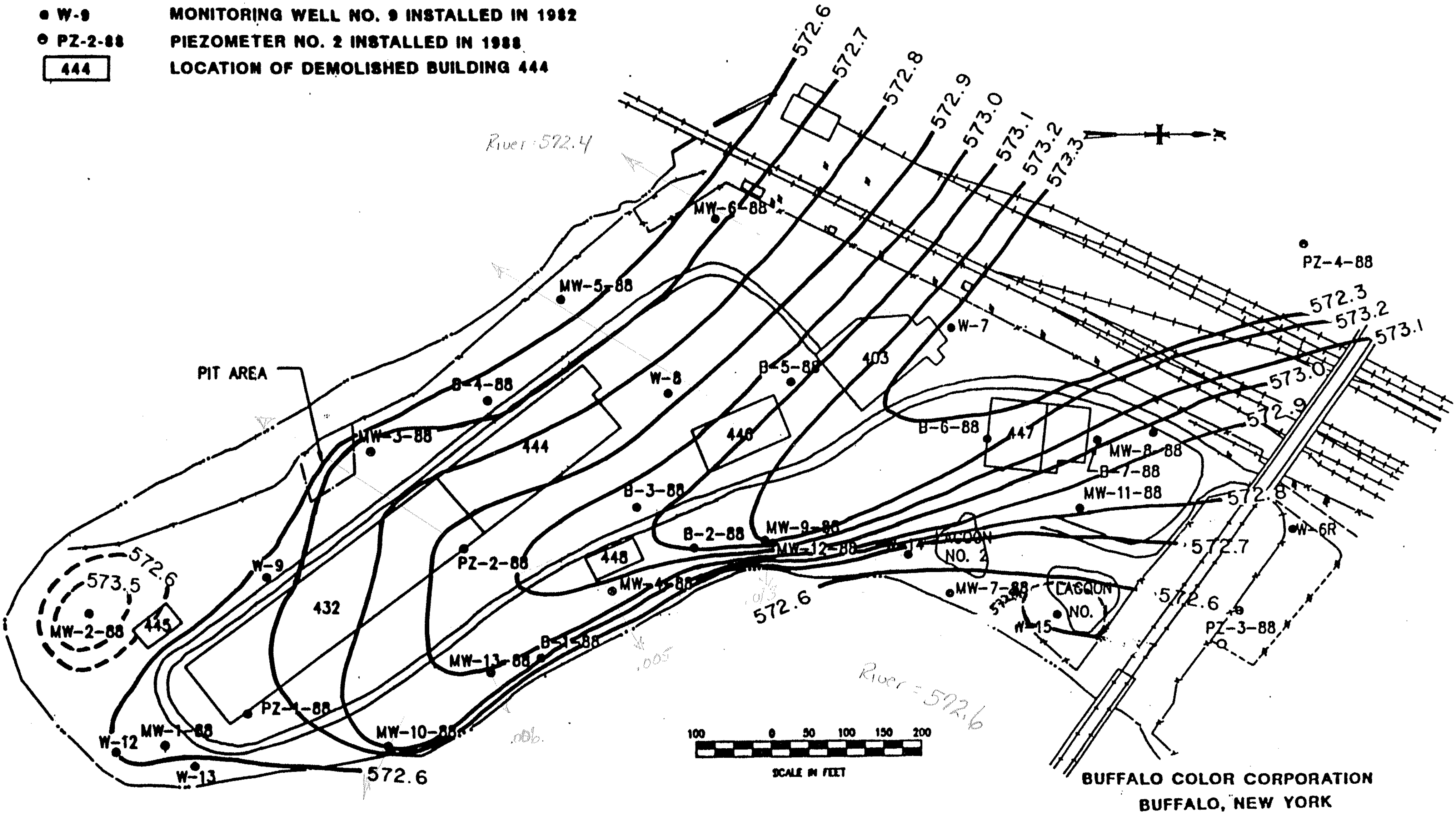
Shallow ground water flow conditions for July 7, 1988 and the August 18, 1988 ground water sampling period are presented in Figures 4-15 and 4-16, respectively. Ground water levels in the shallow water-bearing zone are strongly influenced by the water level in the Buffalo River. This hydraulic relationship is discussed in Section 5.3. Shallow ground water at the site generally discharges to the Buffalo River with flow occurring in the direction of decreasing total hydraulic head. The isopotential map for 07/07/88 represents near static hydrologic conditions at the site where water levels were recorded in the monitoring wells/piezometers after a prolonged period of virtually no precipitation and fairly-constant barometric pressure. At this period in time, normal river gradients were observed with the water level at the upstream staff gauge being 0.25 feet higher than that of the downstream staff gauge (see Figure 4-17).

The isopotential map for 08/16/88 represents a hydrologic dynamic condition where some of the wells at the site were responding to a river flow reversal where the water level at the downstream staff gauge was

FIGURE 4-15

LEGEND

● MW-5-88	MONITORING WELL NO. 5 INSTALLED IN 1988
● B-4-88	TEST BORING NO.4 COMPLETED IN 1988
● W-9	MONITORING WELL NO. 9 INSTALLED IN 1982
⊙ PZ-2-88	PIEZOMETER NO. 2 INSTALLED IN 1988
444	LOCATION OF DEMOLISHED BUILDING 444



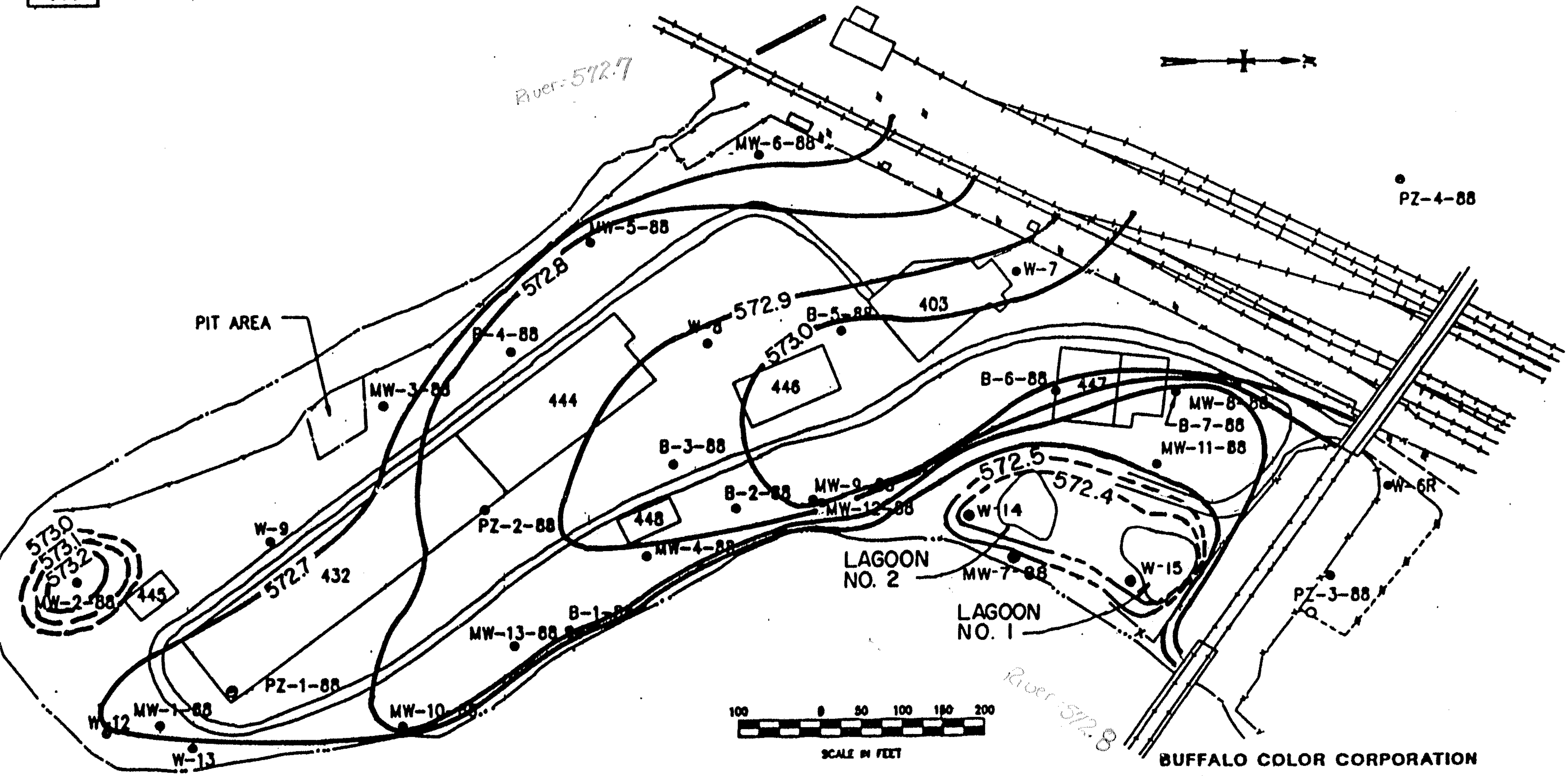
BUFFALO COLOR CORPORATION
BUFFALO, NEW YORK
AREA "D REMEDIAL INVESTIGATION
SHALLOW GROUND WATER
ISOPOTENTIAL MAP
(7-7-88)

MALCOLM PIRNIE

FIGURE 4-16

LEGEND

- ● MW-5-88 — MONITORING WELL NO. 5 INSTALLED IN 1988
- ● B-4-88 — TEST BORING NO.4 COMPLETED IN 1988
- ● W-9 — MONITORING WELL NO. 9 INSTALLED IN 1982
- ○ PZ-2-88 — PIEZOMETER NO. 2 INSTALLED IN 1988
- [444] — LOCATION OF DEMOLISHED BUILDING 444

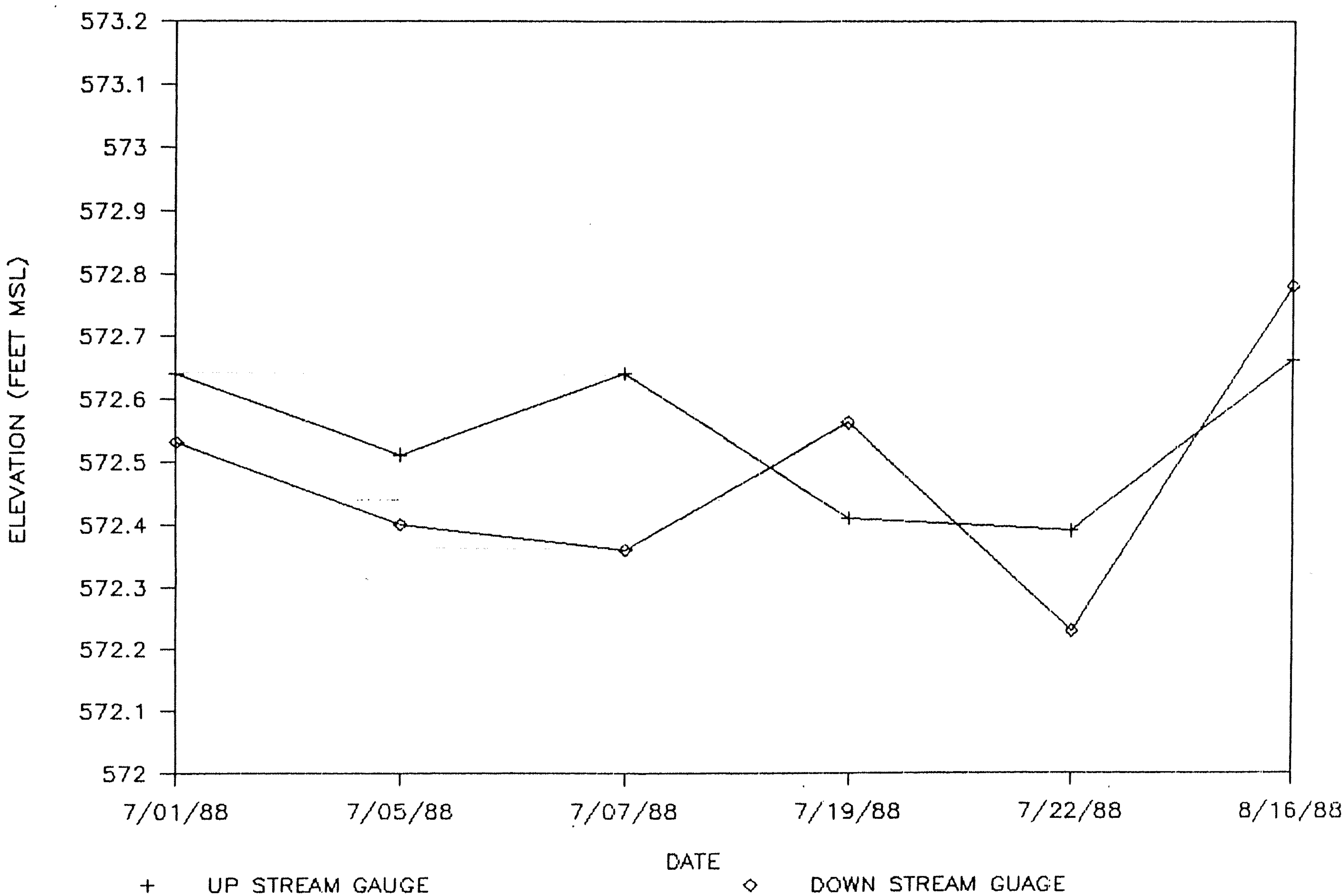


BUFFALO COLOR CORPORATION
BUFFALO, NEW YORK
AREA "D REMEDIAL INVESTIGATION
SHALLOW GROUND WATER
ISOPOTENTIAL MAP
(8-16-88)

MALCOLM PIRNIE

FIGURE 4-17

UP STREAM VS. DOWN STREAM RIVER LEVEL



higher than the river level at the upstream staff gauge (see Figure 4-17). The response time of water level changes occurring in wells located at different areas of the site is influenced by the heterogeneity of the shallow water-bearing zone. River flow reversal was observed on one other monitoring occasion (07/19/88) during this study.

A reversal of river flow direction is not uncommon for the lower portion of the Buffalo River (per. comm. Army Corps of Engineers). These flow reversals may be attributed to Lake Erie seiche conditions. Seiche conditions are caused by winds, changes in barometric pressure, or any other change that disturbs the level of the lake. Fluctuations of several feet have been observed on Lake Erie at Buffalo (Harding, 1942) increasing the head of the river level at the mouth (viz. 1/2-mile away) thereby, causing flow reversal.

Generally, ground water flow in the shallow water-bearing zone is from the northern portion of Area "D", across the site, toward the Buffalo River. Components of flow also move radially from a topographic high near the southwestern end of the peninsula in the vicinity of MW-2-88 and the pit area.

Figure 4-12 presents a cross-section through the shallow water-bearing zone along the section line E-E. The hydraulic gradient across the site as observed between PZ-4-88 and W-12 is 0.006 ft/ft. Hydraulic gradients across other portions of Area "D" include:

- 0.0018 ft/ft on the east site near the incinerator area;
- 0.0004 ft/ft at the weathering area;
- 0.0057 ft/ft at the southwest corner near MW-2-88;
- 0.0009 ft/ft on the west side near MW-6-88; and
- 0.0007 ft/ft at the iron oxide sludge lagoons.

The comparatively small calculated hydraulic gradients are attributed to the very low surface relief.

4.4.2.2 Glaciolacustrine/Till Aquitard

Ground water levels obtained from wells screened in the glacial till indicate that ground water movement occurs in this unit under semiconfined conditions. The unit contains both a horizontal and upward vertical flow component. The horizontal hydraulic gradient based on measured water levels for deep wells MW-7-88 and MW-1-88 is 0.00004 ft/ft, with lateral flow occurring in a northerly direction. The upward flow potential measured in these two wells is 0.46 ft and 0.23 ft, respectively. Vertical leakance through the aquitard as calculated for monitoring wells MW-7-88 and MW-1-88 is 1.7×10^{-9} cm/sec and 8.0×10^{-10} cm/sec, respectively.

4.4.2.3 Bedrock Aquifer

Based on the observed upward gradients across the confining unit, the bedrock aquifer appears to be under confined artesian conditions.

4.4.3 Summary of Hydrogeologic Properties of the Major Hydrostratigraphic Units

The physical hydrogeologic properties of the hydrostratigraphic units as determined by field testing and a review of available literature are summarized in Table 4-8. Ground water flow characteristics, including principal flow direction, hydraulic gradient, and average linear velocity are also included in this table.

In summary, shallow ground water flow is primarily from the north and flows directly to the Buffalo River. A component of shallow flow moves radially from a topographic high near MW-2-88. The average ground water flow velocity in this zone is 1.4×10^{-5} cm/sec. The shallow water-bearing zone is underlain by a clay-rich confining layer (aquitard). Flow in this unit is predominantly upward at a rate of 1.2×10^{-9} cm/sec. Flow in the bedrock aquifer probably occurs under confined conditions beneath the site.

4.4.4 Water Balance

A water balance was performed for the Area "D" site to partition quantities of water which factor into the hydrologic recharge/discharge

MALCOLM PIRNIE

TABLE 4-8

SUMMARY OF HYDROGEOLOGY

HYDROSTRATIGRAPHIC UNIT	AVERAGE PHYSICAL PROPERTIES: SATURATED THICKNESS (ft)	AVERAGE PHYSICAL PROPERTIES: HYDRAULIC CONDUCTIVITY (cm/sec)	AVERAGE PHYSICAL PROPERTIES: POROSITY	AVERAGE GROUND WATER FLOW PROPERTIES: PRINCIPAL FLOW DIRECTION	AVERAGE GROUND WATER FLOW PROPERTIES: HYDRAULIC GRADIENT (ft/ft)	AVERAGE GROUND WATER FLOW PROPERTIES: AVG. SEEPAGE VELOCITY (cm/sec)
SHALLOW WATER-BEARING ZONE: - Fill/Alluvium Deposits	11.4	2.2×10^{-3}	0.3[1]	Lateral to South	.0019	1.4x10-5
AQUITARD: - Glaciolacustrine/Till	40	1.2×10^{-6}	Glacio-lacustrine: 0.4[1] Glacial Till: 0.2[1]	Upward and Lateral to North	.00004	upward: 1.2×10^{-9} lateral: 1.6×10^{-10}
BEDROCK AQUIFER: - Limestone	(140-160)[2]	1.4×10^{-2} - 1.2[2]	Nearly zero porosity; permeability due to fracturing	Unknown	Unknown	Unknown

NOTES:

(1) Assumed value based on range of values from Freeze and Cherry, 1979.

(2) Range reported in Lappala, 1967.

relationship. Recharge is defined as all water entering the site either in the form of infiltration from precipitation falling on the site, ground water inflow along the north-northwestern (upgradient) boundary of the site, or upward leakance of ground water through the confining layer (aquitard). Discharge, defined as all water leaving the site, includes ground water discharge to the Buffalo River (downgradient). The average annual water balance can be expressed mathematically as:

$$I + U + Q_i = Q_o \pm \Delta S$$

where:

I = average annual infiltration (precipitation),

U = average annual upward leakance,

Q_i = average annual ground water inflow,

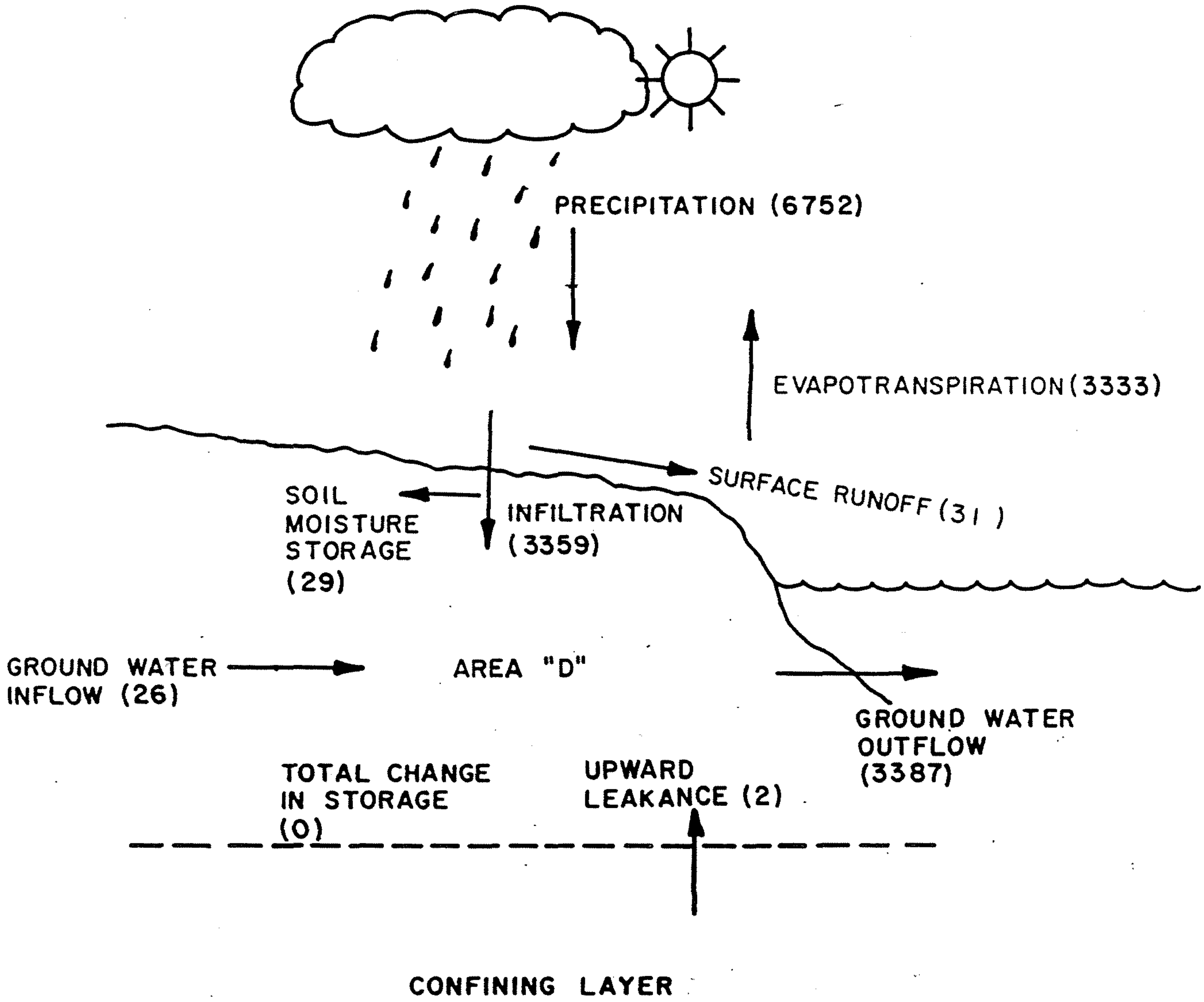
Q_o = average annual ground water outflow to Buffalo River, and

ΔS = annual change in ground water storage.

It should be recognized that this water balance equation provides only a general approximation of the hydrologic budget. This approximation does, however, provide an indication of the relative importance of the various component parameters to the overall budget. Figure 4-18 is provided as a reference that schematically illustrates the following discussion of the various component parameters.

4.4.4.1 Recharge

Infiltration - The Hydrologic Evaluation of Landfill Performance (HELP) computer model developed by Schroeder et.al. (1984), was employed to simulate the movement of precipitation (i.e. runoff, evapotranspiration, and infiltration [percolation]) at the Area "D" site. The HELP model uses climatologic and soil input data which is either specified by the user or selected from default data bases stored within the model. The sources of the input parameters used during the Area "D" simulation (viz. for existing or open condition) are identified below.



NOTE: AVERAGE ANNUAL VALUES EXPRESSED IN CUBIC FEET/DAY.

BUFFALO COLOR CORPORATION
BUFFALO, NEW YORK
AREA "D REMEDIAL INVESTIGATION

SITE WATER BALANCE
(AVERAGE WATER TABLE CONDITIONS)

MALCOLM PIRNIE

	Climatologic Data	Source
A)	Daily precipitation	Weather observation station at the Buffalo International Airport.
B)	Monthly mean temperatures, solar radiation values, leaf area indices, and winter cover factors.	Model default data for Cleveland, Ohio.
C)	Soil characteristics.	Combination of field-derived data (hydraulic conductivity) and model default data (porosity, field capacity, wilting point, and evaporation coefficient).
D)	Design data	Soil layer thickness and total surface area of the site are AUTOCAD (MPI) calculated.

For purposes of simulating actual field conditions, it was assumed that the site consists of only one fill layer with a poorly vegetated surface. Additional design and soil data inputs are summarized in Table 4-9.

The model outputs are presented in Appendix C.7. Average annual precipitation for the five years of records (i.e. 1984 through 1988) is 40.76 inches. Of this amount about 20.28 inches annually (about 50% of precipitation) infiltrates through the unsaturated fill to the water table. Loss to evapotranspiration is 20.12 inches and to surface runoff is 0.19 inches. About 13.54 inches of water was retained to replenish soil moisture. A total infiltration input of 3,359 ft^3/day was determined for the site (area of 725,538 ft^2).

Upward Leakance - Upward leakance through the confining layer (glaciolacustrine/till aquitard) was estimated using the average upward seepage velocity from Section 4.4.3 (1.2×10^{-9} cm/sec or 3.4×10^{-6} ft/day) and the area of the site. The calculated leakance for the site is 2.5 ft^3/day.

MALCOLM PIRNIE

TABLE 4-9

BUFFALO COLOR CORPORATION
AREA "D"

SUMMARY OF DESIGN AND SOIL DATA
FOR HELP MODEL - EXISTING OR OPEN CONDITIONS

PARAMETER	VALUE
Total Surface Area of Area "D"	725,538 ft^2
Average Unsaturated Fill Thickness	7.2 ft
Hydraulic conductivity (Leakance)?	7.2 ft/day (2.5x10^{-3} cm/sec) (arith mean)
Porosity	0.4100 vol/vol
Field Capacity	0.1640 vol/vol
Wilting Point	0.0580 vol/vol
Runoff Curve Number	70.00
Evaporation Coefficient	3.380
Evaporative Zone Depth	10.00 in.

Ground Water Inflow - Ground water inflow across the north - northwestern (upgradient) boundary of the site was estimated by Darcy's Law which is expressed as:

$$Q = K\,i\,A$$

where:

K = average hydraulic conductivity,

i = hydraulic gradient, and

A = cross-sectional area of the shallow aquifer.

The hydraulic conductivity value (2.2×10^{-3} cm/sec or 6.2 ft/day) used in the calculation is the average actual value for slug test analysis results for the shallow water-bearing zone. The hydraulic gradient and cross-sectional area were established for average water table conditions as measured across the upgradient boundary between the DL&W Railroad and MW-6-88. Various input parameters and the calculated ground water inflow are summarized below:

23 ft/day (arith mean)

PARAMETER	VALUE
Hydraulic Conductivity	6.2 ft/day
Hydraulic Gradient	4.0×10^{-4} ft/ft
Cross-Sectional Area	10,260 ft^2
Ground Water Inflow	25.6 ft^3/day or 94 ft^3/d

ft/d · ft/ft · ft^2 = ft^3/d

4.4.4.2 Discharge

Ground Water Outflow - Ground water leaves the site through the shallow water-bearing zone into the Buffalo River. Outflow was calculated to be equal to the sum of infiltration, upward leakance, and ground water inflow. Input parameters and the calculated ground water outflow for average water table (i.e. steady state) conditions are presented below:

PARAMETER	VALUE	
Average Annual Infiltration	3,359 ft^3/day	
Average Annual Upward Leakance	2.5 ft^3/day	
Average Annual Ground Water	25.6 ft^3/day	94
Average Annual Ground Water Outflow	3,387.1 ft^3/day 3455.5 "	=> 25,335 gpd => 25,847 "

Buffalo River flow reversal conditions contribute recharge and discharge to the site (see Section 4.4.2.1), but the changes in ground water levels are considered negligible over average annual conditions.

4.4.4.3 Ground Water Storage

The change in storage parameter is generally disregarded where the water balance is averaged over several years. This assumes that steady state conditions exist over the site and, consequently, that the change in ground water levels is negligible.

5.0 HYDROLOGY

5.1 WATER SHED CHARACTERISTICS

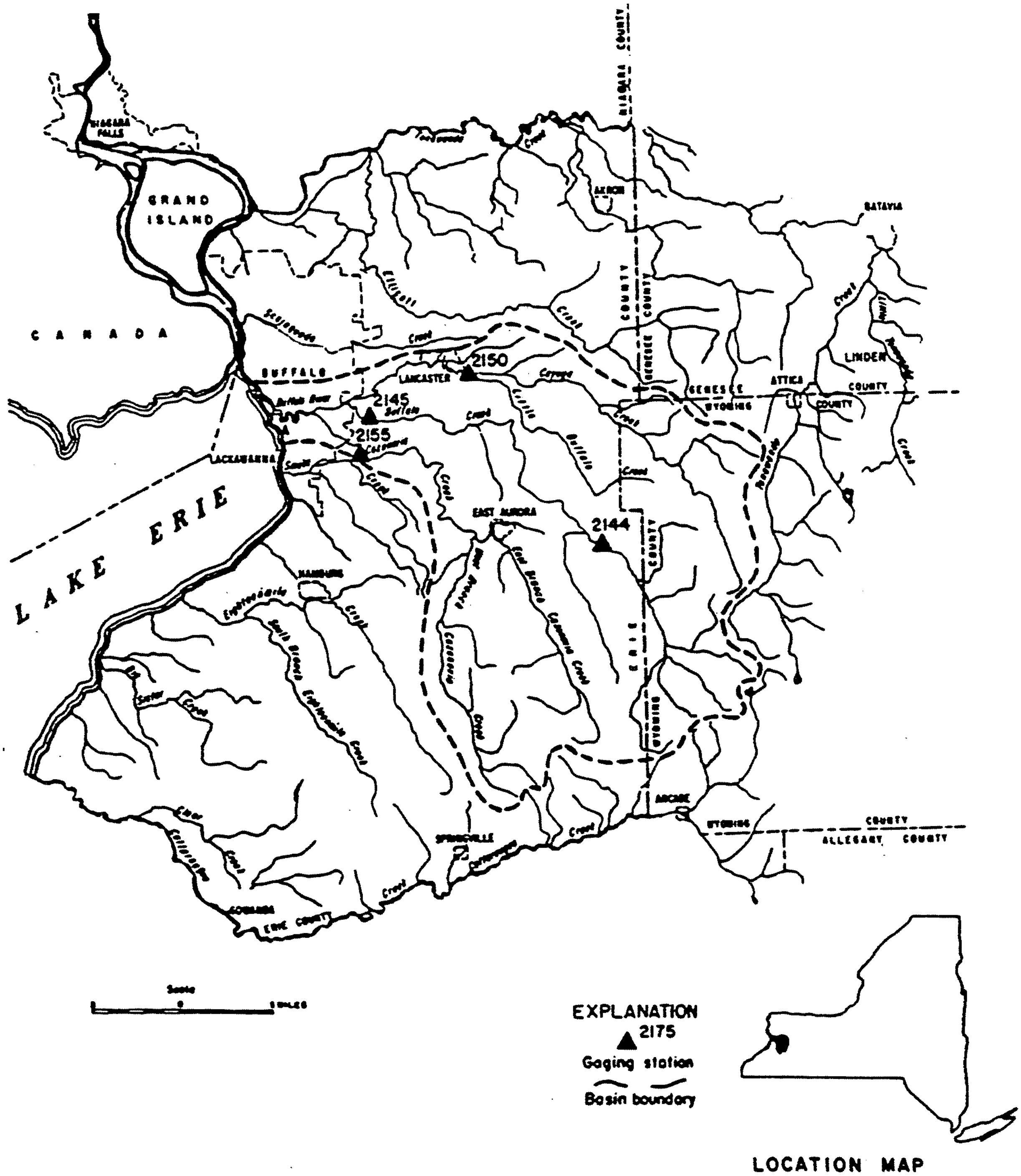
Figure 5-1 illustrates that the Buffalo River drains the water shed of Buffalo, Cayuga, and Cazenovia Creeks (149, 126, and 138 square mile drainage areas, respectively). The River then meanders in a north-westerly direction for approximately 8 miles from its confluence with Cazenovia Creek to the Buffalo Harbor. In total, the Buffalo River Drainage Basin comprises 31 tributaries draining 436 square miles east and south of Buffalo (Hardin and Gilbert, 1968).

Two major physical alterations of the Buffalo River basin have occurred since the late 1930s. The first was the development of extensive sewage collection systems in the upper water shed areas. These systems divert much of the natural run-off away from the basin, thus reducing a primary source of water and decreasing the River's flow (Sweeney and Merckel, 1972).

The second alteration involves the dredging of the Buffalo River by the U.S.Army Corps of Engineers. The Corps presently maintains a channel depth of approximately 23 feet from the Mobil Oil refinery (3/4-mile upstream from Area "D") to the mouth of the River (Sweeney and Merckel, 1972). This alteration also greatly decreases flow of the Buffalo River by widening and deepening the channel.

Such physical alterations lead to relatively stagnant flow conditions. Sweeney and Merckel (1972) noted that during the summer months, when precipitation was low and evaporation high, the Buffalo River flow reverses under westerly wind conditions.

In order to improve water quality and alleviate stagnant flow conditions, the various industries located along the Buffalo River formed the Buffalo River Improvement Corporation (BRIC). The BRIC installed a pumping system which transfers water from the Small Boat Harbor to the participating industries (Sweeney and Merckel, 1972). BRIC's Fuhrmann Boulevard Pump Station currently pumps 10,000,000 - 20,000,000 gallons of water per day from the Harbor intake and transfers this to Buffalo Color



NOTE: INDEX MAP SHOWING PRINCIPAL GAGING STATIONS (AFTER HARDING AND GILBERT, 1968)

MALCOLM PIRNIE

BUFFALO COLOR CORPORATION
BUFFALO, NEW YORK
AREA "D REMEDIAL INVESTIGATION
BUFFALO RIVER BASIN

and PVS Chemical. A 2,000,000-gallon holding tank is also located upriver to maintain pressure in the system. Both Buffalo Color Corporation and PVS Chemicals, Inc. use the BRIC water for non-contact cooling and other related uses. The water is subsequently discharged to the Buffalo River.

5.2 FLOOD PLAIN

The Federal Emergency Management Agency (FEMA) has conducted hydrologic analyses of peak discharge frequency and peak elevation frequency relationships in order to determine the 10-, 50-, 100-, and 500-year discharges of the Buffalo River. Tables 5-1 and 5-2 (after FEMA, 1981) summarize the peak discharge and peak elevation frequencies, respectively. This data provides the hydraulic characteristics required to estimate the elevations of Buffalo River discharges during the selected recurrence intervals. Figure 5-2 illustrates the 100-and 500-year discharges at the Buffalo Color Corporation Area "D" site, and surrounding area. Cross-sections (Figure 5-3) for the Buffalo River reveal the elevations for the 10-, 50-, 100-, and 500-year discharges. Cross-sections V, W, and X represent the Buffalo River adjacent to Area "D".

5.3 RELATIONSHIP BETWEEN RIVER AND GROUND WATER ELEVATIONS

In order to evaluate whether ground water levels are influenced by river water level elevations, the Area "D" site was subdivided into six geographic areas. These are: Western Side, Weathering Area, Outside of Area "D", Lagoon Area, Interior Area, and Eastern Side. Figures 5-4 through 5-10 prominently display the response of the overburden wells in each of the above areas, respectively. The wells in each area, except for Well-7 and Well-8 (Figure 5-8), show positive correlation with river fluctuations, thus suggesting that the shallow water-bearing zone is in direct hydraulic connection with the river. Well-7 and Well-8 ground

TABLE 5-1

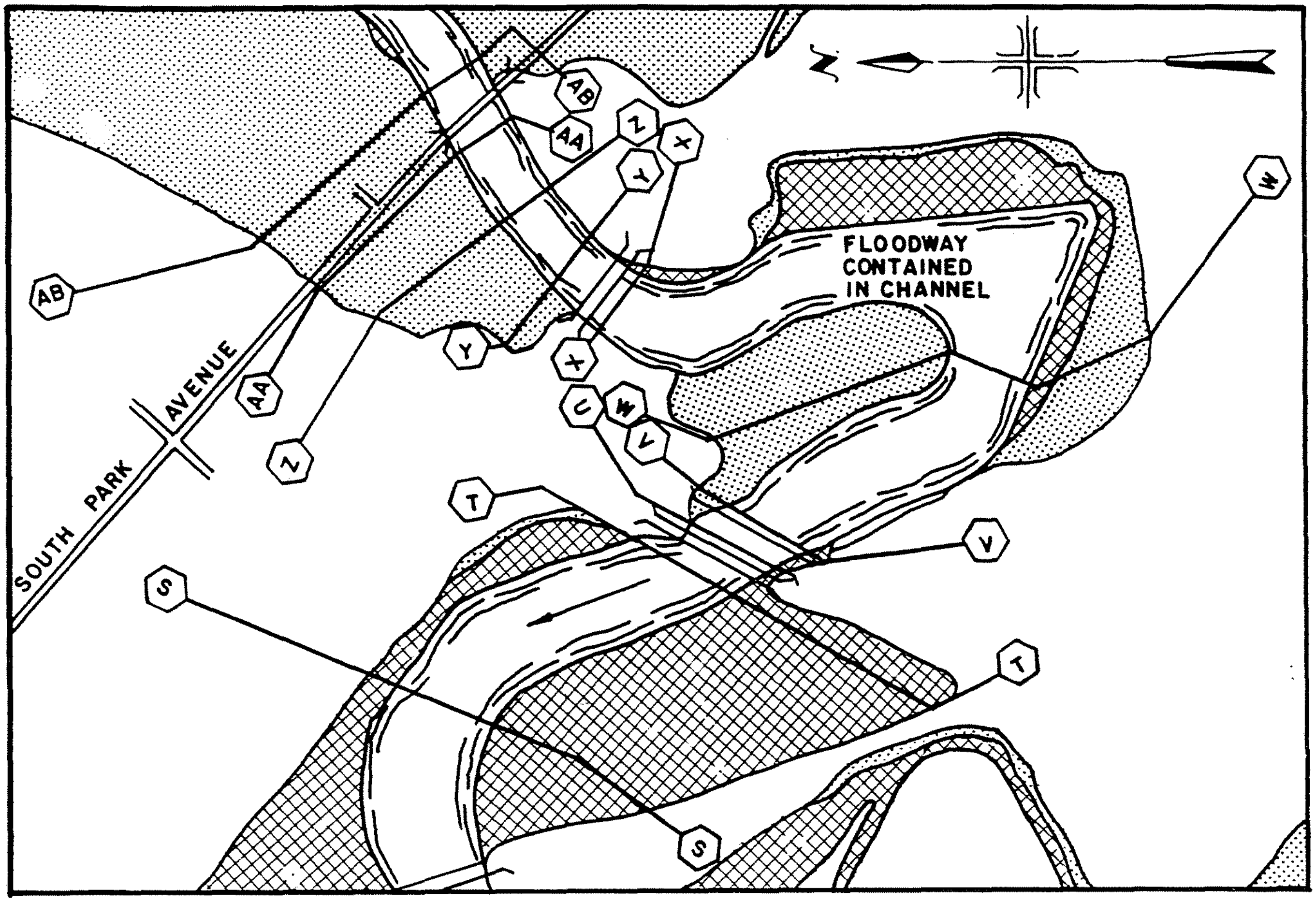
SUMMARY OF PEAK DISCHARGES
(after FEMA, 1981)

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq.mi.)	PEAK DISCHARGES (cfs)			
		10-YEAR	50-YEAR	100-YEAR	500-YEAR
BUFFALO RIVER:					
At the Mouth	431.5	29,500	41,000	47,000	59,000
Downstream of the confluence with Cazenovia Creek	417.2	28,000	40,000	47,000	56,000
Upstream of the confluence with Cazenovia Creek	280.0	20,500	28,500	32,000	41,000
At the upstream corporate limits	276.7	20,000	28,000	32,000	40,500
CAZENOVIA CREEK:					
At the confluence of the Buffalo River	137.2	11,100	15,700	18,000	22,800

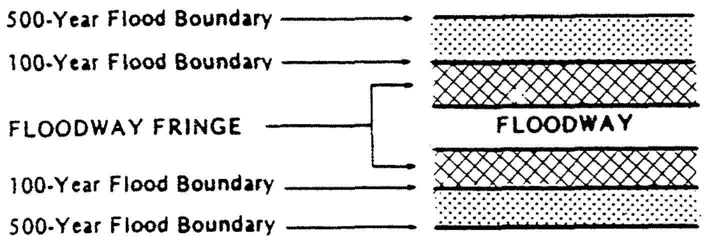
TABLE 5-2

SUMMARY OF PEAK ELEVATIONS
(after FEMA, 1981)

FLOODING SOURCE AND LOCATION	PEAK ELEVATIONS (ft.AMSL)			
	10-YEAR	50-YEAR	100-YEAR	500-YEAR
Lake Erie	579.2	580.3	580.7	581.5



KEY TO MAP



NOTE: FROM FEMA, 1981

MALCOLM PIRNIE

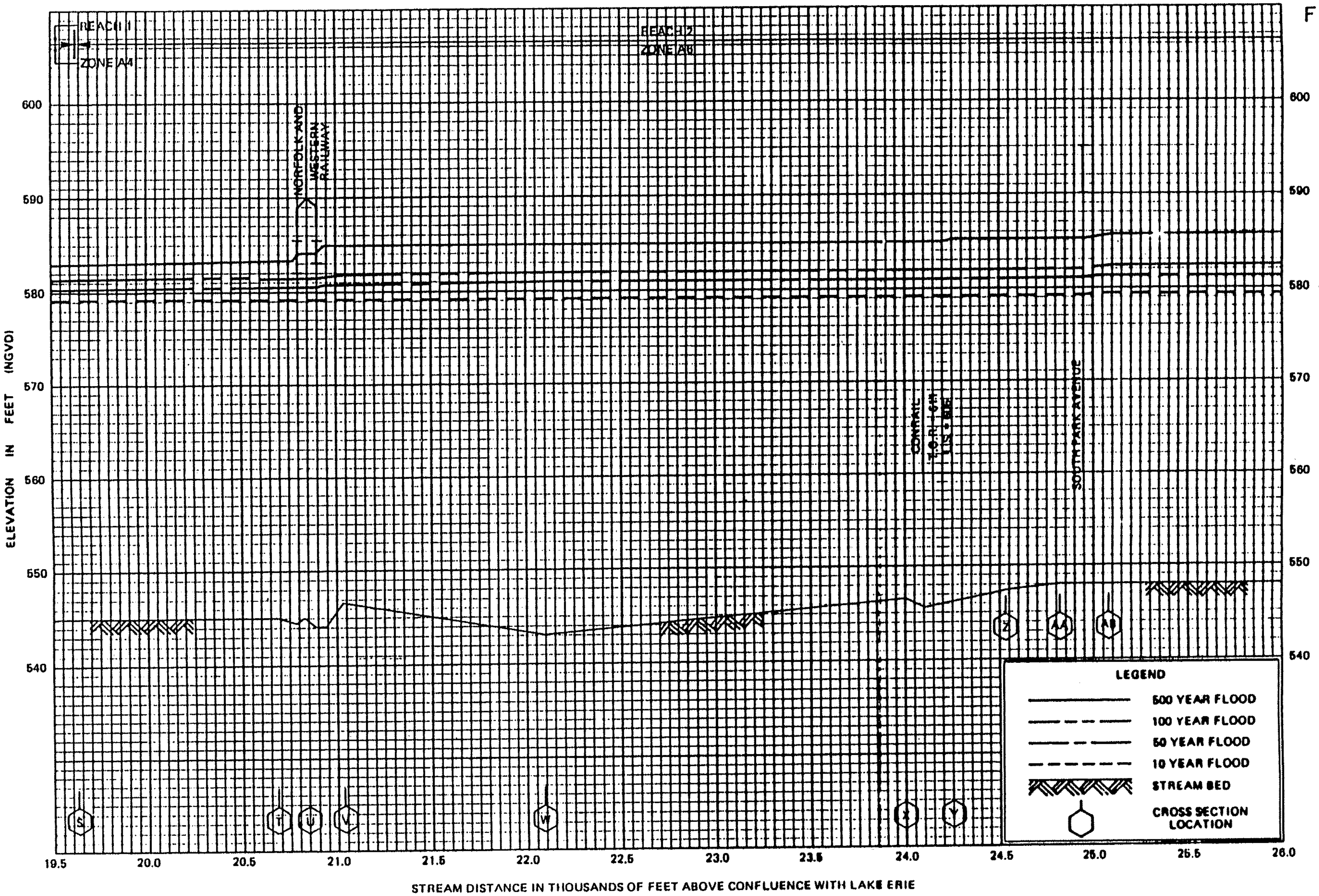
BUFFALO COLOR CORPORATION
BUFFALO, NEW YORK
AREA "D REMEDIAL INVESTIGATION

DISCHARGE BOUNDARIES OF THE BUFFALO RIVER

APPROXIMATE SCALE

800 0 800 FEET

FIGURE 5 - 3



MALCOLM PIRNIE

NOTE : FROM FEMA, 1981

BUFFALO COLOR CORPORATION
BUFFALO, NEW YORK
AREA "D REMEDIAL INVESTIGATION

CROSS - SECTION THROUGH THE BUFFALO RIDER

FIGURE 5-4

RESPONSE OF WELLS ON WESTERN SIDE

TO CHANGES IN RIVER LEVEL

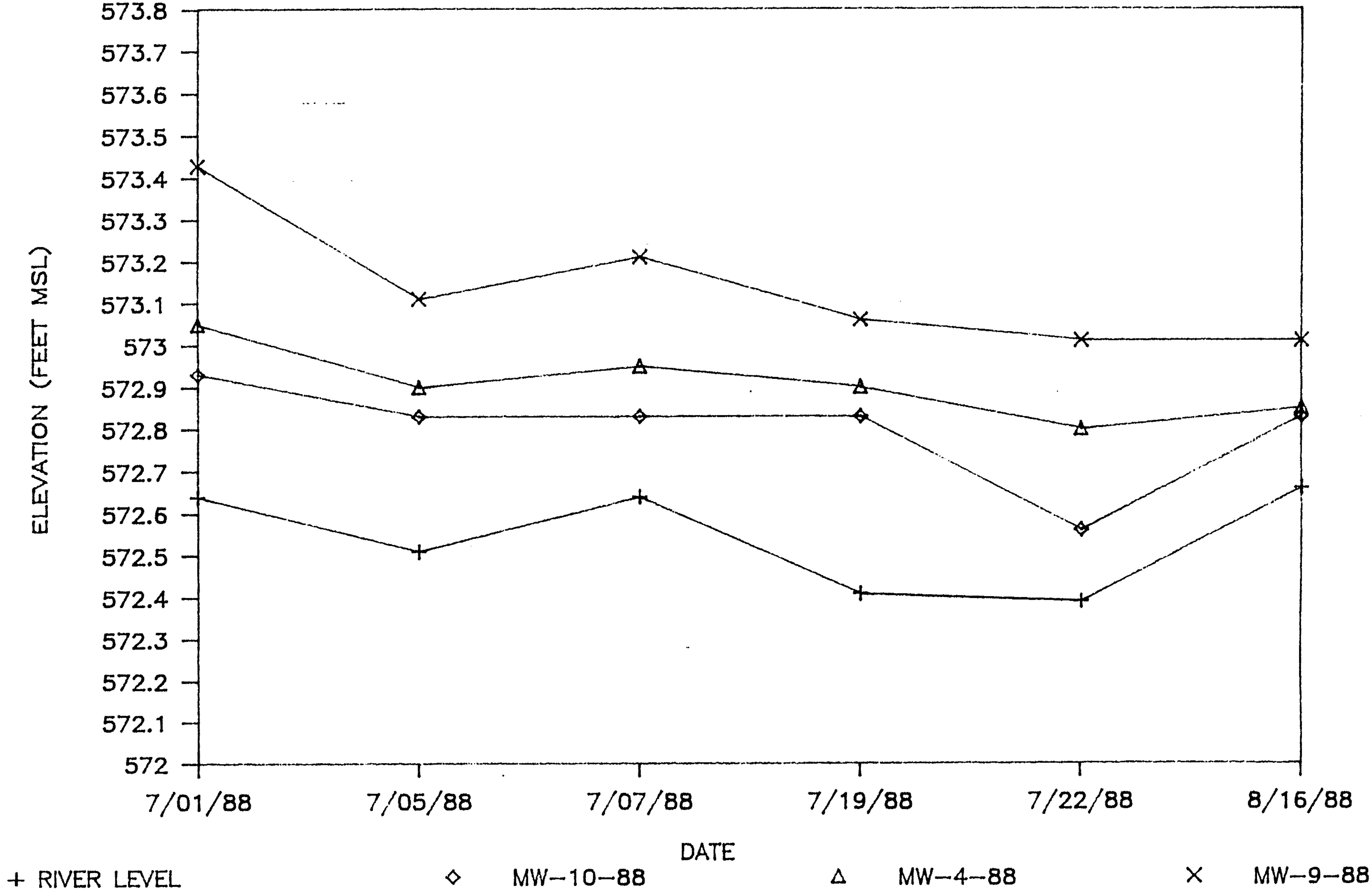


FIGURE 5-5

RESPONSE OF SHALLOW WELLS IN WEATHERING

AREA TO CHANGES IN RIVER LEVEL

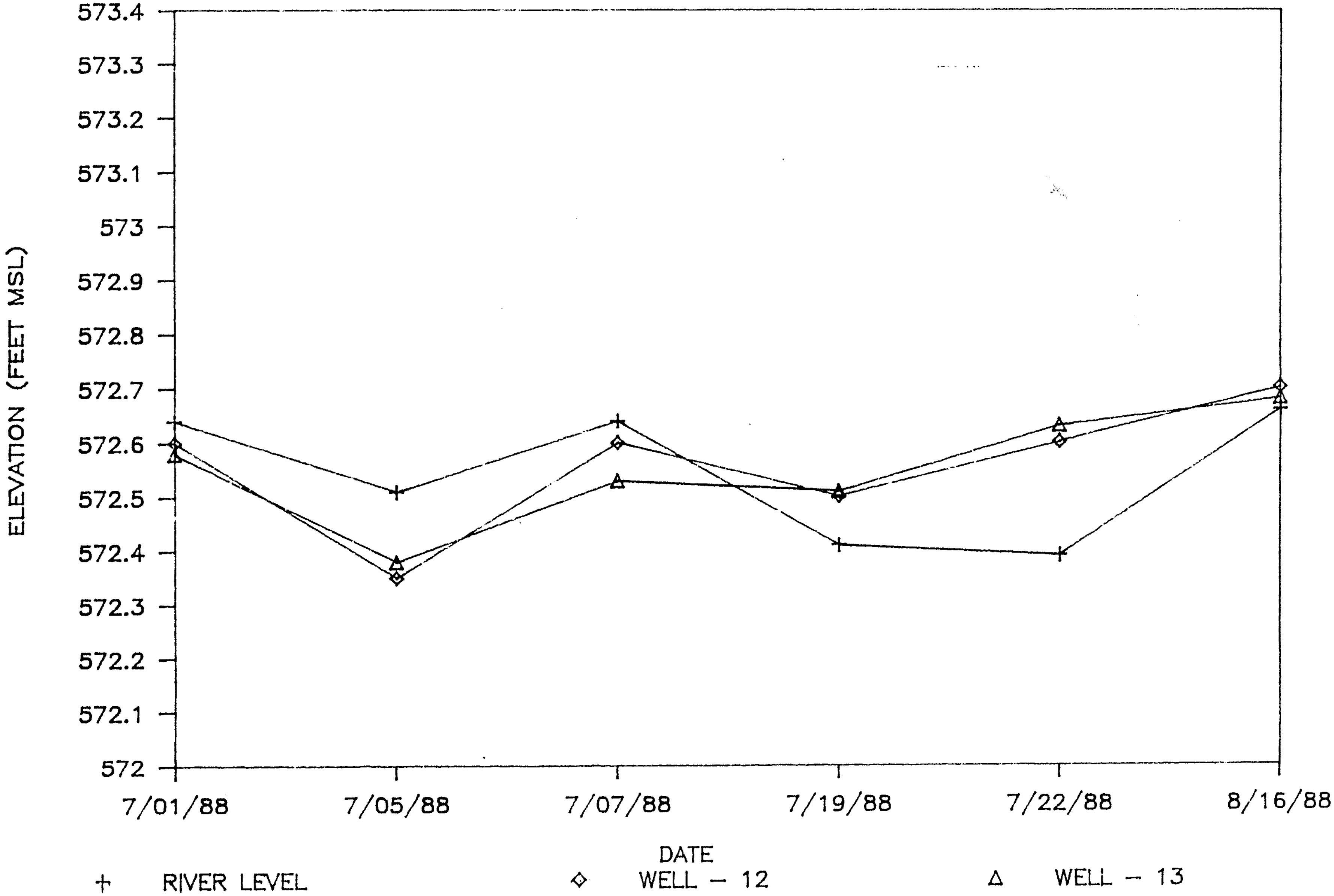


FIGURE 5-6

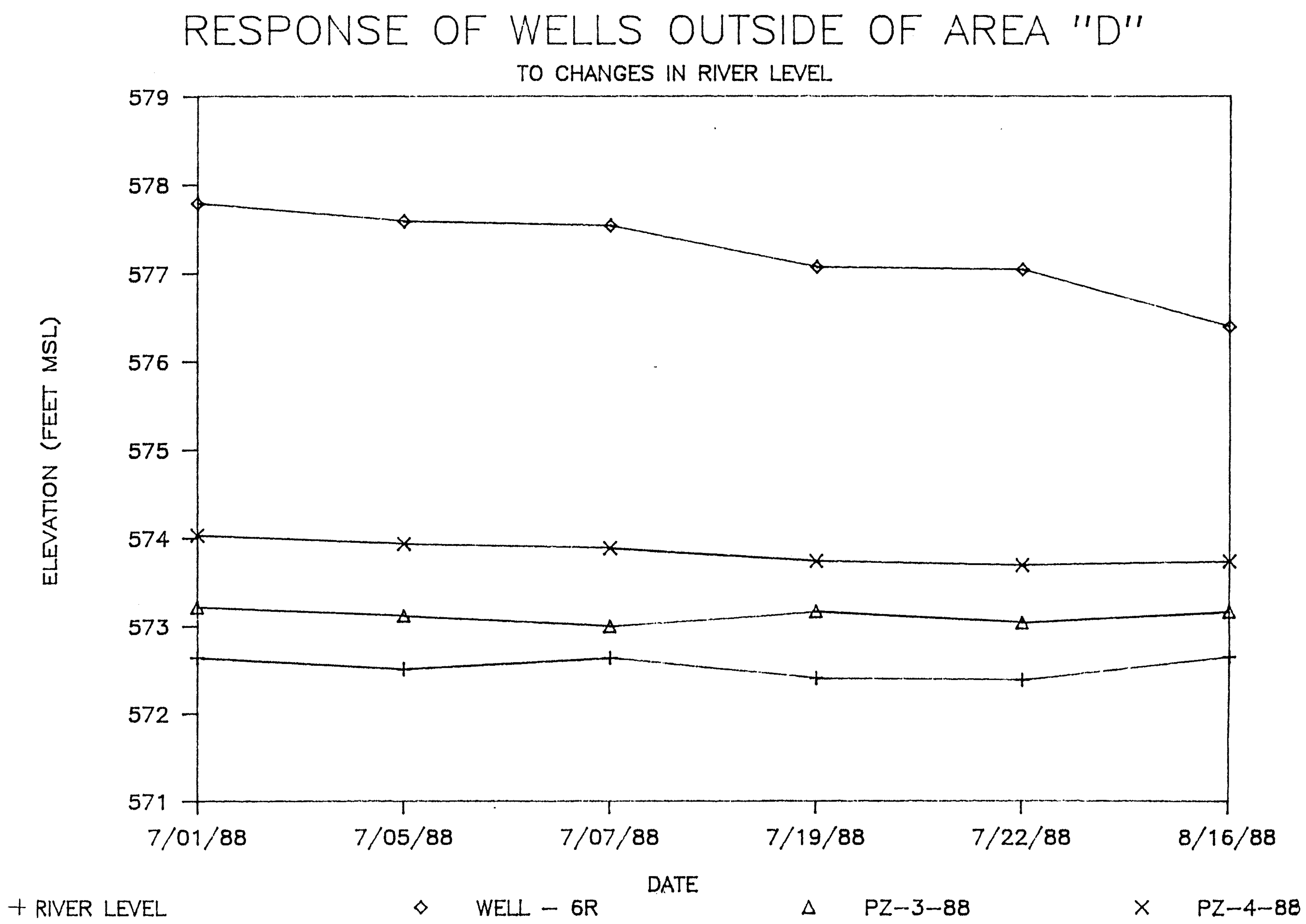

RESPONSE OF WELLS OUTSIDE OF AREA "D"
TO CHANGES IN RIVER LEVEL
ELEVATION (FEET MSL)
579
578
577
576
575
574
573
572
571
7/01/88
7/05/88
7/07/88
7/19/88
7/22/88
8/16/88
DATE
+ RIVER LEVEL
◇ WELL — 6R
Δ PZ--3--88
× PZ--4--88

FIGURE 5 - 7

RESPONSE OF SHALLOW WELLS IN LAGOON

AREA TO CHANGES IN RIVER LEVEL

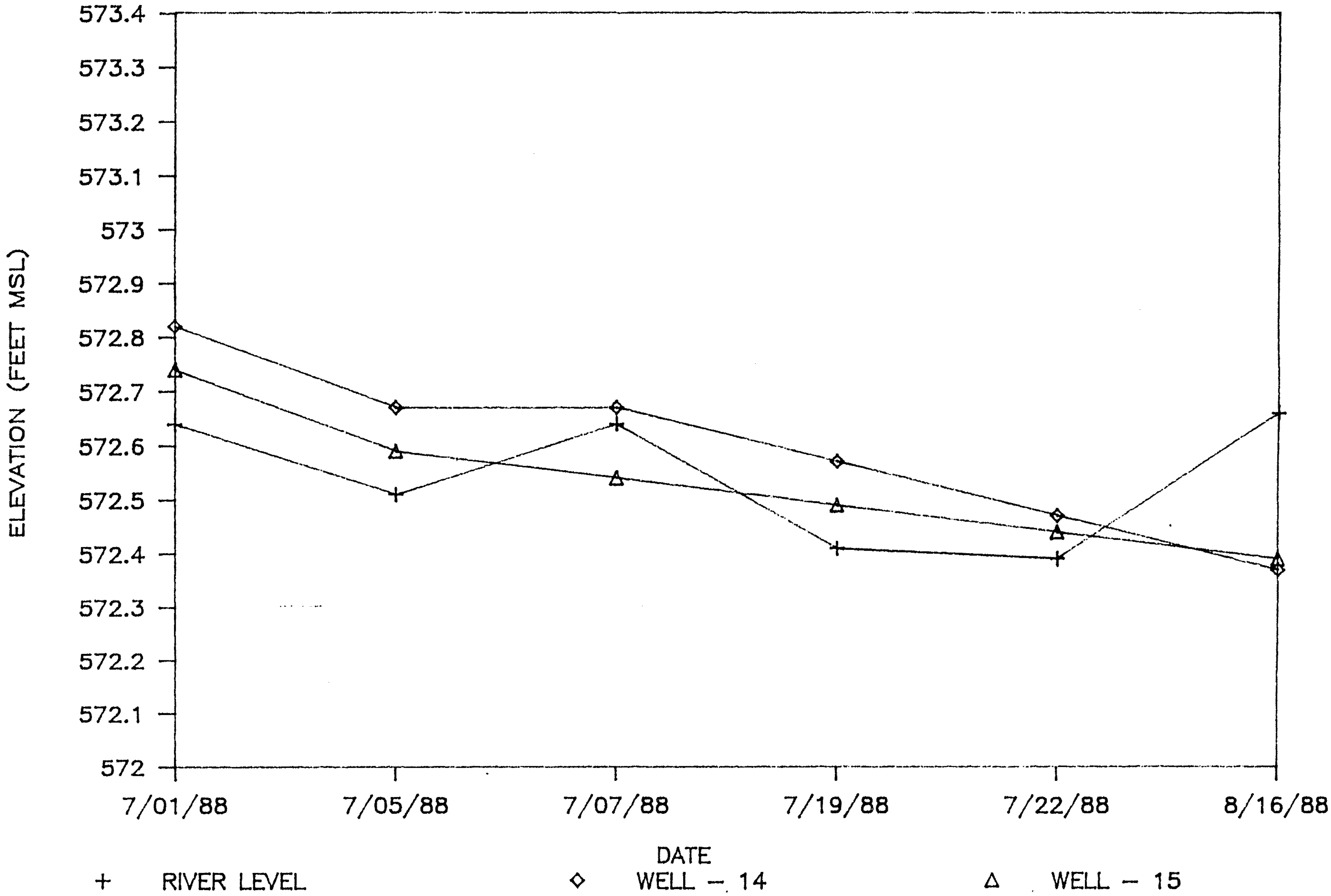
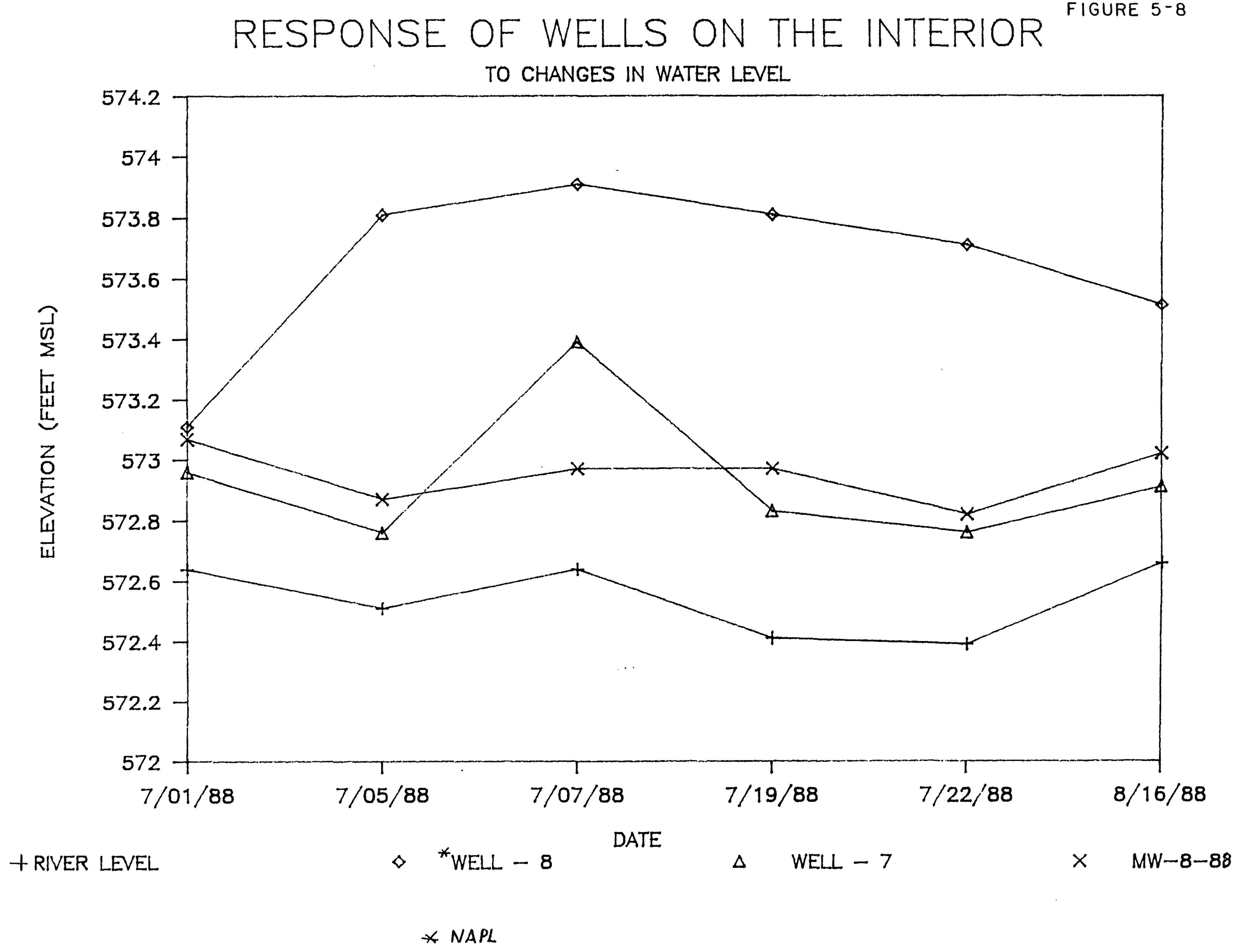
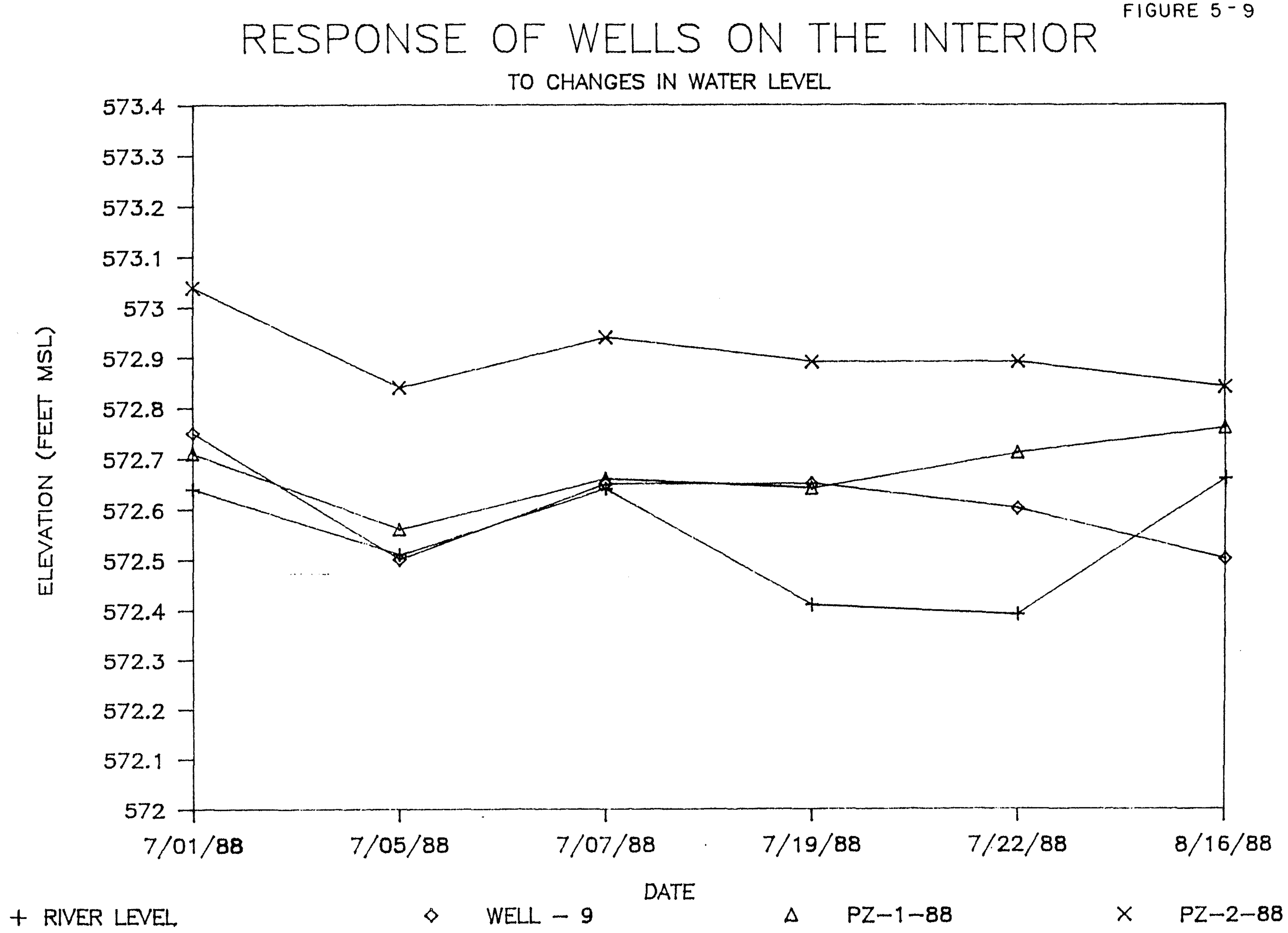


FIGURE 5-8



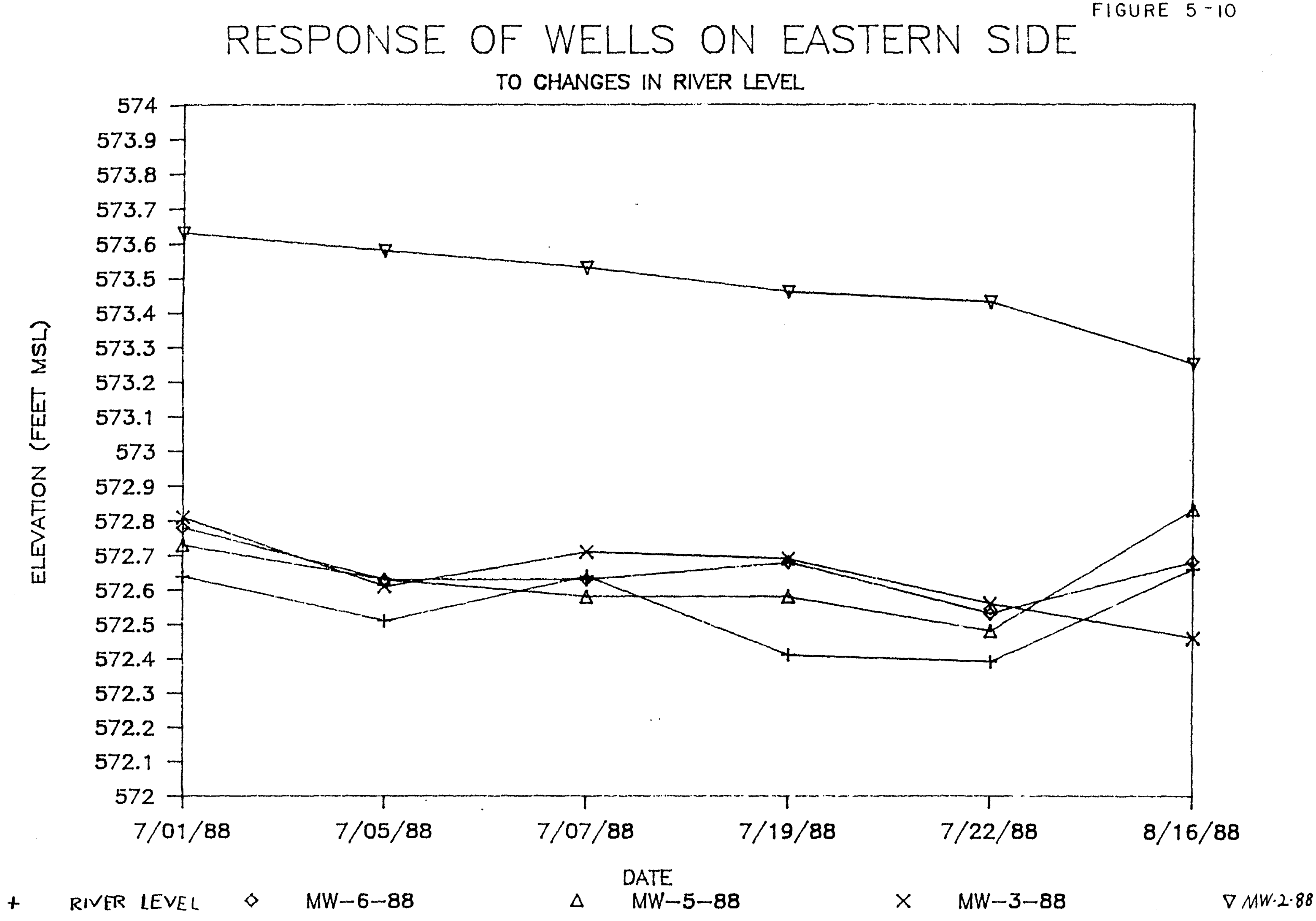
RESPONSE OF WELLS ON THE INTERIOR
TO CHANGES IN WATER LEVEL
ELEVATION (FEET MSL)
574.2
574
573.8
573.6
573.4
573.2
573
572.8
572.6
572.4
572.2
572
7/01/88
7/05/88
7/07/88
7/19/88
7/22/88
8/16/88
DATE
+ RIVER LEVEL
◇ *WELL – 8
Δ WELL – 7
× MW–8–88
* NAPL

FIGURE 5-9



RESPONSE OF WELLS ON THE INTERIOR
TO CHANGES IN WATER LEVEL
573.4
573.3
573.2
573.1
573
572.9
572.8
572.7
572.6
572.5
572.4
572.3
572.2
572.1
572
ELEVATION (FEET MSL)
7/01/88
7/05/88
7/07/88
7/19/88
7/22/88
8/16/88
DATE
+ RIVER LEVEL
◇ WELL − 9
△ PZ−1−88
× PZ−2−88

FIGURE 5-10


RESPONSE OF WELLS ON EASTERN SIDE
TO CHANGES IN RIVER LEVEL
ELEVATION (FEET MSL)
574
573.9
573.8
573.7
573.6
573.5
573.4
573.3
573.2
573.1
573
572.9
572.8
572.7
572.6
572.5
572.4
572.3
572.2
572.1
572
7/01/88
7/05/88
7/07/88
7/19/88
7/22/88
8/16/88
DATE
+ RIVER LEVEL
◇ MW-6-88
Δ MW-5-88
× MW-3-88
∇ MW-2-88

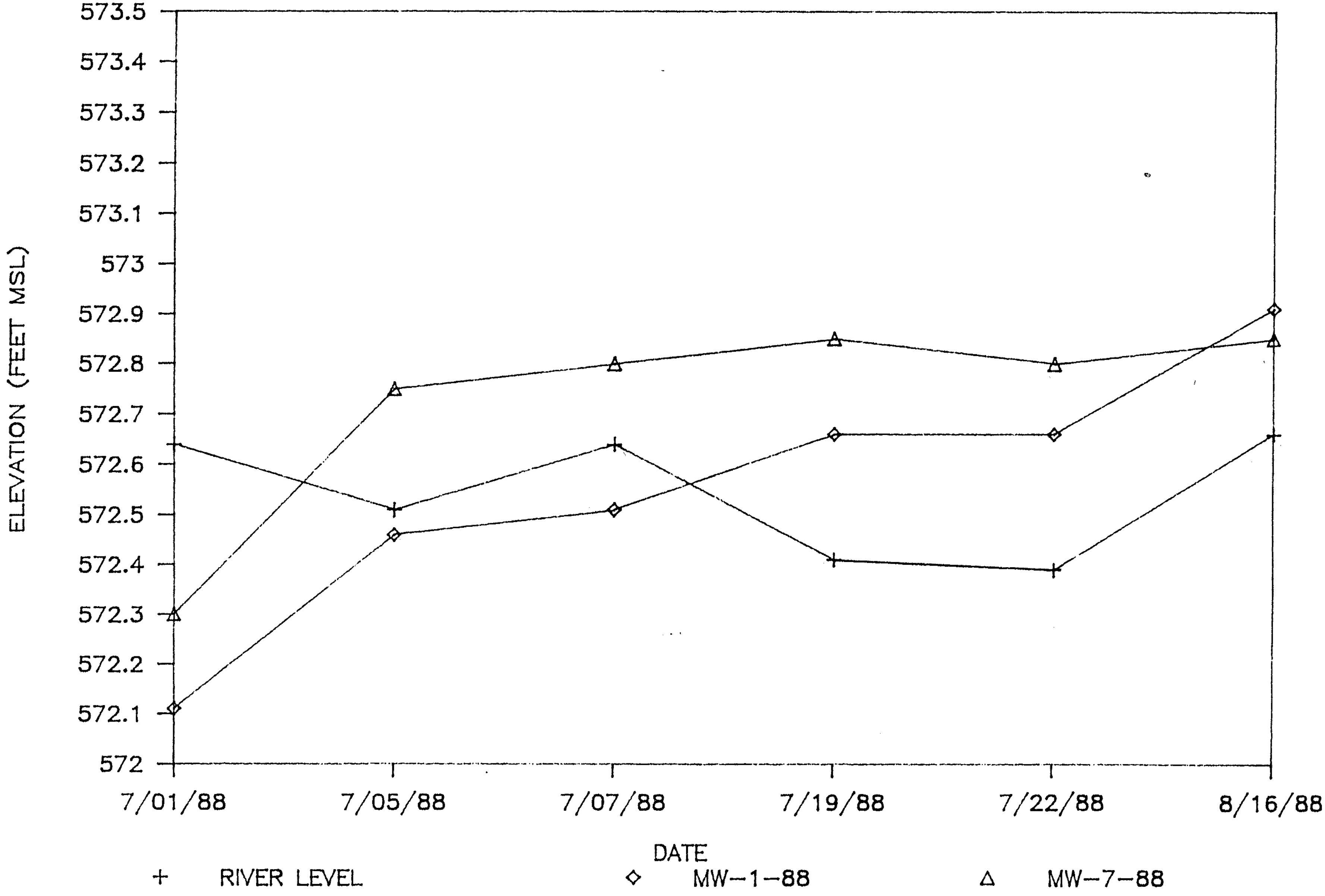
water levels are suspect due to an erroneous peak recorded on 07/07/88 and the presence of NAPL in the well (see Section 7.4), respectively.

Figure 5-11 illustrates the relationship between the ground water levels of the deep wells, MW-1-88 and MW-7-88, and the river water level elevations. Since the deep wells represent confined conditions, a relationship does not exist between these wells and the Buffalo River. The deep wells are, thus, hydraulically isolated.

FIGURE 5-11

RESPONSE OF DEEP WELLS

TO CHANGES IN RIVER LEVEL



6.0 SITE CONTAMINATION CHARACTERIZATION

6.1 METHODOLOGY

The characterization of site contamination was accomplished by analysis of soil, ground water, river water, stream sediments, and waste residuals. Samples were collected during the period of May-November, 1988. A summary of the sample collection and analysis methodology is presented below. A detailed discussion of the procedures that were used to collect and analyze all environmental samples is presented in Appendix A.2.

6.1.1 Soils

Soil samples were collected at the surface and at depth using split-spoon samplers. All surficial soil samples were collected to a depth of two (2) feet. Soil samples collected at depth were composited in accordance with the following protocol:

- For each deep boring, a Composite "A" sample was made of all of the apparently contaminated soil. The physical appearance of the soil (notably discoloration and odor) was used in conjunction with HNu total organic vapor readings to make this determination.

- At each boring, a Composite "B" sample was made of the first complete 2-foot split-spoon sample of apparently uncontaminated soil. This sample was collected within the next six (6) feet of boring sample below the Composite "A" sample.

- A "C" zone sample was made of the 2-foot split spoon sample starting six (6) feet below the top of the composite "B" sample.

If no apparently contaminated soil was encountered, no Composite "A" was collected. If the entire depth of the boring was through an apparently contaminated interval, such as the borings made to a specific depth for piezometer and monitoring well installation, then no Composite "B" and "C" was collected. For the same reason, no Composite "B" and/or "C" was collected at some of the soil borings that were terminated in the till which underlies the fill at the site. The decision to terminate all soil borings in the till was made in the field and is a deviation from the Work Plan that was approved by Buffalo Color/Allied Signal and the NYSDEC to prevent the down hole migration of contaminated fill material (see Appendix B.2). The field observations used as a basis for defining the Composite "A", "B" and "C" intervals are recorded in Appendix C.2, Boring Logs, and are summarized in Table 6-1.

Surficial soil samples were collected at nine (9) locations as shown in Figure 6-1. Soil samples were collected at depth at twenty-four (24) locations including seven (7) soil boring, four (4) piezometer installations and ten (10) monitoring well (i.e. MW-1-88 through MW-10-88) installation locations. No soil samples were collected for chemical analysis at MW-11, MW-12, MW-13, W-6R, or the previously installed monitoring wells (i.e. W-7, W-8, W-12, W-13, W-14, W-15).

The surficial soil samples and deep soil composites were analyzed for the chemical parameters identified in Table 6-2. The analytical methods used for all analyses are summarized in Table 6-3.

6.1.2 Ground Water

Seven (7) previously installed ground water monitoring wells (i.e. W-7, W-8, and W-9 installed May 1982 and W-12, W-13, W-14, and W-15 installed April 1983) and the ten (10) wells installed during May and June 1988 (i.e. MW-1 through MW-10) as a part of this RI program were sampled on two (2) occasions: 6/22-24/88 and 8/16-18/88. Subsequently, three (3) additional wells were installed (i.e. MW-11, MW-12, and MW-13) during November 1988. Samples were collected from these wells on one (1) occasion: 11/21/88. The location of each monitoring well is shown on Figure 6-1. The screened intervals of all the wells is discussed in Section 4.1.3.

All ground water samples were collected using stainless steel or teflon bailers. None of the ground water samples were filtered prior to analysis. The ground water samples were analyzed for the chemical parameters identified in Table 6-2. The analytical methods used are summarized in Table 6-3. As Table 6-2 indicates, the ground water

TABLE 6-1

BUFFALO COLOR CORPORATION

SOIL BORING FIELD OBSERVATIONS[1]

BORING NUMBER	SAMPLE INTERVAL (ft)	HEADSPACE ANALYSIS HNu RANGE (ppm)[2]	OLFACTORY EVIDENCE	VISUAL APPEARANCE	COMMENTS
MW-1-88	0 - 6	0	None	Some bluish purple staining	-
MW-2-88	0 - 16	0	Rotten egg (H_2S)	Black oily staining; cinder-like material	No "B" or "C" samples
MW-3-88	4 - 18	0 - 25	H_2S; hydrocarbon odor	Black staining, black slag, some oily substance	No "B" or "C" samples
MW-4-88	0 - 20	0 - 60	Mothball odor	Black oily NAPL, black staining	No "B" or "C" samples
MW-5-88	12 - 16	0	Hydrocarbon odor	Black oily staining, cinder-like material	No "C" sample
MW-6-88	---	0	None	Backfill material from excavation, some cinder	No "A" zone
MW-7-88	0 - 30	2 - 15	Very strong hydro-carbon odor	Black oily NAPL; black sludge-like material	-
MW-8-88	14 - 18	0 - 250	Very strong hydro-carbon odor	Black cinder-like material, oily feel, clear contaminant	No "B" or "C" samples
MW-9-88	6 - 18	0 - 38	None	Black sludge-like material	No "B" or "C" samples

TABLE 6-1 (Continued)

BUFFALO COLOR CORPORATION

SOIL BORING FIELD OBSERVATIONS[(1)]

BORING NUMBER	SAMPLE INTERVAL (ft)	HEADSPACE ANALYSIS HNu RANGE[(2)] (ppm)	OLFACTORY EVIDENCE	VISUAL APPEARANCE	COMMENTS
MW-10-88	---	0	None	No visual contamination; some construction debris	No "A" zone
MW-11-88	---	0 - 200	Very strong hydro-carbon odor	Colorless oily contaminant	No samples analyzed; Augered to 18' with no sampling
MW-12-88	---	0	None	Slight slippery feel	No samples analyzed; Augered to 18' with no sampling
MW-13-88	---	0 - 10	H_2S; strong musty odor	No visual contamination	No samples analyzed; Augered to 18' with no sampling
PZ-1-88	---	0	None	No visual contamination; some construction debris	No "A" zone
PZ-2-88	6 - 28	0 - 8	slight hydrocarbon odor	No visual contamination; some construction debris	No "B" or "C" samples
PZ-3-88	12 - 18	0 - 10	None	Slight oily sheen; some staining	No "B" or "C" samples
PZ-4-88	---	0	None	No evidence of contamination	No "A" zone

TABLE 6-1 (Continued)

BUFFALO COLOR CORPORATION

SOIL BORING FIELD OBSERVATIONS[1]

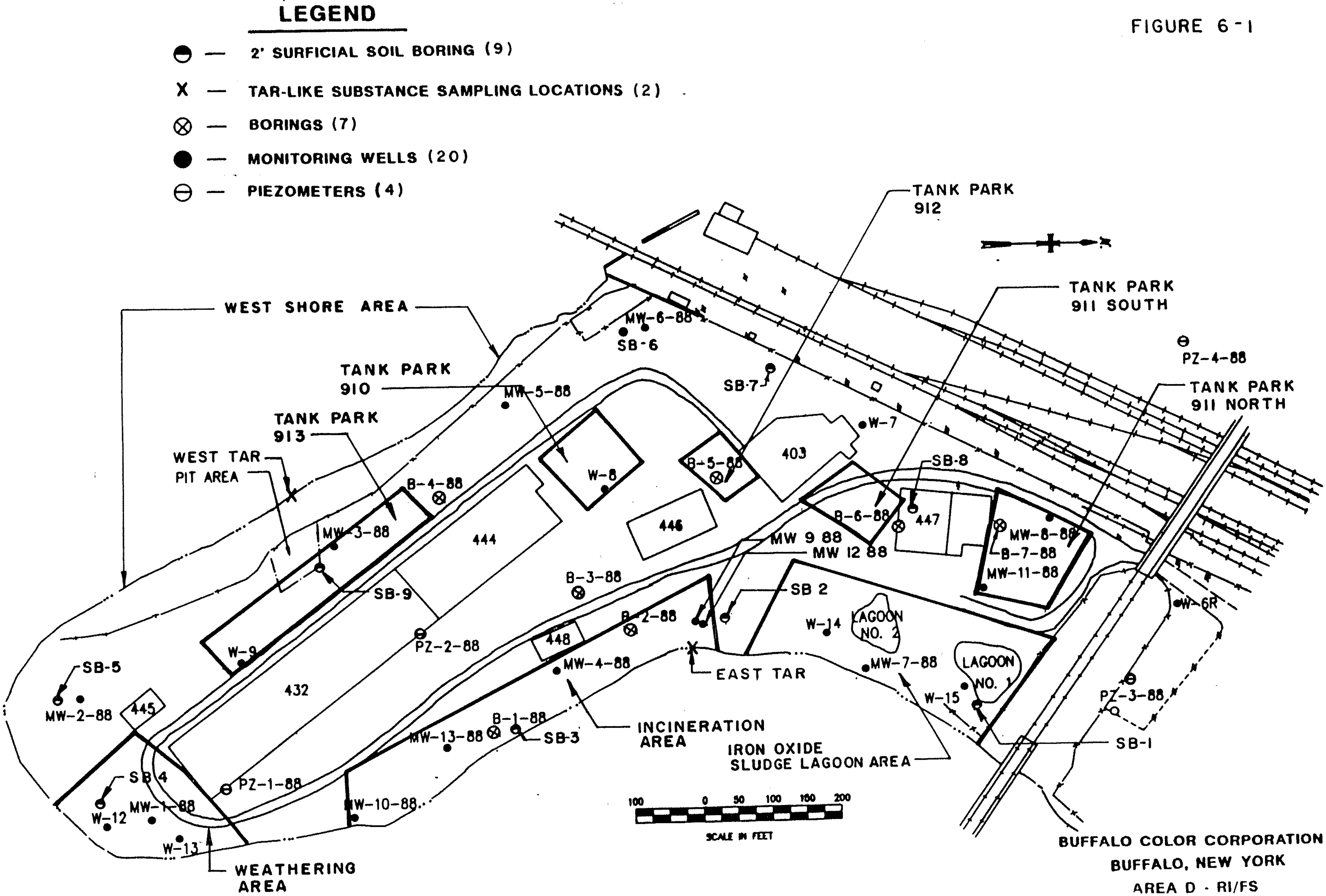
BORING NUMBER	SAMPLE INTERVAL (ft)	HEADSPACE ANALYSIS HNu RANGE[2] (ppm)	OLFACTORY EVIDENCE	VISUAL APPEARANCE	COMMENTS
B-1-88	0 - 26	10 - 240	Strong mothball odor	Black staining; oily NAPL	No "C" sample
B-2-88	6 - 28	0 - 70	Strong hydrocarbon odor	Some black staining; oily NAPL	No "B" or "C" Samples
B-3-88	20 - 24	0 - 1	Very slight hydro-carbon odor	No visual contamination	-
B-4-88	6 - 24	0 - 85	Strong H_2S odor	Black staining; oily residue; NAPL	No "C" Sample
B-5-88	6 - 10	0	None	Slight black oily residue	-
B-6-88	8 - 26	0 - 70	Hydrocarbon odor	Oily NAPL; some black staining	No "B" or "C" samples
B-7-88	4 - 30	0 - 225	Hydrocarbon odor	Black tar-like gravel; black oily NAPL	No "B" or "C" samples

NOTES:

(1) Basis for definition of Composite "A" zone.
(2) Measured using HNu PI-101 total organic vapor analyzer.

NAPL = Nonaqueous phase liquid
H_2S = Hydrogen sulfide

FIGURE 6-1



BUFFALO COLOR CORPORATION
BUFFALO, NEW YORK
AREA D - RI/FS

SAMPLING LOCATIONS

MALCOLM PIRNIE

TABLE 6-2

BUFFALO COLOR CORPORATION

ANALYTICAL PARAMETERS

SAMPLE PARAMETER	SAMPLE MATRIX								
	SURFICIAL SOIL	DEEP SOIL COMPOSITES	STREAM SEDIMENTS	GROUND WATER			RIVER WATER		WASTE RESIDUE
				6/88	8/88	11/88	6/88	8/88	
EPA Priority Pollutants									
- Volatiles				X	X	X	X	X	
- Acid Extractables				X	X	X	X	X	
- Base/Neutrals	X	X	X	X	X	X	X	X	X
- Pesticides/PCBs				X	X		X		
- Metals	X	X	X	X	X	X	X	X	X
- Cyanide (Total)				X	X		X		
1-Napthylamine				X	X		X		
Aniline					X				
N-Nitrosodiphenylamine					X				
Acetone					X				
2-Butanone					X				
Xylene					X				
TCL TICs									
Isomers of:									
Ethylmethyl benzene					X				
Methylchlorobenzene					X				
Propylbenzene					X				
1,2,3,4 Tetrahydro-2-Methyl Naphthalene					X				
Aluminum					X				
Barium					X				
Iron					X				
Magnesium					X				
Manganese					X				
Hexavalent Chromium				X	X		X		
TOX	X	X	X	X	X	X			X
TOC				X	X	X			
pH				X	X	X		X	X
Specific Conductivity				X	X	X			X
Turbidity				X	X	X			

TABLE 6-3

ANALYTICAL METHODS
SURFACE AND GROUND WATER, SOILS AND STREAM SEDIMENTS

PARAMETER	METHOD	METHOD REFERENCE
EPA Priority Pollutant Volatiles	CLP Protocol based on GC/MS Method 624	1
EPA Priority Pollutant Acid Extractables	CLP Protocol based on GC/MS Method 625	1
EPA Priority Pollutant Base/Neutral Extractables	CLP Protocol based on GC/MS Method 625	1
EPA Priority Pollutant Pesticides/PCBs	CLP Protocol based on GC/MS Method 608	1
EPA Priority Pollutant Metals (Total)	CLP Protocol using ICP or AA	2
Total Cyanide	CLP Protocol based on Method 335.2	2
Total Organic Halides (Water Only)	9020	3
Total Organic Halides (Soils Only)	See Appendix D.1	
Total Organic Carbon	9060	3
pH (Water only)	9050	3
Specific Conductivity (Water only)	9050	3

NOTE:
1. Analyzed in field immediately upon collection of sample.

REFERENCES:
1) USEPA Contract Laboratory Program, Statement of Work for Work for Organic Analysis, Multi-Media, Multi-Concentration. October 1986, Revised 1/87, 2/87, 7/87.
2) USEPA Contract Laboratory Program, Statement of Work for Inorganic Analysis, Multi-Media, Multi-Concentration. July 1985.
3) Test Methods for Evaluation Solid Waste, USEPA Office of Solid Waste and Emergency Response. SW846, third edition. November 1986.

analytical parameter list was modified during the course of the RI program. This occurred as a result of on-going discussions between Buffalo Color and the NYSDEC as documented in Appendix A.3.

6.1.3 Surface Water

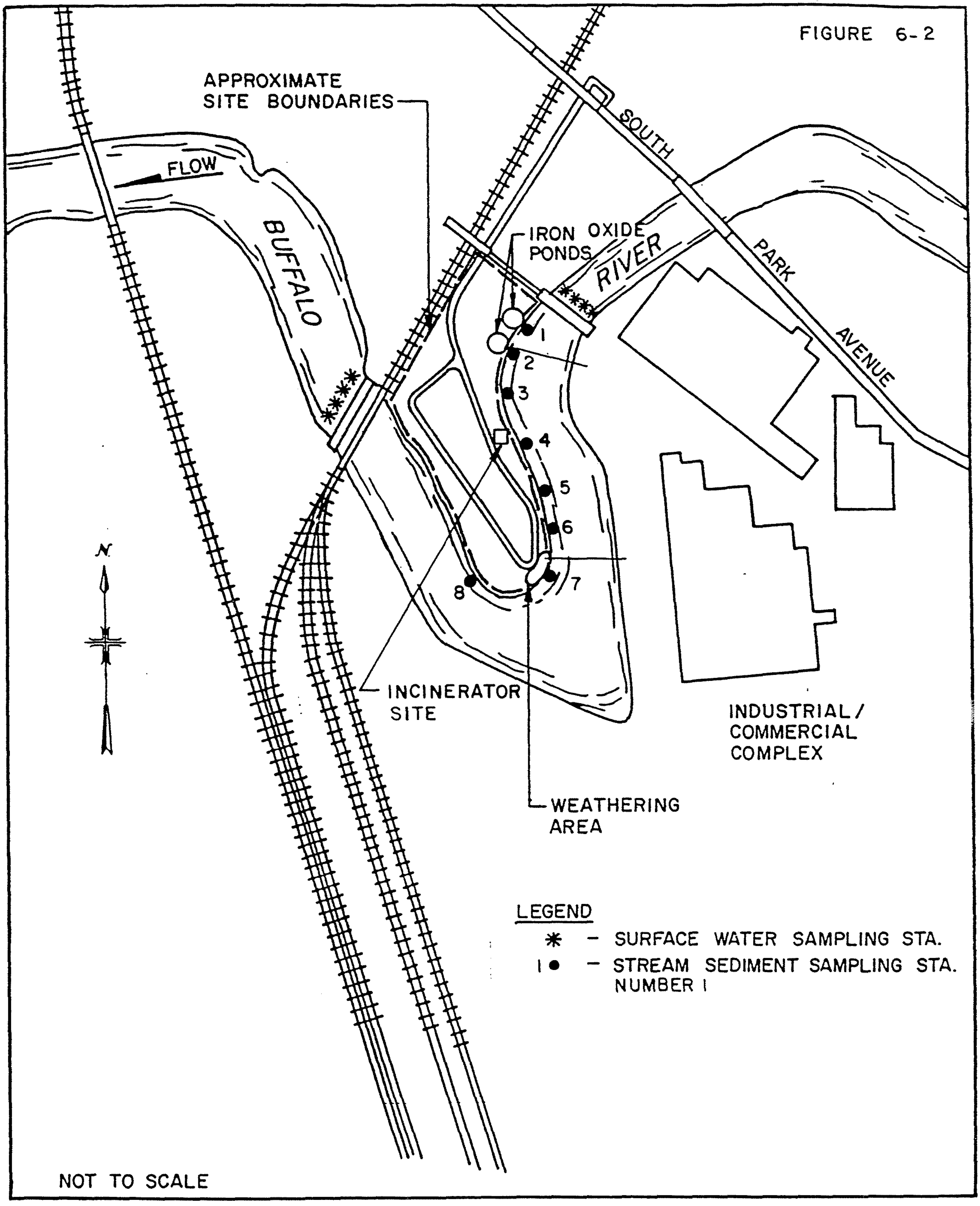
Surface water samples were collected from the Buffalo River on each of the first two (2) occasions that ground water samples were collected (i.e. 6/27/88 and 8/19/88). Samples were collected using grab sampling techniques at two (2) stream monitoring locations as shown on Figure 6-2. These samples were analyzed for the chemical parameters identified in Table 6-2 using the analytical methods given in Table 6-3.

6.1.4 Stream Sediments

A total of eight (8) river-bottom sediment samples were collected from the Buffalo River at the locations shown on Figure 6-2. A description of the sampling locations and field observations is summarized in Table 6-4. All sediment samples were collected on 6/28/88.

As described in the Work Plan (Appendix A.2), the stream sediment samples were to be collected by core sampling. However, the sampling personnel were unsuccessful in obtaining samples in this manner due to the presence of a large quantity of bricks, broken concrete, and other rubble on the stream bottom in the immediate vicinity of Area "D". Consequently, all sediment samples were collected using a Ponar Dredge Sampler. At each sample location, the dredge was lowered to the bottom of the river with a cable, and engaged. Upon retrieval, the dredge was opened into a stainless steel pan and the sediments transferred into the sample jars using a stainless steel spoon. Between each sampling location, all equipment was scrubbed with soap and water, rinsed with distilled/deionized water, and final-rinsed with acetone.

All sediment samples were analyzed for the parameters given in Table 6-2 using the methods given in Table 6-3.



MALCOLM PIRNIE

AREA "D" RI / FS
WATER / SEDIMENT
SAMPLING LOCATIONS

BUFFALO COLOR

MALCOLM PIRNIE

TABLE 6-4

BUFFALO COLOR CORPORATION

STREAM SEDIMENT SAMPLING STATION DESCRIPTIONS

SAMPLING STATION	APPROXIMATE WATER DEPTH (ft.)	OBSERVATIONS(1)
1	10	747+00; very oily-smelling sludge-like sediments
2	10	Very oily-smelling sludge-like sediments
3	10	Very oily-smelling sludge-like sediments; in small cove
4	8	Bottom littered with rubble
5	6	Sample station adjacent to effluent pipe on shore
6	10-12	Bottom littered with brick, rock. Large pieces of slag/cinder on shore
7	6	Adjacent to "Weathering Area"
8	4	Along West Shore

NOTE:

(1) Sample Station No. 1 is centered on sounding line 747+00 on the U.S. Army Corps of Engineers Buffalo Harbor Drawing No. 795-BFR-1/5. This location is also marked on the River by the numbers painted on rocks on shore. All subsequent subsequent stream stations were located at approximate 200-foot intervals from Station No. 1, except Station No. 8 which was further around the tip of the peninsula.

6.1.5 Waste Residuals

On October 7, 1988, Malcolm Pirnie scientists conducted a reconnaissance of the Area "D" shoreline. The Buffalo River had dropped by six (6) inches or more from the time the RI field activities had been initiated during May 1988. The receding water line made possible the inspection of areas that previously had been under water.

During the shoreline reconnaissance, deposits of a tar-like substance were observed at several locations. In each instance this material was observed, it was located at the river's edge. This material had a strong organic odor and, when disturbed, it released substances that formed an oily sheen on the surface of the river. To further characterize this material, two (2) grab samples were collected on 11/8/88. The sample locations are shown on Figure 6-1. These samples were analyzed for parameters given in Table 6-2 using the methods given in Table 6-3.

6.2 SOIL

A summary of the soil sample analytical results for those parameters having at least one detected value is presented in Tables 6-5 and 6-6. The raw data and EPA Contract Laboratory Program (CLP) documentation package are presented in Appendix D.2. A discussion of the character of contamination found in each area of the site is presented below. For the purpose of this discussion, the site has been segregated into the following areas (see Figure 6-1):

- Iron Oxide Sludge Lagoons
- Incineration Area
- Weathering Area
- West Shore
- Tank Parks
- Remainder of Site Interior
- Outside Areas

6.2.1 Iron Oxide Sludge Lagoons

During the course of this study, soil samples were collected at depth at a single location in this area (MW-7-88) and on the surface at

SITE LOCATION	IRON OXIDE SLUDGE LAGOON			<<<INCINERATION AREA>>>						
SAMPLE NUMBER	MW-7-88	MW-7-88	MW-7-88	MW-4-88	MW-10-88	MW-10-88	B-1-88	B-1-88	B-2-88	MW-9-88
SAMPLE ZONE	A	B	C	A	B	C	A	B	A	A
DEPTH OF SAMPLE	0-30'	30-32'	36-38'	0-20'	0-2'	6-8'	0-26'	26-28'	6-28'	6-18'
SEMIVOLATILE ORGANICS (mg/kg)										
1,4-DICHLOROBENZENE				11 D			13 DJ			
1,2-DICHLOROBENZENE				27 D			110 D	1.8 DJ		
NITROBENZENE	8.7 DJ						1100 DE	2.0 DJ		0.21 DJ
1,2,4-TRICHLOROBENZENE							150 D	1.2 DJ		
NAPHTHALENE	4.3 DJ				2.7 DJ			2.8 DJ		
2-CHLORONAPHTHALENE							140 D	0.55 DJ		
2-NITROANILINE										
ACENAPHTHYLENE							0.41 DJ			
ACENAPHTHENE										0.40 DJ
2,4-DINITROTOLUENE										
FLUORENE										0.50 DJ
PHENANTHRENE	1.6 BDJ				2.4 BDJ		5.7 DJ			4.6 BDJ
ANTHRACENE							1.3 DJ			1.3 DJ
DI-n-BUTYLPHTHALATE						0.56 BDJ				0.76 BDJ
FLUORANTHENE					1.7 DJ		1.2 DJ			4.8 DJ
PYRENE	0.83 DJ				1.6 DJ		0.93DJ			3.9 DJ
BENZO(a)ANTHRACENE										1.9 DJ
BIS(2-ETHYLHEXYL) PHTHALATE										0.29 BDJ
CHRYSENE										2.1 DJ
DI-N-OCTYL PHTHALATE										
BENZO(b)FLUORANTHENE										3.1 DJ
BENZO(a)PYRENE										1.7 DJ
INDENO(1,2,3-cd)PYRENE										0.76 DJ
DIBENZO(a,h)ANTHRACENE										0.43 DJ
BENZO(g,h,i)PERYLENE										0.78 DJ
EOX (mg/kg)	220	160	<10	14	360	24	<10	<10	<10	53
TOTAL METALS (mg/kg)										
ANTIMONY	4				39		0.91			
ARSENIC	84	13	15	16	276	2860	27	14	16	133
BERYLLIUM		1	1.1					0.99		
CADMIUM				5			1.5		1.6	
CHROMIUM	37	32	39	19	440	42	48	31	22	319
COPPER	4630	32	32	601	936	186	575	34	209	319
IRON	264000	28700	31500	19800	360000	35300	15500	29100	15100	78600
LEAD	187	29	35	9.2	538	38	410	25	51	719
MERCURY	0.24				1.3		0.28			1.8
NICKEL	467	60	64	25	331	31	20	34	48	104
SELENIUM										9.6
SILVER	3			2.2	4.3	0.71				0.82
THALLIUM					1.9	66				9.6
ZINC	473	86	97	500	1160	84	39	82	270	267

Laboratory Qualifiers: B-Detected in lab blank D-Secondary dilution J-Estimated value

SITE LOCATION	<<<<<<<WEATHERING AREA>>>>>>>>			<<<<<<<<<<<<<<<<<<<<<WEST SHORE>>>>>>>>>>>>>>>>>>>>>				
SAMPLE NUMBER	MW-1-88	MW-1-88	MW-1-88	MW-2-88	MW-5-88	MW-5-88	MW-6-88	MW-6-88
SAMPLE ZONE	A	B	C	A	A	B	B	C
DEPTH OF SAMPLE	0-6'	6-8'	12-14'	0-16'	12-16'	16-18'	2-4'	8-10'
SEMIVOLATILE ORGANICS (mg/kg)								
1,4-DICHLOROBENZENE								
1,2-DICHLOROBENZENE								
NITROBENZENE				5.9 DJ				
1,2,4-TRICHLOROBENZENE								
NAPHTHALENE				8.2 DJ				
2-CHLORONAPHTHALENE								
2-NITROANILINE								
ACENAPHTHYLENE				1.6 DJ				
ACENAPHTHENE								
2,4-DINITROTOLUENE								
FLUORENE				2.5 DJ				
PHENANTHRENE				9.9 DJ			2.1 DJ	
ANTHRACENE				4.8 DJ				
DI-n-BUTYLPHTHALATE			0.54 DJ		0.60 J	0.36 J		
FLUORANTHENE				14 D			2.5 DJ	
PYRENE				13 D			2.1 DJ	
BENZO(a)ANTHRACENE				6.7 DJ			1.1 DJ	
BIS(2-ETHYLHEXYL) PHTHALATE					0.62	0.23 J		
CHRYSENE				8.2 DJ			1.4 DJ	0.35 DJ
DI-N-OCTYL PHTHALATE								
BENZO(b)FLUORANTHENE				9.7 DJ			1.6 DJ	
BENZO(a)PYRENE				5.5 DJ		0.09 J	0.84 DJ	0.17 DJ
INDENO(1,2,3-cd)PYRENE				2.9 DJ			0.49 JD	
DIBENZO(a,h)ANTHRACENE				0.83 DJ				
BENZO(g,h,i)PERYLENE				2.6 DJ			0.48 DJ	
EOX (mg/kg)	68	<10	20	89	11	17	<10	<10
TOTAL METALS (mg/kg)								
ANTIMONY				7.4	0.71		0.81	0.89
ARSENIC	23	8.1	5	84	38	34	54	61
BERYLLIUM				0.93	0.76	0.7		1
CADMIUM	0.93					4.9		2
CHROMIUM	118	15	14	364	17	16	57	47
COPPER	14500	47	168	341	31	29	121	84
IRON	32700	21600	11700	300000	17900	17300	33000	27400
LEAD	1640	331	21	77	22	24	276	151
MERCURY	6		0.68				1.6	0.89
NICKEL	57	19	20	164	28	41	35	35
SELENIUM				14	21	12	15	20
SILVER				2.1			0.7	
THALLIUM				19	6.3			1.4
ZINC	349	58	59	716	82	106	316	397

Laboratory Qualifiers: B-Detected in lab blank D-Secondary dilution J-Estimated value

SITE LOCATION	<<<<<<<<<<TANK PARK 913>>>>>			TANK PARK 911 NORTH		<<<<<<<<<TANK PARK 912>>>>>>>>>		
SAMPLE NUMBER	MW-3-88	B-4-88	B-4-88	MW-8-88	B-7-88	B-5-88	B-5-88	B-5-88
SAMPLE ZONE	A	A	B	A	A	A	B	C
DEPTH OF SAMPLE	4-18'	6-24'	24-26'	14-18'	4-30'	6-10'	10-12'	16-18'
SEMIVOLATILE ORGANICS (mg/kg)								
1,4-DICHLOROBENZENE								
1,2-DICHLOROBENZENE								
NITROBENZENE								
1,2,4-TRICHLOROBENZENE								
NAPHTHALENE	5.5 DJ					1.9 DJ		
2-CHLORONAPHTHALENE								
2-NITROANILINE								1.1 DJ
ACENAPHTHYLENE						1.7 DJ		
ACENAPHTHENE								
2,4-DINITROTOLUENE	2.6 DJ							3.4 DJ
FLUORENE						1.5 DJ		
PHENANTHRENE	0.72 DJ					11 BD		
ANTHRACENE						3.4 DJ		
DI-n-BUTYLPHTHALATE							0.29 BJ	
FLUORANTHENE						11 D		
PYRENE						8.3 D		
BENZO(a)ANTHRACENE						4.6 DJ		
BIS(2-ETHYLHEXYL) PHTHALATE				1.9 DJ			0.73 B	
CHRYSENE						5.0 DJ		
DI-N-OCTYL PHTHALATE							0.06 J	
BENZO(b)FLUORANTHENE						6.1 DJ		
BENZO(a)PYRENE						3.5 DJ		
INDENO(1,2,3-cd)PYRENE						2.0 DJ		
DIBENZO(a,h)ANTHRACENE						0.69 DJ		
BENZO(g,h,i)PERYLENE						1.8 DJ		
EOX (mg/kg)	<10	160	<10	38	33	170	<10	16
TOTAL METALS (mg/kg)								
ANTIMONY		0.91				119		0.63
ARSENIC	69	7.6	43	22	32	61	43	14
BERYLLIUM			1.3					
CADMIUM			7		5.2	0.7		
CHROMIUM	113	13	27	9.1	64	199	31	9.3
COPPER	86	11	27	135	22	644	60	17
IRON	26500	1750	24400	5080	11900	46400	9620	2180
LEAD	66	36	32	12	28	83200	16	94
MERCURY	0.73	0.48			0.19	14		1.9
NICKEL	68	3.9	35	11	37	39	11	8.7
SELENIUM	11	10	19	4	6.5	1.8		0.99
SILVER	1.3	1.8	5.7		1.1	5.9		
THALLIUM								
ZINC	305	43	88	201	237	229	36	12

Laboratory Qualifiers: B-Detected in lab blank D-Secondary dilution J-Estimated value

SITE LOCATION	TP 911S	<<<<<<<<<<<<<<<<SITE INTERIOR>>>>>>>>>>>>>					NORTH	RAILYARD
SAMPLE NUMBER	B-6-88	B-3-88	B-3-88	B-3-88	PZ-1-88	PZ-2-88	PZ-3-88	PZ-4-88
SAMPLE ZONE	A	A	B	C	B	A	A	B
DEPTH OF SAMPLE	8-26'	20-24'	24-26'	29-31'	2-4'	10-18'	12-18'	0-2'
SEMIVOLATILE ORGANICS (mg/kg)								
1,4-DICHLOROBENZENE						1.7 DJ		
1,2-DICHLOROBENZENE						0.91 DJ		
NITROBENZENE								
1,2,4-TRICHLOROBENZENE								
NAPHTHALENE						0.19 DJ		
2-CHLORONAPHTHALENE								
2-NITROANILINE								
ACENAPHTHYLENE								
ACENAPHTHENE								
2,4-DINITROTOLUENE								
FLUORENE						0.10 DJ		
PHENANTHRENE						0.51 BDJ		
ANTHRACENE								
DI-n-BUTYLPHTHALATE						0.47 BDJ		
FLUORANTHENE						0.19 DJ		
PYRENE						0.14 DJ		
BENZO(a)ANTHRACENE								
BIS(2-ETHYLHEXYL) PHTHALATE						1.1 BDJ		
CHRYSENE								
DI-N-OCTYL PHTHALATE								
BENZO(b)FLUORANTHENE								
BENZO(a)PYRENE						0.43 DJ		
INDENO(1,2,3-cd)PYRENE								
DIBENZO(a,h)ANTHRACENE								
BENZO(g,h,i)PERYLENE								
EOX (mg/kg)	<10	<10	<10	<10	<10	260	<10	99
TOTAL METALS (mg/kg)								
ANTIMONY								
ARSENIC	13	4	16	15	14	11	4.6	16
BERYLLIUM			0.76		0.89			0.99
CADMIUM	2						1.5	0.93
CHROMIUM	7.9	5.7	24	27	20	22	12	43
COPPER	10	6	24	28	22	49	32	101
IRON	7580	8070	23600	27600	18000	9560	8220	28400
LEAD	14	8.4	30	28	14	13	8.9	231
MERCURY								1.1
NICKEL	14	7.1	28	33	23	24	18	19
SELENIUM	5.1							
SILVER	1.1	5.8	2.2	0.93		1	0.89	1.2
THALLIUM								
ZINC	55	44	79	85	154	46	437	359

Laboratory Qualifiers: B-Detected in lab blank D-Secondary dilution J-Estimated value

TABLE 6-6: SUMMARY OF CONTAMINANTS IN SURFACE SOIL (0-2')

SITE LOCATION / SAMPLE NUMBER	IRON OX LAGOONS SB - 1	EAST SHORE SB - 2	INCIN AREA SB - 3	WEATHER AREA SB - 4	SOUTH SHORE SB - 5	WEST SHORE SB - 6	WEST BOUNDARY SB - 7	TANK PARK 11S SB - 8	TANK PARK 913 SB - 9
SEMIVOLATILE ORGANICS (mg/kg)									
NITROBENZENE			580						
BENZOIC ACID				2.8 J					
NAPHTHALENE			470						
2-CHLORONAPHTHALENE			66 J						
ACENAPHTHYLENE				16 J					
FLUORENE				25 J					
PHENANTHRENE				270 J					53 J
FLUORANTHENE				330 J					
PYRENE				310 J					
BENZO(a)ANTHRACENE				180 J					
CHRYSENE				180 J					
BENZO(b)FLUORANTHENE				150 J					
BENZO(k)FLUORANTHENE				140 J					
BENZO(a)PYRENE				140 J					
INDENO(1,2,3-cd)PYRENE				77 J					
BENZO(g,h,i)PERYLENE				63 J					
EOX (mg/kg)	87	46	2780	454	66	<10	11	54	27
TOTAL METALS (mg/kg)									
ANTIMONY		25.2	32.2	8					
ARSENIC	20.9	4.5	77.2	16.5	11.1	7.7	9	17.3	25.2
BERYLLIUM		0.9	0.58		1.3	1.2		0.58	1.2
CADMIUM			24.8	3	0.82			1.3	1.9
CHROMIUM	1076	662	1990	804	114	44.2	93.1	153	55.3
COPPER	984	177	3580	1170	118	36.2	44.4	640	134
IRON	537000	71700	80750	38900	53600	25400	98008	43000	15200
LEAD	8.9	224	5520	27300	394	50.4	145	323	221
MERCURY	0.36	4.8	6.2	4.4	3		0.65	1.2	1
NICKEL	351	77.3	363	69.8	33	19.8	14.8	190	17.6
SELENIUM						0.55			
SILVER	4.6	1.3	4.2	1.3	1.1	0.66	1.2	0.93	0.88
ZINC	34.5	159	3320	657	455	203	294	335	639

Sample Date: 11/8/88

Laboratory Qualifiers:

J - Estimated value

one other location (SB-1). The area appears to be dominated by the presence of iron (53.7 percent at the surface and 26.4 percent in the 30-foot deep "A" zone composite). Other notable metals contained in the fill in this area are:

Copper	32 - 4630 ppm
Chromium	32 - 1076 ppm
Zinc	35 - 473 ppm
Nickel	60 - 467 ppm

The concentrations of iron and nickel in this area were the highest detected in the Area "D" soils.

No organic contaminants were found below the 30-foot depth. However, the "A" composite collected from the 0-30 foot interval contained the following:

Nitrobenzene	8.7 ppm
Naphthalene	4.3 ppm
Phenanthrene	1.6 ppm

6.2.2 Incineration Area

Soils collected within this area were found to be highly variable with respect to the type and concentration of contaminants present. The soils in the immediate vicinity of the former incinerator (at MW-4-88, B-1, and SB-3) are highly contaminated. Contaminants in this area include:

Nitrobenzene	ND - 1110 ppm
Naphthalene	ND - 470 ppm
1,2,4-trichlorobenzene	ND - 150 ppm
2-chloronaphthalene	ND - 140 ppm
1,2-dichlorobenzene	27 - 110 ppm
1,4-dichlorobenzene	11 - 13 ppm

Soil in this vicinity is contaminated from the surface to the maximum depth at which samples were collected (i.e. 20-28 ft.), although the organic contaminant concentrations appear to decrease with depth. Iron varies up to 36 percent. Other heavy metals found in this vicinity include:

Lead	25 - 5520 ppm
Copper	34 - 3580 ppm

Zinc	39 - 3320 ppm
Arsenic	14 - 2860 ppm
Chromium	19 - 1990 ppm
Nickel	20 - 361 ppm

In contrast to the above, the types of contaminants found at the sampling locations (MW-10-88 and MW-9-88) up and down the shore from the immediate vicinity of the former incinerator were primarily polycyclic aromatic hydrocarbon compounds (PAHs). The concentrations of these PAHs ranged from less than 1 ppm to approximately 5 ppm at these locations. These contaminants were present at a depth of 6-18 ft. at MW-9-88 but only at the surface (0-2 ft.) at MW-10-88.

6.2.3 Weathering Area

Soils in this area were variable both with respect to visual appearance and contaminant concentrations. The fill in most of the Weathering Area has a purplish-blue color to a depth of approximately 6 ft. Analysis of a composite sample from this depth interval at MW-1-88 showed:

Iron	11,700 - 32,700 ppm
Copper	47 - 14,500 ppm
Lead	21 - 1,640 ppm

The concentration of copper was the highest found in soil at the Area "D" site. The concentrations of these metals decreased with depth. Essentially no semi-volatile organic contaminants were found at MW-1-88.

A surficial soil sample (0-2 ft.) collected a short distance from MW-1-88 at SB-4 was strikingly different in appearance. The soil/fill at this location of the Weathering Area consists of fine black sand, cinders and clay with only small amounts of purplish-blue stained soil. Analysis of this sample also yielded results that were substantially different from those obtained at MW-1-88. Twelve (12) different PAH compounds were detected at concentrations ranging from 16-330 ppm. Naphthalene was also detected at a concentration of 2.8 ppm.

The high degree of variability of contaminants in the fill at the Weathering Area is consistent with the highly variable list of products (see Table 2-4) whose sludges were brought to the site for weathering.

MALCOLM PIRNIE

6.2.4 West Shore

The West Shore is the area that extends from the tip of the peninsula to the Area "D" site boundary on the west side of the peninsula. Soil samples were collected in this area at the following locations: MW-2-88, SB-5, B-4-88, MW-5-88, MW-6-88, and SB-6.

With the exception of MW-2-88, the concentrations of metals found in the soil/fill in this area were generally much lower than those in the Weathering Area, Incineration Area, and Iron Oxide Sludge Lagoon Area. The concentration of metals found in the 0-16-foot interval at MW-2-88 were among the highest found at the Area "D". The notable metals detected at this location were:

Iron	300,000 ppm
Zinc	716 ppm
Chromium	364 ppm
Copper	341 ppm
Nickel	164 ppm
Arsenic	84 ppm

The principal semi-volatile organic contaminants found along the West Shore area are PAH compounds. Thirteen (13) PAH compounds were found in the 0-16 ft. composite collected at MW-2-88 at concentrations of 0.8-14 ppm. Nine (9) PAH compounds were found in the 2-4 ft. composite collected at MW-6-88 at concentrations of 0.5-2.5 ppm. The only other organic contaminants detected in soils along the West Shore were nitrobenzene (5.9 ppm) and naphthalene (8.2 ppm) at MW-2-88 (0-16 ft.) and low concentrations (i.e. less than 1 ppm) of two (2) PAH compounds at MW-5-88 (12-18 ft.). The absence of any semi-volatile contaminants in the surficial soil borings (i.e. SB-5 and SB-6) collected near MW-2-88 and MW-6-88 indicates that the contaminants found in these latter locations occur at depths greater than two (2) feet below the soil surface.

6.2.5 Tank Parks

Soil samples were collected in the areas of former tank parks 911N, 911S, 912 and 913 (see Figure 6-1). These tanks and what is known about the substances that may have been stored in them has been discussed in Section 2.2.3.

Two (2) soil samples were collected for analysis in the area of tank park 911N. Soils collected at both MW-8-88 (14-18 ft.) and B-7-88 (4-30 ft.) were observed to have a strong turpentine-like odor. An oily sheen was also apparent in the soil at B-7-88 and a high HNu reading (250 ppm) was recorded during headspace analysis of the soil sample from MW-8-88. Even so, only one (1) specific chemical parameter was detected [1.9 ppm bis(2-ethylhexyl)phthalate at MW-8-88]. Metal concentrations determined were also low relative to the rest of the site.

The soil sampling results in the area of tank park 911S were similar to those at 911N. Soil collected at depth was observed to contain NAPL and to have a strong turpentine-like odor. However, analysis of the soil samples [SB-8 and B-6-88 (8-26 ft.)] again detected none of the specific chemical parameters analyzed for. Likewise, metal concentrations were low relative to the rest of the site.

A single soil boring was made in the area of tank park 912 (B-5-88). Slight black staining was observed at a depth interval of 6-10 ft. Analysis of a composite sample (Composite "A") from this interval identified the presence of naphthalene (1.9 ppm) and thirteen (13) other PAH compounds (0.7-11 ppm). Iron is present in the soil at 4.6 percent. An extraordinarily high lead result (8.3 percent) indicates the presence of a deposit below the surface at this boring location. Other notable metals detected in the soil at this location were:

Mercury	14 ppm
Silver	4.9 ppm

These soil concentrations of lead, mercury, and silver were the highest detected in the fill at the Area "D". An elevated EOX of 170 mg/Kg was also detected. Analysis of a composite sample (Composite "C") collected at a depth of 16-18 ft. detected 2-nitroaniline (1.1 ppm) and 2,4-dinitrotoluene (3.4 ppm).

Three (3) soil samples (MW-3-88, B-4-88, and SB-9) were collected in the area of tank park 913. Black oily staining and an H_2S odor was observed at MW-3-88 at a depth interval of 4-18 feet. Analysis of the composite sample (Composite "A") collected from this interval detected naphthalene (5.5 ppm), 2,4-dinitrotoluene (2.6 ppm) and phenanthrene (0.7 ppm). An EOX concentration of 160 mg/Kg was also detected.

No specific chemical substances were detected at B-4-88, although an EOX of 160 mg/Kg was found in the 6-24 ft. depth interval (Composite "A"). The soils in this depth interval appeared somewhat oily and exhibited an H_2S odor.

Only phenanthrene (53 ppm) was found in the surficial soil sample (SB-9) collected near MW-3-88 and the former intake water pit (see Figure 6-1). Metals detected in the soil samples collected in the area of tank park 913 were low relative to the rest of the site.

6.2.6 Remainder of Site Interior

No specific organic chemical parameters were analytically detected in soil at B-3-88, located just west of the former incinerator. The concentration of metals detected were also low relative to the rest of the site.

A soil sample collected at a depth interval of 10-18 ft. from PZ-2-88, located at the north corner of former Building 432, was visually observed to contain suds, indicative of detergent, and to have a petro-chemical-like odor. Analysis of this sample determined the presence of 1,4-dichlorobenzene (1.7 ppm), 1,2-dichlorobenzene (0.9 ppm), naphthalene (1.9 ppm), bis(2-ethylhexyl)phthalate (1.1 ppm), and five (5) PAH compounds at concentrations of less than 1 ppm. An elevated EOX of 260 mg/Kg was also detected.

No contamination was found at either PZ-1-88, located at the eastern corner of former Building 432, or SB-7 collected along the northern boundary of the Area "D" site.

6.3 GROUND WATER

The ground water monitoring results for those parameters having at least one detected value are summarized in Tables 6-7, 6-8, 6-9 and 6-10. Two (2) hydrogeologic units were monitored: the shallow unconfined water-bearing zone and the bedrock aquifer (see Section 4.4). A discussion of the character of contamination found in each of these units is presented below.

6.3.1 Shallow Unconfined Water-Bearing Zone

The screened interval of each well installed within this zone can be summarized as follows:

- Straddling the Water Table:

MW-2	MW-6
MW-3	MW-8
MW-4	MW-9
MW-5	MW-10

- Middle of Shallow Water-Bearing Zone:

W-7	W-13
W-8	W-14
W-9	W-15
W-12	

- Top of Uppermost Confining Layer:
  MW-11
  MW-12
  MW-13

The elevation of each screened interval has been presented in Table 4-1. Field observations pertinent to visual and olfactory evidence of contamination at each well is presented in Table 4-2.

For the purpose of discussion of the character of contamination found in this zone, the Area "D" site is again divided into the areas identified in Section 6.2.

6.3.1.1 Iron Oxide Sludge Lagoons

Two (2) wells (W-14 and W-15) were sampled on each of two (2) occasions in this area (see Figure 6-1). During the June sampling event, ground water elevations were higher than during the August sampling

TABLE 6-7

BUFFALO COLOR CORPORATION

FIELD MEASUREMENT OF GROUND WATER PARAMETERS(1)

WELL NUMBER	TEMPERATURE °C		pH		SPECIFIC CONDUCTIVITY (umhos)		TURBIDITY (NTU)	
	6/22-24/88	8/16/88	6/22-24/88	8/16/88	6/22-24/88	8/16/88	6/22-24/88	8/16/88
MW-1-88	14	14	12.35	12.08	8800.	4300.	)100	34
MW-2-88	16	15	6.60	6.78	2710.	2750.	*	*
MW-3-88	16	15	6.61	6.55	2000.	1710.	88	)100
MW-4-88	16	15	6.60	6.44	4600.	3400.	38	(2)
MW-5-88	16	--	5.80	6.35	1800.	1745.	44	75
MW-6-88	16	--	6.77	6.42	1545.	1748.	59	)100
MW-7-88	15	15	10.25	9.22	960.	381.	)100	98
MW-8-88	16	15	6.30	6.51	1710.	1361.	66	75
MW-9-88	17	16	6.81	6.80	2100.	4500.	30	58
MW-10-88	16	16	4.68	4.40	5250.	4320.	15	93
Well 6R	16	16	8.90	8.90	2930.	2220.	*	*
Well 7	16	17	6.22	6.13	1800.	1385.	80	)100
Well 8	16	12	6.96	6.91	1980.	1307.	26	22
Well 9	16	17	7.80	7.87	2400.	2210.	*	*
Well 12	16	15	6.20	6.18	1450.	1225.	*	*
Well 13	16	15	4.72	5.12	2170.	1910.	38	30
Well 14	16	12	7.63	7.21	1540.	1721.	1	*
Well 15	15	14	9.01	6.82	1850.	2450.	54	(2)

NOTES

(1) Determined during 6/22-24/88 and 8/16/88 sampling events.
(2) NTU reading not taken.
* Sample was colored, which interfered with Turbidimeter readings due to light adsorption.

MALCOLM PIRNIE

TABLE 6-8

FIELD MEASUREMENT OF GROUND WATER PARAMETERS[1]

WELL NUMBER	TEMPERATURE °C	pH	SPECIFIC CONDUCTIVITY (umhos)	TURBIDITY (NTU)
MW-11-88	12	6.40	2,800	100
MW-12-88	12	6.60	4,970	50
MW-13-88	12	6.90	16,620	100

NOTE:

(1) Determined during 11/21/88 sampling event.

SITE AREA SAMPLED	IRON OXIDE LAGOON AREA				WEATHERING AREA			
SAMPLE NUMBER	WELL 14	WELL 14	WELL 15	WELL 15	WELL 12	WELL 12	WELL 13	WELL 13
SAMPLE DATE	6/24/88	8/18/88	6/24/88	8/18/88	6/23/88	8/17/88	6/23/88	8/17/88
SEMIVOLATILE ORGANICS (ug/l)								
PHENOL								
2-CHLOROPHENOL								
1,3-DICHLOROBENZENE								
1,4-DICHLOROBENZENE								
1,2-DICHLOROBENZENE		3 J						
2-METHYLPHENOL		4 J		18				
N-NITROSO-DI-n-PROPYLAMINE								
NITROBENZENE							10 J	15
2,4-DIMETHYLPHENOL				69				
BENZOIC ACID								
BIS(2-CHLOROETHYL)OXYMETHANE								
1,2,4-TRICHLOROBENZENE			1200	270				
NAPHTHALENE	12 J	15	670	130				
4-CHLOROANILINE								
4-CHLORO-3-METHYLPHENOL								
2-METHYLNAPHTHALENE				10 J				
2-NITROANILINE							4 J	
ACENAPHTHYLENE								
ACENAPHTHENE			26 J	14				
DIBENZOFURAN				13				
2,4-DINITROTOLUENE		NR		NR		NR	2000 E	NR
2,6-DINITROTOLUENE							1500 E	1700 E
DIETHYL PHTHALATE								
FLUORENE			24 J	17				
N-NITROSODIPHENYLAMINE				6 J				
PENTACHLOROPHENOL								
PHENANTHRENE			63 J	59				
ANTHRACENE			14 J	13				
DI-n-BUTYLPHTHALATE								
FLUORANTHENE			18 J	35				
PYRENE			16 J	24				
BENZO(a)ANTHRACENE			8 J	12				
BIS(2-ETHYLHEXYL)PHTHALATE				6 J		52		
CHRYSENE			5 J	11				
BENZO(b)FLUORANTHENE								
BENZO(k)FLUORANTHENE								
BENZO(a)PYRENE				7 J				
BENZIDINE				360				
1-NAPHTHYLAMINE	16000 D	5600	42000 D	9100				
ANILINE	NR		NR	660	NR		NR	

LABORATORY QUALIFIERS:

E-Exceeded calibrated range
J-Estimated value
D-Detected in diluted sample
B-Analyte detected in lab blank
NR-Parameter not inc. in analysis
N-Spike sample recovery outside limits
S-Determined by method of standard addition

SITE AREA SAMPLED	<<<<<<<<<< IRON OXIDE LAGOON AREA>>>>>>>>>>				<<<<<<<<<<<WEATHERING AREA>>>>>>>>>>>>>>>>>			
SAMPLE NUMBER	WELL 14	WELL 14	WELL 15	WELL 15	WELL 12	WELL 12	WELL 13	WELL 13
SAMPLE DATE	6/24/88	8/18/88	6/24/88	8/18/88	6/23/88	8/17/88	6/23/88	8/17/88
VOLATILE ORGANICS (ug/l)								
VINYL CHLORIDE								
METHYLENE CHLORIDE	650 B	8 B	800 B	91 B	1 BJ	7 B	6 B	7 B
ACETONE		47	510 B	92 B	54 B	110 B	24 B	16 B
CARBON DISULFIDE		NR		NR		NR		NR
1,1-DICHLOROETHENE						1 BJ		1 BJ
1,2-DICHLOROETHENE(TOT)						4 BJ		3 BJ
CHLOROFORM		7						
2-BUTANONE								
BROMODICHLOROMETHANE								
TRICHLOROETHENE								
BENZENE		250 E	1000	510	0.1 BJ		0.4 J	2 J
4-METHYL-2-PENTANONE		NR		NR		NR		NR
TOLUENE			620 B	320	0.09 BJ		1 BJ	2 J
CHLOROBENZENE		2 J	190 J	400			1 J	
ETHYLBENZENE		2 J						
XYLENE (TOTAL)				23 J		7 B		6 B
TOTAL METALS (ug/l)								
ALUMINUM	NR	10200	NR	1200	NR	16800	NR	67000
ANTIMONY	124	58	21			5		7
ARSENIC	1620	1820	35		18	25	460	933
BARIUM	NR	1020	NR	60	NR	112	NR	281
BERYLLIUM							6	7
CADMIUM	127	37	16		6		21	24
CHROMIUM	679	805	24		203	197	62	201
COPPER	27800	3220	49		330	306	28600	78700
IRON	3940	405000	47500	22500	45000	72200	75000	233000
LEAD	2480	3030	22	6.8	2390	1390	312	573
MAGNESIUM	NR	24500	NR	32700	NR	29900	NR	36100
MANGANESE	NR	4440	NR	1230	NR	2770	NR	2170
MERCURY	21	9.6			50	2.8	2.1	5.2
NICKEL	630	760	90		60	60	460	830
SELENIUM								
SILVER			5		9		8	
THALLIUM	57	15	36					
ZINC	3370	4390	72	37	1220	1390	2460	5610
CYANIDE	45	10	13				22	34
HEXAVALENT CHROMIUM (ug/l)		10				130	6	82
TOC (mg/l)	53	110	650	500	27	33	31	39
TOX (ug/l)	27	180	160	5440	29	15	36	21

LABORATORY QUALIFIERS:
E-Exceeded calibrated range
J-Estimated value
D-Detected in diluted sample
B-Analyte detected in lab blank
NR-Parameter not inc. in analysis
N-Spike sample recovery outside limits
S-Determined by method of standard addition

SITE AREA SAMPLED	<<<<INCINERATION AREA>>>>							
SAMPLE NUMBER	MW-4-88	MW-4-88	MW-9-88	MW-9-88	MW-10-88	MW-10-88	MW-12-88	MW-13-88
SAMPLE DATE	6/23/88	8/18/88	6/23/88	8/17/88	6/23/88	8/17/88	11/21/88	11/21/88
SEMIVOLATILE ORGANICS (ug/l)								
PHENOL								
2-CHLOROPHENOL	1800 D	1200 E						
1,3-DICHLOROBENZENE		49	1 J					
1,4-DICHLOROBENZENE	4900 D	510 E	5 J	6 J				
1,2-DICHLOROBENZENE	21000 D	920 E	5 J					4000
2-METHYLPHENOL		47						
N-NITROSO-DI-n-PROPYLAMINE								
NITROBENZENE								
2,4-DIMETHYLPHENOL	94 DJ	130	4 J					
BENZOIC ACID								
BIS(2-CHLOROETHYL)OXYMETHANE								
1,2,4-TRICHLOROBENZENE	25	8 J						
NAPHTHALENE	33		5 J				0.3 J	4900
4-CHLOROANILINE				8 J			22	11000 E
4-CHLORO-3-METHYLPHENOL								
2-METHYLNAPHTHALENE								
2-NITROANILINE								
ACENAPHTHYLENE								
ACENAPHTHENE								
DIBENZOFURAN								
2,4-DINITROTOLUENE		NR		NR		NR		
2,6-DINITROTOLUENE								
DIETHYL PHTHALATE	4 J							
FLUORENE								
N-NITROSODIPHENYLAMINE	4 J							
PENTACHLOROPHENOL	2 J							
PHENANTHRENE	3 J							
ANTHRACENE	0.9 J							
DI-n-BUTYLPHTHALATE	0.7 J						1 J	
FLUORANTHENE	1 J							
PYRENE	1 J							
BENZO(a)ANTHRACENE	1 J							
BIS(2-ETHYLHEXYL)PHTHALATE	2 J	7 J		7 J		7 J	17 B	
CHRYSENE	0.9 J							
BENZO(b)FLUORANTHENE								
BENZO(k)FLUORANTHENE								
BENZO(a)PYRENE								
BENZIDINE								
1-NAPHTHYLAMINE	2800 D	300	97	16			23	
ANILINE	NR		NR		NR		5	250000

LABORATORY QUALIFIERS:

E-Exceeded calibrated range
J-Estimated value
D-Detected in diluted sample
B-Analyte detected in lab blank
NR-Parameter not inc. in analysis
N-Spike sample recovery outside limits
S-Determined by method of standard addition

SITE AREA SAMPLED	<<<<<<<<INCINERATION AREA>>>>>>>>							
SAMPLE NUMBER	MW-4-88	MW-4-88	MW-9-88	MW-9-88	MW-10-88	MW-10-88	MW-12-88	MW-13-88
SAMPLE DATE	6/23/88	8/18/88	6/23/88	8/17/88	6/23/88	8/17/88	11/21/88	11/21/88
VOLATILE ORGANICS (ug/l)								
VINYL CHLORIDE								
METHYLENE CHLORIDE	15000 B	10 B	3 BJ	88 B	2 BJ	10 B	15 BJ	58 B
ACETONE	5400 BJ		14000 BE	93	19 B	55	530	2000 E
CARBON DISULFIDE		NR		NR		NR		
1,1-DICHLOROETHENE		2 BJ		8 J		1 J		
1,2-DICHLOROETHENE(TOT)		6		19 BJ		4 BJ		
CHLOROFORM				24 B				
2-BUTANONE								260
BROMODICHLOROMETHANE				7 J				
TRICHLOROETHENE								3 J
BENZENE		3 J	14 B	10 J	0.7 J		12 J	820
4-METHYL-2-PENTANONE		NR		NR		NR		24 J
TOLUENE	170 BJ	1 BJ	560 BE	21 J	0.4 BJ			4700 E
CHLOROBENZENE	37000	38	320 B	420			82 B	7700 BE
ETHYLBENZENE	43000	130	41	6 J				350
XYLENE (TOTAL)	1700 BJ		1200 BE	120 B		6 B		39
TOTAL METALS (ug/l)	102 ppm		16		Ø		Ø	15.5
ALUMINUM	NR	22600	NR	3160	NR	15300	NR	NR
ANTIMONY				19 N		5 N		—
ARSENIC	144	127	6.4	42 N	1560	440 N	13.6	277
BARIUM	NR	216	NR	48	NR		NR	NR
BERYLLIUM								
CADMIUM	8	5			49	14		
CHROMIUM	40	61	16	36	44	30	13	71
COPPER	422	745	79	141	1800	3710	24	119
IRON	62000	76300	8930	22900	80500	44800	15500	8900
LEAD	66	37	32	11	77			
MAGNESIUM	NR	25100	NR	59700	NR	42900	NR	NR
MANGANESE	NR	4100	NR	21300	NR	9600	NR	NR
MERCURY								
NICKEL	50	60		30	370	430		250
SELENIUM								
SILVER			5		8		11	13
THALLIUM								
ZINC	775	891	156	143	4180	5290	49	90
CYANIDE			15	19			NR	NR
HEXAVALENT CHROMIUM (ug/l)	6	6		15		23	NR	NR
TOC (mg/l)	200	200	49	54	35	32	50	2350
TOX (ug/l)	22600	27200	490	520	220	290	560	19200

LABORATORY QUALIFIERS:

- E-Exceeded calibrated range
- J-Estimated value
- D-Detected in diluted sample
- B-Analyte detected in lab blank
- NR-Parameter not inc. in analysis
- N-Spike sample recovery outside limits
- S-Determined by method of standard addition

SITE AREA SAMPLED	<<<<<<<<<<<<<<< WEST SHORE >>>>>>>>>>>>>>>					
SAMPLE NUMBER	MW-5-88	MW-5-88	MW-6-88	MW-6-88	MW-2-88	MW-2-88
SAMPLE DATE	6/22/88	8/17/88	6/22/88	8/16/88	6/22/88	8/16/88
SEMIVOLATILE ORGANICS (ug/l)						
PHENOL						
2-CHLOROPHENOL						
1,3-DICHLOROBENZENE						
1,4-DICHLOROBENZENE						
1,2-DICHLOROBENZENE						
2-METHYLPHENOL						
N-NITROSO-DI-n-PROPYLAMINE						24 J
NITROBENZENE	11 J	5 J				
2,4-DIMETHYLPHENOL						
BENZOIC ACID						
BIS(2-CHLOROETHYL)OXYMETHANE						20 J
1,2,4-TRICHLOROBENZENE						
NAPHTHALENE						6J 4 J
4-CHLOROANILINE						34 25 J
4-CHLORO-3-METHYLPHENOL						6J
2-METHYLNAPHTHALENE						
2-NITROANILINE						
ACENAPHTHYLENE						
ACENAPHTHENE						
DIBENZOFURAN						2J
2,4-DINITROTOLUENE		NR		NR		NR
2,6-DINITROTOLUENE						
DIETHYL PHTHALATE						
FLUORENE						
N-NITROSODIPHENYLAMINE					15 DJ	55
PENTACHLOROPHENOL						
PHENANTHRENE						
ANTHRACENE						
DI-n-BUTYLPHTHALATE						
FLUORANTHENE						3J
PYRENE						2J
BENZO(a)ANTHRACENE						
BIS(2-ETHYLHEXYL)PHTHALATE	5 BJ		5 BJ	5 J		
CHRYSENE						
BENZO(b)FLUORANTHENE						
BENZO(k)FLUORANTHENE						
BENZO(a)PYRENE						
BENZIDINE						360
1-NAPHTHYLAMINE					2900 D	240
ANILINE	NR		NR		NR	580 460

LABORATORY QUALIFIERS:

E-Exceeded calibrated range
J-Estimated value
D-Detected in diluted sample
B-Analyte detected in lab blank
NR-Parameter not inc. in analysis
N-Spike sample recovery outside limits
S-Determined by method of standard addition

SITE AREA SAMPLED	<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<< WEST SHORE >>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>					
SAMPLE NUMBER	MW-5-88	MW-5-88	MW-6-88	MW-6-88	MW-2-88	MW-2-88
SAMPLE DATE	6/22/88	8/17/88	6/22/88	8/16/88	6/22/88	8/16/88
VOLATILE ORGANICS (ug/l)						
VINYL CHLORIDE						
METHYLENE CHLORIDE	4 BJ	9 B	2 BJ	6 B	2 BJ	4 BJ
ACETONE	380 E	120 B	5 J	19 B	6 J	
CARBON DISULFIDE		NR		NR	1 J	NR
1,1-DICHLOROETHENE				1 BJ		
1,2-DICHLOROETHENE(TOT)		3 BJ		3 BJ		3 BJ
CHLOROFORM						
2-BUTANONE						
BROMODICHLOROMETHANE						
TRICHLOROETHENE		1 J				
BENZENE	0.6 BJ		0.2 BJ	2 J	6 B	7 8
4-METHYL-2-PENTANONE		NR	3 J	NR		NR
TOLUENE	0.2 BJ		0.1 BJ		0.7 BJ	1 J
CHLOROBENZENE	0.2 BJ				6 B	7 9
ETHYLBENZENE					0.2 J	
XYLENE (TOTAL)		6 B		9 B	1 J	8 B
TOTAL METALS (ug/l)						
ALUMINUM	NR	1780	NR	8730	NR	5890
ANTIMONY				12 N	24	37 N
ARSENIC	20		35	22 N	208	55.85 36 N
BARIUM	NR	30	NR	177	NR	183
BERYLLIUM						
CADMIUM	13		5		116	26.1 17
CHROMIUM		16	25	45	2140	1340
COPPER	20	25	40	137	860	520
IRON	30100	32600	4960	18800	381000	378,000 254000
LEAD		11	68	217	2670	2220 S 145
MAGNESIUM	NR	34000	NR	43800	NR	55200 39400
MANGANESE	NR	12000	NR	963	NR	6150 4570
MERCURY			0.72	2.1	50	27.5 12.3
NICKEL	40		40	40	180	90
SELENIUM						
SILVER				16 N		
THALLIUM						
ZINC	84	86	213	453	9950	7110 4590
CYANIDE					12	
HEXAVALENT CHROMIUM (ug/l)	7	25	7		6	59
TOC (mg/l)	32	74	13	27	120	85
TOX (ug/l)	83	85	35	26	160	140

LABORATORY QUALIFIERS:

E-Exceeded calibrated range
J-Estimated value
D-Detected in diluted sample
B-Analyte detected in lab blank
NR-Parameter not inc. in analysis
N-Spike sample recovery outside limits
S-Determined by method of standard addition

SITE AREA SAMPLED	<<<<<<<<<<<<<<<TANK PARK 913>>>>>>>>>>>>>>>>>>				<<<<<<TANK PARK 911 NORTH>>>>>>>>>>		
SAMPLE NUMBER	MW-3-88	MW-3-88	WELL 9	WELL 9	MW-8-88	MW-8-88	MW-11-88
SAMPLE DATE	6/22/88	8/16/88	6/24/88	8/16/88	6/23/88	8/17/88	11/21/88
SEMIVOLATILE ORGANICS (ug/l)							
PHENOL	57	77					8 J
2-CHLOROPHENOL	5 J	7 J	0.8 J		5 J	4 J	49
1,3-DICHLOROBENZENE		3 J					
1,4-DICHLOROBENZENE	130	220			1 J	4 J	35
1,2-DICHLOROBENZENE	52	96	2 J				2 J
2-METHYLPHENOL		6 J					
N-NITROSO-DI-n-PROPYLAMINE							
NITROBENZENE							
2,4-DIMETHYLPHENOL	18	13					
BENZOIC ACID		18 J					
BIS(2-CHLOROETHYL)OXYMETHANE							
1,2,4-TRICHLOROBENZENE							
NAPHTHALENE	30	43					
4-CHLOROANILINE							50
4-CHLORO-3-METHYLPHENOL	4 J	7 J					
2-METHYLNAPHTHALENE							16
2-NITROANILINE							
ACENAPHTHYLENE							
ACENAPHTHENE							1 J
DIBENZOFURAN							
2,4-DINITROTOLUENE		NR		NR		NR	
2,6-DINITROTOLUENE							
DIETHYL PHTHALATE							
FLUORENE							2 J
N-NITROSODIPHENYLAMINE							
PENTACHLOROPHENOL							
PHENANTHRENE							6 J
ANTHRACENE							
DI-n-BUTYLPHTHALATE	0.2 J				0.2 J		
FLUORANTHENE							
PYRENE							
BENZO(a)ANTHRACENE							
BIS(2-ETHYLHEXYL)PHTHALATE	8 BJ	5 J				14 J	20 B
CHRYSENE							
BENZO(b)FLUORANTHENE							
BENZO(k)FLUORANTHENE							
BENZO(a)PYRENE							
BENZIDINE							
1-NAPHTHYLAMINE							46
ANILINE	NR		NR		NR		160

LABORATORY QUALIFIERS:

E-Exceeded calibrated range
J-Estimated value
D-Detected in diluted sample
B-Analyte detected in lab blank
NR-Parameter not inc. in analysis
N-Spike sample recovery outside limits
S-Determined by method of standard addition

SITE AREA SAMPLED	TANK PARK 913				TANK PARK 911 NORTH		
SAMPLE NUMBER	MW-3-88	MW-3-88	WELL 9	WELL 9	MW-8-88	MW-8-88	MW-11-88
SAMPLE DATE	6/22/88	8/16/88	6/24/88	8/16/88	6/23/88	8/17/88	11/21/88
VOLATILE ORGANICS (ug/l)							
VINYL CHLORIDE						6 J	
METHYLENE CHLORIDE	2000 B	6 B	5 B	9 B	480 B	<50 7 B	
ACETONE		740 BE	190	63 B	15000 BE	4700 39 B	
CARBON DISULFIDE		NR		NR		NR	
1,1-DICHLOROETHENE		2 BJ		1 BJ			
1,2-DICHLOROETHENE(TOT)		4 BJ	1 J	3 BJ		6 B	
CHLOROFORM					0.7 J		
2-BUTANONE							
BROMODICHLOROMETHANE							
TRICHLOROETHENE							
BENZENE	28000 B	1100 E	24	46		3 J	6300 E
4-METHYL-2-PENTANONE		NR		NR		NR	
TOLUENE	160 BJ	20	0.2 BJ	1 J	3 BJ		100
CHLOROBENZENE	3600 B	750 E	130	220 E	1400	770 1100 E	48000 E
ETHYLBENZENE	1200 BJ	220 E		1 J	5 J		170
XYLENE (TOTAL)	750 BJ	130 B		10 B		7 B	74
TOTAL METALS (ug/l)							
ALUMINUM	NR	1520	NR	2390	NR	35200	NR
ANTIMONY							
ARSENIC	45		52	31	46	269	5.7
BARIUM	NR	262	NR		NR	259	NR
BERYLLIUM							
CADMIUM	6		11		6	6	
CHROMIUM	27	20		21	80	95	
COPPER	20	16	15	16	168	234	25
IRON	14100	15300	23700	30500	65000	4600 104000	6200
LEAD	28		22		179	138 117 S	
MAGNESIUM	NR	8900	NR	11800	NR	34300	NR
MANGANESE	NR	1700	NR	743	NR	4290 5630	NR
MERCURY						0.29	
NICKEL					120	140	70
SELENIUM							
SILVER							
THALLIUM			94				
ZINC	237	82	38	23	2040	4080	51
CYANIDE			30	56			NR
HEXAVALENT CHROMIUM (ug/l)		8		7		36	NR
TOC (mg/l)	96	190	44	62	19	101	27
TOX (ug/l)	1310	1610	240	520	200	130	24700

LABORATORY QUALIFIERS:

E-Exceeded calibrated range
J-Estimated value
D-Detected in diluted sample
B-Analyte detected in lab blank
NR-Parameter not inc. in analysis
N-Spike sample recovery outside limits
S-Determined by method of standard addition

SITE AREA SAMPLED	<<<<<<<<<<<<<<TANK PARK 910>>>>>>>>>>>>>>>>				<<<<<<<<<<REMAINDER OF SITE INTERIOR>>>>>>>			
SAMPLE NUMBER	WELL 8	WELL 8	8 - NAPL	8 - NAPL	WELL 6R	WELL 6R	WELL 7	WELL 7
SAMPLE DATE	6/24/88	8/18/88	6/24/88	8/18/88	6/23/88	8/18/88	6/24/88	8/17/88
SEMIVOLATILE ORGANICS (ug/l)			(ug/kg)	(ug/l)				
PHENOL								
2-CHLOROPHENOL								
1,3-DICHLOROBENZENE					0.7 J			
1,4-DICHLOROBENZENE					5 J	3 J		
1,2-DICHLOROBENZENE					4 J	3 J		
2-METHYLPHENOL								
N-NITROSO-DI-n-PROPYLAMINE								
NITROBENZENE						18		
2,4-DIMETHYLPHENOL								
BENZOIC ACID								
BIS(2-CHLOROETHYL)OXYMETHANE								
1,2,4-TRICHLOROBENZENE								
NAPHTHALENE					16	14		
4-CHLOROANILINE						17		
4-CHLORO-3-METHYLPHENOL								
2-METHYLNAPHTHALENE			22000 J			5 J		
2-NITROANILINE								
ACENAPHTHYLENE					15			
ACENAPHTHENE						18		
DIBENZOFURAN						9 J		
2,4-DINITROTOLUENE		NR		NR		NR		NR
2,6-DINITROTOLUENE								
DIETHYL PHTHALATE								
FLUORENE		4 J			8 J	12		
N-NITROSODIPHENYLAMINE					2 J	3 J		
PENTACHLOROPHENOL								
PHENANTHRENE					15	14		
ANTHRACENE					3 J	3 J		
DI-n-BUTYLPHTHALATE							0.3 J	
FLUORANTHENE	54		190000	37	2 J	2 J		
PYRENE	4 J	7 J	6100	4 J	4 J			
BENZO(a)ANTHRACENE	1 J		2500 J					
BIS(2-ETHYLHEXYL)PHTHALATE	2 J	16 J				16		11
CHRYSENE	1 J		1900 J					
BENZO(b)FLUORANTHENE	0.3 J		1200 J					
BENZO(k)FLUORANTHENE	0.6 J		1100 J					
BENZO(a)PYRENE	0.6 J		1100 J					
BENZIDINE						90		
1-NAPHTHYLAMINE					9 J	6		
ANILINE	NR		NR		NR		NR	

LABORATORY QUALIFIERS:

E-Exceeded calibrated range
J-Estimated value
D-Detected in diluted sample
B-Analyte detected in lab blank
NR-Parameter not inc. in analysis
N-Spike sample recovery outside limits
S-Determined by method of standard addition

SITE AREA SAMPLED	<<<<<<<<<<<<<<TANK PARK 910>>>>>>>>>>>>>>>>				<<<<<<<<<<<REMAINDER OF SITE INTERIOR>>>>>>>			
SAMPLE NUMBER	WELL 8	WELL 8	8 - NAPL	8 - NAPL	WELL 6R	WELL 6R	WELL 7	WELL 7
SAMPLE DATE	6/24/88	8/18/88	6/24/88	8/18/88	6/23/88	8/18/88	6/24/88	8/17/88
VOLATILE ORGANICS (ug/l)			(ug/kg)	(ug/l)				
VINYL CHLORIDE								
METHYLENE CHLORIDE	140 B	9 B	140 B	6000 B	13 BJ	9 B	1 BJ	7 B
ACETONE	47 J		34 BJ	8900 B	86 B		11	
CARBON DISULFIDE	43	NR	41	NR		NR	7	NR
1,1-DICHLOROETHENE		2 BJ		1100 BJ		1BJ		1 BJ
1,2-DICHLOROETHENE(TOT)		5		3300		5		3 BJ
CHLOROFORM								
2-BUTANONE								
BROMODICHLOROMETHANE		1 BJ		590 BJ		1 BJ		
TRICHLOROETHENE								
BENZENE		5	42	3700	480 B	500 E	16	210 E
4-METHYL-2-PENTANONE		NR		NR		NR		NR
TOLUENE	0.6 BJ	2 BJ	13 BJ	1700 BJ	110 B	88 B		
CHLOROBENZENE	9 J	5 J	110	1200	17 BJ	24		9
ETHYLBENZENE			9 J	920 J			2 J	
XYLENE (TOTAL)	25	11 B	290	37000 B	10 BJ			7 B
TOTAL METALS (ug/l)			(mg/kg)	(mg/kg)				
ALUMINUM	NR	1500	NR	58	NR	2780	NR	2440
ANTIMONY	13						24	
ARSENIC	171	50			41	22	35	
BARIUM	NR	113	NR		NR	84	NR	30
BERYLLIUM				1.6				
CADMIUM	5				5		12	
CHROMIUM	45		1.8	4.9	46	94	40	29
COPPER	25		0.75		78	162	89	61
IRON	9450	6440	16		8140	6890	42400	47600
LEAD	51	5		2.4	82	63	36	17
MAGNESIUM	NR	1780	NR		NR	21800	NR	15600
MANGANESE	NR	1780	NR		NR	214	NR	1640
MERCURY						0.2		
NICKEL					50	70		
SELENIUM					10			
SILVER			0.7		5			
THALLIUM	32		1.9				32	
ZINC	61	27			433	387	114	55
CYANIDE			0.13 mg/kg	38 mg/kg				
HEXAVALENT CHROMIUM (ug/l)	18	6	NR	NR	6			17
TOC (mg/l)	200	1110	NR	NR	51	27	20	25
TOX (ug/l)	77	38	476000 ug/g	404000 ug/g	190	170	62	67

LABORATORY QUALIFIERS:

- E-Exceeded calibrated range
- J-Estimated value
- D-Detected in diluted sample
- B-Analyte detected in lab blank
- NR-Parameter not inc. in analysis
- N-Spike sample recovery outside limits
- S-Determined by method of standard addition

SAMPLE NUMBER	MW-1-88	MW-1-88	MW-7-88	MW-7-88
SAMPLE DATE	6/23/88	8/18/88	6/23/88	8/17/88
SEMIVOLATILE ORGANICS (ug/l)				
DIETHYL PHTHALATE				3 J
BIS(2-ETHYLHEXYL)PHTHALATE		17 J		12 J
VOLATILE ORGANICS (ug/l)				
METHYLENE CHLORIDE	1 BJ	8 B	2 BJ	13 B
ACETONE	62 B	27 B	670 BE	20 B
1,2-DICHLOROETHENE(TOT)				3 BJ
2-BUTANONE	14			
BENZENE	6	4	0.3 J	
4-METHYL-2-PENTANONE		NR		NR
TOLUENE	0.6 BJ		0.1 BJ	
CHLOROBENZENE	0.6 BJ		0.5 J	
ETHYLBENZENE			0.5 J	
XYLENE (TOTAL)	1 BJ			6 B
TOTAL METALS (ug/l)				
ALUMINUM	NR	6170	NR	11600
ARSENIC	7.9		7.3	9 N
BARIUM	NR	872	NR	179
CADMIUM				6
CHROMIUM	41	44	30	49
COPPER	124	47	42	64
IRON	14900	6050	12500	15800
LEAD	61	22	54	43
MAGNESIUM	NR	16400	NR	23500
MANGANESE	NR	144	NR	405
MERCURY				0.26
NICKEL	50			30
SILVER			5	26 N
ZINC	350	56	153	2430
HEXAVALENT CHROMIUM (ug/l)		9		17
TOC (mg/l)	30	19	18	55
TOX (ug/l)	26	32	8.1	21

LABORATORY QUALIFIERS:
E-Exceeded calibrated range
J-Estimated value
D-Detected in diluted sample
NR-Parameter not inc. in analysis
N-Sample spike recovery outside limits
S-Determined by method of standard addition
B-Analyte detected in laboratory blank

event. Contaminant concentrations were also generally higher in samples collected during June.

The principal organic contaminants found in the ground water in the area include:

1-Naphthylamine	5,600 - 42,000 ppb
1,2,4-Trichlorobenzene	270 - 1,200 ppb
Benzene	250 - 1,000 ppb
Naphthalene	12 - 670 ppb
Aniline	ND - 660 ppb
Toluene	320 - 620 ppb
Chlorobenzene	2 - 400 ppb
Benzidine	ND - 360 ppb

Metals present in the ground water include:

Iron	3,940 - 405,000 ppb
Copper	ND - 27,800 ppb
Zinc	37 - 4,400 ppb
Lead	7 - 3,030 ppb
Arsenic	ND - 1,820 ppb
Chromium	ND - 805 ppb
Nickel	ND - 630 ppb

The above results generally correlate with known iron oxide handling practices in this area (see Section 2.2). Nitrobenzene is the only soil contaminant detected in this area (see Section 6.2.1) that was not detected in ground water. The source of the benzene, 1,2,4-trichlorobenzene, chlorobenzene, and toluene detected, primarily at W-15, may be the former tank park 911N area, which is hydraulically upgradient of W-15 (see Section 6.3.1.5).

Oily substances were visually evident on the surface of samples collected from both W-14 and W-15. Well W-15 contained the largest quantity of oily substances which were both free-floating and dispersed throughout the sample. This observation is consistent with the relatively high TOC and TOX concentrations found at W-15 as shown in Table 6-9. The presence of this oily material probably explains the low concentrations (5-63 ppb) of ten (10) PAH compounds, which are essentially insoluble in water, detected in ground water at W-15.

6.3.1.2 Incineration Area

Three (3) wells (MW-4-88, MW-9-88, and MW-10-88) located in this area were sampled on each of two (2) occasions. The results of analysis of these samples indicated that ground water at the water table interface was highly contaminated at MW-4-88 and moderately contaminated at MW-9-88. For this reason, two (2) additional wells (MW-12-88 and MW-13-88) were subsequently installed to screen the interval at the top of the uppermost confining layer to determine the presence of dense NAPL (see Appendix A.3). These latter two (2) wells were sampled on one (1) occasion (11-21-88).

Similar to the soils in this area (see Section 6.2.2), ground water was found to be highly variable with respect to the type and concentration of contaminants present. Also like the soils, ground water in the immediate vicinity (MW-4-88) and hydraulically downgradient (MW-13-88) of the former incinerator was determined to be highly contaminated.

Principal organic contaminants detected at MW-4-88 include:

Ethylbenzene	130 - 43,000 ppb
Chlorobenzene	38 - 37,000 ppb
1,2-Dichlorobenzene	920 - 21,000 ppb
1,4-Dichlorobenzene	510 - 4,900 ppb
1-Naphthylamine	300 - 2,800 ppb
2-Chlorophenol	1,200 - 1,800 ppb
Xylene	ND - 1,700 ppb

In each case, the highest organic contaminant concentration observed was detected during the June sampling event. The highly contaminated nature of ground water at this location was also reflected by the very high TOC (200 ppm) and TOX (22.6-27.2 ppm) concentrations determined.

The principal metals present in the incinerator area ground water include:

Iron	62,000 - 76,300 ppb
Aluminum	NA - 22,600 ppb
Zinc	775 - 891 ppb
Copper	422 - 745 ppb
Arsenic	127 - 144 ppb
Lead	37 - 66 ppb

The single ground water sample collected at MW-13-88 also reflects a highly contaminated condition, although the specific contaminants present are different.

Principal organic contaminants present include:

Aniline	250,000 ppb
4-Chloroaniline	11,000 ppb
Chlorobenzene	7,700 ppb
Naphthalene	4,900 ppb
Toluene	4,700 ppb
1,2-Dichlorobenzene	4,000 ppb
Benzene	820 ppb
Ethylbenzene	350 ppb

Again, TOC (2350 ppm) and TOX (19 ppm) were very high. The TOX values recorded at MW-4-88 and MW-13-88 were the highest of all the ground water samples analyzed. The TOC concentration measured at MW-13-88 was 4-10 times higher than at any other location on-site. The specific conductivity (16,600 umhos) of ground water at this location was also 4-8 times greater than any other sampling location. Principal metals detected at MW-13-88 were:

Iron	8,900 ppb
Arsenic	277 ppb
Chromium	71 ppb

The character of contamination detected at MW-9-88 and MW-12-88 was very similar with respect to the specific contaminants detected at MW-4-88 and MW-13-88, although the concentrations were much lower. This lower level of contamination is reflected by the TOC (50-54 ppm) and TOX (4.9-5.6 ppm) concentrations which are 4 to 10 times lower than those found in the immediate vicinity of the incinerator.

The character of contamination detected at MW-10-88 was quite different from that detected at other locations along the east shore (i.e. incineration area). Essentially no specific organic contaminants were detected at MW-10-88. The relatively low TOC (32-35 ppm) and TOX

(0.22-0.29 ppm) concentrations also indicate that little organic contamination is present. In contrast, the major ground water contaminants at this location are metals:

Iron	44,800 - 80,500 ppb
Zinc	4,180 - 5,290 ppb
Copper	1,800 - 3,710 ppb
Arsenic	440 - 1,560 ppb
Lead	ND - 77 ppb
Cadmium	14 - 49 ppb

Furthermore, the low pH (4.4-4.7) and high specific conductivity (4320-5250 umhos) of ground water at this location (see Table 6-7) may indicate the presence of mineral acid, or acid by-products (e.g. aluminum chloride, hydrogen chloride) associated with detergent manufacturing (see Section 2.2.4.4). As indicated in Section 2.2, detergent manufacturing was conducted in former Building 432, which was located in the site interior adjacent to MW-10-88 (see Figure 6-1).

6.3.1.3 Weathering Area

Two wells (W-12 and W-13) intercept the shallow unconfined ground water in this area. No odors or immiscible layers indicative of organic contamination were observed in either well, although the ground water in W-12 exhibits a blue color. Analysis of samples collected from these wells on two (2) occasions indicated relatively little organic contamination to be present based on the TOC (27-39 ppm) and TOX (0.15-0.36 ppm) concentrations determined. The most notable specific organics detected were 2,4-dinitrotoluene (2000 ppb) and 2,6-dinitrotoluene (1500-1700 ppb) at W-13.

The principal soil contaminants in the Weathering Area are metals (see Section 6.2.3) as would be expected on the basis of the historical use of this area for storage of metal sludges associated with the manufacture of dyes (see Section 2.2). Likewise, the principal ground water contaminants in this area were also determined to be metals, including:

Iron	45,000 - 230,000 ppb
Copper	300 - 79,000 ppb
Zinc	1,200 - 5,600 ppb

Lead	310 -	2,400 ppb
Arsenic	ND -	930 ppb
Chromium	60 -	200 ppb
Mercury	2 -	50 ppb

With the exception of lead, all metals were present at much higher concentration in W-13. This may be related to the much lower ground water pH (4.7-5.1) at W-13 relative to W-12 (6.2). The low pH at W-13 is only slightly higher than the pH at MW-10-88, which is just north of W-13 on the east shore. Given the close proximity of these wells, the low pH may be due to a common source. Such a low pH is conducive to leaching (i.e. solubilization) of metals.

6.3.1.4 West Shore

Three (3) wells (MW-2-88, MW-5-88, and MW-6-88) were sampled on each of two occasions in this area. The screened intervals of each of these wells straddles the water table.

The results of ground water monitoring at MW-5-88 and MW-6-88 were generally consistent with the soil sampling results which indicated that the principal contaminants present in this area are phthalate and PAH compounds, which are typically immobile in ground water. The relatively low TOC (13-74 ppm) and TOX (0.26-0.85 ppm) concentrations and specific conductivity (1500-1800 umhos) in ground water at MW-5-88 and MW-6-88 are indicative of the relatively low level contamination that exists in this area. Only traces of a few specific organic compounds were detected. Most notable was nitrobenzene (5-11 ppb) at MW-5-88. The most notable metals included:

Iron	4,960 -	32,600 ppb
Zinc	84 -	453 ppb

The character of ground water at MW-2-88 is strikingly different from that at MW-5-88 and MW-6-88. Ground water at the latter two locations was observed to be slightly turbid but to exhibit no odor or evidence of oily material. In contrast, the ground water at MW-2-88 is black in color, has an oily film on its surface, and exhibits a H_2S odor. Notable organic compounds detected at MW-2-88 included:

1-Naphthylamine	240 - 2,900 ppb
Aniline	NA - 460 ppb
4-Chloroaniline	NA - 25 ppb
Chlorobenzene	6 - 9 ppb
Benzene	6 - 8 ppb
Naphthalene	NA - 4 ppb

Metals detected include:

Iron	250,000 - 380,000 ppb
Zinc	4,600 - 10,000 ppb
Lead	140 - 2,700 ppb
Chromium	1,300 - 2,100 ppb
Copper	520 - 860 ppb
Arsenic	36 - 210 ppb
Mercury	12 - 50 ppb

No record of waste disposal practice exist to explain the ground water monitoring results at MW-2-88. Likewise, none of the former structures or former manufacturing operations can be specifically correlated with this location. However, some observations are possible. The visual and olfactory characteristics exhibited by ground water collected at MW-2-88 and W-14 are strikingly similar (see Table 4-2). Likewise, the chemical character of ground water at MW-2-88 is very similar qualitatively to that at MW-14 and MW-15. These similarities suggest that some of the iron oxide wastes may have also been deposited in the area of MW-2-88. The topographic high (see Figure 4-3) and mounded ground water (see Figure 4-15) in this area may also be indicative of such waste deposition.

6.3.1.5 Tank Parks

Ground water samples were collected in the areas of former tank parks 911N, 910, and 913. As discussed in Section 2.2.3, these tank parks were employed to store substances used in the manufacture of detergents.

6.3.1.5.1 Tank Park 911N

Two wells were installed in the area of tank part 911N. The first well (MW-8-88) was installed to straddle the water table. Analysis of ground water samples collected from this well on two (2) occasions revealed the presence of chlorobenzene (1100-1400 ppb) and trace concentrations of a few other organics.

During the installation of MW-8-88, soils collected near the bottom of the borehole were found to exhibit a relatively high HNu reading of 250 ppm. For this reason, a second well, which was screened at the top of the uppermost confining layer, was subsequently installed in this area to assess the presence of dense NAPL. This well (MW-11-88) was sampled on one occasion (11-21-88). Analytical results revealed the principal organic contaminants to be:

Chlorobenzene	48,000 ppb
Benzene	6,300 ppb
Ethylbenzene	170 ppb
Toluene	100 ppb
Xylene	74 ppb

A comparison of TOX concentrations between MW-8-88 (TOX = 0.21-0.27 ppm) and MW-11-88 (TOX = 25 ppm) also demonstrates the much greater degree of organic contamination that exists in ground water just above the uppermost confining layer.

In contrast to the above, the shallower ground water was determined to exhibit much higher concentrations of metals. Principal metals detected include:

Iron	65,000 - 104,000 ppb
Zinc	2,040 - 4,000 ppb
Copper	168 - 234 ppb
Lead	117 - 180 ppb
Chromium	80 - 95 ppb

6.3.1.5.2 Tank Park 910

A single well (W-8), previously installed in this location during 1982-83, was sampled on two (2) occasions. On both occasions, an approximately six-foot layer of light NAPL was found floating on the ground water at this well. This light NAPL exhibited a kerosene-like odor and appearance. In accordance with the Work Plan, samples of both the NAPL and ground water were collected for analysis.

The results summarized in Table 6-9 indicate the presence of a number of volatile and semi-volatile substances in the NAPL, including benzene, toluene, xylene, ethylbenzene, 1,1-dichloroethene, 1,2-dichloroethene, 2-methylnaphthalene, and a number of PAH compounds at a concentration of 1.2-190 ppm. Only trace concentrations (approximately 1-50 ppb) of the same substances were detected in the ground water. The most notable characteristic of the ground water was its relatively high TOC concentration (200-1100 ppm), undoubtedly due to dissolution and/or dispersion of the light NAPL.

6.3.1.5.3 Tank Park 913

Two wells (MW-3-88 and W-9) located in this area were monitored on two (2) occasions. It should be noted that MW-3-88 is also located adjacent to the former location of a pit that was a part of a river water intake system.

Ground water at MW-3-88 was found to be much more contaminated than at W-9. This general finding is indicated by the TOC (96-190 ppm) and TOX (1.3-1.6 ppm) concentrations at MW-3-88 which are 2-6 times greater than the comparative concentrations at W-9. The finding that ground water at MW-3-88 is highly contaminated is also consistent with the high HNu headspace analysis (60-85 ppm) obtained during soil sampling in this area (see Section 6.2.5).

Specific contaminants detected at MW-3-88 include:

Benzene	1,100 - 28,000 ppb
Chlorobenzene	750 - 3,600 ppb
Ethylbenzene	220 - 1,200 ppb
1,4-Dichlorobenzene	ND - 220 ppb
Toluene	20 - 160 ppb
Xylene	1 - 130 ppb
Phenol	57 - 77 ppb
Naphthalene	ND - 43 ppb
2-Chlorophenol	5 - 7 ppb

Similar contaminants were detected at W-9, although at much lower concentration. Metals, except for iron (14,000 - 15,000 ppb), aluminum (1,500 - 2,400 ppb), and arsenic (ND - 52 ppb) are present only at relatively low concentration in this area.

6.3.1.6 Remainder of Site

The two remaining wells at which ground water samples were collected during the RI field activities are W-7, located along the northwest site boundary, and W-6R, located outside the northern site boundary adjacent to the site access road. Well W-7 is positioned at the most hydraulically upgradient location of all the wells monitored during this program.

Nine (9) volatile/semi-volatile compounds were detected in W-7, the most notable being benzene (16 - 210 ppb). Except for iron (42,000 - 47,000 ppb) and aluminum (2,400 ppb) metal concentrations were relatively low. The TOC (20-25 ppm), TOX (0.062-0.067 ppm) and specific conductivity (1400-1800 umhos) all reflect a relatively low level of ground water contamination at this well.

The ground water at W-6R contains numerous organic compounds in the low ppb concentration range. The ground water collected from this well was observed to be black in color and to have a slight odor. Notable organic contaminants detected included:

benzene	480 - 500 ppb
toluene	88 - 110 ppb
benzidine	ND - 90 ppb
chlorobenzene	17 - 24 ppb
naphthalene	14 - 16 ppb
xylene	ND - 10 ppb
1-naphthylamine	6 - 9 ppb
1,4-dichlorobenzene	3 - 5 ppb
1,2-dichlorobenzene	3 - 4 ppb

Metals present include:

Iron	6,900 - 8,100 ppb
Aluminum	NR - 2,800 ppb
Zinc	390 - 430 ppb
Copper	80 - 160 ppb
Chromium	50 - 90 ppb
Lead	60 - 80 ppb

6.3.2 Glaciolacustrine/Till Aquitard

Two wells (MW-1-88 and MW-7-88) were installed in the glacial till to monitor the ground water quality of the lower portion of the aquitard that underlies the site. As previously discussed, a continuous glacio-

Sediments

lacustrine/till aquitard is present beneath the site and ground water in this zone exhibits a vertically upward hydraulic gradient (see Section 4.4). These factors would be expected to retard the downward migration of contaminants from the fill.

The analytical data for monitoring wells MW-1-88 and MW-7-88 summarized in Table 6-10 does not present clear evidence that the glacio-lacustrine till has been contaminated.

6.4 SURFACE WATER

The surface water sampling results for those parameters having at least one detected value are summarized in Table 6-11. As indicated, most of the volatiles detected were also detected in the instrument blanks analyzed as a part of the quality control protocol. As discussed previously, acetone was present as a result of its use in field cleaning of sampling equipment.

The surface water sampling locations are shown in Figure 6-2. The designated "upstream" (SW UP) and "downstream" (SW DOWN) sampling locations were so designated on the basis of normal flow direction in the Buffalo River. However, as has been discussed, flow reversals sometimes occur in the river (see Sections 4.4.2.2 and 5.0). During the 8/19/88 sampling event, such a flow reversal was occurring.

6.5 STREAM SEDIMENTS

As discussed in Sections 4.4.2.1 and 5.1, flow direction reversals occur in the Buffalo River as a result of lake seiches. This situation might be expected to have some influence on sediment transport and distribution. However, since flow velocity is low during such flow reversals, the major sediment transport process is likely more a function of sediment scour that occurs during the spring melt/runoff and major storm events. The problem is complicated by the fact that the U.S. Army Corps of Engineers dredges the river bottoms, removing 100,000 - 200,000 tons of sediments per year. This may change the location and

SAMPLE NUMBER	SED - 1	SED - 2	SED - 3	SED - 4	SED - 5	SED - 6	SED - 7	SED - 8
SEMIVOLATILE ORGANICS (mg/kg)								
1,2-DICHLOROBENZENE				1.2 DJ				
NITROBENZENE					0.60 DJ			
NAPHTHALENE				0.46 DJ	0.42 DJ			0.88 DJ
ACENAPHTHENE								0.24 DJ
PHENANTHRENE					0.94 DJ	0.79 DJ	0.87 DJ	0.82 DJ
ANTHRACENE								0.61 DJ
FLUORANTHENE					1.2 DJ	0.81 DJ	0.89 DJ	1.7 DJ
PYRENE					0.95 DJ	0.54 DJ	0.58 DJ	1.2 DJ
BENZO(a)ANTHRACENE						0.39 DJ	0.44 DJ	0.74 DJ
CHRYSENE					0.51 DJ	0.26 DJ	0.29 DJ	0.58 DJ
BENZO(b)FLUORANTHENE					0.59 DJ			0.54 DJ
BENZO(a)PYRENE					0.32 DJ			0.31 DJ
INDENO(1,2,3-cd)PYRENE					0.24 DJ			
BENZO(g,h,i)PERYLENE					0.25 DJ			
EOX (mg/kg)	22		24	15	26	63	27	36
TOTAL METALS (mg/kg)								
ANTIMONY				4.8	38	3.4	4.9	4.6
ARSENIC	17	21	21	19	21	138	10	21
BERYLLIUM	0.92			1.1	1.1			
CADMIUM		1.3	1.3	1.5	1.8	5.5	1.5	2.5
CHROMIUM	36	36	36	41	116	63	51	952
COPPER	32	48	48	77	100	5050	87	111
IRON	24200	33100	25800	30900	28200	38900	27200	32400
LEAD	51	64	93	154	222	497	289	310
MERCURY								4.5
NICKEL	31	42	33	40	100	32	30	36
THALLIUM	2.9	3.3	3.1	3.5	3.1	3.6	2.7	2.3
ZINC	119	162	181	226	182	1100	148	319

LABORATORY QUALIFIERS:

D - Present in secondary dilution of samples

J - Estimated concentration

TABLE 6-11: SUMMARY OF CONTAMINANTS DETECTED IN SURFACE WATER

	DISCRETE DOWNSTREAM SAMPLES				COMPOSITE	DISCRETE UPSTREAM SAMPLES				COMPOSITE
SAMPLE NUMBER	SW-11D	SW-12D	SW-13D	SW-14D	SW-DOWN	SW-21U	SW-22U	SW-23U	SW-24U	SW-UP
SAMPLE DATE	6/27/88	6/27/88	6/27/88	6/27/88	8/19/88	6/27/88	6/27/88	6/27/88	6/27/88	8/19/88
METHYLENE CHLORIDE (ug/l)	1 BJ	1 BJ	1 BJ	1 BJ	6 B	2 BJ	3 BJ	3 BJ	2 BJ	
ACETONE (ug/l)	22000 E	1400 E	320 E	34	35 B	27				5000 BE
1,1-DICHLOROETHENE (ug/l)					1 BJ					2 BJ
1,2-DICHLOROETHENE (TOTAL) (ug/l)					5 J					5 J
XYLENE (TOTAL) (ug/l)					6 B					6 B

SAMPLE NUMBER	SW DOWN	SW DOWN	SW UP	SW UP
SAMPLE DATE	6/27/88	8/19/88	6/27/88	8/19/88
BIS(2-ETHYLHEXYL) PHTHALATE (ug/l)	2 J	9 J		12
TOTAL METALS (ug/l)				
ALUMINUM	NR	530	NR	1140
BARIUM	NR	70	NR	76
CHROMIUM				28
IRON	330	850	170	2170
LEAD		5	13	13
MAGNESIUM	NR	12700	NR	12800
MANGANESE	NR	197	NR	212
THALLIUM	10		15	
ZINC	138	15	131	26
CYANIDE (ug/l)	19	LOST	17	
HEX CHROMIUM (ug/l)	<7	9.5	<7	7
TOC (mg/l)	NR	13	NR	5
TOX (ug/l)	NR	43	NR	53

LABORATORY QUALIFIERS:

NR - Analyte not analyzed for this sample
LOST - Sample lost at lab
E - Analysis exceeded calibrated instrument range
J - Estimated value
D - Detected at secondary dilution
B - Detected in associated lab blank

direction of subsequent deposition of sediments resuspended during dredging. The discussion of the stream sediment sampling results is presented in this context.

The results of analysis of sediments collected from the bed of the Buffalo River just offshore of Area "D" for those parameters having at least one detected value are summarized in Table 6-12. As indicated in Table 6-12, the principal contaminants found in the sediments were eleven (11) PAH compounds, naphthalene, nitrobenzene, and metals, especially iron, copper, lead, chromium, and zinc.

Several trends are apparent with respect to the spatial distribution of the semivolatile organics and metals found in the sediments. First is the occurrence of 1,2-dichlorobenzene, nitrobenzene, and naphthalene at sediment sampling stations 4 and 5. As shown in Figure 6-2, these two stations are located adjacent to the incineration area where the same semivolatile organics are present in high concentration in the soil (see Section 6.2.2).

Another trend was the steadily increasing concentrations of EOX and metals from Station No. 1 through Station No. 6 (see Figure 6-2). Finally, the highest concentration of PAH compounds and chromium was found at Station No. 8, located in the sediment depositional zone on the west side of the peninsula.

6.6 WASTE RESIDUES

Analysis of the two (2) tar-like waste residue samples collected from the shore on the east and west sides of Area "D" yielded inconsistent results. Thirteen (13) PAH compounds and two (2) phthalates were analytically detected in the west tar sample (see Table 6-13). Iron (45,000 ppm) and lead (1,800 ppm) were also reported. In contrast to the above, only bis(2-ethylhexyl)phthalate was reported to be present in the east tar sample. The iron content of this sample was determined to be 52 percent.

TABLE 6-13: SUMMARY OF CONTAMINANTS IN WASTE RESIDUAL

PARAMETER	EAST TAR 11/8/88	WEST TAR 11/8/88
SEMIVOLATILE ORGANICS (mg/kg)		
NITROBENZENE		0.21 DJ
ACENAPHTHENE		0.40 DJ
FLUORENE		0.50 DJ
PHENANTHRENE		4.6 DJ
ANTHRACENE		1.3 DJ
DI-n-BUTYLPHTHALATE		0.76 DJ
FLUORANTHENE		4.8 DJ
PYRENE		3.9 DJ
BENZO(a)ANTHRACENE		1.9 DJ
BIS(2-ETHYLHEXYL) PHTHALATE	1.9 DJ	0.29 DJ
CHRYSENE		2.1 DJ
BENZO(b)FLUORANTHENE		3.1 DJ
BENZO(a)PYRENE		1.7 DJ
INDENO(1,2,3-cd)PYRENE		0.76 DJ
DIBENZO(a,h)ANTHRACENE		0.43 DJ
BENZO(g,h,i)PERYLENE		0.78 DJ
EOX (mg/kg)	5460	300
TOTAL METALS (mg/kg)		
ARSENIC	13.6	25.2
CADMIUM		7.6
CHROMIUM	619	415
COPPER	269	303
IRON	522000	45200
LEAD	74.7	1840
MERCURY	0.07	2.3
NICKEL	405	53.9
SILVER	1.2	1
THALLIUM	0.88	
ZINC	147	593

Laboratory Qualifiers:

J - Estimated concentration
D - Detected in diluted sample

DEC SPLITS ppm

EAST	WEST
	Methylnaphthalene 29
	TCB 6.7 J
	Naphthalene 14
	84
	83

HASP

Toluene = 28
Chlorobenzene = 400
Ethylbenzene = 110

6.7 SUMMARY

The results of sample collection and analysis have demonstrated contamination at the Area "D" to be both widespread and variable with respect to its character and concentration. Contamination was found in the soil and/or ground water at every location of the site investigated during the present RI. The spatial distribution and relative concentration of contamination at the site is depicted schematically in Figures 6-3 and 6-4.

On a weight basis, the principal contaminant found in ground water and soils at the site is iron. An assortment of other heavy metals is also present throughout the site. A wide variety of organics was detected in both the soils and ground water at the site. In addition, an oily sheen was observed in soils at a number of locations and a 6-foot layer of light non-aqueous phase liquid was found floating on ground water in the area of former tank park 912. A summary of the specific chemical substances detected, their frequency of detection and concentration range is presented in Tables 6-14 through 6-17.

PARAMETER	NUMBER OF DETECTIONS	MINIMUM	MAXIMUM	LOCATION OF MAXIMUM	SITE AREA
SEMIVOLATILE ORGANICS (mg/kg)					
NITROBENZENE	2	0.21	580	SB-3	Incineration Area
BENZOIC ACID	1		2.8	SB-4	Weathering Area
NAPHTHALENE	1		470	SB-3	Incineration Area
2-CHLORONAPHTHALENE	1		66	SB-3	Incineration Area
ACENAPHTHYLENE	1		16	SB-4	Weathering Area
FLUORENE	2	0.50	25	SB-4	Weathering Area
PHENANTHRENE	3	4.6	270	SB-4	Weathering Area
FLUORANTHENE	2	4.8	330	SB-4	Weathering Area
PYRENE	2	3.9	310	SB-4	Weathering Area
BENZO(a)ANTHRACENE	2	1.9	180	SB-4	Weathering Area
CHRYSENE	2	2.1	180	SB-4	Weathering Area
BENZO(b)FLUORANTHENE	2	3.1	150	SB-4	Weathering Area
BENZO(k)FLUORANTHENE	1		140	SB-4	Weathering Area
BENZO(a)PYRENE	2	1.7	140	SB-4	Weathering Area
INDENO(1,2,3-cd)PYRENE	2	0.76	77	SB-4	Weathering Area
BENZO(g,h,i)PERYLENE	2	0.78	63	SB-4	Weathering Area
EOX (mg/kg)	8	11	2780	SB-3	Incineration Area
TOTAL METALS (mg/kg)					
ANTIMONY	3	8	32.2	SB-3	Incineration Area
ARSENIC	9	4.5	77.2	SB-3	Incineration Area
BERYLLIUM	6	0.58	1.3	SB-5	West Shore
CADMIUM	5	0.82	24.8	SB-3	Incineration Area
CHROMIUM	9	44.2	1990	SB-3	Incineration Area
COPPER	9	36.2	3580	SB-3	Incineration Area
IRON	9	15200	537000	SB-1	Iron Oxide Lagoons
LEAD	9	8.9	27300	SB-4	Weathering Area
MERCURY	8	0.07	6.2	SB-3	Incineration Area
NICKEL	9	14.8	363	SB-3	Incineration Area
SELENIUM	1		0.55	SB-6	West Shore
SILVER	9	0.66	4.6	SB-1	Iron Oxide Lagoons
ZINC	9	34.5	3320	SB-3	Incineration Area

	NUMBER OF DETECTIONS	MINIMUM	MAXIMUM	LOCATION OF MAXIMUM	SITE AREA
SEMIVOLATILE ORGANICS (mg/kg)					
1,4-DICHLOROBENZENE	3	1.7	13	B-1-88	Incineration
1,2-DICHLOROBENZENE	4	0.91	110	B-1-88	Incineration
NITROBENZENE	5	0.21	1100	B-1-88	Incineration
1,2,4-TRICHLOROBENZENE	2	1.2	150	B-1-88	Incineration
NAPHTHALENE	7	1.9	8.2	MW-2-88	West Shore
2-CHLORONAPHTHALENE	2	0.55	140	B-1-88	Incineration
2-NITROANILINE	1		1.1	B-5-88	Tank Park 912
ACENAPHTHYLENE	3	0.41	1.7	B-5-88	Tank Park 912
ACENAPHTHENE	1		0.40	MW-9-88	Incineration
2,4-DINITROTOLUENE	2	2.6	3.4	B-5-88	Tank Park 912
FLUORENE	4	0.10	2.5	MW-2-88	West Shore
PHENANTHRENE	9	0.51	11	B-5-88	Tank Park 912
ANTHRACENE	4	1.3	4.8	MW-2-88	West Shore
DI-n-BUTYLPHTHALATE	7	0.29	0.76	MW-9-88	Incineration
FLUORANTHENE	7	0.19	14	MW-2-88	West Shore
PYRENE	8	0.14	13	MW-2-88	West Shore
BENZO(a)ANTHRACENE	4	1.1	6.7	MW-2-88	West Shore
BIS(2-ETHYLHEXYL) PHTHALATE	6	0.23	1.9	MW-8-88	Tank Park 910
CHRYSENE	5	0.35	8.2	MW-2-88	West Shore
DI-N-OCTYL PHTHALATE	1		0.07	B-5-88	Tank Park 912
BENZO(b)FLUORANTHENE	4	1.6	9.7	MW-2-88	West Shore
BENZO(a)PYRENE	7	0.09	5.5	MW-2-88	West Shore
INDENO(1,2,3-cd)PYRENE	4	0.49	2.9	MW-2-88	West Shore
DIBENZO(a,h)ANTHRACENE	3	0.43	0.83	MW-2-88	West Shore
BENZO(g,h,i)PERYLENE	4	0.48	2.6	MW-2-88	West Shore
EOX (mg/kg)	18	11	360	MW-10-88	Incineration
TOTAL METALS (mg/kg)					
ANTIMONY	10	0.63	119	B-5-88	Tank Park 912
ARSENIC	34	4	2860	MW-10-88	Incineration
BERYLLIUM	11	0.7	1.3	B-4-88	West Shore
CADMIUM	12	0.7	7	B-4-88	West Shore
CHROMIUM	34	5.7	440	MW-10-88	Incineration
COPPER	34	6	14500	MW-1-88	Weathering
IRON	34	1750	360000	MW-10-88	Incineration
LEAD	34	8.4	83200	B-5-88	Tank Park 912
MERCURY	14	0.19	14	B-5-88	Tank Park 912
NICKEL	34	3.9	467	MW-7-88	Iron Oxide Lagoons
SELENIUM	14	0.99	21	MW-5-88	West Shore
SILVER	19	0.7	5.9	B-5-88	Tank Park 912
THALLIUM	6	1.4	66	MW-10-88	Incineration
ZINC	34	12	1160	MW-10-88	Incineration

(1) Total Number of Samples: 35	NUMBER OF DETECTIONS	CONCENTRATION MINIMUM	CONCENTRATION MAXIMUM	LOCATION OF MAXIMUM	SITE AREA
SEMIVOLATILE ORGANICS (ug/l)					
PHENOL	3	8	77	MW-3-88	Tank Park 913
2-CHLOROPHENOL	8	0.8	1800	MW-4-88	Incineration
1,3-DICHLOROBENZENE	4	0.7	49	MW-4-88	Incineration
1,4-DICHLOROBENZENE	11	1	4900	MW-4-88	Incineration
1,2-DICHLOROBENZENE	11	2	21000	MW-4-88	Incineration
2-METHYLPHENOL	4	4	47	MW-4-88	Incineration
N-NITROSO-DI-n-PROPYLAMINE	1		24	MW-2-88	West Shore
NITROBENZENE	5	5	15	W-13	Weathering
2,4-DIMETHYLPHENOL	6	4	130	MW-4-88	Incineration
BENZOIC ACID	1		18	MW-3-88	Tank Park 913
BIS(2-CHLOROETHYL)OXYMETHANE	1		20	MW-2-88	West Shore
1,2,4-TRICHLOROBENZENE	4	8	1200	W-15	Iron Oxide Lagoons
NAPHTHALENE	13	0.3	4900	MW-13-88	Incineration
4-CHLOROANILINE	6	8	11000	MW-13-88	Incineration
4-CHLORO-3-METHYLPHENOL	2	4	7	MW-3-88	Tank Park 913
2-METHYLNAPHTHALENE	3	5	16	MW-11-88	Tank Park 911N
2-NITROANILINE	1		4	W-13	Weathering
ACENAPHTHYLENE	1		15	W-6R	Main Plant
ACENAPHTHENE	4	1	26	W-15	Iron Oxide Lagoons
DIBENZOFURAN	2	9	13	W-15	Iron Oxide Lagoons
2,4-DINITROTOLUENE (2)	1		2000	W-13	Weathering
2,6-DINITROTOLUENE	2	1500	1700	W-13	Weathering
DIETHYL PHTHALATE	1		4	MW-4-88	Incineration
FLUORENE	6	2	24	W-15	Iron Oxide Lagoons
N-NITROSODIPHENYLAMINE	5	2	15	MW-2-88	West Shore
PENTACHLOROPHENOL	1		2	MW-4-88	Incineration
PHENANTHRENE	6	3	63	W-15	Iron Oxide Lagoons
ANTHRACENE	5	0.9	14	W-15	Iron Oxide Lagoons
DI-n-BUTYLPHTHALATE	5	0.2	1	MW-12-88	Incineration
FLUORANTHENE	6	1	54	W-8	Tank Park 910
PYRENE	6	4	24	W-15	Iron Oxide Lagoons
BENZO(a)ANTHRACENE	4	1	12	W-15	Iron Oxide Lagoons
BIS(2-ETHYLHEXYL)PHTHALATE	18	2	52	W-12	Weathering
CHRYSENE	4	0.9	11	W-15	Iron Oxide Lagoons
BENZO(b)FLUORANTHENE	1		0.3	W-8	Tank Park 910
BENZO(k)FLUORANTHENE	1		0.6	W-8	Tank Park 910
BENZO(a)PYRENE	2	0.6	7	W-15	Iron Oxide Lagoons
BENZIDINE	2	90	360	W-15	Iron Oxide Lagoons
1-NAPHTHYLAMINE	14	6	42000	W-15	Iron Oxide Lagoons
ANILINE (3)	5	5	660	W-15	Iron Oxide Lagoons

(1) Total Number of Samples: 35	NUMBER OF DETECTIONS	CONCENTRATION MINIMUM	MAXIMUM	LOCATION OF MAXIMUM	SITE AREA
VOLATILE ORGANICS (ug/l)					
VINYL CHLORIDE	1		6	MW-8-88	Tank Park 911N
CARBON DISULFIDE (2)	3	1	43	W-8	Tank Park 910
1,1-DICHLOROETHENE	11	1	8	MW-9-88	Incineration
1,2-DICHLOROETHENE(TOT)	16	1	19	MW-9-88	Incineration
CHLOROFORM	3	0.7	24	MW-9-88	Incineration
2-BUTANONE	1		260	MW-13-88	Incineration
BROMODICHLOROMETHANE	4	1	7	MW-9-88	Incineration
TRICHLOROETHENE	2	1	3	MW-13-88	Incineration
BENZENE	28	0.1	28000	MW-3-88	Tank Park 913
4-METHYL-2-PENTANONE (2)	2	3	24	MW-13-88	Incineration
TOLUENE	25	0.09	4700	MW-13-88	Incineration
CHLOROBENZENE	25	0.6	48000	MW-11-88	Tank Park 911N
ETHYLBENZENE	13	0.2	43000	MW-4-88	Incineration
XYLENE (TOTAL)	21	1	1700	MW-4-88	Incineration
TOTAL METALS (ug/l)					
ALUMINUM (3)	16	1200	67000	W-13	Weathering
ANTIMONY	12	5	124	W-14	Iron Oxide Lagoons
ARSENIC	30	5.7	1820	W-14	Iron Oxide Lagoons
BARIUM (3)	14	30	1020	W-14	Iron Oxide Lagoons
BERYLLIUM	2	6	7	W-13	Weathering
CADMIUM	21	5	127	W-14	Iron Oxide Lagoons
CHROMIUM	30	13	2140	MW-2-88	West Shore
COPPER	33	15	78700	W-13	Weathering
IRON	35	3940	405000	W-14	Iron Oxide Lagoons
LEAD	28	5	3030	W-14	Iron Oxide Lagoons
MAGNESIUM (3)	16	8900	59700	MW-9-88	Incineration
MANGANESE (3)	16	214	21300	MW-9-88	Incineration
MERCURY	12	0.29	50	MW-2/W-12	W. Shore/Weathering
NICKEL	23	30	830	W-13	Weathering
SELENIUM	1		10	W-6R	Main Plant
SILVER	9	5	13	MW-13-88	Incineration
THALLIUM	5	15	94	W-9	Tank Park 913
ZINC	35	23	9950	MW-2-88	West Shore
CYANIDE (ug/l)	11	12	56	W-9	Tank Park 913
HEXAVALENT CHROMIUM (ug/l)	20	6	13	W-12	Weathering
TOC (mg/l)	35	19	2350	MW-13-88	Incineration
TOX (ug/l)	35	15	27200	MW-4-88	Incineration

NOTE: (1) The analysis of NAPL-8 and the aquitard wells (MW-1-88 and MW-7-88) are not included in this table.

(2) 2,4-dinitrotoluene, 4-methyl-2-pentanone and carbon disulfide analyzed in first sample round only (19 samples)

(3) Aniline, Al, Ba, Mg and Mn analyzed in second sample round only (16 samples)

TABLE 6-17:FREQUENCY OF DETECTIONS IN STREAM SEDIMENTS

(sedsum2)

	NUMBER OF DETECTIONS	CONCENTRATION MINIMUM	CONCENTRATION MAXIMUM	LOCATION OF MAXIMUM
SEMIVOLATILE ORGANICS (mg/kg)				
1,2-DICHLOROBENZENE	1		1.2	SED-4
NITROBENZENE	1		0.60	SED-5
NAPHTHALENE	3	0.42	0.88	SED-8
ACENAPHTHENE	1		0.24	SED-8
PHENANTHRENE	4	0.79	0.94	SED-5
ANTHRACENE	1		0.61	SED-8
FLUORANTHENE	4	0.81	1.7	SED-8
PYRENE	4	0.54	1.2	SED-8
BENZO(a)ANTHRACENE	3	0.39	0.74	SED-8
CHRYSENE	4	0.26	0.58	SED-8
BENZO(b)FLUORANTHENE	2	0.54	0.59	SED-5
BENZO(a)PYRENE	2	0.31	0.32	SED-5
INDENO(1,2,3-cd)PYRENE	1		0.24	SED-5
BENZO(g,h,i)PERYLENE	1		0.25	SED-5
EOX (mg/kg)	7	0.02	0.06	SED-6
TOTAL METALS (mg/kg)				
ANTIMONY	5	0.003	0.04	SED-5
ARSENIC	8	0.01	0.14	SED-6
BERYLLIUM	3	0.001	0.001	SED-5
CADMIUM	7	0.001	0.006	SED-6
CHROMIUM	8	0.04	0.95	SED-8
COPPER	8	0.03	5.1	SED-6
IRON	8	24	39	SED-6
LEAD	8	0.05	0.50	SED-6
MERCURY	1		0.005	SED-8
NICKEL	8	0.03	0.1	SED-5
THALLIUM	8	0.002	0.004	SED-6
ZINC	8	0.12	1.1	SED-6

7.0 CONTAMINANT MIGRATION

7.1 CONTAMINANT PATHWAYS

Field investigations of the Area "D" site indicate that contaminated ground water generated as a result of dissolution of chemical constituents of the waste fill is moving off-site. In addition, historical aerial photographs indicate that waste fill is entering the Buffalo River as a result of erosion of the river bank along the periphery of the site. Figure 7-1 schematically illustrates contaminant migration pathways for the Area "D" site as identified during field investigations. Identified pathways include:

- continuous release of soluble constituents of the non-aqueous phase liquid located in the area of W-8 to ground water within the shallow overburden;
- overland runoff and mechanical transport of waste particles;
- lateral movement of contaminated ground water through the shallow overburden, with ultimate discharge to the Buffalo River; and
- mechanical erosion of the river bank along the periphery of the site resulting in the release of waste fill to the Buffalo River.

A visual inspection of the site was also performed to determine the presence of underground utilities which might also act as a migration pathway. Each of these pathways is discussed in more detail in the following sections.

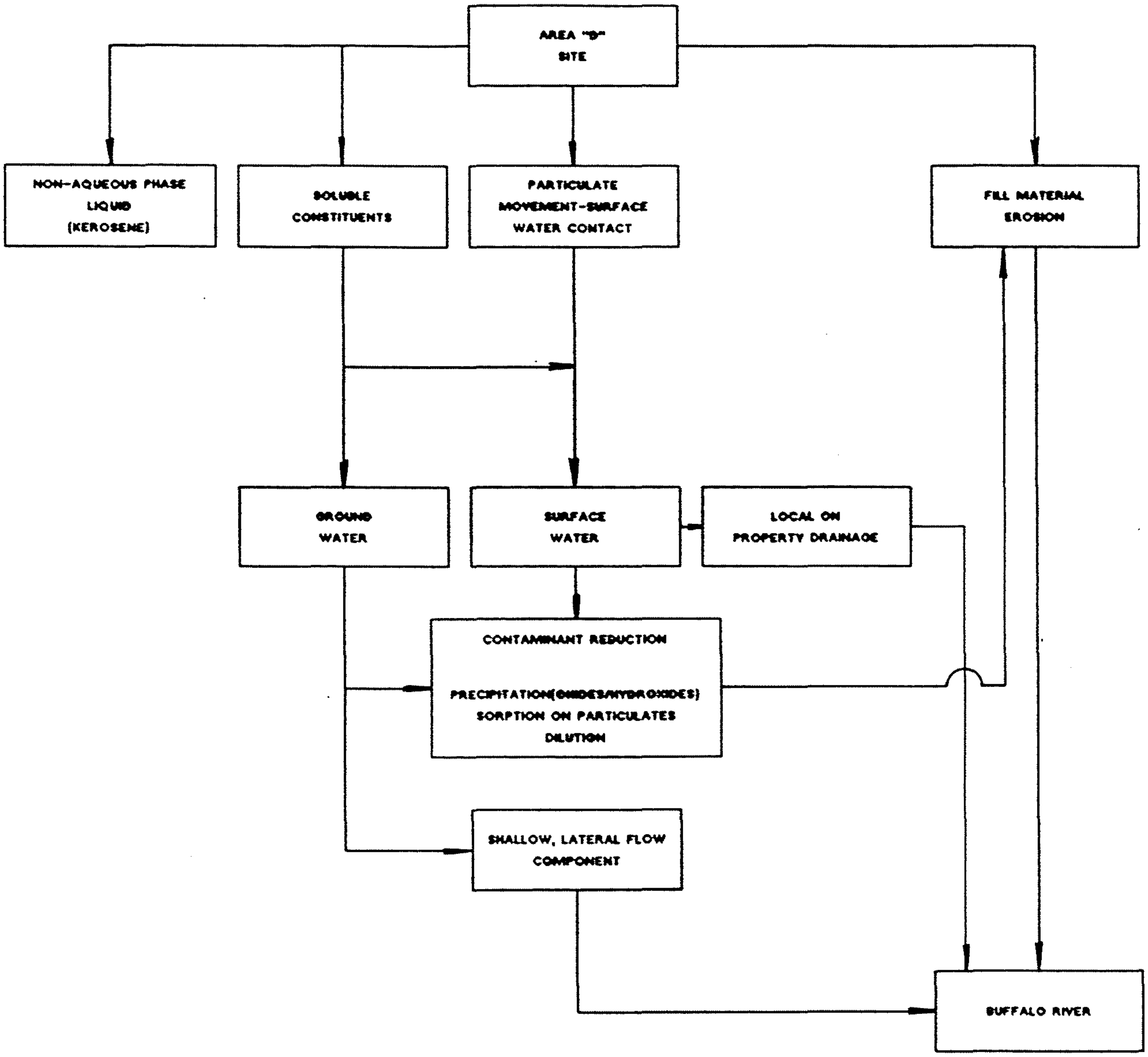
7.2 ASSESSMENT METHODOLOGY

7.2.1 Free-Product (Well W-8)

A slightly viscous golden-colored free-phase product was observed in W-8. The thickness of the product in the well was determined using an electronic water level indicator. The product/ground water interface was recorded when the instrument, after being lowered through the product

SCHEMATIC OF POLLUTANT MIGRATION

(PATHWAYS/FATE)



layer in the well, came in contact with the ground water in the well, causing the instrument to sound. The top of the product layer in the well was obtained by bobbing a plopper up and down until contact was made with the product layer. The thickness of the free-product, as measured in the well, is an apparent thickness rather than a true thickness (Testa et al. 1989). The difference between the true and apparent thickness is attributed to both the contrast in specific gravity between the free-product and water and the fact that free-product is immiscible in water. This results in the free-product perching on the capillary fringe above the actual water table. With penetration of the capillary fringe by the monitoring well, free-product migrates into the well bore. The water surface within the well is lower than the top of the surrounding capillary fringe, thus allowing product to flow into the well. This in turn depresses the water level in the well until density equilibrium is attained. Therefore, a greater apparent product thickness is measured in the well than actually exists in the formation (Testa et al. 1989).

During the field investigation, approximately six (6) feet of free-product was measured in W-8. The same free-product was not observed in any of the other nearby wells or borings completed in the shallow water-bearing zone; however, the nearest monitor location is greater than 100 feet away from W-8.

7.2.2 Overland Flow/Mechanical Transport

Although mechanical transport of waste fill particles by overland flow is identified as a potential pathway, the contaminant loading via this pathway would be expected to be minor due to the relatively flat topographic relief of the site and the presence of vegetative cover over the majority of the site. This expectation is further supported by the site water balance (see Section 4.4.4) which indicates that surface runoff contributes less than one percent (1%) of the water entering the river from the site. Actual contaminant loadings via this pathway were not assessed.

7.2.3 Ground Water

Contaminant loadings to the Buffalo River via the ground water pathway were calculated for the entire Area "D" site using water balance data presented in Section 4.4.4 and concentration data presented in Section 6.0. Considerations made in the performance of these calculations included:

- only ground water in the uppermost saturated zone is contributing contaminants to the Buffalo River;
- the quantity of contaminants present in the uppermost saturated zone was not corrected for potential background sources (viz. hydraulically upgradient and bedrock sources); and
- loading calculations were made for the following groups of parameters:
  - o total volatile organic compounds (VOCs), excluding acetone and methylene chloride,
  - o polynuclear aromatic hydrocarbons (PAHs) and phthalates,
  - o other semi-volatile organic compounds (SVOCs),
  - o total SVOCs including PAHs and phthalates,
  - o total iron
  - o total metals (viz.Sb, As, Be, Cd, Cr, Cu, Pb, Hg, Ni, Se, Ag, Tl, Zn), excluding iron,
  - o total organic carbon (TOC), and
  - o total organic halogens (TOX).

All of the data collected during the present RI from monitoring wells located at the perimeter of the site along the river (viz. MW-2-88, MW-3-88, MW-4-88, MW-5-88, MW-6-88, MW-9-88, MW-10-88, Wells 12, 13, 14 and 15, MW-12-88 and MW-13-88) were utilized to calculate average concentrations of the above-specified groups of contaminants in ground water entering the Buffalo River from Area "D" as summarized in Table 7-1. Contaminant loadings to the Buffalo River were calculated using an estimated ground water outflow from the Area "D" site of 3,387 cubic

MALCOLM PIRNIE

TABLE 7-1

BUFFALO COLOR CORPORATION
AREA "D"

CONTAMINANT LOADINGS TO BUFFALO RIVER VIA GROUND WATER PATHWAY

CONTAMINANT GROUP	NO. OF SAMPLES(1)	AVERAGE CONCENTRATION	LOAD(2) TO RIVER (lbs/day)
Total Volatile Organic Compounds (VOCs) (excluding acetone & methylene chloride)	24	5,758 ug/l	1.2
Poly-Aromatic Hydrocarbons (PAHs) & Phthalates	24	280 ug/l	0.1
Other Semi-Volatile Organic Compounds (SVOCs)	24	15,982 ug/l	3.4
Total SVOCs	24	16,262 ug/l	3.4
Total Metals (excluding iron)	24	9,417 ug/l	2.0
Total Iron	24	82,285 ug/l	17.4
Total Organic Carbon (TOC)	24	210 mg/l	44.5
Total Organic Halogens (TOX)	24	3,352 ug/l	0.7

NOTES:

(1) Sum of two sample events for 11 monitoring wells (MW-2-88, MW-3-88, MW-4-88, MW-5-88, MW-6-88, MW-9-88, MW-10-88, Well 12, Well 35, Well 14, Well 15, and one sample event for two wells (MW-12-88 and MW-13-88) and one sample event for two wells (MW-12-88 and MW-13-88).

(2) Sample calculation for Total VOCs: $5758\ ug/l \times 10^{-6} gm/ug \times 2.205 \times 10^{-3}\ lbs/gm \times 3387\ cf/day = 1.2\ lb/day$.

feet/day (see Section 4.4.4) and the average ground water concentrations determined as described above. A sample calculation is provided in Table 7-1.

7.2.4 Mechanical Erosion

The erosion potential of the river bank along the periphery of the Area "D" site was calculated using the Universal Soil Loss Equation (USLE) as developed by the United States Department of Agriculture (USDA) and summarized in USEPA (1982). Major assumptions used in the performance of these calculations included:

- that no vegetation exists on the river bank;
- that the fill material contains less than 0.5 percent organics; and
- that river scour increases the erosion potential by 25 percent along the eastern bank and by 10 percent along the southwestern bank.

The river bank along the periphery of the Area "D" site was segregated into six (6) areas to facilitate performance of the calculations and use of area-specific soil/waste fill characteristics. The six areas included: the iron oxide sludge pond area, the incineration area, the weathering area, the southwest bank, the area between the iron oxide sludge pond and the incineration area, and the area between the weathering area and the incineration area. No attempt was made to estimate the amount of waste fill which is eroding below the water surface. Erosion potential calculations are presented in Appendix E.1 along with a figure illustrating how the river bank was segregated into the above designated areas for calculation purposes.

Contaminant loadings to the Buffalo River via the mechanical erosion pathway were calculated using the erosion potential calculations and soil/fill contaminant concentration data presented in Section 6.0

Considerations made in the performance of these calculations are presented in Appendix E.2 and include:

- soil density was assumed to be 75 lbs/ft^3;
- only data for soil/fill sample locations at the perimeter of the site were used (see Appendix E.2); and
- loading calculations were made for the following groups of parameters:
  - o polynuclear aromatic hydrocarbons (PAHs) and phthalates,
  - o other semi-volatile organic compounds (SVOCs),
  - o total SVOCs including PAHs and phthalates,
  - o total iron,
  - o total metals (viz., Sb, As, Be, Cd, Cr, Cu, Pb, Hg, Ni, Se, Ag, Tl, Zn), excluding iron, and
  - o extractable organic halogens (EOX).

The specific calculation methodology is presented in Appendix E.2.

7.2.5 Underground Utilities Investigation

A visual inspection of all utility manholes and outfall pipes discovered at Area "D" was performed in order to observe any evidence of contaminant deposition or migration. Findings of this investigation included the following:

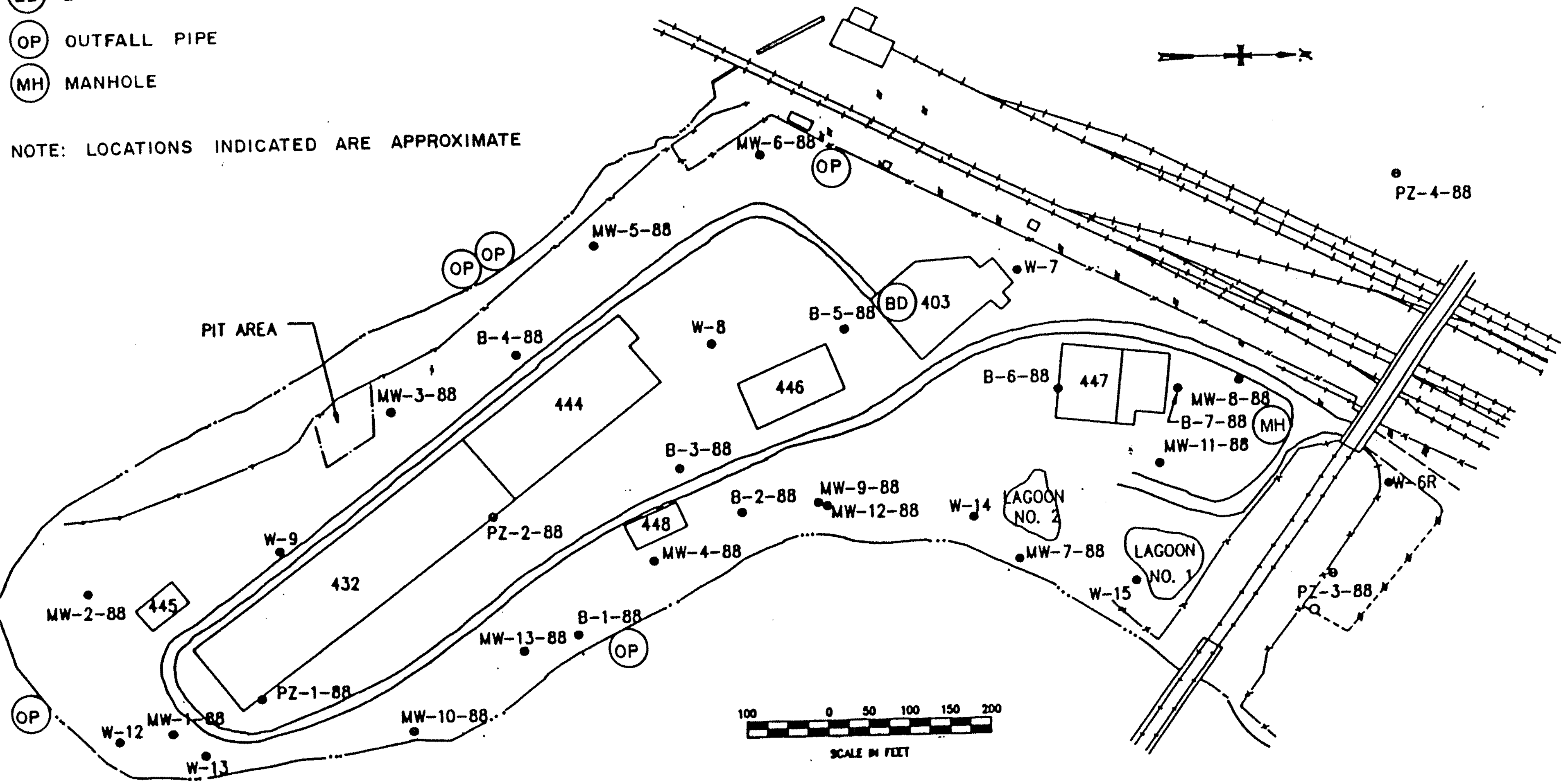
- One (1) plugged manhole approximately 50 feet south of the Area "D" entrance;
- one (1) unplugged drain in foundation slab of former Building 403;
- two (2) outfall pipes plugged with cobbles on the west bank of Area "D" approximately 500 feet south of the railroad drawbridge;
- one (1) outfall pipe plugged with cobbles in a foundation wall on the south bank near the Weathering Area;
- one (1) unplugged outfall pipe on the east bank approximately 10 feet south of the incinerator area; and
- one (1) buried outfall pipe encountered during drilling of MW-6-88.

FIGURE 7-2

LEGEND

- ● TEST BORING (B), MONITORING WELL (MW,W) AND PIEZOMETER (PZ)
- (BD) BUILDING DRAIN
- (OP) OUTFALL PIPE
- (MH) MANHOLE

NOTE: LOCATIONS INDICATED ARE APPROXIMATE



BUFFALO COLOR CORPORATION
BUFFALO, NEW YORK
AREA D - RI/FS

UNDERGROUND UTILITIES INVESTIGATION

MALCOLM PIRNIE

The presence of an oily sheen, odor, HNu reading, or other visible sign of contamination was not observed at any of the underground utilities found. Approximate locations of observed underground utilities are presented on Figure 7-2.

7.3 CONTAMINANT LOADINGS

7.3.1 Free-Product Migration

Free-product migration is generally governed by the viscosity and density of the product, relative permeability of the formation, and the rate at which ground water flows through the formation. The free-product encountered at W-8 is assumed to be immobile based on the fact that it is not encountered in downgradient wells. On the other hand, soluble constituents of the free-product are conservatively assumed to move at the same rate as ground water flow. The organic contaminant plume is, therefore, expected to migrate in a southerly and southwesterly direction at a rate of approximately 2.5 feet/year based on a hydraulic gradient of 0.00089 ft/ft, a hydraulic conductivity of 17 gpd/ft^2, and porosity of 0.3.

7.3.2 Ground Water

Calculated contaminant loadings to the Buffalo River from the Area "D" site via the ground water pathway are summarized in Table 7-1. Examination of the data in Table 7-1 indicates that as much as 17.4 pounds of iron and 2.0 pounds of other metals are being discharged daily to the Buffalo River via ground water. However, these numbers may be unrepresentatively high due to the high turbidity/suspended solids content of the ground water quality samples collected during this investigation. Soluble metals data was not collected (see Section 6.0). Further examination of Table 7-1 indicates that halogenated organics are a minor amount (viz. less than 2 percent) of the total organic carbon being discharged to the Buffalo River. The data also indicate that PAHs and phthalates are a relatively minor amount (viz. less than 5 percent) of the total semi-volatile organic compounds being discharged to the Buffalo River via ground water.

MALCOLM PIRNIE

TABLE 7-2

BUFFALO COLOR CORPORATION
AREA "D"

SUMMARY OF EROSION POTENTIAL CALCULATIONS

AREA DESCRIPTION[1]	EROSION POTENTIAL cubic yards/year	EROSION POTENTIAL inches/year
Iron Oxide Sludge Pond Area	100	4.3
Incineration Area	170	2.5
Weathering Area	32	2.3
Southwest Bank Area	195	1.2
Area Between Iron Oxide Pond and Incineration Areas	32	5.8
Area Between Weathering and Incineration Areas	50	5.3
TOTAL	579	-
AVERAGE	-	3.6[2]

NOTES:

(1) See figure in Appendix E.1 for locations

(2) Along entire length of River bank.

7.3.3 Mechanical Erosion

The Universal Soil Loss Equation (USLE) is a predictive tool for estimating the potential for soil loss due to erosion. Erosion potential values estimated for the river bank of the Area "D" site using the USLE are summarized in Table 7-2. Although these values should not be considered absolute, they are a general indication of the amount of waste fill which is being lost to the Buffalo River as a result of erosion as well as river scour. Examination of Table 7-2 indicates that approximately 575 cubic yards of fill material from the Area "D" is entering the Buffalo River each year. This equates to an average depth of approximately three (3) inches lost to the Buffalo River along the entire length of the river bank each year.

Calculated contaminant loadings to the Buffalo River from the Area "D" site via the mechanical erosion pathway are summarized in Table 7-3.

7.3.4 Summary

The major pathways of contaminant migration from the Area "D" to the Buffalo River are via ground water and erosion of fill material.

A daily loading of 1.2 lbs VOCs and 3.4 lbs SVOCs is estimated, on the basis of data collected during the present RI, to be migrating from the Area "D" to the Buffalo River via ground water. This estimate is comparable to the approximately 4 lbs per day of organic contaminants previously estimated to be migrating to the river on the basis of data collected during 1982-83 (Gradient Corporation, 1988). The total organic carbon loading migrating to the river via ground water is estimated to be 44.5 lbs/day. Assuming that all organic compounds present have an average carbon content of 50-70% by weight, the specific VOC and SVOC compounds detected during this RI make up approximately 6-10% of the total organic loading of the ground water.

The estimated loading of iron (17.4 lbs/day) and other metals (2.0 lbs/day) migrating to the river via ground water may be erroneously high as these estimates are based on total metal concentrations.

An estimated 575 cubic yards per year of fill material is eroding into the Buffalo River from the Area "D". This is the primary pathway for off-site migration of iron and other metals.

MALCOLM PIRNIE

TABLE 7-3

BUFFALO COLOR CORPORATION
AREA "D"

CONTAMINANT LOADINGS TO BUFFALO RIVER
VIA MECHANICAL EROSION PATHWAY

CONTAMINANT GROUP[1]	LOAD TO RIVER[2]
Poly-Aromatic Hydrocarbons (PAHs & Phthalates	0.029
Other Semi-Volatile Organic Compounds (SVOCs)	0.015
Total SVOCs	0.044
Total Metals (excluding iron)	6.2
Total Iron	270
Total Organic Halogens	0.20

NOTES:

(1) Soil/Fill samples were not analyzed for Volatile Organic Compounds (VOCs) or Total Organic Carbon (TOC).

(2) The samples used for the loading calculation and the calculation methodology is presented in Appendix E.2.

MALCOLM PIRNIE

8.0 PUBLIC HEALTH AND ENVIRONMENTAL CONCERNS

This Section presents an assessment of public health and environmental concerns at the Buffalo Color Area "D" site. The objectives of this assessment are to evaluate potential human health and environmental impacts associated with exposure to contaminants associated with the site.

The three factors which govern the potential risk of hazardous wastes to human health and the environment are:

(1) the presence of contaminants;
(2) actual or potential paths of exposure to these contaminants;and
(3) human and/or environmental receptors in the exposure paths.

A discussion of potential pathways of exposure and potential receptors of contaminants that may be migrating off-site from the Area "D" is presented in Section 8.1. An evaluation of specific site contaminants potentially affecting human health is presented in Section 8.2. Potential environmental impacts, including a review of the literature pertinent to environmental quality of the Buffalo River, is presented in Section 8.3.

8.1 POTENTIAL RECEPTORS

Potential human exposure may result from contaminants present at the site or from contaminants emanating from the site (e.g., via ground water, surface run-off, air, etc.). Potential human exposure points are addressed below on a media-specific basis.

Contaminated Soil - The Buffalo Color Area "D" site is located on a peninsula in the Buffalo River. A guarded security fence is located to the north and west of the site that limits entry onto the site to authorized personnel only. The site is not readily accessible to Buffalo Color employees or the general public from land. The steep banks of the south and east sides of Area "D" discourage entry from the Buffalo River. A security fence blocks entry from the smooth-banked west side. Area "D" is patrolled eight (8) times per day by uniformed security. Under a trespass scenario, trespassers could be exposed to contaminated soil by dermal contact or ingestion (i.e., if contaminated soil is transferred to the hands, it could be ingested during activities such as eating or smoking). Dust ingestion

Contaminated Ground Water - The Area "D" site is located in the City of Buffalo. Area residents are supplied with water by the City of Buffalo Department of Public Works, Water Division. There are no known potable water wells in the area, therefore, ingestion of contaminated ground water is not a human exposure route of concern at the site.

Contaminated Surface Water - Any surface water contaminants from the site would flow west and empty into Lake Erie, approximately 4 miles downstream. There are no known surface water intakes on the Buffalo River downstream of the site. The closest downstream surface water intake used for potable supply is located near the confluence of Lake Erie and the Niagara River.

The impact of surface water contamination adjacent to the site would be lessened considerably by natural dilution within the stream system. This dilution results from a number of processes, including mechanical dispersion and physical/chemical/biological reductions (e.g., due to adsorption, settlement, volatilization, decay, etc.).

Air Contamination - Receptors considered potentially at risk from air contamination at the site are persons trespassing on the site. The greatest potential risk would result from volatilization of organics in surface soil. HNu readings taken during soil sampling indicated that there was some volatilization of organics in soil.

Summary - Based upon the foregoing discussions, the most likely human exposure pathways identified at the site are ingestion, dermal contact and inhalation of contaminants in surface soils by trespassers.

8.2 PUBLIC HEALTH IMPACTS

8.2.1 Regulatory Standards and Guidelines

Potential impacts posed by surface water and ground water contamination are identified on the basis of comparison of observed contaminant concentrations at the site with applicable federal and state standards and guidelines. These regulations and guidelines are the following:

- New York State Water Quality Regulations (Title 6, Parts 701 and 703)
- Secondary Drinking Water Regulation (40 CFR, Part 143)
- NYSDEC Ambient Water Quality Guidance Values (TOGS 85-W-38)
- Safe Drinking Water Act, Recommended Maximum Contaminant Levels
- Clean Water Act, Water Quality Criteria for Human Health

Since there are currently no applicable standards or guidelines relating to soil contamination, the potential impacts of soil contamination have not been addressed.

8.2.1.1 Applicable Water Quality Standards and Criteria - Surface water in the State of New York is classified by the New York State Department of Environmental Conservation (NYSDEC) according to the "Best Usage of Waters". The reach of the Buffalo River from the River's mouth to the City of Buffalo West Seneca border is designated as Class "D". New York State Water Quality Regulations (6NYCRR, Part 701) identify the best usage of Class "D" surface water as follows:

> "The waters are suitable for fishing. The water quality shall be suitable for primary and secondary contact recreation even though other factors may limit the use for that purpose. Due to such natural conditions as intermittency of flow, water conditions not conducive to propagation of game fishery or stream bed conditions, the waters will not support fish propagation".

All ground waters in New York State are designated by NYSDEC as Class "GA". New York State Water Quality Regulations (6NYCRR, Part 703) identify the best usage of Class GA ground water as follows:

> "The best usage of Class GA waters is as a source of potable water supply. Class GA waters are fresh ground waters found in the saturated zone of unconsolidated deposits and consolidated rock or bedrock".

According to these regulations, standards applicable to Class GA ground water shall be the most stringent of those from the following four sources:

(1) New York State Water Quality Regulations (6NYCRR, Part 703)

(2) Maximum Contaminant Levels (MCLs) for drinking water promulgated by the New York State Department of Health (10NYCRR, Subpart 5-1, Public Water Supplies)

(3) Standards for raw water promulgated by the New York State Department of Health (10NYCRR, Part 170, Sources of Water Supply)

(4) Maximum Contaminant Levels for drinking water promulgated as Primary Drinking Water Regulations by the U.S. Environmental Protection Agency (USEPA) pursuant to the Safe Drinking Water Act (40 CFR, Part 141).

In addition to the preceding enforceable standards for surface water and ground water, the USEPA has issued water quality guidelines referred to as Secondary Drinking Water Regulations (40 CFR, Part 143). The NYSDEC also has Ambient Water Quality Guidance Values from their Division of Water Technical and Operational Guidance Series, referred to as TOGS 85-W-38. In addition, there are guidelines pursuant to the Clean Water and Safe Drinking Water Acts which are summarized in the USEPA's Guidance on Feasibility Studies Under CERCLA (USEPA, 1985b) which include the following:

(1) Secondary Drinking Water Regulations (applicable to ground water)

(2) Ambient Water Quality Guidance Values (applicable to ground water)

(3) Safe Drinking Water Act, Recommended Maximum Contaminant Levels (applicable to ground water)

(4) Clean Water Act, Water Quality Criteria for Human Health -- Fish and Drinking Water (applicable to surface water)

(5) Clean Water Act, Water Quality Criteria for Human Health - Adjusted for Drinking Water Only (applicable to ground water)

8.2.1.2 Comparison with Standards and Guidelines

Table 8-1 summarizes observed versus allowable concentrations of hazardous surface water and ground water contaminants at the site. For each of the chemical parameters included as part of the analytical program during the present RI, Table 8-1 lists its laboratory detection limit, its maximum observed concentration in surface water and ground water samples, and the corresponding enforceable limits and non-enforceable guidelines applicable to these contaminants. For comparative purposes, the maximum observed soil and sediment concentrations for each contaminant are also presented.

Ground water and surface water parameters detected in excess of the applicable standards and guidelines are summarized in Tables 8-2 through 8-4. As indicated, the most prevalent contaminants in ground water at the site include volatile organics (viz., benzene, toluene, chlorobenzene, and xylene) and metals, (viz., arsenic, cadmium, chromium, lead and zinc). Most of the volatile organics are in violation of the recently revised 10 NYCRR Subpart 5-1, Public Water Supplies regulations, whereas most of the metals are in violation of the New York State Water Quality Regulations (6NYCRR, Part 703). As indicated in Table 8-3, the compounds that exceeded applicable guidelines most frequently include 2-chlorophenol, antimony and arsenic.

The data presented in Table 8-4 indicates a much lower incidence of contaminants in surface water than ground water, based on a comparison with applicable standards and guidelines. However, it should be noted that it is is impractical to access the water quality of the river adjacent to the site based on one round of sampling.

TABLE 8-1

OBSERVED VERSUS ALLOWABLE CONTAMINANT CONCENTRATIONS

		GROUND WATER				SURFACE WATER			SEDIMENT	SOIL
SUBSTANCE	Detection Limit (ug/l)	Max. Conc. (ug/l)	Enforceable Limit	Source[1]	Guideline Limit[2]	Max. Conc. (ug/l)	Enforceable Limit[3]	Guideline Limit[2]	Max. Conc. (ug/kg)	Max. Conc. (ug/kg)
VOLATILES										
Chloromethane	10	ND[4]	5 ug/l	5-1	0	ND		0	NA[7]	NA
Bromomethane	10	ND	5 ug/l	5-1	0	ND		0	NA	NA
Vinyl Chloride	10	6.0	2 ug/l	MCL	0#	ND		0	NA	NA
Chloroethane	10	ND	5 ug/l	5-1		ND			NA	NA
Methylene Chloride	5	15,000(8)	5 ug/l	5-1	[50 ug/l]	ND			NA	NA
Acetone	10	15,000(8)				22,000			NA	NA
Carbon Disulfide	5	43				ND			NA	NA
1,1-Dichloroethene	5	8	5 ug/l	5-1	7.0 ug/l#	2			NA	NA
1,1-Dichloroethane	5	ND	5 ug/l	5-1		ND			NA	NA
1,2-Dichloroethene (total)	5	19	5 ug/l	5-1	[50 ug/l]	5			NA	NA
Chloroform	5	24	100 ug/l	703.5	0	ND		0	NA	NA
1,2-Dichloroethane	5	ND	5 ug/l	5-1	0#	ND		0	NA	NA
2-Butanone (or MEK)	10	260				ND			NA	NA
1,1,1-Trichloroethane	5	ND	5 ug/l	5-1	19 mg/l	ND		18.4 mg/l	NA	NA
Carbon Tetrachloride	5	ND	5 ug/l	703.5	0	ND		0	NA	NA
Vinyl Acetate	10	ND				ND			NA	NA
Bromodichloromethane	5	7			0	ND		0	NA	NA
1,1,2,2-Tetrachloroethane	5	ND	5 ug/l	5-1		ND			NA	NA
1,2-Dichloropropane	5	ND	5 ug/l	5-1		ND			NA	NA
trans-1,2-Dichloropropene	5	ND			87 mg/l	ND		87 mg/l	NA	NA
Trichloroethene	5	3	5 ug/l	5-1	0#	ND			NA	NA
Dibromochloromethane	5	ND			0	ND		0	NA	NA
1,1,2-Trichloroethane	5	ND	5 ug/l	5-1	0	ND		0	NA	NA
Benzene	5	28,000	NT[5]	703.5	0#	ND		0	NA	NA
cis,1,3-Dichloropropene	5	ND	5 ug/l	5-1	87 mg/l	ND		87 mg/l	NA	NA
2-Chloroethyl Vinyl Ether	10	ND				ND			NA	NA
Bromoform	5	ND			0	ND		0	NA	NA
2-Hexanone	10	ND			[50 ug/l]	ND			NA	NA

TABLE 8-1 (Continued)

OBSERVED VERSUS ALLOWABLE CONTAMINANT CONCENTRATIONS

SUBSTANCE	Detection Limit (ug/l)	GROUND WATER Max. Conc. (ug/l)	GROUND WATER Enforceable Limit	GROUND WATER Source (1)	GROUND WATER Guideline Limit (2)	SURFACE WATER Max. Conc. (ug/l)	SURFACE WATER Enforceable Limit (3)	SURFACE WATER Guideline Limit (2)	SEDIMENT Max. Conc. (ug/kg)	SOIL Max. Conc. (ug/kg)
VOLATILES (Continued)										
4-Methyl-2-pentanone	10	24				ND		[50 ug/l]	NA	NA
Tetrachloroethene	5	ND	5 ug/l	5-1	0#	ND			NA	NA
Toluene	5	4,700	5 ug/l	5-1	[50 ug/l]	ND		14.3 mg/l	NA	NA
Chlorobenzene	5	48,000	5 ug/l	5-1	[20 ug/l]	ND	50 ug/l	488 ug/l	NA	NA
Ethyl Benzene	5	43,000	5 ug/l	5-1	2.4 mg/l	ND		1.4 mg/l	NA	NA
Styrene	5	ND	5 ug/l	5-1		ND			NA	NA
Total Xylenes	5	1,700	5 ug/l	5-1		6			NA	NA
Acrolein	400	ND				ND			NA	NA
Acrolynitrile	400	ND				ND			NA	NA
SEMI-VOLATILES										
Phenol	10	77			3.5 mg/l	ND		3.5 mg/l	ND	ND
Aniline	10	660								
bis(2-Chloroethyl)ether	10	ND	1.0 ug/l	703.5	0	ND		0	ND	ND
2-Chlorophenol	10	1,800			0.1 ug/l	ND		0.1 ug/l	ND	ND
1,3-Dichlorobenzene	10	49	5 ug/l	5-1	470 ug/l	ND	50 ug/l	400 ug/l	ND	ND
1,4-Dichlorobenzene	10	4,900	5 ug/l	5-1	470 ug/l	ND	50 ug/l	400 ug/l	ND	13,000
Benzyl Alcohol	10	ND				ND			ND	ND
1,2-Dichlorobenzene	10	21,000	5 ug/l	5-1	470 ug/l	ND	50 ug/l	400 ug/l	1,200	110,000
2-Methylphenol	10	47				ND			ND	ND
bis(2-Chloroisopropyl) ether	10	ND			34.7 ug/l	ND		34.7 ug/l	ND	ND
4-Methylphenol	10	ND				ND			ND	ND
N-Nitroso-Dipropylamine	10	24				ND			ND	ND
Hexachloroethane	10	ND			0	ND		0	ND	ND

TABLE 8-1 (Continued)

OBSERVED VERSUS ALLOWABLE CONTAMINANT CONCENTRATIONS

		GROUND WATER				SURFACE WATER			SEDIMENT	SOIL
SUBSTANCE	Detection Limit (ug/l)	Max. Conc. (ug/l)	Enforceable Limit	Source (1)	Guideline Limit (2)	Max. Conc. (ug/l)	Enforceable Limit (3)	Guideline Limit (2)	Max. Conc. (ug/kg)	Max. Conc. (ug/kg)
SEMI-VOLATILES (Continued)										
Nitrobenzene	10	15			[30 ug/l)	ND		19.8 mg/l	600	1,100,000
Isophorone	10	ND			5.2 mg/l	ND		5.7 mg/l	ND	ND
2-Nitrophenol	10	ND				ND			ND	ND
2,4-Dimethylphenol	10	130			400 ug/l	ND		400 ug/l	ND	ND
Benzoic Acid	50	18				ND			ND	ND
bis(2-Chloroethoxyl) methane	10	20			0	ND		0	ND	ND
2,4-Dichlorophenol	10	ND			[0.3 ug/l]	ND			ND	ND
1,2,4-Trichlorobenzene	10	1,200	5 ug/l	5-1		ND	50 ug/l		ND	150,000
Naphthalene	10	4,900				ND			880	470,000
4-Chloroaniline	10	11,000				ND			ND	ND
Hexachlorobutadiene	10	ND			0	ND		0	ND	ND
4-Chloro-3-methylphenol	10	7			3000 ug/l	ND		3000 ug/l	ND	ND
2-Methylnaphthalene	10	16				ND			ND	ND
Hexachlorocyclopentadiene	10	ND			206 ug/l	ND		206 ug/l	ND	ND
2,4,6-Trichlorophenol	10	ND			0	ND		0	ND	ND
2,4,5-Trichlorophenol	50	ND			2600 ug/l	ND		2600 ug/l	ND	ND
2-Chloronaphthalene	10	ND			[10 ug/l]	ND			ND	140,000
2-Nitroaniline	50	4				ND			ND	1,100
Dimethyl Phthalate	10	ND			350 mg/l	ND		313 mg/l	ND	ND
Acenaphthylene	10	15				ND			240	16,000
3-Nitroaniline	50	ND				ND			ND	ND
Acenaphthene	10	26			20 ug/l	ND		20 ug/l	ND	400
2,4-Dinitrophenol	50	ND			70 ug/l	ND		70 ug/l	ND	3,400
4-Nitrophenol	50	ND				ND			ND	ND
Dibenzofuran	10	13				ND			ND	ND

TABLE 8-1 (Continued)

OBSERVED VERSUS ALLOWABLE CONTAMINANT CONCENTRATIONS

		GROUND WATER				SURFACE WATER			SEDIMENT	SOIL
SUBSTANCE	Detection Limit (ug/l)	Max. Conc. (ug/l)	Enforceable Limit	Source (1)	Guideline Limit (2)	Max. Conc. (ug/l)	Enforceable Limit (3)	Guideline Limit (2)	Max. Conc. (ug/kg)	Max. Conc. (ug/kg)
SEMI-VOLATILES (Continued)										
2,4-Dinitrotoluene	10	2,000				ND			ND	ND
2,6-Dinitrotoluene	10	1,700				ND			ND	ND
Diethylphthalate	10	4			434 mg/l	ND		350 mg/l	ND	ND
4-Chlorophenyl Phenyl Ether	10	ND				ND			ND	ND
Fluorene	10	24				ND			ND	25,000
4-Nitroaniline	50	ND				ND			ND	ND
4,6-Dinitro-2-methylphenol	50	ND				ND			ND	ND
N-nitrosodiphenylamine	10	15			0	ND		0	ND	ND
4-Bromophenyl Phenyl Ether	10	ND				ND			ND	ND
Hexachlorobenzene	10	ND	0.35 ug/l	703.5	0	ND		0	ND	ND
Pentachlorophenol	50	2			1.01 mg/l	ND		1.01 mg/l	ND	ND
Phenanthrene	10	63				ND			940	270,000
Anthracene	10	14			[50 ug/l]	ND			610	4,800
Di-n-butylphthalate	10	1	770 ug/l	703.5	44 mg/l	ND		34 mg/l	ND	760
Fluoranthene	50	54				ND			1700	330,000
Benzidine	50	360			0	ND	0.1 ug/l	0	ND	ND
Pyrene	10	24				ND			1200	310,000
Butyl Benzyl Phthalate	10	ND			[50 ug/l]	ND			ND	ND
3,3'-Dichlorobenzidine	20	ND			0	ND		0	ND	ND
Benzo(a)anthracene	10	12				ND			740	180,000
bis(2-ethyl hexyl)phthalate	10	52	4.2 mg/l	703.5	21 mg/l	12		15 mg/l	ND	1,900
Chrysene	10	11				ND			580	180,000
Di-n-octyl Phthalate	10	ND	4.2 mg/l	703.5		ND			ND	65
Benzo(b)fluoranthene	10	0.3			[0.002 ug/l]	ND			590	150,000
Benzo(k)fluoranthene	10	0.6			[0.002 ug/l]	ND			ND	140,000

TABLE 8-1 (Continued)

OBSERVED VERSUS ALLOWABLE CONTAMINANT CONCENTRATIONS

SUBSTANCE	Detection Limit (ug/l)	GROUND WATER Max. Conc. (ug/l)	GROUND WATER Enforceable Limit	GROUND WATER Source (1)	GROUND WATER Guideline Limit (2)	SURFACE WATER Max. Conc. (ug/l)	SURFACE WATER Enforceable Limit (3)	SURFACE WATER Guideline Limit (2)	SEDIMENT Max. Conc. (ug/kg)	SOIL Max. Conc. (ug/kg)
SEMI-VOLATILES (Continued)										
Benzo(a)pyrene	10	7	NT	703.5	[0.002 ug/l]	ND			320	140,000
Indeno(1,2,3-cd)pyrene	10	ND				ND			240	77,000
Dibenz(a,h)anthracene	10	ND				ND			ND	830
Benzo(g,h,i)perylene	10	ND				ND			250	63,000
1-Naphthyamine	10	42,000				ND			NA	NA
METALS, CYANIDE, HEX.CHROMIUM, TOC, TOX										
Aluminum	2,000	67,000				1,140			NA	NA
Antimony	50	124			[3 ug/l]	ND		146 ug/l	38	119
Arsenic	2	1,820	25 ug/l	703.5	0	ND	360 ug/l	0	138	2,860
Barium	100	1,020	1,000 ug/l	703.5		76			NA	NA
Beryllium	3	7			0	ND	(6)	0	1.1	1.3
Cadmium	3	127	10 ug/l	703.5	10 ug/l	ND	(6)	10 ug/l	2.5	24.8
Calcium	200	NA				NA			NA	NA
Chromium	9	2,140	50 ug/l	5-1	50 ug/l	28	(6)	508 ug/l	952	1,990
Cobalt	430	NA				NA			NA	NA
Copper	10	78,700	700 ug/l	170.4	1 mg/l	ND	(6)	1 mg/l	5,050	14,500
Iron	1,800	405,000				2,170	300		32,409	537,000
Lead	1	3,030	25 ug/l	703.5	50 ug/l	13	(6)	50 ug/l	497	83,200
Magnesium	2,000	59,700				12,800			NA	NA
Manganese	54	21,300				212			NA	NA
Mercury	0.13	50	2 ug/l	703.5	10 ug/l	ND		144 ug/l	45	14
Nickel	15	830			15.4 ug/l	ND	(6)	13.4 mg/l	100	467

TABLE 8-1 (Continued)

OBSERVED VERSUS ALLOWABLE CONTAMINANT CONCENTRATIONS

		GROUND WATER				SURFACE WATER			SEDIMENT	SOIL
SUBSTANCE	Detection Limit (ug/l)	Max. Conc. (ug/l)	Enforceable Limit	Source (1)	Guideline Limit (2)	Max. Conc. (ug/l)	Enforceable Limit (3)	Guideline Limit (2)	Max. Conc. (ug/kg)	Max. Conc. (ug/kg)
METALS, CYANIDE, HEX.CHROMIUM, TOC, TOX (Continued										
Selenium	2	10	10 ug/l	5-1	10 ug/l	ND		10 ug/l	ND	21
Silver	5	13	50 ug/l	703.5	50 ug/l	ND	(6)	50 ug/l		
Sodium	25,000	NA				NA			NA	NA
Thallium	2	94			17.8 ug/l	10	20 ug/l	13 ug/l	3.6	66
Vanadium	170	NA				NA			NA	NA
Zinc	2	9,950	300 ug/l	170.4	5 mg/l	138	(6)	5 ug/l	1,100	3,320
Cyanide	10	56	100 ug/l	170.4	200 ug/l	19	20 ug/l	200 ug/l	NA	NA
Hexavalent Chromium	6	130	50 ug/l	703.5	50 ug/l	.0095	16		NA	NA
TOC		2,350,000				13			NA	NA
TOX (EOX)		27,200				53			63,000	2,780,000

NOTES:

(1) Sources for the Enforceable Limits are as follows:
703.5 6 NYCRR Water Quality Regulations, Part 703.5 Classes and Quality Standards for Ground Water
5-1 10 NYCRR Subpart 5 - Public Water Supplies
170.4 10 NYCRR, Part 170.4 Sources of Water Supply - Standards of Raw Water Quality
MCL Maximum Contaminant Levels for drinking water promulgated under the Safe Drinking Water Act

(2) All Guideline Limits are from the Clean Water Act except as noted by an * which are from 40 CFR, Part 143.3 Environmental Protection Agency National Secondary Drinking Water Regulations - Secondary Maximum Contaminant Levels; or by a # which are from: 40 CFR Part 141 Recommended Maximum Contaminant Levels; or by [] which are from NYSDEC Division of Water Technical and Operational Series (85-W-38)

(3) All Surface Water Enforceable Limits are from: 6 NYCRR Water Quality Regulations Part 701.19 Classes and Standards for Fresh Surface Waters.

(4) ND = Not Detected.
ug/l (liquid) = ppb
mg/l (liquid) = mg/kg (solid) = ppm
ng/l (liquid) = 10^{-3} ppb

(5) NT - Not detectable by tests as referenced in 703.4.

(6) Must be calculated as a function of hardness which was not measured.

(7) NA = Not Analyzed

(8) Methylene Chloride and Acetone were introduced as field and laboratory contaminants.

MALCOLM PIRNIE

TABLE 8-2

GROUND WATER PARAMETERS EXCEEDING ENFORCEABLE STANDARDS

SUBSTANCE	MAXIMUM CONCENTRATION (ug/l)	ENFORCEABLE LIMITS EXCEEDED CONCENTRATION (ug/l)	SOURCE[1]	NO. OF SAMPLES[2]
Vinyl Chloride	6	2	MCL	1
1,1 Dichloroethene	8	5	5-1	1
1,2 Dichloroethene	19	5	5-1	5
Benzene	28,000	NT[1]	703.5	31
Toluene	4,700	5	5-1	12
Chlorobenzene	48,000	5	5-1	22
Ethylbenzene	43,000	5	5-1	9
Xylene	1,700	5	5-1	21
1,3-Dichlorobenzene	49	5	5-1	1
1,4-Dichlorobenzene	4,900	5	5-1	8
1,2-Dichlorobenzene	21,000	5	5-1	6
1,2,4-Trichlorobenzene	1,200	5	5-1	4
Benzo(a)pyrene	7	NT[1]	703.5	1
Arsenic	1,820	25	703.5	22
Barium	1,020	1,000	703.5	1
Cadmium	127	10	703.5	12
Chromium	2,140	50	703.5	13
Copper	78,700	700	170.4	8
Lead	3,030	25	703.5	24
Mercury	50	2	703.5	9
Zinc	9,950	300	170.4	19
Hexavalent Chromium	130	50	703.5	4

NOTES

(1) Refer to Notes in Table 8-1.
(2) Total Number of Samples is 39.

MALCOLM PIRNIE

TABLE 8-3

GROUND WATER PARAMETERS EXCEEDING GUIDELINES[1]

SUBSTANCE	CONCENTRATION (ug/1)	GUIDELINES EXCEEDED CONCENTRATION (ug/1)	SOURCE[2]	NO. OF SAMPLES[3]
Vinyl Chloride	6	0	CWA	1
Chloroform	24	0	CWA	3
Trichloroethene	3	0	RCML	2
2-Chlorophenol	1,800	0.1	CWA	8
bis(2-chloroethoxyl)methane	20	0	CWA	1
Acenopthene	26	20	CWA	1
N-nitrosodiphenylamine	15	0	CWA	5
Benzo(b)fluoranthene	0.3	.002	TOGS	1
Benzo(k)fluoranthene	0.6	.002	TOGS	1
Benzo(a)pyrene	7	.002	TOGS	2
Antimony	124	3	TOGS	12
Arsenic	1,820	0	CWA	33
Beryllium	7	0	CWA	2

NOTES

(1) Only guidelines with limitations more stringent than enforceable standards are included in this table.

(2) Refer to Notes on Table 8-1.

(3) Total number of samples is 39.

MALCOLM PIRNIE

TABLE 8-4

SURFACE WATER PARAMETERS
EXCEEDING ENFORCEABLE STANDARDS AND GUIDELINES

SUBSTANCE	MAX. CONC. (ug/l)	CONCENTRATION (ug/l)	SOURCE[1]	NO. OF SAMPLES[2]
Exceeded Enforceable Limit:				
Iron	2,170	300	701	3
Exceeded Guidelines:				
Zinc	138	5	CWA	4

NOTES

(1) Refer to Notes on Table 8-1.

(2) Total number of samples is 4.

MALCOLM PIRNIE

8.3.1.2 Biota

Sampling and analysis of the Buffalo River to determine if contaminant migration and industrial discharges have adversely affected biota began with J.L. Blum in 1963. He reported the River to be devoid of all plankton life from approximately Seneca Street to the New York Central Railroad bridge and devoid of all macroscopic animal life from Cazenovia Creek to the Michigan Avenue overpass. Since this study, several other programs have been or are being conducted on Buffalo River biota. (Refer to the bibliography presented in Appendix F.1 for a list of completed studies.)

The majority of the studies pertaining to surface water, sediment and biota quality in the Buffalo River that have been completed to date have been performed by the Great Lakes Laboratory at the State University College at Buffalo. Great Lakes has collected and evaluated data since 1968. Earlier studies by the Great Lakes Laboratory indicated some improvement in environmental quality of the River, probably as a result of the federal industrial pollution abatement program, although additional abatement was recommended in these studies to further improve River quality. A study in 1972 (Sweeney 1972) contrasted collected data with 1970 observations. The study showed an increase in the variety of species in the River with nematodes and leeches being observed for the first time. These species are more typical of less polluted environments than species observed in previous years. The total number of macroinvertebrates also increased. In addition, fish that migrated from Lake Erie up the Buffalo river were caught at the confluence of the Buffalo and Cayuga Creeks for the first time in 30 years.

The limnological study of the River in 1975 (Great Lakes 1975) concluded that the improvements observed in the Buffalo River had stabilized and that municipal rather than industrial wastes being discharged upstream of the heavily industrialized zone had the most negative impacts on the River.

Data collected by Great Lakes Laboratories in the fall of 1976 and spring of 1977 (Bergantz 1977) showed a decrease in benthic macroinvertebrate density at the influent of Cazenovia Creek (about 1.5 miles

MALCOLM PIRNIE

8.3.1.2 Biota

Sampling and analysis of the Buffalo River to determine if contaminant migration and industrial discharges have adversely affected biota began with J.L. Blum in 1963. He reported the River to be devoid of all plankton life from approximately Seneca Street to the New York Central Railroad bridge and devoid of all macroscopic animal life from Cazenovia Creek to the Michigan Avenue overpass. Since this study, several other programs have been or are being conducted on Buffalo River biota. (Refer to the bibliography presented in Appendix F.1 for a list of completed studies.)

The majority of the studies pertaining to surface water, sediment and biota quality in the Buffalo River that have been completed to date have been performed by the Great Lakes Laboratory at the State University College at Buffalo. Great Lakes has collected and evaluated data since 1968. Earlier studies by the Great Lakes Laboratory indicated some improvement in environmental quality of the River, probably as a result of the federal industrial pollution abatement program, although additional abatement was recommended in these studies to further improve River quality. A study in 1972 (Sweeney 1972) contrasted collected data with 1970 observations. The study showed an increase in the variety of species in the River with nematodes and leeches being observed for the first time. These species are more typical of less polluted environments than species observed in previous years. The total number of macroinvertebrates also increased. In addition, fish that migrated from Lake Erie up the Buffalo river were caught at the confluence of the Buffalo and Cayuga Creeks for the first time in 30 years.

The limnological study of the River in 1975 (Great Lakes 1975) concluded that the improvements observed in the Buffalo River had stabilized and that municipal rather than industrial wastes being discharged upstream of the heavily industrialized zone had the most negative impacts on the River.

Data collected by Great Lakes Laboratories in the fall of 1976 and spring of 1977 (Bergantz 1977) showed a decrease in benthic macroinvertebrate density at the influent of Cazenovia Creek (about 1.5 miles upstream of the Buffalo Color Area "D" site) with a low but increasing density downstream. Data also indicated a low species diversity beginning at Cazenovia Creek and continuing downstream. The benthic population was dominated (greater than 60%) by immature tubificidae. Sediments supporting a macroinvertebrate population of over 60% tubicidae are considered polluted (Goodnight and Whitley 1960) since tubicidae can survive in contaminated environments that are incompatible to most other organisms. Tubicidae density is often used subjectively to quantify water quality and estimate the extent of pollution while low species diversity in a population is an indicator of an unstable or incompatible environment.

A study of zooplankton diversity in the Buffalo River was published in 1979 by the Great Lakes Laboratory (Ward 1979). In general, zooplankton were less concentrated in samples taken from sampling stations in the area of Buffalo Color compared with an upstream station located near the confluence of the River with Cazenovia Creek. However, data indicated that there were often higher concentrations and more diverse populations of zooplankton at the station immediately downstream of the site than at the station immediately upstream of the site.

A study conducted by the Roswell Park Institute (Black 1979) reported a high incidence of neoplasms in bullhead from the Buffalo River. In addition, extracts from Buffalo River sediments induced tumors in some fish species.

A study of the Niagara River contamination problem (Fredrick 1982) reviewed data pertaining to fish from the Buffalo and Niagara Rivers collected from approximately 1977 to 1981. Review of this data indicated the following:

- Of the metals analyzed from fish (arsenic, chromium, copper, lead, and zinc), zinc occurred in highest concentrations, with 26.07 mg/kg reported in carp at a site just upstream of the confluence of Cazenovia Creek and the Buffalo River.

- Of the fish analyzed for copper, highest concentrations were found in carp at the same site as above (0.66 mg/kg, 1977).

- Chromium concentrations of 0.1-0.2 mg/kg were reported in fish from the segment of the Buffalo River from the Cazenovia Creek confluence to Lake Erie.

- High concentrations of benzanthracene (up to 127.5 mg/kg) and benzyprene (up to 2.46 mg/kg) were reported in a carp and goldfish composite sample collected near the mouth of the Buffalo River.

Data from 1980 indicated the following for macrophytes:

- The greatest number of metals (nine) found in Cladophora (an algal macrophyte) at concentrations above detection limits occurred at a site located near to the entrance to the Buffalo Ship Canal in the Buffalo River.

- Mercury was reported in only two Cladophora samples. One sample was collected at the Ship Canal location mentioned above.

- The highest concentrations of arsenic (35.0 ug/g), chromium (16 ug/g), cobalt (4.0 ug/g), copper (20.0 ug/g), and lead (41.0 ug/g) were found in Cladophora from the Ship Canal location indicating metals pollution in this area.

8.3.1.3 Sediments

Although improved water quality has enhanced biota recovery, a continuing problem documented in the literature is contaminated sediments. Sediment transport to Lake Erie is very slow because of low water levels in the Buffalo River and high water levels in Lake Erie. The higher the Lake, the lower the average amount of discharge from the River. This phenomena results in stagnant conditions, and during the summer months when precipitation is low and evaporation high, the River actually flows upstream (Oleszko 1975). This results in the possibility that a site may not only contribute to downstream contamination, but upstream contamination as well.

NYSDEC investigators have claimed (Litten, 1987) that if transport from the River occurs at all, it would happen during rare high-flow conditions. However, attempts to sample these events; viz. Longabucco and Carich (1982) and Meredith and Rumer (1986) were unsuccessful.

8.3.1.4 Summary

Data collected in the past 20 years has indicated a general improvement in the environmental quality in the Buffalo River. Although the environmental quality of the Buffalo River has improved, there is some evidence that contamination found in River sediments may be a persistent problem since transport of the sediments downstream is believed to be minimal. In addition, there are a number of listed New York State inactive hazardous waste sites located on the Buffalo River that may be acting as continuous sources of contamination. However, it is not clear to what extent, if any, these sites are contributing to water and sediment contamination or are affecting River biota.

8.3.2 Regulatory Standards and Guidelines

Table 8-5 presents reported water quality criteria for fresh water aquatic life for compounds detected in surface water samples. These criteria were obtained from the RCRA Facility Investigation (RFI) Guidance Manual, and are presented for informational purposes only. In this table, the observed concentrations are compared with reported criteria.

8.3.1.4 Summary

Data collected in the past 20 years has indicated a general improvement in the environmental quality in the Buffalo River. Although the environmental quality of the Buffalo River has improved, there is some evidence that contamination found in River sediments may be a persistent problem since transport of the sediments downstream is believed to be minimal. In addition, there are a number of listed New York State inactive hazardous waste sites located on the Buffalo River that may be acting as continuous sources of contamination. However, it is not clear to what extent, if any, these sites are contributing to water and sediment contamination or are affecting River biota.

8.3.2 Regulatory Standards and Guidelines

Table 8-5 presents reported water quality criteria for fresh water aquatic life for compounds detected in surface water samples. These criteria were obtained from the RCRA Facility Investigation (RFI) Guidance Manual, and are presented for informational purposes only. In this table, the observed concentrations are compared with reported criteria.

MALCOLM PIRNIE

TABLE 8-5

WATER QUALITY CRITERIA SUMMARY[1]

PARAMETER	MAX.CONC. (ug/l)	FRESH WATER CRITERIA (ug/l) ACUTE	CHRONIC	SOURCE[2]	NO. OF SAMPLES EXCEEDING CRITERIA ACUTE	CHRONIC
Cyanide	19	22	5.2	1985FR	0	2
Dichloroethene	5	11,600[5]	NR[6]	1980FR	0	0
Hexavalent Chromium	9.5	16	11	1985FR	0	0
Iron	2,170	NR	1,000	1976RB	0	1
Thallium	15	1,400[5]	40[5]	1980FR	0	0

NOTES

(1) This table was published for general information purposes only in the RCRA Facility Investigation (RFI) Guidance of July 1987 (EPA 530/SW-87-001)

(2) FR = Federal Register; RB = Quality Criteria for Water, 1976 (Red Book)

(3) Total number of samples equals four except for dichloroethene, where total samples equals 10.

(4) Insufficient data to develop criteria. Value presented is lowest observed effect.

(5) NR - Not Reported

MALCOLM PIRNIE

REFERENCES

Bouwer, H. and R.C. Rice, 1976. "A Slug Test For Determining Hydraulic Conductivity of Unconfined Aquifers with Completely or Partially Penetrating Wells". Water Resources Research 12(3), 423-428 p.

Buehler, E.J. and I.H. Tesmer, 1963. "Geology of Erie County, New York". Buffalo Society of Natrual Sciences Bulletin 21(3), 118 p.

Federal Emergency Management Agency, 1981. "Flood Insurance Study, City of Buffalo, New York, Erie County". FEMA, Federal Insurance Administration Community - Panel No. 360230-0020.

Freeze, R.A. and J.A. Cherry, 1979. "Ground Water". Prentice-Hall, Inc., Englewood Cliffs, N.J., 604 p.

Harding, S.T. 1942. Hydrology. Dover Publications, Inc., New York, O.E. Meinzer Eds. p.220-241.

Harding, W.E. and B.K. Gilbert, 1968. "Erie-Niagara Basin Surface Waters". Erie-Niagara Basin Regional Water Resources Planning Board, Report 2, 118 p.

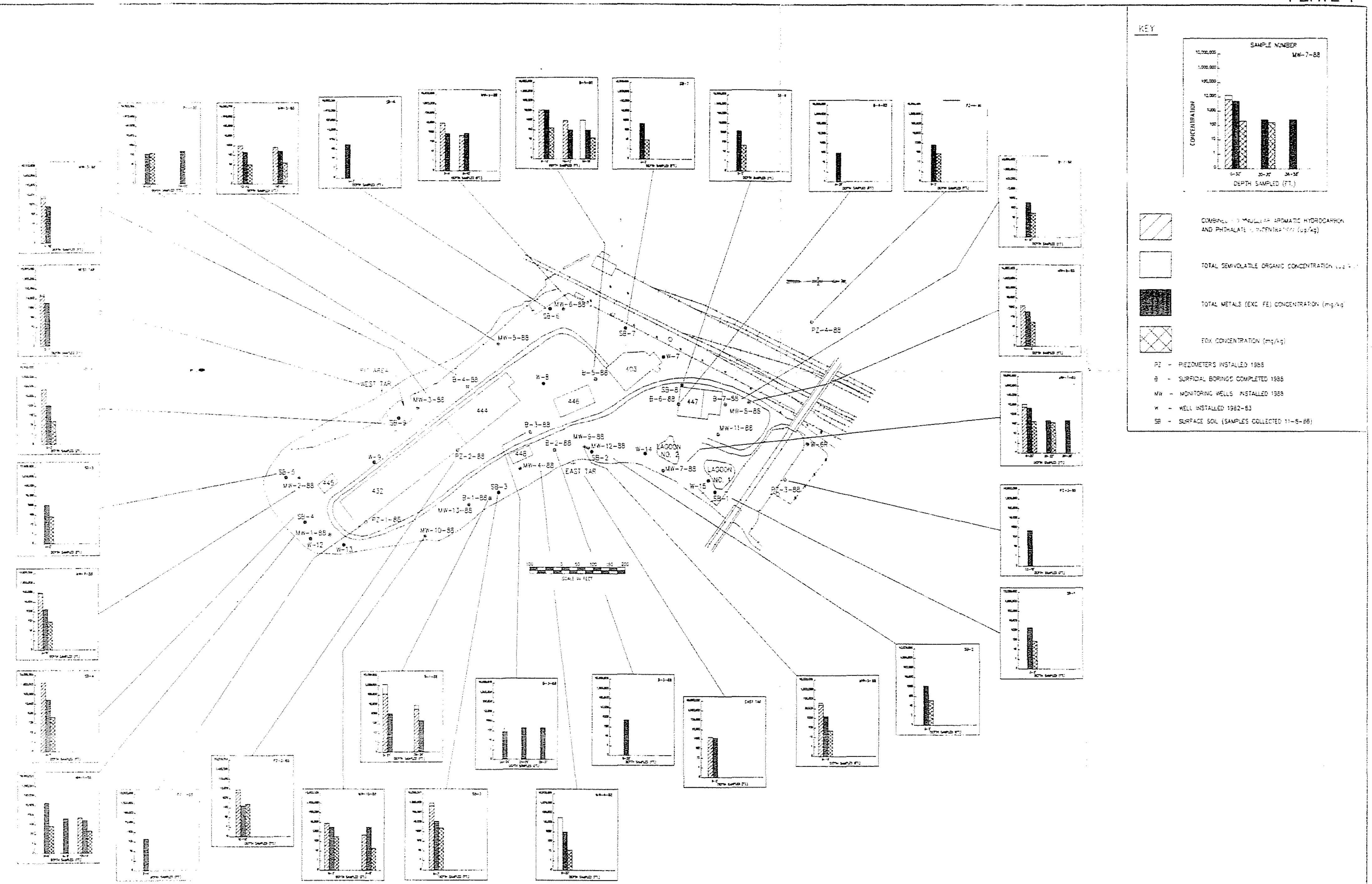
Hvorslev M.J., 1951. "Time Lag and Soil Permeability in Ground Water Observations". U.S. Army Corps of Engineers, Waterways Experimental Station Bulletin 36, Vicksburg, Mississippi.

Lappala, E.G., 1978. Quantitative Hydrogeology of the Upper Republican Natural Resources District, Southwest Nebraska, U.S.G.S., Water Resources Investigations 78-38.

LaSala, A.M., 1968. Ground Water Resources of the Erie-Niagara Basin, New York, New York State Conservation Department of Water Resources Commission, p.114.

Muller, E.H., 1977. "Quaternary Geology of New York, Niagara Sheet". New York Museum of Science Service, Map and Chart Series Number 28.

PLATE 1



MALCOLM PIRNIE

REVISIONS

NO.	BY	DATE	REMARKS

DES
DWN
CKD

BUFFALO COLOR CORPORATION
BUFFALO, NEW YORK

RI/FS

DISTRIBUTION & OCCURRENCE OF SELECTED CONTAMINANTS IN SOIL

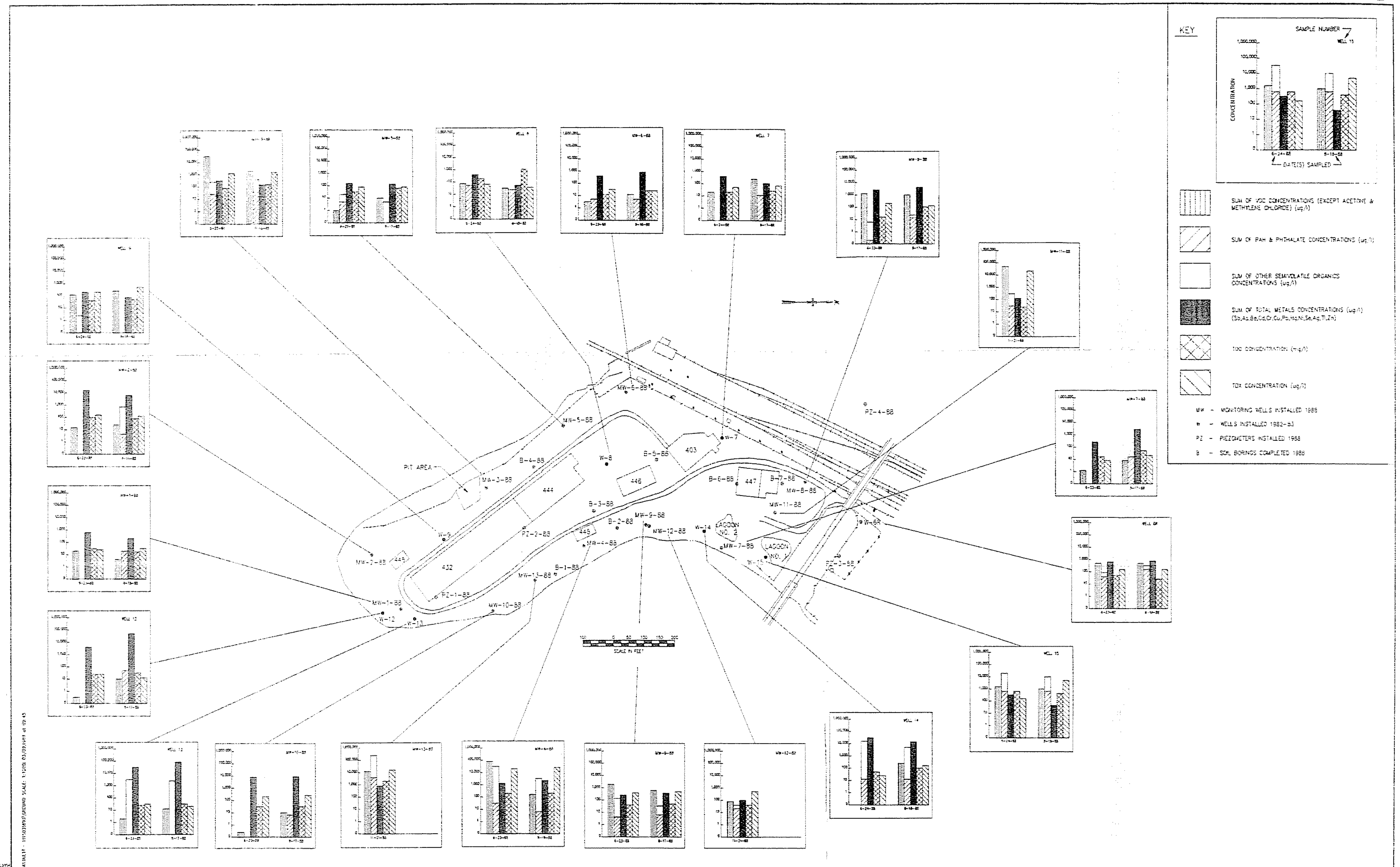
MALCOLM PIRNIE, INC.

DATE MARCH 1989

SHEET 1 OF 2

DWG NO.

PLATE 2



MALCOLM PIRNIE	REVISIONS: NO. / BY / DATE / REMARKS	DES / DWN / CKD	BUFFALO COLOR CORPORATION BUFFALO, NEW YORK RI/FS	DISTRIBUTION & OCCURRENCE OF SELECTED CONTAMINANTS IN GROUND WATER (6/88 & 8/88)	MALCOLM PIRNIE, INC. DATE APRIL 1989 SHEET 3 OF 3