PHASE I
CORRECTIVE MEASURES STUDY
OLIN BUFFALO AVENUE PLANT

Prepared for:
Olin Chemicals
1186 Lower River Road
Charleston, Tennessee 37310
November 1993

Woodward-Clyde

Woodward-Clyde Consultants
3571 Niagara Falls Boulevard
North Tonawanda, New York 14120
Project Number 93C2352

3571 Niagara Falls Boulevard
North Tonawanda
New York 14120
(716) 692-7172
Fax (716) 692-1512

Woodward-Clyde Consultants

November 22, 1993
93C2352

Mr. Michael Bellotti
Olin Chemicals
1186 Lower River Road
Charleston, Tennessee 37310

Subject: Olin - Buffalo Avenue Plant
Phase I Corrective Measures Study

Dear Mr. Bellotti:

Enclosed please find fifteen copies of the Phase I Corrective Measures Study for the Buffalo Avenue Plant. We appreciate this opportunity to work with Olin.

Very truly yours,

Martin S. Leonard

Martin S. Leonard, P.E.
Project Manager

Frank R. Sarbe
FOR
Kelly R. McIntosh, P.E., P.HGW.
Consultant to WCC

James F. Roetzer JE

James F. Roetzer, Ph.D.
Senior Associate

MSL/JFR/KRM:jee

cc: L. Murray

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LIST OF ACRONYMS

ARGC Area -	Area of Plant 2 between Alundum Road and Gill Creek
BHC -	Hexachlorocyclohexane
C-1 and C-2 compounds -	One and two carbon compounds
CAMU -	Corrective Action Management Unit
CB -	Cement-bentonite
CMS -	Corrective Measures Study
DNAPL -	Dense non-aqueous phase liquid
DuPont -	E.I. DuPont de Nemours and Company
E&E -	Ecology & Environment
EPA -	Environmental Protection Agency
HTH™ -	Calcium hypochlorite
HDPE -	High density polyethylene
LDRs -	Land disposal restrictions
NAPL -	Non-aqueous phase liquid
NFWWTP -	Niagara Falls Waste Water Treatment Plant
NYSDEC -	New York State Department of Environmental Conservation
PAHs -	Polycyclic aromatic hydrocarbon compounds
PAL -	Project Analyte List
POTW -	Publicly Owned Treatment Works
RCRA -	Resource Conservation and Recovery Act
RFI -	RCRA Facility Investigation
RI -	Remedial Investigation
SB -	Soil-bentonite
SWMUs -	Solid Waste Management Units
TCLP -	Toxicity Characteristic Leaching Procedure
VOCs -	Volatile Organic Compounds
WCC -	Woodward-Clyde Consultants

1.0
INTRODUCTION

Olin Corporation (Olin) has entered into an Administrative Consent Order (Index No. RCRA-89-3013-0208) with the U.S. Environmental Protection Agency which provides for performance of a RCRA Facility Investigation (RFI) at Olin's Buffalo Avenue Plant in Niagara Falls, New York (Figure 1-1). Woodward-Clyde Consultants (WCC) was retained by Olin to conduct the RFI.

The RFI included monthly groundwater hydraulic head monitoring, quarterly sampling and analysis of groundwater (four quarterly events), and analysis of surface soil and subsurface soil samples. Prior to completion of the RFI, an Interim Report was prepared based on the first quarterly round of analytical results of groundwater, monthly hydraulic head monitoring and the analytical results for soil sampling. Analytical results from each of the following three quarterly groundwater sampling events were validated by WCC and submitted by Olin to EPA and the New York State Department of Environmental Conservation (NYSDEC). The EPA and NYSDEC have determined that the Interim Report and subsequent data submittals are sufficient to form the basis of a Phase I Corrective Measures Study (CMS). WCC was retained by Olin to prepare the Phase I CMS, which is presented herein.

The objectives of the Phase I CMS are as follows:

1. To identify the goals for corrective action.

2. To identify matrices/areas for which some corrective action may be required to attain these goals.

3. To identify available technology alternatives for each area/matrix and eliminate those that are technically and/or economically infeasible.

4. To develop conceptual corrective action alternatives from the retained technology alternatives.

5. To evaluate the conceptual corrective action alternatives and recommend the most feasible for implementation at the facility.

The Phase I CMS is presented in seven sections. Section 2 presents the goals for corrective action at the facility. The presence of chemicals detected during the RFI in soil and groundwater is summarized and potential off-site transport pathways are described in Section 3. Based on Sections 2 and 3, Section 4 identifies areas/matrices potentially subject to corrective action. Section 5 presents the screening of available technology alternatives. Conceptual corrective action alternatives are evaluated in Section 6 and the recommended corrective action alternative for the site is described in Section 7. Section 8 presents the limitations of the Phase I CMS.

2.0
GOALS FOR CORRECTIVE ACTION

The corrective action design goals for the remediation of the Olin Buffalo Avenue Plant are as follows:

1. Restrict off-site migration of Olin-derived hazardous waste constituents in groundwater, particularly via discharge to Gill Creek.

2. Restrict migration of Olin-derived hazardous waste constituents from the overburden to bedrock.

3. Minimize human exposure to Olin-derived hazardous waste constituents in on-site soils.

4. Minimize need for future/ongoing remediation and operation and maintenance activities by implementing solutions or technologies that will be reliable and effective over the long term.

5. Reduce the concentration of hazardous waste constituents within the groundwater at the Buffalo Avenue Plant over time to acceptable levels consistent with the use of the property and adjacent property.

The definition of the word "restrict", as used in this document, is to eliminate significant off-site discharge or migration of Olin-derived hazardous waste constituents that pose significant threats to human health and the environment to the extent technically feasible.

3.0
CONTAMINATION ASSESSMENT

This section summarizes available data concerning contaminant concentrations detected in soil and groundwater at the Olin Buffalo Avenue Plant, and evaluates potential sources and migration pathways for these contaminants.

3.1 SITE SETTING

The Olin Buffalo Avenue Plant is located in an industrial area of Niagara Falls, New York. Olin, under its present name, and earlier as the Olin-Mathieson Chemical Corporation, the Mathieson Chemical Company, and the Castner Electrolytic Company, has manufactured chemical products at the site since 1897.

The site is divided into two areas referred to as Plant 1 and Plant 2. The small (6 acre) western Plant 1 site is separated from Plant 2 (16 acres) by Chemical Road and by 300 feet of property owned by E.I. DuPont de Nemours and Company (DuPont). Plant 1 and Plant 2 are collectively referred to as the Plant. Only when these facilities are discussed individually are the numeric designations used. Figure 1-1 presents a detailed map of the Plant.

Olin's principal business in Niagara Falls has centered around the electrolytic production of chlorine and caustic soda from rock salt (sodium chloride) using various modifications of the mercury-cell/chlor-alkali process. Mercury cells were once operated on both plant sites, but have been confined to Plant 2 for the past 30 years. Plant 1 has been largely inactive since the shutdown of calcium hypochlorite (HTH™) production in September 1982, and is presently used primarily for warehousing. In 1991, Olin discontinued the mercury cell chlor-alkali production at the plant. Despite the historical predominance of inorganic chemical production at Olin's Niagara Falls locations, several organic chemicals, including trichlorobenzene, trichlorophenol, and BHC (hexachlorocyclohexane), were manufactured in the section of Plant 2 between Alundum Road and Gill Creek (ARGC Area) between 1950 and 1956.

Olin has used brine mud, which contains 30 to 50 ppm of mercury, for pothole repair in a parking lot north of Buffalo Avenue and elsewhere at the plant. Brine mud hardens to form a cement-like material which is resistant to leaching.

Figure 3-1 presents the locations of solid waste management units (SWMUs) at the plant. Soils were investigated by sampling from soil borings advanced near individual SWMUs. A site-wide approach was taken for the groundwater investigation, with monitoring wells located throughout the Plant.

The Plant is located in the vicinity of three sites currently being investigated by the NYSDEC for soil and groundwater contamination. These sites are the DuPont Niagara Plant to the south, the Solvent Chemicals Site to the east and the Industrial Welding Site to the north. Each site is discussed briefly below.

The DuPont Niagara Plant is located south of Plant 2 and between Plant 1 and Plant 2. The DuPont Niagara Plant currently manufactures sodium, chlorine, Terathane®, and sodium hydroxide. Extensive investigations of hydrogeology and groundwater quality have been performed and are summarized in the following reports: Geohydrologic Investigations (WCC, December 23, 1983) and Supplemental Geohydrologic Investigation (WCC, October 24, 1984). From the 1930s to the 1970s, the DuPont Plant manufactured chlorinated solvents (C-1 and C-2 compounds). These solvents, particularly chloroform, trichloroethene, tetrachloroethene, and related compounds have been measured in groundwater at elevated concentrations at the DuPont Plant. In addition, dense non-aqueous phase liquid (DNAPL) has been observed in several monitoring wells.

In the early 1980s, volatile organic chemicals were detected in cooling water produced from Olin's two production wells at Plant 1. The two production wells are 24-inch in diameter, cased from 25 to 28 feet below ground surface and open to the bedrock to 110 feet below ground surface. The wells are located 15 feet apart and only one pumps at a given time. For the RFI and CMS, the Olin production wells are considered a single withdrawal point and referred to as the Olin Production Well. Since May 1984, Olin has treated groundwater withdrawn from these bedrock production wells using activated carbon. DuPont entered into an agreement with Olin in February 1985 under which Olin's production wells and treatment system are operated at an average rate of approximately 600 gpm or more as part of DuPont's groundwater remediation program. Since late 1991, DuPont has been pumping A-zone (overburden and top-of-bedrock) groundwater from a line of 22 production wells. DuPont's Groundwater Remediation System is described in detail in the following document: Final Report, DuPont Niagara Falls Plant Interim Remediation Program (WCC, September 21, 1989).

The Solvent Chemicals Site was used for production of chlorinated benzene compounds (dichlorobenzene, trichlorobenzene, and tetrachlorobenzene) during 1974-1978. A Remedial Investigation (RI) Report was prepared for the site by Ecology & Environment (E&E, August 1990). Elevated concentrations of chlorobenzene compounds were found in soil and groundwater at the site, and non-aqueous phase liquid (NAPL) was observed in groundwater.

The Industrial Welding Site was used by Olin to dispose of construction rubble, demolition debris, and lesser quantities of brine mud. Some of the building rubble may have contained residual BHC. An RI Report was prepared for the site by IT Corporation (February 1992). Low concentrations of beta-BHC (maximum of 3.5 ug/L) and mercury (maximum of 240 ug/L) were detected in groundwater samples from the site. Volatile organic chemicals were also detected in groundwater, but are believed to have migrated from an off-site source.

3.2 SOIL CONTAMINATION

The Interim Report presents the results of the soil sampling and analytical program conducted for the RFI. Figure 3-1 shows the locations of Solid Waste Management Units (SWMUs) investigated as part of the RFI. Figure 3-2 shows RFI soil boring locations from which soil samples were obtained in 2-foot intervals. The results of chemical analyses of these soil samples are briefly summarized below.

3.2.1 Mercury

Soil samples were analyzed for total mercury and Toxicity Characteristic Leaching Procedure (TCLP) leachable mercury. Mercury contamination in soil was found to be relatively widespread at the plant. Low concentrations of 2.3 mg/kg or less were reported for OSB-3 located north of Buffalo Avenue in an area where brine mud was used for pothole repair. Concentrations reported for OSB-2, also a location of brine mud deposition, were 6.5 mg/kg or less. Total mercury concentrations in soil were in the range of 1 to 100 mg/kg at OSB-4, OSB-5, OSB-6, OSB-7, OSB-8, OSB-12, and OSB-16. Levels of total mercury exceeding 100 mg/kg were reported for OSB-1, OSB-9, OSB-10, OSB-13, OSB-14, and OSB-15.

Total mercury concentrations were generally highest in the upper 4 feet of soil, with the notable exception of OSB-1, in which the 8 to 10-foot interval showed the highest total mercury levels. Small beads of elemental mercury were noted in the sample obtained from the bottom of the 6 to 8-foot interval. Samples from the 6 to 8 and 8 to 10-foot intervals were the highest total mercury concentrations reported in any of the soil borings. TCLP extract concentrations from these samples were 8.6 and 2.9 ug/L indicating low leachability of mercury in soils at this location.

All TCLP mercury results were less than the regulatory level of 200 ug/L. The maximum TCLP mercury result obtained during the program was 31.7 ug/L from the 0 to 2 foot interval in boring OSB-11. Other soil borings with samples yielding TCLP mercury concentrations higher than 10 ug/L were OSB-10, OSB-11, and OSB-12. TCLP mercury results for all soil samples from the remaining soil borings were less than 10 ug/L.

3.2.2 Organic Chemicals

Soil samples obtained from soil borings OSB-17 and OSB-18 were analyzed for the organic chemicals listed on Table 3-1. The following volatile organic chemicals were detected in soil samples from OSB-17 and OSB-18:

Methylene chloride
Acetone
Chloroform
Trichloroethene
Benzene
Tetrachloroethene

Toluene
Chlorobenzene
Total xylenes

These chemicals were generally detected at trace levels. A few results were in the 0.010 mg/kg range and no reported concentrations exceeded 0.050 mg/kg.

A total of 35 semivolatile compounds were detected in one or more of the soil samples. Neither chlorinated benzene compounds nor chlorinated phenol compounds were measured above 10 mg/kg in samples from OSB-17. 4-Methylphenol was quantified in one sample from OSB-17 (6 to 8 feet) at 25 mg/kg. The semivolatiles present at the highest concentrations in soil samples from OSB-17 were the polyaromatic hydrocarbon compounds (PAHs). Individual PAH compounds were measured at concentrations up to 59 mg/kg in the intervals between 0 to 6 feet. In the lowermost interval of soil (6 to 8 feet) PAH concentrations were much higher. Nine PAH compounds were measured in this interval at levels exceeding 1,000 mg/kg. The elevated PAH levels in OSB-17 are apparently related to the type of fill used in the area. The lowermost split-spoon sample obtained from OSB-17 was noted to contain a black granular fill. This material could possibly contain ash or weathered asphalt.

In soil boring OSB-18, dichlorobenzene compounds were measured above 10 mg/kg in one sample (4 to 6 feet interval). The levels were 17 mg/kg for 1,3-dichlorobenzene and 24 mg/kg for 1,2-dichlorobenzene. 2,4,5-Trichlorobenzene was present in all four samples from OSB-18 at levels ranging from 210 mg/kg to 1,900 mg/kg. Hexachlorobenzene was present in two samples from OSB-18 at 5.8 mg/kg (2 to 4 feet) and 25 mg/kg (0 to 2 feet). No other semivolatile compounds were quantified above 10 mg/kg in soil samples from OSB-18.

No PCB compounds were detected. Of the 15 pesticides detected in at least one sample, only alpha-BHC, beta-BHC and gamma-BHC were quantified above 10 mg/kg. The maximum pesticide concentration in samples from OSB-17 was 44 mg/kg for beta-BHC (2 to 4 feet). The maximum pesticide concentration for OSB-18 was 23 mg/kg of alpha-BHC (4 to 6 feet).

3.3 GROUNDWATER

3.3.1 Groundwater Flow

Groundwater flow directions and hydraulic gradients are described in detail in the Interim Report based on monthly hydraulic head monitoring and a long-term pumping study using the Olin Production Well. The interpretations concerning groundwater flow presented in the Interim Report were supported by an additional hydraulic head monitoring event conducted jointly on October 12, 1993 at the Olin Buffalo Avenue Plant, DuPont Niagara Plant, Solvent Chemicals, and Industrial Welding Sites.

Potentiometric surface maps prepared from the joint round of measurements are presented on Figures 3-3, 3-4, and 3-5 for the A-zone (overburden and top-of-bedrock) and the two uppermost widespread water-bearing fracture zones of the Lockport Dolomite (B- and CD-zones). (The reader is referred to the Interim Report for a detailed presentation of site hydrogeology). A-zone groundwater levels (Figure 3-3) are highest in the vicinity of a bedrock high located near the center of Plant 2. There appears to be a potential for groundwater flow onto the Olin Plant from the south near the southeast corner of the ARGC area. There is also a hydraulic gradient toward Gill Creek in this area, indicating a potential for seepage of A-zone groundwater to the creek.

Comparison of hydraulic heads in OBA-9A and OBA-10A to the stage measurement in Gill Creek indicates potential seepage to Gill Creek from both sides. Observations by WCC during the DuPont/Olin Gill Creek Remediation Project were that only a few inches of granular material (primarily gravel and crushed stone) are present above the bedrock in the reach between Buffalo Avenue and Adams Avenue. Based on these observations and the hydraulic head measurements, Gill Creek fully penetrates the overburden and constitutes a discharge boundary for A-zone groundwater flow from the west (except near Buffalo Avenue where the zone is dry), and from the east (along the southern section of this reach). Thus Gill Creek is a barrier to contaminant migration in A-zone groundwater.

B-zone groundwater (Figure 3-4) at Plant 1 and western Plant 2 appears to flow toward the induced cone-of-depression of the Olin Production Wells, which are cased off from the B-zone but hydraulically connected through vertical fractures. In the east section of Plant 2, B-zone groundwater flow appears to be toward the north.

Figure 3-5 presents the potentiometric surface map for the CD-zone. Groundwater flow appears to be toward the production wells throughout Plant 1 and Plant 2.

Comparison of Figures 3-4 and 3-5 indicates relatively high downward vertical gradients between the B- and CD-zones which are increased by the average 600 gpm withdrawal from the Olin Production Well (as evidenced by the induced B-zone cone of depression at Plant 1). The induced cone-of-depression is also evidence of vertical hydraulic connection between the B- and C/CD-zones. Using the October 12, 1993 measurements and the vertical distance between fracture zones from the well logs (presented in the Interim Report), the average vertical hydraulic gradient from the B- to the C/CD-zone in the ARGC area is approximately 0.1 ft/ft. For comparison, the horizontal hydraulic gradient in the B-zone in the ARGC area is approximately 0.003 ft/ft. Therefore, much of the B-zone groundwater flow may be vertically downward rather than horizontal, and B-zone groundwater throughout the plant may eventually discharge to the Olin Production Well via the C/CD-zone. The actual magnitude of the vertical flow component also depends upon the vertical and horizontal transmissivities.

3.3.2 Groundwater Contamination

Four quarterly rounds of groundwater sampling and analysis were conducted for the Olin RFI monitoring wells from the fourth quarter of 1991 through the third quarter of 1992. Locations of monitoring wells are shown on Figure 3-6. Groundwater samples were analyzed for the chemicals listed on Table 3-1. The first round of analytical results were presented, validated, and interpreted in the Interim Report. Data validation reports presenting analytical results for each of the three subsequent quarterly sampling rounds were submitted to EPA and NYSDEC. The results of groundwater sampling are briefly summarized below.

3.3.2.1 Mercury

Mercury concentrations in A-zone groundwater samples are shown on Figure 3-7. The highest concentrations (approximately 200 ug/L) occurred in the southeast section of Plant 2. Elsewhere, mercury concentrations were approximately 10 ug/L or less. In the B-zone samples (Figure 3-8), the highest mercury levels (greater than 100 ug/L) were quantified in samples from OBA-1B and OBA-7B, located in the western portion of Plant 2. In B-zone wells east of Gill Creek, levels were reported to be less than 1 ug/L. Mercury results for C- and CD-zone wells are plotted on Figure 3-9. Only one well showed a concentration of greater than 1 ug/L (7.9 ug/L to 16.7 ug/L at OBA-7C).

3.3.2.2 Organic Chemicals

3.3.2.2.1 Non-Aqueous Phase Liquid

A denser than water non-aqueous phase liquid (DNAPL) has been observed to collect in the bottom of well OBA-2C, located near Buffalo Avenue. The DNAPL was sampled and analyzed for the Project Analyte List (PAL). Compounds detected were chlorinated aliphatic volatile compounds (total of 29.8 percent), semivolatile organic chemicals (total of 4.7 percent) and pesticides (total of 0.06 percent). Concentrations of compounds quantified in the DNAPL sample are listed in Table 3-2. The predominance of volatile aliphatic organic compounds, which have not been used at the Plant in substantial quantities and were not found at high levels in soil samples, suggests an off-site source. The fact that the only observation of NAPL was in a deep monitoring well is also consistent with an off-site source. This is the only observation of NAPL in Olin monitoring wells to date.

3.3.2.2.2 Volatile Organic Chemicals

In general, the contaminants present at the highest concentrations in groundwater beneath the Olin Plant are the volatile organics, particularly the chlorinated aliphatic (i.e., non-aromatic) hydrocarbons. These chemicals have not been produced or used to any substantial extent at the Olin Plant. However, these chemicals were manufactured at the adjacent DuPont Plant from the 1930s to the 1970s. Figure 3-10 shows the distribution of total chlorinated aliphatic volatile organic compounds in A-zone groundwater. Levels are highest (1,000 to 5,000 ug/L) in the southeastern portion of Plant 2 and at OBA-3A. Figure 3-11 shows the distribution of total chlorinated aliphatic volatile organic compounds in the B-zone. Concentrations are highest (greater than 100,000 ug/L) at OBA-5B near Olin's south boundary (with DuPont). Total chlorinated aliphatic volatile analytical results for the fourth quarter 1992 sample from OBA-8B (225,359 ug/L) were far higher than for the subsequent three sampling rounds (17 to 398 ug/L), suggesting the first result was anomalous. Figure 3-12 shows the distribution of total chlorinated aliphatic volatile organic compounds in the C- and CD-zone groundwater samples. The highest concentrations were reported for the samples from OBA-2C (563,800 to 685,500 ug/L). As described above, this well contained several inches of DNAPL. Levels exceeding 100,000 ug/L were also reported for the samples from OBA-1C and OBA-6C.

The only volatile organic compounds detected in groundwater which are thought to be potentially associated with Olin activities at the Plant are the aromatic compounds benzene and monochlorobenzene. Figure 3-13 shows the distribution of benzene in A-zone groundwater. Elevated benzene concentrations were reported for BH-3 (31,000 to 57,000 ug/L), OBA-3A (1,300 to 4,900 ug/L), and OBA-5A (76 to 620 ug/L). B-zone benzene concentrations are plotted on Figure 3-14. The highest concentrations were reported for samples from OBA-3B (5,200 to 7,100 ug/L) and OBA-5B (6,300 to 32,000 ug/L). C- and CD-zone benzene concentrations are plotted on Figure 3-15. Concentrations were below 1,000 ug/L except for OBA-3C (6,700 to 9,700 ug/L), and for OBA-5C (420 to 1,100 ug/L). Monochlorobenzene is discussed with other chlorinated benzene compounds in the following subsection.

3.3.2.2.3 Chlorinated Benzene Compounds

Chlorobenzenes were used or produced in the section of the Olin Plant between Alundum Road and Gill Creek (ARGC Area) from 1950 to 1956. Chlorobenzenes were also used and produced by Solvent Chemicals (3163 Buffalo Avenue Site) to the east. Figure 3-16 presents the distribution of total chlorinated benzene compounds (including monochlorobenzene, dichlorobenzenes, trichlorobenzenes, and hexachlorobenzene) in A-zone groundwater samples. As with benzene, an elevated A-zone total chlorobenzenes concentration was reported for BH-3 (16,600 to 19,470 ug/L). However, the highest concentration of chlorobenzenes was reported for OBA-3A (9,380 to 23,550 ug/L) located near the Solvent Chemicals Site. B-zone total chlorobenzenes are plotted on Figure 3-17. The highest concentration was again reported for cluster OBA-3 (15,280 to 17,830 ug/L). Concentrations in the eastern portion of Plant 2 were 16 to 2,991 ug/L at OBA-2B, 400 to 6,327 ug/L at OBA-6B, and 3,285 to 7,100 ug/L at OBA-5B. Figure 3-18 presents the C- and CD-zone distribution of total chlorobenzenes. The highest concentration of total chlorobenzenes is again reported at well cluster OBA-3 (26,030 to 33,740 ug/L at OBA-3C). Total concentrations elsewhere were reported to be less than 1,000 ug/L except at OBA-2C (673 to 3,054 ug/L and OBA-6C (495 to 1,353 ug/L).

3.3.2.2.4 Chlorinated Phenols

Chlorinated phenol compounds were produced or used at the Olin Plant from 1954-1956. Figure 3-19 presents the total chlorinated phenol concentrations for the A-zone wells. Chlorinated phenols were detected in five A-zone wells: OBA-1A (ND to 293 ug/L), OBA-3A (14 to 68 ug/L), BH-3 (ND to 130 ug/L), OBA-5A (ND to 32), and OBA-7A (ND to 7 ug/L). Total chlorinated phenol concentrations are plotted for B-zone wells on Figure 3-20. The highest concentrations were reported for OBA-6B (22 to 646 ug/L), OBA-5B (74 to 279 ug/L) and OBA-2B (15 to 150 ug/L). Total chlorinated phenol concentrations for C- and CD-zone wells are plotted on Figure 3-21. The highest total concentrations were reported for OBA-7C (168 to 577 ug/L) and OBA-6C (130 to 878 ug/L).

3.3.2.2.5 Pesticides/PCBs

BHC was produced in the section of Plant between Alundum Road and Gill Creek (ARGC Area) from 1950 through 1956. BHC compounds were the only pesticides consistently detected in groundwater at the Plant. A-zone total BHC concentrations are plotted on Figure 3-22. The highest concentrations were reported for wells BH-3 (1,274 to 2,430 ug/L) and OBA-5A (152.4 to 422.9 ug/L). Figure 3-23 presents total BHC concentrations for B-zone monitoring wells. The highest total concentration in B-zone samples were reported for OBA-5B (275 to 353 ug/L). C- and CD-zone total BHC concentrations are presented on Figure 3-24. The highest concentrations were reported for OBA-6C (38.13 to 65.69 ug/L) and OBA-4C (39.3 to 192.9 ug/L).

3.3.2.2.6 Methanol

Methanol was used at the Olin Plant from 1941 until 1990. Methanol concentrations in groundwater samples are presented in Table 3-3. Concentrations exceeding 10 mg/L were limited to monitoring wells OBA-5B (52 to 68 mg/L), OBA-6A (52 to 1,570 mg/L), OBA-6B (161 to 2,500 mg/L), and OBA-8B (ND to 75 mg/L). Methanol was not detected in OBA-8B in the latter three quarterly rounds of sampling, suggesting that the reported result of 75 mg/L was anomalous.

3.4 CONTAMINANT MIGRATION

3.4.1 Soils

Contaminants present in soils at the plant can potentially migrate through three mechanisms:

1. Airborne fugitive dust. Because of the low concentrations of volatile organic chemicals, potential vapor phase transport is not considered significant.

2. Water erosion and subsequent transport in surface water.

3. Leaching and subsequent transport in groundwater.

3.4.2 Groundwater

3.4.2.1 Sources of Groundwater Contamination

The RFI and CMS are concerned with the evaluation and remediation of releases from SWMUs at the Olin Plant. As described in Section 3.3 above, the presence of detectible levels of mercury, benzene, chlorinated benzene compounds, chlorinated phenol compounds, BHC, and methanol in groundwater could be a result of releases from Olin SWMUs. Later sections of the CMS will evaluate potential corrective measures for groundwater containing elevated levels of these chemicals.

The groundwater monitoring performed for the RFI also identified two contaminant plumes migrating toward the Olin Plant from off-site sources. The more widespread of these (with respect to the presence in Olin monitoring wells) is a plume comprised primarily of chlorinated aliphatic volatile organic compounds (VOCs). The source of the chlorinated aliphatic VOC plume appears to be located south of Olin Plant 2.

Contamination associated with the second off-site plume, which appears to impact chemistry primarily at cluster OBA-3 and at OBA-10A, is comprised primarily of chlorinated benzene compounds.

Figures 3-3 and 3-4 show that there is the potential for A-zone and B-zone groundwater flow from the portion of the DuPont Niagara Plant near the west side of Gill Creek toward the ARGC area of Olin. Olin is sampling selected DuPont monitoring wells as part of the RFI. These results will provide data concerning groundwater chemistry on DuPont property south of Olin Plant 2. Data previously submitted to EPA (with permission from DuPont) for two recent DuPont sampling events provides a preliminary indication of chemical concentrations at the DuPont Plant. DuPont routinely analyzes groundwater samples for a subset of the volatile organic compounds included on the Olin Project Analyte List. DuPont Monitoring Well Cluster 14 is located less than 100 feet southwest of Olin well cluster OBA-5 (across Adams Avenue).

Comparison of the results of chlorinated aliphatic VOC analyses for these two quarters shows much higher concentrations to the south of the Olin Plant.

Monitoring Well	**Quarter Sampled**	**Total Chlorinated Aliphatic VOCs (ug/l)**
DuPont Well 14A	2nd Qtr 1992	148,800
DuPont Well 14A	3rd Qtr 1992	223,000
OBA-5A	2nd Qtr 1992	3,461
OBA-5A	3rd Qtr 1992	3,580

This chemical distribution and the A-zone potentiometric surface shown on Figure 3-3 suggest that the source of chlorinated aliphatic VOC contamination in A-zone groundwater is located off-site to the south of the ARGC area.

For potential contamination related to Olin SWMUs, the comparison is quite different.

		Concentration in ug/L	
Monitoring Well	**Quarter Sampled**	**Benzene**	**Total Chlorobenzenes**
DuPont Well 14A	2nd Qtr 1992	ND	ND
DuPont Well 14A	3rd Qtr 1992	ND	ND
OBA-5A	2nd Qtr 1992	100	4,044
OBA-5A	3rd Qtr 1992	79	6,250

The chemical distributions suggest a source of benzene and chlorinated benzene compounds potentially related to Olin activities in the ARGC area. However, no source of chlorinated aliphatic VOCs related to Olin activities in the ARGC is indicated.

In the B- and C-zones, the potentially Olin-derived chemical contamination in groundwater is generally small compared to the chlorinated aliphatic VOC contamination. The potentially Olin-derived contamination in ARGC B- and C-zone groundwater relative to contamination from off-site sources can be put into perspective by comparing the levels of contamination in B- and C-zone wells containing the highest concentrations of potentially Olin-derived contaminants:

		Concentration in ug/L		
Monitoring Well	**Quarter Sampled**	**Benzene**	**Total Chlorobenzene(s)**	**Total Chlorinated Aliphatics Volatiles**
OBA-2B	4th 1991	2J	1,382	497
	1st 1992	3J	761	314
	2nd 1992	ND	2,991	1,476
	3rd 1992	7	16	497
OBA-5B	4th 1991	6,300	7,100	464,490
	1st 1992	32,000	5,170	288,300
	2nd 1992	18,000	3,285	117,300
	3rd 1992	23,000	4,188	403,000

		Concentration in ug/L		
Monitoring Well	**Quarter Sampled**	**Benzene**	**Total Chlorobenzene(s)**	**Total Chlorinated Aliphatics Volatiles**
OBA-6B	4th 1991	1,100	6,327	10,887
	1st 1992	8J	400	1,549
	2nd 1992	7J	855	1,344
	3rd 1992	38	1,326	1,760
OBA-2C	4th 1991	140J	673	563,800
	1st 1992	ND	728	597,800
	2nd 1992	ND	1,185	510,100
	3rd 1992	ND	3,054	564,100
OBA-5C	4th 1991	420	ND	4,329
	1st 1992	1,100	59	16,340
	2nd 1992	820	ND	17,540
	3rd 1992	870	15	17,970
OBA-6C	4th 1991	230J	495	101,350
	1st 1992	250J	851	173,600
	2nd 1992	180J	1,179	16,301
	3rd 1992	210	1,280	15,040

Notes:

ND - Not detected
J - Concentration estimated

These data show that the chlorinated aliphatic VOC contaminants migrating from off-site are present at much higher concentrations than potentially Olin-derived contaminants throughout the ARGC area.

The second off-site plume identified during the Olin RFI is comprised primarily of chlorinated benzene compounds. This plume appears to have its source to the east of Plant 2 in the area of the Solvent Chemicals Site. Figure 3-25 shows total chlorobenzene concentrations in the A-zone for Plant 2 Olin monitoring wells and for Solvent Chemicals Site wells. The Solvent Chemicals data was obtained from the site RI and is also available in the Niagara Falls Regional Groundwater Assessment prepared jointly by Olin, DuPont, and Occidental Chemicals (October 1992). Chlorobenzene concentrations at OBA-10A are not likely related to Olin SWMUs because:

1. Gill Creek acts as a boundary between OBA-10A and the Olin ARGC area SWMUs. The Gill Creek water level is lower than the hydraulic head in OBA-9A and BH-3 (to the west) and lower than OBA-10A (to the east).

2. OBA-10A is located at approximately the same location as the former Solvent Chemicals effluent outfall to Gill Creek (Gill Creek Sediment Study, WCC 1989). This may have caused preferential migration from the Solvent Chemicals Site.

The lack of contamination at OBA-4A is further evidence that Gill Creek is a barrier to contaminant migration in A-zone groundwater. Comparison of levels at BH-3 (near the source area in the south portion of the ARGC area, OBA-3A and OBA-4A (located directly between the two) suggests that A-zone contamination from the ARGC area has not migrated to OBA-3A.

Rather, the source of the contamination at OBA-3A appears to be located at the Solvent Chemicals Site. According to the Solvent Chemicals RI, the top of bedrock slopes toward well cluster OBA-3 from most of the site as shown on Figure 3-27. Therefore, DNAPL at the Solvent Chemicals Site, if present at sufficient saturation, may flow along the top of bedrock toward cluster OBA-3.

The overburden hydraulic gradients are shown on Figure 3-288(from the Solvent Chemicals RI) and the hydraulic gradients for the B-zone are shown on Figure 3-4. Aqueous contamination in the overburden and in the B-zone at the Solvents Chemicals Site would tend to migrate from the Solvent Chemicals Site, toward cluster OBA-3, which is in the downgradient direction in both zones. This pattern of contaminant migration is evident on Figures 3-25 and 3-26. Total chlorinated benzene concentrations in the A-zone and B-zone are highest throughout the western portion of the Solvent Chemicals Site. OBA-3 is located approximately 200 feet downgradient of the highly contaminated area at the Solvent Chemicals Site. Concentrations at cluster OBA-3 show a drop in concentration of greater than one order of magnitude in both zones relative to the upgradient concentrations.

Based on the lack of contamination at cluster OBA-4 and the upgradient (as shown on

Figures 3-28 and 3-4) presence of highly contaminated overburden and B-zone groundwater within 200 feet at the Solvent Chemicals Site, the chemical presence at well cluster OBA-3 is attributable to an off-site source. Therefore, the CMS does not address groundwater contamination in this area which should be controlled by remediation of the off-site source.

3.4.2.2 Migration of Potentially Olin-Derived Contamination in Groundwater

Of the chemicals detected in groundwater, the following appear to have sources potentially related to the Olin Plant operations:

Mercury
Benzene
Chlorinated benzene compounds
Chlorinated phenol compounds
BHC compounds
Methanol

The highest concentrations of mercury in the A-zone occur in the southeast portion of Plant 2 (between Alundum Road and Gill Creek), but in the western portion of Plant 2 for the B-zone and C/CD-zone. This suggests that mercury-containing groundwater has migrated southeasterly from the source areas located in the central section of Plant 2. There appears to be a potential for discharge of groundwater containing elevated mercury concentrations to Gill Creek.

The potential for migration of contamination via underground man-made passageways was assessed in the Interim Report and the Supplemental Report: Man-Made Passageways (WCC, November 9, 1992). These studies concluded that there is little potential for contaminant migration from the site via buried utilities. Within the B-zone and C/CD-zone, migration appears to be primarily westerly toward the production wells.

The organic chemicals listed above were used or produced over a period of several years in the area of Plant 2 between Alundum Road and Gill Creek (ARGC area). Chlorinated phenol concentrations in A-zone groundwater are relatively low in the

ARGC area, but show an order-of-magnitude increase in some B-zone samples. This is consistent with the possible presence of relatively distinct source areas in the overburden with little horizontal migration (and therefore lack of widespread contamination) in the A-zone. Rather, downward leakage and subsequent migration within the B-zone occurs. A similar pattern is observed for the BHC compounds, except that the highest levels are encountered in the A-zone, perhaps due to the lower mobility of BHCs or the proximity of samples to the source area.

Benzene and chlorinated benzene levels are elevated in the ARGC area within the A- and B-zones some westerly migration of chlorinated benzene compounds toward the production wells appears to have occurred in the B- and C/CD-zones.

Based on the data presented and discussed in this section, groundwater discharge to Gill Creek from the ARGC area is the primary off-site transport route for groundwater contamination. To a much lesser extent, horizontal flow of B-zone groundwater beyond the influence of the Olin Production Well may occur. A portion of this groundwater could discharge to the Buffalo Avenue Sewer. However, it is expected that a substantial component of B-zone groundwater flow is vertically downward due to the hydraulic depression in the deeper bedrock zones caused by the Olin Production Well. Contaminants in this groundwater would tend to migrate toward the Olin Production Well.

4.0
REMEDIATION AREAS

Based on the preliminary findings of the RFI, some soil and groundwater remediation will be necessary at the site. Specific soil and groundwater remediation required to meet the remedial objectives for the site are discussed separately below.

4.1 SOIL

Soils throughout the Olin Plant were found to contain mercury at a wide range of concentrations. Contamination of soil with organic chemicals appears limited primarily to the eastern portion of Plant 2. Based on these findings, some corrective measure will be necessary throughout the Plant to limit direct contact, fugitive dust generation, and water erosion of surficial soil. Thus, the entire plant area west of Gill Creek, including the parking lot area (SWMU LA-4) north of Buffalo Avenue has been designated as a Soils Management Area within which measures should be taken to minimize fugitive dust generation and water erosion. Figure 4-1 shows the Soils Management Area.

The soil analytical data collected to date does not delineate any specific areas where soil contamination constitutes a major source of groundwater contamination which could be feasible to remove. However, Olin retains the option of limited excavation of soil if data are developed in the future which indicate limited removal action could substantially reduce groundwater contamination.

4.2 GROUNDWATER

Groundwater remediation at the Olin Plant must be considered in the context of potentially Olin-derived contamination versus contaminants from off-site sources. Based on the data presented in Section 3, the Olin RFI study area has been impacted by two groundwater contamination plumes originating off-site. Benzene and chlorobenzene contamination present east of Gill Creek (cluster OBA-3 and OBA-10A) appears to have migrated from the Solvent Chemicals Site. Potential Olin-derived contamination does not appear to have significantly impacted groundwater east of Gill Creek. Therefore, this area is excluded from further consideration in the CMS.

The other plume originating off-site is the chlorinated aliphatic VOC plume which appears to have its source south of the Olin Plant at the DuPont Plant. As described in Section 3, potentially Olin-derived contamination in the B- and C-zones makes up a small component of the total contamination present, which is comprised primarily of the chlorinated aliphatic VOCs. Groundwater recovery in this area would tend to cause groundwater chemical concentrations to become higher over time because the hydraulic gradient between Olin and the source of contamination would increase, increasing the rate of contaminant migration to the Olin Plant.

Potentially Olin-derived chemicals, benzene and chlorinated benzenes in particular, are present at high concentrations primarily in the A-zone monitoring wells in the southern portion of the ARGC Area of Plant 2. These are the only A-zone monitoring wells with elevated concentrations in which the potentially Olin-derived chemicals make up a substantial percentage of the total contamination. This portion of the plant is also adjacent to Gill Creek, which appears to receive groundwater discharge in this area. Therefore, corrective action should be undertaken to minimize potential migration of A-zone groundwater from the ARGC area. A-zone groundwater within the ARGC Area has been designated a Groundwater Remediation Area as shown on Figure 4-2.

5.0
TECHNOLOGY SCREENING

Section 4 identified areas of the Olin Plant where corrective measures for soil and/or groundwater are recommended to attain the goals presented in Section 2. Figure 4-1 shows the recommended Soils Management Area, which extends throughout Plant 1 and Plant 2 west of Gill Creek, and includes the parking area north of Buffalo Avenue. Figure 4-2 presents the Groundwater Remediation Area which includes the area of the plant between Alundum Road and Gill Creek (ARGC area).

In this section, alternative technologies which could potentially be employed in these areas are screened. Potentially feasible technologies are incorporated into corrective measure alternatives which are evaluated in Section 6.

5.1 SOILS MANAGEMENT AREA

The following technologies were considered with respect to potential applicability for addressing soil contamination in the Soils Management Area:

Removal

- Excavation

Physical Containment Technologies:

- Cover/Capping
- Surface Drainage Control

Land Disposal Technologies:

- On-Site Land Disposal
- Off-Site Land Disposal

Treatment Technologies:

- In-Situ Treatment
- Incineration
- Fixation/Stabilization
- Thermal Desorption

Each is discussed separately below.

5.1.1 Excavation

Complete excavation of impacted soils would require the demolition of all plant facilities which is not feasible at an operating facility. Complete excavation could generate in excess of 200,000 cubic yards of soil for disposal or treatment. The disposal and treatment costs associated with widespread soil excavation would be prohibitive. In addition, large scale excavation would produce potentially unacceptable short-term impacts, including potential air emissions, unacceptable vehicular traffic, and worker hazards during implementation.

The soil analytical data collected to date does not delineate any specific areas where soil contamination constitutes a major source of groundwater contamination which could be feasible to remove. However, Olin retains the option of limited excavation of soil if data are developed in the future which indicate limited removal action could substantially reduce groundwater contamination.

5.1.2 Physical Containment

5.1.2.1 Cover/Capping

Cover or capping the site would effectively limit contact with surface soils, and would minimize potential fugitive dust emissions and potentially contaminated surface water runoff. In addition, caps and covers reduce infiltration of rainfall and thus reduce contaminant mobility in groundwater. Thus cover or capping would meet the remedial objective for soils. Cover or capping could be achieved by soil, pavement, or geotextiles.

Cover or capping of the entire site would require demolition of all plant facilities, which is not feasible at an operating plant and would be cost prohibitive. A considerable portion of the site is currently effectively capped by buildings and paved areas. Cover or capping of additional unpaved areas of the site is feasible, and is retained for further consideration.

5.1.2.2 Surface Drainage Control

Surface drainage control is a feasible method to reduce infiltration and minimize soil erosion. It is readily implementable in conjunction with partial capping or cover of the site, and is retained for further consideration.

5.1.3 Land Disposal

Limited quantities of excavated contaminated soils could be disposed on-site or off-site. Off-site disposal of soils would be subject to any applicable RCRA land disposal restrictions (LDRs), which could limit its applicability. On-site disposal of limited quantities of excavated soil is feasible, again subject to LDRs, unless on-site disposal occurs within a Corrective Action Management Unit (CAMU), in which case LDRs would not apply. Both off-site and on-site land disposal are retained as feasible technologies for limited quantities of soil which may be excavated during site remediation.

5.1.4 Treatment

5.1.4.1 In-Situ Treatment

In-situ treatment is not feasible for soils at the site. Volatile organics are amenable to in-situ treatment by vapor extraction. However, only low concentrations of volatiles have been detected in soil. Thus, soil vapor extraction would not be effective for remediation of volatile organics. No in-situ treatment technologies have been demonstrated to be effective for chlorinated semivolatile organics, pesticides, or mercury.

5.1.4.2 Incineration

Incineration of mercury-contaminated soils is not feasible, because there are no permitted solid waste incinerators for soils containing mercury. Incineration of soils containing organic compounds, without mercury, is technically feasible, although its applicability is limited. There are no permitted RCRA incinerators for soil in New York State. Due to the high cost and limited capacity of off-site incinerators, this technology is only feasible for low soil quantities. It is retained as feasible technology for low quantities of soil which may be removed during remediation. Due to the high cost of mobilization, trial burns, and permitting, as well as potential community opposition, on-site incineration is feasible only for large quantities of soil, and thus is not considered a feasible technology for the site.

5.1.4.3 Fixation/Stabilization

Fixation/stabilization technologies involve the application of various agents to reduce the mobility of contaminants. These technologies are generally effective for inorganic contaminants. There is some evidence that stabilization may reduce mobility of organic contaminants as well, although the effectiveness for volatile organic compounds is uncertain. Fixation/stabilization are generally effective for leachable contaminants. Due to the low concentrations of volatile organics in soil, and the fact that they have already migrated to groundwater fixation/stabilization would not be effective for treating these compounds. Because pesticides found in soils at the site have limited mobility, fixation/stabilization would have limited effectiveness for these compounds. Although mercury in soils at the site has been demonstrated to have limited leachability through TCLP testing, fixation/stabilization is retained as a candidate technology for mercury contaminated soils if low quantities of soil are excavated during remediation. Bench scale pilot testing to demonstrate the effectiveness of this technology would be required prior to implementation.

5.1.4.4 Thermal Desorption

Thermal desorption is potentially applicable to soils contaminated with volatile or semivolatile organic compounds. However, potential mercury emissions preclude its applicability to many of the soils at the site. Thermal desorption has not been fully demonstrated for pesticides, and permitted commercial off-site thermal desorption units are not available. Due to high mobilization costs, on-site thermal desorption units are only feasible for high soil quantities. Thermal desorption is not considered feasible due to its limited applicability to soils at the site, the potential for mercury emissions, and the lack of commercially available units.

5.1.5 Summary

The results of the screening of potential remedial technologies for soil is summarized on Table 5-1. Technologies retained for further consideration are:

Physical Containment

- Cover or capping for selected areas of the site

- Surface drainage control

Land Disposal

- On-site or off-site land disposal for limited quantities of soil contaminated by organics or mercury (if generated during remediation)

Treatment

- Off-site incineration for limited quantities of soil containing organic contamination only (if generated during remediation)

- Fixation/stabilization for limited quantities of soil contaminated by mercury (if generated during remediation)

5.2 A-ZONE GROUNDWATER

A-zone (overburden and weathered bedrock interface) groundwater in the ARGC area was designated as a Groundwater Remediation Area (see Figure 4-2). The following alternative technologies were considered with respect to potential applicability for addressing groundwater contamination.

Physical Containment Technologies:

- Vertical barriers
- Bottom sealing

Hydraulic Containment Technologies:

- Extraction wells
- Trench drain collection system

Treatment Technologies:

- Biological
- Chemical
- Physical
- In-situ treatment
- Discharge to publicly owned treatment works (POTW)
- Off-site treatment facility

The following subsections assess the potential applicability of these technologies.

5.2.1 Physical Containment Technologies

5.2.1.1 Vertical Barriers

Subsurface vertical barriers in soil can be constructed of clay, cement, soil-bentonite (SB), cement-bentonite (CB), sheet pile or reinforced concrete sections (referred to as diaphragms), high density polyethylene (HDPE), bentonite mats, or other materials. Based on the thickness and nature of the overburden clay, SB, CB, sheet pile, bentonite mats, or other technologies would be feasible for use at the site. Based on the heterogenous nature of the soil and fill present at the site, fine-grained soil from an off-site source would likely be required for SB construction. Since the depth of the wall is likely to be less than approximately 10 to 14 feet, use of clay construction could be easier and less expensive than an SB or CB barrier. To improve the effectiveness in sealing the weathered bedrock interface, some limited grouting in the bottom of the excavated trench could be performed prior placement of the barrier material. For a sheet pile barrier, the weathered bedrock could be sealed with grout injection. For this Phase I CMS, subsurface vertical barriers are retained as a potentially feasible technologies for A-zone groundwater remediation.

There are three types of vertical barrier configurations that are generally considered for groundwater remediation: upgradient barriers, downgradient barriers and circumferential barriers. Upgradient barriers are used to divert groundwater around a contaminated area. Downgradient barriers are used to reduce off-site migration. Neither configuration is entirely effective without groundwater withdrawal (hydraulic control). A circumferential vertical barrier around the contaminated area generally increases the effectiveness with less groundwater withdrawal. Potential vertical barrier configurations are evaluated in Section 6.

5.2.1.2 Bottom Sealing

This technology involves injecting sealant (grout) into the base of the weathered bedrock in order to prevent contaminated groundwater from migrating from the overburden to the bedrock. Injection of the grout is performed via an extensive network of penetration points in the upper bedrock.

This technology has a number of limitations. The extensive number of boreholes required for grout injection could provide pathways for contaminated groundwater to migrate into the upper bedrock. The injection of grout to seal the base of the weathered bedrock interface is further complicated at the Olin Plant by the number of building foundations and underground utilities that would interfere with the injection locations. The costs associated with implementing this technology are prohibitively high.

This technology has not been demonstrated as effective for groundwater remediation.

Pilot scale tests using injection and jet grouting have been conducted by the USACE Experiment Station (May, J.H., 1986). None of the grouts tested were completely successful in sealing the soil and left gaps and voids in the seal indicating that the effectiveness of the grouts currently available is limited. Bottom sealing technology is not feasible for use in this project and is dropped from further consideration.

5.2.2 Hydraulic Containment Technologies

Hydraulic containment (groundwater recovery) is used in groundwater remediation to reduce off-site groundwater flow and to remove and treat groundwater contamination.

Groundwater recovery is feasible for use in remediating the ARGC A-zone. Two general recovery methods are potentially feasible: extraction wells and trench drains (gravel or tile drains placed in a trench).

Groundwater recovery using extraction wells requires little disturbance of surface and subsurface soils. However, extraction wells are more effective in thick highly transmissive water-bearing units. Extraction wells would have a relatively small radius of influence in the A-zone in the ARGC area because of the small saturated thickness (approximately 5 feet or less). This could be compensated for by increasing the number of recovery wells.

Trench drains are effective in controlling shallow groundwater flow. Trench drains are more efficient than recovery wells, but installation generates large quantities of soil which may have to be disposed, treated or consolidated. As with the vertical barrier installation, underground utilities may have to be taken out of service or rerouted to accommodate construction.

Groundwater recovery (either method) is retained for consideration in this Phase I CMS.

5.2.3 Groundwater Treatment Technologies

5.2.3.1 Biological Treatment

Biological treatment is not appropriate for application to heavy metal contamination, since the metals are not degradable. In addition, pesticides and chlorobenzene compounds are not readily amenable to biological degradation. This technology is therefore not applicable at this site and is dropped from further consideration.

5.2.3.2 Chemical Treatment

Chemical treatment methods may include neutralization, precipitation and ion exchange for inorganic contaminants, and chemical oxidation of organic contaminants. Precipitation and ion exchange are potentially applicable to treatment of mercury present in groundwater. Oxidation of chlorinated organic compounds is possible, although generally this method is not cost-effective relative to physical methods (e.g., air stripping and carbon absorption) for treatment of organics in groundwater. Chemical treatment is retained as a potential technology for treatment of mercury.

5.2.3.3 Physical Treatment

Physical treatment technologies separate chemicals without changing the molecular structure. Such technologies may include filtration, flocculation, sedimentation, activated carbon, air stripping, and steam stripping. For contaminants dissolved in groundwater, filtration, flocculation, and sedimentation, which remove particulate matter, will not be effective. Air stripping and steam stripping are effective methods for removing volatile organic and some semivolatile organic compounds from water, and thus are feasible technologies for groundwater at the site. Activated carbon is effective in removing a wide range of organic compounds from water and is also effective at removing low concentrations of mercury. Activated carbon is a feasible technology. Physical treatment of water is retained for further consideration.

5.2.3.4 In-Situ Groundwater Treatment

In-situ groundwater treatment is not feasible in the A-zone for the following reasons:

1. Low permeability of the overburden soils

2. Obstructions to groundwater flow caused by basements and utilities

3. Inability to sufficiently treat chemicals in the overburden groundwater

In-situ treatment has not been demonstrated as an effective technology for mercury and chlorinated organics, and is thus not retained.

5.2.3.5 Groundwater Treatment via Discharge to a POTW

Sanitary discharges from the plant comply with a permit issued by the Niagara Falls Waste Water Treatment Plant (NFWWTP) which lists the chemical loadings that can be discharged by the plant. Currently, all plant discharges are below the required discharge levels. If the remedial activities for the plant involve removal of groundwater with discharge to the sanitary sewer system, it is likely that the chemical loading to the NFWWTP would increase above the currently permitted levels. This technology is retained pending a determination of whether untreated groundwater could be accepted by the POTW.

5.2.3.6 Groundwater Treatment at an Off-Site Treatment Facility

Treatment of groundwater at an off-site facility is feasible for low volumes of water. Off-site treatment would not be cost-effective for large volumes of water, and offers no technical benefit relative to on-site treatment. This technology is retained for further consideration pending a determination of expected groundwater flow rates.

5.2.4 Summary

Table 5-2 provides a summary of the screening of candidate technologies for groundwater treatment. The following technologies are retained for further consideration in assembling remedial alternatives.

Physical Containment

- Vertical Barrier

Hydraulic Containment

- Extraction Wells
- Trench Drain

Groundwater Treatment

- Chemical Treatment (e.g., precipitation)
- Physical Treatment (e.g., activated carbon, air stripping, steam stripping)

These potential groundwater remedial technologies were combined with potential soil remedial technologies to develop overall remedial alternatives, which are evaluated in Section 6.

5.3 B-ZONE GROUNDWATER

As discussed in Sections 3 and 4, the contamination observed in the B-zone is primarily caused by on-site migration of off-site contamination. For this reason, the feasibility of remediation of the B-zone is evaluated in terms of the ability to remove or treat contaminated groundwater without inducing on-site flow of highly contaminated off-site groundwater. Remediation at the source of this contamination would be much more effective than remediation of the downgradient end of the plume. Remediation of the off-site source is not within Olin's control. In addition, B-zone groundwater at the Olin site is largely contained by groundwater recovery in the Olin Production Well which induces downward flow from the B-zone to the C/CD-zone, which is controlled by the production well. Thus B-zone groundwater recovery has the potential incremental benefit of controlling the off-site flow not currently controlled by the production wells;

however recovery of B-zone groundwater could result in increased contaminant levels due to increased flow from off-site. The following technologies were evaluated for potential applicability to groundwater contamination in the B-zone in the ARGC area.

Physical Containment Technologies

- Vertical Barrier
- Bottom Sealing

Hydraulic Containment Technologies

- Extraction Wells
- Trench Drain Collection System

Treatment Technologies

- Biological
- Chemical
- Physical
- In-Situ Treatment
- Discharge to publicly owned treatment works (POTW)
- Off-Site Treatment Facility

5.3.1 Physical Containment Technologies

5.3.1.1 Vertical Barriers

Most of the vertical barrier technologies potentially feasible for the A-zone (see Section 5.2.1.1) are not feasible for the B-zone bedrock using conventional construction methods. A partial physical barrier to on-site migration of contamination could be effected by constructing a grout curtain. However, grout curtains cannot be made impermeable and, while practical for enhancing hydraulic control of recovery systems, a grout curtain will not prevent off-site contamination from migrating on-site toward a recovery system. Potential migration of off-site contamination below the grout curtain and upward due to upward vertical gradients resulting from recovery operations would also limit the utility of a grout curtain. In summary, grout curtains are useful when coupled with groundwater withdrawal for keeping on-site contamination in, but are not practical for keeping off-site contamination out.

5.3.1.2 Bottom Sealing

Bottom sealing would not be feasible or effective for the B-zone bedrock (see Section 5.2.1.2 for additional discussion).

5.3.2 Hydraulic Containment Technologies

Hydraulic containment (groundwater recovery) is used to reduce off-site groundwater flow and to remove and treat groundwater contamination. For the B-zone, groundwater recovery using extraction wells is technically feasible. Recovery trenches are not feasible in the B-zone using conventional construction methods. Recovery of B-zone groundwater in the ARGC area would induce increased flow of off-site contamination, and would not be effective relative to control of the source.

5.3.3 Groundwater Treatment Technologies

The feasibility of treatment technologies for B-zone groundwater is the same as is discussed for A-zone groundwater (see Section 5.2.3).

5.3.4 Summary

Table 5-3 provides a summary of the screening of candidate technologies for B-zone groundwater remediation. The following technologies were identified as implementable:

Physical Containment

- Grout Curtain

Hydraulic Containment

- Extraction Wells

Groundwater Treatment

- Chemical Treatment
- Physical Treatment

However, remediation of B-zone groundwater is not considered feasible because it would not be effective, i.e., would not result in improved groundwater quality. Groundwater recovery from the B-zone, using recovery wells alone or in conjunction with a grout curtain, would result in increased on-site migration of off-site contamination, causing further degradation of on-site groundwater quality.

Potentially Olin-derived chemicals make up only a small portion of the mass of contamination present in the B-zone (see Section 3). The source of most of the contamination is located off-site. Thus groundwater recovery in the B-zone would likely cause groundwater quality to become worse over time as the rate of migration from the source is increased. A partial physical barrier could be effected by constructing a grout curtain. However, grout curtains cannot be made impermeable. A grout curtain would not prevent off-site contamination from migrating on-site toward the recovery system. Potential migration of off-site contamination below the grout curtain and upward due to upward vertical gradients resulting from recovery operations would also limit the utility of a grout curtain. Grout curtains are useful when coupled with groundwater withdrawal for keeping on-site contamination in, but are not practical for keeping off-site contamination out.

In addition, the potential for off-site migration of contaminants in the B-zone under current conditions is minimal, due to the hydraulic impact of the Olin Production Well. Since potential pathways for off-site migration are limited and since attempts at groundwater remediation would cause degradation in groundwater quality, no remediation is necessary or appropriate for the B-zone groundwater. Remediation of B-zone groundwater is therefore not considered further in this CMS.

Similarly, remediation is not warranted for groundwater contamination in the CD-zone. The primary sources of contamination in this zone are off-site. In addition, groundwater in the CD-zone is within the hydraulic influence of the Olin Production Well, which controls potential off-site migration in the CD-zone. Thus remediation of CD-zone groundwater is not considered in this CMS.

6.0
EVALUATION OF ALTERNATIVES

Section 5 identified remedial technologies which are feasible for use at the site. This section incorporates these technologies (as appropriate) into corrective measure alternatives, which are subsequently evaluated. Each alternative provides for:

- Additional cap or cover for soils in currently uncovered areas
- Surface drainage control
- Recovery and treatment of A-zone groundwater
- Management of solid residues generated during remediation

The major components of each alternative are summarized on Table 6-1.

The primary difference between the alternatives is the method of groundwater control and recovery.

6.1 CMS ASSESSMENT PROCESS

Each of the alternatives is evaluated to determine their comparative compatibility with, and applicability to, site conditions, including plant operations and on-going remedial programs. The result of the assessment process will be the selection of a preferred alternative to provide an effective, economically feasible remedy which complies with applicable State and Federal regulations.

Each of the remedial alternatives developed is assessed and a preferred alternative is selected on the basis of:

- Applicability
- Effectiveness (long term and short term)
- Implementability
- Community acceptance
- Protection of human health and the environment

- Consistency with goals for corrective action
- Cost effectiveness
- Permanence of remedy
- Reduction of toxicity, mobility and volume
- Compliance with applicable state and federal regulations

The alternative corrective measures are described and evaluated below.

6.2 ALTERNATIVE 1

Alternative 1 consists of a cover or cap and surface drainage control to limit mobility of contaminants in soil. The alternative employs groundwater recovery (hydraulic control), without installation of vertical barriers, to remediate groundwater in the ARGC Area.

6.2.1 Cover/Capping

Physical containment of soils in the Soils Management Area (Figure 4-1) through application of a cover or cap is a feasible technology. Covering of soils could be effectively accomplished by additional paving of exposed soil areas, and by paving drainage swales and/or ditches. Use of pavement, rather than soil or geomembrane covers, provides an advantage in that much of the plant is presently paved, and maintenance of additional paved areas could be easily incorporated into existing procedures. In addition, pavement is resistant to damage from weather and traffic, and is easily inspected for damage and deterioration.

6.2.2 Surface Drainage Control

Surface drainage control will be achieved in conjunction with provision of a pavement cover in the Soil Management Area (Figure 4-1). Grades to achieve proper drainage can be readily implemented, and pavement can be used to cover drainage swales and ditches, reducing surface water infiltration and soil erosion. Surface drainage control satisfies the alternative evaluation criteria in the same manner as the cover.

6.2.3 Groundwater Recovery

Groundwater recovery for Alternative 1 would consist of either trench drain or series of recovery wells located along a north-south line along most of the east (downgradient) perimeter of the ARGC Area, (parallel to Gill Creek). The trench drain or recovery wells would penetrate the overburden and weathered top-of-bedrock interface to the extent practical using conventional equipment. The trench drain or recovery well line would be approximately 475 feet in length, extending from near Adams Avenue to approximately 200 feet south of Buffalo Avenue. This alternative does not employ a vertical barrier.

6.2.4 Groundwater Treatment

Several feasible technologies for groundwater treatment have been identified. These include:

- Chemical treatment (mercury)
  - Precipitation
  - Ion exchange
- Physical treatment
  - Air or steam stripping (organics)
  - Activated carbon (organics and mercury)
- Treatment at a POTW
- Treatment at an off-site facility

Final selection of a groundwater treatment method will be performed during future conceptual and detailed design studies. Selection of the treatment method will depend upon:

- Estimated flow rates
- Projected constituent concentrations
- POTW discharge limitations
- Availability of off-site treatment capacity

The selected treatment method will satisfy applicable permit requirements.

6.2.5 Residual Management

Excavation and removal of extensive quantities of contaminated soil is not anticipated during implementation of this alternative. However, some contaminated soils may be generated during installation of recovery wells or trenches. Several feasible alternatives for managing these residuals were identified including:

- On-site land disposal
- Off-site land disposal
- Fixation/stabilization (mercury-contaminated soils)
- Off-site incineration (low-quantity organic soils only)

Selection of the method for residual waste management will be performed during future conceptual and detailed design studies. Selection of the treatment/disposal method will depend upon:

- Waste quantities
- Waste characteristics and classification
- Regulatory restrictions (e.g., LDRs)

6.2.6 Evaluation of Alternative

Alternative 1 has limited effectiveness. Groundwater recovery without installation of a vertical barrier would result in induced infiltration of water from Gill Creek, increasing the pumping rate required. Furthermore, the hydraulic depression effected in the groundwater withdrawal will increase the rate of migration of contaminated groundwater to the site from the south. Thus groundwater quality in the ARGC Area will tend to degrade over time rather than improve. Because this alternative would not be effective as a stand-alone method, it is not considered further.

6.3 ALTERNATIVE 2

Alternative 2 is similar to Alternative 1, with the addition of a downgradient vertical barrier. The vertical barrier would be installed in the A-zone, along the western side of Gill Creek, and along a portion of the southern boundary of the Olin Plant between Gill Creek and Alundum Road.

6.3.1 Cover/Capping

The cover is described in Section 6.2.1.

6.3.2 Surface Drainage Control

Surface drainage control is described in Section 6.2.2.

6.3.3 Downgradient Vertical Barrier

A physical barrier to groundwater flow, has been identified as a feasible technology. Several vertical barriers are potentially feasible. The vertical barrier would be aligned along the west bank of Gill Creek, from Buffalo Avenue to Adams Avenue, and also extend along a portion of the southern boundary of Plant 2 (between Gill Creek and Alundum Road). This vertical barrier configuration will present a barrier to groundwater flow from Gill Creek (minimizing groundwater pumping rates). It also presents a physical barrier to groundwater discharge to Gill Creek and to on-site migration of contaminated groundwater from the south. Due to the limited depth of overburden and weathered bedrock, the vertical extent of a physical barrier of this type would be limited to approximately 10 to 15 feet.

6.3.4 Groundwater Recovery

Groundwater recovery for Alternative 2 would consist of either a trench drain or series of recovery wells located along a north-south line along most of the east (downgradient) perimeter of the ARGC Area (parallel to Gill Creek). The trench drain or recovery well line would be approximately 475 feet in length, extending from near Adams Avenue to approximately 200 feet south of Buffalo Avenue. As described above, this alternative employs a vertical barrier between the recovery system line and Gill Creek and along Adams Avenue between Gill Creek and Alundum Road.

6.3.5 Groundwater Treatment

Potential groundwater treatment technologies are identified in Section 6.2.4.

6.3.6 Residual Waste Management

Potential residual waste management technologies are described in Section 6.2.5.

6.3.7 Evaluation of Alternative

Alternative 2 meets the remedial objectives for the site, and satisfies the alternative evaluation criteria. The alternative is applicable, effective, and implementable. Effectiveness, in terms of reducing contaminant mobility and off-site migration can be achieved relatively quickly and can be readily monitored. This remedy would be protective of human health and the environment and would meet the remedial objectives, and thus would likely be acceptable to the community. The remedy would be effective in the long-term and permanent, although maintenance will be required. This alternative reduces toxicity, mobility and volume of contamination through a combination of physical containment and treatment. The alternative should be implementable in accordance with applicable state and federal regulations, although it is possible that the need to obtain some waivers or variances may be identified during detailed design. This alternative is considered cost-effective for the degree of protection provided.

6.4 ALTERNATIVE 3

Alternative 3 is similar to Alternative 1, with the addition of a circumscribing vertical barrier. The vertical barrier would be installed in the A-zone surrounding the ARGC area.

6.4.1 Cover/Capping

The proposed cover is described in Section 6.2.1.

6.4.2 Surface Drainage Control

Surface drainage control is described in Section 6.2.2.

6.4.3 Circumscribing Vertical Barrier

A general description of vertical barriers is provided in Section 6.3.3. In this alternative, the vertical barrier would be installed to fully circumscribe the ARGC area in the A-zone.

6.4.4 Groundwater Recovery

Groundwater recovery for Alternative 3 would consist of either a trench drain or series of recovery wells located along a north-south line along most of the east (downgradient) perimeter of the ARGC Area (parallel to Gill Creek). The trench drain or recovery well line would be approximately 475 feet in length, extending from near Adams Avenue to approximately 200 feet south of Buffalo Avenue. As described above, this alternative employs a circumscribing vertical barrier surrounding the ARGC Area.

6.4.5 Groundwater Treatment

Potential groundwater treatment technologies are described in Section 6.2.1.

6.4.6 Residual Waste Management

Potential residual waste management technologies are described in Section 6.2.5.

6.4.7 Evaluation of Alternative

Alternative 3 meets the remedial objectives for the site, and would satisfy most of the alternative evaluation criteria in the same manner as Alternative 2, as described in Section 6.3.7. The primary differences would be increased costs associated with installation of additional lengths of vertical barrier, and generation of additional quantities of excavated soil to be disposed of. A vertical barrier would be difficult to install in the area near Alundum Road due to subsurface utilities. Furthermore, the shallow depth to bedrock limits the potential benefit from a barrier. Because of the limited saturated zone in some areas of the circumscribing wall, there is little upgradient groundwater flow to intercept, and little benefit to a fully circumscribing barrier relative to a downgradient barrier. Thus this alternative is not considered cost effective relative to Alternative 2.

6.5 SELECTION OF RECOMMENDED ALTERNATIVE

Alternative 1 is not considered effective, since it would induce flow of off-site contaminated water onto the Olin property.

Alternatives 2 and 3 both meet the remedial objectives for the site, and satisfy the alternative evaluation criteria. Alternative 3 would cost substantially more than Alternative 2, without any substantial benefit in terms of protection of human health and the environment, i.e., reducing potential off-site contaminant transport. Because Alternative 2 achieves the same level of performance as Alternative 3 at a lower cost it is the recommended Alternative. Components of the recommended remedial alternative are shown on Figure 6-1.

7.0
LIMITATIONS

WCC's work is in accordance with our understanding of professional practice and environmental standards existing at the time the work was performed. Professional judgements presented are based on our evaluation of technical information gathered and on our understanding of site conditions and site history. Our analyses, interpretations, and judgements rendered are consistent with professional standards of care and skill ordinarily exercised by the consulting community and reflect the degree of conservatism WCC deems proper for this project at this time. Methods are constantly changing and it is recognized that standards may subsequently change because of improvements in the state of the practice.

Information used to prepare this report includes results from soil, surface water, and groundwater analyses collected by WCC. It is assumed that the reported results are representative of the general site conditions.

8.0
REFERENCES

Ecology and Environment, Inc. "Remedial Investigation Report for the 3163 Buffalo Avenue Site, Niagara Falls, New York", prepared for the New York State Department of Environmental Conservation, August 1990.

Woodward-Clyde Consultants and Conestoga-Rovers and Associates, "Niagara Falls Regional Groundwater Assessment", prepared for DuPont Chemicals, Occidental Chemical Corporation and Olin Chemicals, October 1992.

Woodward-Clyde Consultants "Geohydrologic Investigations DuPont Niagara Plant", prepared for DuPont Chemicals, December 23, 1983.

Woodward-Clyde Consultants", Supplemental Geohydrologic Investigation, DuPont Niagara Plant", prepared for DuPont Chemicals, October 24, 1984.

Woodward-Clyde Consultants, "Final Report, DuPont Niagara Falls Plant Interim Remediation Program", prepared for DuPont Chemicals, September 21, 1989.

Woodward-Clyde Consultants, "Interim Report for the Olin Buffalo Avenue Plant RCRA Facility Investigation", prepared for Olin Chemicals, February 7, 1992.

Woodward-Clyde Consultants, "Supplemental Report: Man-Made Passageways" prepared for Olin Chemicals, November 9, 1992.

Tables

TABLE 3-1

PROJECT ANALYTE LIST

TCL VOLATILES

Chloromethane
Bromomethane
Vinyl Chloride
Chloroethane
Methylene Chloride
Acetone
Carbon Disulfide
1,1-Dichloroethene
1,1-Dichloroethane
1,2-Dichloroethene
Chloroform
1,2-Dichloroethane
2-Butanone
1,1,1-Trichloroethane
Carbon Tetrachloride
Vinyl Acetate
Bromodichloromethane
1,2-Dichloropropane
cis-1,3-Dichloropropene
Trichloroethene
Dibromochloromethane
1,1,2-Trichloroethane
Benzene
trans-1,3-Dichloropropene
Bromoform
4-Methyl-2-pentanone
2-Hexanone
Tetrachloroethene
Toluene
1,1,2,2-Tetrachloroethane
Chlorobenzene
Ethyl Benzene
Styrene
Xylenes

TABLE 3-1 (continued)

PROJECT ANALYTE LIST

NON-TCL VOLATILES

Methanol

TCL SEMI-VOLATILES

Phenol
bis(2-Chloroethyl)ether
2-Chlorophenol
1,3-Dichlorobenzene
1,4-Dichlorobenzene
Benzyl alcohol
1,2-Dichlorobenzene
2-Methylphenol
bis(2-Chloroisopropyl)ether
4-Methylphenol
N-Nitroso-di-n-propylamine
Hexachloroethane
Nitrobenzene
Isophorone
2-Nitrophenol
2,4-Dimethylphenol
Benzoic acid
bis(2-Chloroethoxy)methane
2,4-Dichlorophenol
1,2,4-Trichlorobenzene
Naphthalene
4-Chloroaniline
Hexachlorobutadiene
4-Chloro-3-methylphenol(para-chloro-meta-cresol)
2-Methylnaphthalene
Hexachlorocyclopentadiene
2,4,6-Trichlorophenol
2,4,5-Trichlorophenol
2-Chloronaphthalene
2-Nitroaniline
Dimethylphthalate

TABLE 3-1 (continued)

PROJECT ANALYTE LIST

<u>TCL SEMI-VOLATILES (continued)</u>

Acenaphthylene
2,6-Dinitrotoluene
3-Nitroaniline
Acenaphthene
2,4-Dinitrophenol
4-Nitrophenol
Dibenzofuran
2,4-Dinitrotoluene
Diethylphthalate
4-Chlorophenyl-phenyl ether
Fluorene
4-Nitroaniline
4,6-Dinitro-2-methylphenol
N-nitrosodiphenylamine
4-Bromophenyl-phenylether
Hexachlorobenzene
Pentachlorophenol
Phenanthrene
Anthracene
Di-n-butylphthalate
Fluoranthene
Pyrene
Butylbenzylphthalate
3,3'-Dichlorobenzidine
Benzo(a)anthracene
Chrysene
bis(2-Ethylhexyl)phthalate
Di-n-octylphthalate
Benzo(b)fluoranthene

TABLE 3-1 (continued)

PROJECT ANALYTE LIST

NON-TCL SEMI-VOLATILES

Benzo(k)fluoranthene
Benzo(a)pyrene
Indeno(1,2,3-cd)pyrene
Dibenz(a,h)anthracene
Benzo(g,h,i)perylene
3-Chlorophenol
4-Chlorophenol
2,3-Dichlorophenol
2,5-Dichlorophenol
3,4-Dichlorophenol
3,5-Dichlorophenol
2,3,4-Trichlorophenol
2,3,5-Trichlorophenol
2,3,6-Trichlorophenol
3,4,5-Trichlorophenol
2,3,4,5-Tetrachlorophenol
2,3,5,6-Tetrachlorophenol
2,3,4,6-Tetrachlorophenol

PESTICIDES/PCBs

alpha-BHC
beta-BHC
delta-BHC
gamma-BHC (Lindane)
Heptachlor
Aldrin
Heptachlor epoxide
Endosulfan I
Dieldrin
4,4'-DDE
Endrin
Endosulfan II
4,4'-DDD
Endosulfan sulfate
4,4'-DDT

TABLE 3-1 (continued)

PROJECT ANALYTE LIST

<u>PESTICIDES/PCBs (continued)</u>

Methoxychlor
Endrin ketone
alpha-Chlordane
gamma-Chlordane
Toxaphene
Aroclor-1016
Aroclor-1221
Aroclor-1232
Aroclor-1242
Aroclor-1248
Aroclor-1254
Aroclor-1260

<u>TAL INORGANICS</u>

Mercury

TABLE 3-2

DETECTED CHEMICALS IN WELL OBA-2C DNAPL
OLIN BUFFALO AVENUE PLANT RFI

Chemical	Concentration (mg/kg)
Volatile Organic Compounds	
1,2-Dichloroethene (total)	380
Chloroform	600
Carbon tetrachloride	2,300
Trichloroethene	130,000
Tetrachloroethene	130,000
1,1,2,2-Tetrachloroethane	35,000
	Subtotal: 298,280 mg/kg (29.8%)
Semivolatile Organic Compounds	
1,3-Dichlorobenzene	410
1,4-Dichlorobenzene	1,200
1,2-Dichlorobenzene	6,000
1,2,4-Trichlorobenzene	2,800
Hexachlorobutadiene	9,600
Hexachlorobenzene	360
bis(2-Ethylhexyl)phthalate	2,100
Hexachloroethane	25,000
	Subtotal: 47,470 mg/kg (4.7%)
Pesticide/PCB	
alpha-BHC	70
beta-BHC	71
delta-BHC	130
gamma-BHC	50
Heptachlor	7.6
Heptachlor epoxide	5.2
Endrin	130
Endosulfan sulfate	130
alpha-Chlordane	1.8
gamma-Chlordane	3.9
4,4'-DDE	9.0
	Subtotal: 608.5 mg/kg (0.06%)

TABLE 3-3

METHANOL CONCENTRATIONS IN GROUNDWATER
OLIN BUFFALO AVENUE PLANT

Well ID	Sample Date: Sep-91	Mar-92	Jun-92	Sep-92
Olin Production Well	ND	ND	ND	ND
OBA-1A	ND	ND	ND	ND
OBA-1B	2100	ND	ND	ND
OBA-1C	1800	ND	610	ND
OBA-2B	ND	ND	ND	ND
OBA-2C	ND	ND	ND	ND
OBA-3A	ND	ND	ND	ND
OBA-3B	ND	ND	ND	ND
OBA-3C	ND	ND	ND	ND
OBA-4A	ND	ND	ND	ND
OBA-4B	ND	ND	ND	ND
OBA-4C	ND	ND	ND	ND
OBA-5A	1400	ND	ND	ND
OBA-5B	68000	64000J	52000	62000
OBA-5C	ND	1400J	1400	1100
OBA-6A	1570000	560000J	240000	52000
OBA-6B	161000	2500000J	1500000	410000
OBA-6C	1500	500J	930	650
OBA-7A	ND	ND	ND	ND
OBA-7B	2300	1200	1500	900
OBA-7C	ND	ND	ND	1200
OBA-8A	ND	ND	ND	ND
OBA-8B	75000J	ND	ND	ND
OBA-8C	ND	590	ND	1200
OBA-9A	NS	NS	NS	ND*
OBA-10A	NS	NS	NS	ND*
BH-1	ND	ND	ND	ND
BH-3	3000	1200	ND	2200

Notes:

All units in ug/l.

* Samples collected from monitoring wells OBA-9A and OBA-10A in November 1992.

J- Estimated concentration

ND- Not Detected

NS- Not Sampled

By:dpf
Chk by:tmv
11/22/93

OLINMETH.XLS

TABLE 5-1

CANDIDATE REMEDIAL TECHNOLOGIES - SOILS

Remedial Technologies	Feasibility	Comments
Removal		
• Complete Excavation	Not feasible	- Complete excavation would require demolition of all plant facilities which is not feasible at an operating plant. In addition, costs would be prohibitive.
• Partial Excavation	Feasible	- Selected areas, if limited in size and accessible, could be removed for on-site or off-site treatment or disposal.
Physical Containment		
• Cover/Cap - Entire Plant	Not feasible	- Cover of the entire plant would require demolition of all plant facilities which is not feasible at an operating plant.
• Cover/Cap - Partial	Feasible	- Cover with low permeable materials may have specific applications.
• Surface Drainage Control	Feasible	- A surface drainage management scheme to control off-site migration of chemicals from surface soils is feasible.
Land Disposal		
• On-Site	Feasible	- On-Site disposal could be conducted subject to land disposal restrictions (LDRs); application of the CAMU rule could exempt on-site disposal from LDRs.
• Off-Site	Feasible	- Potentially feasible for soils not subject to LDRs.
Treatment		
• In-Situ Treatment	Not feasible	- No demonstrated technologies for in-situ treatment of mercury or pesticide contaminated soils.
• Incineration (Mercury Contaminated Soils)	Not feasible	- No solid incinerators permitted for treatment of mercury in soils.
• Incineration (Organic Contaminated Soils)	Feasible (limited applicability)	- Potentially applicable to low quantities of soils. Off-site incineration is cost-prohibitive for large soil quantities. On-site incineration may not be feasible for low quantities due to high mobilization costs.

TABLE 5-1 (continued)

CANDIDATE REMEDIAL TECHNOLOGIES - SOILS

Remedial Technologies	Feasibility	Comments
Treatment (continued)		
• Fixation/Stabilization	Feasible (limited applicability)	- In-situ fixation/stabilization provides limited benefit for low mobility contaminants (mercury and pesticides) and may have limited effectiveness for volatile organics. Potentially applicable to inorganic (mercury) contaminated soils.
• Thermal Desorption	Not feasible	- Potentially applicable to organic contaminated soils. Potential mercury emissions could preclude application. Technology not demonstrated for these materials.

TABLE 5-2

CANDIDATE REMEDIAL TECHNOLOGIES - A-ZONE GROUNDWATER

Remedial Technologies	Feasibility	Comments
Physical Containment		
• Vertical Barrier Wall	Feasible	- A low permeability vertical barrier to groundwater flow may be feasible for the overburden and upper weathered bedrock strata.
• Bottom Sealing	Not feasible	- Because of the extensive network of penetration points required for injection of sealants, this technology cannot be used effectively in areas with numerous buildings, structures, or in areas with numerous underground or overhead interferences (i.e., sewers, utilities). In addition, for large areas, the costs are prohibitive.
Hydraulic Containment		
• Extraction Wells	Feasible	- Extraction wells allow groundwater removal with limited disturbance of surface and subsurface materials. Extraction wells are most effective in thick aquifers, and could have limited radius of influence in the A-zone at the site.
• Trench Drain Collection System	Feasible	- Trench drains (gravel and tile drains) are effective in controlling shallow groundwater. However, installation of trench drains requires access to and disturbance of a large surface area, and generates large volumes of soil for treatment/disposal.
Treatment		
• Biological	Not feasible	- Technology is not applicable to mercury and pesticide contamination.
• Chemical	Feasible (limited applicability)	- Technologies such as neutralization and precipitation and ion exchange are available, but are not effective in treating organic contamination. Potentially applicable to mercury removal. Oxidation of chlorinated organics in groundwater generally less effective than physical treatment methods (e.g., activated carbon).
• Physical	Feasible	- Several technologies are available including flocculation, sedimentation, activated carbon, air stripping, steam stripping and filtration. Activated carbon is effective for both organics and mercury. Air or steam stripping is effective for volatile organics.

TABLE 5-2 (continued)

CANDIDATE REMEDIAL TECHNOLOGIES - A-ZONE GROUNDWATER

Remedial Technologies	Feasibility	Comments
Treatment (continued)		
• In-situ	Not feasible	- In-situ treatment is generally not feasible in complex heterogeneous groundwater system where delivery and mixing of treatment agents cannot be controlled. In-situ treatment of chlorinated organics and mercury has not been demonstrated.
• Direct discharge to POTW	Potentially feasible	- Discharge of water to the POTW would be subject to pretreatment restrictions imposed by the POTW. This technologically is retained pending a determination of whether untreated water could be accepted by the POTW.
• Off-site treatment facility	Feasible	- Potentially feasible for low volumes. Off-site treatment would not be cost-effective for large volumes of water, and offers no technical advantage.

TABLE 5-3

CANDIDATE REMEDIAL TECHNOLOGIES - B-ZONE GROUNDWATER

Remedial Technologies	Feasibility	Comments
Physical Containment		
• Vertical Barrier Wall	Feasible (limited effectiveness)	- Most vertical barrier technologies are not feasible for bedrock. A grout curtain could be partly effective in reducing groundwater flow, but would not be totally effective due to potential voids. Leakage through or under a grout curtain would allow on-site migration of contaminated off-site groundwater.
• Bottom Sealing	Not feasible	- Because of the extensive network of penetration points required for injection of sealants, this technology cannot be used effectively in areas with numerous buildings, structures, or in areas with numerous underground or overhead interferences (i.e., sewers, utilities). In addition, for large areas, the costs are prohibitive.
Hydraulic Containment		
• Extraction Wells	Feasible (limited effectiveness)	- Extraction wells allow groundwater removal with limited disturbance of surface and subsurface materials. Extraction wells in the B-zone could induce on-site groundwater, producing a degradation of on-site groundwater quality. The Olin Production Well is currently controlling most off-site flow in the B-zone; thus additional groundwater recovery would have little benefit.
• Trench Drain Collection System	Not feasible	- Trench drains cannot be installed in bedrock using conventional methods.
Treatment		
• Biological	Not feasible	- Technology is not applicable to mercury and pesticide contamination.
• Chemical	Feasible (limited applicability)	- Technologies such as neutralization and precipitation and ion exchange are available, but are not effective in treating organic contamination. Potentially applicable to mercury removal. Oxidation of chlorinated organics in groundwater generally less effective than physical treatment methods (e.g., activated carbon).
• Physical	Feasible	- Several technologies are available including flocculation, sedimentation, activated carbon, air stripping, steam stripping and filtration. Activated carbon is effective for both organics and mercury. Air or steam stripping is effective for volatile organics.

TABLE 5-3 (continued)

CANDIDATE REMEDIAL TECHNOLOGIES - B-ZONE GROUNDWATER

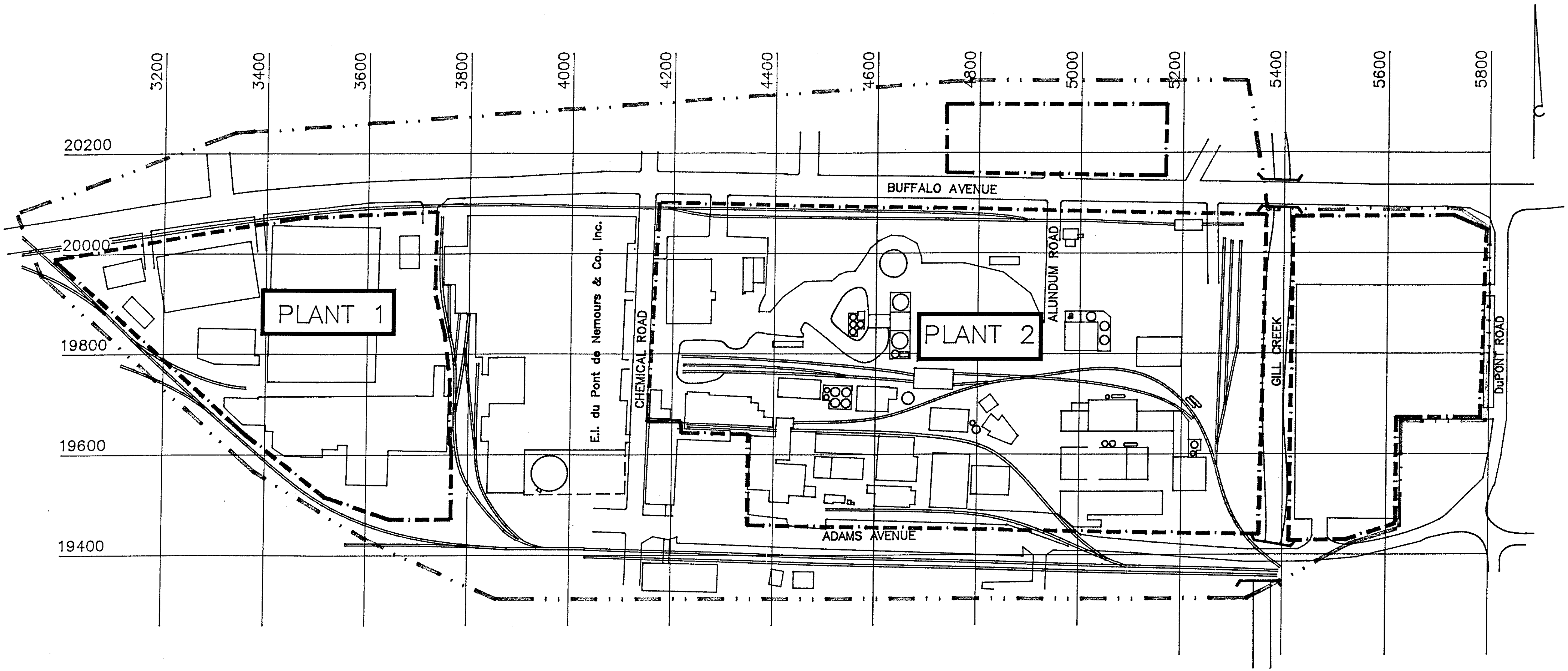
Remedial Technologies	Feasibility	Comments
Treatment (continued)		
• In-situ	Not feasible	- In-situ treatment is generally not feasible in complex heterogeneous groundwater system where delivery and mixing of treatment agents cannot be controlled. In-situ treatment of chlorinated organics and mercury has not been demonstrated.
• Direct discharge to POTW	Potentially feasible	- Discharge of water to the POTW would be subject to pretreatment restrictions imposed by the POTW. This technologically is retained pending a determination of whether untreated water could be accepted by the POTW.
• Off-site treatment facility	Feasible	- Potentially feasible for low volumes. Off-site treatment would not be cost-effective for large volumes of water, and offers no technical advantage.

TABLE 6-1

REMEDIAL ALTERNATIVES
OLIN - BUFFALO AVENUE PLANT

Alternative	Components
1	• Physical Containment (Soil Cover) • Surface Drainage Control • A-Zone Groundwater Recovery • Groundwater Treatment • Residual Waste Management
2	• Physical Containment (Soil Cover) • Surface Drainage Control • Downgradient Vertical Barrier (A-Zone) • Groundwater Recovery • Groundwater Treatment • Residual Waste Management
3	• Physical Containment (Soil Cover) • Surface Drainage Control • Circumscribing Vertical Barrier (A-Zone) • Groundwater Recovery • Groundwater Treatment • Residual Waste Management

Figures



LEGEND

PROPERTY BOUNDRIES

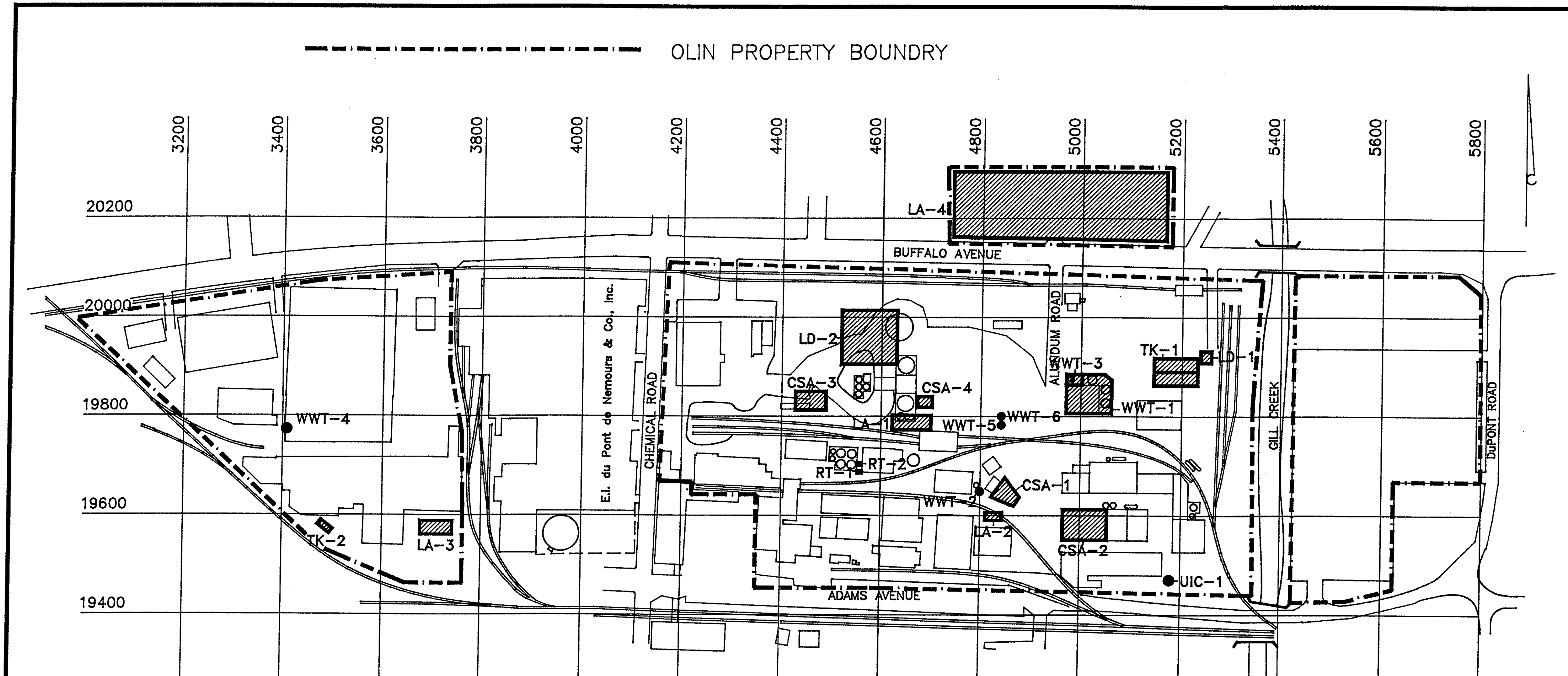
CORRECTIVE MEASURES STUDY AREA BOUNDRY

OLIN CORPORATION BUFFALO AVENUE PLANT
NIAGARA FALLS, NEW YORK
RCRA FACILITY INVESTIGATION

WOODWARD-CLYDE CONSULTANTS
Consulting Engineers, Geologists and Environmental Scientists

CORRECTIVE MEASURES STUDY AREA
OLIN CORPORATION
BUFFALO AVENUE PLANT

Job No.:	Drawing No.	Date: 11-2-93
Checked by: KRM	Rev. No.:	FIGURE 1-1
Scale: 0 — 200 Feet		



UNIT	USAGE	STATUS
CSA-1	Drum Storage Area	Active
CSA-2	Drum Storage Area	Inactive
CSA-3	Drum Storage Area	Inactive (RCRA Closure)
CSA-4	Drum Storage Area	Inactive
LD-1	Brine Mud Waste Pile	Inactive (RCRA Closure)
LD-2	Cooling Water Surface Impoundment	Inactive
WWT-1	Treatment Tank: Hg Removal from Wastewater	Active
WWT-2	Treatment Tank: Sodium Hypochlorite Decomposition	Active
WWT-3	Treatment Tank: pH Adjustment of Wastewater	Active
WWT-4	Treatment Tank: Chlorine Removal from Wastewater	Inactive
WWT-5	Treatment Tank: Sodium Hypochlorite Decomposition	Inactive

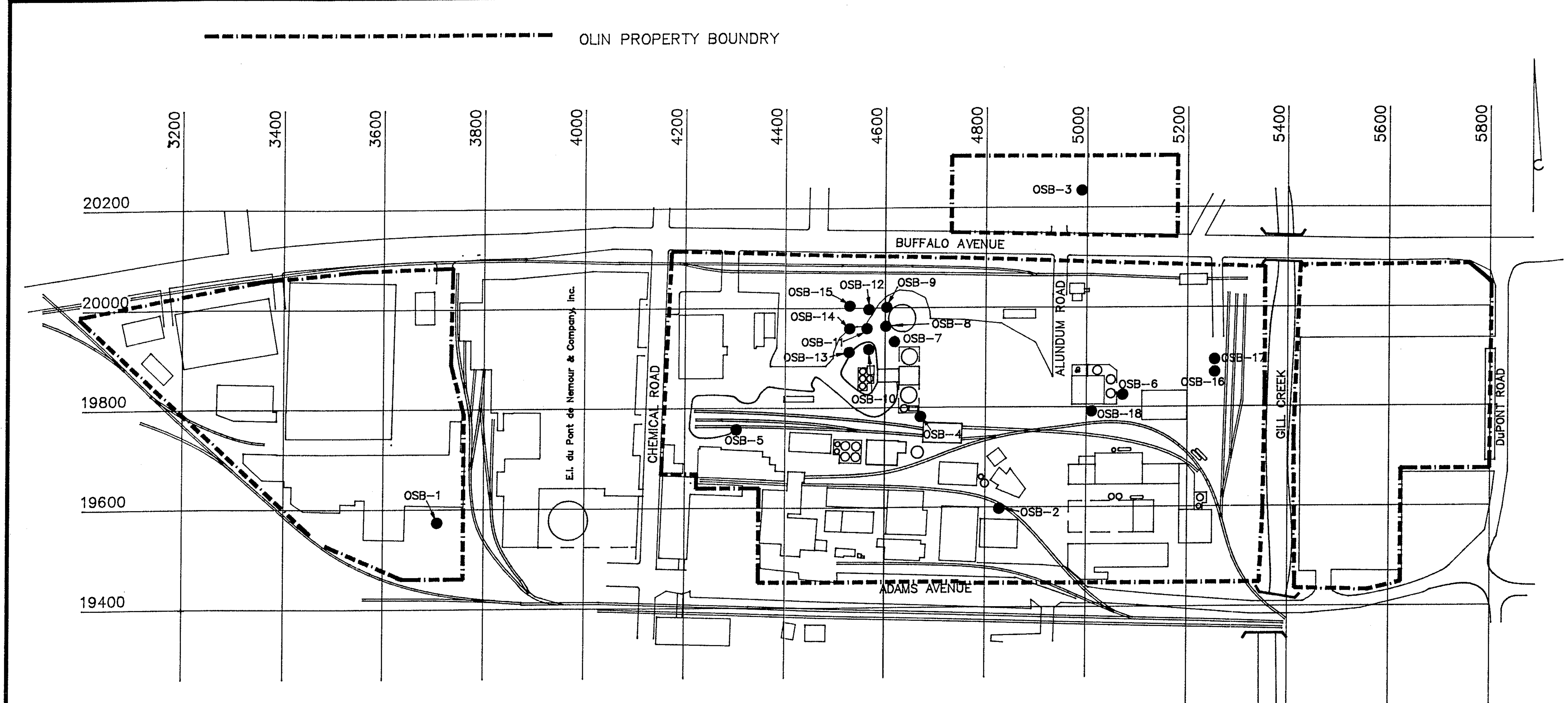
UNIT	USAGE	STATUS
WWT-6	Treatment Tank: Sodium Hypochlorite Decomposition	Inactive
TK-1	Concrete Lined Brine Mud Treatment Tank	Inactive (RCRA Closure)
TK-2	Concrete Lined Waste Calcium Hypochlorite Settling Tank	Inactive (RCRA Closure)
LA-1	Brine Mud Application for Road Repairs	Inactive
LA-2	Brine Mud Application for Road Repairs	Inactive
LA-3	Brine Mud Application to Fill Topographic Low Area	Inactive
LA-4	Brine Mud Application for Road Repairs	Inactive
UIC-1	Bedrock Injection Well	Inactive
RT-1	Thermal Treatment of Mercury Sludge	Active
RT-2	Thermal Treatment of Mercury Sludge (Backup for RT-1)	Active

OLIN CORPORATION BUFFALO AVENUE PLANT
NIAGARA FALLS, NEW YORK
RCRA FACILITY INVESTIGATION

WOODWARD-CLYDE CONSULTANTS
Consulting Engineers, Geologists and Environmental Scientists

OLIN SOLID WASTE MANAGEMENT UNITS (SWMUs)

Job No.:	Drawing No.	Date: 11-19-93
Checked by: KRM	Rev. No.:	FIGURE 3-1
Scale: 0 — 200 Feet		



BORING	SWMU INVESTIGATED	DEPTH TO REFUSAL	NATURE OF REFUSAL
OSB-1	LA-3	9.1'	Bedrock
OSB-2	LA-2	4.6'	Bedrock
OSB-3	LA-4	6.9'	Bedrock
OSB-4	LA-1	2.5'	Old Foundation
OSB-5	North of Building 17	6.5'	Bedrock
OSB-6	WWT-1	8.2'	Bedrock
OSB-7	LD-2	5.3'	Bedrock
OSB-8	LD-2	3.2'	Old Foundation
OSB-9	LD-2	3.2'	Old Foundation

BORING	SWMU INVESTIGATED	DEPTH TO REFUSAL	NATURE OF REFUSAL
OSB-10	LD-2	4'	Old Foundation
OSB-11	LD-2	2.5'	Old Foundation
OSB-12	LD-2	3'	Old Foundation
OSB-13	LD-2	3.4'	Old Foundation
OSB-14	LD-2	2.8'	Old Foundation
OSB-15	LD-2	2.6'	Old Foundation
OSB-16	TK-1	6.7'	Bedrock
OSB-17	BHC Storage Pile	7'	Bedrock
OSB-18	Building 97	6.7'	Bedrock

OLIN CHEMICALS
NIAGARA PLANT – NIAGARA FALLS, N.Y.

WOODWARD-CLYDE CONSULTANTS
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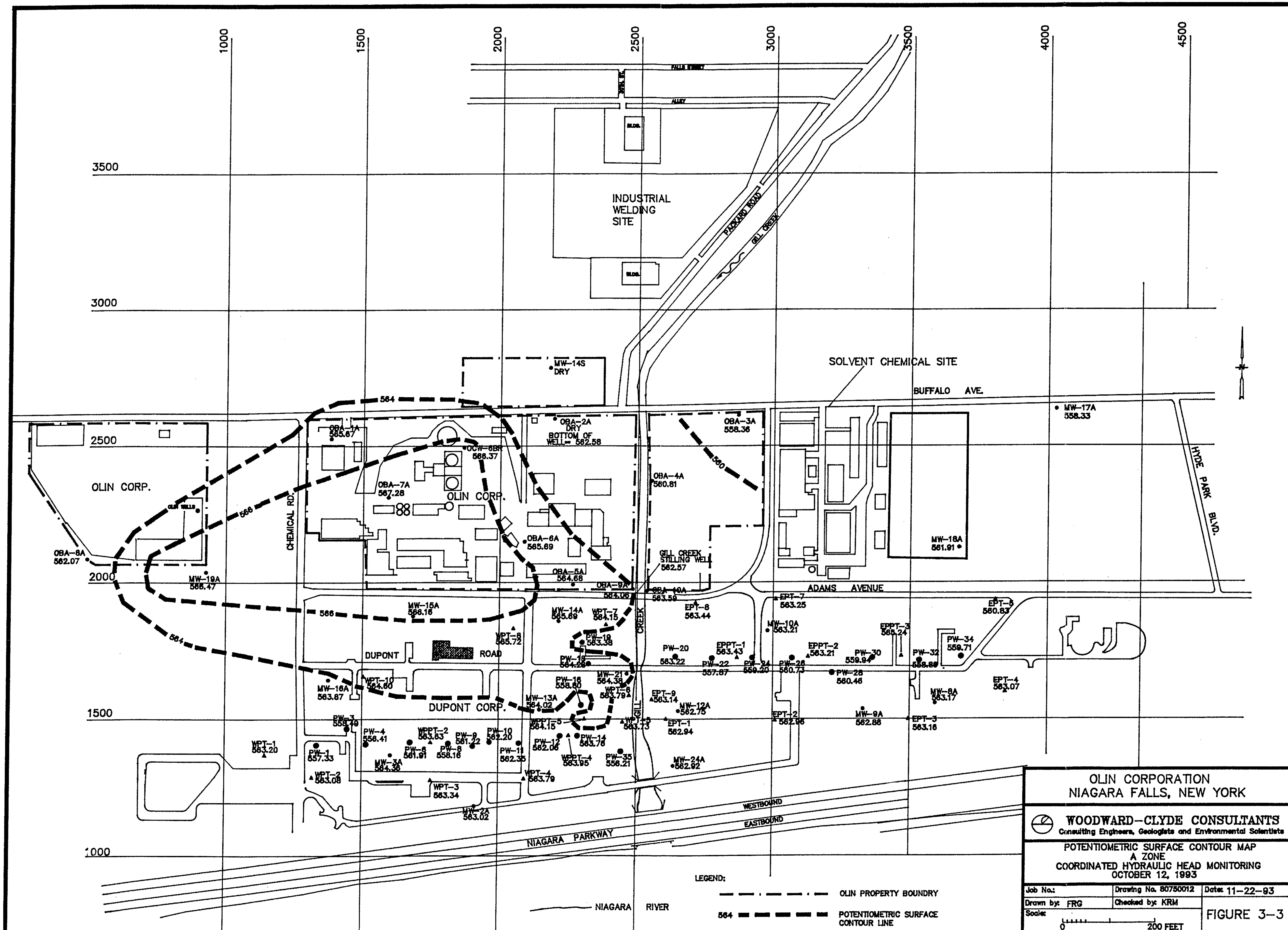
SOIL BORING LOCATIONS

Job No.: 88C2346-12	Drawing No.	Date: 11-22-93
Checked by: KRM	Rev. No.:	FIGURE 3-2
Scale: 0 — 200 Feet		

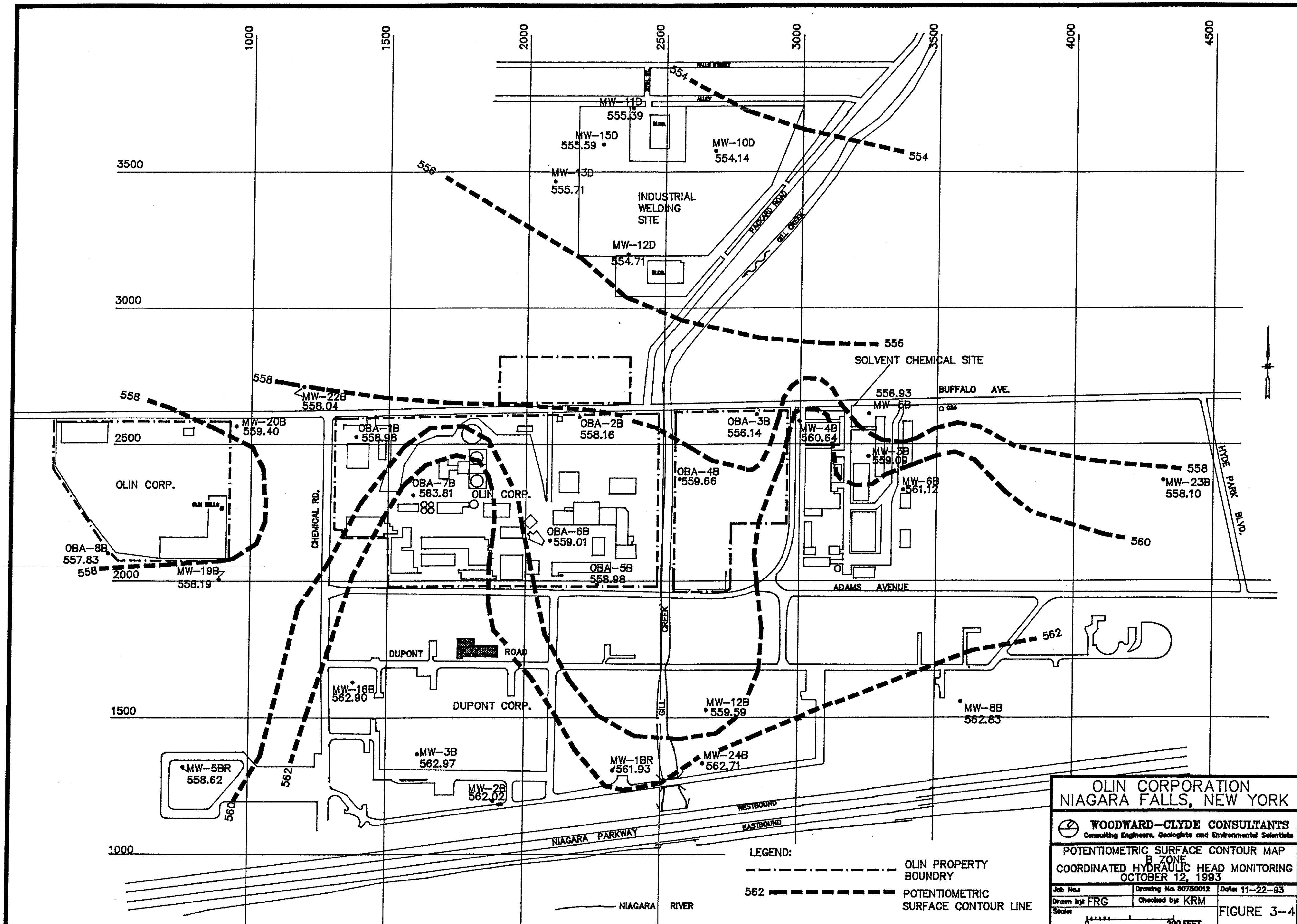


OLIN CORPORATION
NIAGARA FALLS, NEW YORK

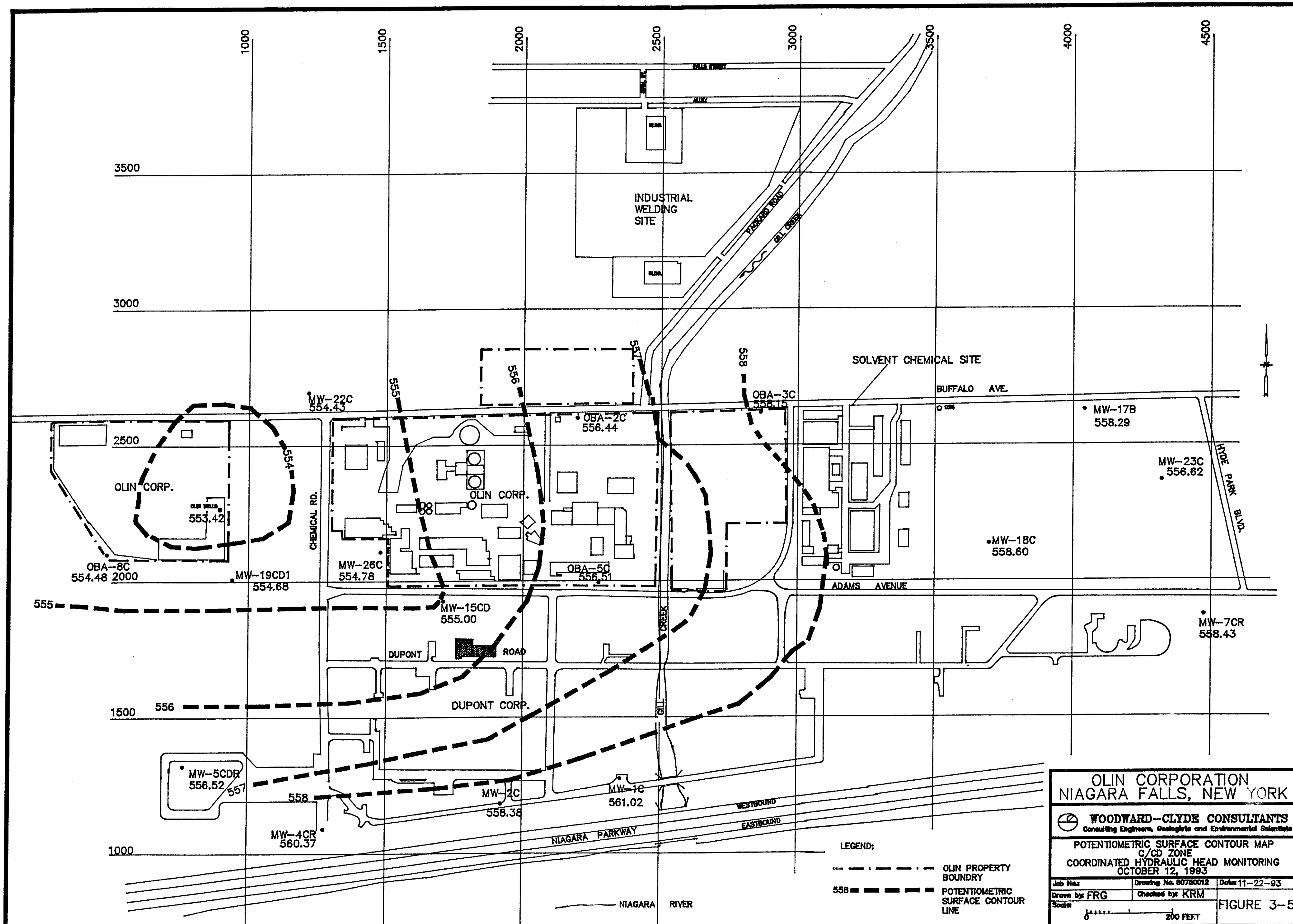
WOODWARD-CLYDE CONSULTANTS
Consulting Engineers, Geologists and Environmental Scientists

POTENTIOMETRIC SURFACE CONTOUR MAP
A ZONE
COORDINATED HYDRAULIC HEAD MONITORING
OCTOBER 12, 1993

Job No.:	Drawing No. 80750012	Date: 11-22-93
Drawn by: FRG	Checked by: KRM	FIGURE 3-3
Scale: 0 — 200 FEET		



OLIN CORPORATION
NIAGARA FALLS, NEW YORK
WOODWARD-CLYDE CONSULTANTS
Consulting Engineers, Geologists and Environmental Scientists
POTENTIOMETRIC SURFACE CONTOUR MAP
B ZONE
COORDINATED HYDRAULIC HEAD MONITORING
OCTOBER 12, 1993
Drawing No. 80780012
Date: 11-22-93
Drawn by: FRG
Checked by: KRM
200 FEET
FIGURE 3-4
LEGEND:
OLIN PROPERTY BOUNDRY
562 POTENTIOMETRIC SURFACE CONTOUR LINE
INDUSTRIAL WELDING SITE
SOLVENT CHEMICAL SITE
OLIN CORP.
DUPONT CORP.
BUFFALO AVE.
ADAMS AVENUE
DUPONT ROAD
CHEMICAL RD.
HYDE PARK BLVD.
PACKARD ROAD
GILL CREEK
NIAGARA PARKWAY
WESTBOUND
EASTBOUND
NIAGARA RIVER
MW-11D 555.39
MW-15D 555.59
MW-10D 554.14
MW-13D 555.71
MW-12D 554.71
MW-22B 558.04
MW-20B 559.40
OBA-1B 558.98
OBA-2B 558.16
OBA-3B 556.14
556.93 MW-5B
MW-4B 560.64
MW-3B 559.09
MW-6B 561.12
MW-23B 558.10
OBA-4B 559.66
OBA-7B 563.81
OBA-6B 559.01
OBA-5B 558.98
OBA-8B 557.83
MW-19B 558.19
MW-16B 562.90
MW-12B 559.59
MW-8B 562.83
MW-3B 562.97
MW-5BR 558.62
MW-2B 562.02
MW-1BR 561.93
MW-24B 562.71
554
556
558
560
562
1000
1500
2000
2500
3000
3500
4000
4500

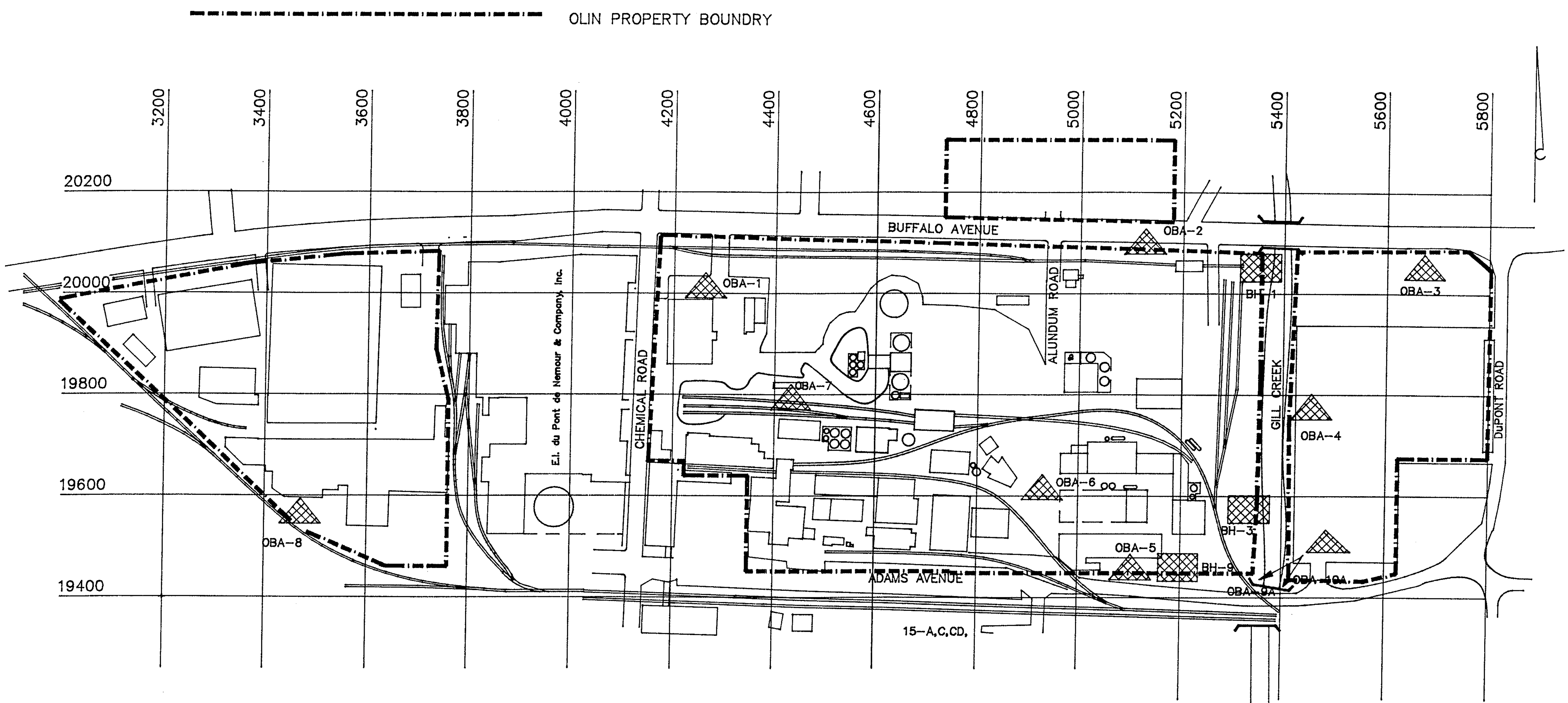


OLIN CORPORATION
NIAGARA FALLS, NEW YORK

WOODWARD-CLYDE CONSULTANTS
Consulting Engineers, Geologists and Environmental Scientists

POTENTIOMETRIC SURFACE CONTOUR MAP
C/CD ZONE
COORDINATED HYDRAULIC HEAD MONITORING
OCTOBER 12, 1993

Job No.:	Drawing No. 80750012	Date: 11-22-93
Drawn by: FRG	Checked by: KRM	FIGURE 3-5
Scale: 0 — 200 FEET		

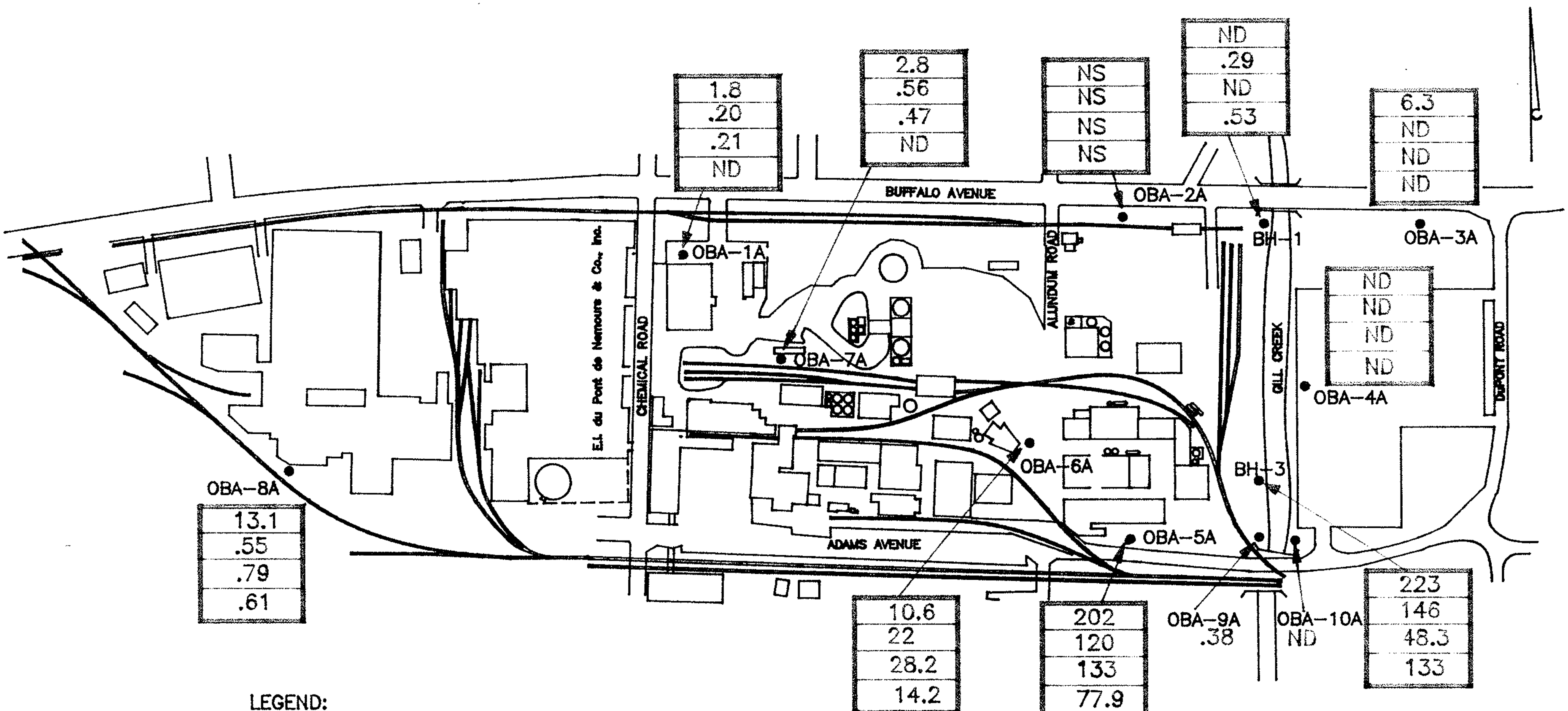


LEGEND

EXISTING HARZA MONITORING WELLS

OLIN MONITORING WELL LOCATIONS

OLIN CHEMICALS NIAGARA PLANT – NIAGARA FALLS, N.Y.	
WOODWARD–CLYDE CONSULTANTS Consulting Engineers, Geologists and Environmental Scientists	
OLIN MONITORING WELL LOCATIONS	
Job No.: 88C2346-12	Drawing No.	Date: 11–22–93
Checked by: KRM	Rev. No.:	FIGURE 3–6
Scale: 0 — 200 Feet		



LEGEND:

10.6	4TH QUARTER 1991	MERCURY CONCENTRATIONS (ug/L)
22	1ST QUARTER 1992	
28.2	2ND QUARTER 1992	
14.2	3RD QUARTER 1992	

● OBA-6A

WELL ID

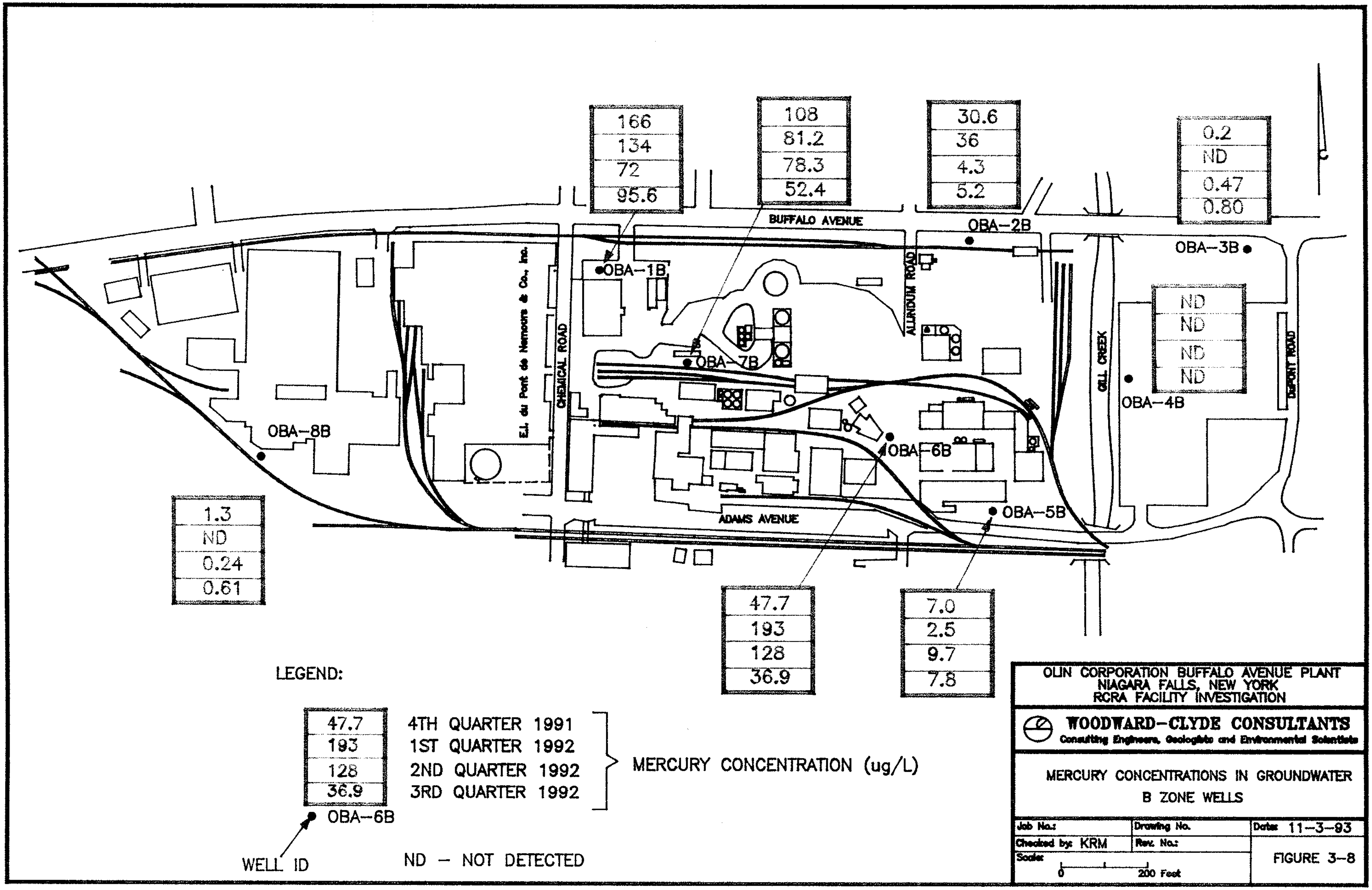
ND – NOT DETECTED
NS – NO SAMPLE COLLECTED (DRY WELL)
NOTE – WELLS OBA-9A AND OBA-10A INSTALLED AND SAMPLED 11/92

OLIN CORPORATION BUFFALO AVENUE PLANT
NIAGARA FALLS, NEW YORK
RCRA FACILITY INVESTIGATION

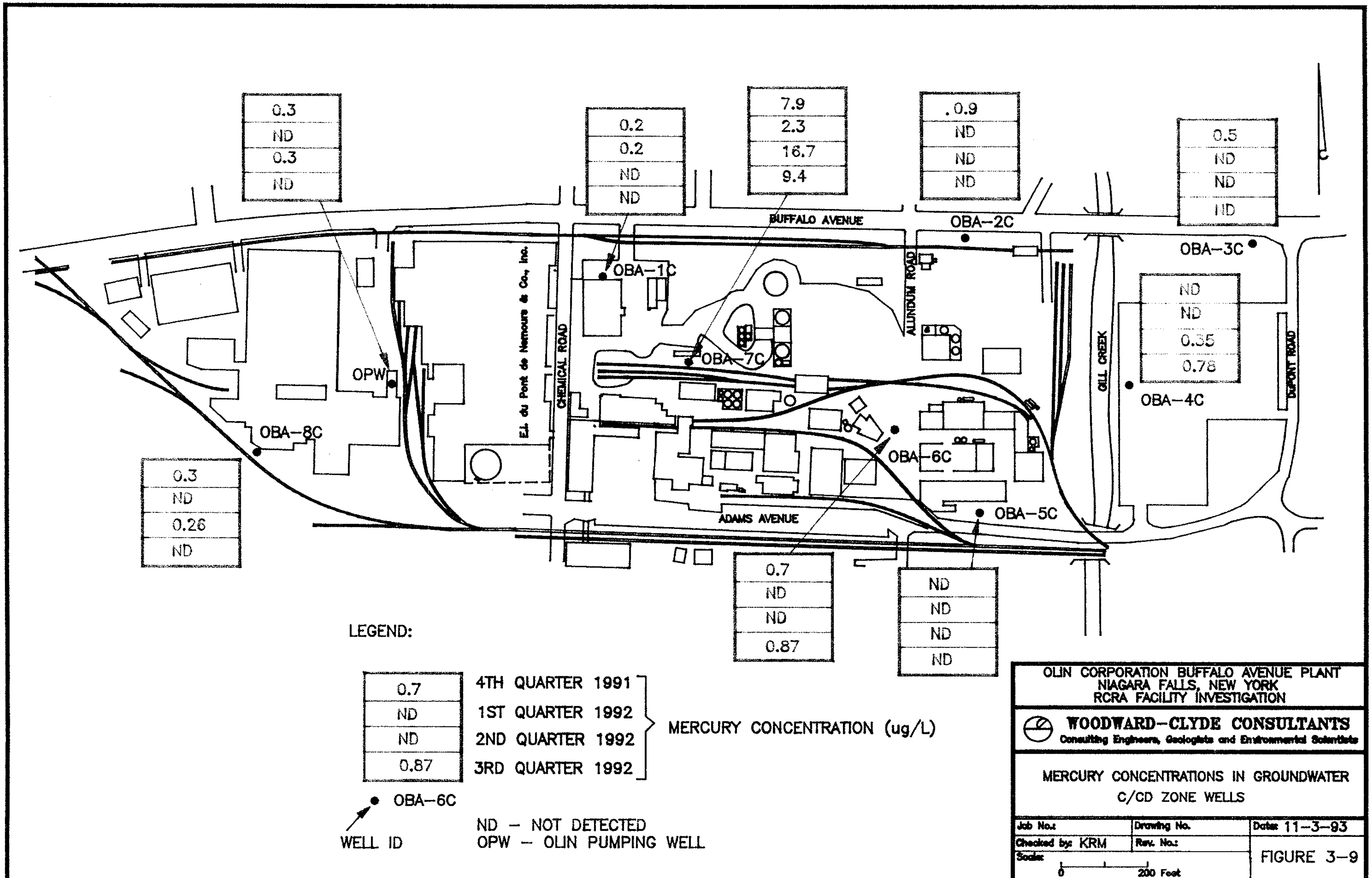
WOODWARD-CLYDE CONSULTANTS
Consulting Engineers, Geologists and Environmental Scientists

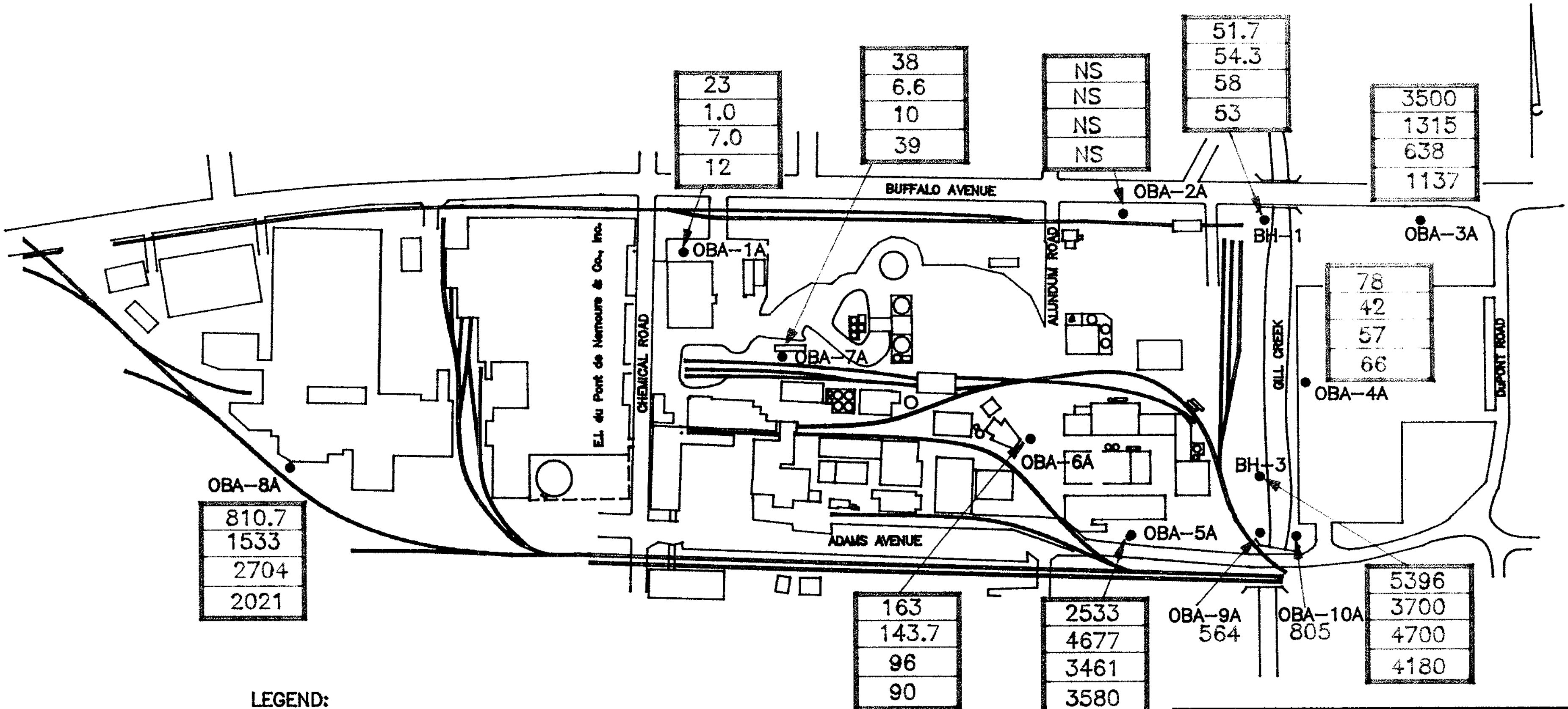
MERCURY CONCENTRATIONS IN GROUNDWATER
A ZONE WELLS

Job No.:	Drawing No.	Date: 11-4-93
Checked by: KRM	Rev. No.:	FIGURE 3-7
Scale: 0 — 200 Feet		



166
134
72
95.6
108
81.2
78.3
52.4
30.6
36
4.3
5.2
0.2
ND
0.47
0.80
BUFFALO AVENUE
OBA-2B
OBA-3B
OBA-1B
ALUNDUM ROAD
ND
ND
ND
ND
E.I. du Pont de Nemours & Co., Inc.
CHEMICAL ROAD
OBA-7B
GILL CREEK
OBA-4B
DEPONT ROAD
OBA-8B
OBA-6B
OBA-5B
1.3
ND
0.24
0.61
ADAMS AVENUE
47.7
193
128
36.9
7.0
2.5
9.7
7.8
LEGEND:
47.7
193
128
36.9
4TH QUARTER 1991
1ST QUARTER 1992
2ND QUARTER 1992
3RD QUARTER 1992
MERCURY CONCENTRATION (ug/L)
OBA-6B
WELL ID
ND - NOT DETECTED
OLIN CORPORATION BUFFALO AVENUE PLANT
NIAGARA FALLS, NEW YORK
RCRA FACILITY INVESTIGATION
WOODWARD-CLYDE CONSULTANTS
Consulting Engineers, Geologists and Environmental Scientists
MERCURY CONCENTRATIONS IN GROUNDWATER
B ZONE WELLS
Job No.:
Drawing No.
Date: 11-3-93
Checked by: KRM
Rev. No.:
Scale:
0
200 Feet
FIGURE 3-8


0.3
ND
0.3
ND
0.2
0.2
ND
ND
7.9
2.3
16.7
9.4
.0.9
ND
ND
ND
0.5
ND
ND
ND
BUFFALO AVENUE
OBA-2C
OBA-3C
OBA-1C
ALUNDUM ROAD
ND
ND
0.35
0.78
OBA-7C
OPW
E.I. du Pont de Nemours & Co., Inc.
CHEMICAL ROAD
GILL CREEK
DUPONT ROAD
OBA-4C
OBA-8C
OBA-6C
0.3
ND
0.26
ND
ADAMS AVENUE
OBA-5C
0.7
ND
ND
0.87
ND
ND
ND
ND
LEGEND:
0.7
ND
ND
0.87
4TH QUARTER 1991
1ST QUARTER 1992
2ND QUARTER 1992
3RD QUARTER 1992
MERCURY CONCENTRATION (ug/L)
OBA-6C
WELL ID
ND – NOT DETECTED
OPW – OLIN PUMPING WELL
OLIN CORPORATION BUFFALO AVENUE PLANT
NIAGARA FALLS, NEW YORK
RCRA FACILITY INVESTIGATION
WOODWARD-CLYDE CONSULTANTS
Consulting Engineers, Geologists and Environmental Scientists
MERCURY CONCENTRATIONS IN GROUNDWATER
C/CD ZONE WELLS
Job No.:
Drawing No.
Date: 11-3-93
Checked by: KRM
Rev. No.:
Scale:
0
200 Feet
FIGURE 3-9



LEGEND:

163	4TH QUARTER 1991	TOTAL CHLORINATED ALIPHATIC ORGANIC COMPOUND CONCENTRATIONS (ug/L)
143.1	1ST QUARTER 1992	
96	2ND QUARTER 1992	
90	3RD QUARTER 1992	

• OBA-6A

WELL ID

ND – NOT DETECTED

NS – NO SAMPLE COLLECTED (DRY WELL)

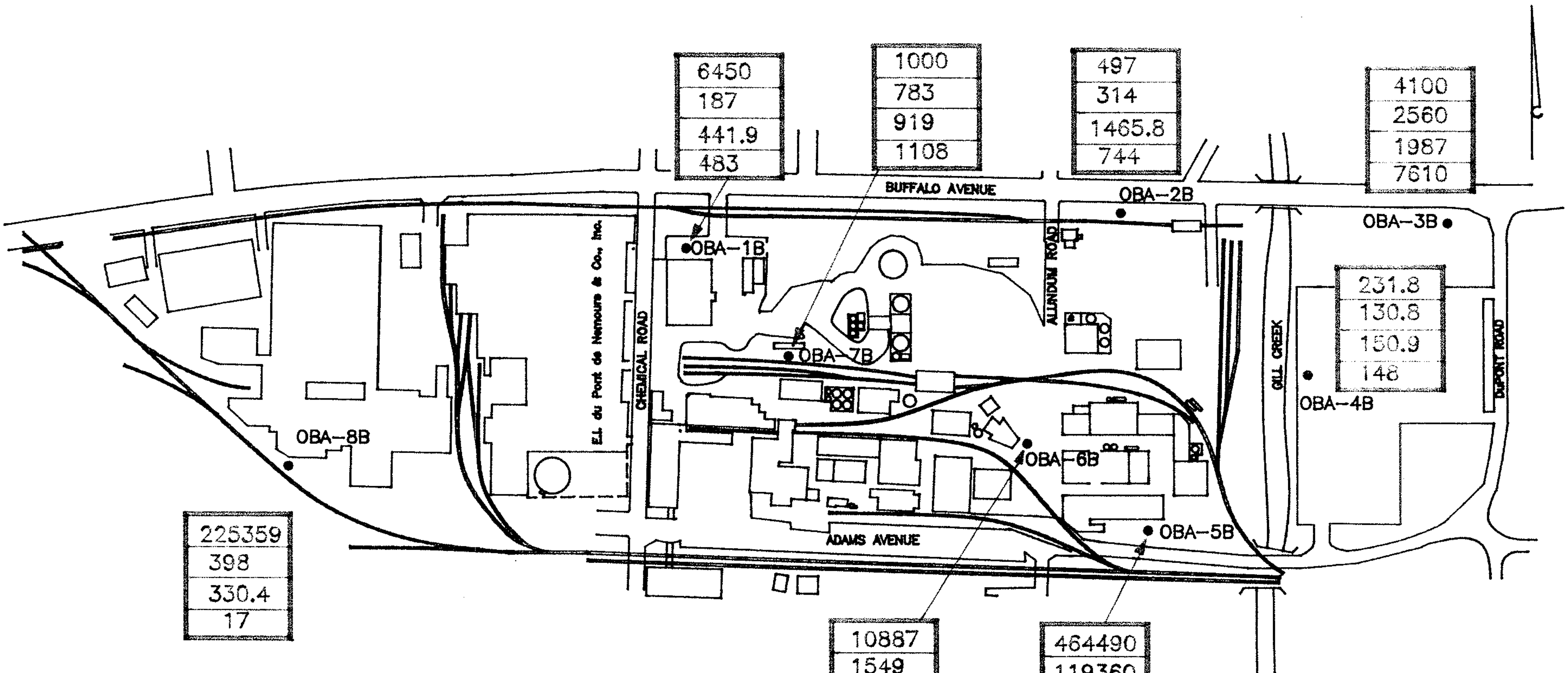
NOTE – WELLS OBA-9A AND OBA-10A INSTALLED AND SAMPLED 11/92

OLIN CORPORATION BUFFALO AVENUE PLANT
NIAGARA FALLS, NEW YORK
RCRA FACILITY INVESTIGATION

WOODWARD-CLYDE CONSULTANTS
Consulting Engineers, Geologists and Environmental Scientists

TOTAL CHLORINATED ALIPHATIC VOLATILE ORGANIC COMPOUND CONCENTRATIONS IN GROUNDWATER A ZONE WELLS

Job No.:	Drawing No. OLINCMS	Date: 11-17-93
Checked by: AJM	Rev. No.:	FIGURE 3-10
Scale: 0 — 200 Feet		



LEGEND:

10887	4TH QUARTER 1991	TOTAL CHLORINATED ALIPHATIC VOLATILE ORGANIC COMPOUND CONCENTRATIONS (ug/L)
1549	1ST QUARTER 1992	
1344	2ND QUARTER 1992	
1760	3RD QUARTER 1992	

OBA-6B

WELL ID

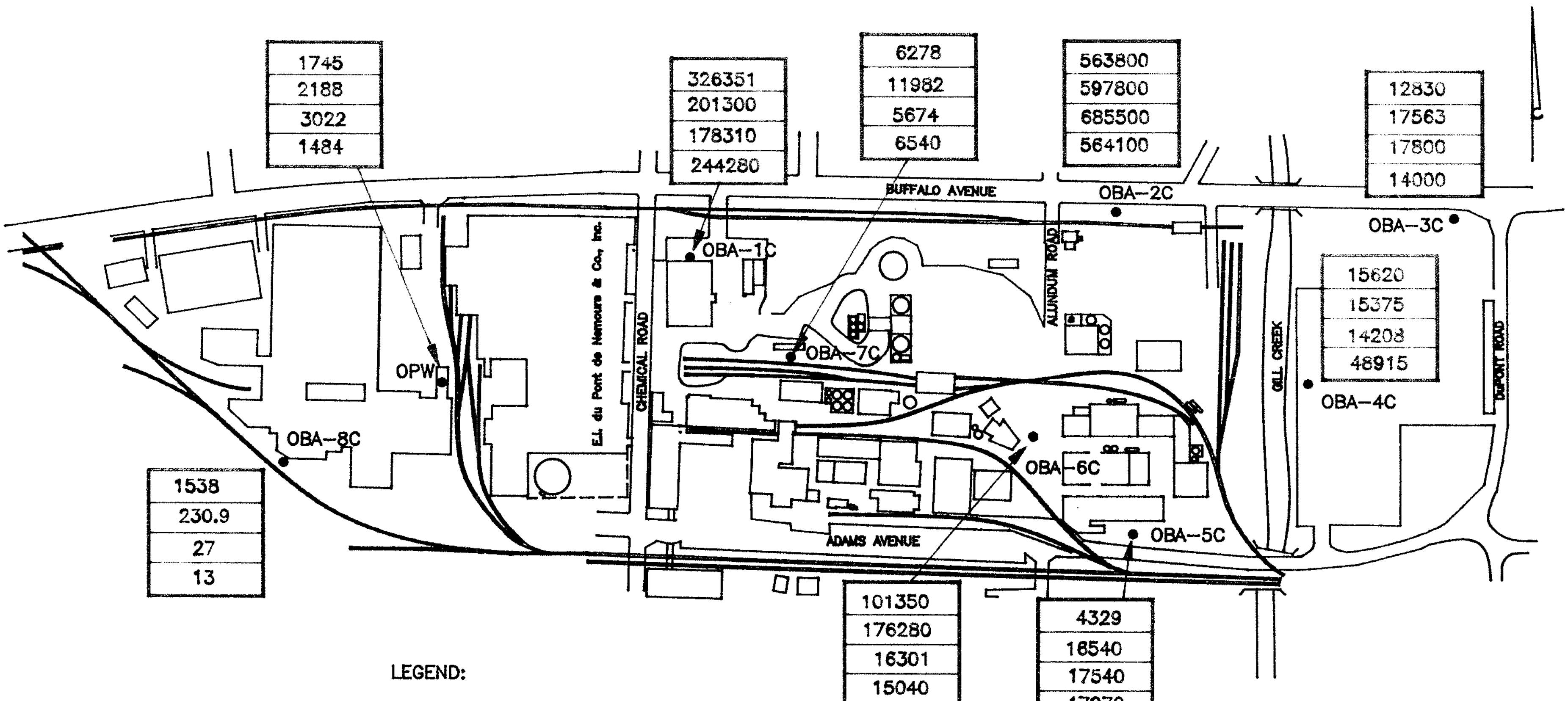
ND – NOT DETECTED

OLIN CORPORATION BUFFALO AVENUE PLANT
NIAGARA FALLS, NEW YORK
RCRA FACILITY INVESTIGATION

WOODWARD-CLYDE CONSULTANTS
Consulting Engineers, Geologists and Environmental Scientists

TOTAL CHLORINATED ALIPHATIC VOLATILE ORGANIC COMPOUND CONCENTRATIONS IN GROUNDWATER
B ZONE WELLS

Job No.:	Drawing No. OLINCMS	Date: 11-17-93
Checked by: AJM	Rev. No.:	FIGURE 3-11
Scale: 0 — 200 Feet		



LEGEND:

101350	4TH QUARTER 1991	TOTAL CHLORINATED ALIPHATIC VOLATILE ORGANIC COMPOUND CONCENTRATIONS (ug/L)
173600	1ST QUARTER 1992	
16301	2ND QUARTER 1992	
15040	3RD QUARTER 1992	

● OBA-6C

WELL ID

ND – NOT DETECTED

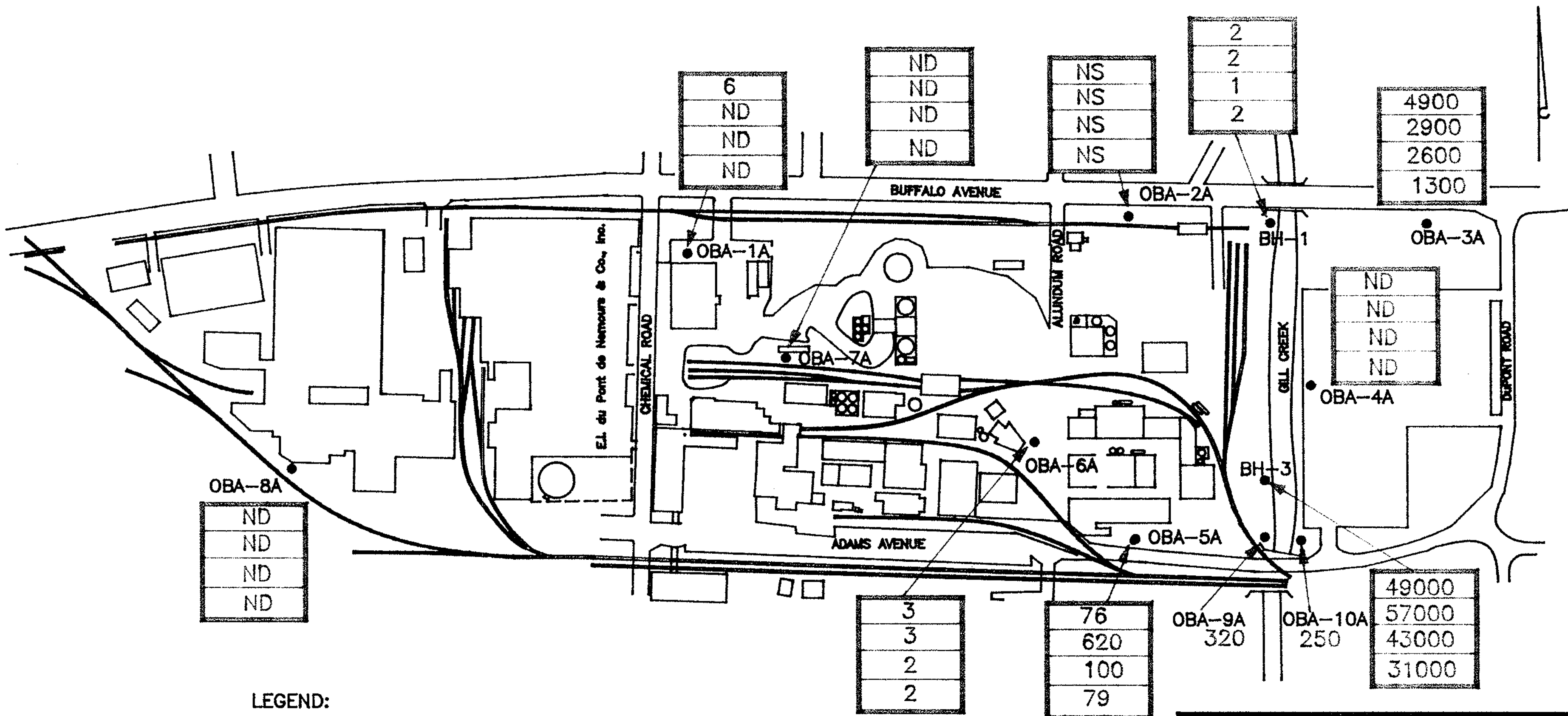
OPW – OLIN PUMPING WELL

OLIN CORPORATION BUFFALO AVENUE PLANT
NIAGARA FALLS, NEW YORK
RCRA FACILITY INVESTIGATION

WOODWARD-CLYDE CONSULTANTS
Consulting Engineers, Geologists and Environmental Scientists

TOTAL CHLORINATED ALIPHATIC VOLATILE ORGANIC COMPOUND CONCENTRATIONS IN GROUNDWATER C/CD ZONE WELLS

Job No.:	Drawing No. OLINCMS	Date: 11-17-93
Checked by: AJM	Rev. No.:	FIGURE 3-12
Scale: 0 — 200 Feet		



LEGEND:

3	4TH QUARTER 1991	BENZENE CONCENTRATIONS (ug/L)
3	1ST QUARTER 1992	
2	2ND QUARTER 1992	
2	3RD QUARTER 1992	

● OBA-6A ← WELL ID

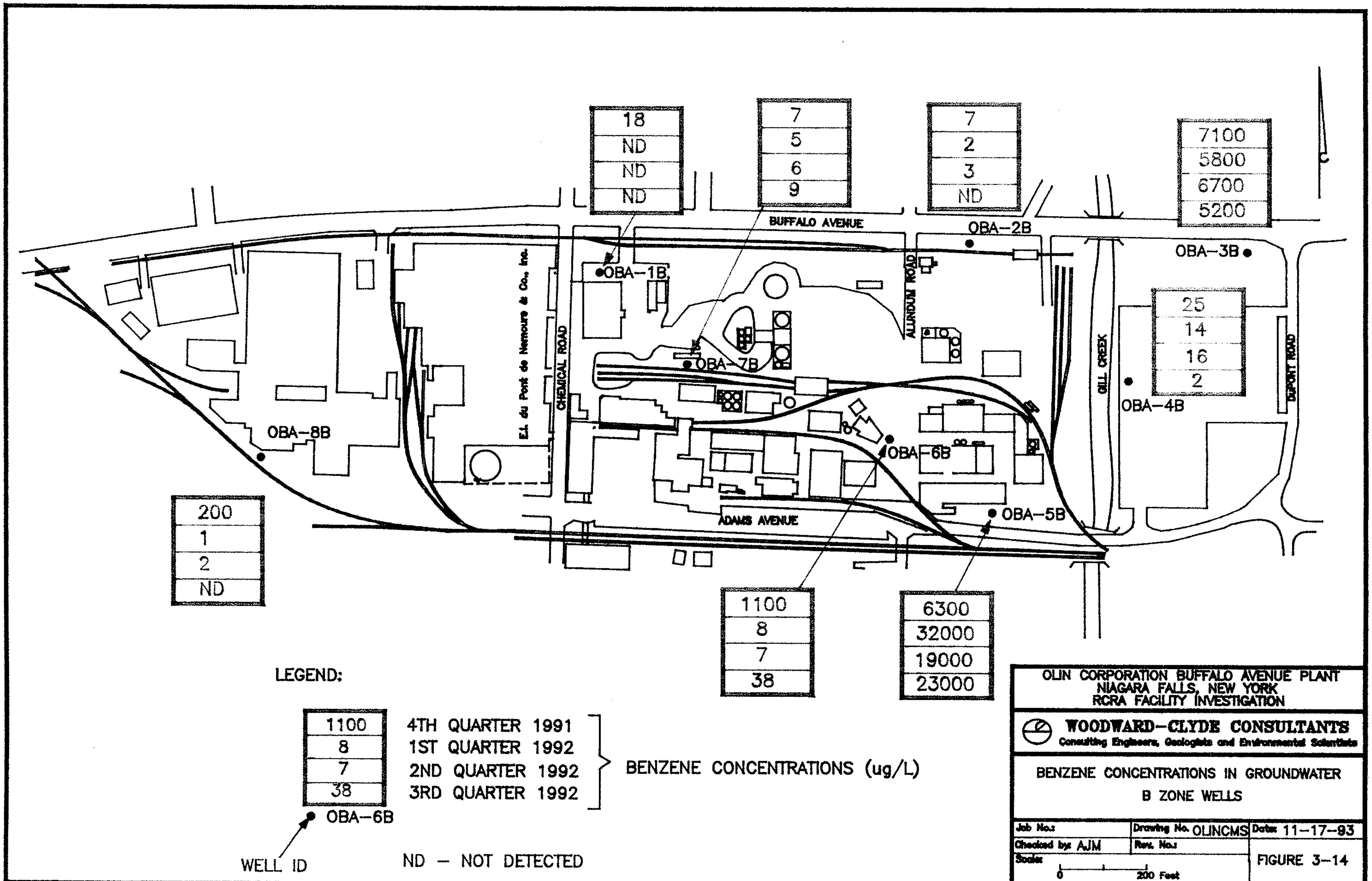
ND – NOT DETECTED
NS – NO SAMPLE COLLECTED (DRY WELL)
NOTE – WELLS OBA-9A AND OBA-10A INSTALLED AND SAMPLED 11/92

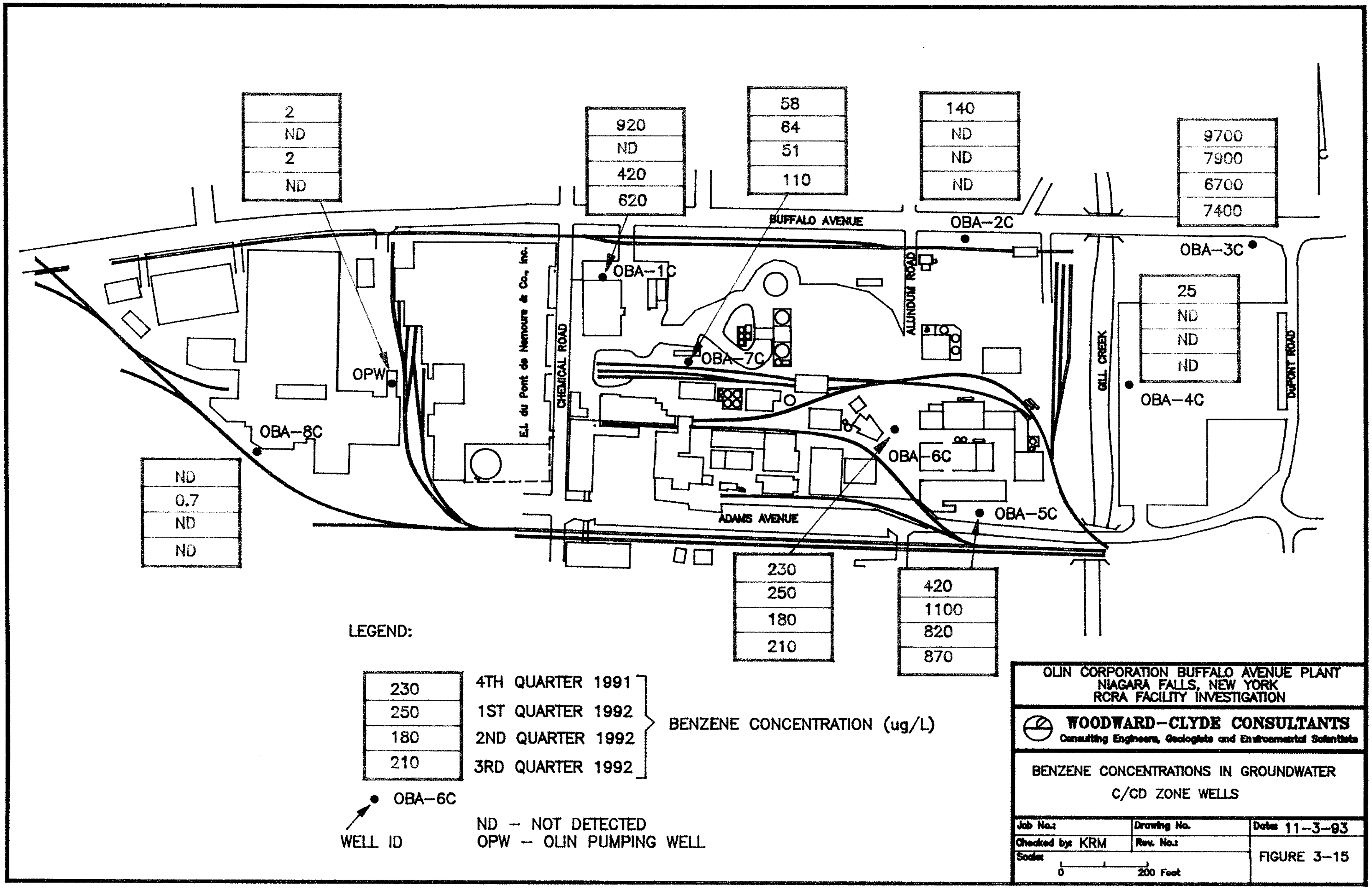
OLIN CORPORATION BUFFALO AVENUE PLANT
NIAGARA FALLS, NEW YORK
RCRA FACILITY INVESTIGATION

WOODWARD-CLYDE CONSULTANTS
Consulting Engineers, Geologists and Environmental Scientists

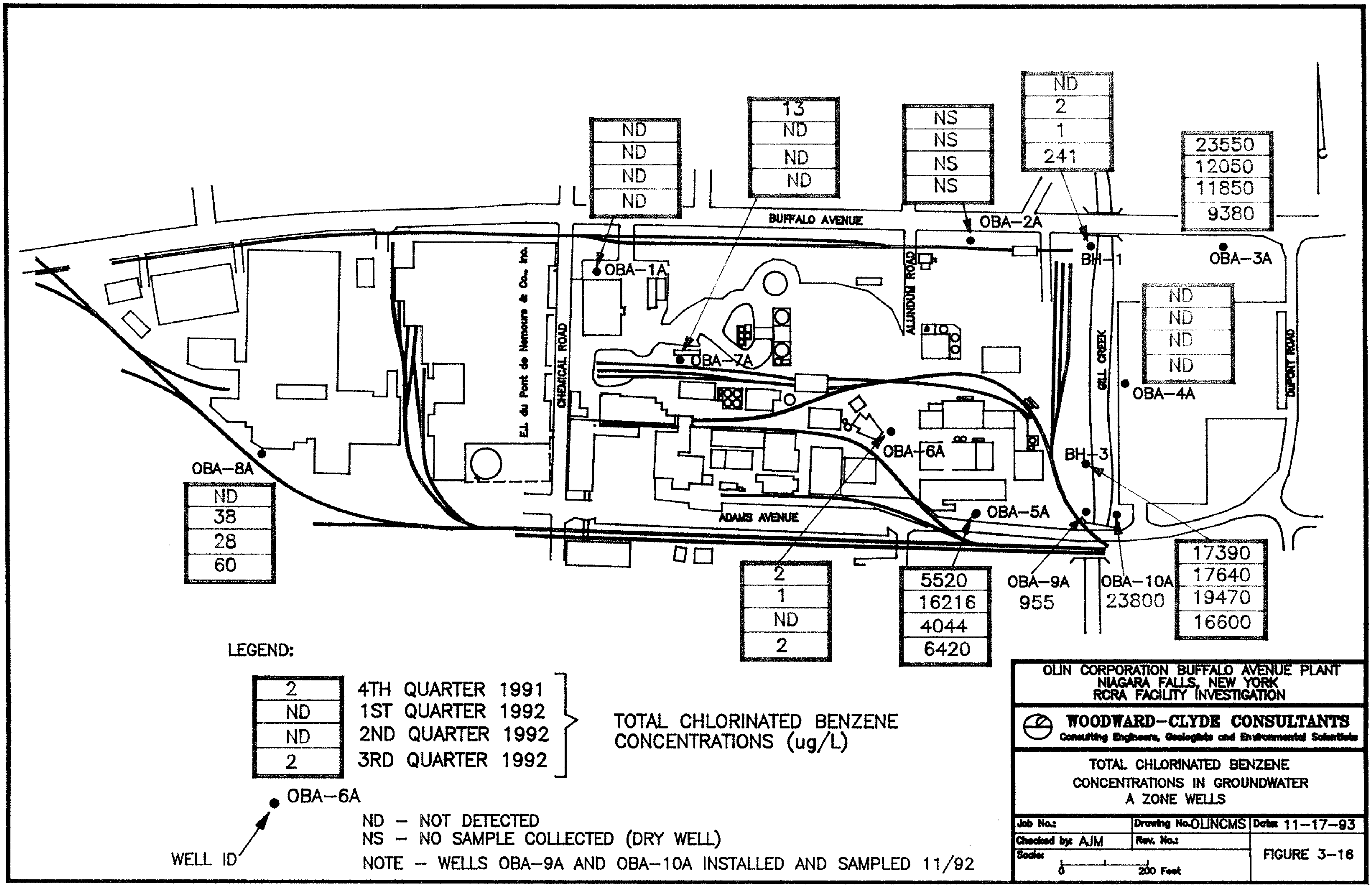
BENZENE CONCENTRATIONS IN GROUNDWATER
A ZONE WELLS

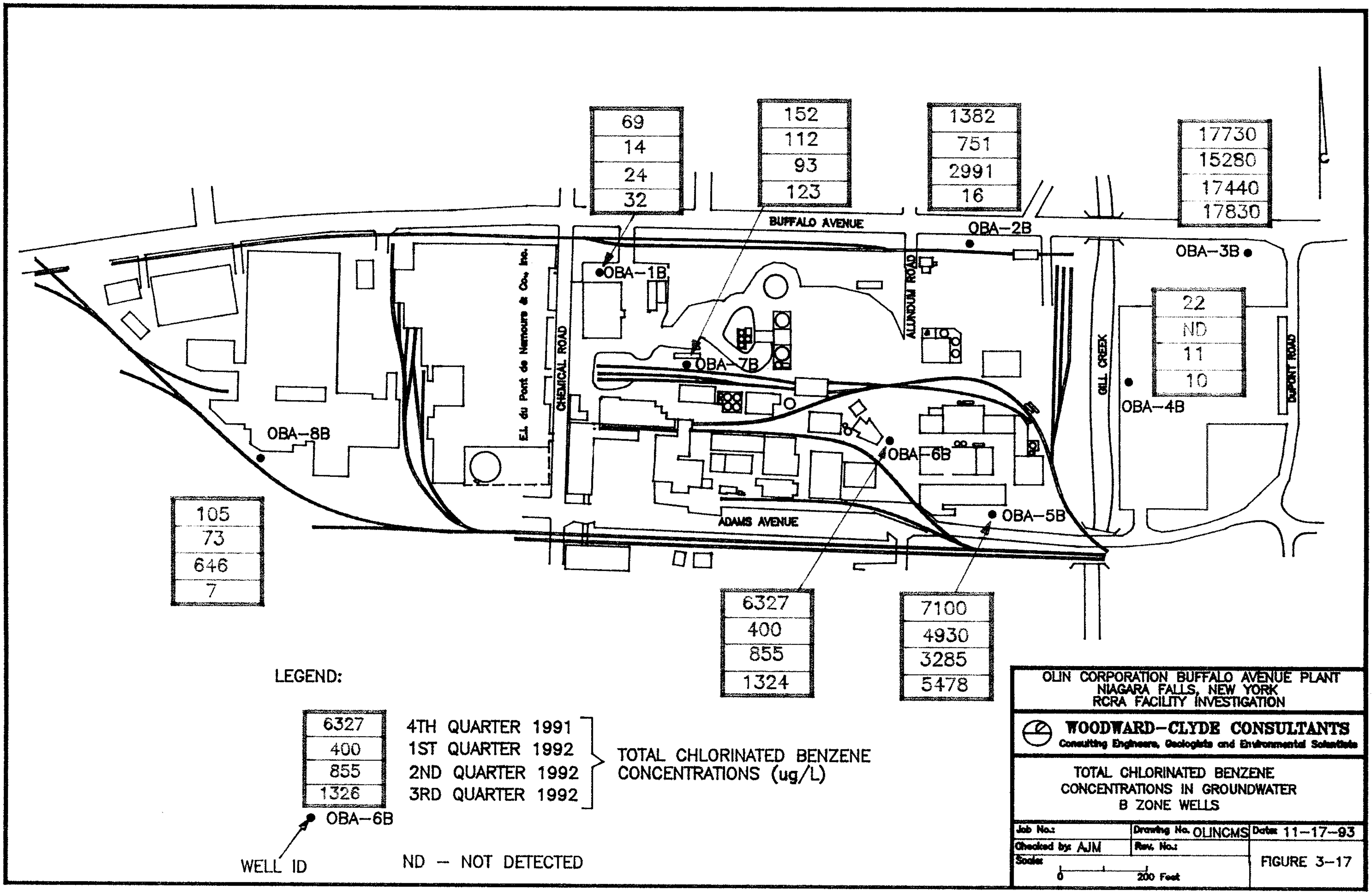
Job No.:	Drawing No. OLINCMS	Date: 11-17-93
Checked by: AJM	Rev. No.:	FIGURE 3-13
Scale: 0 — 200 Feet		


18
ND
ND
ND
OBA-1B
7
5
6
9
OBA-7B
7
2
3
ND
OBA-2B
7100
5800
6700
5200
OBA-3B
25
14
16
2
OBA-4B
200
1
2
ND
OBA-8B
1100
8
7
38
OBA-6B
6300
32000
19000
23000
OBA-5B
BUFFALO AVENUE
ADAMS AVENUE
CHEMICAL ROAD
ALUNDUM ROAD
GILL CREEK
DUPONT ROAD
E.I. du Pont de Nemours & Co., Inc.
LEGEND:
1100
8
7
38
OBA-6B
WELL ID
4TH QUARTER 1991
1ST QUARTER 1992
2ND QUARTER 1992
3RD QUARTER 1992
BENZENE CONCENTRATIONS (ug/L)
ND - NOT DETECTED
OLIN CORPORATION BUFFALO AVENUE PLANT
NIAGARA FALLS, NEW YORK
RCRA FACILITY INVESTIGATION
WOODWARD-CLYDE CONSULTANTS
Consulting Engineers, Geologists and Environmental Scientists
BENZENE CONCENTRATIONS IN GROUNDWATER
B ZONE WELLS
Job No.:
Drawing No. OLINCMS
Date: 11-17-93
Checked by: AJM
Rev. No.:
Scale:
0
200 Feet
FIGURE 3-14

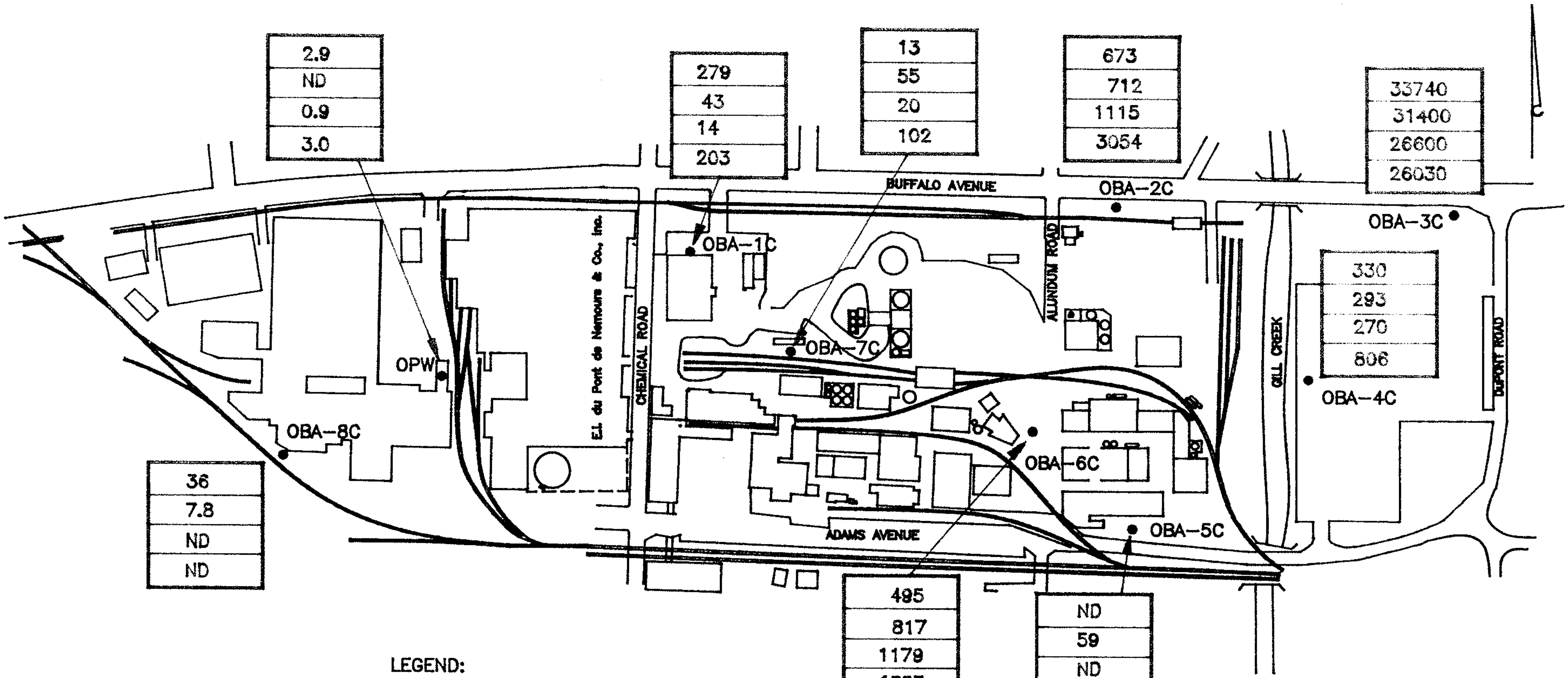


2
ND
2
ND
920
ND
420
620
58
64
51
110
140
ND
ND
ND
9700
7900
6700
7400
BUFFALO AVENUE
OBA-2C
OBA-3C
OBA-1C
OBA-7C
ALUNDUM ROAD
25
ND
ND
ND
GILL CREEK
DUPONT ROAD
OBA-4C
OPW
E.I. du Pont de Nemours & Co., Inc.
CHEMICAL ROAD
OBA-8C
OBA-6C
ND
0.7
ND
ND
OBA-5C
ADAMS AVENUE
230
250
180
210
420
1100
820
870
LEGEND:
230
250
180
210
4TH QUARTER 1991
1ST QUARTER 1992
2ND QUARTER 1992
3RD QUARTER 1992
BENZENE CONCENTRATION (ug/L)
OBA-6C
WELL ID
ND – NOT DETECTED
OPW – OLIN PUMPING WELL
OLIN CORPORATION BUFFALO AVENUE PLANT
NIAGARA FALLS, NEW YORK
RCRA FACILITY INVESTIGATION
WOODWARD-CLYDE CONSULTANTS
Consulting Engineers, Geologists and Environmental Scientists
BENZENE CONCENTRATIONS IN GROUNDWATER
C/CD ZONE WELLS
Job No.:
Drawing No.
Date: 11-3-93
Checked by: KRM
Rev. No.:
Scale:
0
200 Feet
FIGURE 3-15


BUFFALO AVENUE
ADAMS AVENUE
CHEMICAL ROAD
ALUNDUM ROAD
GILL CREEK
DUPONT ROAD
E.I. du Pont de Nemours & Co., Inc.
OBA-1A
ND
ND
ND
ND
OBA-7A
13
ND
ND
ND
OBA-2A
NS
NS
NS
NS
BH-1
ND
2
1
241
OBA-3A
23550
12050
11850
9380
OBA-4A
ND
ND
ND
ND
OBA-8A
ND
38
28
60
OBA-6A
2
1
ND
2
OBA-5A
5520
16216
4044
6420
OBA-9A
955
OBA-10A
23800
BH-3
17390
17640
19470
16600
LEGEND:
2
ND
ND
2
4TH QUARTER 1991
1ST QUARTER 1992
2ND QUARTER 1992
3RD QUARTER 1992
TOTAL CHLORINATED BENZENE CONCENTRATIONS (ug/L)
OBA-6A
WELL ID
ND - NOT DETECTED
NS - NO SAMPLE COLLECTED (DRY WELL)
NOTE - WELLS OBA-9A AND OBA-10A INSTALLED AND SAMPLED 11/92
OLIN CORPORATION BUFFALO AVENUE PLANT
NIAGARA FALLS, NEW YORK
RCRA FACILITY INVESTIGATION
WOODWARD-CLYDE CONSULTANTS
Consulting Engineers, Geologists and Environmental Scientists
TOTAL CHLORINATED BENZENE
CONCENTRATIONS IN GROUNDWATER
A ZONE WELLS
Job No.:
Drawing No. OLINCMS
Date: 11-17-93
Checked by: AJM
Rev. No.:
Scale:
0
200 Feet
FIGURE 3-16



BUFFALO AVENUE
ADAMS AVENUE
CHEMICAL ROAD
ALUNDUM ROAD
GILL CREEK
DUPONT ROAD
E.I. du Pont de Nemours & Co., Inc.
OBA-1B: 69 / 14 / 24 / 32
OBA-7B: 152 / 112 / 93 / 123
OBA-2B: 1382 / 751 / 2991 / 16
OBA-3B: 17730 / 15280 / 17440 / 17830
OBA-4B: 22 / ND / 11 / 10
OBA-8B: 105 / 73 / 646 / 7
OBA-6B: 6327 / 400 / 855 / 1324
OBA-5B: 7100 / 4930 / 3285 / 5478
LEGEND:
6327 4TH QUARTER 1991
400 1ST QUARTER 1992
855 2ND QUARTER 1992
1326 3RD QUARTER 1992
TOTAL CHLORINATED BENZENE CONCENTRATIONS (ug/L)
OBA-6B
WELL ID
ND – NOT DETECTED
OLIN CORPORATION BUFFALO AVENUE PLANT
NIAGARA FALLS, NEW YORK
RCRA FACILITY INVESTIGATION
WOODWARD-CLYDE CONSULTANTS
Consulting Engineers, Geologists and Environmental Scientists
TOTAL CHLORINATED BENZENE
CONCENTRATIONS IN GROUNDWATER
B ZONE WELLS
Job No.:
Drawing No. OLINCMS
Date: 11-17-93
Checked by: AJM
Rev. No.:
Scale:
0
200 Feet
FIGURE 3-17



LEGEND:

495	4TH QUARTER 1991	TOTAL CHLORINATED BENZENE CONCENTRATIONS (ug/L)
857	1ST QUARTER 1992	
1179	2ND QUARTER 1992	
1280	3RD QUARTER 1992	

● OBA-6C — WELL ID

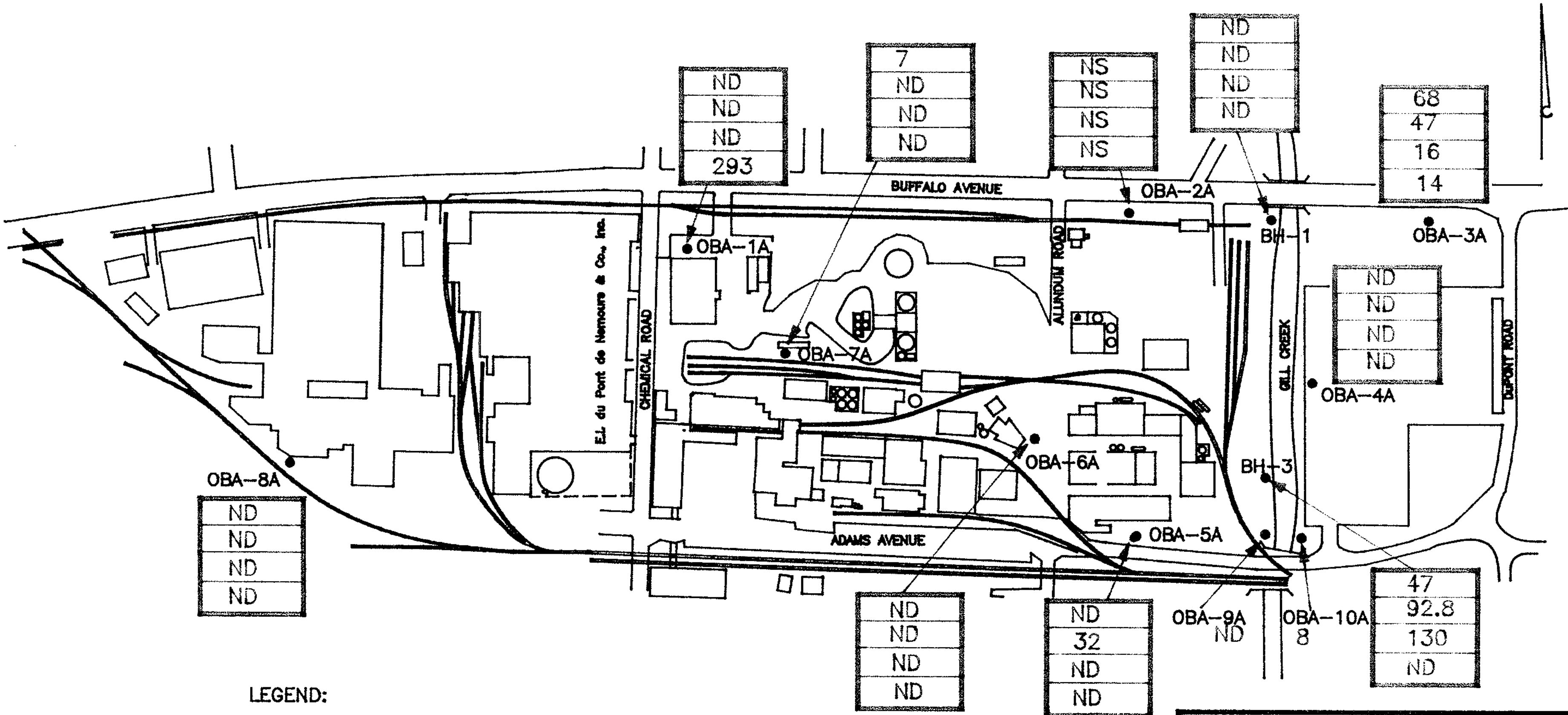
ND – NOT DETECTED
OPW – OLIN PUMPING WELL

OLIN CORPORATION BUFFALO AVENUE PLANT
NIAGARA FALLS, NEW YORK
RCRA FACILITY INVESTIGATION

WOODWARD-CLYDE CONSULTANTS
Consulting Engineers, Geologists and Environmental Scientists

TOTAL CHLORINATED BENZENE CONCENTRATIONS IN GROUNDWATER C/CD ZONE WELLS

Job No.:	Drawing No. OLINCMS	Date: 11-17-93
Checked by: AJM	Rev. No.:	FIGURE 3-18
Scale: 0 — 200 Feet		



LEGEND:

ND	4TH QUARTER 1991
ND	1ST QUARTER 1992
ND	2ND QUARTER 1992
ND	3RD QUARTER 1992

} TOTAL CHLORINATED PHENOL CONCENTRATION (ug/L)

● OBA-6A ← WELL ID

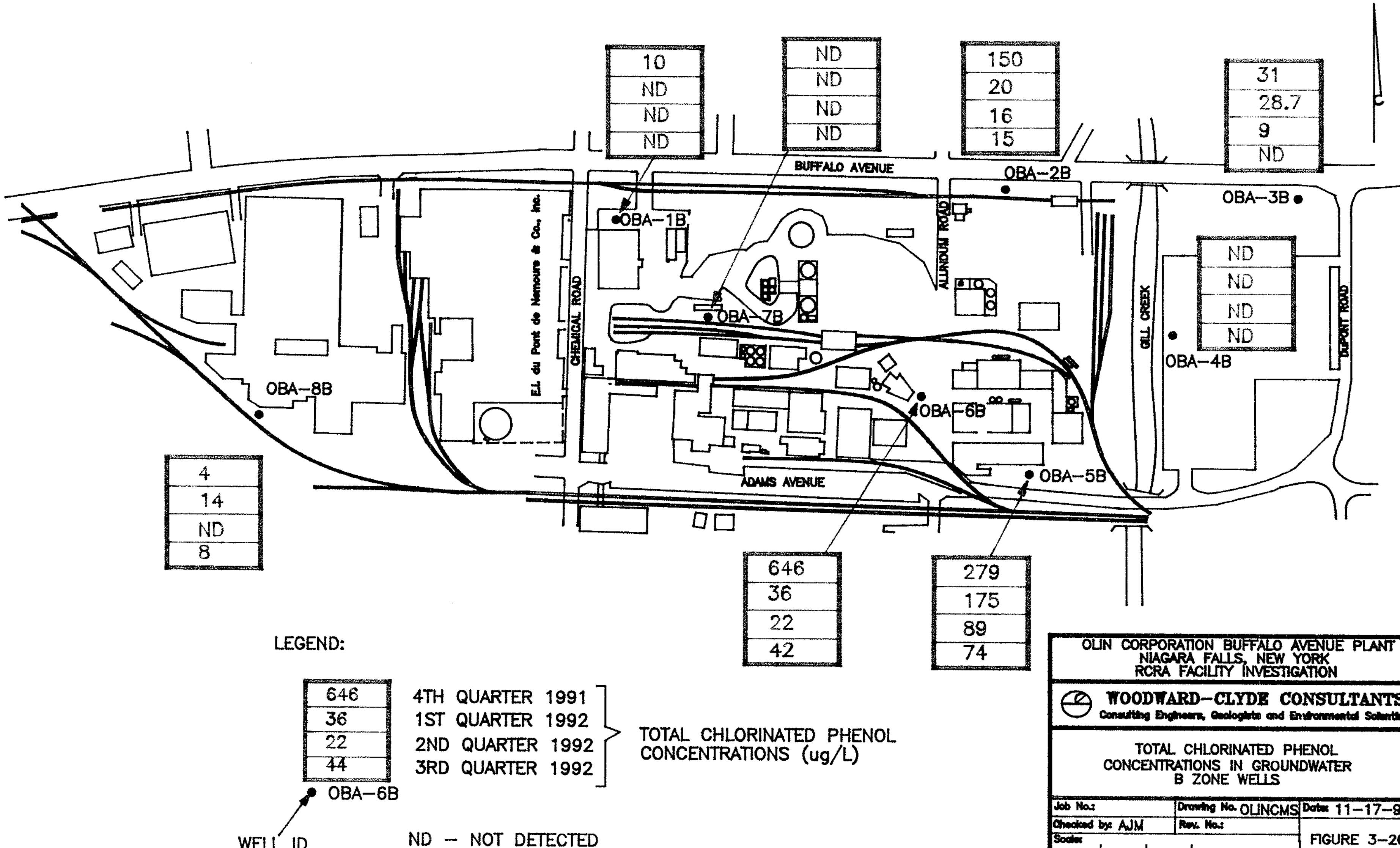
ND – NOT DETECTED
NS – NO SAMPLE COLLECTED (DRY WELL)
NOTE – WELLS OBA-9A AND OBA-10A INSTALLED AND SAMPLED 11/92

OLIN CORPORATION BUFFALO AVENUE PLANT
NIAGARA FALLS, NEW YORK
RCRA FACILITY INVESTIGATION

WOODWARD-CLYDE CONSULTANTS
Consulting Engineers, Geologists and Environmental Scientists

TOTAL CHLORINATED PHENOL
CONCENTRATIONS IN GROUNDWATER
A ZONE WELLS

Job No.:	Drawing No. OLINCMS	Date: 11-17-93
Checked by: AJM	Rev. No.:	FIGURE 3-19
Scale: 0 — 200 Feet		

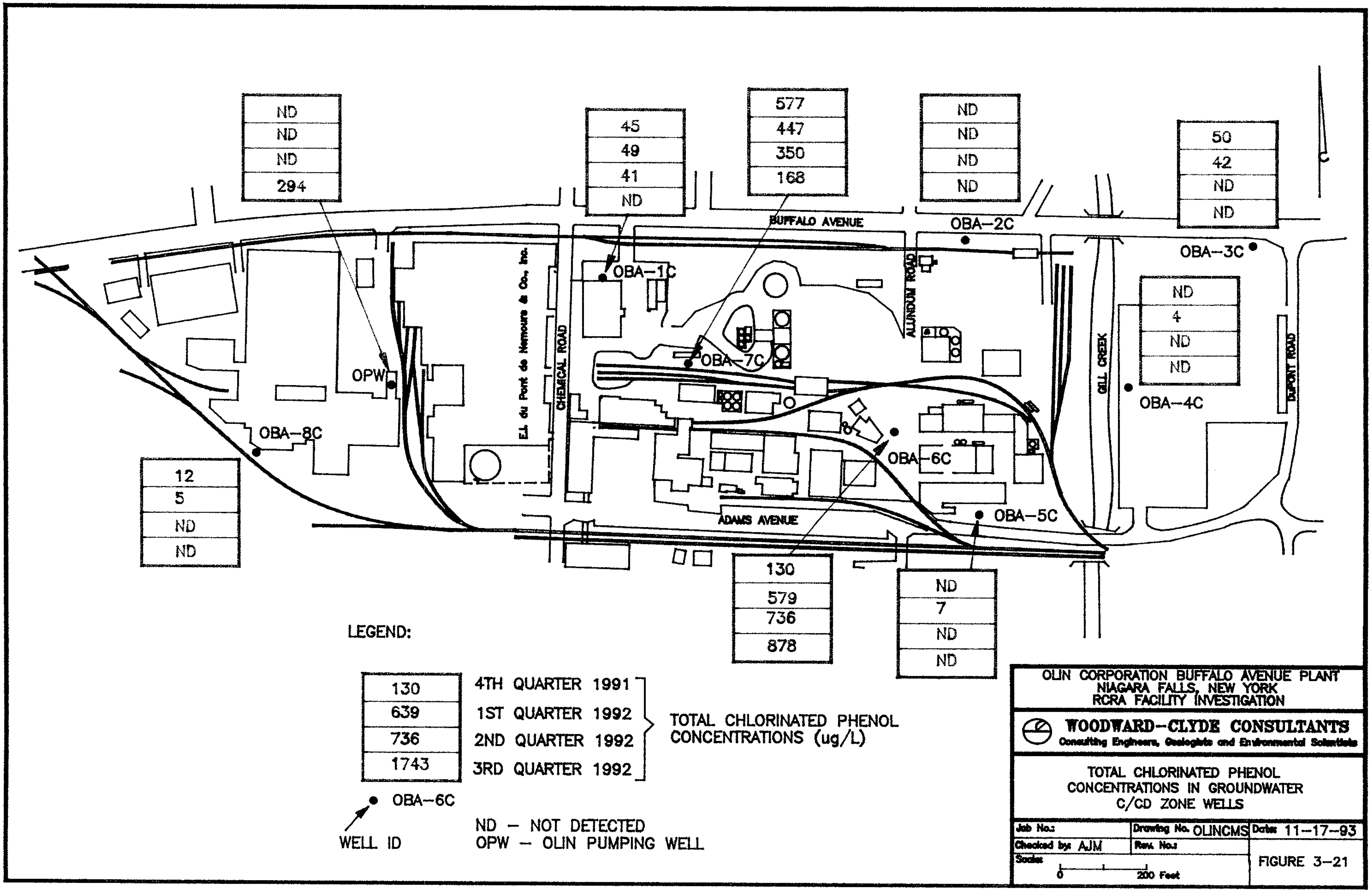


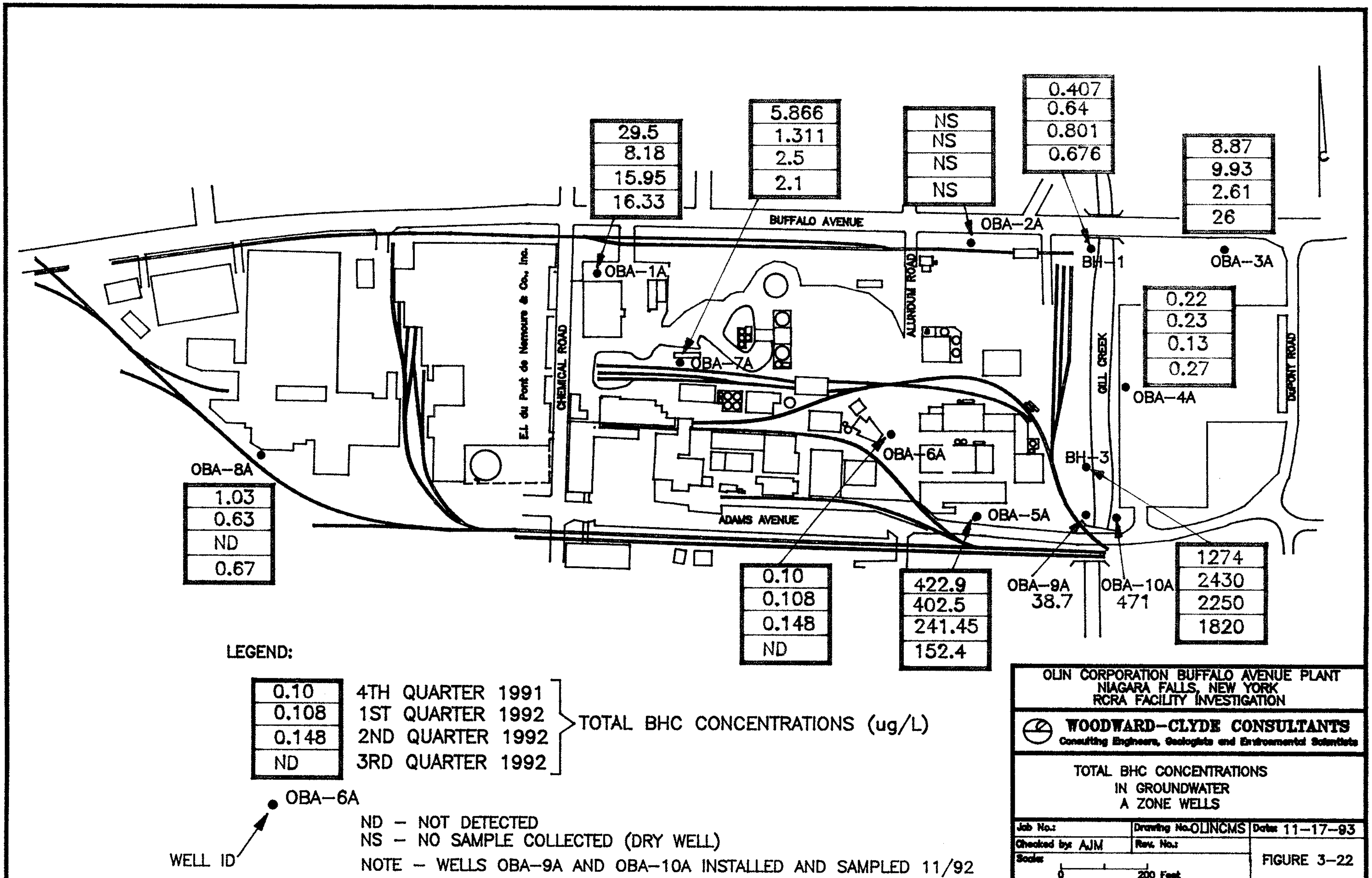
OLIN CORPORATION BUFFALO AVENUE PLANT
NIAGARA FALLS, NEW YORK
RCRA FACILITY INVESTIGATION

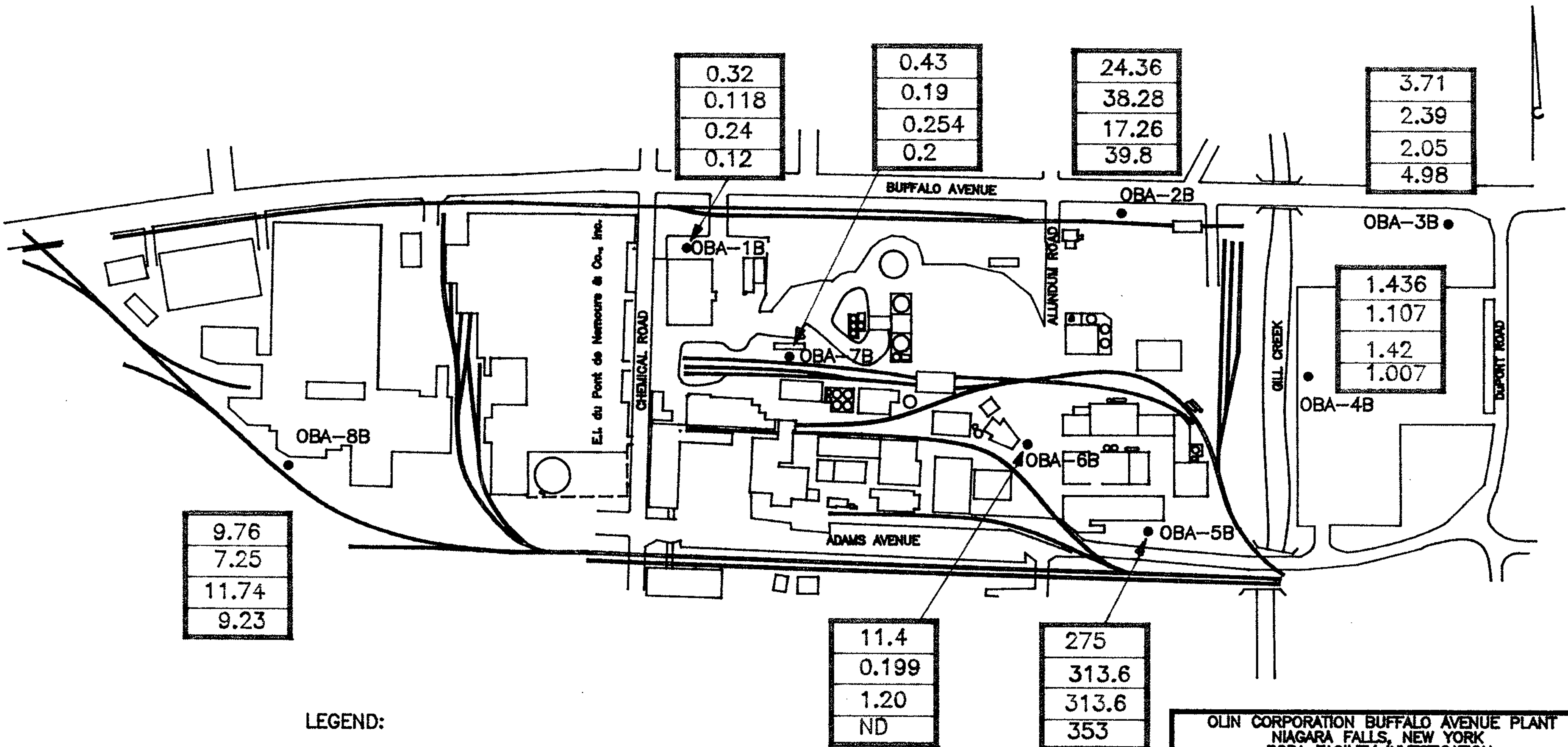
WOODWARD-CLYDE CONSULTANTS
Consulting Engineers, Geologists and Environmental Scientists

TOTAL CHLORINATED PHENOL
CONCENTRATIONS IN GROUNDWATER
B ZONE WELLS

Job No.:	Drawing No. OLINCMS	Date: 11-17-93
Checked by: AJM	Rev. No.:	FIGURE 3-20
Scale: 0 — 200 Feet		


ND
ND
ND
294
45
49
41
ND
577
447
350
168
ND
ND
ND
ND
50
42
ND
ND
BUFFALO AVENUE
OBA-2C
OBA-3C
OBA-1C
ALUNDUM ROAD
ND
4
ND
ND
E.I. du Pont de Nemours & Co., Inc.
CHEMICAL ROAD
OBA-7C
GILL CREEK
DUPONT ROAD
OPW
OBA-4C
OBA-8C
OBA-6C
12
5
ND
ND
ADAMS AVENUE
OBA-5C
130
579
736
878
ND
7
ND
ND
LEGEND:
130
639
736
1743
4TH QUARTER 1991
1ST QUARTER 1992
2ND QUARTER 1992
3RD QUARTER 1992
TOTAL CHLORINATED PHENOL CONCENTRATIONS (ug/L)
OBA-6C
WELL ID
ND - NOT DETECTED
OPW - OLIN PUMPING WELL
OLIN CORPORATION BUFFALO AVENUE PLANT
NIAGARA FALLS, NEW YORK
RCRA FACILITY INVESTIGATION
WOODWARD-CLYDE CONSULTANTS
Consulting Engineers, Geologists and Environmental Scientists
TOTAL CHLORINATED PHENOL
CONCENTRATIONS IN GROUNDWATER
C/CD ZONE WELLS
Job No.:
Drawing No. OLINCMS
Date: 11-17-93
Checked by: AJM
Rev. No.:
Scale:
0
200 Feet
FIGURE 3-21


BUFFALO AVENUE
ADAMS AVENUE
CHEMICAL ROAD
ALUNDUM ROAD
GILL CREEK
DEPONT ROAD
E.I. du Pont de Nemours & Co., Inc.
OBA-1A
29.5
8.18
15.95
16.33
OBA-7A
5.866
1.311
2.5
2.1
OBA-2A
NS
NS
NS
NS
BH-1
0.407
0.64
0.801
0.676
OBA-3A
8.87
9.93
2.61
26
OBA-4A
0.22
0.23
0.13
0.27
OBA-8A
1.03
0.63
ND
0.67
OBA-6A
0.10
0.108
0.148
ND
OBA-5A
422.9
402.5
241.45
152.4
OBA-9A
38.7
OBA-10A
471
BH-3
1274
2430
2250
1820
LEGEND:
0.10 4TH QUARTER 1991
0.108 1ST QUARTER 1992
0.148 2ND QUARTER 1992
ND 3RD QUARTER 1992
TOTAL BHC CONCENTRATIONS (ug/L)
OBA-6A
WELL ID
ND - NOT DETECTED
NS - NO SAMPLE COLLECTED (DRY WELL)
NOTE - WELLS OBA-9A AND OBA-10A INSTALLED AND SAMPLED 11/92
OLIN CORPORATION BUFFALO AVENUE PLANT
NIAGARA FALLS, NEW YORK
RCRA FACILITY INVESTIGATION
WOODWARD-CLYDE CONSULTANTS
Consulting Engineers, Geologists and Environmental Scientists
TOTAL BHC CONCENTRATIONS
IN GROUNDWATER
A ZONE WELLS
Job No.:
Drawing No. OLINCMS
Date: 11-17-93
Checked by: AJM
Rev. No.:
Scale:
0
200 Feet
FIGURE 3-22



LEGEND:

11.4	4TH QUARTER 1991
0.199	1ST QUARTER 1992
1.20	2ND QUARTER 1992
ND	3RD QUARTER 1992

} TOTAL BHC CONCENTRATIONS (ug/L)

● OBA-6B — WELL ID

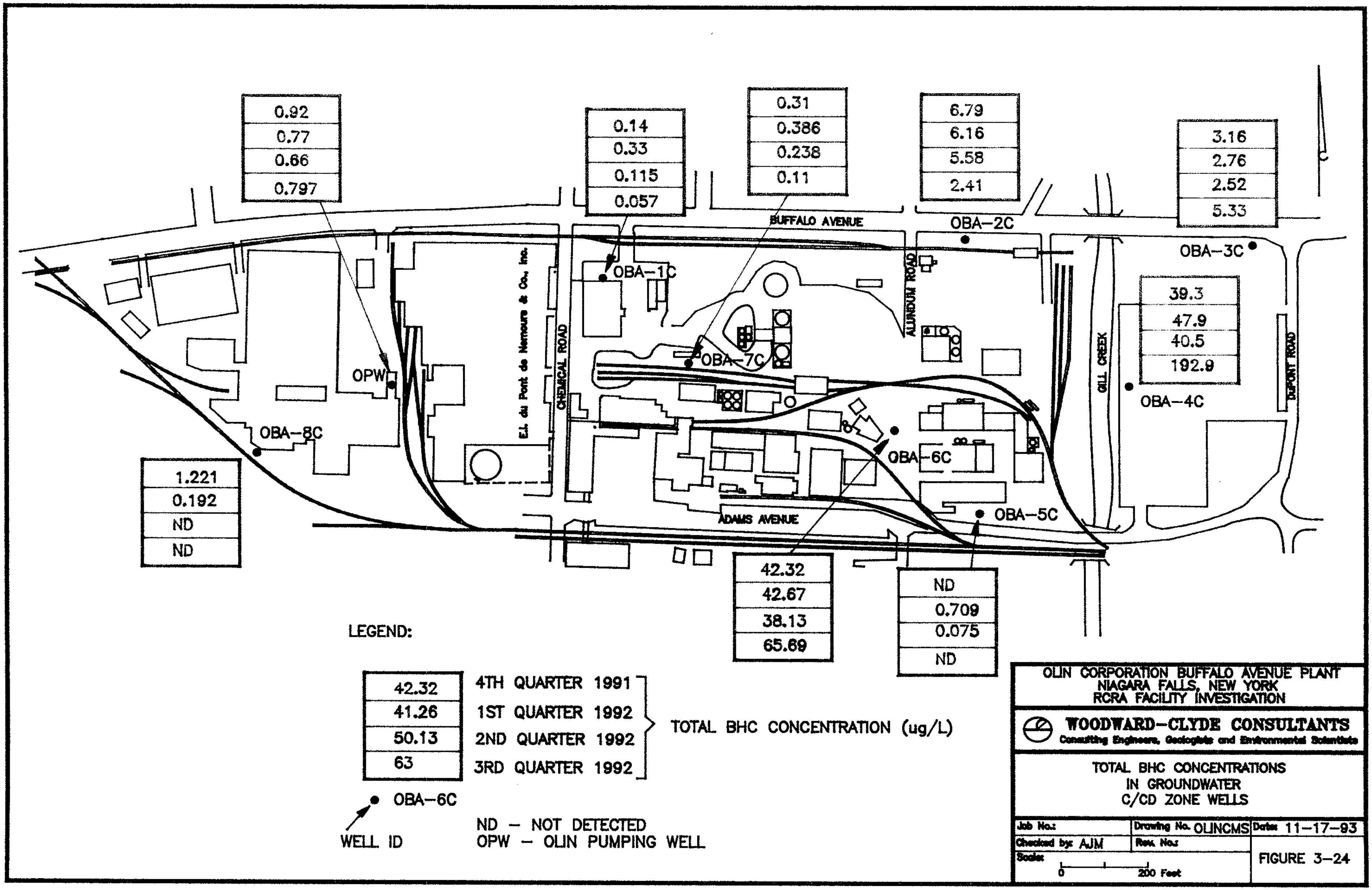
ND — NOT DETECTED

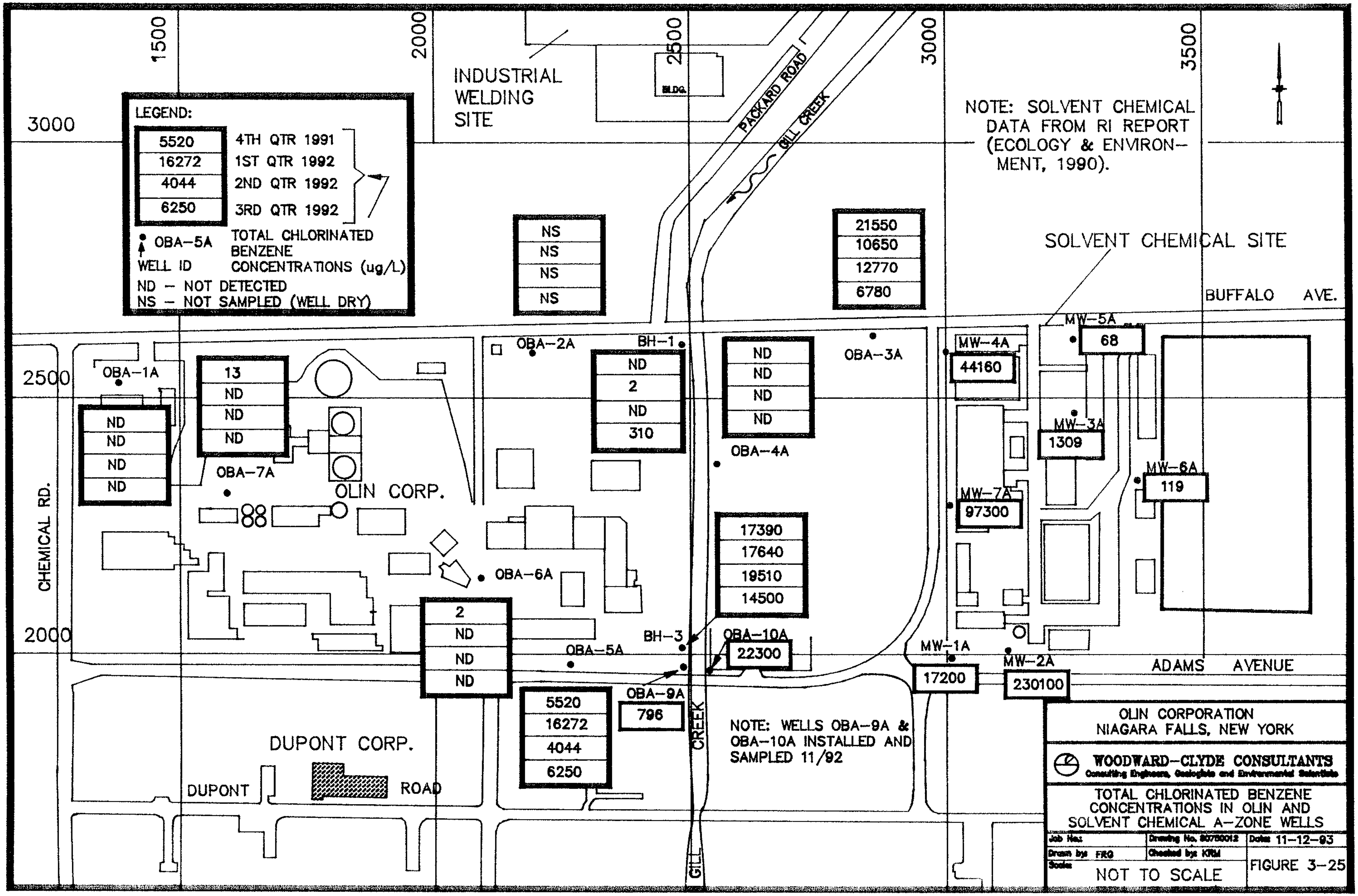
OLIN CORPORATION BUFFALO AVENUE PLANT
NIAGARA FALLS, NEW YORK
RCRA FACILITY INVESTIGATION

WOODWARD-CLYDE CONSULTANTS
Consulting Engineers, Geologists and Environmental Scientists

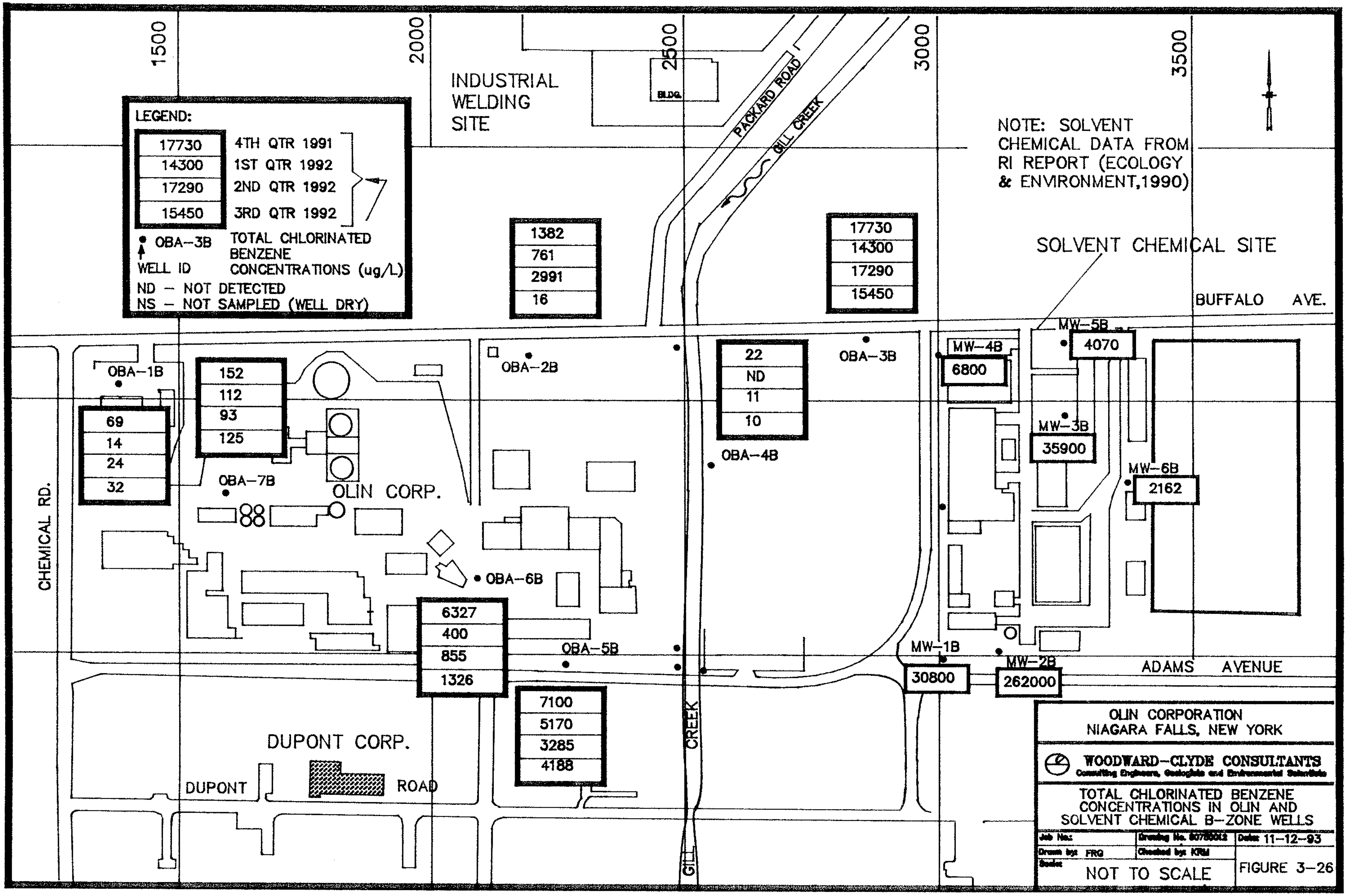
TOTAL BHC CONCENTRATIONS
IN GROUNDWATER
B ZONE WELLS

Job No.:	Drawing No. OLINCMS	Date: 11-17-93
Checked by: AJM	Rev. No.:	
Scale: 0 — 200 Feet		FIGURE 3-23

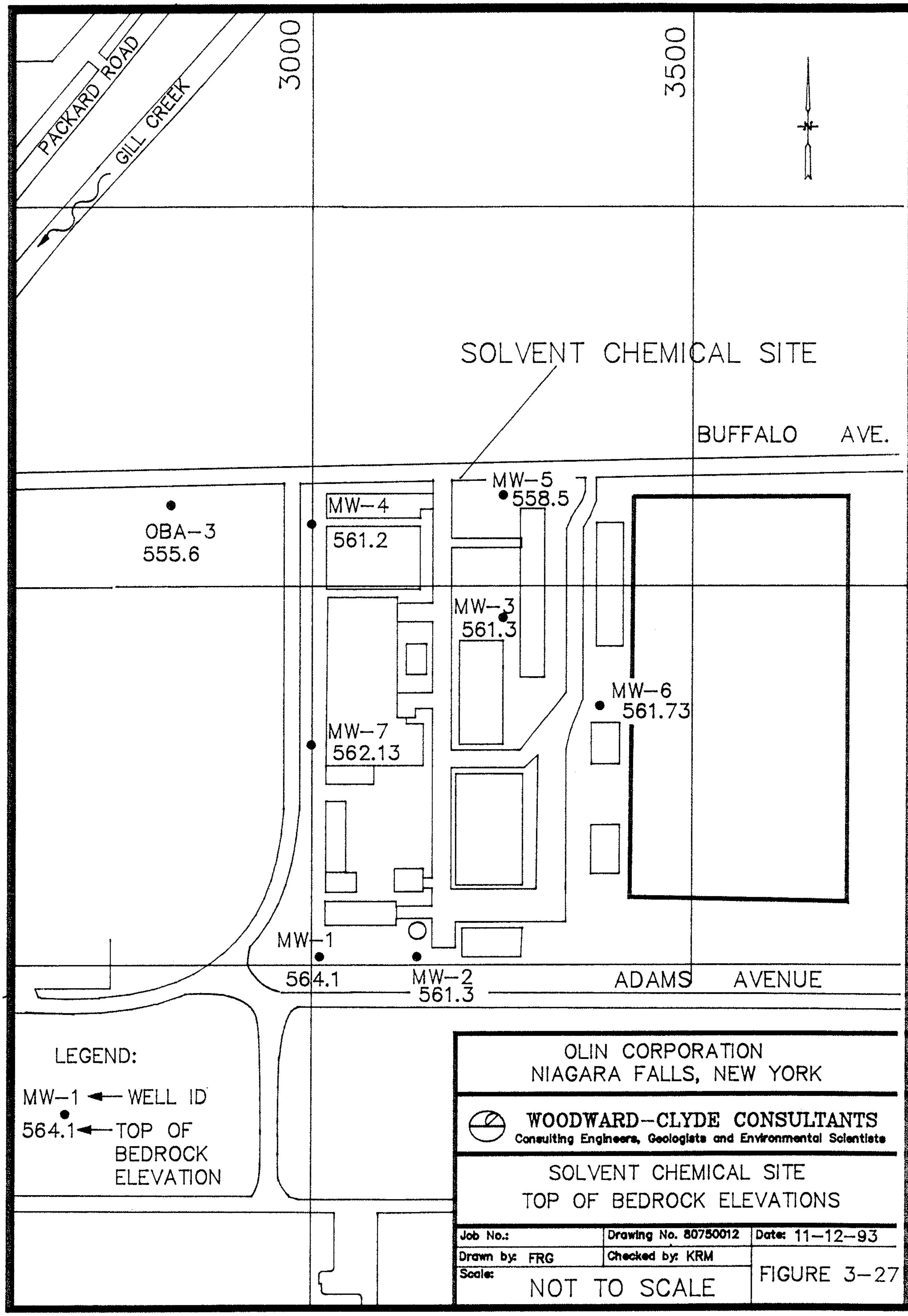

0.92
0.77
0.66
0.797
0.14
0.33
0.115
0.057
0.31
0.386
0.238
0.11
6.79
6.16
5.58
2.41
3.16
2.76
2.52
5.33
BUFFALO AVENUE
OBA-2C
OBA-3C
OBA-1C
ALUNDUM ROAD
39.3
47.9
40.5
192.9
E.I. du Pont de Nemours & Co., Inc.
CHEMICAL ROAD
OBA-7C
GILL CREEK
DUPONT ROAD
OPW
OBA-4C
OBA-8C
OBA-6C
1.221
0.192
ND
ND
ADAMS AVENUE
OBA-5C
42.32
42.67
38.13
65.69
ND
0.709
0.075
ND
LEGEND:
42.32
41.26
50.13
63
4TH QUARTER 1991
1ST QUARTER 1992
2ND QUARTER 1992
3RD QUARTER 1992
TOTAL BHC CONCENTRATION (ug/L)
OBA-6C
WELL ID
ND - NOT DETECTED
OPW - OLIN PUMPING WELL
OLIN CORPORATION BUFFALO AVENUE PLANT
NIAGARA FALLS, NEW YORK
RCRA FACILITY INVESTIGATION
WOODWARD-CLYDE CONSULTANTS
Consulting Engineers, Geologists and Environmental Scientists
TOTAL BHC CONCENTRATIONS
IN GROUNDWATER
C/CD ZONE WELLS
Job No.:
Drawing No. OLINCMS
Date: 11-17-93
Checked by: AJM
Rev. No.:
Scale:
0
200 Feet
FIGURE 3-24



1500
2000
2500
3000
3500
3000
2500
2000
LEGEND:
5520 4TH QTR 1991
16272 1ST QTR 1992
4044 2ND QTR 1992
6250 3RD QTR 1992
TOTAL CHLORINATED BENZENE CONCENTRATIONS (ug/L)
OBA-5A WELL ID
ND – NOT DETECTED
NS – NOT SAMPLED (WELL DRY)
INDUSTRIAL WELDING SITE
BLDG.
PACKARD ROAD
GILL CREEK
NOTE: SOLVENT CHEMICAL DATA FROM RI REPORT (ECOLOGY & ENVIRONMENT, 1990).
SOLVENT CHEMICAL SITE
BUFFALO AVE.
NS
NS
NS
NS
21550
10650
12770
6780
OBA-1A
ND
ND
ND
ND
13
ND
ND
ND
OBA-7A
OBA-2A
BH-1
ND
2
ND
310
ND
ND
ND
ND
OBA-3A
OBA-4A
MW-4A
44160
MW-5A
68
MW-3A
1309
MW-6A
119
MW-7A
97300
OLIN CORP.
CHEMICAL RD.
OBA-6A
17390
17640
19510
14500
2
ND
ND
ND
OBA-5A
BH-3
OBA-10A
22300
MW-1A
17200
MW-2A
230100
ADAMS AVENUE
5520
16272
4044
6250
OBA-9A
796
CREEK
GILL
NOTE: WELLS OBA-9A & OBA-10A INSTALLED AND SAMPLED 11/92
DUPONT CORP.
DUPONT ROAD
OLIN CORPORATION
NIAGARA FALLS, NEW YORK
WOODWARD-CLYDE CONSULTANTS
Consulting Engineers, Geologists and Environmental Scientists
TOTAL CHLORINATED BENZENE CONCENTRATIONS IN OLIN AND SOLVENT CHEMICAL A-ZONE WELLS
Date: 11-12-93
Drawn by: FRG
Checked by: KRM
NOT TO SCALE
FIGURE 3-25



1500
2000
2500
3000
3500
INDUSTRIAL WELDING SITE
BLDG.
PACKARD ROAD
GILL CREEK
NOTE: SOLVENT CHEMICAL DATA FROM RI REPORT (ECOLOGY & ENVIRONMENT,1990)
LEGEND:
17730 4TH QTR 1991
14300 1ST QTR 1992
17290 2ND QTR 1992
15450 3RD QTR 1992
OBA-3B WELL ID
TOTAL CHLORINATED BENZENE CONCENTRATIONS (ug/L)
ND – NOT DETECTED
NS – NOT SAMPLED (WELL DRY)
1382
761
2991
16
17730
14300
17290
15450
SOLVENT CHEMICAL SITE
BUFFALO AVE.
OBA-1B
69
14
24
32
152
112
93
125
OBA-2B
22
ND
11
10
OBA-3B
OBA-4B
MW-4B
6800
MW-5B
4070
MW-3B
35900
MW-6B
2162
OBA-7B
OLIN CORP.
CHEMICAL RD.
OBA-6B
6327
400
855
1326
OBA-5B
MW-1B
30800
MW-2B
262000
ADAMS AVENUE
7100
5170
3285
4188
CREEK
DUPONT CORP.
DUPONT
ROAD
GILL
OLIN CORPORATION
NIAGARA FALLS, NEW YORK
WOODWARD-CLYDE CONSULTANTS
Consulting Engineers, Geologists and Environmental Scientists
TOTAL CHLORINATED BENZENE CONCENTRATIONS IN OLIN AND SOLVENT CHEMICAL B-ZONE WELLS
Job No.:
Drawing No. 9075012
Date: 11-12-93
Drawn by: FRG
Checked by: KRM
Scale: NOT TO SCALE
FIGURE 3-26

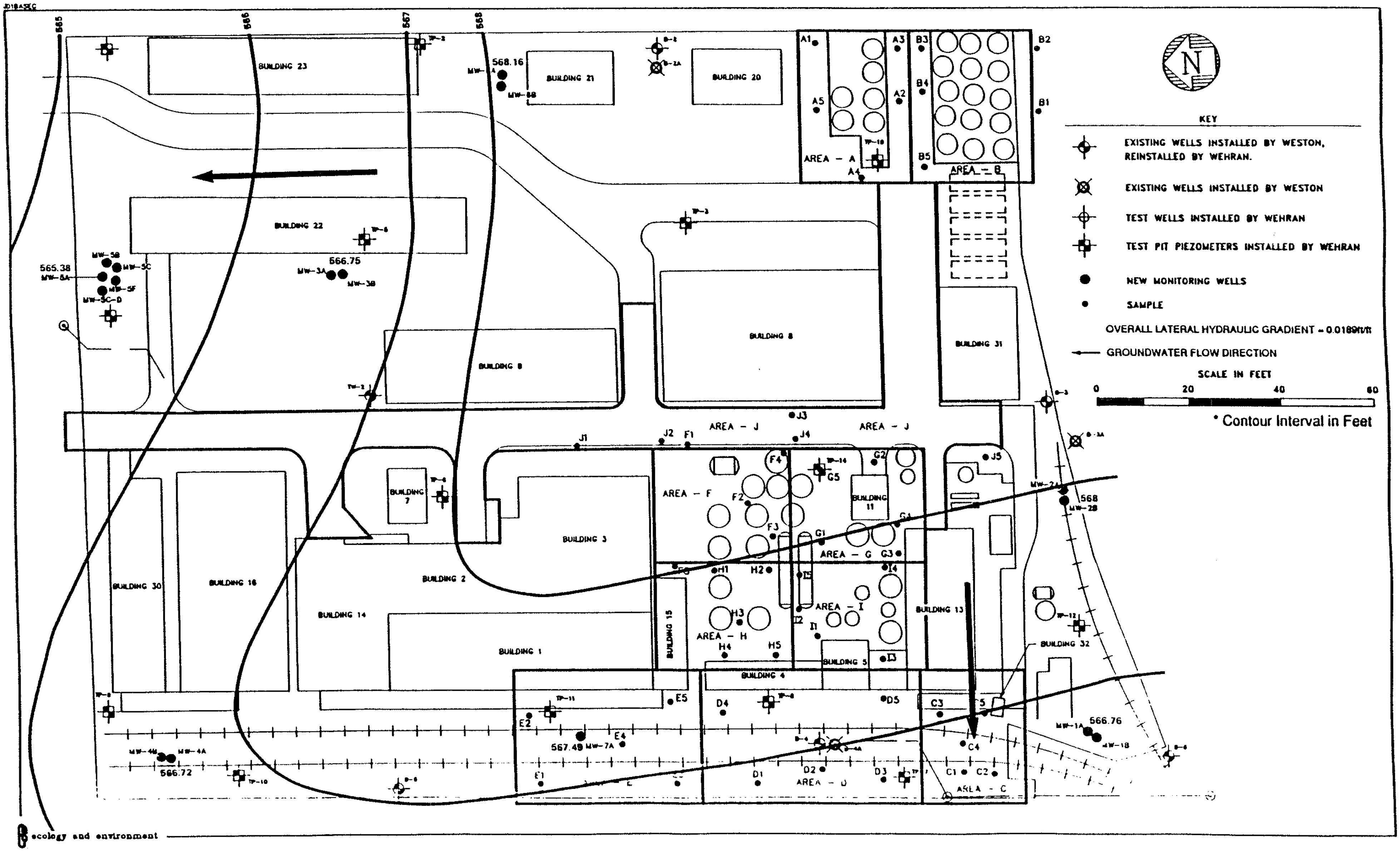


OLIN CORPORATION
NIAGARA FALLS, NEW YORK

WOODWARD-CLYDE CONSULTANTS
Consulting Engineers, Geologists and Environmental Scientists

SOLVENT CHEMICAL SITE
TOP OF BEDROCK ELEVATIONS

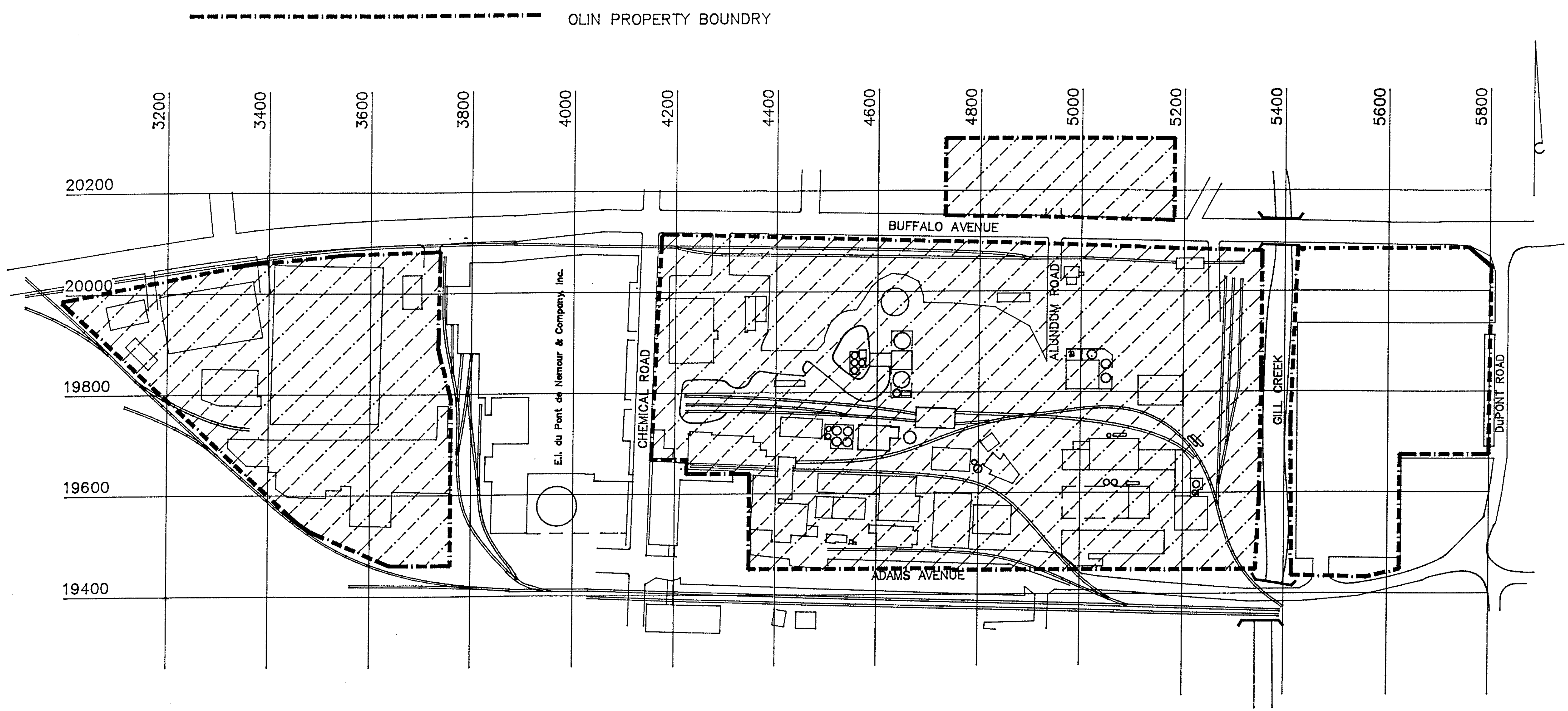
Job No.:	Drawing No. 80750012	Date: 11-12-93
Drawn by: FRG	Checked by: KRM	FIGURE 3-27
Scale: NOT TO SCALE		



Source: Solvent Chemicals Remedial Investigation Report (E&E, 1990)

GROUNDWATER ELEVATIONS IN A ZONE
(READINGS TAKEN 2/6/90 AND 2/9/90)

FIGURE 3-28



LEGEND:

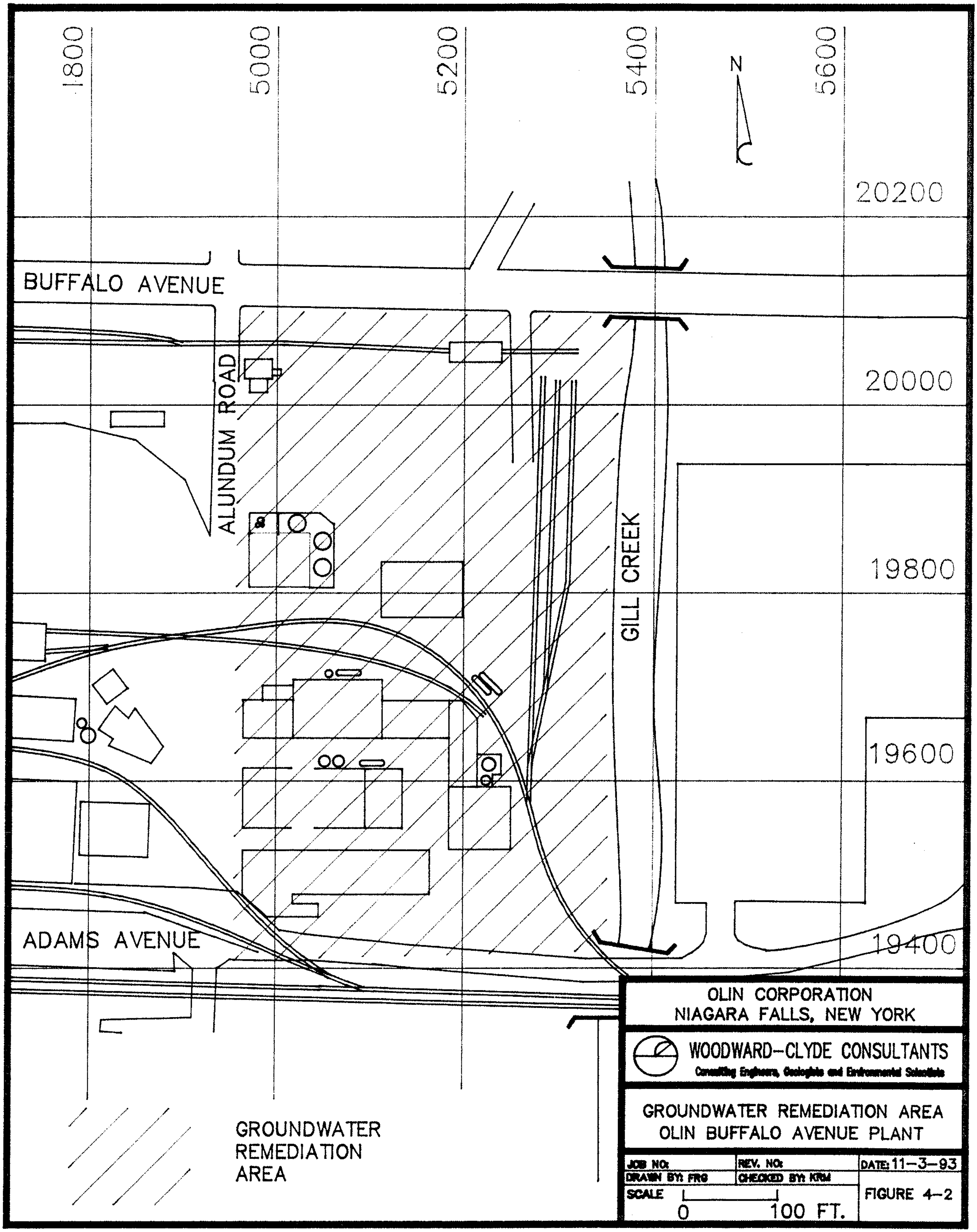
SOIL MANAGEMENT AREA

OLIN CHEMICALS
NIAGARA PLANT – NIAGARA FALLS, N.Y.

WOODWARD-CLYDE CONSULTANTS
Consulting Engineers, Geologists and Environmental Scientists

SOIL MANAGEMENT AREA
OLIN CORPORATION
BUFFALO AVENUE PLANT

Job No.: 88C2346-12	Drawing No.	Date: 11-22-93
Checked by: KRM	Rev. No.:	FIGURE 4-1
Scale: 0 — 200 Feet		

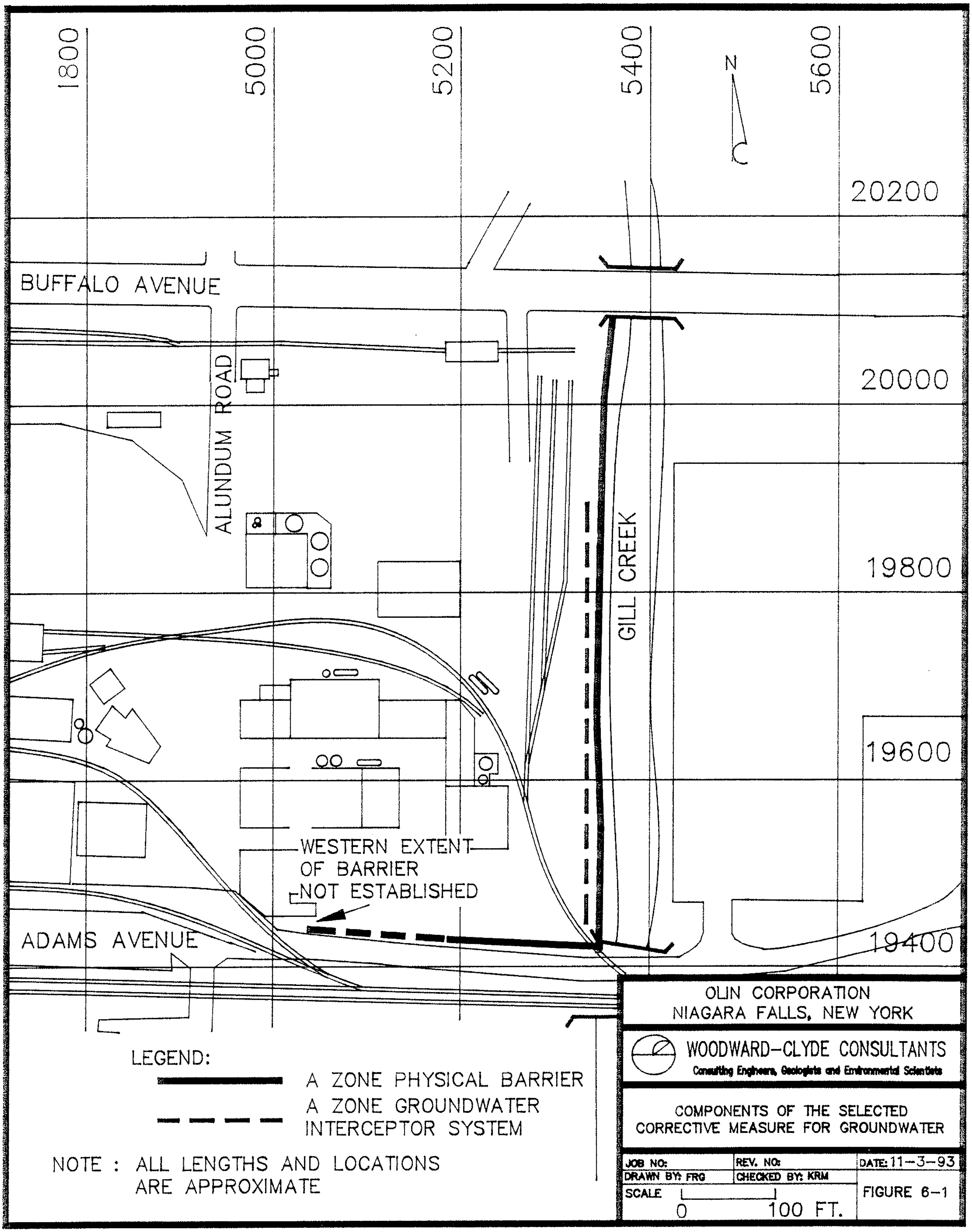


OLIN CORPORATION
NIAGARA FALLS, NEW YORK

WOODWARD-CLYDE CONSULTANTS
Consulting Engineers, Geologists and Environmental Scientists

GROUNDWATER REMEDIATION AREA
OLIN BUFFALO AVENUE PLANT

JOB NO:	REV. NO:	DATE: 11-3-93
DRAWN BY: FRG	CHECKED BY: KRM	
SCALE 0 100 FT.		FIGURE 4-2



1800
5000
5200
5400
5600
N
20200
20000
19800
19600
19400
BUFFALO AVENUE
ALUNDUM ROAD
GILL CREEK
ADAMS AVENUE
WESTERN EXTENT OF BARRIER NOT ESTABLISHED
LEGEND:
A ZONE PHYSICAL BARRIER
A ZONE GROUNDWATER INTERCEPTOR SYSTEM
NOTE : ALL LENGTHS AND LOCATIONS ARE APPROXIMATE
OLIN CORPORATION
NIAGARA FALLS, NEW YORK
WOODWARD-CLYDE CONSULTANTS
Consulting Engineers, Geologists and Environmental Scientists
COMPONENTS OF THE SELECTED CORRECTIVE MEASURE FOR GROUNDWATER
JOB NO:
REV. NO:
DATE: 11-3-93
DRAWN BY: FRG
CHECKED BY: KRM
SCALE
0
100 FT.
FIGURE 6-1