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REMEDIAL INVESTIGATION REPORT
ALSCO-ANACONDA NPL SITE
GNADENHUTTEN, OHIO

PREPARED FOR:

ATLANTIC RICHFIELD COMPANY
LOS ANGELES, CALIFORNIA

PREPARED BY:

IT CORPORATION
PITTSBURGH, PENNSYLVANIA

JANUARY 1989
PROJECT NO. 303029

Only portions of the following Remedial Investigation Report, January 1989, for the Alsco Anaconda Site in Gnadenhutten, Ohio are approved by the United States Environmental Protection Agency. Specifically, only those portions which discuss the site solid waste and air investigation are approved. Please refer to pages 2 and 3 of the following letter dated June 14, 1989 for specific reference to approved and not approved portions of the Remedial Investigation Report.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 5
230 SOUTH DEARBORN ST.
CHICAGO, ILLINOIS 60604

REPLY TO THE ATTENTION OF:
5HS-11

JUN 14 1989

Mr. Thomas McLane
ARCO
515 South Flower Street
Los Angeles, CA 90071

Dear Mr. McLane:

This letter serves as a follow up to our recent telephone conversations concerning the groundwater contamination at the Alsco Anaconda Superfund National Priorities List Site in Gnadenhutten, Ohio. As significant questions still remain as to the exact nature and extent of this groundwater contamination, U.S. Environmental Protection Agency (EPA) has decided to postpone the decision on the groundwater remedial action selection until these remaining questions are resolved.

We agreed to remove references to groundwater remedial action technologies and alternatives from the draft FS. The revised FS will serve as a Focused FS developing and evaluating alternatives for the site source materials (sludge and contaminated soils) only. The revised FS of June 1989 received by the U.S. EPA on June 8, 1989 will serve to meet the deliverable identified as the "public comment draft" planned for June 12, 1989 in the schedule for site tasks. U.S. EPA will be making final comments to be incorporated into this report before approving the final Focused FS.

A decision for the source materials remedial action will be made by us sometime late this summer. A decision for the groundwater contamination remedial action will be made by us in a timely manner after adequate information has been gathered.

As various communications between myself and ARCO staff have indicated, there remain some important questions about the site contaminated groundwater and the risk it may pose to surrounding exposure points. It is important that these questions are resolved before a protective, cost-effective groundwater remedial action can be selected. As such, the RI Report submitted by ARCO dated January 1989 in compliance with Administrative Order by Consent U.S. EPA Docket NO. VW 87C002 is approved in reference to definition of the site solid waste and air investigation only. The conclusions drawn about the nature, extent and final disposition of groundwater contamination, as well as information presented about the risks posed from this groundwater, are not supported with sufficient data, therefore, are not approved. Additionally, information in the RI Report in reference to the surface water/groundwater relationships is also not approved at this time.

Specifically the following portions of the RI Report are approved and provide adequate information, along with the draft FS, to allow selection of a remedial action for the site solid wastes and contaminated soils operable unit.

1.1 Site Background Investigation

1.2 Nature and Extent of the Problem

2.0 Site Features Investigation

3.0 Hazardous Substances Investigation

4.2 Hydrogeologic Investigations Soils

5.2 Surface Water Investigation - Drainage patterns

5.3.1 through 5.3.3 Tuscarawas River

- 5.3.1 Physical Characteristics
- 5.3.2 Flooding Tendencies
- 5.3.3 Manmade Structures

5.4 Tuscarawas River Quality

6.0 Air Investigations

8.7 Potential Receptors Via Direct Contact

8.8 Impact of Direct Contact

8.11 Conclusions - Paragraphs referring to direct contact and air migrations pathways only.

The following portions of the RI Report are not approved:

Executive Summary

1.3 Remedial Investigation Summary

1.4 Remedial Investigation Report Overview

4.1 Introduction - Hydrogeologic Investigations

4.3 Groundwater

5.1 Introduction - Surface Water Investigation

5.3.4 Surface Water/Groundwater Relationship

5.5 Tuscarawas River Sediments

7.0 Biota Investigation

8.1 Design of Risk Assessment

8.2 Selection of Indicator Parameters

8.3 Methodology

8.4 Environmental Migration Pathway

8.5 Potential Receptors for Water Pathway

8.6 Impact of Constituents in Groundwater

8.9 Impact on Wildlife

8.10 Uncertainty Analysis

8.11 Conclusions - Paragraphs referring to public health and environmental concerns due to contaminated groundwater.

Addendum 2 of the RI, Evaluation of Monitoring and Pumping Wells PW-4 and PW-5, dated May 1989 is also not approved at this time as U.S. EPA is currently reserving judgement on groundwater components of the RI. This information may be useful in future groundwater investigation and evaluation.

Additions to Remedial Investigation which must be made prior to U.S. EPA approval include the following:

- Definition of the horizonal and vertical extent of groundwater contamination;

- The discharge points of contaminated groundwater (i.e., to the Tuscarawas River or beneath it, toward the Alsco pumping well #5 or away from it);

- A proper public health evaluation of actual and potential exposure routes of the contaminated groundwater in accordance with the Superfund Public Health Evaluation Manual, October 1986 (OSWER Directive 9285.4-1); and

- A sampling of the benthic community in the Tuscarawas River to evaluate exposure from site contaminants.

In accordance with Section XIII. Review of Documents of the Administrative Order by Consent, please provide a work plan with an appropriate schedule to address these items by August 7, 1989. Once the necessary data are collected and evaluated, a small Phase II FS can be performed (relying, as appropriate, on information already developed about groundwater remedial actions) to evaluate groundwater remedial actions.

I look forward to completion of the source material FS currently being finalized. Please do not hesitate to contact me if I can provide any further clarification or information concerning the above letter.

Sincerely,

Diana Mally

Diana Mally
Remedial Project Manager

cc: John Rochotte, OEPA
Kathy Davidson, OEPA (TUS-OCA)
Jess Womack, ARCO

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EXECUTIVE SUMMARY

IT Corporation (IT) was contracted by ARCO Chemical Company (ARCO) to conduct a Remedial Investigation (RI) at the former Alsco Anaconda site herein referred to as the ARCO Gnadenhutten, Ohio plant site. Gnadenhutten, a community of about 1,320 residents, is located in Tuscarawas County, about 49 miles south of Akron, Ohio. The former ARCO Alsco plant was located on 23.6 acres along the floodplain of the Tuscarawas River, and consisted of an architectural aluminum manufacturing plant, office building, wastewater treatment plant, sludge settling basin, and sludge pit (Figure ES-1). The settling basin and sludge pit were used for the disposal of chromium- and cyanide-containing sludge, a by-product from the production of aluminum siding and coated coil, that consists mostly of aluminum oxyhydroxides, calcium carbonate, calcium sulfate, and water. Sludge was also deposited in a wooded marsh (swamp) area adjacent to the settlement basin as a result of effluent overflow from the basin and plant wastewater discharge to this area. Because of concerns for the possible contamination of water resources due to leachate from the sludge, in October 1984 the site was proposed for inclusion on the National Priorities List (NPL) of sites eligible for cleanup under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA). The site was formally placed on the NPL in June 1986. In December 1986, ARCO sold the plant to Pony Industries, Inc., a subsidiary of Horsehead Industries, Inc., but ARCO retained ownership of the areas (approximately 4.8 acres) used for sludge disposal that are included on the NPL. The chronology of the Alsco-Anaconda NPL site is summarized in Table ES-1.

The purpose of the RI was to determine the nature and extent of contamination at the Alsco-Anaconda NPL site and the potential environmental impact of site conditions and contaminant migration. The information obtained in the RI was used to develop and evaluate a number of remedial alternatives and to identify, on the basis of technical adequacy and cost-effectiveness, the recommended remedial action to mitigate the impacts identified in the RI consistent with an acceptable level of potential risk.

RI activities for the Alsco-Anaconda NPL site have been conducted in accordance with the February 1987 consent order (Table ES-1) Statement of Work

(SOW), CERCLA and National Contingency Plan (NCP) (40 CFR 300) guidelines, and applicable U.S. Environmental Protection Agency (U.S. EPA) and Ohio Environmental Protection Agency (OEPA) requirements. This report has been prepared to document the activities that were undertaken by IT in order to meet the objectives of the RI. The format of the RI report follows the outline presented in the U.S. EPA document EPA/540/6-85/002, "Guidance on Remedial Investigations under CERCLA," 1985, Washington, D.C.

Several phases of field activities, sample collection, and chemical constituent analyses were planned and conducted during the period from March 1985 through January 1987 (Table ES-2). The project tasks were performed in accordance with Revision I and Addenda I and II of the RI Work Plan and Revisions I, II, or III of the Quality Assurance Project Plan (QAPP), documents which were prepared by IT for ARCO and which were reviewed and approved by representatives of the U.S. EPA Region V and the OEPA.

As summarized in Table ES-2, the Alsco Anaconda site RI involved the installation of nine monitoring wells and the collection of corresponding borehole soil samples and ground water samples, plus ground water from plant production wells, sediments from the Tuscarawas River, and sludge and underlying soil samples from the sludge settlement basin, the sludge disposal pit, and the swamp area. Representative composite sludge and soil samples were analyzed for Hazardous Substance List (HSL) organic compounds, cyanide, fluoride, nitrate, hexavalent chromium, total chromium, and other total metals as well as leachable metals by the Extraction Procedure Toxicity (E.P. Toxicity) test method. Ground waters were monitored for HSL organic compounds, cyanide, fluoride, nitrate, chromium, and selenium, plus water levels, pH, temperature, and specific conductance. The river sediments were analyzed for polychlorinated biphenyls (PCBs), total chromium, and hexavalent chromium.

The major findings of the RI are that sporadic and seasonal ground water contamination occurs within and is limited to the immediate area surrounding the impoundment, sludge pit, and swamp area (Section 4.3.7) and the endangerment assessment for human exposure scenarios indicates that the site ground water does not pose any undue risk (Section 8.6). Metals and volatile organic

contaminants (VOCs) detected at the site also do not pose an undue risk (Section 8.8). However, PCB concentrations within Area No. 4 sludge may pose an unacceptable level of risk based on the human exposure scenarios evaluated (ingestion and direct contact, Section 8.8.7). Additionally, Area No. 4 is within the floodplain of the Tuscarawas River. In summary, the results of the risk assessment indicate the PCB concentrations only in Area No. 4 may pose a potential risk.

TABLE ES-1

CHRONOLOGY OF ARCO ALSCO ANACONDA SITE

Site Ownership and Development

1948	Harvard Industries established the Alsco plant and began manufacture of aluminum siding and coated coil at the facility
1949-1960	Additions to plant structures and product line
1965	Construction of sludge settlement basin
August 1971	Anaconda Company purchased the Alsco plant
1972	Major expansion to plant
January 1977	ARCO Chemical Company purchased the Alsco plant
1978	Filter press installed to dewater sludge; settlement lagoon taken out of service, but clarified water routed through lagoon to swamp until rerouted directly to swamp in 1980
October 1984	U.S. EPA proposed site for inclusion on NPL
November 1984	ARCO retained IT to perform RI/FS
March 1985	RI activities begun on site
June 1986	Site formally listed on NPL
December 1986	Horsehead Industries purchased Alsco plant; ARCO retained ownership of NPL site property
February 1987	Consent order between U.S. EPA, OEPA, and ARCO issued for public comment

Wastewater Treatment

Prior to 1965	Wastewater discharged untreated to Tuscarawas River
1965 to 1972	Wastewater discharged to settling lagoon; untreated effluent overflow discharged to river
January 1971	Industrial Waste Permit received from Ohio
May 1971	NPDES permit applied for to discharge 72,000 gal/day
March 1972	Chromium reduction system linked in wastewater treatment; treated wastewater discharged to lagoon
1974	Chromium reduction system enlarged

TABLE ES-1
(Continued)

1978	Lamella (plate and frame) filter press installed for sludge dewatering; clarified water discharged to lagoon
November 1980	Clarified water rerouted to bypass lagoon, discharged to swamp
1986	Sand filter added to wastewater treatment system
October 1986	Treated, clarified wastewater discharge rerouted from swamp to NPDES permitted outfall to river

TABLE ES-2

REMEDIAL INVESTIGATION ACTIVITIES FOR THE ARCO ALSCO ANACONDA SITE GNADENHUTTEN, OHIO

A. Remedial Investigation Work Plan; Sumitted December 1984, revised March 1985 (Revision I), and amended May 1985 (Addendum I) and August 1986 (Addendum II)

B. Quality Assurance Project Plan; Submitted January 1985 and revised March 1985 (Revision I), August 1986 (Revision II), and October 1986 (Revision III)

C. Health and Safety Plan; Submitted January 1985, revised March 1985 (Revision I), and amended November 1986 (Addendum I)

D. Investigation of Site History

1. Documentation of site history

   a. Plant records

   b. Aerial photographs

   c. Corps of Engineers flood records

2. Literature search

   a. Published literature

   b. STORET data

   c. ODNR water well inventory data

E. Field Investigation

1. Settlement lagoon and sludge pit sampling

   a. Sludge pit - Test pits TP-1 through TP-5 (April 1985) and auger samples S-1 through S-4 (November 1986) and S-1 through S-5 (January 1987)

   b. North segment of settlement lagoon - Test pits TP-6 through TP-8 (April 1985) and auger samples S-1 through S-3 (November 1986 and January 1987)

   c. South segment of settlement lagoon - Test pits TP-9 through TP-13 (April 1985) and auger samples S-4 through S-6 (November 1986 and January 1987)

TABLE ES-2
(Continued)

2. Swamp area sludge and underlying soil sampling

   a. Forty sludge and subsurface soil samples collected on 75-foot by 50-foot grid system from April 5, 1985 to April 8, 1985

   b. One hundred and forty sludge and subsurface soil samples collected on a 37.5-foot by 25-foot grid system from November 24 to December 2, 1986 and then repeated from January 19 to 22, 1987

   c. Forty-nine sludge and soil samples collected on a 18.75-foot by 12.5-foot grid and an extended 37.5-fooy by 25-foot grid on March 26, 1987.

3. River sediment sampling

   a. One hundred and one bottom sediment samples collected along fifteen traverses from November 11 to 14, 1986. Twenty-six upstream and twenty-three downstream samples collected at 30-foot intervals across six traverses extended the width of the river; fifty-two near-plant samples collected at 20-foot intervals across nine traverses half the width of the river

4. Soil boring program and sampling

   a. Nine soil borings to a depth of 50 feet from March 18 to April 9, 1985

5. Monitoring well installation

   a. Nine monitoring wells, MW-1 through MW-9, installed from March 18 to April 9, 1985

6. Monitoring well and site survey

7. Ground water level measurements and sampling (monitoring)

   a. First quarter ground water monitoring, April 9 to 12, 1985

   b. Second quarter ground water monitoring, July 30 to 31, 1985

   c. Third quarter ground water monitoring, November 4 to 5, 1985

   d. Fourth quarter ground water monitoring, January 28 to 30, 1986

   e. Final quarter ground water monitoring, November 18 to 20, 1986

   f. Limited ground water monitoring, January 27 to 29, 1987

   g. Water table measurements, July 17, 1986, September 29, 1986, and February 25, 1987

TABLE ES-2
(Continued)

8. Exploratory trench excavated through paved parking area on October 2, 1986.

F. Laboratory Program

1. Settlement lagoon and sludge pit samples

   a. Sludge and soil sample composites and selected individual soil samples

      - Total constituent and E.P. toxicity cyanide, fluoride, nitrate, 17 metals, and HSL organic parameters

   b. Test pit vertical composite samples

      - Thirteen composites for E.P. toxicity cyanide, fluoride, nitrate, and 14 metals

      - Eleven composites for HSL organic parameters

   c. Test pit samples

      - Fifteen samples - Total constituent cyanide, fluoride, nitrate, 17 metals, and HSL organic parameters

      - Five samples - X-ray diffraction

      - Five samples - permeability testing

2. Swamp area sludge and underlying soils

   a. Sludge and soil composites

      - Total constituent and E.P. toxicity cyanide, fluoride, nitrate, 17 metals, and HSL organic parameters

   b. Individual sludge and soil samples

      - Two hundred and twenty samples for polychlorinated biphenyl (PCB) analysis

3. River sediment samples

   a. Thirty-six individual and five composite samples for total chromium, hexavalent chromium, and PCBs

4. Soil boring samples

   a. Twenty-seven soil samples for total constituent and E.P. toxicity cyanide, fluoride, chromium, iron, and manganese

TABLE ES-2
(Continued)

5. Quarterly ground water monitoring samples - Nine monitoring wells and two production wells

   a. First quarter ground water monitoring, April 9 and 12, 1985

      - HSL organic parameters (six wells only) and total and amenable cyanide, fluoride, nitrate, and 14 metals

   b. Second quarter ground water monitoring, July 30 and 31, 1985

      - HSL organic parameters and total and amenable cyanide, fluoride, nitrate, total and hexavalent chromium, iron, manganese, selenium, and total organic carbon

   c. Third quarter ground water monitoring, November 4 and 5, 1985

      - PCBs (five wells only) and total and amenable cyanide, fluoride, nitrate, total and hexavalent chromium, selenium, total organic carbon, and total organic halogens

   d. Fourth quarter ground water monitoring, January 28 to 30, 1986

      - Total and amenable cyanide, fluoride, nitrate, total and hexavalent chromium, selenium, total organic carbon, and total organic halogens

   e. Final quarter ground water monitoring, November 18 to 20, 1986

      - HSL organic parameters (both production wells and upper zones in monitoring wells), total and amenable cyanide, fluoride, and nitrate, and 14 metals (both production wells and upper and lower zones in monitoring wells)

   f. Limited ground water monitoring, January 27 to 29, 1987

      - Hexavalent chromium and mercury

G. Preparation of the RI/FS Report

   1. Draft, Revision 0.0, May 1987
      Draft, Revision 1.0, August 1987

1.0 INTRODUCTION

IT Corporation (IT) was contracted by ARCO Chemical Company (ARCO) to conduct a Remedial Investigation (RI) at the former Alsco-Anaconda NPL site herein referred to as the ARCO Gnadenhutten Ohio plant site.

1.1 SITE BACKGROUND INFORMATION

Gnadenhutten, a community of about 1,320 residents, is located in Tuscarawas County, about 49 miles south of Akron, Ohio. The former ARCO Alsco plant, a fully integrated mill product and extrusion facility that produces painted and unpainted architectural aluminum building products, is located within the Gnadenhutten village limits on 23.6 acres along the flood plain of the Tuscarawas River (Figure 1-1). The present Alsco plant occupies 18.9 acres of the original 23.6 acres excluding 4.8 acres retained by ARCO (Figure 1-2). Structures at the former ARCO facility include an aluminum processing plant, an office building, a security and scale house, a wastewater treatment plant, a sludge settling basin, and a sludge disposal pit (Figure 1-2). Water resources upgradient and within one mile of the site include the Tuscarawas River, and the Gnadenhutten municipal well field. Several private water wells are located approximately three quarters of a mile downgradient of the site (Figure 1-1).

1.1.1 Site History

During the period from 1965 to 1978, the settling basin and sludge pit were used for the disposal of chromium- and cyanide-containing sludge, which consists mostly of aluminum oxyhydroxides, calcium carbonate, calcium sulfate, and water. As a result of effluent overflow from the basin and plant wastewater discharge, sludge is now located in a wooded marsh (swamp) area, adjacent to the settlement basin to this area. Because of a concern for the potential contamination of water resources from the sludge leachate, the site was proposed for inclusion on the National Priorities List (NPL) of sites eligible for cleanup under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) in October 1984. The site was formally placed on the NPL in June 1986. The chronology of the Alsco-Anaconda NPL site is summarized in Table 1-1.

In December 1986, ARCO sold the Alsco plant to Pony Industries, Inc., a subsidiary of Horsehead Industries, Inc., however, ARCO retained ownership of the portions of the plant site that were used for sludge disposal and that are included on the NPL. This approximately 4.8-acre area, including the settlement basin (impoundment), sludge pit, swamp, and adjacent land up to the Tuscarawas River constitutes the Alsco-Anaconda NPL site as referred to in this report (Figure 1-2). The Alsco-Anaconda NPL site is bounded by the Tuscarawas River, the Penn-Central Railroad right-of-way, the Alsco manufacturing building and parking lot, and Anaconda Drive (County Road 39) on the southwest, northwest, northeast, and southeast, respectively.

1.1.2 Regional Physiography, Geology, and Hydrogeology

Gnadenhutten is located in east-central Ohio within the unglaciated Kanawha section of the Appalachian Plateaus physiographic province (Fenneman, 1946; Goldthwait and others, 1967). The plant site occupies a portion of the Tuscarawas River valley flood plain, which is about 1.5 miles wide and which is relatively flat, with valley floor elevations from 820 to 850 feet above mean sea level (MSL) in the vicinity of Gnadenhutten (Figure 1-1). Within a two-mile radius of the site, peak elevations approach 1,250 feet above MSL.

Subsurface materials in the Tuscarawas River valley consist of unconsolidated fluvial silt and sand deposits, along with glacial outwash sands, silts, and gravels. This valley fill overlies relatively flat-lying sedimentary bedrock, mostly shale and sandstone with minor beds of limestone and coal (Brownocker, 1947; Lamborn, 1956), generally occurring greater than 160 feet below the site surface. The surficial deposits of sand and gravel and bedrock formations of shale, limestone, and coal are mined locally. Within a two-mile radius of the site, there are several sand and gravel pits in the valley bottom and coal strip mines in the valley sides.

The unconsolidated alluvial valley deposits form extensive aquifers (Cummins, 1959) which are the principal water supplies for municipalities in the valley. A regional water table map (Figure 1-3) based on available data from the Ohio Department of Natural Resources (ODNR) shows that the water table configuration is a subdued expression of the topography, generally with a flat surface interrupted by cones of depression in the valley and an irregular,

steep gradient leading to ground water divides through the uplands. Ground water flow from the uplands is toward the Tuscarawas River Valley. Ground water flow in the valley is generally southwestward (downriver) except in the general vicinities of municipalities such as Tuscarawas, Warwick, Gnadenhutten, and Seventeen.

Nine 50-foot-deep ground water monitoring wells were installed at the Alsco-Anaconda NPL site to characterize the local ground water quality and flow direction. The nine monitoring well borings each encountered the coarse alluvial valley deposits (mainly medium dense sands and fine gravels with some lenses of sand and silt as shown in Appendix C). One site production well (PW-5) boring encountered similar materials to a depth of 159 feet (Ohio Drilling Company, 1980). None of the site wells encountered bedrock. Water table measurements from these on-site wells indicate the local flow is generally to the southwest toward the Tuscarawas River, with the exception of inward-radial flow proximal to Pumping Well PW-5.

1.2 NATURE AND EXTENT OF THE PROBLEM

Waste streams associated with the aluminum siding manufacturing process at the ARCO facility included wastewater and a wastewater treatment sludge from the conversion coating of aluminum forms as pretreatment for painting. This sludge is a process waste which is included in the Resource Conservation and Recovery Act (RCRA) list of hazardous wastes (F019), because the sludge contains chromium and cyanides.

1.2.1 Current and Potential Situation

During the period from 1965 to 1978, the sludge was deposited on site mainly in the settlement basin (impoundment) and sludge pit, where it accumulated to present quantities. The impoundment and sludge pit combined occupy approximately four-tenths of an acre. The depth of the sludge in these unlined excavations is approximately eight feet in the impoundment and seven feet in the sludge pit. The estimated total volume of sludge in both excavations is 5,570 cubic yards. In addition, nearly 1.2 acres of the swamp area adjacent to the impoundment are covered by sludge, with an average thickness of about 1.7 feet. The estimated volume of sludge in the swamp is 3,280 cubic yards. Assuming an average density of 1,100 pounds per cubic

yard, the total sludge volume of 8,850 cubic yards at the Alsco-Anaconda NPL site would weigh nearly 4,868 tons.

The sludge consists mostly of aluminum oxyhydroxides, calcium carbonate, calcium sulfate, and water with lesser amounts of various other inorganic and organic constituents. Trace component concentrations vary depending on activities, processes, or sources that differed over time. In addition to cyanide and chromium, the sludge was found to contain several other potentially hazardous or toxic substances, including fluoride, nitrate, volatile organic compounds, and polychlorinated biphenyls (PCBs).

The nature of the problems associated with these constituents depends on the environmental distribution of hazardous chemicals and on the potential for the migration of contaminants to potential receptors. Because some of the sludge is present in areas subject to flooding, the potential for mass movement exists. The Gnadenhutten municipal water supply derived from wells upgradient from the site and not the Tuscarawas River. Therefore, potential impacts from the unmitigated site are greatest for the Tuscarawas River biota, fishermen, trappers, and others that may contact the contaminated waste.

1.2.2 Historical Waste Management Practices

Prior to 1965, neutralized process wastewater was discharged directly to the Tuscarawas River. Historical information indicates that wastewater discharge from the aluminum conversion coating process was approximately 400 gpm and had suspended solids concentration of about 125 parts per million (ppm). The suspended solids primarily consisted of sodium aluminate and aluminum hydroxide, which were precipitated from etching process wastewater. The sodium aluminate was derived from the reaction of sodium hydroxide with the dissolved aluminum. Hexavalent chromium was also present as neutral sodium chromate. Sodium chromate was formed by neutralization of chromic acid residues present in the wastewater from the chromic acid treatment of aluminum.

The settlement basin was completed in 1965 at the request of the State of Ohio Department of Health and, during the period from 1965 to late 1972, was used to remove the settleable solids from the coating process wastewater. Prior to

1972, the aluminum pretreatment wastewater were discharged directly to the Tuscarawas River under Industrial Waste Permit No. 1495.2 issued by the State of Ohio Water Pollution Control Board.

Beginning in late 1972 or early 1973, Alsco began operating a chromium reduction wastewater treatment process that generated a metallic hydroxide sludge, primarily consisted of aluminum hydroxide and trivalent chromium hydroxide, plus calcium carbonate and calcium sulfate.

The precipitation of the metal hydroxide sludge took place in the settlement basin and the clear overflow was discharged to the adjacent Tuscarawas River under a National Pollutant Discharge Elimination System (NPDES) permit issued in 1972. The wastewater entered the impoundment on the south side where the larger and heavier particles were expected to settle. The clear overflow discharged from the north side of the impoundment where the finer precipitates were expected to settle. Periodically, as the settlement basin filled with wastewater treatment sludge, a dragline was used to remove the sludge for disposal in an adjacent sludge pit. The aluminum pretreatment wastewater was treated in this manner until 1978, when a plate and frame filter press was installed in the wastewater treatment building for the removal and dewatering of sludge.

Since 1978, no solid wastes have been placed in the impoundment or sludge pit; wastewater treatment sludges have been mechanically dewatered on site and shipped to an off-site facility for disposal. However, the treated wastewater discharge route included the impoundment until October 1980, when the effluent discharge was rerouted around the impoundment to the swamp, which drained to the river. The treated process wastewater has been discharged to the Tuscarawas River through an NPDES permitted outfall since 1972.

Prior to 1978, when the settlement basin and sludge pit were an active part of the wastewater treatment process, three chemical pretreatment lines contributed to the system. Two of these lines were used to process aluminum coil while the third line treated aluminum extrusions. The purpose of each pretreatment line was to prepare the aluminum for subsequent painting operations by cleaning (etching) the metal and applying an amorphous chromate coating to

enhance corrosion resistance and to provide a basis for paint adhesion. Following the pretreatment processes, the aluminum coils or extrusions were transferred by lift truck to the painting operations located elsewhere in the plant.

The etchants consisted primarily of sodium hydroxide and detergents. The chromate coating solutions consisted of mixtures of hexavalent chromium as chromic acid, hydrofluoric and nitric acids, and ferro-ferri cyanide which was used as a catalyst (accelerator). The drag from the three pretreatment lines contained small amounts of chromic, hydrofluoric, and nitric acids plus cyanide as well as the reaction products from the conversion coating process. The continuous overflows and periodic bath discharges from the pretreatment lines were routed into a drain system, which was isolated from the general plant sewer system and which carried the waste effluent directly to the wastewater treatment building.

In October 1986, the outflow from the wastewater treatment plant was rerouted away from the swamp directly to a NPDES permitted outfall at the Tuscarawas River to dry the swamp area. No standing water was present in the former marsh area within one month following the diversion of the outfall. Similarly, after the effluent was diverted to bypass the settlement lagoon in 1980, standing water was eliminated in the settlement lagoon and sludge pit.

1.3 REMEDIAL INVESTIGATION SUMMARY

The purpose of the Remedial Investigation (RI) was to determine the nature and extent of contamination at the Alsco-Anaconda NPL site and the potential environmental impact of site conditions and contaminant migration.

RI activities for the Alsco-Anaconda NPL site have been conducted in accordance with CERCLA and National Contingency Plan (NCP) (40 CFR 300) guidelines and applicable U.S. Environmental Protection Agency (U.S. EPA) and Ohio Environmental Protection Agency (OEPA) requirements. Several phases of field activities, sample collection, and chemical constituent analyses were planned and conducted during the period from March 1985 through January 1987 (Table 1-2). The project tasks were performed in accordance with Revision I and Addenda I and II of the RI Work Plan and Revisions I, II, or III of the

Quality Assurance Project Plan (QAPP), documents which were prepared by IT for ARCO and which were reviewed and approved by representatives of the U.S. EPA Region V and the OEPA. These documents, together, constitute the Work Plan as referred to in this report.

The scope of the RI for the Alsco-Anaconda NPL site consisted of the following:

- Determine if ground water or surface water contamination has occurred on site and/or off site as the result of contaminant migration from the site and determine the quality, concentration, and direction of contaminant flow
- Identify any contaminated soil and/or sediment that may be present on or adjacent to the site as the result of migration from the site
- Identify specific contaminants posing acute or chronic hazards to the public health, welfare, or the environment
- Identify existing or potential pathways and receptors of contaminant migration from the site which affect or may pose a threat to the public health, welfare, or the environment (Endangerment Assessment)

The data-gathering activities necessary to meet the RI Work Plan objectives emphasized sampling of the following on-site and off-site matrices:

- Sludge pit and settlement lagoon wastes and underlying soils
- Ground water
- Swamp area sludge and underlying soil
- Tuscarawas River sediments

Each medium was sampled from multiple source locations in accordance with the Work Plan. Sample chain-of-custody procedures were followed from the time of sample collection through analysis and archiving. Initial field investigations and laboratory studies were performed in accordance with the OEPA approved March 1985, Revision I, Quality Assurance/Quality Control (QA/QC) Plan. U.S. EPA Region V, assumed primacy for regulatory review of the RI/FS

in February 1986 following the addition of the site to the National Priorities List (NPL). The U.S. EPA conducted an audit of RI laboratory data in April 1986 and ruled that the existing OEPA-approved QA/QC Plan did not meet U.S. EPA requirements and future analyses had to be performed in accordance with U.S. EPA Contract Laboratory Program (CLP) analytical procedures. The original March 1985 QA/QC Plan had specified U.S. EPA approved Safe Drinking Water Act and SW-846 laboratory procedures. As a result of the U.S. EPA audit the July 1986 Revision II Quality Assurance Project Plan (QAPP) was generated and final U.S. EPA approval of the QAPP was received November 7, 1986 (October 1986, Revision III, QAPP). All subsequent analyses were performed in accordance with CLP laboratory procedures. Table 1-2 provides an outline of the field investigation and analytical program.

The Alsco-Anaconda NPL site RI began with an initial site screening program from March through May 1985 that involved the installation of nine monitoring wells and the collection of borehole soil samples, ground water samples, and sludge and underlying soil samples from the sludge settlement basin, the sludge disposal pit, and the swamp area along the river bank that received outflow from the settlement lagoon and other plant discharges. Representative composite sludge and soil samples were analyzed for Hazardous Substance List (HSL) organic compounds, cyanide, fluoride, nitrate, hexavalent chromium, total chromium, and other total metals as well as leachable metals by the Extraction Procedure Toxicity (E.P. Toxicity) test method. Ground waters were monitored quarterly through January 1986 and again in November 1986 for HSL organic compounds, cyanide, fluoride, nitrate, chromium, and selenium, plus water levels, pH, temperature, and specific conductance.

Because PCBs were found in swamp sludge and soil samples and considering other results from the first phase RI field and analytical tasks, the second phase of sampling and analysis was planned. The second phase was conducted during the period from November 1986 through January 1987 in order to repeat sampling of the monitor wells, settlement lagoon, and sludge pit, to provide more extensive coverage in the swamp area, and to include sediment sampling from the Tuscarawas River. The ground water, sludge, and soil samples were analyzed for identical parameters tested in the first phase, except the swamp samples and the river sediments were analyzed only for PCBs, total chromium, and hexavalent chromium.

The major findings of the RI are that the ground water is not adversely affected, the sludges impounded on site are not toxic by leaching, and no adverse impact on the Tuscarawas River was found. However, the sludge samples from the southern segment of the settlement lagoon contained volatile organic contaminants. Furthermore, the swamp area sludge present a potential hazard because PCB concentrations range up to 3,000 milligrams per kilogram (mg/kg) and this area is within the 100-year flood plain.

1.4 REMEDIAL INVESTIGATION REPORT OVERVIEW

This report has been prepared to document the activities that were undertaken by IT in order to meet the objectives of the RI. The format of the RI report follows the outlines presented in the U.S. EPA documents EPA/540/G-85/002, "Guidance on Remedial Investigations under CERCLA" (U.S. EPA, 1985b), and EPA/540/G-85/003, "Guidance on Feasibility Studies under CERCLA" (U.S. EPA, 1985c).

In addition to the Executive Summary, the report comprises eight chapters, references, tables, figures, and three appendices. A brief outline of the subsequent chapters and their contents follows:

- Chapter 2.0 - Site Features Investigation: Information presented on socioeconomics, regional physiography and hydrogeology, climatology, land use, and natural resources that are relevant to the RI

- Chapter 3.0 - Hazardous Substances Investigation: Description of waste quantities and distribution and of waste component characteristics and environmental behavior

- Chapter 4.0 - Hydrogeologic Investigations: Discussion of site-specific physical and chemical characteristics of soils, geology, and ground water

- Chapter 5.0 - Surface water Investigation: Presentation of general and site-specific data on drainage patterns and Tuscarawas River hydrology and chemical quality of water and river bottom sediments

- Chapter 6.0 - Air Investigation: General information on extreme and prevailing wind conditions plus airborne contaminant characterization

- Chapter 7.0 - Biota Investigations: Survey of flora and fauna, critical habitats, land and water use, and biocontamination potential in vicinity of the site

- Chapter 8.0 - Public Health and Environmental Concerns: Endangerment assessment considering potential receptors, public health, and environmental impact

The contents of the chapters are limited to the features that are useful in characterizing site problems and potential environmental impacts.

2.0 SITE FEATURES INVESTIGATION

2.1 INTRODUCTION

The village of Gnadenhutten is located within Clay Township in Tuscarawas County, Ohio. Gnadenhutten has a population of less than 1,400 and inhabitants are employed in nearby mining, manufacturing, and agricultural industries. Both land and water resources are used by individuals and local industries. Natural resource development activities include farming, mining of coal, clay, sand and gravel, and drilling of gas and oil wells. The Tuscarawas River is used for recreation as well as for industrial and agricultural water supplies. Ground water provides municipal, domestic, and industrial water supplies. The following sections are a more detailed description of important features of Gnadenhutten and vicinity.

2.2 DEMOGRAPHY

According to the 1980 census, the village of Gnadenhutten has a population of 1,320 (Bureau of the Census, 1980). This is a ten percent decrease from the 1970 figures. Census tract data are not available for such small villages; therefore, specific age distributions, occupations, and incomes are not available. A discussion with the mayor of Gnadenhutten (Miller, March 31, 1987) revealed that a higher than average percentage of the inhabitants is over the age of 55. Mr. Miller also indicated that most of the working population is employed at the two manufacturing plants in Gnadenhutten (Alsco and Tusco Manufacturing Company) or else in industries situated approximately 10 miles north in New Philadelphia. Local clay mines have largely been closed, no longer employing local residents, and farming is a minor full-time occupation. Two local sand and gravel companies are still in operation, but they have only a few employees in Gnadenhutten.

2.3 CLIMATOLOGY

Ohio's climate is characterized by moderate extremes of heat and cold, wetness and dryness (National Oceanic and Atmospheric Administration [NOAA], 1978). The normal annual temperature for the state of Ohio ranges between 48 degrees Fahrenheit and 57 degrees Fahrenheit. Tuscarawas County has a mean annual temperature of approximately 53 degrees Fahrenheit, with average monthly temperatures ranging from approximately 31 to 74.5 degrees Fahrenheit

(measured near Coshocton, Ohio) (Ohio Department of Natural Resources [ODNR], 1968).

Mean annual precipitation in Tuscarawas County is 39 inches (ODNR, 1968), with February and October having the least precipitation and May, June, July, and August having the greatest.

The prevailing wind direction for Akron (which is the closest area to the site with historic records) is south at approximately ten miles per hour (NOAA, 1978). Severe weather in Ohio typically occurs as thunderstorms or tornadoes, with 90 percent of the tornadoes approaching from the southwest or west.

As the village of Gnadenhutten is immediately adjacent to the Tuscarawas River, flooding is a concern. In this portion of Ohio, two different types of storms produce flooding (ODNR, 1968). The first is a convectional thunderstorm occurring between late spring and early fall. It normally covers only a small area. The other type of storm occurs in the winter and covers a large area with heavy rainfall for days at a time. The worst flood on record in this area occurred in March 1913. There are no flood levels recorded for the 1913 flood in Gnadenhutten, but data from other floods, such as the 1969 flood, indicate that normal flooding would not necessarily reach the level of the Alsco-Anaconda NPL site or the village of Gnadenhutten. However, as shown in Figure 1-2, 100-year flood levels would reach the elevation of the Alsco-Anaconda NPL site (estimated 100-year flood level is 827 feet mean sea level [MSL] ([Army] Corps of Engineers, 1973).

2.4 LAND USE

2.4.1 Regional Land Use

Tuscarawas County, which includes the town of Gnadenhutten, is largely developed for agriculture. In 1964, approximately 200,000 acres were used for farming and constituted 57 percent of the total land area of the county (ODNR, 1968). Farms are concentrated mainly in the floodplain areas. Agricultural products include dairy products, cattle, poultry, hogs, truck crops and fruit, corn, wheat, soybeans, sheep and wool, oats, and hay.

The mining industry exploits the Pennsylvanian Pottsville sedimentary rock units and unconsolidated Pleistocene glacial valley fill deposits. In 1965, 2,960 tons of coal per year were removed from Tuscarawas County, 449 tons of sand, 513 tons of gravel, 57 tons of crushed sandstone, 39 tons of limestone, 738 tons of clay, and 227 tons of shale (ODNR, 1968).

In 1965, oil and gas wells completed in all of Tuscarawas County for that year accounted for only a little over one percent of the state's total production wells. Petroleum exploration activities have varied over time with a resurgence in the early 1970s, and then a decline in the early 1980s. In the past 12 to 18 months, additional producing oil and gas wells have been drilled in the vicinity of Gnadenhutten (Figure 1-1) and are currently in operation.

2.4.2 Local Land Use

In the village of Gnadenhutten, most of the agriculture consists of subsistence or additional-income farming, not sole-source income farming. The two main commercial facilities in the village are the Alsco plant, which employs upward to 350 people, and the Tusco Manufacturing Company, which employs approximately 100 people and produces steel products such as shelving, boat seats, and other items. Local clay mining companies, which had employed local residents, are now closed. Two sand and gravel companies are still in operation: Stocker Sand and Gravel Company and Wrightman Sand and Gravel Company.

2.5 NATURAL RESOURCES

2.5.1 Land Resources

In Ohio, units belonging to the Pennsylvanian system generally crop out in 39 counties (Lamborn, 1956). Pennsylvanian units in the Appalachian basin generally consist of interbedded units of sandstone, shale, clay, limestone, and coal. In Tuscarawas County, bedrock exposed at the surface is all of Pennsylvanian Age. The strata have a thickness of about 650 feet (Lamborn, 1956).

In Clay Township, which includes Gnadenhutten village, the Brookville, Lower Freeport, Lower Kittanning, Middle Kittanning, and Upper Freeport coals are

exposed. Of these coals, only the Lower Kittanning coal, which was formerly mined, and the Middle Kittanning coal, which is presently mined, are economic sources of coal. The Middle Kittanning coal has been mined in and near Gnadenhutten in the past, as evidenced by abandoned strip mines within a two-mile radius of the site (Figure 1-1).

Of the various clay units in this vicinity, the Lower Kittanning and Brookville clays have been mined for utilization in local plants. These abandoned clay mining operations are still located on the U.S. Geological Survey (USGS) Gnadenhutten topographic map (USGS, 1962, photo revised 1978) and are partially shown in Figure 1-1.

In some areas of the township, surficial sand and gravel deposits are also mined, such as those mined by Wrightman Sand and Gravel Company and Stocker Sand and Gravel Company, which is currently in operation about 0.5 mile from the Alsco-Anaconda NPL site.

Oil and gas wells have been drilled into the Berea and Oriskany sands near Gnadenhutten. Very little oil and gas was discovered in these units (Lamborn, 1956). However, the Clinton sandstone, located approximately 5,050 feet below land surface, is a much better source of oil and gas (Burgess and Niple, 1984), and available logs indicate oil and gas wells near Gnadenhutten are completed in the Clinton Sandstone at an average depth of 5,060 feet. According to the mayor of Gnadenhutten, there has been successful drilling activity over the past 12 to 18 months. There is currently no information to indicate to what depth these wells were drilled.

2.5.2 Water Resources

The Tuscarawas River flows immediately adjacent to the Alsco-Anaconda NPL site and forms the southwest Gnadenhutten village limit. The Tuscarawas is not on Ohio's Scenic Rivers list (ODNR, April, 1985); it is classified as a warm water habitat and is used for recreation, such as fishing, boating, and swimming. The river is also utilized as an agricultural and industrial water supply.

The village of Gnadenhutten does not, however, use the Tuscarawas River as a drinking water supply. Instead, most of the local water is obtained from municipal water wells or several private ground water wells (Appendix C). Ground water resources in Tuscarawas County are best developed in the Tuscarawas River Valley, where the wells yield an average of 500 gpm. Outside of the buried river valley sediments, yields are normally 5 to 25 gpm (ODNR, 1968.) Therefore, Gnadenhutten is ideally located to make use of local ground water resources.

3.0 HAZARDOUS SUBSTANCES INVESTIGATION

3.1 INTRODUCTION

The RI field and analytical program emphasized the collection and analysis of environmental media potentially containing HSL and Safe Drinking Water Act (SDWA) chemical constituents. The semisolid waste sludge in the northern and southern impoundment areas (settlement basin), sludge pit, and swamp areas (Figure 1-2) was collected on three different occasions in anticipation of finding SDWA inorganic chemicals including hexavalent chromium, cyanide, fluoride, and nitrate, which result from aluminum anodizing processes in the painting operations. The impoundment and sludge pit were also considered as potential receptacles for improperly disposed paints and associated solvents containing HSL organic compounds.

Migration routes for the potential sludge contaminants include airborne particulates and volatiles, surface water runoff, and ground water flow. Volatile and soluble constituents would tend toward depletion from the sludge as they migrated into the surrounding environment. Of the different migration routes, both surface and ground water transport pertain to the waste and site conditions such that the sludges have been in place, open to the atmosphere and/or below the water table, for nearly a decade. Because any airborne materials would disperse relatively quickly and widely compared with water and sediment-bound materials, the environmental media considered for the RI include the sludge, undersoil, ground water, and river sediments.

3.2 WASTE TYPES

Waste streams associated with the aluminum siding manufacturing process at the Alsco facility included wastewater and wastewater treatment sludge from the conversion coating of aluminum forms as pretreatment for painting. This sludge is a process waste which is included in the RCRA list of hazardous wastes (F019), because the sludge contains chromium and cyanide.

Prior to 1965, neutralized process wastewater was discharged directly to the Tuscarawas River. Historical information indicates that wastewater discharge from the aluminum conversion coating process was approximately 400 gpm and had a suspended solids concentration of about 125 ppm. The suspended solids

primarily consisted of sodium aluminate and aluminum hydroxide, which were precipitated from etching process wastewater. The sodium aluminate was derived from the reaction of sodium hydroxide with the dissolved aluminum. Hexavalent chromium was also present as neutral sodium chromate. Sodium chromate was formed by neutralization of chromic acid residues present in the wastewater from the chromic acid treatment of aluminum.

The settlement basin was completed in 1965 at the request of the State of Ohio Department of Health and, during the period from 1965 to late 1972, was used to remove the settleable solids from the coating process wastewater. Prior to 1972, the aluminum pretreatment wastewater was discharged directly to the Tuscarawas River under Industrial Waste Permit No. 1495.2 issued by the State of Ohio Water Pollution Control Board.

Beginning in late 1972 or early 1973, Alsco began operating a chromium reduction wastewater treatment process that generated a metallic hydroxide sludge. The existing impoundment was converted into a sedimentation basin for removal of the metallic hydroxide sludge from the process wastewater. The metallic hydroxide sludge primarily consisted of aluminum hydroxide and trivalent chromium hydroxide, plus calcium carbonate and calcium sulfate.

The wastewater treatment operation that generated the sludge was a typical chromium reduction process: the pH of the wastewater was lowered to 2.5, sulfur dioxide gas was added to reduce the hexavalent chromium to the trivalent form, then the pH was raised to 8.5 through the addition of a lime slurry. The trivalent chromium was then precipitated out of solution via the following reaction:

$$Cr_2(SO_4)_3 + 3Ca(OH)_2 \rightarrow 2Cr(OH)_3\downarrow + 3CaSO_4$$

The precipitation of the metal hydroxide sludge took place in the settlement lagoon and the clear overflow was discharged to the adjacent Tuscarawas River under a NPDES permit. The wastewater entered the impoundment on the south side where the larger and heavier particles were expected to settle. The clear overflow discharged from the north side of the impoundment where the finer precipitates were expected to settle. As the settlement basin filled

with wastewater treatment sludge, a dragline was used to remove the sludge for disposal in an adjacent sludge pit. Alsco treated its aluminum pretreatment wastewater in this manner until 1978. Since 1978, wastewater treatment sludges have been mechanically dewatered on site using a filter press and shipped to an off-site facility for disposal. No solid wastes have been placed in the impoundment or sludge pit since 1978. However, the treated wastewater discharge route included the impoundment until October 1980, when the effluent discharge was rerouted around the impoundment to the swamp, which drained to the river. The treated process wastewater has been discharged to the Tuscarawas River through an NPDES permitted outfall since 1972.

Prior to 1978, when the settlement basin and sludge pit were an active part of the wastewater treatment process, three chemical pretreatment lines contributed to the system. Two of these lines were used to process aluminum coil while the third line treated aluminum extrusions. The purpose of each pretreatment line was to prepare the aluminum for subsequent painting operations by cleaning the metal and applying the amorphous chromate coating to enhance corrosion resistance and to provide a basis for paint adhesion. Following the pretreatment processes, the aluminum coils or extrusions were transferred by lift truck to the painting operations located elsewhere in the plant.

The two aluminum pretreatment lines each consisted of five stages:

- Stage 1 - Caustic Etch
- Stage 2 - Water Rinse
- Stage 3 - Chromate Solution Treatment
- Stage 4 - Water Rinse
- Stage 5 - Acidulated Water Rinse.

The extrusion pretreatment line consisted of the following stages:

- Stage 1 - Caustic Cleaning
- Stage 2 - Water Rinse
- Stage 3 - Phosphoric Acid Deoxidizing
- Stage 4 - Chromate Solution Treatment
- Stage 5 - Water Rinse
- Stage 6 - Water Rinse.

The chemicals used in these treatment lines were the Alodine 1200E system for coils and the Alodine 407-47 system for extrusions, both products of the Amchem Corporation.

The etchants consisted primarily of sodium hydroxide and detergents. The chromate coating solutions consisted of mixtures of hexavalent chromium in the form of a chromic acid, hydrofluoric and nitric acids, and ferro-ferri cyanide which was used as a catalyst (accelerator). The overflows from the lines contained small amounts of these chemicals as well as the reaction products from the conversion coating treatment.

The continuous overflows and periodic bath discharges from the above three pretreatment lines drained into a sewer system isolated from the general plant drain system. This isolated drain system carried the waste effluent directly to the wastewater treatment building. In October 1986, the outflow from the wastewater treatment plant was rerouted away from the swamp directly to a NPDES permitted outfall at the Tuscarawas River in order to dry out the swamp area. Standing water was not present in the former marsh area within one month following the diversion of the outfall. Similarly, after the effluent was diverted to bypass the settlement lagoon in 1980, standing water was eliminated in the settlement lagoon and sludge pit.

3.2.1 Waste Distribution and Quantities

Until 1978, when the wastewater treatment plant was fitted with a sludge-dewatering filter press, the metallic sludge was deposited on site, mainly in the settlement basin and sludge pit, where the sludge accumulated to present quantities. The impoundment and sludge pit combined occupy approximately four-tenths of an acre. The depth of the sludge in these unlined excavations is approximately eight feet in the lagoon and seven feet in the sludge pit (Table 3-1). The estimated total volume of sludge in both excavations is 5,570 cubic yards. In addition, nearly 1.5 acres of the swamp area adjacent to the lagoon are covered by sludge, with an average thickness of about 1.7 feet. The estimated volume of sludge in the swamp is 3,280 cubic yards. Figure 3-1 shows the approximate thickness of sludge over the Alsco-Anaconda NPL site. Assuming an average density of 1,100 pounds per cubic yard, the total sludge volume of 8,850 cubic yards at the Alsco-Anaconda NPL site would weigh nearly 4,868 tons.

Due to concern that waste-filled drums may have been buried in the past under the currently paved company parking lot, an investigation of this area was

undertaken. On October 2, 1986, an approximately 90-foot-long exploratory trench was completed through the Alsco parking lot. Representatives from the U.S. EPA, OEPA, ARCO, and IT witnessed the excavation. No buried drums or waste sludges were found, nor were any organic vapors detected. No further investigation of this area was considered to be necessary.

3.2.2 Sludge Sampling and Analysis

The distribution and quantities of sludge in the impoundments and the swamp area were determined from field investigations and sludge sampling conducted to evaluate the composition and extent of contamination of the sludge and undersoil. The sludge and undersoil sampling was performed according to the following schedule at the locations shown in Figure 3-1:

- Sludge Pit
  - April 1985: Test pits TP-1 through TP-5
  - November 1986: Auger sample locations S-1 through S-4
  - January 1987: Auger sample locations S-1 through S-5
- Settlement Basin
  - April 1985: Test pits TP-6 through TP-13
  - November 1986: Auger sample locations S-1 through S-6
  - January 1987: Auger sample locations S-1 through S-6
- Swamp Area
  - April 1985: Forty samples on 75-by-50-foot grid
  - November 1986: One hundred and forty samples on 37.5-by-25-foot grid
  - January 1987: One hundred and forty samples on 37.5-by-25-foot grid
  - March 1987: Forty-eight samples on 37.5-by-25 and 18.75-by-12.5-foot grid

3.2.2.1 Sludge Sampling and Analysis - April 1985

Impoundment and Sludge Pit

Sludge and underlying soils were sampled within the impoundment and sludge pit by test pit excavations using a backhoe. The March 1985 RI Work Plan originally specified the excavation of eight test pits within the impoundment and six test pits within the sludge pit. Because it was believed at the time that the sludge was stratified into four discrete layers, a total of 56 sludge

samples (four samples per test pit) and 14 underlying soil samples (one sample per test pit) were to be collected.

However, several changes were made to the sludge sampling plan for the impoundment and sludge pit based on field conditions. Changes were made to the location of the test pits (as originally shown in Figure 3-2 of the March 1985, RI Work Plan) due to the limitations of the topography around the impoundment and sludge pit upon backhoe access for test pit excavation (Figure 3-2). As a result five test pits, instead of the original six, were excavated in the sludge pit.

Although the sludge was found to be stratified as originally stated in the work plan, in most cases, four discrete sludge layers could not be identified in the field. Samples were taken whenever changes in the sludge could be recognized and, as a result, a total of 27 sludge samples (eight from the northern impoundment area, nine from the southern impoundment area, and ten from the sludge pit) and 20 underlying soil samples, (13 from the impoundment areas, and seven from the sludge pit) were collected.

One undisturbed Shelby tube sample of sludge from both the northern impoundment area and the sludge pit were collected along with Shelby tube samples of the underlying soils in the northern and southern impoundment areas and the sludge pit. The Shelby tube samples were collected for permeability testing.

Three sludge composite samples were prepared from equal portions of the sludge samples for laboratory analysis to determine the parameters of concern in the sludge. One composite was generated from the ten sludge samples collected from the sludge pit; one composite from the eight samples collected from the northern segment of the impoundment; and one composite from the nine sludge samples collected from the southern segment of the impoundment. The three composite samples were analyzed for total constituents, U.S. EPA Extraction Procedure (E.P.) Toxicity Test Method leachate constituents, and U.S. EPA CLP HSL organic compounds as described in Table 3-2 in accordance with the work plan. Soluble or extractable fluoride was determined in lieu of total fluoride due to the nature of the analysis, since naturally occurring mineralogical fluoride is not extracted by the analysis.

Because four stratified layers could not be identified in the sludge during field operations and sample collection, 13 vertical sludge composite samples were generated; one from each of the test pits excavated in the sludge pit and settlement lagoon as shown in Figure 3-2. The vertical sludge composites were leached by the E.P. Toxicity Test Method and the resulting leachate was analyzed for the same parameters as described above for the three sludge composite leachates (Table 3-2).

Based on the results of the three sludge composites and E.P. toxicity on the vertical sludge composites, selected individual sludge samples from test pits TP-1 through TP-13 were analyzed for the following identified parameters of concern:

- Cyanide, Amenable
- Cyanide, Total
- Fluoride
- Chromium, Hexavalent
- Iron
- Manganese
- Silver.

The physical characteristics of the 13 vertical sludge composites, as they relate to handling and stabilization characteristics, were determined from moisture content determinations and qualitative liquid limit analyses.

One undisturbed sample of sludge from both the sludge pit and the northern segment of the settlement lagoon were used to determine sludge permeability in accordance with the work plan. An undisturbed sludge sample from the southern segment of the settlement lagoon was not available for permeability testing. The sources of the undisturbed sludge samples used for permeability testing are as follows:

- Test Pit No. 5, 1 to 3.5 foot depth, sludge pit
- Test Pit No. 7, 0.5 to 3.0 foot depth, northern segment of the impoundment.

In addition to the analysis of the three sludge composites, a subsurface water sample was collected from Test Pit No. 11, three feet below the sludge surface. This water was analyzed for total chromium to be used as an indicator for chromium concentrations in the sludge leachate.

Two soil composite samples were prepared from equal portions of the soil samples for analysis in the laboratory to determine the same parameters as described above for the sludge composite samples (Table 3-2). One composite was generated from the 7 soil samples underlying the sludge in the sludge pit and one composite was generated from the 13 soil samples underlying the sludge in both the northern and southern segments of the settlement lagoon. As previously discussed, the number and location of the above soil samples is at variance with the RI Revision I Work Plan due to access restrictions around the sludge pit and settlement lagoon. Soil samples were collected whenever changes in physical consistency were observed.

Three undisturbed soil samples, each representing the respective underlying soil from the sludge pit and the northern and southern segments of the impoundment, were used for permeability testing:

- Soil between Test Pit Nos. 2 and 3, 7.5 foot depth, sludge pit
- Test Pit No. 7, 7.1 foot depth, northern segment of the impoundment
- Test Pit No. 11, 6.0 foot depth, souther segment of the impoundment.

Swamp Area

At the request of OEPA, an additional sampling area was required outside the impoundment area as depicted in Figure 3-2. The swamp sludge was observed in the field by OEPA, ARCO, and IT personnel; the sludge was visible in an area downgradient of the former impoundment discharge weir.

The sampling plan developed for this area included a 50-by-75-foot sampling grid, which was laid out in the field to establish sampling locations. A total of 22 points were sampled using a hand auger. At each sampling location, samples of sludge material as well as underlying soils were collected. A total of 22 sludge samples and 18 underlying soil samples were obtained from this area.

Sludge and soil samples were collected at the request of OEPA from the swamp area downgradient of the former settlement lagoon discharge weir. One sludge

composite and one underlying soil composite were generated from equal portions of each respective sludge and soil sample collected from the swamp area with the following exceptions: sample areas B-2,0, B-4,0 and B-4,1 do not contain a sludge layer and accordingly were excluded from the sludge composite. Pursuant to the May 24, 1985 Addendum to the RI Revision I Work Plan, the two composites were analyzed in accordance with the program defined in Table 3-2 for the sludge and soil composites collected from the impoundment and sludge pit. Initially no organic analyses were to be performed (May 24, 1985 Addendum I) but subsequent OEPA modifications to the work plan added EPA CLP HSL organic compounds to the sludge and soil composite programs. A summary of the swamp area analytical program is presented in Table 3-2.

Additionally, based upon the finding of PCBs in the swamp area sludge and soil composite samples, a phased PCB analysis program was implemented for this area. Selected individual sludge and soil samples were analyzed for PCBs. Due to the presence of PCBs in both the soil and sludge composite, the remaining individual samples were analyzed for PCBs with the exception of soil samples B-4,0 and B-4,1 which were withheld from analysis. Soil samples B-4,0 and B-4,1 were not analyzed for PCBs because these sampling locations were not overlain with sludge as the other swamp sampling locations. Considering the PCB analytical results, PCB contamination in the swamp area appeared to be restricted to the surface sludge.

3.2.2.2 Sludge Sampling and Analysis - November 1986

Impoundment and Sludge Pit

To respond to the U.S. EPA and IT laboratory audit findings, IT resampled and analyzed the sludge and underlying soil in the impoundment and sludge pit to confirm the previously generated analytical data and to satisfy U.S. EPA concerns regarding the accuracy of portions of the analytical data. Additional borings were drilled using a hand auger in the northern and southern segments of the impoundment and the sludge pit for a total of 10 borings as follows:

- Northern segment of the impoundment; three borings
- Southern segment of the impoundment; three borings
- Sludge pit; four borings.

The locations of the borings are presented in Figure 3-2. The boring and previous test pit locations varied because the impoundment and sludge pit could not support heavy excavation equipment and equipment access to the perimeter of the impoundment and sludge pit was limited.

As observed during previous field investigations, the sludge was sometimes stratified and samples were accordingly collected at two-foot intervals and whenever changes in the sludge material were observed during boring. Samples of the underlying soils in each boring were also collected and the dimensions and depth of the sludge in each impoundment were recorded.

The following samples of sludge and soil were collected from the impoundment and sludge pit:

- Northern Impoundment Area
  - Sample Location S-1: 5 sludge and 2 soil samples
  - Sample Location S-2: 5 sludge and 2 soil samples
  - Sample Location S-3: 2 sludge and 2 soil samples
- Southern Impoundment Area
  - Sample Location S-4: 3 sludge and 1 soil sample
  - Sample Location S-5: 5 sludge and 1 soil sample
  - Sample Location S-6: 5 sludge and 2 soil samples
- Sludge Pit
  - Sample Location S-1: 3 sludge and 1 soil sample
  - Sample Location S-2: 5 sludge and 1 soil sample
  - Sample Location S-3: 6 sludge and 1 soil sample
  - Sample Location S-4: 5 sludge and 2 soil samples

Equal portions of the sludge samples were separately composited for the northern and southern portions of the impoundment and the sludge pit as follows:

- Sludge Composite No. 1 - All sludge samples collected in the three borings in the northern segment of the impoundment
- Sludge Composite No. 2 - All sludge samples collected in the three borings or test pits in the southern segment of the impoundment
- Sludge Composite No. 3 - All sludge samples collected in the four borings in the sludge pit.

Equal portions of the underlying soils in the impoundment and the sludge pit were separately composited to generate a total of three soil composites as follows:

- Soil Composite No. 1 - All underlying soil samples collected from the three borings in the northern segment of the impoundment
- Soil Composite No. 2 - All underlying soil samples collected from the three borings in the southern segment of the impoundment
- Soil Composite No. 3 - All underlying soil samples collected from the four borings in the sludge pit.

Sludge and soil composites were analyzed for the following parameters:

- pH (1:1)
- Cyanide, total
- Fluoride, total
- Nitrate, water leachable
- Aluminum
- Arsenic
- Barium
- Cadmium
- Chromium, hexavalent
- Chromium, total
- Iron
- Copper
- Lead
- Manganese
- Mercury
- Selenium
- Silver
- Zinc.

The E.P. Toxicity Test Method was also performed on the sludge and underlying soil composites. The E.P. toxicity leachates generated were analyzed for the above parameters.

A vertical sludge composite was generated from equal portions of the individual samples collected from each of the ten borings in the impoundment and sludge pit (three borings each in the northern and southern impoundment areas and four borings in the sludge pit). The ten vertical sludge composites generated in this manner were analyzed for the HSL organic compounds in accordance with the QAPP. The underlying soil samples from each of the three

borings in the southern segment of the impoundment were also individually analyzed for HSL organic compounds. The moisture content of each composite was also determined to allow reporting on a dry-weight basis.

Swamp Area

A more extensive sampling and analysis program was carried out in the swamp area to better define the levels and areal extent of polychlorinated biphenyls (PCBs). The previous sampling plan developed for this area included a 50-by-75-foot sampling grid system, which was laid out in the field to establish sampling locations. At each grid node, individual samples of the surface sludge material and the underlying soil were collected using a hand auger. A total of 22 sludge samples and 18 underlying soil samples were obtained from this area.

The November 1986 sampling plan superimposed a smaller 25-by-37.5-foot grid spacing over the previously used 50-by-75-foot grid system in areas where high PCBs concentrations were known or expected to exist to further refine existing information (Figures 3-2 and 3-3). Samples of the sludge and underlying soils were collected at each grid node including grid nodes sampled during the previous investigation. The original grid spacing system was used in areas expected to exhibit low or nonexistent PCB concentrations. Samples collected on the original grid spacing were analyzed first. When PCBs were found in expected low concentration areas, the smaller grid spacing samples were subsequently analyzed. Additionally, the grid system was extended to the south-southeast between the fenced plant perimeter and the Tuscarawas River. The area south-southeast of the existing grid system borders some of the highest concentrations of PCBs found, and sampling of this area was necessary to determine whether PCBs exist south-southeast of the previously sampled area. The sampling grid system was also extended to the river bank in an attempt to determine whether PCBs may have been transported to the river. All grid nodes were also sampled to generate sludge and underlying soil composites for general chemistry, metals, and E.P. toxicity testing.

The sampling grid system and sampling locations are presented in Figures 3-2 and 3-3. Seventy-nine sampling locations (grid nodes) were established in November 1986 for the collection of sludge and underlying soil samples.

Sampling locations were identified in the field with markers to facilitate later remedial activities.

Samples of the sludge and underlying soil were collected at each grid node using a hand auger. A single representative sample of the entire vertical thickness of the sludge at each grid node (sampling location) was collected. The underlying soil samples were collected from the 3- to 12-inch zone below the sludge. A total of 61 sludge samples and 79 soil samples were collected from 79 sampling locations for PCB and sludge characterization testing.

The above samples were analyzed to better define the concentration and extent of PCBs in the swamp area indicated in Figure 3-2. Initially, samples representing an extension of the original 50-by-75-foot grid system (approximately 10 sludge and 10 soil samples) were analyzed to extend the original grid boundaries and to define the general extent of PCBs to the southeast between the perimeter fence and the river. Once the initial PCB analyses were completed, additional samples collected utilizing a smaller 25-by-37.5-foot grid spacing were analyzed for PCBs in those areas where PCBs were found to be present.

Equal portions of the sludge and underlying soil samples collected within five areas of the sampling grid were separately composited to generate a total of five sludge and five underlying soil composite samples. The sludge samples collected at the locations indicated in Figure 3-2 were composited as follows:

- Composite No. 1, Area No. 1 - Sludge samples collected from Sampling Locations Columns 1 through 10, Rows A through E
- Composite No. 2, Area No. 2 - Sludge samples collected from Sampling Locations Columns 4 through 10, Rows F through G
- Composite No. 3, Area No. 3 - Sludge samples collected from Sampling Locations Columns 1 through 3, Rows F through J
- Composite No. 4, Area No. 4 - Sludge samples collected from Sampling Locations Columns 4 through 10 and Rows H through J

- Composite No. 5, Area No. 5 - Sludge samples collected from Sampling Locations Columns 1 through 8, Rows K through M.

The underlying soil samples (Figure 3-3) were composited as follows:

- Composite No. 6, Area No. 1 - Soil samples collected from Sampling Locations Columns 1 through 10, Rows A through E
- Composite No. 7, Area No. 2 - Soil samples collected from Sampling Locations Columns 4 through 10, Rows F and G
- Composite No. 8, Area No. 3 - Soil samples collected from Sampling Locations Columns 1 through 3 and Rows F through J
- Composite No. 9, Area No. 4 - Soil samples collected from Sampling Locations Columns 4 through 10 and Rows H through J
- Composite No. 10, Area No. 5 - Soil samples collected from Sampling Locations Columns 1 through 8 and Rows K through L.

Composites Nos. 1 through 6 (Area No. 1) represented the northwest area of the sampling grid system, based on previous PCB testing, PCBs were not expected to be present. Composites Nos. 2 and 7 (Area No. 2) represented an area between the northwestern area and the area exhibiting the highest PCB concentration (Area No. 4). Composites Nos. 3 and 8 (Area No. 3) represented the swamp area adjacent to the river. Composites Nos. 4 and 9 (Area No. 4) represented the area exhibiting the highest PCB concentrations. Composites Nos. 5 and 10 (Area No. 5) represented the southeastern area of the sampling grid system adjacent to the area of highest PCB concentration.

The above composite samples were analyzed for the following parameters:

- pH (1:1)
- Cyanide, total
- Fluoride, total
- Nitrate, water leachable
- Aluminum
- Arsenic
- Barium
- Cadmium
- Chromium, hexavalent

- Chromium, total
- Iron
- Copper
- Lead
- Manganese
- Mercury
- Selenium
- Silver
- Zinc.

The E.P. Toxicity Test leaching was performed on the ten composites, and the leachates were analyzed for the same chemical parameters as the sludge and soil composites. The moisture content of each composite sample was determined to allow reporting of analytical results on a dry-weight basis. Swamp area sludge and soil composite testing is discussed in Section 3.2.3 and reported in Tables 3-10 and 3-16.

3.2.2.3 Sludge Sampling and Analysis - January 1987

Due to nonconformances with the QAPP in the execution of the laboratory program described in Section 3.2.2.2 for the sludge and soil samples from the impoundment, sludge pit, and swamp areas, additional samples were collected in January 1987 for analysis of holding time sensitive and other selected parameters.

Impoundment and Sludge Pit

Samples were recollected at the original sampling locations using a hand auger with one exception; an additional hand auger boring S-5 was drilled and sampled in the sludge pit (Figures 3-2 and 3-3). The following samples of sludge and soil were collected from the impoundment and sludge pit:

- Northern Impoundment Area
  - Sample Location S-1: 4 sludge and 1 soil sample
  - Sample Location S-2: 4 sludge and 1 soil sample
  - Sample Location S-3: 4 sludge and 1 soil sample
- Southern Impoundment Area
  - Sample Location S-4: 4 sludge and 1 soil sample
  - Sample Location S-5: 4 sludge and 1 soil sample
  - Sample Location S-6: 5 sludge and 1 soil sample
- Sludge Pit
  - Sample Location S-1: 3 sludge and 1 soil sample
  - Sample Location S-2: 4 sludge and 1 soil sample
  - Sample Location S-3: 4 sludge and 1 soil sample

- Sample Location S-4: 3 sludge and 1 soil sample
- Sample Location S-5: 3 sludge and 1 soil sample

Equal portions of the sludge samples were separately composited for the northern and southern impoundment areas and sludge pit to generate a total of three sludge composites as described in Section 3.2.2.2. Equal portions of the underlying soils from the five borings in the sludge pit were similarly composited to generate a single soil composite. The soil samples collected within the impoundment areas were analyzed individually.

The three sludge and single soil composites and the six individual soil samples from the northern and southern impoundment areas were analyzed for the following parameters:

- Moisture content
- pH (1:1)
- Cyanide, total
- Fluoride, total
- Nitrate, water leachable
- Chromium, hexavalent
- Mercury.

The E.P. Toxicity Test Method was also performed and the leachates generated were also analyzed for the above parameters.

A vertical sludge composite was generated from equal portions of individual samples collected from each of the 11 borings (three each from the northern and southern impoundment areas and five from the sludge pit) for a total of eleven vertical composites. The composites were analyzed for HSL organic compounds and moisture content in accordance with the QAPP. The three soil samples collected in the southern impoundment area were also analyzed for HSL organic compounds. All analytical results were reported on a dry-weight basis.

Sludge Area

The 79 sampling locations (grid nodes) established for the November 1986 field investigation were resampled using a hand auger for sample compositing and analysis of time sensitive and other selected parameters. Sludge samples were composited vertically to represent the entire thickness of the sludge at each

grid node (sampling location). As with the November 1986 sampling, a total of 61 sludge and 79 soil samples were collected.

Equal portions of the sludge and soil samples collected within the five sampling grid areas (Figures 3-2 and 3-3) were separately composited to generate five sludge and five underlying soil composite samples as described in Section 3.2.2.2.

A total of ten area composite samples were analyzed for the following parameters:

- Moisture content
- pH (1:1)
- Cyanide, total
- Fluoride, total
- Nitrate, water leachable
- Chromium, hexavalent
- Mercury.

The E.P. Toxicity Test Method was also performed on the ten composite samples and the leachates generated were also analyzed for the above parameters.

3.2.2.4 Sludge Sampling and Analysis - March 1987

As requested by U.S. EPA, Region V, a total of 18 sludge and 31 additional soil samples were collected within and around the swamp area in March 1987 to provide greater detail within the area exhibiting the highest PCB concentrations and to attempt to locate any additional areas containing PCBs (Figures 3-2 and 3-3) outside the original grid limits.

The existing 25- by 37.5-foot grid system was further subdivided into 12.5-by-18.75-foot grid squares for sampling within the area surrounding Sampling Location H-10 and adjacent to the J-8 through J-10 and K-5 through K-8 sampling points (areas of highest PCB concentrations). The 25-by 37.5-foot grid system was extended downstream along the river with sampling at grid locations M-2 through M-4, N-2 through N-4, O-2 through O-3.5, and P-1 through P-3.

A total of 33 sludge and soil samples were collected and analyzed for PCBs. Soil samples O-2 through O-3.5 and P-1 through P-3 were not analyzed because

the M and N series samples indicated that PCBs did not extend beyond N-2 through N-4 sampling locations. As always, moisture contents were determined for all samples so that results could be reported on a dry-weight basis.

3.2.3 Sludge Composition and Characteristics

The sludge sampling and analytical program was a phased program with the following task objectives:

- Provide permeability data to assess infiltration into and leachate flow rates from the impoundments
- Identify the parameters of concern in the sludge to determine the constituents for subsequent sludge, soil, and ground water analyses
- Provide distribution and concentration variance data for the identified parameters of concern
- Provide data to assess vertical differences in the sludge chemical, mineralogical and physical characteristics.

Table 3-2 presents the experimental design of the sludge testing program.

During the field sampling of the sludges from the impoundment, sludge pit, and swamp areas, it was observed that the sludges contained a high water content (greasy feel), which prevented blowing dust or dry waste conditions, and were densely vegetated.

Impoundment and Sludge Pit

Permeability tests were conducted on two test pit sludge samples, one from the northern impoundment area (TP-7, 2.5 feet) and one from the sludge pit (TP-5, 3.05 feet). Three underlying soil samples (one each from the northern and southern impoundment areas and one from the sludge pit) were also tested for permeability; TP-2/TP-3, 7.5 feet, TP-7, 7.10 feet, and TP-11, 6.0 feet, respectively. Table 3-3 presents the results of the permeability testing, which indicate that the TP-5 and TP-7 sludge samples both exhibit permeabilities of 6.6×10^{-7} centimeters per second (cm/s). The silt and fine sand undersoil collected immediately below the soil exhibited permeabilities ranging from 1.4×10^{-7} to 9.6×10^{-6} cm/s.

The impoundment test pit sludge samples were also analyzed for major mineral and major elemental composition by X-ray diffraction and energy-dispersive techniques, respectively. The results for these analyses are presented in Tables 3-4 and 3-5. The X-ray diffraction analysis (Table 3-5) indicates that crystalline mineral composition of the sludge samples is predominantly calcite ($CaCO_3$), quartz (SiO_2), and gypsum ($CaSO_4 \cdot 2H_2O$), with some magnesium and aluminum mineral phases including oxides, hydroxides, and phosphates; two sludge samples were also composed of titanium and chromium minerals. The titanium is believed to be due to the presence of titanium dioxide, a common white paint pigment.

Amorphous mineral phases are not identifiable by X-ray diffraction techniques, and energy dispersive analysis was performed to identify relative elemental abundances in the sludge. Table 3-5 presents the qualitative energy-dispersive analytical results, which compare well with the mineral compositions. In general, the major elements composing the sludge samples are calcium (Ca), aluminum (Al), silicon (Si), sulfur (S), and iron (Fe), with moderate amounts of magnesium (Mg), potassium (K), chromium (Cr), and titanium (Ti). The higher relative abundance of aluminum detected in the energy dispersive analyses may be due to the presence of amorphous aluminum oxyhydroxides.

As indicated, the impoundment and sludge it were originally sampled from perimeter test pits in April 1985 (Figure 3-2). Samples were continuously collected over the full depth of the sludge and into the underlying soil at each test pit location. The collected samples were segregated by sampling location (test pit) and sample type (sludge or soil) and composited for analysis. Two compositing procedures were performed:

- Sludge and soil samples were separately composited according to waste area locations; northern settlement basin (impoundment), southern settlement basin (impoundment), and sludge pit
- Sludge samples from each test pit were separately composited to generate vertical composites at each sampling location (test pit).

Composites generated in the above manner were analyzed for parameters specific to plant processes, SDWA metals and inorganics and U.S. EPA HSL organic constituents. Because the objective of the impoundment and sludge pit sampling was to chemically and physically characterize the waste, the northern and southern impoundment and sludge pit waste area composites were analyzed for total constituent and E.P. Toxicity Test Method leachable cyanide, fluoride, nitrate, and 17 metals as presented in Table 3-6. The test pit vertical sludge composites were analyzed for E.P. toxicity cyanide, fluoride, nitrate, and 14 metals (Table 3-7) to evaluate the leachate variability of the sludge relative to the area composite leachates. Selected individual test pit sludge samples were analyzed for total constituent cyanide, fluoride, chromium, iron, manganese, and silver (Table 3-8) to assess compositional variability. Total constituent HSL organic compound analyses were performed on the three waste area sludge composites (Table 3-9) to assess the potential presence of organic contaminants.

Table 3-6 presents the total constituent and E.P. toxicity leachate inorganic results for the impoundment and sludge pit area composites. The major total constituents in the sludge composites are:

- Aluminum (22,000 to 49,000 ppm)
- Iron (10,000 to 23,000 ppm)
- Calcium (16,000 to 38,000 ppm)
- Magnesium (19,000 to 47,000 ppm)
- Chromium (3,300 to 6,100 ppm)
- Lead (23 to 170 ppm)
- Manganese (610 to 1,000 ppm)
- Silicon (180 to 350 ppm)
- Zinc (96 to 980 ppm)
- Cyanide (250 to 320 ppm)
- Fluoride (84 to 110 ppm).

Minor concentrations of arsenic, barium, cadmium, mercury, and silver were also indicated. Table 3-8 presents the results of selected total constituent analyses (cyanide, fluoride, chromium, iron, manganese, and silver) on individual test pit sludge samples collected in April 1985. These results confirm sludge composite analyses and indicate that cyanide, chromium, and fluoride are the potential parameters of concern based on sludge composition. However, sludge constituents were not leachable as evidenced by the E.P. Toxicity Test Method leachate analyses. Only total chromium exceeded

the E.P. toxicity standards (5.0 mg/l total chromium) in the northern impoundment sludge composite (9.3 mg/l in Table 3-6). All constituents in the southern impoundment and sludge pit passed E.P. toxicity standards by wide margins and in most cases leachate values compared favorably to SDWA drinking water standards at a factor of one hundredth of the corresponding E.P. standards.

The underlying soil composites for the impoundment and sludge pit generally exhibited the same major constituents as the sludge composite but at concentrations a tenth to a hundredth less than the sludge values (Table 3-6). Iron and manganese concentrations were approximately equivalent in the sludge and soil composites with concentrations within the ranges previously described for these constituents. No constituents in the soil composites exceeded E.P. toxicity standards and leachate concentrations compared favorably to SDWA standards for all constituents including chromium.

Results of the HSL organic compound analyses of the area sludge composites (Table 3-9) indicated the presence of the following constituents in the southern impoundment area: xylenes (410 ppm), ethylbenzene (110 ppm), 2-hexanone (43 ppm), toluene (5.3 ppm), naphthalene (200 ppm), isophorone (16 ppm), with minor concentrations of bis(2-ethylhexyl)phthalate (1.1 ppm), di-n-butylphthalate (0.80 ppm), N-nitrosodiphenylamine (0.45 ppm), tetrachloroethylene (0.28 ppm), and Endrin (0.066 ppm). The northern impoundment area and sludge pit composites exhibited limited organic contamination with bis(2-ethylhexyl)phthalate as the major HSL constituent at 1.5 and 2.6 ppm, respectively. Other constituents present in the sludge pit composite included: di-n-butylphthalate (0.35 ppm), Endrin (0.032 ppm), and xylenes (0.012 ppm). The presence of xylenes, ethylbenzene, toluene, and 2-hexanone in the southern impoundment sludge correlates with the titanium dioxide identified in Test Pit No. 9 to indicate that paint solvents and pigments are the probable source of these constituents.

Results of the E.P. toxicity leachate analysis of the test pit sludge composites (Table 3-7) indicate that all constituents except chromium are below the E.P. toxicity standards. Total chromium exceeded the E.P. toxicity leachate standard of 5.0 mg/l in Test Pit Composite Nos. 6 and 9 at 8.0 and

11 mg/l, respectively. However, hexavalent chromium was not the major chromium species for those sludge composites which exceeded the E.P. toxicity standard. E.P. toxicity leachate results for the test pit sludge composites were equivalent to the area sludge composites previously discussed indicating a similarity and consistency in sludge composition and general characteristics within the northern and southern impoundment areas and the sludge pit.

As previously discussed, the impoundment and sludge pit were resampled in November 1986. November 1986 impoundment and sludge pit samples were collected using a hand auger from the northern impoundment area (Sampling Location S-1 through S-3), southern impoundment area (S-4 through S-6), and the sludge pit (S-1 through S-4). Hand auger sampling locations are identified in Figure 3-2. Samples were continuously collected over the full depth of the sludge and into the underlying soil at each sampling location. As with previous sampling efforts, all sludge samples collected within the northern and southern impoundment areas and the sludge pit were to be combined to generate three area sludge composites and sludge samples collected at each sampling location were to be individually composited to generate a total of ten vertical sludge composites. Soil samples were to be composited into a total of two area composites, one each for the sludge pit and northern impoundment area, respectively, and soil samples from the southern impoundment area were to be individually analyzed. However, problems were encountered in the laboratory during execution of the intended compositing and analysis program and not all scheduled compositing and analysis was performed and in some cases analyses were performed which were not part of the project work plan. These analyses are nonetheless summarized in Tables 3-10 through 3-11 to provide additional information pertaining to sludge and underlying soil characteristics. Detailed analytical results for all parameters tested are presented in Appendix A.

Results of the impoundment and sludge pit sludge composite and individual soil analyses (Table 3-10) are consistent with previous sludge and soil analyses which indicate the presence of aluminum, cyanide, fluoride, chromium, iron, manganese, and zinc with arsenic, barium, lead, cadmium, and selenium representing trace constituents. However, all leachate parameters meet E.P. Toxicity Test Method standards and in general compare favorably to SDWA standards.

Table 3-11 summarizes the HSL organic compound results for the impoundment sludge composites and soil analyses. Sludge pit analyses were not performed on the samples collected in November 1986. Volatile HSL compounds detected in the sludge composite and individual soil samples from the northern impoundment area indicate no compounds in excess of sample detection limits except methylene chloride (0.075 to 0.63 ppm), acetone (0.075 to 0.35 ppm), and chloroform (0.062 to 0.33 ppm). 2-Butanone was also detected (0.032 to 0.21 ppm) in all the samples and laboratory method blanks (Appendix A). The most frequent compounds detected but below sample detection limits were xylenes (0.012 to 0.062 ppm), ethylbenzene (0.009 to 0.029 ppm), toluene (0.08 to 0.032 ppm) and 1,2-dichloroethane (0.008 to 0.040 ppm) with occasional occurrences of benzene (0.005 to 0.007 ppm), and 2-hexanone (0.33 to 0.055 ppm) (Appendix A).

Southern impoundment area volatile HSL compound results (Table 3-11) are similar to the northern impoundment area results presented above. Methylene chloride (0.025 to 0.78 ppm), acetone (0.077 to 0.48 ppm), chloroform (0.035 to 0.29 ppm), are the only compounds detected in excess of sample detection limits with the exception of xylenes (0.88 ppm) in the sludge composite. The sludge composite xylene value was the only compound detected significantly above both sample detection limits and laboratory method blank results. Methylene chloride, acetone, and chloroform values were equivalent to laboratory method blank results when corrected for sample concentration (dilution) factors. 2-Butanone was also detected (0.013 to 0.14 ppm) in both samples and laboratory method blanks (Appendix A). With the single exception noted above (xylene) all other compounds detected were less than sample detection limits: ethylbenzene (0.005 to 0.17 ppm), toluene (0.008 to 0.043 ppm), 1,2-dichloroethane (0.007 to 0.019 ppm), tetrachloroethylene (0.007 ppm), and benzene (0.006 ppm) (Appendix A).

HSL acid and base-neutral compound results for the northern and southern impoundment area sludge composites and soil samples (Appendix A) detected 1,3-dichlorobenzene (0.13 to 0.21 ppm), 1,4-dichlorobenzene (0.054 to 0.26 ppm), 2-methylphenol (0.16 ppm), n-nitrosophenylamine (0.043 ppm to 0.072 ppm), di-n-butylphthalate (0.053 to 0.061 ppm), and bis(2-ethylhexyl)phthalate (0.039 to 0.053 ppm), although none of the above

compounds occurred at concentrations in excess of sample detection limits. The dichlorobenzene isomers were also identified in the laboratory method blanks but below CLP method detection limits.

HSL pesticide analyses were only performed on the soil samples from the northern and southern impoundment areas. The November 1986 sludge composites were omitted from the analytical program. No pesticides were detected in any of the individual soil samples from the impoundment.

Due to nonconformances with the QAPP laboratory program for the November 1986 samples, additional sampling was performed during January 1987 and samples were composited and analyzed according to the original sampling and analytical plan to complete the data requirements omitted in the November 1986 analytical program. Table 3-12 presents the results of the selected inorganics and metals analyses for the impoundment areas and sludge pit. Total constituent analyses were similar to previous results. No parameter exceeded E.P. Toxicity Test Method standards and with only two exceptions all parameters were below SDWA standards in the E.P. toxicity leachate. The two exceptions were the southern impoundment area sludge composite leachate (fluoride 4.5 mg/l) and the sludge pit sludge composite leachate (hexavalent chromium 0.38 mg/l).

Sludge samples collected in January 1987 from the impoundment areas and sludge pit were composited on a equal weight basis to generate vertical sludge composites at each sampling location:

- Northern Impoundment Area - Locations S-1 through S-3
- Southern Impoundment Area - Locations S-4 through S-6
- Sludge Pit - Locations S-1 through S-5.

Individual soil samples were collected and analyzed from Sampling Locations S-4 through S-6 in the southern impoundment area.

Results of the volatile HSL compound analyses at the above sludge composites and soil samples are presented in Table 3-13. Methylene chloride (0.11 to 1.3 ppm), acetone, (0.22 to 1.5 ppm), and chloroform (0.088 to 0.53 ppm) were detected in both samples and laboratory method blanks at equivalent

concentrations when corrected for sample concentration (dilution) factors. 2-Butanone (0.054 to 0.2[illegible] ppm) was also detected but below sample detection limits in samples and laboratory method blanks. Only xylene was detected in the samples above sample detection limits and laboratory method blank values. The S-4 and S-6 vertical sludge composites from the southern impoundment areas exhibited xylenes concentrations of 1.7 and 0.50 mg/kg or ppm, respectively.

All other compounds detected were below sample detection limits (Appendix A): toluene (0.13 to 0.26 ppm), ethylbenzene (0.047 to 0.17 ppm), trichloroethylene (0.024 to 0.052 ppm), and 4-methyl-2-pentanone (0.073 ppm).

HSL acid and base-neutral compound results for the sludge composites and soil samples from the impoundment areas and sludge pit are summarized in Table 3-13. No compounds were detected in excess of sample detection limits with the exception Bis(2-ethylhexyl)phthalate (0.92 to 2.1 ppm) which occurred at 2.1 mg/kg or ppm in the S-3 vertical sludge composite from the sludge pit. As indicated in Appendix A, di-n-butylphthalate (0.088 to 0.49 ppm) was present in many samples but usually below sample detection limits (0.33 ppm); other components detected in some samples were: N-nitrosophenylamine (0.063 to 0.39 ppm), phenanthrene (0.066 to 0.17 ppm), benzo(a)pyrene (0.10 ppm), and naphthalene (0.36 ppm).

HSL pesticide and PCB analyses were performed on the vertical sludge composites from the impoundment and sludge pit and results are presented in Appendix A. Neither pesticides nor PCBs were detected in any of the sludge composites.

Swamp Area

As previously indicated the swamp area sludge and soil was sampled in April 1985, November 1986, January 1987, and March 1987. A total of 40 sludge and underlying soil samples were collected at the nodes of 50-by-75-foot grid system in April 1985. Sludge and soil samples were segregated and individually composited on an equal weight basis to generate single sludge and soil composites, respectively. The swamp sludge and soil composites (total of two) were screened for HSL organic compounds, cyanide, fluoride, nitrate, SDWA

metals, and other metals potentially associated with plant processes. Results of these analyses are presented in Tables 3-6 and 3-9, which summarize the inorganic/metals and the HSL organic compounds data, respectively.

As indicated in Table 3-6 swamp sludge and soil composite characteristics are similar to impoundment and sludge pit values. Swamp sludge composite constituents include aluminum (57,000 ppm), calcium (49,000 ppm), magnesium (24,000 ppm), iron (19,000 ppm), chromium (14,000 ppm), zinc (4,300 ppm), manganese (2,800 ppm), cyanide (520 ppm), and fluoride (110 ppm). Lesser constituents include lead (93 ppm), arsenic (41 ppm), barium (210 ppm), copper (36 ppm), and silver (14 ppm).

The swamp soil composite exhibits similar constituents albeit at a lower concentration than the sludge composite; the exception being iron which is present at a higher concentration in the soil than the sludge. However, the soil iron concentrations are within the range common to natural soils. Subsurface soils of the Tuscarawas River Valley typically exhibit relatively high iron and manganese values. Chromium and cyanide soil composite concentrations are on the order of one hundreth the concentrations present in the sludge composite.

Neither the swamp sludge nor the soil composite exceeded E.P. Toxicity Test Method standards for any parameter. In general, E.P. Toxicity Test leachate concentrations compared favorably to SDWA standards. Chromium and lead exhibited leachate concentrations of 0.13 to 0.10 mg/l and less than 0.01 to 0.18 mg/l, respectively, for the sludge and soil composites. Cyanide was not detected in either of the swamp leachates.

HSL organic compound analyses of the swamp sludge and soil composites are presented in Table 3-9. Volatile HSL compounds were not detected in the sludge and soil composites.

Acid and base-neutral HSL compounds in the sludge composite are limited to Bis(2-ethylhexyl)phthalate (2.9 ppm), di-n-butylphthalate (0.52 ppm), N-nitrosodiphenylamine (0.67 ppm), and pyrene (0.38 ppm). Soil composite acid and base-neutral HSL compound results detected Bis(2-ethylhexyl)phthalate

(0.75 ppm), fluoranthene (0.51 ppm), phenanthrene (0.38 ppm), and pyrene (0.66 ppm).

HSL pesticides and PCBs results are also presented in Table 3-9 and indicate the presence of PCBs in the sludge and soil composites at 1.2 and 30 ppm, respectively. Because PCBs were detected in the composites, a total of 18 sludge and 19 soil samples (total of 37 samples) were individually analyzed for PCBs as presented in Table 3-14. Results indicate that PCB contamination is generally limited to the sludge in Areas B-2,4 (670 ppm), B-0,3 (460 ppm), B-1,3 (180 ppm), B-2,3 (146 ppm), B-1,4 (18 ppm), and B-3,4 (14 ppm) assuming a 10 ppm threshold (Figure 3-2). Only one soil sample B-1,3 (9 to 15 inches) exceeded the 10 ppm threshold at 16 ppm. The source aroclors were identified as 1248 and/or 1254.

As a result of the initial screening and U.S. EPA audit results, the swamp area was resampled in November 1986 using a 25-by-37.5-foot grid system to better define the lateral extent of PCB contamination. A total of 61 sludge and 79 soil samples were collected. Additionally, the swamp was divided into five areas for compositing purposes. Sludge and soil samples collected within each area were segregated and separately composited to generate a total of ten area composites (five sludge and five soil composites). The ten area composites were analyzed for the same total and E.P. toxicity leachate constituents as previously described for the impoundment and sludge pit.

Results of the November 1986 swamp sludge and soil PCBs analyses are presented in Table 3-15 and on Figure 3-2. Figures 3-2 and 3-3 illustrate sampling grid locations and isoconcentration contours for PCBs in sludge and soil, respectively. As previously indicated, PCB contamination is largely limited to the sludge within the swamp area with only limited soil contamination in excess of the 10 ppm threshold. PCB concentrations are highest adjacent to the southern impoundment area and decrease rapidly as sampling points approach the river.

Total constituent and E.P. toxicity leachate results of the sludge and soil area composites are presented in Tables 3-10 and 3-16. Results indicate that sludge and soil characteristics are similar to the results previously reported

for the April 1985 swamp samples and the impoundment and sludge pit waste characteristics. Table 3-10 indicates the major sludge constituents include: aluminum (36,000 to 72,000 ppm), iron (18,000 to 26,000 ppm), chromium (11,000 to 17,000 ppm) zinc (4,000 to 6,000 ppm), fluoride (2,000 to 13,000 ppm), manganese (870 to 7,200 ppm), and cyanide (24 to 670 ppm) with arsenic, barium, and lead present as minor constituents. Soil constituents were again similar to sludge constituents but at lower concentrations with the exception of iron which exhibited a higher concentration in the soil composites. No parameters exceeded E.P. Toxicity Test Method standards and in most cases leachate concentrations approximate SDWA standards, although Area 1 through 3 sludge composites exhibited total chromium leachate concentrations from 1.7 to 1.9 mg/l, respectively. Soil composite leachates exhibited chromium concentrations at or below SDWA standards.

As previously discussed, problems with the execution of the laboratory program necessitated resampling of the swamp at the 25-by-37.5-foot grid locations in January 1987 for analysis of selected time sensitive parameters. Results of these analyses (cyanide, fluoride, nitrate, hexavalent chromium, and mercury), presented in Table 3-16, are consistent with previous results and indicate that the constituents present in the swamp area sludge are not in leachable form and leachate values do not exceed E.P. Toxicity Test Method or SDWA standard with one exception. Hexavalent chromium leachate concentrations from Area Nos. 1 and 2 sludge composites and Area Nos. 3 and 5 soil composites exceeded the SDWA standard (0.05 mg/l) at 0.54, 0.19, 0.16, and 0.06 mg/l, respectively. However, all values were below the E.P. toxicity standard of 5.0 mg/l total chromium.

Following evaluation of the November 1986 PCBs analyses presented in Table 3-15 and at the request of U.S. EPA Region V additional swamp sampling was performed in March 1987 to extend the existing 25-by-37.5-foot grid system downstream along the river and to provide a 12.5-by-18.75-foot grid spacing in the area around Sampling Location H-10 which exhibited the highest PCB concentrations. The purpose of this sampling effort was to define the limits of PCB contamination along the river and to provide better resolution of sludge and soil PCB concentrations in the area of maximum contamination. Results of these analyses are presented in Table 3-17, are consistent with the iso-

concentration contours illustrated in Figures 3-2 and 3-3, and indicate that PCB concentrations downgradient of the swamp area along the river rapidly decrease below detection limits.

3.3 WASTE COMPONENT CHARACTERISTICS AND BEHAVIOR

The sludge analyses indicate the presence of several potentially hazardous and/or toxic constituents including chromium, cadmium, mercury, arsenic, cyanide, fluoride, PCBs, and various organic compounds. The nature of potential environmental problems due to these constituents depends on the contaminant levels, the migration of the hazardous components, and the persistence of the toxic forms in the environment.

In order to assess the significance of contaminant levels and migration forms, the natural forms and background concentrations of potentially hazardous substances require investigation. The environment of the Alsco-Anaconda NPL site has been characterized with respect to the climate, geology, and hydrology (this report), which control the natural distribution and forms of chemical constituents. In the surficial environment, physical and chemical weathering processes and biological processes cause transformations of geologic materials leading to the aquatic/volatile release and/or stabilization of metals and organic compounds. Environmental controls that determine the fate of environmental contaminants include the following physical, chemical, and biological processes:

- Physical processes
  - Fluid flow
  - Dilution
  - Dispersion
  - Evaporation/volatilization
  - Filtration
- Chemical processes
  - Acid-base reactions
  - Adsorption-desorption
  - Complexation-dissociation
  - Oxidation-reduction
  - Precipitation-dissolution
  - Hydrolysis
- Biological processes
  - Bioaccumulation/cell synthesis
  - Biotransformation/biodegradation

- Transpiration
- Translocation of materials.

The following literature sources were reviewed in an attempt to obtain information on the normal background concentrations and the geochemical characteristics of the contaminants of concern:

- Bartlett and Kimble, 1976
- Bartlett and James, 1979
- Bowen, 1966
- Boyle and Jonasson, 1973
- Connor and Shacklette, 1975
- Fowler et al., 1979
- Hem, 1970a, 1970b, 1985
- James and Barlett, 1983
- Jenne, 1970
- Jonasson and Boyle, 1972
- Lerman, 1979
- Pierce et al., 1970
- Shacklette et al., 1971a, 1971b
- Shepard et al., 1980
- Stollenverk and Morgan, 1970
- Stumm and Morgan, 1970
- U.S. Geological Survey, 1970.

Local (site specific) soil and water background metals concentration data were not available from any of the above references. Data for unidentified soil locations in Ohio were reported as statistical classes in Shacklette et al., (1971a,b); however, specific values and sample descriptions were not reported. Because a wide range of values is normally found in a given geologic setting, individual samples are not likely to be representative of background and, therefore, the mean values for metals in soils of the conterminous United States (Bowen, 1966) are referred to in later discussions (Table 8-2).

General characteristics and probable behaviors of chromium, cadmium, mercury, arsenic, cyanide, fluoride, and PCBs in the environment of the Alsco-Anaconda NPL site are discussed below. However, the evaluation of the hazards and potential impacts to the local environment and receptors is discussed separately in Chapter 8, "Public Health and Environmental Concerns."

3.3.1 Chromium

Chromium oxidation states (speciation) play important roles in determining the fate of this metallic transition element in the environment. Chromium occurs as trivalent (Cr^{+3}) and hexavalent (Cr^{+6}) ions in natural waters, although valency states of 0, 2, 3, 4, and 6 are possible in a range of environments. The geochemical factors determining the fate of chromium in the natural aquatic environment include redox reactions, complexation, sorption, precipitation, hydrolysis, and bioaccumulation (Stumm and Morgan, 1970). Evaluation of the environmental fate of dissolved chromium, requires consideration of the speciation of introduced chromium, the redox potential (Eh), pH, and ionic strength of the aqueous system, equilibrium constants, redox reactions mediated by organic carbon and manganese oxides, adsorption by aluminum and ferric oxyhydroxides and clay minerals, and effects of major anions including orthophosphate, sulfate, chloride, and biocarbonate on complexation, solubility, and sorption characteristics. The following factors are significant in controlling chromium chemistry within the aquatic environment:

- Hexavalent chromium stability under the Eh and pH conditions of the ground water or Tuscarawas River water
- Coprecipitation of hexavalent chromium with aluminum hydroxide $Al(OH)_3$
- Adsorption of hexavalent chromium by aluminum and ferric hydroxides and clay minerals
- Potential oxidation of trivalent chromium hydroxide $Cr(OH)_3$ in the fluvial environment.

Hexavalent Chromium Stability Under the Eh and pH Conditions of the Tuscarawas River

Under normal fluvial Eh-pH conditions for the Tuscarawas River (Eh 0.40 volts and pH 7.5 to 8.5), Cr^{+6} is stable as the chromate anion (CrO_4^{-2}) provided that organic carbon and/or other reducing agents are absent. However, organic matter and other reducing agents are present in the river sediments and the Eh and pH conditions within the Tuscarawas River fall within the stability field of solid chromium III hydroxide $Cr(OH)_3$. Accordingly, calculation of equilibrium conditions requires consideration of the equilibrium effects of precipitation of $Cr(OH)_3$ on Cr^{+3}/Cr^{+6} equilibrium. Calculation of the aqueous

concentration of Cr^{+6} as CrO_4^{2-} in equilibrium with solid $Cr(OH)_3$ at an Eh of 0.40 volts and a pH of 8.0 provides an aqueous Cr^{+6} equilibrium concentration of $10^{-6.24}$ M or less than 50 micrograms per liter (Pourbaix, 1974). The eventual environmental fate of Cr^{+6} in the fluvial environment is reduction to Cr^{+3} and precipitation as $Cr(OH)_3$ (Bartlett and Kimble, 1976). Studies have shown that reduction of Cr^{+6} to Cr^{+3} by organic carbon will occur under aerobic and anaerobic conditions. Low pH (acid) environments favor reduction in both cases but Cr^{+6} reduction will still proceed at pH values above 7.3 as indicated by the above equilibrium calculation (Bartlett and Kimble, 1976; James and Bartlett, 1983).

Hexavalent chromium in the process wastewater discharged to the Tuscarawas River prior to 1973 would likely have remained in solution as CrO_4^{2-} for a sufficient period of time for dilution and dispersion to have significantly reduced the downstream Cr^{+6} concentration. Because a significant organic matter content is expected to be present in the river sediments, particularly due to agricultural runoff to the Tuscarawas River, and the Eh and pH are oxidizing and neutral-to-alkaline, respectively, the ultimate fate of Cr^{+6} in the fluvial environment will be reduction to Cr^{+3} and precipitation as trivalent chromium hydroxide $Cr(OH)_3$. Calculations indicate that the maximum solubility of Cr^{+6} in equilibrium with $Cr(OH)_3$ under standard fluvial conditions will be less than the SDWA primary drinking water standard of 50 ug/l.

Coprecipitation of Hexavalent Chromium with Aluminum Hydroxide

Hexavalent chromium Cr^{+6} will coprecipitate with aluminum hydroxide $Al(OH)_3$ within the pH range from 4.0 to 11.5 (Bartlett and Kimble, 1976; James and Bartlett, 1983). This observation closely parallels $Al(OH)_3$ solubility in water with a minimum solubility at pH 5.3 (0.78 mg/l, 10^{-5} M) and solubility increasing at lower and higher pH values. An $Al(OH)_3$ solubility of 78 mg/l or 10^{-3} corresponds to approximate pH values of 4.3 and 7.7 (Pourbaix, 1974). Therefore, extensive precipitation of $Al(OH)_3$ occurs during neutralization of the process wastewater, and coprecipitation of Cr^{+6} will occur in the absence of a chromium reduction process.

Neutralization of the process wastewater prior to discharge will cause almost complete precipitation of dissolved aluminum as aluminum hydroxide $Al(OH)_3$. Calculations indicate that at a pH of 7.7, the dissolved aluminum concentration will be approximately 78 mg/l. Cr^{+6} will coprecipitate at a minimum rate of approximately 0.79 kilogram per ton [1 mole CrO_4^{2-} to 5,000 moles

78 mg/l aluminum for amorphous $Al(OH)_3$ to less than 0.008 mg/l aluminum for $Al_2O_3 \cdot 3H_2O$.

Similarly, Cr^{+6} coprecipitation reactions can occur with ferric hydroxide $Fe(OH)_3$ to form $Fe(OH)_2HCrO_4$. However, $Fe(OH)_3$ is not soluble at neutral to alkaline pHs and undergoes progressive precipitation at the pH range from 3 to 6 with complete precipitation at pH 6.0 (Pourbaix, 1974). Therefore, coprecipitation of Cr^{+6} with $Fe(OH)_3$ and $Al(OH)_3$ should reduce the environmental availability of Cr^{+6}.

Adsorption of Hexavalent Chromium by Aluminum and Ferric Hydroxides and Clay Minerals

Adsorption of Hexavalent Chromium by Aluminum and Ferric Hydroxides and Clay Minerals

Adsorption of Cr^{+6} is dependent upon pH, other competing aqueous anions, and the presence of an adsorbing substrate such as aluminum hydroxide $Al(OH)_3$, ferric hydroxide $Fe(OH)_3$, and/or clay minerals such as kaolinite and montmorillonite. Review of existing studies indicate that the pH within the fluvial environment will be the controlling factor since anionic adsorption is directly proportional to the degree of net positive surface change on the adsorbing substrate, i.e., directly proportional to the hydrogen ion concentration, pH, of the aqueous environment.

Aluminum hydroxide is formed as a natural weathering product from clays and feldspars and as an industrial waste product from neutralization of the

aluminum conversion coating process wastewater. Ferric oxides and hydroxides in the regional soils are present as precipitation coatings on the silt and clay size particles and in the ground water as colloidal particles as evidenced by the elevated ground water iron concentrations in the Tuscarawas River drainage basin. Because aluminum hydroxide precipitated during neutralization of the process wastewater will occur as colloids, the $Al(OH)_3$, will tend to flocculate and settle slowly from the water column. Accordingly, suspended aluminum hydroxide and ferric oxyhydroxide solids would be the most significant substrate for potential Cr^{+6} adsorption in the fluvial water column. Within the river water and sediments, ferric oxyhydroxides and clay minerals are additional significant potential substrates for Cr^{+6} adsorption.

Hexavalent chromium speciation in aqueous solution must be considered in order to evaluate the potential for adsorption of Cr^{+6} by process generated $Al(OH)_3$ or by naturally occurring ferric hydroxide and clay minerals. Above pH 6.4, the dominant form of Cr^{+6} in aqueous solution will be chromate CrO_4^{2-}. As in all ion exchange reactions, similar ions will compete for adsorption sites. Accordingly, at pHs above 6.4, sulfate (SO_4^{2-}) and orthophosphate (HPO_4^{2-} and $H_2PO_4^-$) will compete for adsorption sites with CrO_4^{2-}. Nitrate (NO_3^-), and chloride (Cl^-) ions do not as effectively compete with CrO_4^{2-} for adsorption sites. Aqueous SO_4^{2-} and $H_2PO_4^-$ and HPO_4^{2-} concentrations must exceed approximately 0.001M (98 mg/l SO_4) and 0.0001 M (3.1 mg/l phosphorus-P, 9.5 mg/l PO_4), respectively, before significant inhibition of Cr^{+6} adsorption is likely to occur. Aqueous chloride (Cl^-) and nitrate (NO_3^-) concentrations must exceed approximately 0.01M (355 mg/l Cl^-) and 0.01 M (140 mg/l,N, 620 mg/l NO_3^-), respectively, before inhibition of Cr^{+6} adsorption is likely to occur. Evaluation of OEPA STORET Tuscarawas River water quality data (OEPA, 1985) indicates once dilution of the process wastewater occurs, the ionic strength of the river water is unlikely to interfere with Cr^{+6} adsorption. Only SO_4^{2-} approaches a significant concentration at roughly 0.002 M (178 to 186 mg/l).

Adsorption of Cr^{+6} is also affected by the pH of the aqueous solutions. Because Cr^{+6} forms anionic species in aqueous solution, the adsorption of these negatively charged species is dependent upon the degree of net positive surface charge on the aluminum hydroxide $Al(OH)_3$, aluminum oxide

($Al(OH)_3 \cdot 3H_2O$), ferric hydroxide $Fe(OH)_3$, geothite $FeO(OH)$, and clay minerals serving as adsorption substrates. The net positive surface charge is due to hydrogen bonding between hydrogen ions (H^+) and the substrate. The greater the aqueous hydrogen ion (H^+) concentration, the greater the net positive surface charge due to hydrogen bonding. As the hydrogen ion concentration decreases, the net positive surface charge correspondingly decreases. The pH at which the net positive surface charge equals zero is termed the zero point of charge (ZPC).

According to the STORET data (OEPA, 1985), the mean pH of the river water varies between 7.9 to 8.5, which is near the calculated ZPC of 8.5 for ferric hydroxide $Fe(OH)_3$. At pH 7.9 to 8.5, only a small net positive surface charge is expected on the ferric hydroxide surface which will be correspondingly the most significant potential adsorbing substrate for Cr^{+6}. The pHs of the ZPC for aluminum hydroxide $Al(OH)_3$, kaolinite, and montmorillonite are 5.0, 4.6, and 2.5, respectively (Stumm and Morgan, 1970). These adsorbing substrates will have a net negative surface charge at the mean river water pH of 7.9 to 8.5. However, although the ZPC pH for $Fe(OH)_3$ is 8.5, any adsorption of competing anions such as sulfate SO_4^{2-} will shift the ZPC to a lower pH value (Stumm and Morgan, 1970). Under these conditions, significant adsorption of Cr^{+6} is unlikely and will be readily reversible provided that long residence times on the adsorbing substrate do not occur. Long residence times will tend to irreversibly bind Cr^{+6}.

Potential Oxidation of Trivalent Chromium Hydroxide $Cr(OH)_3$ in the Fluvial Environment

As indicated above, the equilibrium concentration of Cr^{+6} at fluvial Eh and pH environmental conditions is less than 50 ug/l in the presence of freshly precipitated amorphous $Cr(OH)_3$. Soil manganese III or IV oxides present in highly oxidizing environments can act as a redox couple and oxidize Cr^{+3} to Cr^{+6}. However, the Cr^{+3} must be in solution for oxidation to take place either as Cr^{+3} or as an organic complex with humates, fulvates, etc. Solubility of Cr^{+3} is favored by low pH (acid) environments (pH 3.0). Laboratory studies have shown that oxidation of Cr^{+3} under optimum conditions is least efficient at pH 7.0 to 9.0. However, the ambient pH and Eh of the Tuscarawas River precludes the existence of the highly oxidizing, low pH environment necessary for the oxidation of Cr^{+3} to Cr^{+6}.

Investigation of Cr^{+3}, Cr^{+6}, and $Cr(OH)_3$ equilibrium constants and mechanisms for Cr^{+3} oxidation indicate that the absence of organic carbon in suspended and bottom river sediments and low pH, highly oxidizing environments with the presence of oxidized manganese oxides, MnO_2, or Mn_2O_3, are required for oxidation of Cr^{+3} to Cr^{+6} to occur, (Pourbaix, 1974; Bartlett and James, 1979). These conditions do not occur in a fluvial environment. Laboratory studies under optimum oxidizing conditions show that chromium oxidation is short-lived in most soil/sediment environments with aqueous Cr^{+6} concentrations decreasing after several days due to reduction by organic matter. Even in the absence of reducing organic matter and with increased Cr^{+3} solubility due to complexation, mean Eh and pH values indicate a maximum river water equilibrium Cr^{+6} concentration of less than 0.05 mg/l.

3.3.2 Cadmium

Cadmium is a rare element that is relatively mobile compared to other heavy metals in the aquatic environment. Cadmium may be transported in solution as either hydrated divalent cations or as organic and inorganic complexes (Fowler, et al., 1979; Shephard, et al., 1980). The speciation of cadmium will depend on the chemistry of the surface or ground water. In the ground water and Tuscarawas River water near the Alsco-Anaconda NPL site, abundant Cl^- and SO_4^{-2} in the neutral, hard water will lead to complexation of cadmium in solution.

With equal concentrations of the ligands, the affinity/stability of complexing ligands for cadmium cations in natural fresh waters generally follows the order: humic acids > OH^- $\geq$ CO_3^{-2} > Cl^- > SO_4^{-2} (Fowler, et al., 1979; Shephard, et al., 1980)

The probable solubility controls for cadmium are solid $Cd(OH)_2$ and $CdCO_3$, with $Cd(OH)_2$ becoming especially important when waters have pH > 9. Under reducing conditions, and in the presence of sulfur, however, cadmium may react to form the insoluble sulfide, CdS, and/or may coprecipitate with zinc and iron, should these metals be abundant in solution. Coprecipitation with hydrous iron, aluminum, and manganese oxides will also control cadmium mobility in oxygenated, unpolluted waters. In polluted or organic-rich waters, however, the adsorption of cadmium by humic substances and the other organic complexing

agents will determine, transport, partitioning, and potential for remobilization (Fowler, et al., 1979). Although sorption processes affect cadmium to a lesser extent than most of the other heavy metals (e.g., Fe, Cu, Zn) sorption by mineral surfaces, hydrous metal oxides, and organic materials probably removes more cadmium from solution than does precipitation.

Neither volatilization nor photolysis is a significant process controlling the environmental fate of cadmium. Biota strongly accumulate cadmium with concentration factors ranging from 10^2 to 10^4 or more, however, biotransformation (biomethylation) is not known to occur (Fowler, et al., 1979).

3.3.3 Mercury

Under the usual conditions of temperature and pressure that occur in surface and ground waters, mercury can be present in one or more of three oxidation states. The most reduced form is the metal, which is liquid at ordinary temperatures and which has a tendency to vaporize. The other forms are ionic; the more reduced of the ions is the mercurous ion, Hg_2^{+2}, where the average valency of mercury is +1. In oxidizing conditions, especially at low pH, the stable form is the mercuric ion, Hg^{+2} (Hem, 1970b). The nature of the mercury species which will occur or predominate in solution depends on the redox potential and pH of the aquatic environment as well as solute (liquid) concentrations.

At the conditions of pH and Eh likely to occur in aerated or anaerobic water (pH 5 to 9 and Eh <0.5 volts), the metallic liquid and mineral cinnabar (HgS) are the principal forms affecting the solubility of mercury (Hem, 1970b). Under reducing conditions, in the presence of sulfur, H_2S will precipitate and may constitute a major chemical sink (Fowler, et al., 1979). Under these conditions with solute concentrations as found in surface and ground waters of the Alsco-Anaconda NPL site, the predominant mercury species in solution will be undissociated mercury, Hg^o. The addition of organic complexing agents to the system may increase the soluble fraction of mercury by the formation of organo-mercury species, thus mercury may have greater mobility in waters containing large amounts of dissolved organics (Jenne, 1970).

Dissolved mercury has a tenacious affinity for surfaces of many types. Solute mercury introduced into streams is quickly transformed to the particulate form by reduction to metallic mercury, sorption onto inorganic sorbates (microcrystalline oxides) and nonviable particulate organics, and by sorption and ingestion by viable biota (Jenne, 1970). The organic matter in soils, sediments, and rocks account for much of the mercury in these materials (Pierce, et al., 1970). The particulate phases may be transported downstream and subsequently settle to the bed sediment. Secondary transformations of mercury in the sediments including precipitation as HgS and methylation by bacteria may occur. Thus, the bottom sediments constitute a sink, although, ionic or metallic mercury may be released back into the water by methylation and by resuspension of sediments by turbulence or benthic organisms.

Metallic mercury can enter the atmosphere from the aquatic environment as several different gaseous compounds. Thus, volatilization is an important process controlling the environmental fate of mercury. The rate of volatilization/vaporization of mercury and certain of its inorganic compounds decreases in the sequence: $Hg > Hg_2Cl_2 > HgCl_2 > HgS > HgO$ (Fowler, et al., 1979; Jenne, 1970). Furthermore, the microbial methylation will enhance the evaporative losses of mercury. The rate of volatilization of some organic mercury compounds decreases in the order: methylmercury chloride > methylmercury compounds = ethylmercury compounds = mercury (Hg) > phenylmercury compounds (Jenne, 1970).

Photolysis may be of significance to the chemical speciation of mercury in the atmosphere and perhaps in the aquatic environment; however, it is not clear what impact this process might have on the overall fate of mercury in the aquatic environment (Fowler, et al., 1979).

Many different mercury compounds may be biotransformed by bacteria common in most natural waters. The organomercury compounds so formed are strongly bioaccumulated through the food chain. The major source of mercury for bioaccumulation by fish is not inorganic mercury, but is biomethylated mercury. Upon entering the aqueous system, virtually any mercury compound may be microbially converted to methylmercury (biomethylated). Conditions reported in enhance the biomethylation process include large amounts of

available mercury, large numbers of bacteria, absence of strong complexing/compounding agents such as sulfur, near-neutral pH, moderate to warm temperature, and a moderately aerobic environment (Fowler, et al., 1979).

3.3.4 Arsenic

Arsenic is considered to be a rare but extremely mobile and ubiquitous element in the aquatic environment. Levels of dissolved arsenic in rivers are controlled by the availability of arsenic, redox conditions, rainwater dilution, complexation, and metabolic activities of aquatic plants (Fowler et al., 1979) In the natural aquatic environment, arsenic is stable in four oxidations states (+5, +3, 0, -3). The pentavalent (+5) and trivalent (+3) states are common in a variety of complex minerals and in natural waters. Arsenic metal (valence 0) occurs only rarely, and the -3 oxidation state is stable only under extremely reducing (anaerobic) conditions (Fowler, et al., 1979). Because of the high charges on the pentavalent and trivalent states of arsenic, and hence the rapid hydrolysis of these ionic states in aqueous solutions, there is practically no cationic chemistry of arsenic except in extremely strong acid solutions. As a consequence of this, arsenic forms mobile anionic complexes and polymers mainly with oxygen and sulfur in most natural processes (Boyle and Jonasson, 1973). Since the valence state of arsenic determines its relative toxicity (the +3 state is more toxic than the +5 state) as well as complexation behavior, the chemical speciation of arsenic is important when considering its aquatic fate (Fowler, et al., 1979).

Under oxidizing conditions, the monovalent arsenate ion $H_2AsO_4^-$ would be expected to predominate between pH 3 and 7, and the divalent species $HAsO_4^{-2}$ would take over from pH 7 to 11. Mildly reducing conditions would favor the arsenite uncharged ion $HAsO_2$ (Hem, 1985). Data on the solubility controls of the oxyanions, particularly arsenites, are sparse. Although ferric arsenate and some other metal arsenates have rather low solubilities, the importance of solubility controls on the aqueous chemistry of arsenic cannot be closely evaluated (Hem, 1985).

Adsorption by or coprecipitation with hydrous iron and/or manganese oxides or combination with sulfide in reduced bottom mud, appear to be major factors that can maintain concentrations of arsenic at very low levels in water (Hem,

1985). Adsorption of pentavalent and trivalent arsenic species tends to be greatest in aerobic, acidic, fresh waters. As conditions become more reducing, alkaline, and/or saline, arsenic is less likely to be sorbed and more likely to remain dissolved (Fowler, et al., 1979). However, where solutions are weakly acid, neutral, or alkaline, soluble arsenic is subject to immobilization by hydrolysis and coprecipitation with various natural compounds, particularly hydrous iron oxides (Boyle and Jonasson, 1973).

Although arsenic is toxic, it is bioaccumulated and biotransformed in aquatic environments. The organic and biochemical aspects of arsenic chemistry are potentially of considerable significance in determining the environmental fate of arsenic. Arsenic may migrate as various chelated or organic compounds resulting from the decay at plant and animal matter, and in a colloidal form or adsorbent to hydrous iron oxide, silicate, and humic colloids (Boyle and Jonasson, 1973). Arsenic forms stable bonds with sulfur and carbon in organic compounds, and it is the affinity for trivalent arsenic for sulfhydryl groups, most notably amino acids, which accounts for its toxicity. Methylation may be a detoxification mechanism, since most of the organic metabolites are considerably less toxic than arsenite (Fowler, et al., 1979). As a result of biologically mediated methylation, derivatives of arsenic such as dimethyl arsenic ($[CH_3]_2$ AsOOH) and methylarsenic acids ($CH_3AsO[OH]_2$) can be synthesized (Hem, 1985). Dimethyl arsenic acid is difficult to oxidize and may be a major portion of dissolved arsenic in surface water (Hem, 1985).

Volatilization is an important environmental process controlling arsenic when biological activity or highly reducing conditions produce methylarsenics or arsine (AsH_3), which is gaseous (Fowler, et al., 1979). Photolysis is not an important environmental control of the fate of arsenic (Fowler, et al., 1979).

3.3.5 Cyanide

Cyanides are a diverse group of organic and inorganic compounds/complexes, which contain the -CN group. In the aquatic environment, the cyanides are subject to photolysis, volatilization, biotransformation, and other relatively less important fates (Fowler, et al., 1979). Hydrogen cyanide (HCN), which occurs only rarely in nature, is the most reactive and most toxic of the cyanides. In natural waters ($4 \leq pH \leq 9$), free cyanide (uncomplexed by

metals) is predominant as HCN, with the remainder present as the cyanide anion (CN^-). However, HCN is extremely volatile and is subject to volatilization to the atmosphere where it diffuses rapidly, such that well mixed aqueous solutions in equilibrium with the atmosphere would tend towards reduced cyanide concentrations, especially as wind speeds and water/air temperatures increase.

The cyanide forms complexes with a variety of metals, especially the multi-valent transition series elements (Fowler, et al., 1979). The ferri- and ferro-cyanides ($[Fe(CN)_6]^{-3}$ and $[Fe(CN)_6]^{-4}$, respectively) used as process chemicals are very stable in aqueous solutions and do not release cyanide unless exposed to ultraviolet light. Yet, hydrogen cyanide is resistant to photolysis by wavelengths of light reaching the earth's surface. Thus, photodecomposition of the metallocyanide coupled with volatilization of the HCN are potentially significant environmental processes which could reduce total cyanide levels in surface waters.

In biological systems, HCN interferes with enzymes associated with cellular oxidation. The HCN is either quickly metabolized or the organism dies; thus, there is little potential for bioaccumulation of HCN. However, fish have been found to bioaccumulate metallocyanide complexes, and many plants synthesize and accumulate cyanogenic glycosides (Fowler, et al., 1979). Many independent studies have indicated that HCN or its salts are metabolized by numerous varieties of bacteria, indicating biodegradation is relatively important as an environmental control.

Hydrogen cyanide, metallocyanide complexes, and nitriles are all subject to biodegradation (Fowler, et al., 1979). Although most organisms can tolerate only very low concentrations, a bacterium has been isolated that is capable of using cyanide as its sole source of carbon and nitrogen. Many common bacteria also metabolize lower concentrations of cyanides. Thus, biodegradation is an important environmental process determining the fate of cyanides. However, the effectiveness of organisms to metabolize cyanides in natural waters depends on many factors including cyanide concentrations, pH, temperature, concentration of microbes, availability of nutrients, and whether the organisms are acclimated to cyanides (Fowler, et al., 1979).

3.3.6 Fluorides

Fluorides include natural and synthesized inorganic compounds/complexes which contain or consist of the halogen F. In the aquatic environment, fluoride occurs principally as the free fluoride ion (F^-), which is subject to complexation, precipitation, sorption, and other less important fates (Hem, 1970a; 1985). Fluoride ions have the same charge and nearly the same radius as hydroxide ions (OH^-), and thus the ions tend to replace each other. Fluoride forms strong solute complexes with many cations and low-solubility mineral compounds, which are fairly common in nature.

In the extreme anhydrous form, synthetic hydrofluoric acid (HF) used in the plant process, is produced by reacting sulfuric acid (H_2SO_4) with the mineral fluorite (CaF_2). Liquid HF is an excellent solvent, because it is highly polar, and it dissolves salts and oxides even better than water does (Rochow, 1977). Although HF is extremely corrosive, the anhydrous liquid does not occur naturally because it reacts so completely with its surroundings, producing fluorides in aqueous environments. The fluoride anion forms strong aqueous complexes with aluminum, beryllium, ferric iron, silicon, and other cations in solution (Hem, 1970a; 1985). In turn, the mineral fluorite may act as a fluoride solubility control in the natural aqueous system, thus reducing dissolved F^- concentrations.

In natural aqueous systems, mineral equilibrium and sorption/ion exchange are major controls of F^- mobility. Although F^- is relatively ubiquitous at low concentrations (less than 1 ppm) in surface and ground waters (Hem, 1970a; 1985), F^- mobility depends on many factors. Factors controlling fluoride in aquatic environments include pH, temperature, and the concentrations of F^- and complexing cations, ionic strength, the concentrations of ions such as calcium (Ca^{+2}) and orthophosphate (PO_4^{+3}) which will form fluoride minerals. The higher concentrations of fluoride observed in natural waters are generally in waters that are relatively low in calcium (Hem, 1970a; 1985), because fluorite (CaF_2) and fluor-apatite ($Ca_5[PO_4]_3F$) minerals will precipitate F^- from solution. Hard waters (Tuscarawas River) typically contain high concentrations of Ca^{+2} and waters containing detergents, decay products of organic matter (aquatic vegetation, sewage effluent), and/or fertilizer runoff, usually have high levels of PO_4^{-3}, such that F^- concentrations will tend to be

low. Fluoride concentrations will tend to be greater in waters with relatively high pH (pH greater than 8) and thus high OH^- concentrations, because fluoride-containing minerals can exchange surface-bound F^- for OH^-. In contrast, in more neutral to acidic environs; the reverse substitution of F^- for OH^- in minerals, bones, and teeth may occur, thus reducing F^- concentrations in solution and producing acid-resistant characteristics of the solid compounds.

3.3.7 Polychlorinated Biphenyls

PCBs are a family of chlorinated hydrocarbon compounds (C_{12} $[H,Cl]_{10}$) which vary widely in physical, chemical, and biological properties according to the degree and position of chlorination. Though all the PCBs have a very low water solubility, low vapor pressure, and a high dielectric constant (Fowler et al., 1979). In the aquatic environment, the PCBs are subject to sorption, volatilization, photolysis, bioaccumulation, and biotransformation/biodegradation (Fowler, et al., 1979). However, the relative importance of the different fates varies with chlorination of the compounds.

The identification of PCBs is designated by the individual Aroclors 1221, 1232, 1242, 1248, 1254, and 1260 (Monsanto trademark). The first two digits, 12, indicate the preparation is a mixture, and the second two digits denote the approximate chlorine content in weight percent (Fowler, et al., 1979). Thus, Aroclor 1242 is a mixture having an average chlorine content of 42 weight percent. When environmental problems were found to be associated with the more chlorinated (heavier) mixtures, the manufacturer prepared a new, lighter mixture of the mono-, di-, tri-, and tetrachloro isomer ($C_{12}H_9Cl$, $C_{12}H_8Cl_2$, $C_{12}H_7Cl_3$, and $C_{12}H_6Cl_4$, respectively) that carried the designation Aroclor 1016. Because the Aroclors are mixtures of different PCBs isomers, the physical properties cannot be defined as constants.

Environmental processes which are known to destroy PCBs include biotransformation and photolysis. For those compounds with four or fewer chlorine atoms per molecule, biodegradation appears to be the dominant fate process and results in significant destruction and transformation. PCBs with five or more chlorine atoms per molecule have been photolyzed in experimental situations. However, dissolved oxygen limits the rate of PCBs photodegradation, which

would presumably occur in the oxygenated photic zone of surface waters. Nevertheless, even though the rate of photolytic breakdown may be slow, it may be significant since none of the other environmental fate processes results in the degradation of the heavier PCBs (Fowler, et al., 1979).

Nondestructive processes which affect the distribution and transport of PCBs are adsorption, volatilization, and bioaccumulation. In natural water systems, the greatest concentration of these compounds is sorbed to suspended and stream bed sediments and aquifer materials due to their very low solubility in water. The tendency of PCBs for adsorption increases with the degree of chlorination and with the organic content of the absorbent. The biota are another environmental compartment into which these compounds are strongly partitioned (measured bioconcentration factors range up to 10^6 (Fowler, et al., 1979).

Volatilization and transport as an aerosol followed by fallout with dust or rain is the probable cause of the ubiquitous environmental distribution of PCBs. The more highly chlorinated species are less volatile than the lighter species. The presence of suspended solids in water tends to reduce volatilization from the aqueous system presumably because the solids adsorb the PCBs and reduce the concentration in solution (Fowler, et al., 1979).

The available empirical evidence indicates that PCBs, especially those with four or more chlorines, are persistent in the environment. The composition of polychlorinated biphenyls in the atmosphere is similar to that of Aroclor 1242 or 1016, while those in surface waters (mostly adsorbed to suspended solids) approach the composition of Aroclor 1254. Polychlorinated biphenyls in biota are heavier and more chlorinated still, and approximate the composition of Aroclor 1260. Thus, the processes controlling distribution are somewhat selective, with the lighter species more likely to volatilize and the heavier species more likely to be incorporated into sediments and biota (Fowler, et al., 1979).

3.3.8 Environmental Transformation of Organic Chemicals

Degradation and transformation of organic chemicals can occur in both soil and aquatic environments. Mechanisms that can be involved in degradation and

transformation processes include biodegradation under aerobic and anaerobic conditions and photodecomposition. Table 3-18 summarizes the physical and chemical characteristics of compounds that have been identified above detection limits at the Alsco-Anaconda NPL site, while Table 3-19 summarizes the known environmental transformation pathways for the same organic compounds.

4.0 HYDROGEOLOGIC INVESTIGATIONS

4.1 INTRODUCTION

The hydrogeologic investigations at the Alsco-Anaconda NPL site included literature and file reviews, field investigations, laboratory analyses, and interpretation of results. These activities were conducted in order to determine physical and chemical characteristics of site soils, geology, and ground water, and to delineate the levels and extent of contamination of the environmental media.

Field activities conducted at the site included the following:

- Drilling of nine subsurface borings and the collection of corresponding soil boring samples
- Installation of nine monitoring wells and the periodic collection of water level data and ground water samples
- Survey of the site topography, well locations, and elevations.

The topographic survey and field measurements of well water elevations were performed in order to prepare site maps and to evaluate ground water flow and solute transport.

Laboratory activities included physical and chemical characterization of soil boring and ground water samples. Permeability (hydraulic conductivity) tests of site soils and chemical analyses of soil and ground water samples were completed in order to assess the potential for chemical migration (leaching and solute transport) and the extent of contamination. Soils were tested for total and EP toxicity leachable constituents, and ground waters were analyzed for organic and inorganic parameters.

The descriptions, results, and interpretations of the hydrogeologic investigations are presented below according to the different media - soils, geology, and ground water.

4.2 SOILS

4.2.1 Background

The surface soils at the site are derived from alluvial materials and are classified as Chagrin silt loam (Wildermuth and others, 1953). These natural soils are floodplain deposits, which are brown near the surface changing to brownish yellow below about 30 inches. Chagrin soils are friable and easily workable with good drainage and low erodability. Natural organic matter content of these soils is variable, from less than 5 up to 30 percent.

4.2.2 Soil Sampling

Shallow soil samples from the swamp and surrounding areas adjacent to the sludge-covered area were collected using clean hand augers. The sludge pit and settlement basin soils were sampled using test pits and hand auger to penetrate the overlying sludge (Figure 3-1).

The site soils sampled from the swamp and surrounding area along the Tuscarawas River are typical Chagrin silt loam except beneath some areas where the sludge is black, as opposed to pale greenish-blue. Below the black sludge, the soil color is black and changes to brown as the depth is increased. The black discoloration is not apparently attributable to a single cause but may result from a combination of several hypothetical causes, such as natural swamp organic matter and/or oil and grease or similar contamination. The black coloration also could result from the presence of naturally occurring iron and manganese, which may form black colored, reduced ferrous and manganese oxide or sulfide compounds under relatively anoxic conditions. Black coloration of subsoils also occurred beneath the sludge in some areas of the sludge pit and settlement basins. However, the subsoil samples collected at the base of the impoundments generally had coarse grain sizes, ranging from silty sand to one-inch-diameter gravel.

Nine subsurface borings (MW-1 through MW-9 in Figure 1-2) were completed to a depth of 50 feet around the Alsco plant and on the Alsco-Anaconda NPL site. The boring logs showing sampled intervals and lithologic descriptions are presented in Appendix C. Samples obtained from these borings indicate the Alsco plant and a portion of the Alsco-Anaconda NPL site are situated on

several feet of fill material composed of loose to medium dense, brown, black and gray silt, sand, gravel, and cinders. The remaining area of the Alsco-Anaconda NPL site is covered by natural alluvial soil and glacial outwash sediments. Beneath the fill and soil are deposits of fine to medium sand and fine to medium gravel with interbeds of sand and silt (Figures 4-1 and 4-2). The well log obtained for Production Well PW-5 (Ohio Drilling Company, 1980; Appendix C) shows similar materials with sands and gravels extending to the bottom of the boring at 159 feet. The predominance of coarser grained materials at depth is apparent in the geologic cross sections (Figures 4-1 and 4-2), which were prepared from the boring logs.

4.2.3 Laboratory Analyses of Soils

Laboratory permeability (hydraulic conductivity) tests were conducted on three soil samples collected from the base of the sludge pit (Table 3-3). These soils described as brown silt, brown silty fine sand, and black silty fine sand had permeabilities ranging from 9.59×10^{-6} to 1.43×10^{-7} cm/s. Such values are expected for unconsolidated, fine-grained deposits (Freeze and Cherry, 1979, p. 29) and are indicative of relatively impermeable materials. In addition to permeability testing, one soil boring sample SB-B-series soil was analyzed by X-ray diffraction and energy-dispersive spectrometer techniques (Tables 3-4 and 3-5). The X-ray diffraction analysis (Table 3-4) indicated the mineral composition of the sample was predominantly quartz with traces of feldspar (microcline and oligoclase), muscovite, and kaolinite, which are typical minerals composing sandy-silt loams (Brady, 1974, p. 44-47). The soil mineral composition explains the results of the energy-dispersive spectrometer analysis (Table 3-5), which indicates silicon, aluminum, iron, potassium, and calcium are the dominant elements, in that order. Because X-ray diffraction is limited to crystalline phases, it is probable that much of the iron and aluminum in the sample was present as amorphous iron and/or aluminum oxyhydroxides and some was crystalline hematite, goethite, and limonite, which were not identified in the X-ray analysis.

The soil samples collected from the impoundments and the swamp area were composited for laboratory chemical analysis of total and E. P. Toxicity Test Method inorganic constituents plus HSL organic compounds. The results of

these analyses are listed in Tables 3-6 through 3-13 and 3-16. In addition, individual soil samples from the swamp area were analyzed for PCBs (Tables 3-14, 3-15, and 3-17). Figure 4-1 shows the distribution of PCBs in soils at the Alsco-Anaconda NPL site. The swamp grid areas were reduced from 50 by 75 feet to 25 by 37.5 feet, and in selected areas where PCBs were relatively high, to 12.5 by 18.75 feet in sequential sampling and analysis efforts to determine the extent of contamination.

Twenty-seven subsurface boring soil samples collected during drilling operations for monitoring well installation were analyzed for the following parameters:

- Cyanide, total and amenable
- Fluoride, soluble
- Nitrate, leachable
- Chromium, total and hexavalent
- Iron
- Manganese.

The E.P. Toxicity Test method was also performed on the samples and the resulting leachates were also analyzed for the above parameters. The results for these analyses are listed in Table 4-1.

The soil boring analytical results, presented in Table 4-1, indicate high iron and manganese concentrations, which are characteristic of area soils, and some occurrences of chromium, fluoride, and cyanide. Chromium is present in soils in the conterminous United States at concentrations ranging from 1 to 1,500 ppm with a mean concentration of approximately 53 ppm. Using these criteria, all soil boring samples were within the range of naturally occurring chromium concentrations. Chromium concentrations in excess of the mean value occurred in Soil Borings MW-2, S-1 (950 ppm), MW-3, S-1 (91 ppm), MW-3, S-3 (57 ppm), MW-4, S-1 (280 ppm), and MW-5, S-1 (87 ppm) which are located immediately adjacent to the sludge pit and impoundment. Fluoride concentrations were generally limited in Soil Borings MW-2, S-4 (31 ppm), MW-3, S-1 (40 ppm), MW-3, S-3 (63 ppm), MW-4, S-4 (24 ppm), MW-5, S-1 (86 ppm), MW-5, S-3 (21 ppm), MW-5, S-7 (18 ppm), MW-7, S-1 (25 ppm), and MW-7, S-3 (14 ppm). Excepting Soil Boring MW-7, fluoride concentrations are limited to those soil borings adjacent to the sludge pit and impoundment. With the

exception of Samples MW-2, S-1 (60 ppm) and MW-4, S-1 (25 ppm), no cyanide concentrations exceeded 5.0 ppm and detectable cyanide was limited to Soil Borings MW-2, MW-3, MW-4, and MW-5 adjacent to the sludge pit and impoundment and MW-7 in the swamp area.

Most significantly, E.P. Toxicity Test Method results indicate that the chromium, fluoride, and cyanide present in the samples is not in a leachable form. Maximum chromium concentrations the EP toxicity leachates were MW-2, S-1 (0.78 mg/l) and MW-4, S-1 (0.29 mg/l) which are well below the EP Toxicity leachate standard of 5.0 mg/l. Fluoride concentrations did not exceed the SDWA standard of 4.0 mg/l in any of soil boring leachates. Cyanide was not detected in any of the soil boring leachates above the 0.02 mg/l method detection limit.

4.3 GROUND WATER

4.3.1 Background

A discussion of the regional geology as it relates to the site is included in Chapter 1. Site-specific details are presented in the following section. The Alsco-Anaconda NPL site is located adjacent to the Tuscarawas River, which flows within a buried postglacial valley (Cummins, 1959). The buried valley bottom is incised into relatively flat-lying sedimentary rocks composed mainly of shale and sandstone with minor beds of limestone and coal (Brownocker, 1947; Lamborn, 1956). The valley fill material is composed of unconsolidated fluvial deposits of glacial outwash sands, silts, and gravels. The thickness of these unconsolidated materials is generally greater than 160 feet but less than 200 feet in the vicinity of the site (Ohio Drilling Company, 1972).

The unconsolidated glacio-fluvial deposits of the Tuscarawas River valley form extensive aquifers (Cummins, 1959), which are the principal water supplies for residents and municipalities in the valley (Ohio Department of Natural Resources [ODNR], 1968). The village of Gnadenhutten established a municipal water supply from ground water in 1936 (Virtue, 1976). The Gnadenhutten municipal well field is located approximately 4,000 feet northeast (upgradient) of the Alsco-Anaconda NPL site. Several municipal wells have been drilled in the well field (Figure 1-1, Wells WW-8, WW-9, and WW-10),

called Heck's Grove, with the last well completed in 1976 (Appendix C). The ODNR (1968, pp. 104, 108) estimated the municipal water per capita usage in Gnadenhutten is 115 gallons per day (gpd) such that the total Gnadenhutten population of 1,320 residents requires approximately 152,000 gpd or an average of 106 gpm. Private industrial use of ground water in Gnadenhutten is estimated to be about 131,000 gpd (ODNR, 1968). The gravelly fraction of the aquifer is capable of producing thousands of gallons per minute (Ohio Drilling Company, 1972).

4.3.2 Water Well Inventory

The ODNR Division of Water maintains a file of "Well Log and Drilling Report" forms, which were completed by the drilling companies and collected by the ODNR. The available well logs for 62 water wells, including the five Alsco plant wells, within a 1.5-mile radius from the Alsco-Anaconda NPL site are presented in Appendix C, and the locations of these water wells are shown in Figure 1-1. The Alsco plant production wells (PW-1 through PW-5) and the Gnadenhutten municipal water wells (WW-8 through WW-10) were installed over a range of about 30 years, and the oldest wells have been abandoned. It is probable that many of the older residential wells also have been abandoned, especially as the municipal water lines were extended to homes more distant from the municipal well field. Considering that some residential wells probably were installed without the proper completion of corresponding well logs and that some wells for which logs were recorded have been abandoned, the total count of 62 wells within 1.5 miles of the Alsco-Anaconda NPL site is reasonable. The relevant issue is the locations of drinking water wells with respect to the location of the Alsco-Anaconda NPL site and the direction of ground water flow and possible contaminant transport from the site.

The Alsco plant production wells are not used for drinking water; the plant drinking water is supplied by the municipal water system. Four domestic wells for which logs were obtained are approximately 0.5 mile from the Alsco-Anaconda NPL site (Figure 1-1). All four wells produce water from the unconsolidated sand and gravel aquifer. Wells WW-1, WW-2, and WW-3 are about 0.5 mile northeast of the Alsco-Anaconda NPL site, on the north side of U.S. Highway 36. These wells were drilled since 1970 and are from 53 to 65 feet deep (Appendix C). A fourth domestic well, WW-11, approximately 0.5 mile east

of the Alsco-Anaconda NPL site was drilled in 1961 to a depth of 40 feet (Appendix C). It is anticipated that the ground water flow direction is generally southwestward down the Tuscarawas River valley, and there are no known water wells south or west of the site within 0.5 mile.

Accurately measured ground water level data for a specific time interval are necessary to determine the potential ground water flow directions. However, the static water levels indicated on the well logs (Appendix C) are for a wide range of times, and the ground surface elevations necessary to convert the static water depths to elevations are inaccurate due to imprecise well locations and 20-foot contour intervals on the topographic maps (Figure 1-1).

Three plant production wells at the Alsco plant (PW-3, PW-4, and PW-5) and nine monitoring wells installed as part of the Alsco-Anaconda NPL site RI were used to obtain ground water level and chemical quality data for the Alsco-Anaconda NPL site investigation.

4.3.3 Monitoring Well Installation

Two changes have been made to the boring program March 1985 Revision I RI Work Plan based on field conditions and/or recommendations by IT. After Monitoring Well MW-6 had been moved to its present location at the request of OEPA (Mark Besel's letter of March 11, 1985), it was recommended by IT and then approved by ARCO that an additional monitoring well (MW-9) be installed to monitor upgradient ground water conditions. This monitoring well was placed at the location shown in Figure 1-2.

Due to field conditions, Monitoring Well MW-5 was relocated to its present location shown in Figure 1-2 with the approval of ARCO and OEPA field personnel. The original location for MW-5 (as originally shown in Figure 3-1 of the March 1985 Revision I, RI Work Plan) was not accessible to the drilling equipment. Ground water monitoring wells were installed from March 18 to April 9, 1985 at the nine boring locations (Figure 1-2).

The monitoring wells were constructed of two-inch-diameter Schedule 40 PVC riser pipe and No. 10 (0.010-inch) slot size manufactured PVC screen. The saturated thickness of each borehole was screened to provide for assessment of

vertical variation in ground water quality. All the monitoring wells were not packed with sand; instead, natural materials were allowed to collapse around the well casings as the augers were removed. Where screens were exposed after the collapse (due to shallow ground water conditions in some areas), monitoring wells were sand packed to a minimum of one foot and a maximum of two feet above the screened interval. A two-foot bentonite seal was placed above the sand pack to minimize vertical communication and contamination from the overlying grout seal. The remainder of the annular space was filled with a cement-bentonite grout to the ground surface. Well completion diagrams are presented in Appendix C. Monitoring wells were pumped at a rate of 15 gpm until clear water was produced. Rapid well recovery due to high aquifer permeability rates prohibited in situ aquifer permeability testing.

4.3.4 Alsco Plant Production Wells

The three production wells (PW-3, PW-4, and PW-5) used to obtain water level data were installed prior to 1980 at different locations around the Alsco plant (Figures 1-1, 1-2, and 4-1). All three wells, PW-3 through PW-5, are accessible, although only one of these wells, PW-5, is currently in daily operation. Two other production wells, PW-1 and PW-2, were abandoned and are not easily accessed. Wells PW-3 and PW-4 are used only on a standby basis. Well PW-5 is pumped at approximately 1,000 gpm and has a total depth of about 140 feet. The pumping produces a cone of depression that influences the local ground water table configuration (Figure 4-4).

4.3.4.1 Current Status of Alsco Plant Production Wells

Currently Production Wells PW-4 and PW-5 are active and both have the capacity to provide process water to the Alsco Plant. Production Well PW-5 is the primary source while Well PW-4 is on standby and also provides the water to the 100,000 gallon emergency fire protection storage tank.

The process water is used throughout the plant as both noncontact and contact cooling water. All contact cooling water is collected and discharged to the wastewater treatment plant. After the wastewater has been treated the water is discharged out the NPDES outfall. The noncontact cooling water is collected in sumps with oil skimmers at the northwest and southwest corners of the plant to the Tuscarawas River through the NPDES outfalls. In selected

areas of the plant, city water is used with the process and is discharged similar to the Production Well PW-5 water as described above.

Therefore, the water supplied by Production Wells PW-4 and PW-5 to the Alsco Plant, other than for evaporation, is returned to the Tuscarawas River through the three Alsco Plant NPDES outfalls.

4.3.5 Ground Water Level Measurements

In order to determine the direction(s) and rate(s) of ground water flow from the Alsco-Anaconda NPL site, ground water levels were measured periodically (usually during quarterly ground water monitoring) over the two-year period since the monitoring wells were installed (Table 4-2). The monitoring and production wells and the locations of surrounding landmarks were surveyed with reference to a USGS benchmark (Figure 4-1) to establish true well, ground, and ground water table elevations. In addition, painted benchmarks were surveyed on the railroad bridge across the Tuscarawas River and on the plant discharge outflow pipe down river (outfall 006 in Figure 1-2) as reference points for determination of river water levels (Table 4-2, February and March 1987 data).

Water level measurements from the production and monitoring wells, plus the river, indicate that the local ground water flow is to the southwest in the direction of the Tuscarawas River and down the buried valley. The ground water table varies seasonally about four to six feet from high to low water conditions (Figure 4-5). However, the relationship of water levels between wells is relatively constant, indicating a stable hydraulic gradient. River elevations also fluctuate during this period, probably affecting local ground water levels. During low flow and drought periods, ground water base flow sustains the river (ODNR, 1968).

Localized variations of the ground water flow patterns are produced by the plant production well PW-5 used for process water. This effect is minimized by the high permeability if the subsurface materials. Aquifer pump tests conducted by the Ohio Drilling Company (1972) indicate the sand and gravel aquifer has a coefficient of transmissivity of about 685,000 gallons per day per foot (gpd/ft), which is equivalent to a hydraulic conductivity of 0.185 cm/s for a saturated thickness of 175 feet. Field tests show the

shallow subsurface soils have a hydraulic conductivity of about 10^{-3} cm/s. A hydraulic conductivity value of 10^{-1} cm/s for the deeper coarse-grained strata was calculated from PW-5 specific capacity data (Appendix B). Using the hydraulic conductivity calculated for PW-5, the hydraulic gradient across the site, and assuming an effective porosity of 0.25, the average rate of ground water flow velocity is estimated to be about 2 ft/day in areas out of the range of influence from PW-5.

4.3.6 Ground Water Sampling and Analysis

Ground water monitoring well samples were collected at Monitoring Wells MW-1 through MW-9 and Production Wells PW-4 and PW-5. Because the monitoring wells were screened continuously through the saturated zone, and contaminant sources occur near the surface on the site, upper zone and lower zone ground water samples were collected from the 0-to-25-foot and 25-to-50-foot depth intervals, respectively. The upper zone samples were collected at about middepth between the static water level and 25-foot depth, but at least five feet below the water table. The lower zone samples were collected at a depth of about 37.5 feet below the ground surface. Continuous downhole conductivity measurements and water level measurements were conducted prior to well purging to assist in the final determination of the sampling depth (Table 4-3). The profiles indicated essentially constant conductivities within a range of about ten percent. The pumps were set near the highest conductance readings in the upper zone but still at least five feet below the static water level.

Ground water samples were collected first from the lower depth intervals of the monitoring wells following purging of approximately three well volumes of water. The pump was then raised to the upper zone for additional purging and then sampling. At each sampling depth, measurements of pH, conductivity, and temperature were determined (Table 4-3 and Appendix D). Ground water samples and field measurements were also collected from the plant production wells, PW-4 and PW-5, which were sampled from the attached spigots following brief purging using the existing well pumps when the wells were not already in operation.

A total of six sets of ground water samples were collected during the two-year remedial investigation. Each set consisted of upper and lower zone samples from Monitoring Wells MW-1 through MW-9 and pumping zone samples from Production Wells PW-4 and PW-5 (a total of 20 ground water samples per set).

A summary of the ground water monitoring events and the corresponding analytical programs follows.

- First quarter ground water monitoring, April 9 and 12, 1985:

  - HSL volatile, semivolatile, and pesticide/PCB organic constituents (six wells only; MW-1, MW-2, MW-3, MW-5, MW-6, and PW-5)

  - Amenable cyanide

  - Total constituent cyanide, fluoride, and nitrate

  - Thirteen total metals (Al, As, Ba, Cd, Cr, Cu, Fe, Pb, Mn, Hg, Se, Ag, and Zn)

  - Hexavalent chromium

- Second quarter ground water monitoring, July 30 and 31, 1985

  - HSL volatile and semivolatile organic constituents
  - Amenable cyanide
  - Total constituent cyanide, fluoride, and nitrate
  - Four total metals (Cr, Fe, Mn, and Se)
  - Hexavalent chromium
  - Total organic carbon

- Third quarter ground water monitoring, November 4 and 5, 1985

  - PCBs (five wells only; MW-4, MW-5, MW-7, MW-8, and MW-9)

  - Amenable cyanide

  - Total constituent cyanide, fluoride, and nitrate

  - Two total metals (Cr and Se)

  - Hexavalent chromium

  - Total organic carbon

  - Total organic halogens

- Fourth quarter ground water monitoring, January 28 to 30, 1986

  - Amenable cyanide
  - Total constituent cyanide, fluoride, and nitrate
  - Two total metals (Cr and Se)
  - Hexavalent chromium
  - Total organic carbon
  - Total organic halogens

- Final quarter ground water monitoring, November 18 to 20, 1986

  - HSL volatile, semivolatile, and pesticide/PCB organic constituents (both production wells and nine monitoring wells)

  - Amenable cyanide

  - Total constituent cyanide, fluoride, and nitrate

  - Thirteen total metals (Al, As, Ba, Cd, Cr, Cu, Fe, Pb, Mn, Hg, Se, Ag, and Zn)

  - Hexavalent chromium

- Limited ground water monitoring, January 27 to 29, 1987

  - Hexavalent chromium
  - Total cyanide.

The complete results for the ground water analytical program are presented in Appendix D. Summaries of the detected parameters are presented in Tables 4-4 through 4-11.

4.3.7 Ground Water Quality

As indicated, ground water monitoring was originally performed on a quarterly basis April 1985 through January 1986 with additional monitoring performed in November 1986 and January 1987. Ground water monitoring results for the above sampling events are reported in Appendix D for the program described in Section 4.3.6. Results are summarized for those inorganic and metals parameters detected above SDWA standards or U.S. EPA water quality criteria in Tables 4-4 through 4-9.

Table 4-4 presents a summary of cyanide results for those monitoring well samples which exhibited values greater than 0.02 mg/l. Monitoring Well MW-3 exceeds the U.S. EPA Water Quality Criteria (WQC) for maximum protection of human health (0.20 mg/l) with a maximum cyanide concentration of 0.39 mg/l (considering both upper and lower sampling zones). Monitoring Wells MW-2 and MW-4 have exceeded the WQC in three out of six monitoring events with maximum cyanide concentrations of 0.23 and 0.35 mg/l, respectively.

Monitoring Wells MW-5 and MW-6 exhibited detectable cyanide concentrations but only the January 1987 samples from Monitoring Well MW-5 exceeded the WQC at a mean concentration of 0.60 mg/l. The U.S. EPA does not currently propose to establish a regulatory SDWA maximum contaminant level (MCL) or nonregulatory Recommended Maximum Contaminant Level (RMCL) for cyanide. However, the U.S. EPA has proposed (Federal Register, Volume 50, No. 219, November 13, 1985) to establish a provisional Average Adjusted Daily Intake (AADI) of 0.75 mg/l. Should this AADI guidance level be established, none of the monitoring well results will exceed the U.S. EPA's AADI for consumption of cyanide in drinking water. All monitoring well cyanide results with the exception of the January 1987 samples from Monitoring Wells MW-5 are within a factor of two of the current WQC. Additionally, the above cyanide results represent worst case conditions due to the proximity of Monitoring Wells MW-2, MW-3, MW-4, and MW-5 to the sludge pit and impoundment.

A summary of chromium results, presented in Table 4-5, indicates that only Monitoring Wells MW-7 and MW-9 consistently exceeded the SDWA regulatory standard MCL of 0.05 mg/l, although maximum chromium concentrations were limited to 0.11 and 0.14 mg/l, respectively. Monitoring Wells MW-2 and MW-3 exceeded the MCL on only one of six monitoring events with maximum values of 0.05 and 0.13 mg/l, respectively.

Monitoring Wells MW-5 and MW-8 did not exceed the MCL of 0.05 mg/l chromium. Production Well PW-4 only exceeded the MCL on one occasion and chromium was usually not detectable in most samples. None of the remaining wells exhibited chromium values above 0.02 mg/l and values were usually less than the method detection limit.

Fluoride results, presented in Table 4-6, indicate that Monitoring Wells MW-3, MW-4, and MW-9 consistently exceeded the SDWA regulatory MCL of 4.0 mg/l but values did not exceed 8.7 mg/l (MW-4) and were usually within a factor at two of the standard (i.e., 4 to 8 mg/l). Monitoring Well MW-5 exceeded the MCL on only one of five monitoring events. Monitoring Well MW-7 exhibited fluoride concentration in excess of 1.0 mg/l but less than 2.6 mg/l. The other wells (MW-1, MW-2, MW-6, and MW-8) did not exceed 1.0 mg/l fluoride.

Nitrate results, presented in Table 4-7, indicate that nitrate values were less than SDWA MCL of 10 mg/l except for the April 1985 sampling of Monitoring Wells MW-3 and MW-6 which exhibited nitrate concentrations of 11 and 21 mg/l, respectively.

Selenium results, presented in Table 4-8, indicate that the SDWA MCL of 0.010 mg/l was only exceeded in one of five sampling events in Monitoring Wells MW-2, MW-3, and MW-5 at concentrations of 0.015, 0.010, and 0.013 mg/l, respectively.

HSL organic compound results are summarized in Tables 4-9, 4-10, and 4-11 for the first, second, and final quarterly ground water monitoring. Results indicate the sporadic presence of tetrachloroethylene, toluene, xylene, and 1,3-dichlorobenzene at concentrations slightly above the method detection limits. Tetrachloroethylene was identified during the first quarterly monitoring in Wells MW-1, MW-2, and MW-3 at 6.8, 5.3, and 9.7 ug/l, respectively (Table 4-9). Tetrachloroethylene was not detected in subsequent quarterly monitoring. No HSL organic compounds were identified above the U.S. EPA HSL contract required detection limits (CRDL) in the second quarterly ground water monitoring (Table 4-10). Toluene, xylenes, and 1,3-dichlorobenzene were detected at the following levels in the final quarterly ground water monitoring (Table 4-11):

- Monitoring Well MW-1 - 6.2 ug/l xylenes
- Monitoring Well MW-8 - 13 ug/l 1,3-dichlorobenzene
- Production Well PW-4 - 6.9 ug/l toluene and 13 ug/l xylenes.

Xylenes and 1,3-dichlorobenzene were also detected in the corresponding laboratory method blank. Methylene chloride and acetone were detected in all the final quarterly monitoring well samples as well as the laboratory method blanks. Because methylene chloride and acetone are common laboratory contaminants, and occurred in the laboratory, field, and rinsate blanks these results reflect laboratory artifacts and not ground water quality.

5.0 SURFACE WATER INVESTIGATION

5.1 INTRODUCTION

Because the plant site is situated next to the Tuscarawas River, a surface water study was conducted during the course of this remedial investigation. Knowledge of the flow rates, flooding conditions, water quality, and other characteristics are necessary to achieve an accurate assessment of the site/river relationship. The effect that the Tuscarawas River may have on the site is just as important as any possible impact the site may have on the river, either now or during remediation. The following is a description of the major features of the river.

5.2 DRAINAGE PATTERNS

5.2.1 Basin Topography

The Tuscarawas River basin lies within the Allegheny Plateau, which has been divided into two areas based upon the extent of the Pleistocene continental ice sheet. Tuscarawas County lies within the unglaciated portion of the basin and, therefore, has a more highly dissected topography with a dendritic drainage pattern. Relatively low relief sand and gravel glacial outwash deposits are present in the river valleys, and these deposits may exceed 200 feet in thickness.

5.2.2 Tuscarawas River Basin Drainage Patterns

The Tuscarawas River is one of two main tributaries of the Muskingum River and flows southward from Akron in the northeast corner of the Muskingum basin. It meets the Walhonding River at Coshocton, and this confluence forms the Muskingum River (ODNR, 1968).

The Tuscarawas River is 129.9 miles long with a drainage area of 2,589.7 square miles (ODNR, 1968). Elevations at the source and mouth are 1,140 feet MSL and 738 feet MSL respectively, with an average fall of 3.1 feet per mile. There are four main tributaries to the Tuscarawas River: Stillwater, Sugar, Conotton, and Sandy creeks. The drainage areas of these four streams contain over 60 percent of the drainage area for the Tuscarawas River basin. Stillwater Creek, which is 63.5 miles long, has a drainage area of 485.1

square miles, and joins the Tuscarawas approximately six miles upstream from Gnadenhutten. This is the last major tributary to join the Tuscarawas River before the Walhonding and Tuscarawas Rivers meet in Coshocton.

5.2.3 Site Drainage

Overland flow at the plant site occurs by two methods:

- Surface runoff from rainfall
- Directed water flow from rainfall and plant discharge water.

Runoff generally flows in the direction of the Tuscarawas River, which is downgradient from the site. Topographic lows, such as the swamp area on the river floodplain, are at a higher elevation than the river but are poorly drained.

Site frontage along the Tuscarawas River encompasses a distance of approximately 1,000 feet from the Conrail bridge at the upstream boundary to the County Road 39 bridge (Anaconda Drive) at the downstream boundary. Two former and four present NPDES permitted outfalls discharge to the Tuscarawas River along this frontage. Waters draining into these outfalls include:

- Outfall 001 - Casting cooling water (diverted to Outfall 006)
- Outfall 002 - Cold rolling cooling water
- Outfall 003 - Noncontact cooling water and roof drains
- Outfall 004 - Coil coating quench water, roof drains, and parking lot
- Outfall 005 - Treated process wastewater (diverted to Outfall 006)
- Outfall 006 - Casting cooling water and treated process water.

Prior to October 1986, water from Outfalls 001 and 005 was discharged into the swamp area. Since that time, outfalls 001 and 005 were diverted into an underground pipeline that discharges from Outfall 006 directly into the Tuscarawas River (Figures 1-2 and 5-1).

5.3 TUSCARAWAS RIVER

5.3.1 Physical Characteristics

The Tuscarawas River gaging station nearest Gnadenhutten is located approximately 16 miles downstream in Newcomerstown, Ohio. No major stream joins the Tuscarawas between Gnadenhutten and Newcomerstown; therefore, measurements obtained at this gaging station would be generally representative of river flow conditions at the Alsco-Anaconda NPL site.

Since 1938, a series of reservoirs has regulated the Tuscarawas River below Dover, Ohio, and flow rates are based on data obtained since that time. Low flow for the Tuscarawas at Newcomerstown is 236 mgd (365 ft^3/s) with a median flow of 769 mgd (1190 ft^3/s). The highest flow since 1938 was 14,282 mgd (22,100 ft^3/s) in 1940. The calculated 25-year flow rate is 14,153 mgd (21,900 ft^3/s) (ODNR, 1968).

Flow measurements obtained 2.7 miles down valley of Gnadenhutten in July 1972 (Ohio Drilling Company, 1972) were 276 mgd (427 ft^3/s) and 263 mgd (407 ft^3/s) on two-consecutive days.

The Tuscarawas River near Gnadenhutten is 270 feet across at its widest point (upstream of the site at the railroad bridge adjacent to the U.S. Route 36 bridge) and 120 feet in width at its narrowest point (at the dismantled bridge immediately downstream of the plant, along Anaconda Drive). The river depth averages approximately three feet throughout the wider areas, with a range of 0 feet (at sand bars and islands) to about 6 feet. In the narrow section it ranges from 12 to 15 feet (beneath the former bridge at Anaconda Drive, in an anomalously deep area which was dredged to install an optic fiber cable across the river).

The Tuscarawas River water levels fluctuate seasonally and with extreme rainfall events, even though reservoirs exist upstream to regulate the flow. During the site survey, the benchmarks on the railroad bridge across the Tuscarawas River and on the plant Outfall Pipe 006 (Figure 1-2) were installed. River water levels were measured in February and March 1987 (Table 4-2) from the benchmarks. On February 25, 1987, the water level

elevations were 813.8 and 813.1 feet above MSL at the upstream (railroad bridge) and downstream (outfall 006) benchmarks, respectively. On March 26, 1987, the water level elevations at the same points had dropped 0.3 feet to 813.5 and 812.8 feet above MSL, respectively. The stream gradient between the two benchmarks is 0.00002 degrees, or 0.001 feet/foot.

5.3.2 Flooding Tendencies

As mentioned previously, a series of four reservoirs (Bolivar, Atwood, Leesville, and Dover) located above the city of Dover regulates the water levels and flow rates of the Tuscarawas River (ODNR, 1968). Since 1938, the maximum flood on record occurred in 1940, with a flow of 22,100 ft^3/s. The following are predicted high flow rates at the Newcomerstown gage (Webber and Bartlett, 1977):

- Two-year interval - 9,500 mgd (12,700 ft^3/s)
- Five-year interval - 10,146 mgd (15,700 ft^3/s)
- Ten-year interval - 11,439 mgd (17,700 ft^3/s)
- Twenty-five-year interval - 12,990 mgd (20,100 ft^3/s)
- Fifty-year interval - 14,153 mgd (21,900 ft^3/s)
- One-hundred-year interval - Not calculated by ODNR because of flow regulation.

Tuscarawas River flood flow estimates by the Army Corps of Engineers (Herndon, 1985) indicate a 50-year high flow rate of 16,800 ft^3/s and a 100-year high flow rate of 30,400 ft^3/s at stream mile 37.7 between U.S. Route 36 and County Road 39; the respective 50-year and 100-year flood elevations are predicted to be 825 and 827 feet MSL. Since the swamp area and impoundments have elevations from 823 to 824 feet for the former and 823 to 829 feet MSL, for the latter, a large portion of the Alsco-Anaconda NPL site would be inundated during a 100-year flow (Figure 1-2).

5.3.3 Manmade Structures

Manmade nearby structures near the Alsco-Anaconda NPL site include two bridges just upstream of the site--a Penn-Central Railroad bridge and a bridge along U.S. Route 36--both of which cross the Tuscarawas River. Immediately downstream of the site is a dismantled bridge which previously traversed the river at Anaconda Drive. NPDES permitted outfalls are also located at the site, as discussed in Section 5.2.3.

5.3.4 Surface Water/Ground Water Relationships

The precise relationship between the Tuscarawas River and the ground water is not known at present. However, the aquifer at Gnadenhutten, as discussed in Appendix B of this report, consists of unconsolidated fine-grained silt and sand and coarse-grained sandy gravel. Hydraulic conductivities, therefore, are likely to be variable. Laboratory analysis performed by IT indicate hydraulic conductivities of 10^{-5} cm^3/s for the silty sand. Calculations of hydraulic conductivity for Well PW-5 (Appendix B) result in a value of 0.14 cm^3/s for the sandy gravel. When IT personnel developed the wells on site, an attempt was made to measure drawdown in the pumping wells; however, no significant drawdown was measured due to the rapid recovery of water levels. This is not inconsistent with the hydraulic conductivity calculated in Appendix B.

Results of pumping tests performed near Gnadenhutten (Ohio Drilling Company, 1972), indicate the aquifer is hydraulically connected with the river. A reduction of chlorides noted in the pumping well during an aquifer test (1,000 ppm to 590 ppm) is inferred to be the result of recharge from the Tuscarawas River (average chlorides content of 268 ppm). The conclusion is therefore, drawn that any well that is pumping at high rates (>700 gpm) near the Tuscarawas would eventually approach the chemical composition of the river water due to this recharge. This recharge was estimated to range from 15 mgd per mile to 8[illegible] mgd per mile.

5.4 TUSCARAWAS RIVER QUALITY

Data available from the OEPA (STORET data system) does not include results for most organic compounds and PCBs. Also, the data for Gnadenhutten and New Philadelphia only represent one year's information compared to eight year's

from Newcomerstown. Therefore, any comparison between the water quality upstream and downstream of Gnadenhutten would be very inconclusive. The data do show very slight increases in aluminum, cadmium, copper, and iron downstream from New Philadelphia (Table 5-1). Alkalinity (and pH), chloride, nitrate, and phenols decrease slightly. There is no definite trend in chromium, cyanide, magnesium, manganese, phosphate, and sulfate. The above trends may be caused by an incomplete data set, as they are not pronounced.

The elevated concentration of chloride in the Tuscarawas River upstream from Gnadenhutten is believed to be due to:

- Industrial activity in the Barberton, Ohio area (Burgess and Niple Ltd., 1984)
- Oil and gas drilling activity upstream of the test site (Ohio Drilling Company, 1972 and Burgess and Niple, Ltd., 1984).

Table 5-1 mean iron and manganese levels exceed U.S. Secondary Drinking Water Standards (0.30 mg/l and 0.05 mg/l, respectively) in samples taken upstream (New Philadelphia) and downstream (Newcomerstown) of Gnadenhutten. Other measured constituents are below the regulated limits.

5.5 TUSCARAWAS RIVER SEDIMENTS

An investigation of the Tuscarawas River sediments was conducted in November 1986 to determine the levels and extent of PCBs and hexavalent and total chromium in the bottom sediments of the river. A total of 101 sediment samples were collected along 15 traverses across the Tuscarawas River at locations upstream, adjacent to, and downstream of the Alsco-Anaconda NPL site (Figure 5-1). Within each zone, the traverses were spaced 100 feet apart and were approximately perpendicular to the river banks. Upstream samples were collected to serve as background. Near-site samples were collected to evaluate the potential contamination from site related sources. Downstream samples were collected to test for the potential migration of site-derived contaminants.

5.5.1 Tuscarawas River Sediment Sampling

The upstream traverses, RS-1 through RS-3 across the Tuscarawas River, were located about 1,000 to 1,200 feet upstream from the Conrail bridge, respectively (Figure 5-1). A total of 26 samples were collected at 30-foot intervals across the three traverses extended the width of the river. Eight samples were collected across RS-1, and nine samples were collected across each of RS-2 and RS-3, with sample numbers increasing from east to west across each traverse. The sediments 10 to 20 feet outward from the banks were generally gray to brown, fine-grained, soft clay, silt, and sand mixed with organic matter. The sediments across the channel bottom, away from the shore, where the water depth was about three feet deep, consisted of brown, white, black, and green, medium-to-course-grained sand mixed with generally flattened gravel to one inch in diameter. The sand and gravel included mineral and rock fragments of quartz, shale, sandstone, and limestone, with some clam shell fragments.

The near-plant traverses, RS-4 through RS-12, were located along about 900 feet of the Alsco-Anaconda site river frontage (Figure 5-1). A total of 52 samples were collected at 20-foot intervals across the nine traverses extended about half the width of the river from the east bank. Seven samples were collected along each of traverses RS-4 through RS-7, six along RS-8 and RS-9, five along RS-10, four along RS-11, and three along RS-12. Traverse RS-4 was located about 160 feet downstream from the Conrail bridge or 100 feet downstream from Outfall 002. Sequential traverses were spaced 100 feet apart down to RS-12, which extended westward across the river from County Road 39 (Anaconda Drive) bridge abutment. The width of the channel decreased from about 270 feet to 120 feet, whereas the average depth increased from about 3.5 feet to 10 feet, downstream from RS-4 to RS-12. The sediments along traverses RS-4 through RS-10 and the near-shore samples along RS-11 and RS-12 were identical in appearance to those collected upstream. However, due to the faster current in the relatively narrow channel traversed by RS-11 and RS-12, only coarse sand and gravel with cobbles to about six inches were derived toward midchannel.

The downstream traverses, RS-13 and RS-15, were located about 1,000 to 1,200 feet downstream from the County Road 39 bridge abutment or traverse

RS-12, respectively. A total of 23 samples were collected at 30-foot intervals across the three traverses extended the width of the river. Seven samples were collected across RS-13, and eight samples were collected across each of RS-14 and RS-15. The sediments collected along the downstream traverses were generally similar to those collected across the upstream traverses, except the grain sizes were finer in the downstream samples. The river channel width was about 200 feet, and the average depth about five feet at these locations.

5.5.2 Tuscarawas River Sediment Analyses

Selected individual samples and representative composite samples of the river sediments were analyzed for PCBs and hexavalent and total chromium (Table 5-2). Five composite samples were created from equal weight portions of the samples from three adjacent traverses as follows:

- Background
  - Composite RS-1, 2, 3: Composite of individual samples RS-1-1 through RS-1-8, RS-2-1 through RS-2-9, and RS-3-1 through RS-3-9
- Near-Plant
  - Composite RS-4, 5, 6: Composite of individual samples RS-4-1 through RS-4-7, RS-5-1 through RS-5-7, and RS-6-1 through RS-6-7
  - Composite RS-7, 8, 9: Composite of individual samples RS-7-7, RS-8-1 though RS-8-6, and RS-7-1 through RS-9-1 through RS-9-6
  - Composite RS-10, 11, 12: Composite of individual samples RS-10-1 through RS-10-5, RS-11-1 through RS-11-4 and RS-12-1 through RS-12-2
- Downstream
  - Composite RS-12, 14, 15: Composite of individual samples RS-13-1 through RS-13-7, RS-14-1, through RS-14-8, and RS-15-1 through RS-15-8.

The above five composites, plus 36 individual samples, were processed and analyzed. Among the individual samples, the second sample about 20 to 25 feet from the east bank (plant side) of the river was analyzed for each of the near-plant traverses (RS-4-2 through RS-12-2). In addition, the individual samples across four traverses RS-2, RS-7, RS-10, and RS-14 (Samples RS-2-1 through RS-2-9, RS-7-1 through RS-7-7, RS-10-1 through RS-10-5, and RS-14-1 through RS-14-8) were analyzed.

5.5.3 Evaluation of River Sediment Analyses

Results of the river sediment analyses, presented in Table 5-2, indicate that river sediment chromium species are primarily trivalent chromium and little hexavalent chromium is present. This is expected in typical fluvial environments, as previously discussed in Chapter 3, because typical pH and Eh conditions favor the stability of trivalent chromium, and oxidation of organic carbon will form a redox couple with hexavalent chromium reducing it to the trivalent form.

Total chromium concentrations present in the individual sediment samples are highest for the samples nearest the river banks and decreases towards the middle of the channel. This concentration profile corresponds to the grain-size distribution in the river sediments with the finer-grained sediments being present along the river banks where water velocities are lowest. The correlation of higher chromium concentrations with finer grain-sized sediments is expected because adsorption and/or reduction-precipitation reactions favor fine-grained sediments. The positive bias in chromium concentrations of fine-grained sediments skews the results presented in Table 5-2 such that total chromium concentrations appear to increase adjacent and downstream of the site. This is because the nearshore RS-X-2 (20 feet from shore) samples were analyzed at each traverse adjacent to the site. These samples are in the finer-grained sediments with correspondingly higher chromium concentrations. Upstream traverses were collected at 30-foot intervals and the near shore samples are correspondingly closer to the main channel.

Additionally, a small island is present about 20 feet from the site river bank just downstream of Traverse RS-7. River flow forms a minor channel between the island the site river bank with the main river channel on the opposite side of the island (Figure 1-2). The sluggish river velocities upstream and downstream of this area result in the presence of finer river sediments and a bias for higher chromium concentrations. Traverses RS-11 and RS-12 were sampled where the river channel narrowed and the main channel flow moved towards the site river bank. Accordingly, coarser sediments were encountered and total chromium concentrations were correspondingly lower.

Downstream sediments from Traverses RS-13, RS-14, and RS-15 were collected where the river channel widened from 120 to 200 feet with an average depth of five feet and a correspondingly lower flow velocity. As a result, downstream sediments exhibited a finer grain-size than the upstream (background) sediments. As a result, downstream total chromium results tended to be slightly higher. This was particularly noticeable in the sediment composites in Table 5-2.

The sampling/analytical results for total chromium of individual samples in upstream, adjacent to site, and downstream classes were compared statistically. The distributional form of the data was evaluated using the Wilk-Shapiro test for normality (Shapiro and Wilk, 1965). Data for the chromium analysis of sediments from each location appear to be accurately described by the normal distribution, but the variances are apparently unequal (Steel and Torrie, 1980).

SAMPLE LOCATION	NO. OF SAMPLES	CHROMIUM CONCENTRATION (mg/kg) MEAN	STANDARD DEVIATION
Upstream	9	67.8	14.3
Near Plant	19	81.2	36.2
Downstream	8	71.0	26.3

The equality of variances was examined using an F-test (Steel and Torrie, 1980). The downstream and upstream reaches may have equal variances, but the near-plant reach has a significantly larger variance than the other two. Consistent with these findings, all three locations were compared to one another using Satterthwaite's approximation (Satterthwaite, 1946) for the degrees of freedom, a method which adjusts for unequal variances when applying the students t-test. All three locations are not significantly different from one another with respect to mean total chromium concentration.

There are two reasons why a statistical test may fail to reject the hypothesis that there is no difference between the data at different locations: either there actually is no difference in the populations being compared, or the number of samples collected is too small to provide sufficient discriminatory power for the statistical test. The site and downstream reaches would have to have an average total chromium concentration at least 25 mg/kg greater than

the average upstream concentration for the statistical test to have approximately an 80 percent chance of rejecting, given the number of samples collected. IT believes that the sampling effort is sufficient, and that differences of 25 mg/kg or less do not have practical significance.

The distribution of the data and the lack of a significant difference in total chromium concentrations suggest that the variations observed in total chromium are probably due to a natural process, such as stream velocity/sediment transport (sedimentation) causing sorting of bed sediments. A typical traverse across the river would encounter fine-grained clay and silt adjacent to the bank, with coarser-grained sand and gravel along the main channel bottom and then finer-grained materials at the opposite bank. The fine-grained materials have significantly larger surface areas per unit mass, and therefore tend to sorb greater quantities of metals from the water contacting the suspended and settled sediment load. The observed difference in variances may be because both upstream and downstream traverses were conducted with 30-foot sample spacing from one side of the river to the other. However, near-site traverses were conducted with 20-foot sample spacing less than two thirds of the way across the river from north to south, and analyses of the fine-grained samples 20 feet from the north bank are most numerous in Table 5, biasing the near-site means.

Given the bias in the chromium results, a greater probability exists that the near-site and downstream traverses would exhibit statistically greater chromium concentrations than the upstream (background) traverses. However, the statistical analysis of the individual sediment sample analysis indicates that the upstream, near-site, and downstream chromium concentrations are statistically equivalent indicating little or no plant-site impact upon ambient river sediment chromium concentrations.

PCBs results for the river sediment samples (Table 5-2) indicate that only two sediment samples exhibited detectable PCB concentrations: RS-9-2 and RS-12-2 at 0.47 and 0.11 mg/kg, respectively. Accordingly, PCB contamination of river sediments does not appear to be an issue for further concern in the remedial investigation.

6.0 AIR INVESTIGATION

6.1 INTRODUCTION

Due to the nature of the waste present at the Alsco-Anaconda NPL site (high water content, preventing dust or dry waste conditions, and vegetation overgrowing the waste disposal areas), an air emissions pathway was not considered a primary contaminant migration route. Rather, surface and/or ground water are the principal means of contaminant transport. Therefore, in accordance with the site work plan, a site-specific air investigation was not conducted. The following general discussion of regional weather and wind characteristics serves to present background climatic information.

6.2 WEATHER EXTREMES

As discussed in Chapter 2, Tuscarawas County, Ohio, has moderate weather extremes (NOAA, 1978), with a mean annual temperature range of 31 to 74.5 degrees Fahrenheit (ODNR, 1968). Mean annual precipitation is 39 inches. Extreme weather occasionally occurs in the form of tornadoes and thunderstorms. Extreme rainfall can lead to flooding of the Tuscarawas River and tributary creeks. The Tuscarawas River flooding characteristics are discussed in more detail in Chapter 5.0 of this report.

6.3 WIND SPEED/DIRECTION

There are no weather stations near Gnadenhutten, Ohio which have historic data in regard to wind speed and direction. Akron is the closest area to the site with such records. The prevailing wind direction in Akron is south at approximately 10 miles per hour (NOAA, 1978); however, because Gnadenhutten lies in a valley oriented northeast-southwest, it is not clear whether this information can be correlated to the village of Gnadenhutten.

6.4 CONTAMINANT CHARACTERIZATION

As discussed in Chapter 3.0, the sludge at the site contains mostly calcium carbonate, gypsum, and aluminum oxyhydroxide compounds, including cyanide, chromium, fluoride, plus trace nitrate, volatile organic compounds, and PCBs. Waste component migration routes are primarily via surface and

ground water flow because the sludge impoundments are not lined. The contaminants present in the sludge have a low potential to migrate via an air pathway due to the high water content of the sludge and vegetation cover over the waste disposal areas.

7.0 BIOTA INVESTIGATION

The scope of work for the Alsco-Anaconda NPL site RI did not include a comprehensive biota survey or a biocontamination study. However, in order to address concerns for sensitive biota or habitats, information regarding the potential presence of officially designated endangered or threatened flora and fauna was requested from the ODNR Division of Natural Areas and Preserves, Natural Heritage Program. A map showing the Alsco-Anaconda NPL site and vicinity with concentric circles of 0.5-, 1.0-, 1.5-, and 2.0-mile radii around the site was sent along with a data request form to the Natural Heritage Program. In a letter dated May 21, 1987 to C. Cravotta of IT, the Natural Heritage Program Data Management Supervisor, P. D. Jones, stated, "...the Heritage Program has no records for rare or endangered species within a two-mile radius of the former ARCO-Alsco plant site in Gnadenhutten, Ohio. There are no existing or proposed state nature preserves or scenic rivers in Tuscarawas County, and we [Heritage Program] are unaware of any unique ecological sites in the vicinity of your study area [Alsco-Anaconda NPL site]."

3.0 PUBLIC HEALTH AND ENVIRONMENTAL CONCERNS

3.1 DESIGN OF RISK ASSESSMENT

This risk assessment has been prepared to evaluate the level of potential risk associated with the Alsco-Anaconda NPL site in Gnadenhutten, Ohio. This assessment addresses the northern and southern impoundment areas, the sludge pit, and the swamp area.

The purpose of this risk assessment is to evaluate whether there are potential public health or environmental risks associated with the no-action alternative. This assessment conforms to appropriate guidelines as set forth in the Superfund Public Health Evaluation Manual (SPHEM) and, as designed, is biased toward health protection. The effects of potential risks are evaluated with respect to the most sensitive receptor populations that may potentially be affected by the site. The presence of the more toxic or mobile chemicals is compared with any current standards or criteria for drinking water, ambient water, and appropriate risk factors. The following sources were used to evaluate the potential significance of the chemicals during this investigation:

- Suspect Chemical Source Book (Clansky, 1986)
- SPHEM (U.S. EPA, 1986b)
- Sittig (1985)
- Registry of Toxic Effects of Chemical Substances (RTECS) (1983)
- Quality Criteria for Water 1986 (U.S. EPA, 1986)
- National Primary Drinking Water Standards (Federal Register, 1985, 1987)

3.2 SELECTION OF INDICATOR PARAMETERS

Constituents considered for inclusion in the risk assessment initially included all those detected in the sludges, soils, and ground water, even though not all of the constituents were expected to pose potential health risks. To assess the potential impacts of the site, the results of the RI were reviewed with respect to concentrations in the ground water, sludges, and soils.

Parameters considered in the ground water pathway were chosen because they were detected in ground water or were above the Extraction Procedure (EP) toxicity standard. A review of all EP toxicity data, as explained in detail in Chapter 2.0, showed only one parameter, total chromium, to be above the EP toxicity standard for all sludge and soil samples. Additionally, constituent levels in the leachate analyses compared favorably with SDWA standards. Ground water samples were analyzed for the following:

- Hazardous Substance List (HSL) organic parameters
- Total and amenable cyanide, fluoride, and nitrate
- Fourteen metals
- Total organic carbon
- PCBs

Only six constituents were found above detection limits in ground water. These contaminants were chosen as the constituents of concern via the water pathway and are:

- Chromium (hexavalent)
- Chromium (total)
- Cyanide (total)
- Fluoride
- Nitrate
- Selenium
- Tetrachloroethylene

The constituents of concern via direct contact (ingestion and dermal pathways) were those metals present above background, all inorganic constituents of toxicological concern, PCBs, and all organic constituents detected above detection limits. These constituents are:

- Arsenic, cadmium, chromium (total), chromium (hexavalent), and mercury
- Cyanide (total) and PCBs
- Ethylbenzene, 2-hexanone, tetrachloroethylene, toluene, and xylenes (total)
- Bis (2-ethyl hexyl) phthalate, di-n-butyl phthalate, fluoranthene, isophorone, naphthalene, n-nitrosodiphenylamine, phenanthrene, and pyrene

The chronic acceptable intake of silver is significantly higher than cadmium (SPHEM, 1986b). If the potential risk associated with cadmium is considered

Sorption of chemicals to organic soil constituents is influenced by lipid solubility. A measure of lipid solubility is the relative partitioning of a chemical between octanol and water. Tetrachloroethylene has the lowest potential for partitioning to the sorbed phase and thus is likely to be one of the more mobile chemicals.

Chemical transport in air generally exists in two forms:

- Volatilization to gases/vapors
- Wind dispersion of solids (particulates)

The former is dependent on the ability of a contaminant to diffuse through the soil and to have a sufficiently high vapor pressure that it will volatilize under atmospheric conditions. For the VOC group, the individual chemicals were ranked by vapor pressure (Table 3-18). Organic contaminants sorbed to the soil and inorganic contaminants as particulates or associated with particulates can be dispersed by wind to potential receptors. At the Alsco-Anaconda NPL site, however, the sludges have a high water content and are covered with vegetation. The organic constituents are present at levels not expected to result in volatilization to air and particulate dispersion is unlikely. Therefore, air does not represent a potential pathway of concern at this site. In summary, the pathways of concern in the health evaluation are ground water transport to the river and direct contact of soils or sludges.

8.5 POTENTIAL RECEPTORS FOR WATER PATHWAY

Human exposure to chemicals from the Alsco-Anaconda NPL site via the water pathway could potentially result from contact with or ingestion of contaminated ground water. However, investigation of this site has shown (Chapter 4.0) that ground water flow is away from the community of Gnadenhutten and toward the Tuscarawas River. Drinking water for the community is derived from a series of wells hydrologically upgradient of the Alsco-Anaconda NPL site. Thus, there is no potential for contaminants from this site to have an impact on community drinking water.

The primary consideration for chemicals migrating from the site in the ground water is the impact on the river. Ground water flow has been estimated using Darcy's equation (Appendix B). Using low flow conditions of the river and

assuming 100 percent of the ground water flow beneath the site enters the river, dilution of ground water by the river, under the "worst-case" scenario, may be represented by:

$$\text{Dilution Factor} = \frac{\text{Ground water volume (L/day)}}{\text{River volume (L/day)}} = \frac{2.62 \times 10^{6}}{8.93 \times 10^{8}}$$

$$= 2.93 \times 10^{-3}$$

The ground water contaminants migrating from the site were also evaluated assuming that none of the ground water discharges to the river and that the contaminants are diluted by vertical and horizontal mixing along the flow path through the aquifer. An analytical approach using the U.S. EPA Vertical Horizontal Speed (VHS) model was employed (Appendix B) to evaluate chromium cyanide, fluoride, and arsenic. The VHS model calculations used the sludge volume at the Alsco-Anaconda NPL site and the maximum concentrations observed in ground water of chromium, cyanide, fluoride, and arsenic as input. The VHS model results indicate that at a receptor point 50 meters from the leaching sludge (at the opposite bank of the river), which is a worst-case example, none of the above contaminants of concern exceed the SDWA standards or U.S. EPA WQC (Appendix B). The nearest downgradient water wells are more than 0.5 mile from the site and, thus, would not be impacted.

The Tuscarawas River is not used by the town of Gnadenhutten as a water supply. However, human exposure to constituents from the site could potentially occur through drinking the water from the river although this is unlikely. Since the river is used for recreation, potential exposure may also occur through fishing, boating, and swimming. These potential receptors are addressed in the following section.

8.6 IMPACT OF CONSTITUENTS IN GROUND WATER

As discussed in Chapter 4.0, ground water flow is to the southwest and, thus, is flowing away from the community of Gnadenhutten and its drinking water sources. As previously indicated, the primary receptor is considered to be the river. Estimates of contaminant contribution to the river were made based on detected levels in ground water and the dilution factor previously calculated.

8.6.1 Comparison with Standards and Criteria

Only six contaminants were found above detection limits in ground water. Of these, chromium values are reported as total and hexavalent forms. Analytical data for ground water samples are available for four quarterly periods from nine monitoring wells around the site (Tables 4-4 through 4-11). The highest value from these sampling rounds was used to evaluate potential contamination of the river. The estimated concentrations of constituents in the river have been compared to Drinking Water Standards, Ambient Water Quality Criteria (WQC) Freshwater Fish and Ambient WQC for Water and Fish Ingestion. Table 8-1 shows that all constituents are well below standards and criteria for the protection of human health and aquatic species. The ambient water quality criteria developed by the U.S. EPA were based on toxicity data for the most sensitive aquatic species on which data were available. These criteria, then, can be considered to be protective of all aquatic species for the particular constituent of concern. Additionally, estimated concentrations of constituents in the river are several orders of magnitude below criteria for water and fish ingestion.

This comparison indicates that swimmers, boaters, and fishermen will not suffer any adverse effects due to the constituents in the river from the Alsco-Anaconda NPL site in Gnadenhutten.

8.6.2 Exposure Scenarios for Ingestion of Water from the River

Although chronic exposure to constituents potentially in the Tuscarawas River is unlikely, a potential exposure scenario for drinking the Tuscarawas River water was developed. The following assumptions are used:

Scenario 1

- Children from 5 to 12 are the receptors
- Average body weight is 25 kilograms
- Water ingestion is the only route of exposure to the contaminants of concern
- The amount of water ingested is 1.25 liters per day (interpolated from SPHEM, 1986b)

- For the purposes of this scenario, 100 percent of the water is ingested from the river and 100 percent of the constituents is absorbed

Scenario 2

- Adults are the receptors
- Average body weight is 70 kilograms
- Water ingestion is the only route of exposure to the contaminants of concern
- The amount of water ingested is 2 liters per day (SPHEM, 1986b)
- For the purposes of this scenario, 100 percent of the water is ingested from the river and 100 percent of the constituents is absorbed

8.6.3 Risk Evaluation

8.6.3.1 Estimation of Risk for Noncarcinogens

The potential impacts of noncarcinogenic constituents are addressed in this section.

To evaluate the significance of estimated exposure to noncarcinogens, the method of deriving a hazard index (SPHEM, 1986b) was used. When constituents may have both noncarcinogenic and carcinogenic effects, such as tetrachloroethylene, the constituent is evaluated for each.

The risk assessment methodology used by the U.S. EPA for systemic toxicants generally results in the derivation of an exposure level which is not anticipated to cause significant adverse effects. These "acceptable levels" may be expressed in a variety of ways such as acceptable daily intakes (ADI), reference doses, levels associated with various margins of safety, or acceptable concentrations in various media. Levels of exposure are estimates obtained following the current regulatory guidelines. For such estimates, the "hazard index" formula for a mixture of components based on the assumption of dose addition is appropriate.

For the ingestion pathway, the chemical-specific is given by:

$$HI_{ip} = \frac{D_{ip}}{AIC_i}$$

where

HI_{ip} = hazard index for chemical i at location p by the ingestion pathway,

D_{ip} = daily dose by the ingestion pathway for chemical i at location p (mg/kg/day), and

AIC_i = acceptable intake for chronic exposure by the ingestion pathway for chemical i (mg/kg/day).

The hazard index does not define dose-response relationships and its numerical value should not be construed to be a direct estimate of risk. The hazard index is only a numerical indication of the nearness to acceptable limits of exposure or the degree to which acceptable exposure levels are exceeded. As this index approaches unity, concern for the potential hazard of the mixture increases. Exceeding unity does not in itself imply a potential hazard. It does suggest that a given situation should be more closely scrutinized.

The hazard index for a given chemical may be defined as the ratio between the daily intake of that chemical and an estimated ADI for that chemical. The ADI is commonly derived from animal experiments and is frequently obtained by estimating the "no observed adverse effect level" (NOAEL) and applying a safety factor to extrapolate to man.

Usually both chronic and subchronic exposures are considered. However, the constituents at the present levels detected at the site do not pose a health risk due to subchronic exposure. In this risk assessment, chronic exposure will be emphasized. Chronic exposure in humans is considered to be a significant part of that person's natural life (Versar, 1986). In general, the body can tolerate higher levels of exposure to a chemical over a shorter exposure period than over a longer period.

The AIC is defined as the acceptable intake for chronic exposure (U.S. EPA, 1986b). These values are based on empirical data and have not been adjusted

for site-specific conditions. The AIC values are derived from quantitative information available from studies in animals (or observations made in human epidemiologic studies) on the relationship between intake and noncarcinogenic toxic effects. They are designed to be protective of sensitive populations.

In general, AIC values are based on long-term animal studies. For a few chemicals, however, adequate human data are available and are used. The highest chronic exposure level not causing an adverse NOAEL is determined by examining literature values from all appropriate animal (or human) studies. The NOAEL value is then divided by uncertainty factors. A factor of 10 is used for extrapolation from animal effects to human effects and an additional factor of 10 is used to account for intraspecies variability. If chronic studies are not available, subchronic NOAELs are used and divided by an additional factor of 10 to account for uncertainties in extrapolation from subchronic to chronic exposures.

In this section, constituent levels in the river were used to calculate the average daily dose (mg/kg/day) for noncarcinogens. As shown in Tables 8-2 and 8-4, for all constituents the average daily dose is orders of magnitude below the reference dose, or ADI, for chronic exposure. The hazard indices for a child and an adult, are 0.06 and 0.03, respectively. These values are well below unity.

8.6.3.2 Estimation of Excess Cancer Risks

The excess lifetime cancer risk for tetrachloroethylene, a potential carcinogen, was also calculated. For potential carcinogens, risks are estimated as probabilities. Incremental risks are calculated for each chemical using (1) a carcinogenic potency factor (an upper-bound confidence limit on the probability of a response) for that chemical and (2) its absorbed dose. Cancer in all its forms is a prevalent disease, with approximately one in every four persons being affected by some form of cancer during their lifetime. Thus, in a population of one million (1×10^{-6}) approximately 250,000 persons are likely to contract cancer. Excess cancer risk is expressed in terms of additional cancers that might be anticipated as a result of specific exposure to an external influence such as exposure to a carcinogen in drinking water, food, or air. Thus, a 1×10^{-6} excess cancer risk implies

one additional person in one million is likely to contract cancer. In real terms, it means that 250,001 per million will be affected by cancer compared with the background of 250,000 per million. A calculation of the excess lifetime cancer risk due to ingestion is given by:

$$CR = CPF \times CDI$$

where

CR = lifetime cancer risk,
CPF = carcinogenic potency factor, and
CDI = chronic daily intake (mg/kg/day).

The carcinogenic potency factor for tetrachloroethylene is 5.10×10^{-2} (SPHEM, 1986b). As shown in Tables 8-3 and 8-5, the excess lifetime cancer risks for a child and an adult are 7.65×10^{-8} and 4.37×10^{-8}. Both values are more than one order of magnitude below the 1×10^{-6} risk level.

Therefore, even under low flow conditions in the river, the contribution of constituents from the ground water will not have a significant adverse impact on public health.

8.6.4 Potential for Bioaccumulation

Available data on the potential for bioaccumulation or biomagnification of these compounds in aquatic life are summarized in this section. Chromium is not biomagnified in the environment. Chironomid larvae (benthic invertebrates) bioaccumulate more chromium from water (bioconcentration factor [BCF] = 3,000) than from sediments (BCF = 0.39). Similarly, in another survey, the concentration in bottom-feeding fish was lower than in the sediment. The BCF in fish is 70 to 200, in invertebrates 2,000, and in plants 4,000. Hydrogen cyanide interferes with the enzymes associated with cellular oxidation; therefore, the compound is either quickly metabolized or the organism dies. Metal cyanide complexes are known to bioaccumulate but to what degree is not known. Fluorine is a naturally occurring element in the earth's crust. Under environmental conditions, it normally occurs as a metal fluoride. No data are available on chronic studies or bioassays for

carcinogenicity of the fluorides in animals. The LD_{50} of magnesium fluoride in guinea pigs is 1.0 gram per kilogram (g/kg); and for calcium fluoride, greater than 5 g/kg. Nitrates are ubiquitous in the environment, occurring naturally in the earth's crust, and widely applied as fertilizer. Nitrates are also utilized in tobacco products and in meats. Nitrates are not expected to be of environmental concern with respect to toxicity to aquatic life. Selenium is a naturally occurring element in the earth's crust. It has been observed to have little potential for biomagnification. Bioconcentration factors are 800 for freshwater plants and 400 for invertebrates and fish. Tetrachloroethene does not appear to undergo biomagnification in the food chain. There is some evidence for weak to moderate bioaccumulation in marine organisms. No data are available on the potential for bioaccumulation in fresh water aquatic life.

8.7 POTENTIAL RECEPTORS VIA DIRECT CONTACT

Direct contact with the sludge is a potential exposure pathway. Exposure may result from dermal absorption of contaminants and ingestion of contaminated sludges. At the present time, the site remains unfenced. Thus, it is possible that children may be casually exposed to contaminants within the boundaries of the swamp and impoundment areas.

At this time, the impoundment and swamp areas are not owned by the present facility operator. Since plant workers would not routinely visit the sludge areas to fulfill work duties and would be trespassing, it is unlikely that the postulated plant worker exposure scenario would occur. However, to be protective of human health, the potential significance of the exposure of both children and plant workers to site contaminants is evaluated.

8.8 IMPACT OF DIRECT CONTACT

First, the toxicology of the contaminants of primary concern is examined briefly, then an exposure scenario is developed that estimates the potential exposure if it is assumed that activities occur once per week in the areas with the highest chemical concentrations.

8.8.1 Toxicological Studies on PCBs

PCBs are a class of lipid soluble, synthetic, chlorinated, organic chemicals. Two hundred and nine congeners of PCBs have been identified. The commercially manufactured mixtures that have been used historically in this country contain many of these congeners in varying proportions and in varying percentages of chlorination. Long-term toxic effects of PCBs have been shown to increase in direct proportion to the average percent chlorination of the commercial mixture in question.

Despite the numerous studies on PCB toxicity in animals, little quantifiable data are available on the adverse effects in humans. This gap is particularly evident for chronic low dose effects, such as those that may occur during occupational and environmental exposure. However, a few recent and ongoing studies of electrical industry workers and persons living in the vicinity of PCB waste sites have made data available on the effects on man of low dose rates (Maroni et, al., 1981a,b; Fischbein, et al., 1982; and Stehr, et al., 1984).

Personnel at the Centers for Disease Control (CDC) in Atlanta, Georgia studied health effects in communities near toxic waste sites (Stehr, et al., 1984). Results suggest that community residents were not significantly exposed to PCBs from the toxic waste sites. The study by Stehr and colleagues illustrates the important principle that, although concentrations of chemicals may be quite high at waste sites, they must be present in environmental pathways that lead to community exposure before public health is threatened.

The studies by Maroni and coworkers (1981a, 1981b) found no association between blood levels of PCB and chloracne. However, abnormal findings in blood chemistries indicative of possible liver damage were observed and were positively correlated to blood PCB concentrations. Fischbein, et al. (1982), observed some skin effects among capacitor plant workers, but no serious disease was reported.

The carcinogenicity of PCBs has been tested in several animal species. In the opinion of the International Agency for Research on Cancer (IARC) (1978), there is experimental evidence for carcinogenic effects of PCBs in rodents.

This carcinogenicity is associated with the higher chlorinated products (e.g., Aroclor 1260) but not the lower (e.g., 1242). There is no conclusive correlation between PCB exposure and the occurrence of cancer in man.

8.8.2 Toxicological Studies on Metals

Concentrations of a number of metals occur in the swamp, impoundment, and sludge pit areas of the Alsco-Anaconda NPL site. If the maximum levels detected are compared against the normal range of background levels occurring in the soil (Tables 8-6, 8-7, and 8-8), cadmium, chromium, and zinc are the three metals with significant presence above background. Using the mean background level for comparison, these metals at their highest concentration exceed background by 113-, 170-, and 120-fold, respectively. The chronic acceptable intake of zinc is significantly higher than either cadmium or chromium (U.S. EPA, 1986b) and it is the latter metals which should be considered of more significance in terms of defining the hazard associated with their presence in the swamp. Although present at significantly lower levels (9.5-fold above background), arsenic is considered because of its known carcinogenic potential. A short summary of the toxic potential of the three metals of concern follows along with relevant chemistry.

Arsenic

The forms of arsenic likely to be present in the soil at the Alsco-Anaconda NPL site are unknown. Arsenic has not been detected in ground water and soil and sludge samples passed EP toxicity tests. Thus, it may be assumed that the metal is in a relatively insoluble form.

The water solubility of arsenical compounds is highly variable. Arsenic pentoxide is the most water soluble of all arsenical compounds (150 micrograms per liter [μg/ℓ] at 16 degrees Celsius). Arsenic pentoxide slowly combines with water to form orthoarsenic acid (Windholz, et al., 1976). The acid, in turn, may form toxic salts in the soil in combination with other metals present. The adsorption/desorption processes in soil and sediment also promote the formation of volatile alkylarsines, leading to potential air transport loss from soils (Hammond and Beliles, 1980).

Acute arsenic poisoning usually results from ingestion while chronic poisoning results from ingestion or inhalation. Inorganic forms are more toxic than organic forms and the trivalent arsenites are more toxic than the pentavalent arsenates (Sax, 1984). Natural oxidation favors the conversion of trivalent arsenic to pentavalent.

Carcinogenicity studies on laboratory animals are inconclusive. In humans, tumors of the skin, lungs, genitals, and visual organs have been associated with arsenic exposure.

Cadmium

The source of cadmium at the site has not been directly identified but is probably a by-product of the painting operation that has been ongoing at this facility. The form of cadmium has also not been identified. The water solubility of cadmium compounds is highly variable from practically insoluble (cadmium carbonate) to freely soluble in water (cadmium acetate). Cadmium ions form insoluble compounds with ferro- and ferri-cyanides (Stokinger, 1981).

A primary route of human exposure is through ingestion. However, cadmium is poorly absorbed from the gastrointestinal tract (Hammond and Beliles, 1980). When ingested, the critical target organ is the kidney, with the most common abnormality being proteinuria (Federal Register, 1985a; Stokinger, 1981).

IARC has classified cadmium in Group 2B which includes metals where evidence for carcinogenicity in animals or humans is limited (Federal Register, 1985a). Oral LD_{50}s (the oral LD_{50} represents the dose which is lethal to 50 percent of a group of animals under given experimental conditions) in the rats for cadmium and cadmium compounds range from 72 to 950 mg/kg (Sax, 1984).

Chromium

Chromium was used in the painting operations at the ARCO facility. Initially in the form of chromium sulfate, it was precipitated as chromium hydroxide prior to disposal. Analytical results indicate that the majority of the chromium found in the swamp area is in the trivalent state. This is important since there is no known biological conversion between the two valency states

and it is hexavalent chromium that has the more significant toxicity. Trivalent chromium is in fact an essential element and deficiency leads to diabetic-like symptoms (Hammond and Beliles, 1980). The occurrence of chromium in food and water has not been shown to produce any adverse effects in man or experimental animals (Hammond and Beliles, 1980). Absorption is limited to approximately 1 percent of an ingested dose (Schroeder, et al., 1962).

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The trivalent chromium compounds are amphoteric while the hexavalent compounds are anionic. As indicated in Chapters 1.0 and 3.0, chromium was precipitated as chromium hydroxide and, based on EP toxicity data, insoluble hydroxides exist in the swamp area. As shown in Tables 8-7 and 8-8, out of 40 samples of surface sludges and underlying soils analyzed for hexavalent chromium, only two samples contained levels above the detection limit. Therefore, the data generally indicate that the chromium at the site is not in the hexavalent form. The maximum level of hexavalent chromium detected at the site was evaluated in the risk assessment.

Occupational exposure to hexavalent chromium may cause dermatitis, penetrating ulcers on hands and arms, perforation of the nasal septum, and inflammation of the larynx and liver. Epidemiological studies have shown that inhaled chromate is a carcinogen with bronchogenic carcinoma as the principle lesion. Hexavalent chromium in drinking water (5 ppm) has produced a slightly higher incidence of malignant forms in mice but trivalent chromium given to rats has not produced the same effects (Schroeder and Mitchner, 1971; Kanisawa and Schroeder, 1969).

Mercury

Mercury is considered in this assessment at the specific request of OEPA and U.S. EPA. Mercury is strongly bound to soil and is predominantly attached to soil organic matter. Therefore, the mobility of mercury and compounds in soil is minimal.

Inorganic mercury is poorly absorbed from the gastrointestinal tract. Methylmercury is more readily absorbed. Inhaled metallic mercury vapor is also absorbed.

Mercury poisoning has been reported after occupational or subchronic exposure. Major signs of toxicity include paresthesia of the extremities, impaired peripheral field of vision, slurred speech, and unsteadiness of gait and limbs.

Pertinent data regarding the chronic oral toxicity teratogenicity or carcinogenicity of metallic mercury are not available.

8.8.3 Toxicological Studies on Cyanide

Because of the industrial processes involved, it is known that the cyanide detected in the swamp area at the Alsco-Anaconda NPL site was originally in the form of soluble ferro- and ferri-cyanide complexes. Ferro- and ferri-cyanide do not have the typical toxic properties of cyanides and may act by different mechanisms (Hartung, 1982). No toxicity data are available for the reduced state; however, potassium ferri-cyanide, the closest chemical form, appears to be only slightly toxic with the oral LD_{50} in rats ranging from 1,600 to 3,200 mg/kg (Hartung, 1982). Dogs tolerated 2,626 mg/kg administered intravenously and rapidly excreted it via the kidney. Poisoning from oral ingestion seems to have been questionable.

8.8.4 Exposure Scenarios for Direct Contact

As has been previously mentioned, the Alsco-Anaconda NPL site is accessible to trespassers. In developing a potential exposure scenario to contaminants from this site, the following assumptions are used:

Scenario 1

- Children from 5 to 12 are the receptors.
- Average body weight for this age group is 25 kilograms.
- With the exception of PCBs, soil ingestion is the only route of exposure to the contaminants of concern.
- Total soil ingested in a day is estimated to be 100 milligrams (Paustenbach, et al., 1986). For the purposes of this scenario, 100 percent of the soil ingested is derived from the swamp.
- Dermal absorption is also considered as a route of exposure for PCBs.
- Children are exposed one day per week over a seven-year period.

- Absorption of the metals, cyanides, and organics following ingestion is assumed to be 100 percent.

- Of the PCB-contaminated sludge ingested, 100 percent of the PCBs is absorbed.

- Dermal absorption of PCBs is estimated to be 100 percent at the request of the Office of Solid Waste and Emergency Response, OWPE, and also 20 percent, as discussed below.

Scenario 2

- Workers at the Alsco plant are the receptors.

- Average body weight for this age group is 70 kilograms.

- With the exception of PCBs, soil ingestion is the only route of exposure to the contaminants of concern.

- Total soil ingested in a day is estimated to be 100 milligrams (Paustenbach, et al., 1986). For the purposes of this scenario, 100 percent of the soil ingested is derived from the swamp.

- Dermal absorption is also considered as a route of exposure for PCBs.

- Workers are exposed one day per week over a 40-year working life.

- Absorption of the metals, cyanides, and organics following ingestion is assumed to be 100 percent.

- Of the PCB-contaminated sludge ingested, 100 percent of the PCBs is absorbed.

- Dermal absorption of PCBs is estimated to be 100 percent at the request of the Office of Solid Waste and Emergency Response, OWPE, and also 20 percent, as discussed below.

A 20 percent dermal absorption factor for PCBs in an eight-hour work day exposure is health protective since Wester et. al. (1983) have shown that the dermal absorption of PCBs by the rhesus monkey was only about ten percent over a 48-hour period. For the guinea pig, a species that is less similar to man than the monkey, dermal absorption was about 18 percent over 48 hours.

8.8.5 Cadmium, Chromium, Cyanide, and Mercury Risk Evaluation

Based on a review of data for sludges and adjacent or underlying soils, the maximum concentrations of cadmium, chromium, cyanide, and mercury were evaluated for risk via ingestion only. This is the pathway of concern for the metals under consideration. The dermal pathway is not considered a pathway of concern for these constituents at these levels.

For soil ingestion, the total amount (TA) of a chemical absorbed (in milligrams) during the exposure period is:

$$TA = (C)\ (IR)\ (Y)\ (E)\ (YR)\ (ABS_g)$$

where

C = concentration of contaminant in soil (mg/kg),
IR = soil ingestion rate (100 mg/day),
Y = conversion factor (1 kg/10^6 mg),
E = number of exposures per year (52 days per year),
YR = number of years site is visited per lifetime (7 years for child, 40 years for adult), and
ABS_g = absorption factor through gut (1.0).

The lifetime average daily dose of each chemical absorbed (in mg/kg/day) is calculated by:

$$ADD = (TA)\ (1/L)\ (1/BW)$$

where

L = 25,550 days per lifetime and
BW = average body weight (25 kilograms for child and 70 kilograms for adult).

An average daily dose was used to calculate a hazard index for each constituent for a child and a worker. As shown in Table 8-9, the total hazard index for children is 0.020 and for a worker 0.041. These values are well below unity. Based on this evaluation, the metals detected at the site do not pose a hazard in a no-action scenario.

8.8.6 Arsenic

Arsenic is considered a carcinogen; therefore, a carcinogenic potency factor (U.S. EPA, 1986b) and the average daily dose are multiplied to define the excess cancer risk associated with intakes of arsenic above background levels (Table 8-10). The carcinogenic potency of arsenic via the oral route of

exposure has recently been evaluated for the U.S. EPA by the Risk Assessment Forum (RAF, 1987). The recommended carcinogenic potency factor is 1.75 $mg/kg/day^{-1}$. In addition, the RAF recommended that the cancer risk value that results from multiplying the carcinogenic potency factor by the chronic daily intake should be lowered by one order of magnitude to reflect the RAF's "judgment of the seriousness of impacts of the exposure, primarily the limited likelihood of inducing lethal cancer" (RAF, 1987).

The average daily dose via ingestion was calculated, as explained in Section 8.8.5, and multiplied by the cancer potency factor to obtain the excess lifetime cancer risk. Excess lifetime cancer risk was calculated as detailed in Section 8.6.3.2.

In developing the exposure scenario for ingestion, the upper bound of the range of input factors has been consistently assumed, including number of exposure incidents, amount of skin surface area being completely covered with contaminated soil, and availability of the contaminated soil for exposure. The resulting risks for a child and a worker due to arsenic exposure are 5.68×10^{-7} and 1.16×10^{-6}, respectively. Placing the risk values into the context of the site itself, it is highly unlikely that any actual exposure scenario would approach even these numbers for potential carcinogenic risk.

8.8.7 PCBs Risk Evaluation

A wealth of toxicological information exists from which an acceptable daily dose can be recommended. However, at the request of the OEPA, the carcinogenic potency factor (CPF) from the SPHEM has been used to calculate excess cancer risk associated with PCBs at the subject site. The CPF is based on Aroclor 1260 and assumes all PCBs are equivalent to Aroclor 1260 in potential carcinogenic potency. However, long-term bioassays conducted in rodents showed that Aroclor 1254 was not carcinogenic. The aroclors detected were 1248 and 1254; Aroclor 1260 was not detected on the Alsco-Anaconda NPL site. Therefore, the use of the CPF is conservative.

PCB Risk Characterization

Even though an acceptable daily dose can be calculated based on the literature, the estimated daily dose has been calculated and multiplied by the

carcinogenic potency factor to evaluate the level of risk in the most conservative fashion. Intake via ingestion was calculated as explained in Section 8.8.5, where ABS_g = 1.0 for PCBs.

The TA of a chemical absorbed through the skin (in milligrams) during the exposure period is:

$$TA = (C)\ (CR)\ (Y)\ (E)\ (YR)\ (ABS_g)$$

where

C = concentration of contaminant in soil (mg/kg),

CR = soil contact rate (mg/day) (478.5 mg/day, equal to the skin surface area exposed times the quantity of soil adhering to the skin in an exposure episode,

Y = conversion factor (1 kg/10^6 mg),

E = number of exposures per year (52 days/year),

YR = number of years site is visited per lifetime (7 years for child and 40 years for adult), and

ABS_g = absorption factor through skin (two scenarios - 1.0 and 0.2).

The lifetime daily dose of each chemical absorbed (in mg/kg/day) is calculated by:

$$\text{AVERAGE DAILY DOSE} = (TA)\ (1/L)\ (1/BW)$$

where

L = 25,550 days per lifetime and

BW = average body weight (25 kg for child and 70 kg for adult).

Total intake of PCBs was estimated for two exposure scenarios, upper-bound exposure and average exposure, on those days when someone has direct access to the swamp area (Table 8-11 and 8-12). As shown in Table 8-11, the estimated total intake of PCBs for a child is 2.67 x 10^{-5} using the average exposure scenario with 100 percent dermal absorption, 9.01 x 10^{-6} with 20 percent

dermal absorption and 9.9×10^{-4} using the upper-bound exposure scenario with 100 percent dermal absorption, 3.34×10^{-4} with 20 percent dermal absorption. The estimated total intake of PCBs for an adult is 5.04×10^{-5} using the average exposure scenario with 100 percent dermal absorption, 1.83×10^{-5} with 20 percent dermal absorption and 2.0×10^{-3} using the upper-bound exposure scenario with 100 percent dermal absorption, 6.81×10^{4} with 20 percent dermal absorption (Table 8-12). These estimates were based on the child playing or the adult working on the most highly contaminated area and being exposed to 80.8 mg/kg PCBs (average exposure scenarios) and 3,000 mg/kg PCBs (upper-bound exposure scenario). The excess cancer risks incurred by a child are 2.05×10^{-4} and 6.94×10^{-5} for the average exposure scenario using 100 and 20 percent dermal absorption respectively, and 7.63×10^{-3} and 2.58×10^{-3} for the upper-bound exposure scenarios using 100 and 20 percent dermal absorption, respectively. The excess cancer risks incurred by a worker are 4.18×10^{-4} and 1.41×10^{-4} for the average exposure scenario using 100 and 20 percent dermal absorption, respectively and 1.54×10^{-2} and 5.24×10^{-3} for the upper-bound exposure scenarios using 100 and 20 percent dermal absorption, respectively.

A review of Tables 3-15 and 3-17 shows that 74 samples were taken of soils adjacent to and underlying the swamp sludges. Only five samples, samples of soil underlying the sludge to a depth of one foot, have levels of PCBs detected above 10 mg/kg. Those samples are I-6, J-6, J-9, K-5, and K-6. In two samples, I-6 and J-6, PCBs were detected at a level of 11 mg/kg. The remaining three samples, J-9, K-5, and K-6, had levels of PCBs detected at 23, 19, and 23, respectively. Due to general earth excavation practices, if Area 4 sludge were to be removed, approximately 6 to 12 inches of additional soil would be expected to be removed also. The one-foot layer of underlying soil in which 23 mg/kg PCBs were detected would be removed with the sludge. The site data indicate that PCB levels between a range of 12 inches can decrease by an order of magnitude. Therefore, after Area 4 sludge removal, levels in the remaining soils can be expected to be below 10 mg/kg.

The excess carcinogenic risk was also evaluated for Areas 1, 2, 3, and 5 only, excluding Area 4. Estimates of the average daily dose were based on the child or worker being exposed to 4.89 mg/kg PCBs (average exposure scenario) and

110 mg/kg PCBs (upper-bound exposure scenario). The excess cancer risks potentially incurred by a child and a worker are shown in Tables 8-13 and 8-14. The excess cancer risks incurred by a child are 1.24×10^{-5} and 3.2×10^{-6} for the average exposure scenarios using 100 and 20 percent dermal absorption, respectively and 2.79×10^{-4} and 9.45×10^{-5} for the upper-bound exposure scenarios using 100 and 20 percent dermal absorption, respectively. The excess cancer risks incurred by a worker are 2.52×10^{-5} and 8.55×10^{-6} for the average exposure scenarios, using 100 and 20 percent dermal absorption, respectively, and 5.69×10^{-4} and 1.92×10^{-4} for the upper-bound exposure scenarios using 100 and 20 percent dermal absorption, respectively. These risks are above the 1×10^{-6} target level. In conclusion, the PCBs in the sludge in Areas 1, 2, 3, and 5 pose an undue risk to the potential receptors evaluated.

8.8.8 Organic Constituent Risk Evaluation

Sludges and soils were analyzed for organic constituents. Levels of several volatile and acid/base-neutral extractable compounds were found predominantly in southern impoundment sludges as discussed in Chapter 3.0. Tables 3-11 and 3-13 indicate that organics were not detected in soils underlying the impoundment areas. As shown in Appendix A and summarized in Tables 3-9, 3-11, and 3-13, the values detected above detection limits were used in this risk evaluation. Values of constituents also found in the sample blanks were considered to be laboratory artifacts and were not included.

The maximum level of organic constituent detected, shown in Table 8-15, was used in the calculation of estimated daily intakes via the ingestion and dermal routes for both a child and an adult employee. As shown in Tables 8-16 through 8-19, the total hazard index for a child and adult is 0.01 and 0.005, respectively. The total hazard index for children and adults is at least two orders of magnitude less than unity. Additionally, excess lifetime cancer risks for carcinogens are below the target risk level. Therefore, the organic constituents detected at the site do not pose an unacceptable risk to human health based on the no-action alternative.

8.9 IMPACT ON WILDLIFE

As the site is unfenced, there is potential for wildlife to come in contact with the sludges on the site. This section provides a review of the toxic effects on wildlife of the compounds found in the sludge. This information is summarized from the appropriate U.S. EPA Health Effects Assessment documents (U.S. EPA, 1984a-k). The available evidence suggested that these compounds have low potential for causing a toxic effect to wildlife due to the moderate to high NOAEL and the occasional contact of the wildlife with the site.

Arsenic

The subchronic oral toxicity of arsenic has been investigated in dogs. For sodium arsenite or sodium arsenate, the NOAEL was determined to be a 50 mg/kg diet. The NOAEL for chronic oral consumption of arsenic by rats was determined to be a 100 mg/kg diet when arsenic was administered as sodium arsenate or lead arsenate. Investigations of carcinogenicity in animals by oral bioassay have generally produced negative results.

Barium

Investigations of the subchronic toxicity of barium in rats have been inconclusive as no clear pattern of dose effect or dose duration could be established. The only effect that was detected was a change in adrenal weight but this effect was not dose related. Under conditions of chronic oral exposure, based on rat experiments, the U.S. EPA established a NOAEL of 0.51 mg/kg body weight (bw)/day and a lowest observed adverse effect level (LOAEL) of 5.1 mg/kg bw/day. Oral bioassay studies of carcinogenicity in both mice and rats failed to show a statistical difference in tumor incidence between controls and treated animals at lifetime drinking water levels of 5 mg Ba/ℓ.

Cadmium

Cadmium is poorly absorbed following oral administration. Several studies have shown that about 2 percent of orally administered cadmium was absorbed by experimental animals. The U.S. EPA has established a LOAEL of 301 μg Ca/day, corresponding to 0.004 mg Ca/kg bw/day. Oral bioassays have generally failed to find an effect of cadmium on tumor incidence in mice or rats.

Chromium

Absorption of chromium is estimated to be about 3 to 5 percent in rats following oral administration. A NOAEL for rats was calculated to be 2.50 mg/kg/day based on a subchronic study of potassium dichromate in drinking water. A single chronic study of oral toxicity in dogs indicated no effects at any treatment level. From these data, a NOAEL of 0.089 mg Cr(VI)/kg/day was calculated. No data are available regarding the carcinogenicity of orally administered Cr(VI) in animal systems.

Copper

Dietary levels of about 200 ppm (2.5 mg Cu^{+2}/kg bw/day) copper were used as growth promoters in the production of market hogs. The National Academy of Sciences (NAS) has given 15 ppm copper in pig feed a generally recognized as safe (GRAS) designation. No data on chronic exposure of laboratory animals to copper are available. Bioassay studies for carcinogenicity in mice and rats have generally proved negative.

Iron

Iron is absorbed from two natural dietary sources, heme iron from meats and nonheme iron from grains and vegetables. The subchronic toxicity of iron to animals depends on the form of iron. Oral LD_{50} values in animals range from 12 mg/kg for iron carbonyl in rabbits to 4,000 mg/kg for ferric dimethyl-dithiocarbamate in rats. Ferrous sulfate had oral LD_{50}s ranging from 319 mg/kg in rats to 979 to 1,520 mg/kg in mice. Pertinent data on the chronic oral toxicity of iron in animals were not available. No data resulting from oral bioassay studies of carcinogenicity were available.

Lead

Studies of subchronic exposure of rats to lead permitted a LOAEL of 0.5 mg/kg bw/day to be calculated. A LOAEL of 0.5 mg/kg bw/day was also calculated for chronic oral toxicity of lead in experimental animals. Several oral bioassay studies have associated specific lead salts with tumor formation in experimental animals.

Manganese

Manganese is a nutritionally required trace element that is poorly absorbed from the diet; about 3 to 4 percent of the orally administered dose was absorbed in rats. The acute toxicity of manganese and its compounds varies with the chemical form. Adequate studies of chronic oral exposure in laboratory animals are not available. A single oral bioassay study for carcinogenicity indicated a difference in effects between controls and treated animals.

Mercury

No reports on the subchronic toxicity of orally administered mercury other than methylmercury are available. Rats fed diets containing mercuric acetate showed no treatment-related effects at levels below 40 ppm mercury. Studies on the carcinogenic potential of mercury in experimental animals were not available.

PCBs

PCBs have been extensively studied. The results of several investigations which led to calculation of LOAELs for subchronic oral exposure are as follows: Frank exposure level (FEL) of 20 ppm Aroclor 1260 or 1254 for rats; LOAEL of 5 ppm Aroclor 1242 for rats exposed for up to six months; LOAEL of 10 ppm Aroclor 1254 for rats; LOAEL of 3.75 ppm Aroclor 1254 for mice; NOAEL of 2 ppm Aroclor 1254 for nonreproductive parameters in female mink. Studies of chronic oral exposure have generally been designed to investigate the frank effects of PCBs and LOAELs could not be calculated from the data. Oral bioassay studies on carcinogenicity are inconclusive. Kanechlor 500 has been shown to be carcinogenic in mice and Aroclor 1260 in rats.

Zinc

The oral absorption of zinc is dependent in part upon the existing zinc levels in the body, the dietary levels of other nutrients and protein, and the chemical form of zinc. For animals, a NOAEL of 95 mg/kg/day for rats and 188 mg/kg/day for mice was calculated from studies of subchronic oral exposure to zinc. A study of rats exposed to zinc chloride resulted in a calculated NOAEL of 125 mg/kg/day. A study using cats resulted in a NOAEL of 76.4 mg/kg/day. Under conditions of chronic oral exposure, a NOAEL of

250 mg/kg/day was calculated for rats ingesting zinc oxide and 125 mg/kg/day for rats ingesting zinc dust. No bioassay studies for carcinogenicity of zinc in animals were available.

8.10 UNCERTAINTY ANALYSIS

The risk assessment process makes use of certain assumptions that help define the specific set of circumstances under review. These assumptions allow the evaluation to proceed in the face of incomplete data but a degree of uncertainty is associated with the risk assessment. The magnitude of the uncertainty was minimized or accounted for by using health-protective assumptions and by utilizing upper-bound values for estimated parameters, where appropriate. Specific areas of uncertainty associated with this site and the steps taken to account for them include the following:

- The chemical analytical data base is believed to be sufficiently comprehensive to allow a reasonable assessment.
- The selected exposure scenarios, that of children and workers exposed for defined periods of time, are judged to be more rigorous than any expected contact with the site.
- Minor potential exposure pathways have been evaluated but have not been characterized because there is no evidence of likely occurrence. These pathways include ingestion/dermal absorption by swimmers.
- Chemical transformation products due to photochemical or biological interactions are believed to be less toxic than the parent chemicals and have not been characterized.
- The dilution factor utilized to assess impact on the river has been estimated from limited data on ground water flow and river volume. The worst case data were utilized and most likely overestimate potential impact on the river.
- The toxicity to humans of PCBs and the other chemicals of concern has not been well established and is generally extrapolated from animal studies. Health protective assumptions were used in the extrapolation protocol.
- Human ingestion, absorption, and biotransformation rates of the chemicals of concern have been estimated from available data for other chemicals.

8.11 CONCLUSIONS

The principle environmental migration pathway for contaminant transport from the Alsco-Anaconda NPL site is water transport. The air pathway is not considered significant due to the high water content of the waste sludge on site and vegetation covering the waste disposal areas.

Dilution calculations have shown that, even under low flow conditions in the Tuscarawas River, the contribution of contaminants from the ground water will not have a significant impact on the public health or the environment. No other ground water receptor has been identified.

A potential direct contact exposure scenario for two subpopulations was employed to assess the possible human health risks posed by contamination of the Alsco-Anaconda NPL site in Gnadenhutten, Ohio. These target subpopulations were defined to be children, ages 5 to 12 (average weight 25 kilograms) and adult workers with an average weight of 70 kilograms.

Of the potential contaminants found on the Alsco-Anaconda NPL site, only arsenic, cadmium, chromium, cyanide, and PCBs were found at levels thought to pose a potential hazard to human health. By comparing cadmium, chromium, and cyanide to established U.S. EPA standards for acceptable daily intake, the hazards posed by these compounds were shown to be, both individually and in a multiple exposure scenario, well below the U.S. EPA guidelines for a potential risk to human health.

Arsenic was evaluated with respect to carcinogenic effects on human health. The possible risk to human health posed by the presence of arsenic was estimated using a carcinogenic potency factor derived by the U.S. EPA. Excess cancer risk for arsenic at the Alsco-Anaconda NPL site was found to be 5.68×10^{-7} and 1.16×10^{-6} for a child and adult, respectively, based on the scenarios postulated. The affected population would be those exposed through direct contact with the soils only.

For PCBs, excess cancer risk was calculated using the U.S. EPA carcinogenic potency factor, which are data developed for carcinogens and potential carcinogens. Based on this health-protective scenario, excess cancer risk

exists for those subpopulations who come in direct contact with the Area 4 sludges and Area 1, 2, 3 and 5 sludges at the site. Direct contact with the remaining sludges and soils does not pose an unacceptable level of risk based on a total hazard index and risk characterization for both children and adults.

Organic constituents were evaluated with respect to both subpopulations. The hazard indices for a child and an adult worker are 0.01 and 0.005, respectively. Excess cancer risks due to organic carcinogens for a child and an adult are 1.38×10^{-8} and 2.81×10^{-8}, respectively. The organic constituents do not pose an undue risk at the site. Available data on the impact of these compounds on aquatic and wildlife suggest low potential for causing a toxic effect.

TABLES

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TABLES

TABLE 1-1

CHRONOLOGY OF ARCO GNADENHUTTEN SITE

Site Ownership and Development

1948	Harvard Industries established the Alsco plant and began manufacture of aluminum siding and coated coil at the facility
1949-1960	Additions to plant structures and product line
1965	Construction of sludge settlement basin
August 1971	Anaconda Company purchased the Alsco plant
1972	Major expansion to plant
January 1977	ARCO Chemical Company purchased the Alsco plant
1978	Filter press installed to dewater sludge; settlement lagoon taken out of service, but clarified water routed through lagoon to swamp until rerouted directly to swamp in 1980
October 1984	U.S. EPA proposed site for inclusion on NPL
November 1984	ARCO retained IT to perform RI/FS
March 1985	RI activities begun on site
June 1986	Site formally listed on NPL
December 1986	Horsehead Industries purchased Alsco plant; ARCO retained ownership of NPL site property
February 1987	Consent order between U.S. EPA, OEPA, and ARCO issued for public comment

Wastewater Treatment

Prior to 1965	Wastewater discharged untreated to Tuscarawas River
1965 to 1972	Wastewater discharged to settling lagoon; untreated effluent overflow discharged to river
January 1971	Industrial Waste Permit received from Ohio
May 1971	NPDES permit applied for to discharge 72,000 gal/day
March 1972	Chromium reduction system linked in wastewater treatment; treated wastewater discharged to lagoon
1974	Chromium reduction system enlarged

TABLE 1-1
(Continued)

1978	Lamella (plate and frame) filter press installed for sludge dewatering; clarified water discharged to lagoon
November 1980	Clarified water rerouted to bypass lagoon, discharged to swamp
1986	Sand filter added to wastewater treatment system
October 1986	Treated, clarified wastewater discharge rerouted from swamp to NPDES permitted outfall to river

TABLE I-2
(Continued)

2. Swamp area sludge and underlying soil sampling

   a. Forty sludge and subsurface soil samples collected on 75-foot by 50-foot grid system from April 5, 1985 to April 8, 1985

   b. One hundred and forty sludge and subsurface soil samples collected on a 37.5-foot by 25-foot grid system from November 24 to December 2, 1986 and then repeated from January 19 to 22, 1987

   c. Forty-nine sludge and soil samples collected on a 18.75-foot by 12.5-foot grid and an extended 37.5-foot by 25-foot grid on March 26, 1987.

3. River sediment sampling

   a. One hundred and one bottom sediment samples collected along fifteen traverses from November 11 to 14, 1986. Twenty six upstream and twenty three downstream samples collected at 30-foot intervals across six traverses extended the width of the river; fifty-two near-plant samples collected at 20-foot intervals across nine traverses half the width of the river

4. Soil boring program and sampling

   a. Nine soil borings to a depth of 50 feet from March 18 to April 9, 1985

5. Monitoring well installation

   a. Nine monitoring wells, MW-1 through MW-9, installed from March 18 to April 9, 1985

6. Monitoring well and site survey

7. Ground water level measurements and sampling (monitoring)

   a. First quarter ground water monitoring, April 9 to 12, 1985

   b. Second quarter ground water monitoring, July 30 to 31, 1985

   c. Third quarter ground water monitoring, November 4 to 5, 1985

   d. Fourth quarter ground water monitoring, January 28 to 30, 1986

   e. Final quarter ground water monitoring, November 18 to 20, 1986

   f. Limited ground water monitoring, January 27 to 29, 1987

   g. Water table measurements, July 17, 1986, September 29, 1986, and February 25, 1987

TABLE 1-2
(Continued)

8. Exploratory trench excavated through paved parking area on October 2, 1986.

F. Laboratory Program

1. Settlement lagoon and sludge pit samples

   a. Sludge and soil sample composites and selected individual soil samples

      - Total constituent and E.P. toxicity cyanide, fluoride, nitrate, 17 metals, and HSL organic parameters

   b. Test pit vertical composite samples

      - Thirteen composites for E.P. toxicity cyanide, fluoride, nitrate, and 14 metals

      - Eleven composites for HSL organic parameters

   c. Test pit samples

      - Fifteen samples - Total constituent cyanide, fluoride, nitrate, 17 metals, and HSL organic parameters

      - Five samples - X-ray diffraction

      - Five samples - permeability testing

2. Swamp area sludge and underlying soils

   a. Sludge and soil composites

      - Total constituent and E.P. toxicity cyanide, fluoride, nitrate, 17 metals, and HSL organic parameters

   b. Individual sludge and soil samples

      - Two hundred and twenty samples for polychlorinated biphenyl (PCB) analysis

3. River sediment samples

   a. Thirty-six individual and five composite samples for total chromium, hexavalent chromium, and PCBs

4. Soil boring samples

   a. Twenty-seven soil samples for total constituent and E.P. toxicity cyanide, fluoride, chromium, iron, and manganese

TABLE 1-2
(Continued)

5. Quarterly ground water monitoring samples - Nine monitoring wells and two production wells

   a. First quarter ground water monitoring, April 9 and 12, 1985

      - HSL organic parameters (six wells only) and total and amenable cyanide, fluoride, nitrate, and 14 metals

   b. Second quarter ground water monitoring, July 30 and 31, 1985

      - HSL organic parameters and total and amenable cyanide, fluoride, nitrate, total and hexavalent chromium, iron, manganese, selenium, and total organic carbon

   c. Third quarter ground water monitoring, November 4 and 5, 1985

      - PCBs (five wells only) and total and amenable cyanide, fluoride, nitrate, total and hexavalent chromium, selenium, total organic carbon, and total organic halogens

   d. Fourth quarter ground water monitoring, January 28 to 30, 1986

      - Total and amenable cyanide, fluoride, nitrate, total and hexavalent chromium, selenium, total organic carbon, and total organic halogens

   e. Final quarter ground water monitoring, November 18 to 20, 1986

      - HSL organic parameters (both production wells and upper zones in monitoring wells), total and amenable cyanide, fluoride, and nitrate, and 14 metals (both production wells and upper and lower zones in monitoring wells)

   f. Limited ground water monitoring, January 27 to 29, 1987

      - Hexavalent chromium and mercury

G. Preparation of the RI/FS Report

   1. Draft, Revision 0.0, May 1987
   2. Draft, Revision 1.0, August 1987

TABLE 3-1

SLUDGE EXTENT, THICKNESS, AND VOLUME
ARCO SITE
GNADENHUTTEN, OHIO

LOCATION(a)	APPROXIMATE AREA(b) (ft^2)	AVERAGE THICKNESS(c) (ft)	APPROXIMATE VOLUME(d)	
			(ft^3)	(yd^3)
Sludge Disposal Pit	5,775	7.1	41,000	1,520
Sludge Settlement Basin	13,800	7.9	109,360	4,050
Northern Impoundment	6,400	7.4	47,360	1,750
Southern Impoundment	5,900	8.5	50,150	1,860
Earthen Berm Divider	1,500	7.9	11,850	440
Swamp	53,500	1.7	88,580	3,280
Area No. 1	11,600	1.6	18,680	690
Area No. 2	11,500	1.7	19,780	730
Area No. 3	5,300	0.8	4,080	150
Area No. 4	19,200	2.1	39,550	1,470
Area No. 5	5,900	1.1	6,490	240
Total Site	73,075	3.2	238,940	8,850

(a)Locations are shown on the ARCO Alsco site plan (Figure 1.2).

(b)Areas in square feet (ft^2) are estimates based on the site plan and sludge thickness maps (Figures 1.2 and 3.1).

(c)Average thicknesses in feet (ft) are based on November 1986 sample data. For the total settlement basin and swamp areas, the values are areal weighted averages.

(d)Approximate volume in cubic feet (ft^3) of sludge is the product of the area and average thickness estimates. The volume in cubic yards (yd^3) is derived by dividing the volume in cubic feet by 27.

TABLE 3-2

EXPERIMENTAL DESIGN
SLUDGE/SOIL ANALYTICAL PROGRAM
ARCO CHEMICAL COMPANY
CHARLESTOWN, OHIO

C0001753

TESTING PROGRAM

NO. OF SAMPLES	SAMPLE DESCRIPTION	TOTAL METALS AND GENERAL CHEMISTRY(a)	E.P. TOXICITY TEST(b)	U.S. EPA CLP ORGANICS(c)	TOTAL PARAMETERS OF CONCERN(d)	PHYSICAL CHARACTERISTICS(e)	MINERALOGICAL INVESTIGATION(f)	PERMEABILITY	POLYCHLORINATED BIPHENYLS
5	Impoundment and Sludge Pit Sludge Composite Samples	X	X	X					
2	Impoundment and Sludge Pit Soil Composite Samples	X	X	X					
10	Impoundment and Sludge Pit Soil Individual Samples	X	X	X					
13	Impoundment and Sludge Pit Sludge Vertical Composites		X			X			
10	Impoundment and Sludge Pit Sludge Vertical Composites	X	X	X		X			
11	Impoundment and Sludge Pit Sludge Vertical Composites		X	X	X	X			
6	Impoundment and Sludge Pit Soil Vertical Composites		X	X	X	X			
15	Impoundment and Sludge Pit Sludge Individual Samples			X	X				
5	Impoundment and Sludge Pit Sludge Individual Samples						X	X	
2	Undisturbed Impoundment and Sludge Pit Sludge Samples (TP-5, 1 to 3.5 feet depth and TP-7, 0.5 to 3.0 feet depth)							X	
3	Undisturbed Impoundment and Sludge Pit Soil Samples (Between TP-2 and 3, 7.55 feet depth, TP-7, 7.1 feet depth and TP-11, 6.0 feet depth)							X	
27	Individual Monitoring Well Soil Boring Samples		X(g)		X(h)				
8	Swamp Sludge Composite Samples	X	X	X					
5	Swamp Sludge Composite Samples		X		X				
5	Swamp Soil Composite Samples	X	X	X					
5	Swamp Soil Composite Samples		X		X				
1	Swamp Soil Composite Sample						X		
2	Swamp Sludge Individual Samples (B-0, 3.0 to 12" and B-1, 3.0 to 6")					X(i)			
97	Swamp Sludge Individual Samples								X
123	Swamp Soil Individual Samples								X
7	Swamp Soil Individual Samples					X(i)			
6	Swamp Sludge Individual Samples					X(i)			

(a) Total metals and general chemistry include: pH (1:1), amenable and total cyanide, fluoride, nitrate, aluminum, arsenic, barium, chromium, calcium, total and hexavalent chromium, copper, iron, lead, magnesium, manganese, mercury, selenium, silicon, silver, and zinc.

(b) The E.P. Toxicity Test Method leachate analysis program includes: amenable and total cyanide, fluoride, nitrate, aluminum, arsenic, barium, cadmium, calcium, total and hexavalent chromium, copper, iron, lead, magnesium, manganese, mercury, selenium, silicon, silver, and zinc.

(c) The U.S. EPA Contract Laboratory Program (CLP) organic compounds include: Hazardous Substance List (HSL) volatile compounds, acid and base-neutral extractable compounds, organochloride pesticides and polychlorinated biphenyls.

(d) The total parameters of concern include: amenable and total cyanide, fluoride, total and hexavalent chromium, iron, manganese, and silver.

(e) Physical characteristics include: moisture content and qualitative liquid limits.

(f) The mineralogical investigation includes determination of minerals present by x-ray diffraction and energy dispersive analysis.

(g) The E.P. Toxicity Test Method leachate analysis program for the monitoring well soil boring samples includes: amenable and total cyanide, fluoride, and hexavalent chromium, iron, and manganese.

(h) The total parameters of concern for the monitoring well soil boring samples include: amenable and total cyanide, fluoride, total and hexavalent chromium, iron, and manganese.

(i) Physical characteristics for the indicated samples are limited to water content.

TABLE 3-3

SUMMARY OF HYDRAULIC CONDUCTIVITY RESULTS
TEST PIT SLUDGES AND SOILS(a)
ARCO CHEMICAL COMPANY
GNADENHUTTEN, OHIO

SAMPLE IDENTIFICATION	DEPTH (ft)	SOIL TYPE	TEST GRADIENT	HYDRAULIC CONDUCTIVITY K_{20} (cm/s)(b)
Between TP-2 and TP-3	7.55	Brown silty fine sand	53	9.59×10^{-6}
TP-5	3.05	Sludge	50	6.56×10^{-7}
TP-7	2.50	Sludge	49	6.56×10^{-7}
TP-7	7.10	Black silty fine sand	59	1.43×10^{-7}
TP-11	6.0	Brown silt	43	4.93×10^{-6}

(a)Test pit soil samples were collected from April 1, 1985 to April 3, 1985.

(b)The hydraulic conductivity, K_{20}, is expressed in centimeters per second at 20 degrees Celsius (°C).

TABLE 3-4

SUMMARY OF X-RAY DIFFRACTION RESULTS
TEST PIT SLUDGES(a)
ARCO CHEMICAL COMPANY
GNADENHUTTEN, OHIO

SAMPLE IDENTIFICATION	QUALITATIVE ELEMENTAL COMPOSITION(b)
Test Pit No. 6, 2-3'	Aluminum, Calcium, Magnesium, Sulfur, Chromium Silicon, Phosphorus, Iron
Test Pit No. 7, 4.5'	Aluminum, Calcium, Silicon, Chromium, Phosphorus, Magnesium, Sulfur, Iron
Test Pit No. 8, 1-2'	Calcium, Magnesium, Aluminum, Sulfur, Chromium, Silicon, Iron
Test Pit No. 9, 3'	Titanium, Silicon, Aluminum, Potassium, Iron, Calcium, Magnesium, Chromium
Test Pit No. 13, 3'	Calcium, Magnesium, Sulfur, Aluminum, Silicon, Chromium

(a)Test pit sludge samples were collected from April 1, 1985 to April 3, 1985.

(b)The identified elements are presented in their approximate order of abundance.

TABLE 3-5

SUMMARY OF X-RAY DIFFRACTION AND ENERGY DISPERSIVE RESULTS
TEST PIT SLUDGE SAMPLES(a)
ABCO CHEMICAL COMPANY
CRAGHOUTTER, OHIO

SAMPLE IDENTIFICATION	alpha-QUARTZ	MUSCOVITE	ETTRINGITE	BRUCITE	GYPSUM	CALCITE	RUTILE	CORUNDUM	ALUMINUM HYDROXIDE	ALUMINUM PHOSPHATE	CHROMIUM SULFIDE	ALUMINUM SULFATE HYDRATE	CHROMIUM SULFATE HYDRATE
Test Pit No. 6, 2-3'	5-10%	ND	ND	5-10%	5-10%	50%	ND	10-25%	5-10%	ND	ND	ND	ND
Test Pit No. 7, 4.5'	25-50%	ND	ND	Trace	ND	10-25%	ND	ND	10-25%	10-25%	10-25%	ND	ND
Test Pit No. 8, 1-2'	ND	ND	ND	10-25%	10-25%	50%+	ND	10-25%	ND	ND	ND	Trace	Trace
Test Pit No. 9, 3'	10-25%	5-10%	ND	ND	ND	ND	50%+	ND	ND	ND	ND	ND	ND
Test Pit No. 13, 3'	ND	ND	25-50%	25-50%	5-10%	25-50%	ND	ND	ND	ND	ND	ND	ND

alpha-Quartz = SiO_2

Muscovite = $KAl_2(Si_3Al)O_{10}(OH,F)_2$

Ettringite = $CaAl(SO_4, SiO_4, CO_3)_3(OH)_{12} \cdot 26H_2O$

Brucite = $Mg(OH)_2$

Gypsum = $CaSO_4 \cdot 2H_2O$

Calcite = $CaCO_3$

Rutile = TiO_2

Corundum = Al_2O_3

Aluminum Hydroxide = $Al(OH)_3$

Aluminum Phosphate = $AlPO_4$

Chromium Sulfide = CrS

Aluminum Sulfate Hydrate = $Al_2(SO_4)_3 \cdot 18H_2O$

Chromium Sulfate Hydrate = $Cr_2(SO_4)_3 \cdot 16H_2O$

(a)Test pit sludge samples were collected from April 1, 1985 to April 3, 1985.

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[illegible]

[illegible]

[illegible]

[illegible]

PARAMETERS	CONCENTRATION UNITS	[illegible] TOTAL(a)	[illegible] E.P. TOX(b)	[illegible] TOTAL	[illegible] E.P. TOX	[illegible] TOTAL	[illegible] E.P. TOX	[illegible] TOTAL	[illegible] E.P. TOX	[illegible] TOTAL	[illegible] E.P. TOX	[illegible] TOTAL	[illegible] E.P. TOX	[illegible] TOTAL	[illegible] E.P. TOX	[illegible] TOTAL	[illegible] E.P.
pH (1:1)	pH Units	8.43	NA(d)	9.05	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Cyanide, Amenable	ppm(e)	0.030(f)	0.03	[illegible]	0.05	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Cyanide, Total	ppm	260	0.03	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Fluoride	ppm	110	1.7	[illegible]	11	36	0.7	110	3.1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Nitrate	ppm	0.4	0.3	0.3	0.10	0.6	0.10	0.6	0.1	0.6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Metals																	
Aluminum	ppm	29,000	16	12,000	0.01	[illegible]	[illegible]	[illegible]	0.010	[illegible]	[illegible]	[illegible]	0.07	[illegible]	[illegible]	[illegible]	[illegible]
Arsenic	ppm	38	0.010	14	0.010	[illegible]	0.010	11	0.010	[illegible]	[illegible]	[illegible]	0.010	11	[illegible]	[illegible]	[illegible]
Barium	ppm	130	0.42	75	0.16	56	0.48	130	0.13	[illegible]	0.21	210	0.13	170	[illegible]	[illegible]	[illegible]
Cadmium	ppm	1.00	0.010	2.0	0.010	1.00	0.010	2.0	0.010	2.0	[illegible]	[illegible]	0.010	1.0	[illegible]	[illegible]	[illegible]
Calcium	ppm	16,000	NA	27,000	NA	[illegible]	NA	[illegible]	NA	[illegible]	[illegible]	[illegible]	NA	[illegible]	[illegible]	[illegible]	[illegible]
Chromium, Hexavalent	ppm	0.10	0.010	0.10	0.010	0.10	0.010	0.10	0.010	0.1	[illegible]	0.1	0.010	0.10	[illegible]	[illegible]	[illegible]
Chromium, Total	ppm	3,300	9.3	4,200	0.08	56	0.05	6,100	0.11	110	[illegible]	[illegible]	0.13	[illegible]	[illegible]	[illegible]	[illegible]
Copper	ppm	17	0.010	12	0.010	18	0.010	11	0.01	19	0.010	16	0.01	41	[illegible]	[illegible]	[illegible]
Iron	ppm	23,000	0.78	10,000	0.01	25,000	22	12,000	0.03	23,000	0.09	19,000	0.01	[illegible]	[illegible]	[illegible]	[illegible]
Lead	ppm	23	0.18	170	0.12	5.0	0.010	43	0.18	25	0.010	93	0.18	62	[illegible]	[illegible]	[illegible]
Magnesium	ppm	19,000	NA	47,000	NA	1,700	NA	19,000	NA	[illegible]	NA	24,000	NA	1,700	[illegible]	[illegible]	[illegible]
Manganese	ppm	1,600	20	410	0.53	400	6.1	750	1.8	[illegible]	15	2,400	15	1,100	[illegible]	[illegible]	[illegible]
Mercury	ppm	0.36	[illegible]	18	[illegible]	[illegible]	[illegible]	0.37	0.020	0.11	[illegible]	[illegible]	[illegible]	0.22	[illegible]	[illegible]	[illegible]
Selenium	ppm	0.10	0.010	0.10	0.010	0.10	0.010	0.10	0.010	0.10	0.010	0.10	0.010	0.10	[illegible]	[illegible]	[illegible]
Silicon	ppm	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	260	[illegible]	420	NA	260	[illegible]	[illegible]	[illegible]
Silver	ppm	3.8	[illegible]	4.0	0.03	16	[illegible]	13	0.04	8.0	0.03	16	0.06	3.0	[illegible]	[illegible]	[illegible]
Zinc	ppm	[illegible]	[illegible]	5.3	[illegible]	47	0.19	[illegible]	0.010	140	0.45	4,300	1.7	150	[illegible]	[illegible]	[illegible]

(a) [illegible] were collected from [illegible] to April 8, 1985

(b) The indicated values represent the total concentration in milligrams per kilogram (mg/kg) or parts per million of the corresponding parameter present in the sample

(c) "E.P. TOX" refers to E.P. toxicity leachate generated by the Extraction Procedure (E.P.) Toxicity Test method, SW 1310 as described in U.S. Environmental Protection Agency, 1986, "Test Methods for Evaluating Solid Waste Physical/Chemical Methods," [illegible], Second Edition Revised, Waste Characterization Branch, Office of Solid Waste, Washington, D.C.

(d) "NA" indicates not determined.

(e) The units for total constituent analyses are reported in milligrams per kilogram (mg/kg) or parts per million (ppm). The E.P. Toxicity Test Method leachate analyses are reported in milligrams per liter (mg/l) or ppm

(f) "N" indicates that the compound was analyzed, but not detected. The corresponding number represents the method detection limit for the sample

00001757

TABLE 3-7

SUMMARY OF E.P. TOXICITY TEST METHOD RESULTS
APRIL 1985 IMPOUNDMENT AND SLUDGE TEST PIT VERTICAL COMPOSITE SAMPLES(a)
ARCO CHEMICAL COMPANY
CHADEMMUTTER, OHIO

PARAMETERS	CONCENTRATION UNITS	SAMPLE IDENTIFICATION						
		TP-1 VERTICAL COMPOSITE	TP-2 VERTICAL COMPOSITE	TP-3 VERTICAL COMPOSITE	TP-4 VERTICAL COMPOSITE	TP-5 VERTICAL COMPOSITE	TP-6 VERTICAL COMPOSITE	TP-7 VERTICAL COMPOSITE
Cyanide, Amenable	mg/l(b)	0.02U(c)	0.04	0.13	0.02U	0.02U	0.02U	0.57
Cyanide, Total	mg/l	0.04	0.10	0.45	0.02	0.02	0.02	0.90
Fluoride	mg/l	3.9	7.4	2.8	2.3	1.3	0.9	1.5
Nitrate	mg/l	0.2	0.1U	0.2	0.2	0.1	0.2	0.4
Metals:								
Aluminum	mg/l	0.13	0.01U	1.0	2.4	0.14	26	7.9
Arsenic	mg/l	0.01U	0.01U	0.01U	0.01U	0.02	0.01U	0.01U
Barium	mg/l	0.12	0.16	0.28	0.13	0.10	0.44	0.76
Cadmium	mg/l	0.01U	0.01U	0.01U	0.01U	0.01U	0.01U	0.01U
Chromium, Hexavalent	mg/l	0.43	0.47	0.16	0.01U	0.01U	0.01U	0.01U
Chromium, Total	mg/l	0.45	0.46	0.32	0.50	0.09	8.0	3.9
Copper	mg/l	0.01U	0.01U	0.01U	0.01U	0.01U	0.01	0.01
Iron	mg/l	0.05	0.05	0.25	0.04	0.07	7.5	0.50
Lead	mg/l	0.16	0.13	0.12	0.13	0.13	0.02	0.12
Manganese	mg/l	0.94	0.47	3.6	6.6	1.5	24	30
Mercury	mg/l	0.0039	0.0035	0.012	0.0022	0.0002U	0.0002U	0.011
Selenium	mg/l	0.01U	0.01U	0.01U	0.01U	0.01U	0.01U	0.01U
Silver	mg/l	0.04	0.03	0.03	0.03	0.03	0.34	0.04
Zinc	mg/l	0.01U	0.01U	0.01U	0.01U	0.01U	0.02	0.24

00001758

TABLE 3.7
(Continued)

PARAMETERS	CONCENTRATION UNITS	TP-8 VERTICAL COMPOSITE	TP-9 VERTICAL COMPOSITE	TP-10 VERTICAL COMPOSITE	TP-11 VERTICAL COMPOSITE	TP-12 VERTICAL COMPOSITE	TP-13 VERTICAL COMPOSITE
Cyanide, Amenable	mg/l	0.020	0.020	0.020	0.020	0.020	0.02
Cyanide, Total	mg/l	0.020	0.02	0.02	0.04	0.020	0.16
Fluoride	mg/l	7.1	0.9	2.5	12	14	3.5
Nitrate	mg/l	0.1	0.10	0.20	0.7	0.2	4.6
Metals:							
Aluminum	mg/l	0.12	47	7.4	0.010	0.010	1.1
Arsenic	mg/l	0.010	0.010	0.010	0.010	0.010	0.010
Barium	mg/l	0.12	0.78	0.35	0.13	0.14	0.07
Cadmium	mg/l	0.010	0.010	0.010	0.010	0.010	0.02
Chromium, Hexavalent	mg/l	0.010	0.010	0.010	0.12	0.01	0.06
Chromium, Total	mg/l	0.06	11	1.7	0.15	0.11	0.13
Copper	mg/l	0.010	0.010	0.010	0.010	0.010	0.05
Iron	mg/l	0.02	40	0.66	0.01	0.010	0.18
Lead	mg/l	0.13	0.56	0.13	0.09	0.15	0.17
Manganese	mg/l	0.60	22	8.8	0.03	0.06	0.08
Mercury	mg/l	0.0025	0.011	0.00020	0.0025	0.00020	0.016
Selenium	mg/l	0.010	0.010	0.010	0.010	0.010	0.010
Silver	mg/l	0.03	0.16	0.04	0.02	0.03	0.07
Zinc	mg/l	0.010	1.2	0.03	0.010	0.010	0.010

(a)Samples were collected from April 1, 1985 to April 3, 1985. Analytical results of leachates generated by the Extraction Procedure (E.P.) Toxicity Test Method, SW-1310, as described in U.S. Environmental Protection Agency, 1984, "Test Methods for Evaluating Solid Waste: Physical/Chemical Methods," SW-846, Second Edition Revised, Waste Characterization Branch, Office of Solid Waste, Washington, D.C.

(b)"mg/l" = milligrams per liter or parts per million (ppm).

(c)"U" indicates that the compound was analyzed, but not detected. The corresponding number represents the method detection limit for the sampling.

00001759

TABLE 3-8

SUMMARY OF GENERAL INORGANIC RESULTS
APRIL 1985 SLUDGE PIT AND IMPOUNDMENT TEST PIT SAMPLES(a)
ARCO CHEMICAL COMPANY
CHADEMHUTTEN, OHIO

PARAMETERS	CONCENTRATION UNITS	SAMPLE IDENTIFICATION TP-1 0-1 FEET	TP-2 2-3 FEET	TP-3 4-5 FEET	TP-4 4.5-6 FEET	TP-5 5-5.5 FEET	TP-6 3.3-4 FEET	TP-7 1-2 FEET
Cyanide, Amenable	mg/kg(b)	0.5U(c)	0.5U	0.5U	75	140	0.5U	550
Cyanide, Total	mg/kg	820	580	7.8	520	1,100	39	1,200
Fluoride	mg/kg	140	110	110	103	36	66	110
Metals:								
Chromium, Hexavalent	mg/kg	0.1U	0.1U	0.1U	0.1U	0.1U	3.1	0.1U
Chromium, Total	mg/kg	7,100	5,600	91	5,200	22,000	46	11,000
Iron	mg/kg	6,900	16,000	34,000	16,000	5,700	31,000	2,700
Manganese	mg/kg	370	520	1,200	550	700	1,100	310
Silver	mg/kg	0.10U	0.10U	0.23	0.10U	0.10U	0.10U	0.10U

00001760

TABLE 3-8
(Continued)

PARAMETERS	CONCENTRATION UNITS	SAMPLE IDENTIFICATION TP-8 1-2 FEET	TP-9 2.5 FEET	TP-9 3 FEET	TP-10 1.5 FEET	TP-10 6 FEET	TP-11 1-3 FEET	TP-12 1-2 FEET	TP-13 3 FEET
Cyanide, Amenable	mg/kg	400	0.5U	3.2	0.5U	0.5U	0.5U	820	0.5U
Cyanide, Total	mg/kg	720	22	8.0	1,500	0.8	660	890	210
Fluoride	mg/kg	120	120	35	12	21	100	12	18
Metals:									
Chromium, Hexavalent	mg/kg	0.1	0.1U	0.6	0.1U	0.1U	0.1U	0.1U	0.1U
Chromium, Total	mg/kg	7,000	30	240	9,800	33	5,500	8,400	2,200
Iron	mg/kg	2,300	29,000	9,700	1,800	24,000	3,100	1,700	1,900
Manganese	mg/kg	300	1,000	250	270	790	230	180	120
Silver	mg/kg	0.10U	0.10U	0.23	0.10U	0.10U	0.10U	0.10U	0.10U

(a)Test pit soil samples were collected from April 1, 1985 to April 3, 1985.

(b)"mg/kg" = milligrams per kilogram or parts per million (ppm).

(c)"U" indicates that the compound was analyzed, but not detected. The corresponding number represents the method detection limit for the sample.

C0001761

TABLE 3-9

SUMMARY OF HAZARDOUS SUBSTANCE LIST COMPOUND RESULTS
APRIL 1985 IMPOUNDMENT, SLUDGE PIT, AND SWAMP COMPOSITE SAMPLES(a)
ARCO CHEMICAL COMPANY
CHAGRINUTTEN, OHIO

PARAMETERS	CAS NUMBER(b)	CONCENTRATION UNITS	SAMPLE IDENTIFICATION				
			N. IMPOUNDMENT SLUDGE COMPOSITE	S. IMPOUNDMENT SLUDGE COMPOSITE	SLUDGE PIT SLUDGE COMPOSITE	SWAMP SLUDGE COMPOSITE	SWAMP SOIL COMPOSITE
VOLATILES:							
Ethylbenzene	100-41-4	mg/kg(c)	BDL(d)	110	BDL	BDL	BDL
2-Hexanone	591-78-6	mg/kg	BDL	43	BDL	BDL	BDL
Tetrachlorethylene	127-18-4	mg/kg	BDL	0.28	BDL	BDL	BDL
Toluene	108-88-3	mg/kg	BDL	5.3	BDL	BDL	BDL
Xylenes, Total	--(e)	mg/kg	BDL	410	0.012	BDL	BDL
Acid/Base-Neutral Extractables:							
Bis(2-ethylhexyl) phthalate	117-81-7	mg/kg	1.5	1.1	2.6	2.9	0.75
Di-n-butyl phthalate	84-74-2	mg/kg	BDL	0.80	0.35	0.52	BDL
Fluoranthene	206-44-0	mg/kg	BDL	BDL	BDL	BDL	0.51
Isophorone	78-59-1	mg/kg	BDL	16	BDL	BDL	BDL
Naphthalene	91-20-3	mg/kg	BDL	200	BDL	BDL	BDL
N-Nitrosodiphenylamine (Diphenylamine)(f)	86-30-6	mg/kg	BDL	0.45	BDL	0.67	BDL
Phenanthrene	85-01-8	mg/kg	BDL	BDL	BDL	BDL	0.38
Pyrene	129-00-0	mg/kg	BDL	BDL	BDL	0.38	0.66
PESTICIDES/POLYCHLORINATED BIPHENYLS:							
Endrin	72-20-8	mg/kg	BDL	0.066	0.032	BDL	BDL
Aroclor 1248	12672-29-6	mg/kg	BDL	BDL	BDL	1.2	30

(a)Samples were collected from April 1, 1985 to April 8, 1985.

(b)The numbers presented in this column are the Chemicals Abstracts Service (CAS) numbers used for cataloging the indicated compounds in the Chemical Abstracts Index.

(c)"mg/kg" = milligrams per kilogram or parts per million (ppm).

(d)"BDL" indicates not detected above the U.S. Environmental Protection Agency (EPA) Contract Laboratory Program (CLP) Hazardous Substance List (HSL) contract required detection limits (CRDL).

(e)Total xylenes include the ortho-, meta-, and para-xylene isomers. A CAS number is not available for total xylenes.

(f)The indicated compound is detected as the compound in parentheses.

00001762

TABLE 3-10

SUMMARY OF GENERAL INORGANIC AND EP TOXICITY TEST METHOD RESULTS
NOVEMBER 1986 IMPOUNDMENT, SLUDGE PIT, AND SWAMP COMPOSITE SAMPLES(a)
ARCO CHEMICAL COMPANY
CHARDEMUTTER, OHIO

PARAMETERS	CONCENTRATION UNITS	SAMPLE IDENTIFICATION NORTHERN IMPOUNDMENT AREA									
		SLUDGE COMPOSITE		S-1 SOIL (9.4-10.0')		S-1 SOIL (10.0-10.6')		S-3 SOIL (3.8-5.5')		S-3 SOIL (5.5-6.5')	
		TOTAL(b)	EP TOX(c)	TOTAL	EP TOX	TOTAL	EP TOX	TOTAL	EP TOX	TOTAL	EP TOX
pH (1:1)	pH Units	8.20	ND(d)	8.20	ND	8.20	ND	7.80	ND	7.50	ND
Cyanide, Total	ppm(e)	680	0.02U(f)	90	0.02U	8.9	0.02U	37	0.29	21	0.24
Fluoride, Total	ppm	3,900	2.3	360	1.5	240	1.0	180	0.7	170	1.0
Nitrate, Leachable	ppm	1.8U	0.1U	1.2U	0.2	1.2U	0.2	1.2U	0.2	1.2	0.2
Metals:											
Aluminum	ppm	42,000	0.1U	11,000	5.3	5,000	1.3	7,200	0.5	7,500	0.9
Arsenic	ppm	32	0.005U	16	0.005U	14	0.005U	12	0.005U	9.6	0.005U
Barium	ppm	43	0.059	79	0.20	81	0.27	100	0.10	110	0.05
Cadmium	ppm	5.5	0.020	1.0U	0.005U	1.0U	0.005U	1.0U	0.005U	1.0U	0.005U
Chromium, Hexavalent	ppm	0.44J	0.01U	1.2U	0.01U	1.0J	0.01U	0.30J	0.01U	0.30J	0.01U
Chromium, Total	ppm	8,800	0.15	1,200	0.09	200	0.01	75	0.02	25	0.01
Copper	ppm	2.9	0.03	62	0.01U	75	0.02	22	0.01U	17	0.01
Iron	ppm	2,800	0.13	52,000	11	52,000	49	23,000	0.15	24,000	0.03
Lead	ppm	29	0.005U	9.7	0.005U	9.2	0.005U	12	0.005U	12	0.005U
Manganese	ppm	260	0.44	310	1.2	270	1.3	1,100	6.7	1,000	8.6
Mercury	ppm	0.89	0.0002U	0.61	0.0002U	0.53	0.0002U	0.56	0.0002U	0.52	0.0002U
Selenium	ppm	1.7	0.085	1.9	0.005U	2.3	0.011	1.2	0.010	1.2	0.012
Silver	ppm	2.2	0.03	2.0U	0.01U	2.0U	0.01U	2.0U	0.01U	2.0U	0.01U
Zinc	ppm	1,700	0.04	160	0.25	51	0.09	54	0.01	59	0.01

See footnotes at end of table.

00001763

TABLE 3-10

SUMMARY OF GENERAL INORGANIC AND EP TOXICITY TEST METHOD RESULTS
NOVEMBER 1986 IMPOUNDMENT, SLUDGE PIT, AND SWAMP COMPOSITE SAMPLES(a)
ARCO CHEMICAL COMPANY
CHARDEMUTTEN, OHIO

PARAMETERS	CONCENTRATION UNITS	SAMPLE IDENTIFICATION NORTHERN IMPOUNDMENT AREA									
		SLUDGE COMPOSITE		S-1 SOIL (9.4-10.0')		S-1 SOIL (10.0-10.6')		S-3 SOIL (3.8-5.5')		S-3 SOIL (5.5-6.5')	
		TOTAL(b)	EP TOX(c)	TOTAL	EP TOX	TOTAL	EP TOX	TOTAL	EP TOX	TOTAL	EP TOX
pH (1:1)	pH Units	8.20	ND(d)	8.20	ND	8.20	ND	7.80	ND	7.50	ND
Cyanide, Total	ppm(e)	680	0.02U(f)	90	0.02U	8.9	0.02U	37	0.29	21	0.24
Fluoride, Total	ppm	3,900	2.3	360	1.5	240	1.0	180	0.7	170	1.0
Nitrate, Leachable	ppm	1.8U	0.1U	1.2U	0.2	1.2U	0.2	1.2U	0.2	1.2	0.2
Metals:											
Aluminum	ppm	42,000	0.1U	11,000	5.3	5,000	1.3	7,200	0.5	7,500	0.9
Arsenic	ppm	32	0.005U	16	0.005U	14	0.005U	12	0.005U	9.6	0.005U
Barium	ppm	43	0.059	79	0.20	81	0.27	100	0.10	110	0.05
Cadmium	ppm	5.5	0.020	1.0U	0.005U	1.0U	0.005U	1.0U	0.005U	1.0U	0.005U
Chromium, Hexavalent	ppm	0.44J	0.01U	1.2U	0.01U	1.0J	0.01U	0.30J	0.01U	0.30J	0.01U
Chromium, Total	ppm	8,800	0.15	1,200	0.09	200	0.01	75	0.02	25	0.01
Copper	ppm	2.9	0.03	62	0.01U	75	0.02	22	0.01U	17	0.01
Iron	ppm	2,800	0.13	52,000	11	52,000	49	23,000	0.15	24,000	0.03
Lead	ppm	29	0.005U	9.7	0.005U	9.2	0.005U	12	0.005U	12	0.005U
Manganese	ppm	260	0.44	310	1.2	270	1.3	1,100	6.7	1,000	8.6
Mercury	ppm	0.89	0.0002U	0.61	0.0002U	0.53	0.0002U	0.56	0.0002U	0.52	0.0002U
Selenium	ppm	1.7	0.085	1.9	0.005U	2.3	0.011	1.2	0.010	1.2	0.012
Silver	ppm	2.2	0.03	2.0U	0.01U	2.0U	0.01U	2.0U	0.01U	2.0U	0.01U
Zinc	ppm	1,700	0.04	160	0.25	51	0.09	54	0.01	59	0.01

See footnotes at end of table.

00001764

TABLE 3-10
(Continued)

PARAMETERS	CONCENTRATION UNITS	SAMPLE IDENTIFICATION SOUTHERN IMPOUNDMENT AREA: SLUDGE COMPOSITE TOTAL(b)	SLUDGE COMPOSITE EP TOX(c)	S-4 SOIL (6.0-8.0') TOTAL	S-4 SOIL (6.0-8.0') EP TOX	S-5 SOIL (9.5-11.0') TOTAL	S-5 SOIL (9.5-11.0') EP TOX	S-6 SOIL (10.1-1.1.4) TOTAL	S-6 SOIL (10.1-1.1.4) EP TOX
pH (1:1)	pH Units	8.4	ND[d]	8.3	ND	8.2	ND	8.6	ND
Cyanide, Total	ppm(e)	490	0.02	1.6	0.02	18	0.02	25	0.02
Fluoride, Total	ppm	3,400	6.1	58	0.02	190	0.02	310	1.1
Nitrate, Leachable	ppm	1.8	0.1	1.2	0.4	1.2	0.3	4.6	0.4
Metals:									
Aluminum	ppm	34,600	0.245	8,240	0.161	6,460	1.62	5,560	2.72
Arsenic	ppm	20	.005U	7.1	0.005U	10U	0.005U	7.5	0.005U
Barium	ppm	32	0.82	11.3	0.273	64	0.258	32	0.184
Cadmium	ppm	4.7	0.014	1.0U	0.005U	1.0U	0.005U	1.0U	0.005U
Chromium, Hexavalent	ppm	4.4	0.01	3.6	0.01	3.0	0.01	1.3	0.01
Chromium, Total	ppm	5,760	0.012	19	0.012	212	0.022	410	0.044
Copper	ppm	2.6	0.023	15	0.010	48	0.012	61	0.024
Iron	ppm	2,410	0.119	24,300	2.0	30,300	20.7	31,100	47.9
Lead	ppm	15	0.005U	13	0.005U	13	0.005U	8.3	0.005U
Manganese	ppm	217	0.170	764	9.49	365	2.32	308	1.9
Mercury	ppm	0.58	0.002U	0.71	0.0002U	0.5	0.0002U	0.41	0.0002U
Selenium	ppm	1.6	0.132	1.4	0.016	1.1	0.019	1.3	0.027
Silver	ppm	2.1	0.025	2.0U	0.010	2.0U	0.010U	2.0U	0.017
Zinc	ppm	754	0.028	56	0.013	62	0.093	62	0.171

See footnotes at end of table.

0001765

TABLE 3-10
(Continued)

PARAMETERS	CONCENTRATION UNITS	SAMPLE IDENTIFICATION SLUDGE PIT			
		SLUDGE COMPOSITE		SOIL COMPOSITE	
		TOTAL(b)	EP TOX(c)	TOTAL	EP TOX
pH (1:1)	pH Units	8.2	ND[d]	7.9	ND
Cyanide, Total	ppm(e)	560	0.02	18	0.02
Fluoride, Total	ppm	5,200	1.9	250	1.2
Nitrate, Leachable	ppm	1.7	0.2	2.6	0.1
Metals:					
Aluminum	ppm	50,800	0.1U	8,070	2.13
Arsenic	ppm	16	0.01U	8.2	0.10U
Barium	ppm	136	0.122	130	0.146
Cadmium	ppm	4.3	0.007	1.0U	0.005U
Chromium, Hexavalent	ppm	1.2	0.02	1.2	0.03
Chromium, Total	ppm	6,180	0.103	78	0.010U
Copper	ppm	8.4	0.010U	22	0.010U
Iron	ppm	13,500	0.086	25,100	0.010U
Lead	ppm	22	0.005U	13	0.005U
Manganese	ppm	564	1.26	991	12.3
Mercury	ppm	0.57	0.0002U	0.1U	0.0002U
Selenium	ppm	1.7	0.005U	1.3	0.005U
Silver	ppm	2.4	0.010U	2.0U	0.010U
Zinc	ppm	95	0.015	80	0.053

See footnotes at end of table.

00001766

TABLE 3-10
(Continued)

PARAMETERS	CONCENTRATION UNITS	SAMPLE IDENTIFICATION											
		SWAMP AREA											
		AREA NO. 1 COMPOSITE				AREA NO. 2 COMPOSITE				AREA NO. 3 COMPOSITE			
		SLUDGE		SOIL		SLUDGE		SOIL		SLUDGE		SOIL	
		TOTAL(b)	EP TOX(a)	TOTAL	EP TOX	TOTAL	EP TOX	TOTAL	EP TOX	TOTAL	EP TOX	TOTAL	EP TOX
pH (1:1)(g)	pH Units	8.15	ND	7.10	ND	8.00	ND	7.00	ND	8.05	ND	7.20	ND
Cyanide, Total	ppm	670	0.02U	17	0.02U	120	0.02U	20	0.04	40	0.04	30	0.02U
Fluoride, Total	ppm	6,700	2.3	340	1.6	13,000	2.9	310	1.8	3,700	1.5	150	0.6
Nitrate, Leachable	ppm	2.3	0.1U	2.2	0.2	8.9	0.3	5.5	0.2	9.7	0.4	9.4	0.2
Metals:													
Aluminum	ppm	72,000	0.2	16,000	2.6	70,000	0.7	17,000	3.5	39,000	0.1U	14,000	1.5
Arsenic	ppm	45	0.01U	16	0.01U	31	0.01U	21	0.01U	26	0.01U	14	0.01U
Barium	ppm	180	0.28	170	0.18	190	0.26	210	0.14	180	0.05U	150	0.33
Cadmium	ppm	6.8	0.006	1.0U	0.005U	6.8	0.008	1.0U	0.005U	3.4	0.006	1.0U	0.009
Chromium, Hexavalent	ppm	4.2U	0.02	1.6J	0.01U	0.20J	0.11	13	0.01U	4.0U	0.01U	0.82J	0.14
Chromium, Total	ppm	17,000	1.7	660	0.03	17,000	1.9	450	0.02	11,000	1.9	620	0.03
Copper	ppm	21	0.01	44	0.01U	24	0.01	53	0.01U	31	0.01	47	0.01U
Iron	ppm	18,000	0.48	41,000	0.05	17,000	0.42	48,000	0.05	26,000	0.33	44,000	0.04
Lead	ppm	87	0.005U	63	0.005U	88	0.005U	73	0.005U	98	0.005U	91	0.006
Manganese	ppm	870	3.0	1,200	5.4	960	3.3	900	4.4	1,400	5.7	1,400	13
Mercury	ppm	0.96	0.0004U	0.82	0.0002U	0.87	0.0002U	0.84	0.0002U	0.79	0.0002U	0.79	0.0002U
Selenium	ppm	2.3	0.005U	1.0U	0.005U	1.0U	0.005U	1.0U	0.005U	2.2	0.005U	1.2	0.005U
Silver	ppm	2.6	0.01U	2.0U	0.01U	3.2	0.01U	2.0U	0.01U	2.3	0.01	2.0U	0.01U
Zinc	ppm	5,500	0.60	360	0.36	6,000	2.4	360	0.26	4,500	0.86	600	0.90

00001767

TABLE 3-10
(Continued)

PARAMETERS	CONCENTRATION UNITS	SAMPLE IDENTIFICATION							
		SWAMP AREA							
		AREA NO. 4 COMPOSITE				AREA NO. 5 COMPOSITE			
		SLUDGE		SOIL		SLUDGE		SOIL	
		TOTAL	EP TOX	TOTAL	EP TOX	TOTAL	EP TOX	TOTAL	EP TOX
pH (1:1)(g)	pH Units	7.85	ND	6.90	ND	7.70	ND	7.10	ND
Cyanide, Total	ppm	24	0.02U	10	0.02U	42	0.02U	11	0.02U
Fluoride, Total	ppm	2,000	1.0	120	0.3	4,600	1.6	150	0.6
Nitrate, Leachable	ppm	2.9	0.1U	1.3U	0.1U	1.9	0.1U	5.6	0.2
Metals:									
Aluminum	ppm	60,000	0.1U	16,000	0.3	36,000	0.2	12,000	1.5
Arsenic	ppm	57	0.03	25	0.01U	35	0.04	18	0.01U
Barium	ppm	430	0.22	180	0.14	240	0.008	130	0.33
Cadmium	ppm	6.0	0.005	1.0U	0.005U	3.6	0.006	1.0U	0.009
Chromium, Hexavalent	ppm	1.73	0.01U	3.43	0.01U	0.633	0.01U	6.4U	0.14
Chromium, Total	ppm	13,000	0.42	290	0.01U	14,000	0.18	380	0.03
Copper	ppm	54	0.01	53	0.01U	44	0.01U	47	0.01U
Iron	ppm	24,000	0.32	50,000	0.16	20,000	0.08	39,000	0.04
Lead	ppm	130	0.006	72	0.005U	120	0.006	71	0.006
Manganese	ppm	7,200	29	780	5.0	5,600	23	1,600	13
Mercury	ppm	0.93	0.0004	0.99	0.0002U	0.80	0.0002U	0.99	0.0002U
Selenium	ppm	3.3	0.005U	1.0	0.005U	25	0.011	1.0U	0.005U
Silver	ppm	3.1	0.01	2.0U	0.01U	2.9	0.01	2.0U	0.01U
Zinc	ppm	4,000	1.1	380	0.21	4,700	2.6	350	0.90

(a)Samples were collected from November 17, 1986 to December 2, 1986.

(b)*The indicated values represent the total concentration in milligrams per kilogram (mg/kg) or parts per million of the corresponding parameter present in the sample.*

(c)"EP TOX" refers to the EP toxicity leachate generated by the Extraction Procedure (EP) Toxicity Test Method, SW-1310 as described in U.S. Environmental Protection Agency, 1985, "Test Methods for Evaluating Solid Waste: Physical/Chemical Methods," SW-846, Second Edition Revised, Waste Characterization Branch, Office of Solid Waste and Emergency Response, Washington, DC.

(d)"ND" indicates not determined.

(e)*The units for total constituent analyses are reported in milligrams per kilogram (mg/kg) or parts per million (ppm).* The EP toxicity test method leachate analyses are reported in milligrams per liter (mg/l) or ppm.

(f)"U" indicates that the compound was analyzed, but not detected. The corresponding number represents the method detection limit for the sample.

(g)The pH values for the swamp area sludge samples were determined on a ratio of one part sludge to five parts deionized water (1:5) instead of the usual 1:1 ratio because samples were not wet enough for pH measurements at 1:1 ratio.

00001768

TABLE 3-10
(Continued)

PARAMETERS	CONCENTRATION UNITS	SAMPLE IDENTIFICATION SWAMP AREA											
		AREA NO. 1 COMPOSITE				AREA NO. 2 COMPOSITE				AREA NO. 3 COMPOSITE			
		SLUDGE		SOIL		SLUDGE		SOIL		SLUDGE		SOIL	
		TOTAL(b)	EP TOX(c)	TOTAL	EP TOX	TOTAL	EP TOX	TOTAL	EP TOX	TOTAL	EP TOX	TOTAL	EP TOX
pH (1:1)(g)	pH Units	8.15	ND	7.10	ND	8.00	ND	7.00	ND	8.05	ND	7.20	ND
Cyanide, Total	ppm	670	0.02U	17	0.02U	170	0.02U	20	0.04	40	0.04	30	0.02U
Fluoride, Total	ppm	6,700	2.3	340	1.6	13,000	2.9	310	1.8	3,700	1.5	150	0.6
Nitrate, Leachable	ppm	2.3	0.1U	2.2	0.2	8.9	0.3	5.5	0.2	9.7	0.4	9.4	0.2
Metals:													
Aluminum	ppm	72,000	0.2	16,000	2.6	70,000	0.7	17,000	3.5	39,000	0.1U	14,000	1.5
Arsenic	ppm	45	0.01U	16	0.01U	31	0.01U	21	0.01U	26	0.01U	14	0.01U
Barium	ppm	180	0.28	170	0.18	190	0.26	210	0.14	180	0.05U	150	0.33
Cadmium	ppm	6.8	0.006	1.0U	0.005U	6.8	0.008	1.0U	0.005U	3.4	0.006	1.0U	0.009
Chromium, Hexavalent	ppm	4.2U	0.02	1.6J	0.01U	0.20J	0.11	13	0.01U	4.0U	0.01U	0.82J	0.14
Chromium, Total	ppm	17,000	1.7	660	0.03	17,000	1.9	450	0.02	11,000	1.9	620	0.03
Copper	ppm	21	0.01	44	0.01U	24	0.01	53	0.01U	31	0.01	47	0.01U
Iron	ppm	18,000	0.48	41,000	0.05	17,000	0.42	48,000	0.05	26,000	0.33	44,000	0.04
Lead	ppm	87	0.005U	63	0.005U	88	0.005U	73	0.005U	98	0.005U	91	0.006
Manganese	ppm	870	3.0	1,200	5.4	960	3.3	900	4.4	1,400	5.7	1,400	13
Mercury	ppm	0.96	0.0004U	0.82	0.0002U	0.87	0.0002U	0.84	0.0002U	0.79	0.0002U	0.79	0.0002U
Selenium	ppm	2.3	0.005U	1.0U	0.005U	1.0U	0.005U	1.0U	0.005U	2.2	0.005U	1.2	0.005U
Silver	ppm	2.6	0.01U	2.0U	0.01U	3.2	0.01U	2.0U	0.01U	2.3	0.01	2.0U	0.01U
Zinc	ppm	5,500	0.60	360	0.36	6,000	2.4	360	0.26	4,500	0.86	600	0.90

00001769

TABLE 3-10
(Continued)

PARAMETERS	CONCENTRATION UNITS	SAMPLE IDENTIFICATION SWAMP AREA							
		AREA NO. 4 COMPOSITE				AREA NO. 5 COMPOSITE			
		SLUDGE		SOIL		SLUDGE		SOIL	
		TOTAL	EP TOX	TOTAL	EP TOX	TOTAL	EP TOX	TOTAL	EP TOX
pH (1:1)(g)	pH Units	7.85	ND	6.90	ND	7.70	ND	7.10	ND
Cyanide, Total	ppm	24	0.02U	10	0.02U	42	0.02U	11	0.02U
Fluoride, Total	ppm	2,000	1.0	120	0.3	4,600	1.6	150	0.6
Nitrate, Leachable	ppm	2.9	0.1U	1.3U	0.1U	1.9	0.1U	5.8	0.2
Metals:									
Aluminum	ppm	60,000	0.1U	16,000	0.3	36,000	0.2	12,000	1.5
Arsenic	ppm	57	0.03	25	0.01U	35	0.04	18	0.01U
Barium	ppm	430	0.22	180	0.14	240	0.008	130	0.33
Cadmium	ppm	6.0	0.005	1.0U	0.005U	3.6	0.006	1.0U	0.009
Chromium, Hexavalent	ppm	1.7J	0.01U	3.4J	0.01U	0.63J	0.01U	6.4U	0.14
Chromium, Total	ppm	13,000	0.42	290	0.01U	14,000	0.18	380	0.03
Copper	ppm	54	0.01	53	0.01U	44	0.01U	47	0.01U
Iron	ppm	24,000	0.32	50,000	0.16	20,000	0.08	39,000	0.04
Lead	ppm	130	0.006	72	0.005U	120	0.006	71	0.006
Manganese	ppm	7,200	29	780	5.0	5,600	23	1,600	13
Mercury	ppm	0.93	0.0004	0.99	0.0002U	0.80	0.0002U	0.99	0.0002U
Selenium	ppm	3.3	0.005U	1.0	0.005U	25	0.011	1.0U	0.005U
Silver	ppm	3.1	0.01	2.0U	0.01U	2.9	0.01	2.0U	0.01U
Zinc	ppm	4,000	1.1	380	0.21	4,700	2.6	350	0.90

(a) Samples were collected from November 17, 1986 to December 2, 1986.

(b) The indicated values represent the total concentration in milligrams per kilogram (mg/kg) or parts per million of the corresponding parameter present in the sample.

(c) "EP TOX" refers to the EP toxicity leachate generated by the Extraction Procedure (EP) Toxicity Test Method, SW-1310 as described in U.S. Environmental Protection Agency, 1985, "Test Methods for Evaluating Solid Waste: Physical/Chemical Methods," SW-846, Second Edition Revised, Waste Characterization Branch, Office of Solid Waste and Emergency Response, Washington, DC.

(d) "ND" indicates not determined.

(e) The units for total constituent analyses are reported in milligrams per kilogram (mg/kg) or parts per million (ppm). The EP toxicity test method leachate analyses are reported in milligrams per liter (mg/l) or ppm.

(f) "U" indicates that the compound was analyzed, but not detected. The corresponding number represents the method detection limit for the sample.

(g) The pH values for the swamp area sludge samples were determined on a ratio of one part sludge to five parts deionized water (1:5) instead of the usual 1:1 ratio because samples were not wet enough for pH measurements at 1:1 ratio.

00001770

TABLE 3-11

SUMMARY OF HAZARDOUS SUBSTANCE LIST COMPOUND RESULTS
NORTHERN AND SOUTHERN IMPOUNDMENT SLUDGE COMPOSITES
AND SOIL SAMPLES(a)
ABCO CHEMICAL COMPANY
CHARLESTOWN, OHIO

				SAMPLE IDENTIFICATION											
				NORTHERN IMPOUNDMENT AREA					SOUTHERN IMPOUNDMENT AREA						
PARAMETERS	CAS REGISTRY NUMBER(b)	CONCENTRATION UNITS(c)	SLUDGE COMPOSITE	S-1 SOIL (9.4-10.0')	S-2 SOIL (10.0-10.6')	S-3 SOIL (3.8-5.5')	S-3 SOIL (5.5-6.5')	SLUDGE COMPOSITE	S-4 SLUDGE COMPOSITE	S-5 SLUDGE COMPOSITE	S-6 SLUDGE COMPOSITE	S-4 SOIL (6.0-8.0')	S-5 SOIL (9.5-11')	S-6 SOIL (10.1-11.6')
Volatiles:														
Methylene Chloride	75-09-2	mg/kg	0.638(d)	0.075B	0.21B	0.19B	0.29B	0.78B	--(e)	--	--	0.25B	0.025JB(f)	0.022JB
Acetone	67-64-1	mg/kg	0.35JB	0.31B	0.10B	0.075JB	0.094JB	0.68B	--	--	--	0.077JB	0.20B	0.11B
Chloroform	67-66-3	mg/kg	0.13B	0.075B	0.062B	0.099B	0.079B	0.29B	--	--	--	0.071JB	0.035JB	0.036JB
Xylenes, Total(g)	1330-20-7	mg/kg	0.062JB	0.011JB	0.018JB	0.012JB	0.021B	0.88B	--	--	--	0.062JB	0.015J	0.018J
Acid/Base-Neutral Extractables:	--	mg/kg	--	BDL(h)	BDL	BDL	BDL	--	BDL	BDL	BDL	BDL	BDL	BDL
Pesticides/PCBs:	--	mg/kg	--	BDL	BDL	BDL	BDL	--	--	--	--	--		

(a)Samples were collected from November 24, 1986 to November 25, 1986.

(b)The numbers presented in this column are the Chemical Abstracts Service (CAS) Registry Numbers used for cataloging the indicated compounds in the Chemical Abstracts Index.

(c)"mg/kg" equals milligrams per kilogram or parts per million (ppm).

(d)"B" indicates that the corresponding compound was found in the blank as well as the sample.

(e)"--" indicates that the corresponding parameter or group of parameters was not determined.

(f)"J" indicates that the corresponding compound is present, but the calculated concentration is less than the specified detection limit.

(g)Total xylenes include the ortho-, meta-, and para-xylene isomers.

(h)"BDL" indicates that the corresponding compounds were not detected above the sample detection limits indicated in Appendix A.

00001771

TABLE 3-12

SUMMARY OF GENERAL INORGANIC AND EP TOXICITY TEST METHOD RESULTS
JANUARY 1987 NORTHERN AND SOUTHERN IMPOUNDMENT AND SLUDGE PIT SAMPLES(a)
ARCO CHEMICAL COMPANY
GNADENHUTTEN, OHIO

PARAMETERS	CONCENTRATION UNITS	SAMPLE IDENTIFICATION NORTHERN IMPOUNDMENT AREA							
		SLUDGE COMPOSITE		S-1 SOIL (8.0-8.8 ft)		S-2 SOIL (7.2-8.5 ft)		S-3 SOIL (7.0-7.8 ft)	
		TOTAL(b)	EP TOX(c)	TOTAL	EP TOX	TOTAL	EP TOX	TOTAL	EP TOX
pH (1:1)	pH Units	8.50	ND(d)	7.85	ND	7.90	ND	8.40	ND
Cyanide, Total	ppm(e)	5,000	0.02U(f)	230	0.02U	240	0.02U	8.3	0.02U
Fluoride, Total	ppm	3,900	1.8	160	0.3	240	0.8	160	0.5
Nitrate, Leachable	ppm	1.8U	0.1U	1.1U	0.1	1.2U	0.1U	1.1U	0.1U
Metals:									
Chromium, Hexavalent	ppm	1.8U	0.01U	1.1U	0.01U	1.2U	0.01U	1.1U	0.01U
Mercury	ppm	0.23	0.0002U	0.64	0.0002U	0.10U	0.0002U	0.10U	0.0002U

C00017772

TABLE 3-12
(Continued)

SAMPLE IDENTIFICATION
SOUTHERN IMPOUNDMENT AREA

PARAMETERS	CONCENTRATION UNITS	SLUDGE COMPOSITE		S-4 SOIL (8.0-9.0 ft)		S-5 SOIL (8.5-9.0 ft)		S-6 SOIL (9.5-10.1 ft)	
		TOTAL	EP TOX	TOTAL	EP TOX	TOTAL	EP TOX	TOTAL	EP TOX
pH (1:1)	pH Units	8.90	ND	7.75	ND	8.50	ND	8.60	ND
Cyanide, Total	ppm	440	0.02U	170	0.02U	35	0.02U	120	0.02U
Fluoride, Total	ppm	2,300	4.5	160	1.1	290	0.9	570	0.6
Nitrate, Total	ppm	1.8U	0.1U	1.3U	0.1U	1.2U	0.1U	1.3U	0.1U
Metals:									
Chromium, Hexavalent	ppm	1.8U	0.03	3.6U	0.01U	3.0U	0.01U	1.3U	0.01U
Mercury	ppm	1.3	0.0003	0.12	0.0002U	0.29	0.0002U	0.27	0.0002

00001773

TABLE 3-12
(Continued)

PARAMETERS	CONCENTRATION UNITS	SAMPLE IDENTIFICATION SLUDGE PIT			
		SLUDGE COMPOSITE		SOIL COMPOSITE	
		TOTAL	EP TOX	TOTAL	EP TOX
pH (1:1)	pH Units	8.10	ND	7.60	ND
Cyanide, Total	ppm	4,700	0.02U	740	0.02U
Fluoride, Total	ppm	4,000	1.8	350	1.1
Nitrate, Total	ppm	2.1	0.1U	2.4	0.1
Metals:					
Chromium, Hexavalent	ppm	1.2U	0.38	1.2U	0.02
Mercury	ppm	0.43	0.0002U	0.10U	0.0002U

(a)Samples were collected from January 26, 1987 to January 28, 1987.

(b)The indicated values represent the total concentration in milligrams per kilogram (mg/kg) or parts per million (ppm) for the corresponding parameter present in the sample.

(c)"EP TOX" refers to the EP toxicity leachate generated by the Extraction Procedure (EP) Toxicity Test Method, SW-1310 as described in U.S. Environmental Protection Agency, 1985, "Test Methods for Evaluating Solid Waste: Physical/Chemical Methods," SW-846, Second Edition Revised, Waste Characterization Branch, Office of Solid Waste and Emergency Response, Washington, D.C.

(d)"ND" indicates not determined.

(e)The units for total constituent analyses are reported in mg/kg or ppm. The EP toxicity test method leachate analyses are reported in milligrams per liter (mg/l) or ppm.

(f)"U" indicates that the compound was analyzed, but not detected. The corresponding number represents the method detection limit for the sample.

00001774

TABLE 3-13

SUMMARY OF HAZARDOUS SUBSTANCE LIST COMPOUND RESULTS
JANUARY 1987 IMPOUNDMENT AND SLUDGE PIT VERTICAL SLUDGE
COMPOSITES AND SOIL SAMPLES(a)
ARCO CHEMICAL COMPANY
CHARLESTOWN, OHIO

			SAMPLE IDENTIFICATION								
			NORTHERN IMPOUNDMENT AREA			SOUTHERN IMPOUNDMENT AREA					
PARAMETERS	CAS REGISTRY NUMBER(b)	CONCENTRATION UNITS(c)	S-1 VERTICAL COMPOSITE	S-2 VERTICAL COMPOSITE	S-3 VERTICAL COMPOSITE	S-4 VERTICAL COMPOSITE	S-5 VERTICAL COMPOSITE	S-6 VERTICAL COMPOSITE	S-4 SOIL (8.0-9.0')	S-5 SOIL (8.5-9.0')	S-6 SOIL (9.5-10.1'
Volatiles:											
Methylene Chloride	75-09-2	mg/kg	0.84B(d)	0.46B	0.77B	1.1B	0.95B	1.3B	0.11B	0.12B	0.16B
Acetone	67-64-1	mg/kg	1.2B'	0.22JB(e)	6.9B	0.28JB	1.2B	0.30JB	1.5B	0.65B	0.37B'
Chloroform	67-66-3	mg/kg	0.37B	0.31B	0.31B	0.12B	0.53B	0.46B	0.088B	0.088B	0.10B
Xylenes, Total(f)	1330-02-7	mg/kg	0.072B	BDL(g)	0.13JB	1.7	0.19J	0.50	0.060B	BDL	0.022JB
Acid/Base-Neutral Extractables:											
Bis(2-ethylhexyl) phthalate	117-81-7	mg/kg	0.48J	1.1J	0.74J	0.47J	0.27J	0.72J	BDL	0.093J	0.12J
Pesticides/PCBs:	--	mg/kg	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL

00001775

TABLE 3-13
(Continued)

PARAMETERS	CAS REGISTRY NUMBER(b)	CONCENTRATION UNITS(c)	SAMPLE IDENTIFICATION				
			SLUDGE PIT				
			S-1 VERTICAL COMPOSITE	S-2 VERTICAL COMPOSITE	S-3 VERTICAL COMPOSITE	S-4 VERTICAL COMPOSITE	S-5 VERTICAL COMPOSITE
Volatiles:							
Methylene Chloride	75-09-2	mg/kg	0.21B	0.22B	0.19B	0.24B	0.35B
Acetone	67-64-1	mg/kg	0.44B	0.72B	0.51B	0.94B	0.50B
Chloroform	67-66-3	mg/kg	0.17B	0.19B	0.16B	0.17B	0.19B
Xylenes, Total	1330-02-7	mg/kg	BDL	BDL	0.066JB	0.028JB	BDL
Acid/Base-neutral Extractables:							
Bis(2-ethyhexyl) phthalate	117-81-7	mg/kg	0.69J	0.92J	2.1	0.21J	0.55J
Pesticides/PCBs:	--	mg/kg	--	--	--	--	--

(a)Samples were collected on January 26, 1987 and January 28, 1987.

(b)The numbers presented in this column are the Chemical Abstracts Service (CAS) Registry Numbers used for cataloging the indicated compounds in the Chemical Abstracts Index.

(c)"mg/kg" equals milligrams per kilogram or parts per million (ppm).

(d)"B" indicates that the corresponding compound was found in the blank as well as the sample.

(e)"J" indicates that the corresponding compound is present, but the calculated concentration is less than the specified detection limit.

(f)Total xylenes include the ortho-, meta-, and para-xylene isomers.

(g)"BDL" indicates that the corresponding compounds were not detected above the sample detection limits indicated in Appendix A.

TABLE 3-14

SUMMARY OF POLYCHLORINATED BIPHENYL RESULTS
APRIL 1985 SWAMP AREA SLUDGES AND SOILS (a)
ARCO CHEMICAL COMPANY
GNADENHUTTEN, OHIO

SAMPLE IDENTIFICATION(b) GRID COORDINATES OLD	NEW	DEPTH INTERVAL	WATER CONTENT (%)	POLYLCHLORINATED BIPHENYLS mg/kg(c)	Source Aroclor(d)
B-0,2	F-10	0-6"	ND(e)	1.2	1248
B-0,2	F-10	50-56"	ND	1.0U(f)	--(g)
B-0,3	H-10	0-12"	81.8	460	1248
B-0,3	H-10	48"	ND	1.2	1248
B-1,1	F-8	30-36"	ND	1.4	1248
B-1,1	F-8	72"	ND	1.0U	--
B-1,2	F-8	0-6"	ND	<1.0U	--
B-1,2	F-8	30-36"	ND	<1.0U	--
B-1,3	H-8	0-6"	81.1	180	1248
B-1,3	H-8	9-15"	ND	16	1242
B-1,4	J-8	0-6"	ND	18	1248+1254
B-1,4	J-8	6-12"	ND	1.6	1254
B-2,0	B-6	0-6"	ND	2.5	1248
B-2,1	D-6	0-6"	ND	1.0U	--
B-2,1	D-6	18-24"	ND	1.0U	--
B-2,2	F-6	0-1"	ND	1.0U	--
B-2,2	F-6	30"	ND	1.0U	--
B-2,3	H-6	0-6"	ND	146	1248+1254
B-2,3	H-6	24-30"	ND	6.7	1248
B-2,4	J-6	0-6"	ND	670	1248+1254
B-2,4	J-6	12-18"	ND	7.4	1248+1254
B-3,0	B-4	0-6"	ND	1.0U	--
B-3,0	B-4	22-24"	ND	1.0U	--
B-3,1	D-4	0-5"	ND	1.0U	--
B-3,1	D-4	5-11"	ND	1.0U	--
B-3,2	F-4	0-4"	ND	1.0U	--
B-3,2	F-4	4-10"	ND	1.0U	--

TABLE 3-14
(Continued)

SAMPLE IDENTIFICATION(b) GRID COORDINATES OLD	NEW	DEPTH INTERVAL	WATER CONTENT (%)	POLYLCHLORINATED BIPHENYLS mg/kg(c)	Source Aroclor(d)
B-3,3	H-4	0-6"	ND	8.7	1248+1254
B-3,3	H-4	14-20"	ND	1.0U	--
B-3,4	J-4	0-6"	ND	14	1254
B-3,4	J-4	9-15"	ND	2.1	1248
B-4,2	F-2	0-6"	ND	1.0U	--
B-4,2	F-2	6-12"	ND	1.0U	--
B-4,3	H-2	0-6"	ND	1.0U	--
B-4,3	H-2	6-12"	ND	1.0U	--
B-4,4	J-2	0-6"	ND	1.0U	--
B-4,4	J-2	6-12"	ND	1.2	1254

(a)Samples were collected from April 5, 1985 to April 8, 1985.

(b)The upper depth at each sampling station represents sludge materials, while the lower depth represents the underlying soil. The grid coordinate system indicates the closest corresponding sampling locations between the old and new grid systems, although the coordinate systems do not exactly correspond.

(c)"mg/kg" = milligrams per kilogram or parts per million on a dry weight basis.

(d)The indicated commercial aroclor mixture represents the source of the polychlorinated biphenyl contamination and the standard used for instrument calibration and analysis. All samples were screened for Aroclors 1016, 1221, 1232, 1242, 1248, 1254, and 1260 to determine which aroclors are present in the sample and therefore should be used for instrument calibration.

(e)"ND" indicates not determined.

(f)"U" indicates that the compound was analyzed, but not detected. The corresponding number represents the method detection limit for the sample.

(g)"--" indicates that PCBs were not detected in the corresponding sample. Therefore, no source aroclor is given.

TABLE 3-15

SUMMARY OF POLYCHLORINATED BIPHENYLS (PCB) RESULTS
NOVEMBER 1986 SWAMP AREA SLUDGES AND SOILS(a)
ARCO CHEMICAL COMPANY
GNADENHUTTEN, OHIO

SAMPLE IDENTIFICATION AREA NO. 1	DEPTH INTERVAL (ft)	POLYCHLORINATED BIPHENYLS mg/kg(b)	SOURCE AROCLOR(c)
B-4	0.0-1.0	0.16U(d)	--(e)
B-6	0.0-1.0	0.16U	--
B-7	0.0-1.0	0.17	1254
C-6	0.0-1.2	1.7	1248 & 1254
C-6	1.2-2.2	0.16U	--
C-7	0.0-1.0	0.16U	--
D-2	0.0-1.0	0.22U	1254
D-4	0.0-1.2	0.75	1248 & 1254
D-4	1.2-2.2	0.16U	--
D-5	0.0-0.3	0.16U	--
D-5	0.3-1.3	0.16U	--
D-6	0.0-0.3	0.16U	--
D-6	0.3-1.3	0.16U	--
D-7	0.0-0.8	0.16U	--
D-7	0.8-1.8	0.16U	--
E-3	0.0-1.0	0.16U	--
E-4	0.0-1.5	0.69	1248 & 1254
E-4	1.5-2.5	0.16U	--
E-5	0.0-0.5	0.16	1254
E-5	0.5-1.5	0.16U	--
E-6	0.0-0.6	0.16U	--
E-6	0.6-1.6	0.16U	--
E-7	0.0-2.3	0.89	1248 & 1254
E-7	2.3-3.3	0.16U	--
E-8	0.0-5.5	0.17	1254
E-8	5.5-6.5	0.16U	--
E-9	0.0-3.5	0.87	1248 & 1254
E-9	3.5-4.5	0.16U	--

TABLE 3-15
(Continued)

SAMPLE IDENTIFICATION AREA NO. 2	DEPTH INTERVAL (ft)	POLYCHLORINATED BIPHENYLS mg/kg(b)	Source Aroclor(c)
F-4	0.0-0.5	0.16U	--
F-4	0.5-1.5	0.16U	--
F-5	0.0-1.0	0.68	1248 & 1254
F-5	1.0-2.0	0.16U	--
F-6	0.0-1.2	2.2	1248 & 1254
F-6	1.2-2.2	0.16U	--
F-7	0.0-2.0	2.5	1248 & 1254
F-7	2.0-3.0	0.16U	--
F-8	0.0-3.3	0.56	1248 & 1254
F-8	3.3-4.3	0.16U	--
F-9	0.0-0.5	0.16U	--
F-9	0.5-1.5	0.16U	--
G-4	0.0-0.8	0.16U	--
G-4	0.8-1.8	0.21	1248
G-5	0.0-1.5	4.5	1248 & 1254
G-5	1.5-2.5	3.7	1248
G-6	0.0-0.6	0.37	1254
G-6	0.6-1.6	0.16U	--
G-7	0.0-1.5	5.5	1248
G-7	1.5-2.5	0.11	1248
G-8	0.0-3.0	4.3	1248
G-8	3.0-4.0	0.16U	1248
G-9	0.0-3.0	0.28	1254
G-9	3.0-4.0	0.16U	--
G-10	0.0-3.5	0.56	1248 & 1254
G-10	3.5-4.5	0.16U	--

TABLE 3-15
(Continued)

SAMPLE IDENTIFICATION AREA NO. 3	DEPTH INTERVAL (ft)	POLYCHLORINATED BIPHENYLS mg/kg(b)	SOURCE AROCLOR(c)
F-1	0.0.1.0	0.27	1248 & 1254
F-2	0.0-1.0	0.16U	--
F-3	0.0-0.5	0.16U	--
F-3	0.5-1.5	0.16U	--
G-1	0.0-1.0	0.36	1248 & 1254
G-2	0.0-0.6	0.16U	--
G-2	0.6-1.6	0.18	1248
G-3	0.0-1.8	0.59	1248 & 1254
G-3	1.8-2.8	0.16U	--
H-1	0.0-1.0	0.42	1248 & 1254
H-2	0.0-1.0	0.16U	--
H-3	0.0-1.0	0.16U	--
H-3	1.0-2.0	0.16U	--
I-1	0.0-1.0	0.39	1248 & 1254
I-2	0.0-1.0	0.24	1254
I-3	0.0-0.5	1.8	1248 & 1254
I-3	0.5-1.5	0.52	1248 & 1254
J-1	0.0-1.0	0.36	1254
J-2	0.0-0.8	0.32	1248 & 1254
J-2	0.8-1.8	0.16U	--
J-3	0.0-0.2	1.9	1248 & 1254
J-3	0.2-1.2	0.80	1248 & 1254

TABLE 3-15
(Continued)

SAMPLE IDENTIFICATION AREA NO. 4	DEPTH INTERVAL (ft)	POLYCHLORINATED BIPHENYLS mg/kg(b)	SOURCE AROCLOR(c)
H-4	0.0-1.8	2.8	1248 & 1254
H-4	1.8-3.0	0.09	1248
H-5	0.0-1.7	5.1	1248 & 1254
H-5	1.7-3.2	0.15	1248
H-6	0.0-1.3	6.5	1248 & 1254
H-6	1.3-2.3	0.51	1248
H-7	0.0-1.3	21	1248 & 1254
H-7	1.3-2.3	0.91	1248
H-8	0.0-2.0	21	1248 & 1254
H-8	2.0-3.0	0.65	1248
H-9	0.0-2.8	2.7	1248 & 1254
H-9	2.8-3.8	0.58	1248
H-10	0.0-3.5	3,000	1248
H-10	3.5-4.5	1.1	1248
I-4	0.0-1.5	12	1248 & 1254
I-4	1.5-2.5	0.19	1248
I-5	0.0-1.5	51	1248 & 1254
I-5	1.5-2.5	5.9	1248 & 1254
I-6	0.0-1.0	68	1248 & 1254
I-6	1.0-2.0	11	1248
I-7	0.0-1.5	108	1248 & 1254
I-7	1.5-2.5	7.5	1248
I-8	0.0-2.5	51	1248
I-8	2.5-3.5	0.44	1248
I-9	0.0-2.5	160	1248
I-9	2.5-3.5	1.6	1248
I-10	0.0-3.5	93	1248 & 1254
I-10	3.5-4.5	0.41	1248
J-4	0.0-1.8	22	1248 & 1254
J-4	1.8-2.8	6.4	1248
J-5	0.0-1.5	95	1248 & 1254
J-5	1.5-2.5	9.8	1248
J-6	0.0-1.5	89	1248 & 1254
J-6	1.5-2.5	11	1248
J-7	0.0-1.5	65	1248 & 1254
J-7	1.5-2.5	3.8	1248
J-8	0.0-1.5	54	1248 & 1254
J-8	1.5-2.5	4.8	1248
J-9	0.0-3.0	220	1248 & 1254
J-9	3.0-4.0	23	1248
J-10	0.0-4.0	61	1248
J-10	4.0-5.0	0.16U	--

TABLE 3-15
(Continued)

SAMPLE IDENTIFICATION AREA NO. 5	DEPTH INTERVAL (ft)	POLYCHLORINATED BIPHENYLS mg/kg(b)	SOURCE AROCLOR(c)
K-2	0.0-1.0	1.9	1248 & 1254
K-3	0.0-0.8	14	1248 & 1254
K-3	0.8-1.8	0.12	1248
K-4	0.0-1.5	21	1248 & 1254
K-4	1.5-2.5	4.9	1248
K-5	0.0-2.3	42	1248 & 1254
K-5	2.3-3.3	19	1248
K-6	0.0-1.0	110	1248 & 1254
K-6	1.0-2.0	23	1248 & 1254
K-7	0.0-1.0	11	1248 & 1254
K-7	1.0-2.0	0.42	1248
K-8	0.0-0.7	3.5	1248 & 1254
K-8	0.7-1.7	1.6	1248
KL-6	0.0-0.4	9.3	1248 & 1254
KL-6	0.4-1.4	0.75	1248 & 1254
KL-7	0.0-2.0	1.0	1248 & 1254
KL-7	2.0-3.0	4.2	1248 & 1254
KL-8	0.0-0.2	66	1248 & 1254
KL-8	0.2-1.2	1.2	1248
L-2	0.0-1.0	0.25	1254
L-3	0.0-1.0	1.2	1248 & 1254
L-4	0.0-1.0	7.4	1248 & 1254

(a)Samples were collected on November 24, 25, and 26, 1986 and December 2, 1986.

(b)"mg/kg" equals milligrams per kilogram or parts per million (ppm).

(c)The indicated commercial aroclor mixture represents the source of the polychlorinated biphenyl contamination and the standard used for instrument calibration and analysis. All samples were screened for Aroclors 1016, 1221, 1232, 1242, 1254, and 1260 to determine which aroclors are present in the sample and therefore should be used for instrument calibration.

(d)"U" indicates that the compound was analyzed, but not detected. The corresponding number represents the method detection limit for the sample.

(e)"--" indicates that PCBs were not detected in the corresponding sample.

TABLE 3-16

SUMMARY OF GENERAL INORGANIC AND EP TOXICITY
TEST METHOD RESULTS
JANUARY 1987 SWAMP AREA SLUDGE AND SOIL COMPOSITE SAMPLES(a)
ARCO CHEMICAL COMPANY
GNADENHUTTEN, OHIO

		SAMPLE IDENTIFICATION							
		AREA NO. 1 COMPOSITE				AREA NO. 2 COMPOSITE			
PARAMETERS	CONCENTRATION UNITS	SLUDGE		SOIL		SLUDGE		SOIL	
		TOTAL(b)	EP TOX(c)	TOTAL	EP TOX	TOTAL	EP TOX	TOTAL	EP TOX
pH (1:1)(d)	pH Units	8.25	ND(e)	7.35	ND	8.05	ND	7.40	ND
Cyanide, Total	ppm(f)	800	0.02U(g)	27	0.03	630	0.02U	63	0.02U
Fluoride, Total	ppm	7,900	2.1	440	1.7	12,000	2.1	560	2.5
Nitrate, Leachable	ppm	10	0.3	5.0	0.3	6.9	0.3	5.4	0.4
Metals:									
Chromium, Hexavalent	ppm	1.7U	0.54	3.2U	0.01U	1.7U	0.19	3.4U	0.01U
Mercury	ppm	0.65	0.0002U	0.31	0.0002U	0.19	0.0002U	0.32	0.0002U

00001784

TABLE 3-16
(Continued)

PARAMETERS	CONCENTRATION UNITS	SAMPLE IDENTIFICATION							
		AREA NO. 3 COMPOSITE				AREA NO. 4 COMPOSITE			
		SLUDGE		SOIL		SLUDGE		SOIL	
		TOTAL	EP TOX	TOTAL	EP TOX	TOTAL	EP TOX	TOTAL	EP TOX
pH (1:1)	pH Units	7.85	ND	7.40	ND	7.80	ND	7.45	ND
Cyanide, Total	ppm	350	0.10	21	0.02U	360	0.02U	21	0.02U
Fluoride, Total	ppm	3,300	1.3	350	0.9	2,400	0.5	170	0.4
Nitrate, Leachable	ppm	1.6	0.1U	11	0.2	1.7U	0.1U	1.3U	0.1U
Metals:									
Chromium, Hexavalent	ppm	1.6U	0.03	1.8U	0.16	1.7U	0.04	1.3U	0.01U
Mercury	ppm	0.25	0.0002U	0.14	0.0002U	0.39	0.0002U	0.56	0.0002U

00001785

TABLE 3-16
(Continued)

SAMPLE IDENTIFICATION

AREA NO. 5 COMPOSITE

PARAMETERS	CONCENTRATION UNITS	SLUDGE TOTAL	SLUDGE EP TOX	SOIL TOTAL	SOIL EP TOX
pH (1:1)	pH Units	7.85	ND	7.30	ND
Cyanide, Total	ppm	77	0.02U	7.5	0.02U
Fluoride, Total	ppm	7,100	1.7	120	0.5
Nitrate, Leachable	ppm	1.8U	0.1U	1.3U	0.1U
Metals:					
Chromium, Hexavalent	ppm	1.8U	0.01U	1.3U	0.06
Mercury	ppm	0.45	0.0002U	0.99	0.0002U

(a)Samples were collected from January 19, 1987 to January 22, 1987.

(b)The indicated values represent the total concentration in milligrams per kilogram (mg/kg) or parts per million (ppm) for the corresponding parameter present in the sample.

(c)"EP TOX" refers to the EP toxicity leachate generated by the Extraction Procedure (EP) Toxicity Test Method, SW-1310, as described in U.S. Environmental Protection Agency, 1985, "Test Methods for Evaluating Solid Waste: Physical/Chemical Methods," SW-846, Second Edition Revised, Waste Characterization Branch, Office of Solid Waste and Emergency Response, Washington, D.C.

(d)The pH values for the swamp area sludge samples were determined on a ratio of one part sludge to five parts deionized water (1:5) instead of the usual 1:1 ratio because samples were not wet enough for pH measurements at the 1:1 ratio.

(e)"ND" indicates not determined.

(f)The units for total constituent analyses are reported in mg/kg or ppm. The EP Toxicity Test Method leachate analyses are reported in milligrams per liter (mg/l) or ppm.

(g)"U" indicates that the compound was analyzed, but not detected. The corresponding number represents the method detection limit for the sample.

TABLE 3-17

SUMMARY OF POLYCHLORINATED BIPHENYLS (PCB) RESULTS
MARCH 1987 SWAMP AREA SLUDGES AND SOILS(a)
ARCO CHEMICAL COMPANY
GNADENHUTTEN, OHIO

SAMPLE IDENTIFICATION	DEPTH INTERVAL (ft)	POLYCHLORINATED BIPHENYLS mg/kg(b)	SOURCE AROCLOR(c)
AREA NO. 2			
G-10.5	0.0-0.5	0.30U(d)	--(e)
G-10.5	0.5-1.5	0.11U	--
AREA NO. 4			
GH-9.5	0.0-3.0	0.91	1248
GH-9.5	3.0-4.0	0.11	1248
GH-10	0.0-3.0	4.3	1242
GH-10	3.0-4.0	0.16	1242
GH-10.5	0.0-3.5	9.0	1248
GH-10.5	3.5-4.5	0.12U	--
H-9.5	0.0-3.0	39	1248
H-9.5	3.0-4.0	0.23	1248
H-10.5	0.0-2.0	480	1248
H-10.5	2.0-3.0	8.0	1248
HI-8.5	0.0-2.0	98	1242
HI-8.5	2.0-3.0	2.4	1242
HI-9.5	0.0-2.5	77	1242
HI-9.5	2.5-3.5	2.3	1242
HI-10	0.0-3.0	400	1248
HI-10	3.0-4.0	2.8	1248
HI-10.5	0.0-2.0	160	1242
HI-10.5	2.0-3.0	6.4	1242
I-10.5	0.0-3.0	58	1248
I-10.5	3.0-4.0	2.3	1248
IJ-8	0.0-1.5	60	1248
IJ-8	1.5-2.5	0.43	1248
IJ-9	0.0-2.5	78	1242
IJ-9	2.5-3.5	2.7	1242
IJ-10	0.0-3.5	57	1248
IJ-10	3.5-4.5	0.52	1248
JK-8	0.0-1.0	35	1248
JK-8	1.0-2.0	2.6	1248
JK-9	0.0-3.0	140	1248
JK-9	3.0-4.0	0.60	1248
JK-10	0.0-4.0	4.5	1248
JK-10	4.0-5.0	0.92	1248

TABLE 3-17
(Continued)

SAMPLE IDENTIFICATION AREA NO. 5	DEPTH INTERVAL (ft)	POLYCHLORINATED BIPHENYLS mg/kg(b)	SOURCE AROCLOR(c)
KL-5	0.0-1.0	0.20U	--
KL-8.5	0.0-1.0	0.18U	--
M-2.5	0.0-1.0	0.22U	--
M-3	0.0-1.0	0.44U	--
M-4	0.0-1.0	1.0	1254
N-2	0.0-1.0	0.21	1248
N-3	0.0-1.0	0.23U	--
N-4	0.0-1.0	0.18U	--

(a)Samples were collected on March 26, 1987.
(b)"mg/kg" equals milligrams per kilogram or parts per million (ppm).

(c)The indicated commercial aroclor mixture represents the source of the polychlorinated biphenyl contamination and the standard used for instrument calibration and analysis. All samples were screened for Aroclors 1016, 1221, 1232, 1242, 1254, and 1260 to determine which aroclors were present in the sample and therefore should be used for instrument calibration.

(d)"U" indicates that the compound was analyzed, but not detected. The corresponding number represents the method detection limit for the sample.

(e)"--" indicates that PCBs were not detected in the corresponding sample.

00001789

TABLE 3-18

PHYSICAL AND CHEMICAL CHARACTERISTICS OF COMPOUNDS IDENTIFIED ABOVE DETECTION LIMITS AT THE ARCO CHEMICAL COMPANY SITE, CHADENHUTTEN, OHIO

COMPOUND	CAS NO.	MOL. WT.	SOLUBILITY IN H_2O (mg/L)	VAPOR(a) PRESSURE (mm Hg)	LOG K_{ow}	REFERENCES
VOLATILE ORGANIC CONTAMINANTS:						
Ethylbenzene	100-41-4	106	1.52E+02	7.00E+00	3.15	1
2-Hexanone	591-78-6	100.2	1.40E+04	2.00E+00		2,3,7
Tetrachloroethylene	127-18-4	166	1.50E+02	1.78E+01	2.60	1
Toluene	108-88-3	92	5.35E+02	2.81E+01	2.73	1
Total Xylenes	1330-20-7	106	1.98E+02	1.00E+01	3.26	8
BASE NEUTRAL ACID EXTRACTS:						
Bis(2-ethylhexyl)phthalate	117-81-7	360.6	NA	NA	NA	3
Di-n-butylphthalate	84-74-2	278	1.30E+01	1.00E-05	5.60	1
Fluoranthene	206-44-0	202	2.06E-01	5.00E-06	4.90	8
Isophorone	78-59-1	138.2	1.2E-04	4.40E-01 (25°C)		2,7
Naphthalene	91-20-3	128.2	3.00E+01	1.00E+00 (53°C)		2,3
N-nitrosodiphenylamine	86-30-6	198.2	NA	NA	NA	3
Phenanthrene	85-01-8	178	1.00E+00	6.80E-04	4.46	1
Pyrene	129-00-0	202	1.32E-01	2.50E-06	4.88	8

00061790

TABLE 3-18
(Continued)

COMPOUND	CAS NO.	MOL. WT.	SOLUBILITY IN H_2O (mg/L)	VAPOR(a) PRESSURE (mm Hg)	LOG K_{ow}	REFERENCES
METALS:						
Aluminum	7429-90-5	27.0	NA	NA	NA	4,5,6
Arsenic	7440-38-2	75.0	NA	NA	NA	1,5
Barium	7440-39-3	137.7	NA	NA	NA	4,5,6
Cadmium	7440-43-9	112.4	NA	NA	NA	9
Chromium (+6)	18540-29-9	52.0	NA	NA	NA	3,9
Chromium (total)	7440-47-3	52.0	NA	NA	NA	9
Copper	7440-50-8	64.0	NA	NA	NA	1,5
Iron	15438-31-0	56.0	NA	NA	NA	1,5
Lead	7439-92-1	207.0	NA	NA	NA	3,5
Manganese	7439-96-5	55.0	NA	NA	NA	1,5,6
Mercury	7439-97-6	201.0	NA	2.00E-03	NA	1,5
Selenium	7782-49-2	79.0	NA	NA	NA	1,5,6
Silver	7440-22-4	108.0	NA	NA	NA	1,5
Zinc	7440-66-6	65.0	NA	NA	NA	1,5,6

00001791

TABLE 3-18
(Continued)

COMPOUND	CAS NO.	MOL. WT.	SOLUBILITY IN H_2O (mg/L)	VAPOR(a) PRESSURE (mm Hg)	LOG K_{ow}	REFERENCES
OTHER:						
Aroclor 1248	12672-29-6			0.6(b)	4.3(c)	6
Aroclor 1254	11097-69-1		5.7E-02	0.6(b)	4.3(c)	2,6
Cyanide(d)						
Endrin	72-20-8	380.9	2.50E-01	2.00E-07		2,9
Fluoride(d)						
Nitrate(d)						

NA = No data available

(a) Vapor pressure is given at room temperature unless otherwise indicated.
(b) With no Aroclor specific data available, the highest vapor pressure for the chlorinated biphenyls of concern was selected to represent the maximum potential for migration by the airborne pathway.
(c) With no Aroclor specific data available, the lowest log Kow for the chlorinated biphenyls of concern was selected to represent the maximum potential for migration in groundwater.
(d) May exist in multiple forms.

(1) USEPA, 1985
(2) Verschueren, 1983
(3) RTECS, 1983
(4) Merck Index, 1976
(5) CRC Handbook, 1984
(6) Sax, 1984
(7) CHEMTOX database, 1987
(8) Superfund Manual, 1986
(9) Clement Assoc., Inc., 85

00001792

TABLE 3-19

ENVIRONMENTAL TRANSFORMATION OF ORGANIC COMPOUNDS IDENTIFIED AT THE ARCO CHEMICAL COMPANY SITE, GNADENHUTTEN, OHIO

CHEMICAL	RELEVANT PATHWAYS	RATE OF DEGRADATION	COMMENT
ACID/BASE NEUTRAL EXTRACTABLES			
Bis(2-ethylhexyl)phthalate	Aerobic Riverwater Model ecosystem	50% in 14 days 10% in 7 days 50% in 5 days	Intermediate in the degradation process is phthalic acid which will undergo decomposition by soil microflora in 2 days.
Di-n-butylphthalate	Aerobic Anaerobic	53% in 1 day 98% in 5 days 98% in 30 days	Degradation products are mono-n-butyl()phthalate and phthalic acid.
Fluoranthene	Unknown	Unknown	Biological purification of mechanically purified sewage reduced levels from 14.6 ppb to 0.26 ppb and from 1.22 ppb to 0.28 ppb in two separate tests.
Isophorone	-	-	No information available.
Naphthalene	Microbial	0.1-5.0)g/l/day	Degradation to carbon dioxide and water by certain species of Pseudomonas
	Evaporation	50% in 7-15 hours	Calculated half-life in 1 m depth of water at 25°C.
N-nitrosodiphenylamine			No information available.
Phenanthrene	Microbial	Not available	Metabolized by Pseudomonas along a complex pathway to 1,2-di-hydroxynaphthalene which is then presumed to be further metabolized to carbon dioxide and water.
Pyrene	UV irradiati	Unknown	To bipyrene and pyrenedione

00001793

TABLE 3-19
(Continued)

CHEMICAL	RELEVANT PATHWAYS	RATE OF DEGRADATION	COMMENT
VOLATILE ORGANIC CONTAMINANTS:			
Ethylbenzene	Biodegradation	100% in 8 days	In presence of other components of high octane gas.
2-Hexanone			No data available.
Tetrachloroethylene	Evaporation	90% in 90 min.	From water at 25°C.
Toluene	Biodegradation	100% in 8 days	Incubation with natural flora in ground water at 1°C (in presence of other high octane gas components).
Xylene	Microbial	100% in 8 days	In presence of high octane gas components
OTHER:			
Endrin	Photooxidation by UV light	75% in 7 days	In aqueous medium at 90-95°C. Forms CO_2.
PCBs	In activated sludge	10-15% in 2 days	As chlorine content increases degradation decreases.

C0001794

TABLE 4-1

SUMMARY OF GENERAL INORGANIC AND E.P. TOXICITY TEST METHOD RESULTS
MARCH 1985 MONITORING WELL SOIL BORING SAMPLES(a)
ARCO CHEMICAL COMPANY
CHAGRINFALLS, OHIO

PARAMETERS	CONCENTRATION UNITS	SAMPLE IDENTIFICATION													
		MW-1, S-5		MW-1, S-9		MW-2, S-1		MW-2, S-4		MW-2, S-6		MW-3, S-1		MW-3, S-3	
		TOTAL(b)	E.P. TOX.(c)	TOTAL	E.P. TOX.	TOTAL	E.P. TOX.	TOTAL	E.P. TOX.	TOTAL	E.P. TOX.	TOTAL	E.P. TOX.	TOTAL	E.P. TOX
Cyanide, Amenable	ppm(d)	<0.5(e)	<0.02	<0.5	<0.02	18	<0.02	1.2	<0.02	<0.5	<0.02	<0.5	<0.02	5.0	<0.02
Cyanide, Total	ppm	<0.5	<0.02	<0.5	<0.02	60	<0.02	2.8	<0.02	<0.5	<0.02	2.7	<0.02	5.0	<0.02
Fluoride	ppm	2.2	0.1	1.2	0.1	6.4	1.1	31	0.3	1.3	0.2	40	0.4	63	0.6
Metals:															
Chromium, Hexavalent	ppm	<0.1	<0.01	<0.1	0.02	<0.1	<0.01	<0.1	<0.01	<0.1	<0.01	<0.1	<0.01	<0.1	<0.01
Chromium, Total	ppm	16	0.02	12	0.05	950	0.18	47	0.03	17	0.07	91	0.07	57	0.04
Iron	ppm	28,000	37	15,000	2.5	57,000	2.1	29,000	59	18,000	58	28,000	22	29,000	<0.01
Manganese	ppm	480	22	350	5.1	1,000	24	540	8.7	560	12	940	13	580	3.7

C0001795

TABLE 4-1
(Continued)

PARAMETERS	CONCENTRATION UNITS	SAMPLE IDENTIFICATION													
		MW-3, S-7		MW-4, S-1		MW-4, S-4		MW-4, S-10		MW-5, S-1		MW-5, S-1		MW-5, S-7	
		TOTAL(b)	E.P. TOX.(c)	TOTAL	E.P. TOX.	TOTAL	E.P. TOX.	TOTAL	E.P. TOX.	TOTAL	E.P. TOX.	TOTAL	E.P. TOX.	TOTAL	E.P. TOX
Cyanide, Amenable	ppm	<0.5	<0.02	<0.5	<0.02	<0.5	<0.02	0.7	<0.02	<0.5	<0.02	<0.5	<0.02	<0.5	<0.02
Cyanide, Total	ppm	<0.5	<0.02	25	0.02	<0.5	<0.02	0.7	<0.02	7.9	0.02	1.8	<0.02	1.7	<0.02
Fluoride	ppm	2.7	0.2	2.6	2.3	24	0.3	1.2	0.1	86	1.4	21	0.3	18	0.3
Metals:															
Chromium, Hexavalent	ppm	<0.1	<0.01	<0.1	<0.01	<0.1	<0.01	<0.1	<0.01	<0.1	0.12	<0.1	<0.01	<0.1	<0.01
Chromium, Total	ppm	13	0.05	280	0.29	28	0.04	12	0.05	87	0.14	27	0.02	10	0.04
Iron	ppm	17,000	5.4	41,000	0.22	84,000	160	16,000	36	29,000	<0.01	52,000	37	32,000	12
Manganese	ppm	470	12	960	17	600	4.4	370	6.2	1,300	1.7	710	7.6	390	8.4

00001796

TABLE 4-1
(Continued)

PARAMETERS	CONCENTRATION UNITS	SAMPLE IDENTIFICATION													
		MW-6, S-4		MW-6, S-7		MW-6, S-8		MW-7, S-1		MW-7, S-3		MW-7, S-5		MW-8, S-1	
		TOTAL(b)	E.P. TOX.(c)	TOTAL	E.P. TOX.	TOTAL	E.P. TOX.	TOTAL	E.P. TOX.	TOTAL	E.P. TOX.	TOTAL	E.P. TOX.	TOTAL	E.P. TOX
Cyanide, Amenable	ppm	<0.5	<0.02	<0.5	<0.02	<0.5	<0.02	0.7	<0.02	<0.5	<0.02	<0.5	<0.02	<0.5	<0.02
Cyanide, Total	ppm	<0.5	<0.02	<0.5	<0.02	<0.5	<0.02	0.7	<0.02	<0.5	<0.02	0.7	<0.02	<0.5	<0.02
Fluoride	ppm	1.5	0.3	1.1	0.1	1.0	0.1	25	0.2	14	0.2	6.9	0.2	1.4	<0.1
Metals															
Chromium, Hexavalent	ppm	<0.1	<0.01	<0.1	<0.01	<0.1	<0.01	<0.1	<0.01	<0.1	0.03	<0.1	<0.01	<0.1	<0.01
Chromium, Total	ppm	21	0.06	12	0.06	7.4	0.04	40	0.02	18	0.04	10	0.06	13	0.04
Iron	ppm	38,000	57	13,000	31	12,000	16	37,000	0.05	42,000	30	14,000	4.1	28,000	37
Manganese	ppm	680	10	380	7.5	290	6.6	1,300	15	880	21	420	8.6	650	12

00001797

TABLE 4-1
(Continued)

PARAMETERS	CONCENTRATION UNITS	SAMPLE IDENTIFICATION											
		MW-8, S-4		MW-8, S-6		MW-9, S-2		MW-9, S-3		MW-9, S-6		MW-9, S-8	
		TOTAL(b)	E.P. TOX.(c)	TOTAL	E.P. TOX.	TOTAL	E.P. TOX.	TOTAL	E.P. TOX.	TOTAL	E.P. TOX.	TOTAL	E.P. TOX.
Cyanide, Amenable	ppm	<0.5	<0.02	<0.5	<0.02	3.4	<0.02	0.9	<0.02	<0.5	<0.02	<0.5	<0.02
Cyanide, Total	ppm	<0.5	<0.02	<0.5	<0.02	4.0	<0.02	1.8	<0.02	<0.5	<0.02	<0.5	<0.02
Fluoride	ppm	1.0	<0.1	0.6	0.1	8.1	0.1	7.0	0.2	7.6	0.3	6.8	0.3
Metals													
Chromium, Hexavalent	ppm	0.5	<0.01	<0.1	0.02	<0.1	<0.01	<0.1	<0.01	<0.1	<0.01	<0.1	<0.01
Chromium, Total	ppm	21	0.04	11	0.08	21	0.05	19	0.05	10	0.06	13	0.08
Iron	ppm	35,000	91	17,000	35	47,000	<0.01	40,000	9.7	13,000	12	15,000	32
Manganese	ppm	760	12	340	7.5	890	2.3	980	30	320	6.3	320	7.2

(a)Monitoring well soil boring samples were collected from March 18, 1985 to April 9, 1985.

(b)The indicated values represent the total concentration in milligrams per kilogram (mg/kg) or parts per million (ppm) of the corresponding parameter present in the sample.

(c)"E.P. TOX" refers to EP toxicity leachate generated by the Extraction Procedure (EP) Toxicity Test Method, SW-1310, as described in "U.S. Environmental Protection Agency, 1984," Test Methods for Evaluating Solid Waste: Physical/Chemical Methods," SW-846, Second Edition Revised, Waste Characterization Branch, Office of Solid Waste, Washington, DC.

(d)The units for total constituent analyses are reported in milligrams per kilogram (mg/kg) or parts per million (ppm). The EP Toxicity Test Method leachate analyses are reported in milligrams per liter (mg/l) or ppm.

(e)"<" = less than the reported value which is the detection limit of the analysis.

TABLE 4-2

GROUND WATER LEVEL ELEVATIONS
ARCO CHEMICAL COMPANY
GNADENHUTTEN, OHIO

MONITORING LOCATION	DATE	INITIAL READING	4-10-85	7-30-85	11-4-85	1-30-86
MW-1		818.3	819.6	813.6	813.5	818.0
MW-2		817.6	818.2	813.1	813.7	816.1
MW-3		813.8	(818.5)	813.3	813.9	815.8
MW-4		811.7	817.2	812.9	813.8	816.1
MW-5		813.1	818.1	813.5	815.3	816.9
MW-6		816.3	818.0	813.1	812.6	816.2
MW-7		815.7	817.4	812.9	813.0	816.1
MW-8		817.2	817.9	812.7	812.5	815.7
MW-9		815.8	817.5	813.8	814.2	816.4
PW-4		--	--	--	809.0	--
PW-5		--	--	811.1	805.7	--

MONITORING LOCATION	DATE	7-17-86	9-29-86	11-20-86	1-29-87	2-25-87	3-26-87
MW-1		(816.7)	814.3	814.9	816.4	815.2	814.8
MW-2		815.8	813.3	814.1	814.8	813.8	813.5
MW-3		815.9	813.4	814.4	814.7	813.8	813.6
MW-4		816.0	813.9	814.0	(814.4)	813.7	813.3
MW-5		816.6	814.5	814.4	815.4	813.6	813.4
MW-6		815.8	813.2	813.9	814.9	813.8	813.6
MW-7		815.8	813.3	813.9	814.6	813.5	813.2
MW-8		815.6	813.1	813.6	814.3	813.4	813.1
MW-9		816.2	813.5	814.5	814.8	813.9	813.6
PW-3		--	--	--	--	--	814.6
PW-4		817.2	--	814.4	--	--	814.1
PW-5		811.9	809.8	809.0	--	804.3	808.9
River near MW-7						813.1	812.8
River at Railroad Bridge						813.8	813.5

OTE: Elevations given in feet above mean sea level.
Values in parenthesis are estimates.

TABLE 4-3

SUMMARY OF NOVEMBER 1986 SPECIFIC CONDUCTIVITY PROFILE RESULTS
GROUND WATER MONITORING WELLS, ARCO CHEMICAL COMPANY,
GNADENHUTTEN, OHIO(a)

DEPTH BELOW TOP OF CASING (FEET)	MONITORING WELL NUMBER								
	MW-1	MW-2	MW-3	MW-4	MW-5	MW-6	MW-7	MW-8	MW-9
	SPECIFIC CONDUCTANCE (μmho/cm)(a)(b)								
10	-	-	-	-	-	-	1,280	-	1,200
12	-	-	-	-	-	-	1,290	-	1,210
14	-	-	-	-	-	-	1,300	-	1,210
16	-	-	-	1,650	1,500	-	1,300	-	1,210
18	-	-	-	1,610	1,500	-	1,290	-	1,210
20	-	-	-	1,700	1,510*	-	1,290*	1,010	1,210*
22	-	1,400	1,890	1,750*	1,510	-	1,280	1,010	1,210
24	-	1,450	1,890	1,700	1,510	880	1,250	1,010	1,210
26	800	1,410*	1,900*	1,500	1,510	820	1,250	1,010*	1,210
28	800	1,410	1,890	1,510	1,500	810*	1,240	1,010	1,210
30	800*	1,410	1,890	1,510	1,500	810	1,230	1,000	1,210
32	800	1,400	1,880	1,500	1,500	810	1,220	950	1,200
34	800	1,400	1,850	1,490	1,490	800	1,220	900	1,190
36	800	1,400	1,850	1,490	1,490	800	1,220	900	1,180
38	800	1,400	1,850	1,500	1,490	800	1,220	900	1,140
40	800	1,400	1,820	1,500	1,480	810	1,220	900	1,110
42	800	1,480	1,810	1,510	1,500	810	1,200	900	1,100
44	790	1,580	1,800	1,570	1,520	830	1,180	900	1,100
46	800	1,600	1,790	1,600	1,520	830	1,180	900	1,080
48	800	1,620	1,660	1,590	1,600	840	1,200	900	1,090
	STATIC WATER TABLE DEPTH (Feet Below Top of Casing)								
	25.3	20.5	21.2	14.5	14.7	23.8	10.3	18.8	10.8

(a)Specific conductance values in micromhos per centimeter (μmho/cm) measured using Yellow Springs conductivity meter with a 50-foot cable attached to the probe. The measurements were conducted November 18 through 20, 1986 during the final quarter ground water monitoring.

(b)Ground water samples were obtained at two levels: The lower level was sampled at 37 feet below the ground surface (at about 40 feet below the top of casing) in all the wells. The upper level samples were collected at different depths in the different wells, indicated with an asterisk(*) following the conductivity value nearest that depth.

TABLE 4-4

CYANIDE SUMMARY OF
QUARTERLY GROUND WATER MONITORING(a)
ARCO CHEMICAL COMPANY
CHADERHUTTEN, OHIO

QUARTERLY MONITORING	CONCENTRATION UNITS	SAMPLE IDENTIFICATION									
		MW-2		MW-3		MW-4		MW-5		MW-9	
		UPPER ZONE	LOWER ZONE	UPPER ZONE	LOWER ZONE	UPPER ZONE	LOWER ZONE	UPPER ZONE	LOWER ZONE	UPPER ZONE	LOWER ZONE
April 9-12, 1985											
Cyanide, Total	mg/l(b)	0.22	0.23	0.36	0.29	0.35	0.26	0.04	0.05	0.08	0.07
July 30-31, 1985											
Cyanide, Total	mg/l	0.07	0.11	0.02U(c)	0.06	0.17	0.21	0.07	0.05	0.10	0.08
November 4-5, 1985											
Cyanide, Total	mg/l	0.03	0.03	0.23	0.47	0.09	0.08	0.08	0.05	0.05	0.03
January 29-30, 1986											
Cyanide, Total	mg/l	0.21	0.27	0.25	0.33	0.17	0.13	0.09	0.12	0.15	0.18
November 18-20, 1986											
Cyanide, Total	mg/l	0.17	0.13	0.28	0.21	0.25	0.14	0.11	0.12	0.06	0.05
January 27-29, 1987											
Cyanide, Total	mg/l	0.18	0.23	0.39	0.39	0.05	0.12	0.70	0.50	0.02	0.02

(a)Cyanide concentrations are summarized for those monitoring wells which exhibited values greater than 0.02 milligram per liter (mg/l).

(b)"mg/l" = milligrams per liter or parts per million (ppm).

(c)"U" indicates that the compound was analyzed, but not detected. The corresponding number represents the method detection limit for the sample.

00001800

TABLE 4-5

CHROMIUM SUMMARY OF
QUARTERLY GROUND WATER MONITORING(a)
ANCO CHEMICAL COMPANY
CHARDMUTTEN, OHIO

QUARTERLY MONITORING	CONCENTRATION UNITS	SAMPLE IDENTIFICATION												
		MW-2		MW-3		MW-5		MW-7		MW-8		MW-9		
		UPPER ZONE	LOWER ZONE	UPPER ZONE	LOWER ZONE	UPPER ZONE	LOWER ZONE	UPPER ZONE	LOWER ZONE	UPPER ZONE	LOWER ZONE	UPPER ZONE	LOWER ZONE	PW-4
April 9-12, 1985														
Chromium, Hexavalent	mg/l(b)	0.01U(c)	0.01U	0.01U	0.01U	0.01U	0.01U	0.01	0.01U	0.01U	0.01U	0.14	0.14	0.01U
Chromium, Total	mg/l	0.02	0.01U	0.04	0.01U	0.02	0.03	0.11	0.01U	0.03	0.02	0.14	0.14	0.08
July 30-31, 1985														
Chromium, Hexavalent	mg/l	0.01U	0.01U	0.13	0.13	0.01U	0.01U	0.10	0.10	0.01U	0.01U	0.14	0.10	0.01U
Chromium, Total	mg/l	0.01U	0.01U	0.11	0.13	0.01U	0.01U	0.05	0.05	0.01U	0.01U	0.10	0.06	0.01U
November 4-5, 1985														
Chromium, Hexavalent	mg/l	0.01U	0.01U	0.02	0.01	0.01U	0.01U	0.08	0.07	0.01U	0.01U	0.10	0.10	0.01U
Chromium, Total	mg/l	0.05	0.01U	0.04	0.03	0.01U	0.01U	0.06	0.06	0.01U	0.01U	0.10	0.08	0.01U
January 29-30, 1986														
Chromium, Hexavalent	mg/l	0.01U	0.03	0.04	0.03	0.01U	0.01	0.08	0.05	0.01U	0.01U	0.13	0.13	0.02
Chromium, Total	mg/l	0.02	0.02	0.02	0.02	0.01U	0.01U	0.04	0.04	0.01U	0.01U	0.11	0.11	0.02
November 18-20, 1986														
Chromium, Hexavalent	mg/l	0.03	0.03	0.01	0.05	0.01U	0.01U	0.03	0.01	0.03	0.01U	0.06	0.06	0.01U
Chromium, Total	mg/l	0.02	0.02	0.01	0.01U	0.01U	0.01U	0.02	0.01	0.01U	0.01U	0.04	0.04	0.01U
January 27-29, 1987														
Chromium, Hexavalent	mg/l	0.02	0.01U	0.02	0.03	0.01U	0.01U	0.01U	0.01U	0.01U	0.01U	0.02	0.01U	0.01U

(a)Chromium concentrations are summarized for those monitoring wells which exhibited values greater than 0.02 milligram per liter (mg/l).

(b)"mg/l" = milligrams per liter or parts per million (ppm).

(c)"U" indicates that the compound was analyzed, but not detected. The corresponding number represents the method detection limit for the sample.

00001801

TABLE 4-6

FLUORIDE SUMMARY OF
QUARTERLY GROUND WATER MONITORING(a)
ARCO CHEMICAL COMPANY
CHARDEMUTTEN, OHIO

QUARTERLY MONITORING	CONCENTRATION UNITS	SAMPLE IDENTIFICATION											
		MW-2		MW-3		MW-4		MW-5		MW-7		MW-9	
		UPPER ZONE	LOWER ZONE	UPPER ZONE	LOWER ZONE	UPPER ZONE	LOWER ZONE	UPPER ZONE	LOWER ZONE	UPPER ZONE	LOWER ZONE	UPPER ZONE	LOWER ZONE
April 9-12, 1985	mg/l(b)	0.6	0.6	5.9	5.7	8.0	7.8	4.2	4.4	2.0	1.6	7.2	6.8
July 30-31, 1985	mg/l	0.2	0.2	1.8	1.8	8.7	8.6	3.8	3.7	2.0	2.2	5.6	4.8
November 4-5, 1985	mg/l	0.1	0.1	4.0	4.4	8.3	8.2	3.6	3.7	2.3	2.3	7.2	7.2
January 29-30, 1986	mg/l	0.5	0.5	6.0	5.9	7.3	7.4	3.4	3.6	2.6	2.6	7.1	7.0
November 18-20, 1986	mg/l	0.3	0.3	6.4	5.6	6.0	6.4	3.5	3.8	2.4	2.4	4.0	3.9

(a)Fluoride concentrations are summarized for those monitoring wells which exhibited values greater than 1.0 milligram per liter (mg/l).

(b)"mg/l" = milligrams per liter or parts per million (ppm).

0001803

TABLE 4-7

NITRATE SUMMARY OF
QUARTERLY GROUND WATER MONITORING(a)
ARCO CHEMICAL COMPANY
CHAGRINUTTER, OHIO

QUARTERLY MONITORING	CONCENTRATION UNITS	SAMPLE IDENTIFICATION															
		MW-1		MW-2		MW-3		MW-4		MW-6		MW-7		MW-8		MW-9	
		UPPER ZONE	LOWER ZONE	UPPER ZONE	LOWER ZONE	UPPER ZONE	LOWER ZONE	UPPER ZONE	LOWER ZONE	UPPER ZONE	LOWER ZONE	UPPER ZONE	LOWER ZONE	UPPER ZONE	LOWER ZONE	UPPER ZONE	LOWER ZONE
April 9-12, 1985	mg/l NO_3-N(b)	1.6	1.0	1.7	1.3	9.1	11	<0.1	<0.1	19	21	0.8	0.3	<0.1(c)	<0.1	2.1	2.4
July 30-31, 1985	mg/l NO_3-N	2.9	4.4	3.3	3.6	8.2	6.1	0.7	0.2	5.0	5.6	6.4	7.4	0.8	<0.1	2.0	1.5
November 4-5, 1985	mg/l NO_3-N	2.4	1.3	5.0	4.8	3.0	2.7	<0.1	<0.1	6.4	6.6	7.2	7.3	1.6	1.0	1.0	1.0
January 29-30, 1986	mg/l NO_3-N	3.4	2.9	4.2	3.0	5.9	5.4	0.2	0.2	8.2	8.1	3.4	3.2	0.9	0.7	1.0	1.0
November 18-20, 1986	mg/l NO_3-N	3.6	3.8	2.8	2.7	4.0	4.3	1.7	1.4	6.4	6.6	1.0	0.6	0.9	0.3	0.7	1.2

(a)Nitrate concentrations are summarized for those monitoring wells which exhibited values greater than 1.0 milligram per liter (mg/l).
(b)"mg/l" = *milligrams per liter or parts per million (ppm)*.
(c)"<" = less than the reported value which is the detection limit of the analysis.

00018003

TABLE 4-8

SELENIUM SUMMARY OF
QUARTERLY GROUND WATER MONITORING(a)
ABCO CHEMICAL COMPANY
CHARLESTOWN, OHIO

QUARTERLY MONITORING	CONCENTRATION UNITS	SAMPLE IDENTIFICATION MW-1 UPPER ZONE	MW-1 LOWER ZONE	MW-2 UPPER ZONE	MW-2 LOWER ZONE	MW-3 UPPER ZONE	MW-3 LOWER ZONE	MW-5 UPPER ZONE	MW-5 LOWER ZONE	MW-6 UPPER ZONE	MW-6 LOWER ZONE	MW-7 UPPER ZONE	MW-7 LOWER ZONE	MW-8 UPPER ZONE	MW-8 LOWER ZONE	PW-4	PW-5
April 9-12, 1985	mg/l(b)	0.007	0.008	0.014	0.015	0.010	0.007	0.001	<0.001	0.004	0.004	0.002	0.002	0.002	0.001	0.002	0.001
July 30-31, 1985	mg/l	<0.01(c)	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
November 4-5, 1985	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
January 29-30, 1986	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.004	0.004	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
November 18-20, 1986	mg/l	0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.012	0.013	<0.005	<0.005	0.006	0.007	0.008	0.005	0.008	0.007

(a)Selenium concentrations are summarized for those monitoring wells which exhibited values greater than 0.002 milligrams per liter (mg/l).

(b)"mg/l" = milligrams per liter or parts per million (ppm).

(c)"<" = less than the reported value which is the detection limit of the analysis.

TABLE 4-9

SUMMARY OF HAZARDOUS SUBSTANCE LIST ORGANIC COMPOUND RESULTS
APRIL 1985 FIRST QUARTER GROUND WATER MONITORING(a)
ARCO CHEMICAL COMPANY
CHARDENHUTTEN, OHIO

PARAMETERS	CAS NUMBER(b)	CONCENTRATION UNITS	SAMPLE IDENTIFICATION MW-1 20 FEET	MW-2 18 FEET	MW-3 16 FEET	MW-5 17 FEET	MW-6 19 FEET	PW-5 PUMP ZONE
Volatiles:								
Tetrachloroethylene	127-18-4	ug/l(c)	6.8	5.3	9.7	BDL	BDL	BDL
Other Volatiles	--	ug/l	BDL(d)	BDL	BDL	BDL	BDL	BDL
Acid/Base-Neutral Extractables	--	ug/l	BDL	BDL	BDL	BDL	BDL	BDL
Pesticides/Polychlorinated Biphenyls	--	ug/l	BDL	BDL	BDL	BDL	BDL	BDL

(a)First quarter ground water monitoring samples were collected from April 9, 1985 to April 12, 1985.

(b)The numbers presented in this column are the Chemical Abstracts Service (CAS) numbers used for cataloging the indicated compounds in the Chemical Abstracts Index.

(c)"ug/l" = micrograms per liter or parts per billion (ppb).

(d)"BDL" indicates not detected above the U.S. Environmental Protection Agency (EPA) Contract Laboratory Program (CLP) Hazardous Substance List (HSL) contract required detection limits (CRDL).

TABLE 4-10

SUMMARY OF HAZARDOUS SUBSTANCE LIST ORGANIC COMPOUND RESULTS
JULY 1985 SECOND QUARTER GROUND WATER MONITORING(a)
ARCO CHEMICAL COMPANY
CHARENHUTTEN, OHIO

PARAMETERS	CONCENTRATION UNITS	SAMPLE IDENTIFICATION MW-1 29 FEET	MW-2 23 FEET	MW-3 24 FEET	MW-4 17 FEET	MW-5 18 FEET	MW-6 25 FEET	MW-8 17 FEET	MW-9 22 FEET	PW-4 PUMP ZONE	PW-5 PUMP ZONE
Volatiles	ug/l(b)	BDL(c)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Acid/Base-Neutral Extractables	ug/l	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL

(a)Second quarter ground water monitoring samples were collected from July 30, 1985 to July 31, 1985.

(b)"ug/l" = micrograms per liter or parts per billion (ppb).

(c)"BDL" indicates not detected above the U.S. Environmental Protection Agency (EPA) Contract Laboratory Program (CLP) Hazardous Substance List (HSL) contract required detection limits (CRDL).

00001806

TABLE 4-11

SUMMARY OF HAZARDOUS SUBSTANCE LIST ORGANIC COMPOUND RESULTS
NOVEMBER 1986 FINAL QUARTER GROUND WATER MONITORING(a)
ARCO CHEMICAL COMPANY
CHAGRIN FALLS, OHIO

PARAMETERS	CAS REGISTRY NUMBER(b)	CONCENTRATION UNITS	MW-1 27 FEET	MW-2 23 FEET	MW-3 24 FEET	MW-4 20 FEET	MW-5 19 FEET	MW-6 26 FEET	MW-7 17 FEET	MW-8 23 FEET	MW-9 16 FEET	PW-4 PUMP ZONE	PW-5 PUMP ZONE
Volatiles:													
Methylene Chloride	75-09-2	ug/l(c)	13B(d)	17B	14B	11B	11B	12B	5.1B	8.3B	7.0B	15B	8.9B
Acetone	67-64-1	ug/l	13B	15B	46B	36B	31B	BDL(e)	52B	97B	26B	140B	BDL
Toluene	108-88-3	ug/l	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	6.9	BDL
Total Xylene(i)	1330-20-7	ug/l	6.2B	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	13B	BDL
Acid/Base-Neutral Extractables:													
1,3-Dichlorobenzene	541-73-1	ug/l	BDL	BDL	BDL	BDL	BDL	BDL	BDL	13B	BDL	BDL	BDL

(a)Final quarter ground water monitoring samples were collected from November 18, 1986 to November 20, 1986.

(b)The numbers presented in this column are the Chemical Abstracts Service (CAS) Registry Numbers used for cataloging the indicated compounds in the Chemical Abstracts Index.

(c)"ug/l" = micrograms per liter or parts per billion (ppb).

(d)"B" indicates that the corresponding compound was found in the blank as well as the sample.

(e)"BDL" indicates not detected above the U.S. Environmental Protection Agency (EPA) Contract Laboratory Program (CLP) Hazardous Substance List (HSL) contract required detection limits (CRDL).

00001807

TABLE 5-1

TUSCARAWAS RIVER STORET DATA(a)

PARAMETER	UNITS(b)	NEWCOMERSTOWN	GNADENHUTTEN	NEW PHILADELPHIA
Alkalinity, Total	mg/ℓ CaCO	100.86	128.0	111.0
pH	pH units	7.75	8.4	8.5
Field Conductivity	µmhos/cm @ 25°C	1,109.0	1,086.3	1,050.0
Aluminum	mg/ℓ	0.97	0.80	0.80
Chloride	mg/ℓ	95.55	131.0	146.0
Chromium	mg/ℓ	0.03	<0.03	<0.03
Cadmium	mg/ℓ	0.003	0.002	<0.0005
Copper	mg/ℓ	0.039	0.01	0.01
Cyanide, Total	mg/ℓ	<0.01	<0.01	0.011
Fluoride	mg/ℓ	1.3	NA(c)	NA
Iron	mg/ℓ	2.57	1.34	1.22
Lead	mg/ℓ	0.01	0.005	0.003
Magnesium	mg/ℓ	24.98	26.58	24.86
Manganese	mg/ℓ	0.60	0.49	0.66
Mercury	mg/ℓ	0.0005	NA	NA
Nitrate	mg/ℓ NO_3-N	1.72	2.15	2.84
Phenols	mg/ℓ	0.007	0.010	0.012
Phosphate, Total	mg/ℓ PO_4-P	0.24	0.20	0.28
Sulfate	mg/ℓ SO_4	172.07	186.0	170.0

(a)Concentrations are mean values for 1977-1985 at Newcomerstown, for 1983 immediately upstream of Gnadenhutten and 1983 at New Philadelphia. Source of data is the Ohio Environmental Protection Agency, 1985.

(b)mg/ℓ = milligrams per liter.

(c)NA = Not Available.

TABLE 5-2

SUMMARY OF CHROMIUM AND POLYCHLORINATED BIPHENYLS RESULTS
FOR THE NOVEMBER 1986 RIVER SEDIMENT SAMPLES(a)
ARCO CHEMICAL COMPANY
CHADEMHUTTEN, OHIO

SAMPLE IDENTIFICATION	TOTAL CHROMIUM (mg/kg)(b)	HEXAVALENT CHROMIUM (mg/kg)	POLYCHLORINATED BIPHENYLS (mg/kg)
RS-2-1	38	0.15J(c)	0.16U(d)
RS-2-2	70	1.2U	0.16U
RS-2-3	78	0.29J	0.16U
RS-2-4	67	0.14J	0.16U
RS-2-5	83	1.2U	0.16U
RS-2-6	61	1.2U	0.16U
RS-2-7	82	0.43J	0.16U
RS-2-8	74	0.44J	0.16U
RS-2-9	57	0.33J	0.16U
RS-4-2	78	0.84J	0.16U
RS-5-2	120	0.74J	0.16U
RS-6-2	82	1.1U	0.16U
RS-7-1	120	1.5	0.16U
RS-7-2	60	0.91J	0.16U
RS-7-3	69	0.89J	0.16U
RS-7-4	89	0.29J	0.16U
RS-7-5	81	0.27J	0.16U
RS-7-6	58	0.29J	0.16U
RS-7-7	56	0.56J	0.16U
RS-8-2	120	1.5	0.16U
RS-9-2	100	0.42J	0.47(e)
RS-10-1	180	0.17J	0.16U
RS-10-2	83	0.58J	0.16U
RS-10-3	85	0.45J	0.16U
RS-10-4	29	0.27J	0.16U
RS-10-5	32	0.41J	0.16U
RS-11-2	46	0.13J	0.16U
RS-12-2	55	1.3U	0.11(f)
RS-14-1	120	1.3U	0.16U
RS-14-2	65	1.2U	0.16U
RS-14-3	71	1.2U	0.16U
RS-14-4	67	0.14J	0.16U
RS-14-5	45	1.1U	0.16U
RS-14-6	51	1.1U	0.16U
RS-14-7	49	3.2U	0.16U
RS-14-8	100	1.4U	0.16U
Composite RS-1,2,3 Traverses	17	1.2U	0.16U
Composite RS-4,5,6 Traverses	38	4.1	0.16U
Composite RS-7,8,9 Traverses	48	1.1U	0.16U
Composite RS-10,11,12 Traverses	33	3.1U	0.16U
Composite RS-13,14,15 Traverses	59	3.0U	0.16U

(a)Samples were collected from November 11, 1986 to November 14, 1986.

(b)"mg/kg" equals milligrams per kilogram or parts per million (ppm)

(c)"J" indicates that the corresponding compound is present, but the calculated concentration is less than the specified detection limit.

(d)"U" indicates that the compound was analyzed, but not detected. The corresponding number represents the method detection limit for the sample.

(e)The source aroclors for the indicated polychlorinated biphenyls were Aroclor 1248 and 1254.

(f)The source aroclor for the indicated polychlorinated biphenyls was Aroclor 1248.

TABLE 8-1

ESTIMATED CONSTITUENT LEVELS IN THE TUSCARAWAS RIVER
COMPARED TO STANDARDS AND CRITERIA

CONTAMINANT	CONTRIBUTION TO RIVER CONCENTRATION[a] (μg/ℓ)	NATIONAL DRINKING WATER STANDARD OR MCL[bc] (μg/ℓ)	CRITERIA FOR FRESH WATER FISH CHRONIC EXPOSURE[c] (μg/ℓ)	CRITERIA FOR WATER AND FISH INGESTION[c] (μg/ℓ)
Chromium (hexavalent)	0.41	50	11	50
Chromium (Total)	0.41	50[d]	-	-
Cyanide	1.38	200	5.2	200
Fluoride	25.5	4,000[e]	-	-
Nitrate (NO_3-N)	26.7	10,000	-	10,000
Selenium	0.04	10	36	10
Tetrachloroethylene	0.03	-	840	0.8

[a]A dilution factor of 2.93×10^{-3} was used.

[b]"MCL" is a maximum contaminant level, enforceable drinking water standard under the Safe Drinking Water Act.

[c]Water Quality Criteria, May 1986. U.S. Environmental Protection Agency, U.S. EPA 440/5-86-001.

[d]November 13, 1985. Federal Register 50 FR 46902.

[e]40 CFR Part 141.11(c) National Primary Drinking Water Regulations.

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TABLE 8-2

NONCARCINOGENIC RISK FACTORS FOR A CHILD VIA WATER INGESTION

CONSTITUENT	CONTRIBUTION TO RIVER CONCENTRATION (µg/ℓ)	ORAL REFERENCE DOSE (mg/kg/day)[a]	AVERAGE DAILY DOSE[b] mg/kg/day	HAZARD INDEX[c]
Chromium (hexavalent)	0.41	5.00×10^{-3}	2.05×10^{-5}	4.1×10^{-3}
Chromium (total)	0.41	-[d]	-	-
Cyanide	1.38	2.00×10^{-3}	6.9×10^{-5}	3.45×10^{-2}
Fluoride	25.5	6.00×10^{-2}	1.28×10^{-3}	2.13×10^{-2}
Nitrate (NO_3-N)	26.7	-[d]	-	-
Selenium	0.04	3.00×10^{-3}	2.0×10^{-6}	6.67×10^{-4}
Tetrachloroethylene	0.03	2.00×10^{-2}	1.5×10^{-6}	7.50×10^{-5}

[a]SPHEM, 1986b.

[b]Average Daily Dose Child = (Concentration in Water µg/ℓ) (1.25 ℓ/day) (1 mg/1,000 µg) (1/25 kg body weight) Interpolated from SPHEM, 1986.

[c]Hazard Index = Average Daily Dose/Oral Reference Dose.

[d]None Available.

TABLE 8-3

RISK FACTORS ASSOCIATED WITH POTENTIAL CARCINOGENS FOR A CHILD VIA WATER INGESTION

CONSTITUENT	AVERAGE DAILY DOSE (mg/kg/day)	CARCINOGENIC POTENCY FACTOR[a] $(mg/kg/day)^{-1}$	LIFETIME CANCER RISK[b] (CR)
Tetrachloroethylene	1.5×10^{-6}	5.10×10^{-2}	7.65×10^{-8}

[a]SPHEM, 1986b.

[b]Lifetime Cancer Risk = (Average Daily Dose [mg/kg/day]) (Carcinogenic Potency Factor $[mg/kg/day]^{-1}$).

TABLE 8-4

NONCARCINOGENIC RISK FACTORS
FOR AN ADULT VIA WATER INGESTION

CONSTITUENT	CONTRIBUTION TO RIVER CONCENTRATION (µg/ℓ)	ORAL REFERENCE DOSE (RfD)[a] (mg/kg/day)	AVERAGE DAILY DOSE[b] (mg/kg/day)	HAZARD INDEX[c]
Chromium (+6)	0.41	5.00×10^{-3}	1.17×10^{-5}	2.34×10^{-3}
Chromium (total)	0.41	-[d]	-	-
Cyanide	1.38	2.00×10^{-3}	3.94×10^{-5}	1.97×10^{-2}
Fluoride	25.5	6.00×10^{-2}	7.28×10^{-4}	1.21×10^{-2}
Nitrate (NO_3-N)	26.7	-[d]	-	-
Selenium	0.04	3.00×10^{-3}	1.14×10^{-6}	3.81×10^{-4}
Tetrachloroethylene	0.03	2.00×10^{-2}	8.57×10^{-7}	4.29×10^{-5}

[a]SPHEM, 1986b.

[b]Average Daily Dose = (Concentration in Water µg/ℓ) (2 ℓ/day) (1 mg/1,000µg) (1/70 kg body weight).

[c]Hazard Index = Average Daily Dose/Oral Reference Dose.

[d]None Available.

TABLE 8-5

RISK FACTORS ASSOCIATED WITH POTENTIAL CARCINOGENS FOR AN ADULT VIA WATER INGESTION

CONSTITUENT	AVERAGE DAILY DOSE (mg/kg/day)	CARCINOGENIC POTENCY FACTOR[a] $mg/kg/day)^{-1}$	LIFETIME CANCER RISK[b] (CR)
Tetrachloroethylene	8.57×10^{-7}	5.10×10^{-2}	4.37×10^{-8}

[a]SPHEM, 1986b.

[b]Lifetime Cancer Risk = (Average Daily Dose $[mg/kg/day]^{-1}$) (Carcinogenic Potency Factor $[mg/kg/day]^{-1}$).

TABLE 8-6

SITE SPECIFIC METALS DATA COMPARED TO NATURALLY OCCURRING BACKGROUND LEVELS IN SWAMP AREA
ARCO CHEMICAL COMPANY
GNADENHUTTEN, OHIO

METAL	BACKGROUND LEVEL[a] MEAN DRY SOIL IN MG/KG AND (RANGE)	AREA[b] 1	2	3	4	5
Aluminum	71,000(10,000-300,000)	72000	70000	39000	60000	36000
Arsenic	6(0.1-40)	45	31	26	57	35
Barium	500(100-3,000)	180	190	180	430	240
Cadmium	0.06(0.01-0.7)	6.8	6.8	3.4	6.0	3.6
Chromium (total)	100(5-3,000)	17000	17000	11000	13000	14000
Copper	20(2-100)	21	24	31	54	44
n	38,000(7,000-550,000)	18000	17000	26000	24000	20000
Lead	10(2-200)	87	88	98	130	120
Manganese	850(100-4,000)	870	960	1400	7200	5600
Mercury	0.03(0.01-0.3)	0.96	0.87	0.79	0.93	0.80
Zinc	50(10-300)	5500	6000	4500	4000	4700

[a]Bowen, 1966.
[b]Table 3.10

TABLE 8-7

METALS AND INORGANIC CONSTITUENT LEVELS IN THE NORTHERN IMPOUNDMENT, SOUTHERN IMPOUNDMENT AND THE SLUDGE PIT AND UNDERLYING SOILS AS COMPARED TO BACKGROUND VALUES IN SOIL
ALSCO ANACONDA SITE
CHADWRITTEN, OHIO

CONSTITUENT	BACKGROUND LEVEL[a] DRY SOIL MEAN AND (RANGE) (mg/kg)	MAXIMUM CONCENTRATION IN IMPOUNDMENT AND SLUDGE PIT SURFACE SLUDGES[b] (mg/kg)	NUMBER OF ANALYSES	NUMBER OF DETECTS	MAXIMUM CONCENTRATION IN UNDERLYING SOILS (mg/kg)	NUMBER OF ANALYSES	NUMBER OF DETECTS
Aluminum	71,000 (10,000-300,000)	49,000	4	4	18,000	6	7
Arsenic	6 (0.1-40)	37	4	4	22	6	7
Barium	500 (100-3,000)	130	4	4	300	6	6
Cadmium	0.06 (0.01-0.7)	5.5	4	3	2.0	6	1
Chromium (Hexavalent)	-[c]	0.1	13	1	0.1	13	1
Chromium (Total)	100 (5-3,000)	11,000	10	10	1,200	6	6
Copper	20 (2-100)	33	4	4	75	6	6
Iron	38,000 (7,000-550,000)	23,000	10	10	52,000	6	6
Lead	10 (2-200)	170	4	4	25	6	6
Manganese	850 (100-4,000)	1,000	10	10	1,100	6	6
Mercury	0.03 (0.01-0.3)	18	7	7	0.64	13	12
Selenium	1-7[d]	1.7	4	1	2.3	6	4
Zinc	50 (10-300)	1,700	4	4	160	6	6
Cyanide (Total)	-[c]	5,000	9	3	740	13	13

[a]Bowen, 1966.

[b]Maximum concentration derived from data on impoundment samples, test pit samples to a depth no greater than two feet, and sludge composite samples which contain surface samples (Tables 3-6, 3-8, 3-10, and 3-12).

[c]None Available.

[d]Hazardous Waste Land Treatment, 1983, U.S. Environmental Protection Agency, SW-874.

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TABLE 8-8

METALS AND INORGANIC CONSTITUENT LEVELS
IN MONITORING WELL SOIL BORINGS ADJACENT TO SLUDGE AREAS[a]

CONSTITUENTS	BACKGROUND LEVEL[b] DRY SOIL MEAN AND (RANGE) (mg/kg)	CONCENTRATION (mg/kg)	NUMBER OF ANALYSES	NUMBER OF DETECTS
Cyanide, Total	-[c]	60	27	13
Chromium, Hexavalent	-[c]	0.5	27	1
Chromium, Total	100 (5-3,000)	950	27	27
Iron	38,000 (7,000-550,000)	84,000	27	27
Manganese	850 (100-4,000)	1,000	27	27

[a]Table 4-1.

[b]Bowen, 1966.

[c]None Available.

TABLE 8-9

AVERAGE DAILY DOSE OF METALS VIA INGESTION
AND THE RESULTING HAZARD INDEX FOR CHILDREN AND ADULTS
ALSCO ANACONDA SITE
GNADENHUTTEN, OHIO

CONSTITUENT	HIGHEST CONCENTRATION IN SLUDGE, ADJACENT OR UNDERLYING SOILS (mg/kg)	AVERAGE DAILY DOSE CHILDREN (mg/kg/day)	AVERAGE DAILY DOSE ADULTS (mg/kg/day)	ORAL REFERENCE DOSE (Rfd)[a] (mg/kg/day)	HAZARD INDEX CHILDREN[b]	HAZARD INDEX ADULTS[b]
Cadmium	6.8	3.88×10^{-7}	7.89×10^{-7}	2.9×10^{-4}	1.34×10^{-3}	2.72×10^{-3}
Chromium (total)	17,000	9.69×10^{-4}	1.97×10^{-3}	1.0×10^{0}	9.69×10^{-4}	1.97×10^{-3}
Chromium (hexavalent)	13	7.41×10^{-7}	1.51×10^{-6}	5.0×10^{-3}	1.48×10^{-4}	3.02×10^{-4}
Cyanide (total)	5,000	2.85×10^{-4}	5.80×10^{-4}	2.0×10^{-2}	1.4×10^{-2}	2.90×10^{-2}
Mercury	18	1.03×10^{-6}	2.09×10^{-6}	3.0×10^{-4}[c]	3.43×10^{-3}	6.96×10^{-3}

[a]SPHEM, 1986b.

[b]Hazard Index = Average daily dose/Oral Reference Dose.

[c]Value for mercury (alkyl).

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TABLE 8-10

EXCESS CANCER RISK TO CHILDREN AND ADULTS
INGESTING ARSENIC-CONTAINING SLUDGE
ALSCO ANACONDA SITE
GNADENHUTTEN, OHIO

CONSTITUENT	CONCENTRATION IN SLUDGE (mg/kg)	AVERAGE DAILY DOSE (mg/kg/day)	CARCINOGENIC POTENCY FACTOR[a] $(mg/kg/day)^{-1}$	LIFETIME CANCER RISK[b] (CR)
Child				
Arsenic	57	3.25×10^{-6}	1.75	5.68×10^{-7}
Adult				
Arsenic	57	6.6×10^{-6}	1.75	1.16×10^{-6}

[a]SPHEM, 1986b.

[b]Lifetime Cancer Risk = (Average Daily Dose [mg/kg/day]) (Carcinogenic Potency Factor $[mg/kg/day]^{-1}$). The carcinogenic potency factor for arsenic is 1.75 $(mg/kg/day)^{-1}$ according to the U.S. EPA Risk Assessment Forum (RAF), 1987. Risk value lowered by one order of magnitude as recommended by RAF. See Section 8.8.6 for details.

TABLE 8-11

PCBs AVERAGE DAILY DOSE
AND RISK FACTORS VIA DIRECT CONTACT
FOR A CHILD IN AREA 4

CONSTITUENT	CONCENTRATION (mg/kg)	AVERAGE DAILY DOSE (mg/kg/day)	CARCINOGENIC POTENCY FACTOR (CPF)[a] $(mg/kg/day)^{-1}$	LIFETIME CANCER RISK[b]
		100 PERCENT ABSORPTION		
AVERAGE EXPOSURE				
Ingestion				
PCBs	80.8[c]	4.61×10^{-6}	7.7	3.55×10^{-5}
Dermal				
PCBs	80.8	2.21×10^{-5}	7.7	1.70×10^{-4}
UPPER-BOUND EXPOSURE				
Ingestion				
PCBs	3,000	1.71×10^{-4}	7.7	1.32×10^{-3}
Dermal				
PCBs	3,000	8.19×10^{-4}	7.7	6.31×10^{-3}
		20 PERCENT ABSORPTION		
AVERAGE EXPOSURE				
Ingestion				
Dermal				
PCBs	80.8	4.40×10^{-6}	7.7	3.39×10^{-5}
UPPER-BOUND EXPOSURE				
Ingestion				
Dermal				
PCBs	3,000	1.63×10^{-4}	7.7	1.26×10^{-3}

[a]U.S. Public Health Service, 1987, Draft Toxicological Profile for Selected PCBs, Agency for Toxic Substances and Disease Registry. Published by Oak Ridge National Laboratory.

[b]Lifetime Cancer Risk = (Average Daily Dose [mg/kg/day]) (Carcinogenic Potency Factor $[mg/kg/day]^{-1}$).

[c]The average concentration was calculated without the assumed outlier of 3,000 mg/kg.

TABLE 8-12

PCBs AVERAGE DAILY DOSE
AND RISK FACTORS VIA DIRECT CONTACT
FOR AN ADULT IN AREA 4

CONSTITUENT	CONCENTRATION (mg/kg)	AVERAGE DAILY DOSE (mg/kg/day)	CARCINOGENIC POTENCY FACTOR (CPF)[a] $(mg/kg/day)^{-1}$	LIFETIME CANCER RISK (CR)
		100 PERCENT ABSORPTION		
AVERAGE EXPOSURE				
Ingestion				
PCBs	80.8[c]	9.37×10^{-6}	7.7	7.22×10^{-5}
Dermal				
PCBs	80.8	4.49×10^{-5}	7.7	3.46×10^{-4}
UPPER-BOUND EXPOSURE				
Ingestion				
PCBs	3,000	3.48×10^{-4}	7.7	2.68×10^{-3}
Dermal				
PCBs	3,000	1.67×10^{-3}	7.7	1.28×10^{-2}
		20 PERCENT ABSORPTION		
AVERAGE EXPOSURE				
Dermal				
PCBs	80.8	8.97×10^{-6}	7.7	6.91×10^{-5}
UPPER-BOUND EXPOSURE				
Dermal				
PCBs	3,000	3.33×10^{-4}	7.7	2.56×10^{-3}

[a]U.S. Public Health Service, 1987, Draft Toxicological Profile for Selected PCBs, Agency for Toxic Substances and Disease Registry. Published by Oak Ridge National Laboratory.

[b]Lifetime Cancer Risk = (Average Daily Dose [mg/kg/day]) (Carcinogenic Potency Factor $[mg/kg/day]^{-1}$).

[c]The average concentration was calculated without the assumed outlier of 3,000 mg/kg.

TABLE 8-13

PCBs AVERAGE DAILY DOSE
AND RISK FACTORS VIA DIRECT CONTACT FOR A CHILD
IN AREAS 1, 2, 3, AND 5

CONSTITUENT	CONCENTRATION (mg/kg)	AVERAGE DAILY DOSE (mg/kg/day)	CARCINOGENIC POTENCY FACTOR (CPF)[a] $(mg/kg/day)^{-1}$	LIFETIME CANCER RISK[b]
		100 PERCENT ABSORPTION		
AVERAGE EXPOSURE				
Ingestion				
PCBs	4.89	2.79×10^{-7}	7.7	2.15×10^{-6}
Dermal				
PCBs	4.89	1.33×10^{-6}	7.7	1.03×10^{-5}
UPPER-BOUND EXPOSURE				
Ingestion				
PCBs	110	6.27×10^{-6}	7.7	4.83×10^{-5}
Dermal				
PCBs	110	3.00×10^{-5}	7.7	2.31×10^{-4}
		20 PERCENT ABSORPTION		
AVERAGE EXPOSURE				
Dermal				
PCBs	4.89	2.67×10^{-7}	7.7	2.05×10^{-6}
UPPER-BOUND EXPOSURE				
Dermal				
PCBs	110	5.99×10^{-6}	7.7	4.62×10^{-5}

[a]U.S. Public Health Service, 1987, Draft Toxicological Profile for Selected PCBs, Agency for Toxic Substances and Disease Registry. Published by Oak Ridge National Laboratory.

[b]Lifetime Cancer Risk = (Average Daily Dose [mg/kg/day]) (Carcinogenic Potency Factor $[mg/kg/day]^{-1}$).

TABLE 8-14

PCBs AVERAGE DAILY DOSE
AND RISK FACTORS VIA DIRECT CONTACT FOR AN ADULT
IN AREAS 1, 2, 3, AND 5

CONSTITUENT	CONCENTRATION (mg/kg)	AVERAGE DAILY DOSE (mg/kg/day)	CARCINOGENIC POTENCY FACTOR (CPF)[a] $(mg/kg/day)^{-1}$	LIFETIME CANCER RISK[b]
		100 PERCENT ABSORPTION		
AVERAGE EXPOSURE				
Ingestion				
PCBs	4.89	5.67×10^{-7}	7.7	4.37×10^{-6}
Dermal				
PCBs	4.89	2.72×10^{-6}	7.7	2.09×10^{-5}
UPPER-BOUND EXPOSURE				
Ingestion				
PCBs	110	1.28×10^{-5}	7.7	9.83×10^{-5}
Dermal				
PCBs	110	6.12×10^{-5}	7.7	4.71×10^{-4}
		20 PERCENT ABSORPTION		
AVERAGE EXPOSURE				
Dermal				
PCBs	4.89	5.43×10^{-7}	7.7	4.18×10^{-6}
UPPER-BOUND EXPOSURE				
Dermal				
PCBs	110	1.22×10^{-5}	7.7	9.40×10^{-5}

[a]U.S. Public Health Service, 1987, Draft Toxicological Profile for Selected PCBs, Agency for Toxic Substances and Disease Registry. Published by Oak Ridge National Laboratory.

[b]Lifetime Cancer Risk = (Average Daily Dose [mg/kg/day]) (Carcinogenic Potency Factor $[mg/kg/day]^{-1}$).

TABLE 8-15

ORGANIC CONSTITUENTS MAXIMUM CONCENTRATION DETECTED IN SLUDGE COMPOSITES, SWAMP SOILS, AND UNDERLYING IMPOUNDMENT SOILS[a]

CONSTITUENTS	SLUDGE MAXIMUM CONCENTRATION (mg/kg)	NUMBER OF DETECTS	NUMBER OF ANALYSES	SWAMP SOILS MAXIMUM CONCENTRATION (mg/kg)	NUMBER OF DETECTS	NUMBER OF ANALYSES	UNDERLYING IMPOUNDMENT SOILS NUMBER OF DETECTS	NUMBER OF ANALYSIS
Volatiles								
Ethyl benzene	110	1	20	BDL[b]	0	1	0	10
2-Hexanone	43	1	20	BDL	0	1	0	10
Tetrachloroethylene	0.28	1	20	BDL	0	1	0	10
Toluene	5.3	1	20	BDL	0	1	0	10
Xylenes, Total	410	4	20	BDL	0	1	0	10
Acid/Base-Neutral Extractables								
Bis(2-ethylhexyl)phthalate	2.9	5	20	0.75	1	1	0	10
Di-n-butyl phthalate	0.8	3	20	BDL	0	1	0	10
Fluoranthene	BDL	0	20	0.51	1	1	0	10
Isophorone	16	1	20	BDL	0	1	0	10
Naphthalene	200	1	20	BDL	0	1	0	10
N-Nitrosodiphenylamine	0.67	2	20	BDL	0	1	0	10
Phenanthrene	BDL	0	20	0.38	1	1	0	10
Pyrene	0.38	1	20	0.66	1	1	0	10

[a]Tables 3-9, 3-11, and 3-13.

[b]"BDL" indicates not detected above the U.S. Environmental Protection Agency (U.S. EPA) Contract Laboratory Program (CLP) Hazardous Substance List (HSL) contract required detection limits.

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TABLE 8-16

ORGANIC CONSTITUENT AVERAGE DAILY DOSE
FOR INGESTION AND DERMAL CONTACT AND HAZARD INDEX FOR NONCARCINOGENS FOR CHILD[a]

CONSTITUENT	MAXIMUM CONCENTRATION IN SLUDGE OR SOIL (mg/kg)	DERMAL CONTACT AVERAGE DAILY DOSE (mg/kg/day)	INGESTION AVERAGE DAILY DOSE (mg/kg/day)	REFERENCE DOSE[b] (mg/kg/day)	HAZARD INDEX DERMAL	HAZARD INDEX INGESTION	HAZARD INDEX TOTAL
Volatiles							
Ethylbenzene	118	3.0×10^{-5}	6.27×10^{-6}	1.0×10^{-1}	3.00×10^{-4}	6.27×10^{-5}	3.63×10^{-4}
2-Hexanone (butyl methyl ketone)	43	1.17×10^{-5}	2.45×10^{-6}	5.0×10^{-2}[c]	2.34×10^{-4}	4.9×10^{-5}	2.83×10^{-4}
Tetrachloroethylene	0.28	7.64×10^{-8}	1.60×10^{-8}	2.0×10^{-2}	3.82×10^{-6}	7.98×10^{-7}	4.62×10^{-6}
Toluene	5.3	1.45×10^{-6}	3.02×10^{-7}	3.0×10^{-1}	4.82×10^{-6}	1.01×10^{-6}	5.83×10^{-6}
Xylenes, Total	410	1.12×10^{-4}	2.34×10^{-5}	1.0×10^{-2}	1.12×10^{-2}	2.34×10^{-3}	1.35×10^{-2}
Acid/Base-Neutral Extractables							
Bis(2-ethylhexyl)phthalate	2.9	7.91×10^{-7}	1.65×10^{-7}	2.0×10^{-2}	3.95×10^{-5}	8.26×10^{-6}	4.78×10^{-5}
Di-N-Butylphthalate	0.8	2.18×10^{-7}	4.56×10^{-8}	2.0×10^{-2}[d]	1.09×10^{-5}	2.28×10^{-6}	1.32×10^{-5}
Fluoranthene	0.51	1.39×10^{-7}	2.91×10^{-8}	4.0×10^{-1}[e]	3.48×10^{-7}	7.27×10^{-8}	4.2×10^{-7}
Isophorone	16	4.36×10^{-6}	9.12×10^{-7}	2.0×10^{-1}	2.18×10^{-5}	4.56×10^{-6}	2.6×10^{-5}
Naphthalene	200	5.45×10^{-5}	1.14×10^{-5}	4.0×10^{-1}[e]	1.36×10^{-4}	2.85×10^{-5}	1.65×10^{-4}
N-Nitrosodiphenylamine	0.67	1.83×10^{-7}	3.82×10^{-8}	-[f]	-	-	
Phenanthrene	0.38	1.04×10^{-7}	2.17×10^{-8}	4.0×10^{-1}	2.59×10^{-7}	5.41×10^{-8}	5.14×10^{-7}
Pyrene	0.66	1.80×10^{-7}	3.76×10^{-8}	4.0×10^{-1}	4.50×10^{-7}	9.40×10^{-8}	5.44×10^{-7}

[a]Tables 3-9, 3-11, and 3-13.

[b]SPHEM, 1986b.

[c]Reference dose, or Acceptable Intake for Chronic Exposure (AIC), for methyl ethyl ketone used.

[d]Reference dose for Bis (2-ethyl hexyl) phthalate used.

[e]Based on the unverified reference dose for Naphthalene. Integrated Risk Information System (IRIS) Office of Health and Environmental Assessment, U.S. Environmental Protection Agency, 1986.

[f]Carcinogenic effects only.

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TABLE 8-17

RISK CHARACTERIZATION OF ORGANIC POTENTIAL CARCINOGENS FOR A CHILD VIA INGESTION AND DERMAL CONTACT

	INGESTION AVERAGE DAILY DOSE (mg/kg/day)	DERMAL AVERAGE DAILY DOSE (mg/kg/day)	CARCINOGENIC POTENCY FACTOR (CPF)[a] $(mg/kg/day)^{-1}$	TOTAL LIFETIME CANCER RISK[b]
Bis (2-ethyl hexyl) phthalate	1.65×10^{-7}	7.91×10^{-7}	8.4×10^{-3}[c]	$8.02\ 10^{-9}$
N-Nitrosodiphenyl-amine	3.82×10^{-8}	1.83×10^{-7}	4.92×10^{-3}[d]	1.09×10^{-9}
Tetrachloroethylene	1.60×10^{-8}	7.64×10^{-8}	5.10×10^{-2}[a]	4.71×10^{-9}
Isophorone	9.12×10^{-7}	4.36×10^{-6}	-[e]	-[e]

[a]SPHEM, 1986.

[b]Lifetime Cancer Risk = (Average Daily Dose [mg/kg/day]) (Carcinogenic Potency Factor (CPF) $[mg/kg/day]^{-1}$).

[c]Toxicological Profile for Di(2-ethyl hexyl) phthalate, December 1987.

[d]U.S. EPA Health Assessment Document for Epichlorohydrin, 1983, U.S. EPA 600/8-83-032A.

[e]The carcinogenic potency factor for isophorone has not yet been established. (U.S. EPA, 1986, Integrated Risk Information System [IRIS] accessed December 27, 1988, Carcinogenic Potency Factor, for Oral Exposure for Isophorone, on-line, verification date June 30, 1988, Office of Health and Environmental Assessment, Environmental Criteria and Assessment Office, Cincinnati, Ohio.

TABLE 8-18

ORGANIC CONSTITUENT AVERAGE DAILY DOSE
FOR INGESTION AND DERMAL CONTACT AND HAZARD INDEX FOR NONCARCINOGENS FOR ADULT[a]

CONSTITUENT	MAXIMUM CONCENTRATION IN SLUDGE OR SOIL (mg/kg)	DERMAL CONTACT AVERAGE DAILY DOSE (mg/kg/day)	INGESTION AVERAGE DAILY DOSE (mg/kg/day)	REFERENCE DOSE[b] $(mg/kg/day)^{-1}$	HAZARD INDEX DERMAL	HAZARD INDEX INGESTION
Volatiles						
Ethylbenzene	110	6.11×10^{-5}	1.28×10^{-5}	1.0×10^{-1}	6.11×10^{-4}	1.28×10^{-4}
2-Hexanone	43	2.39×10^{-5}	4.99×10^{-6}	5.0×10^{-2}[c]	4.77×10^{-4}	9.98×10^{-5}
Tetrachloroethylene	0.28	1.55×10^{-7}	3.25×10^{-8}	2.0×10^{-2}	7.77×10^{-6}	1.62×10^{-6}
Toluene	5.3	2.94×10^{-6}	6.15×10^{-7}	3.0×10^{-1}	9.81×10^{-6}	2.05×10^{-6}
Xylenes, Total	410	2.28×10^{-4}	4.76×10^{-5}	1.0×10^{-2}	2.28×10^{-2}	4.76×10^{-3}
Acid/Base-Neutral Extractables						
Bis(2-ethylhexyl)phthalate	2.9	1.61×10^{-6}	3.36×10^{-7}	2.0×10^{-2}	8.05×10^{-5}	1.68×10^{-5}
Di-n-butyl phthalate	0.8	4.44×10^{-7}	9.28×10^{-8}	2.0×10^{-2}[d]	2.22×10^{-5}	4.64×10^{-6}
Fluoranthene	0.51	2.83×10^{-7}	5.92×10^{-8}	4.0×10^{-1}[e]	7.08×10^{-7}	1.48×10^{-7}
Isophorone	16	8.88×10^{-6}	1.86×10^{-6}	2.0×10^{-1}	4.44×10^{-5}	9.28×10^{-6}
Naphthalene	200	1.11×10^{-4}	2.32×10^{-5}	4.0×10^{-1}[e]	2.77×10^{-4}	5.8×10^{-5}
N-Nitrosodiphenylamine	0.67	3.72×10^{-7}	7.77×10^{-8}	-[f]	-[f]	-[f]
Phenanthrene	0.38	2.11×10^{-7}	4.41×10^{-8}	4.0×10^{-1}	5.27×10^{-7}	1.10×10^{-7}
Pyrene	0.66	3.66×10^{-7}	7.66×10^{-8}	4.0×10^{-1}	9.16×10^{-7}	1.91×10^{-7}

[a]Tables 3-9, 3-11, and 3-13.
[b]SPHEM, 1986b.
[c]Reference dose, or Acceptable Intake for Chronic Exposure (AIC), for methyl ethyl ketone used.
[d]Reference dose for Bis(2-ethyl hexyl)phthalate used.
[e]Based on the unverified reference dose for Naphthalene. Integrated Risk Information System (IRIS) Office of Health and Environmental Assessment, U.S. Environmental Protection Agency, 1986.
[f]Carcinogenic effects only.

C0001827

TABLE 8-19

RISK CHARACTERIZATION OF ORGANIC POTENTIAL CARCINOGENS VIA INGESTION AND DERMAL CONTACT FOR AN ADULT

CONSTITUENT	INGESTION AVERAGE DAILY DOSE (mg/kg/day)	DERMAL CONTACT AVERAGE DAILY DOSE (mg/kg/day)	CARCINOGENIC POTENCY FACTOR[a] $(mg/kg/day)^{-1}$	LIFETIME CANCER RISK[b] (CR)
Bis(2-ethyl hexyl) phthalate	3.36×10^{-7}	1.61×10^{-6}	8.40×10^{-3}[c]	1.63×10^{-8}
N-Nitrosodiphenyl-amine	7.77×10^{-8}	3.72×10^{-7}	4.92×10^{-3}[d]	2.21×10^{-9}
Tetrachloroethylene	3.25×10^{-8}	1.55×10^{-7}	5.10×10^{-2}	9.61×10^{-9}
Isophorone	1.86×10^{-6}	8.88×10^{-6}	-[e]	-[e]

[a]SPHEM, 1986.

[b]Lifetime Cancer Risk (CR) = (Estimated Daily Intake [mg/kg/day]) (Carcinogenic Potency Factor $[mg/kg/day]^{-1}$).

[c]Toxicological Profile for Di(2-ethyl hexyl) phthalate, December 1987.

[d]U.S. EPA Health Assessment Document for Epichlorohydrin, 1983, U.S. EPA 600/8/83-032A.

[e]The carcinogenic potency factor for isophorone has not yet been established. (U.S. EPA, 1986, Integrated Risk Information System [IRIS] accessed December 27, 1988, Carcinogenic Potency Factor [CPF], for Oral Exposure for Isophorone, on-line, verification date June 30, 1988, Office of Health and Environmental Assessment, Environmental Criteria and Assessment Office, Cincinnati, Ohio.

FIGURES

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FIGURES

00001831

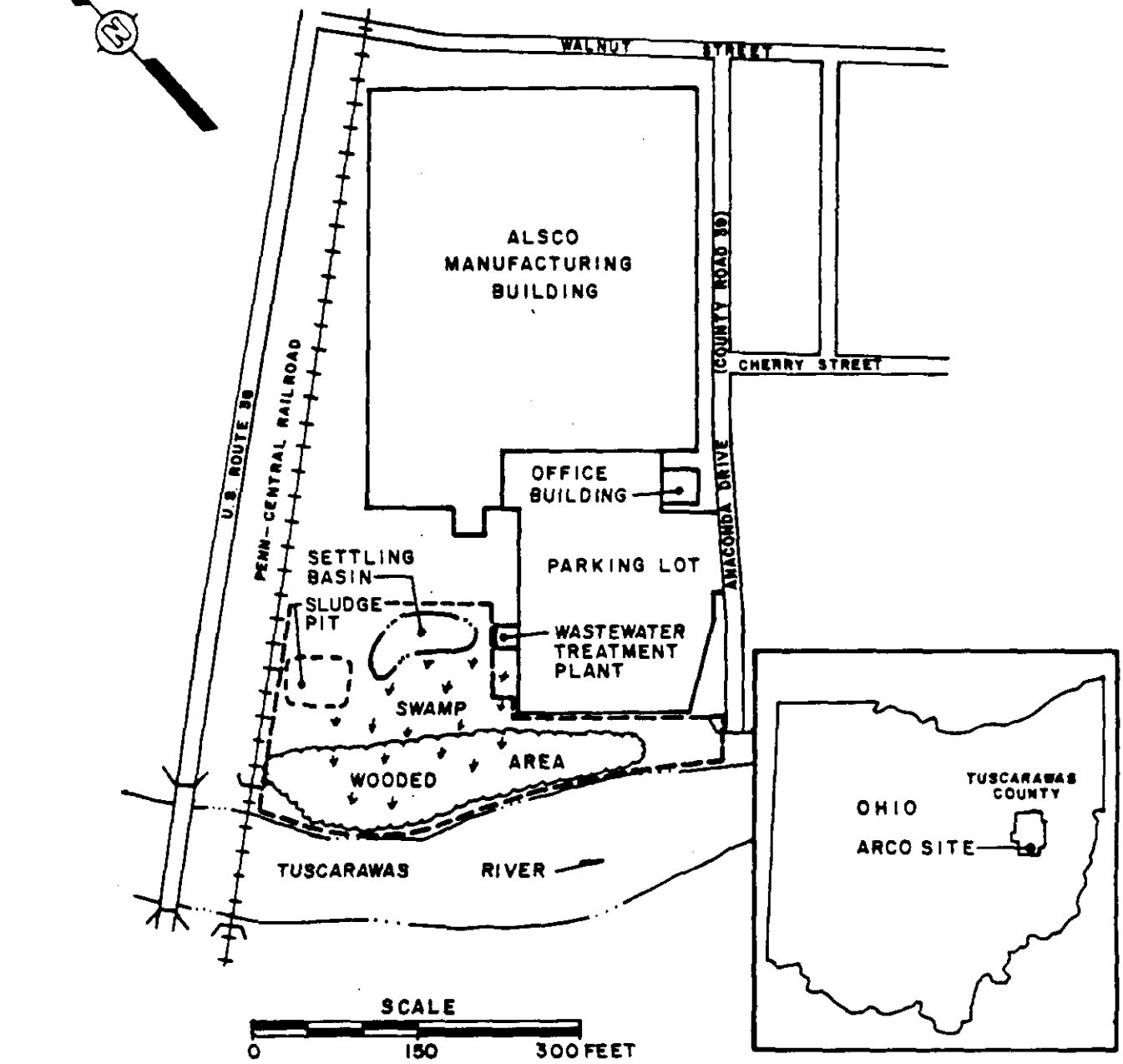

FIGURE ES-1

ALSCO-ANACONDA
SITE LOCATION MAP
GNADENHUTTEN, OHIO

PREPARED FOR

ARCO CHEMICAL COMPANY
NEWTOWN SQUARE, PENNSYLVANIA

LEGEND

- - - - 4.8 ACRE SITE BOUNDARY

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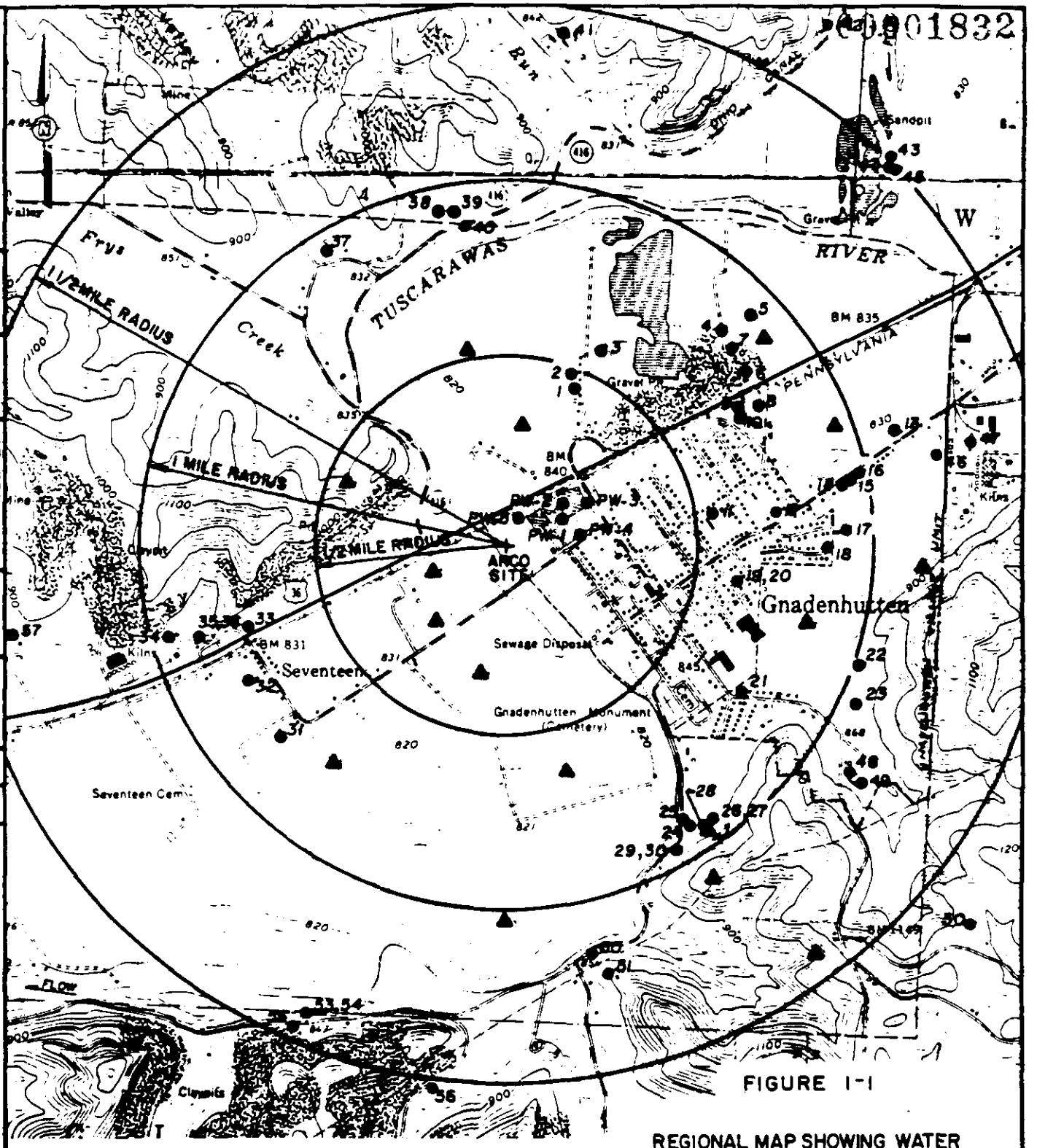

FIGURE 1-1

REGIONAL MAP SHOWING WATER AND OIL/GAS WELL LOCATIONS
GNADENHUTTEN, OHIO

PREPARED FOR

ATLANTIC RICHFIELD COMPANY
LOS ANGELES, CALIFORNIA

SCALE
0 2000 4000 FEET

REFERENCES:

1. U.S.G.S. 7.5-MINUTE SERIES GNADENHUTTEN AND NEW PHILADELPHIA, OHIO QUADRANGLES DATED 1962, SCALE: 1" = 2000'
2. ODNR DIVISION OF WATER, 1945-1985 WELL LOGS AND DRILLING REPORTS
3. BURGESS & NIPLE LTD., 1984 HYDROGEOLOGIC STUDY, ARCO METALS CO. GNADENHUTTEN, OHIO.

LEGEND

10● WATER WELL (LOG IN APPENDIX C)

▲ OIL / GAS WELL

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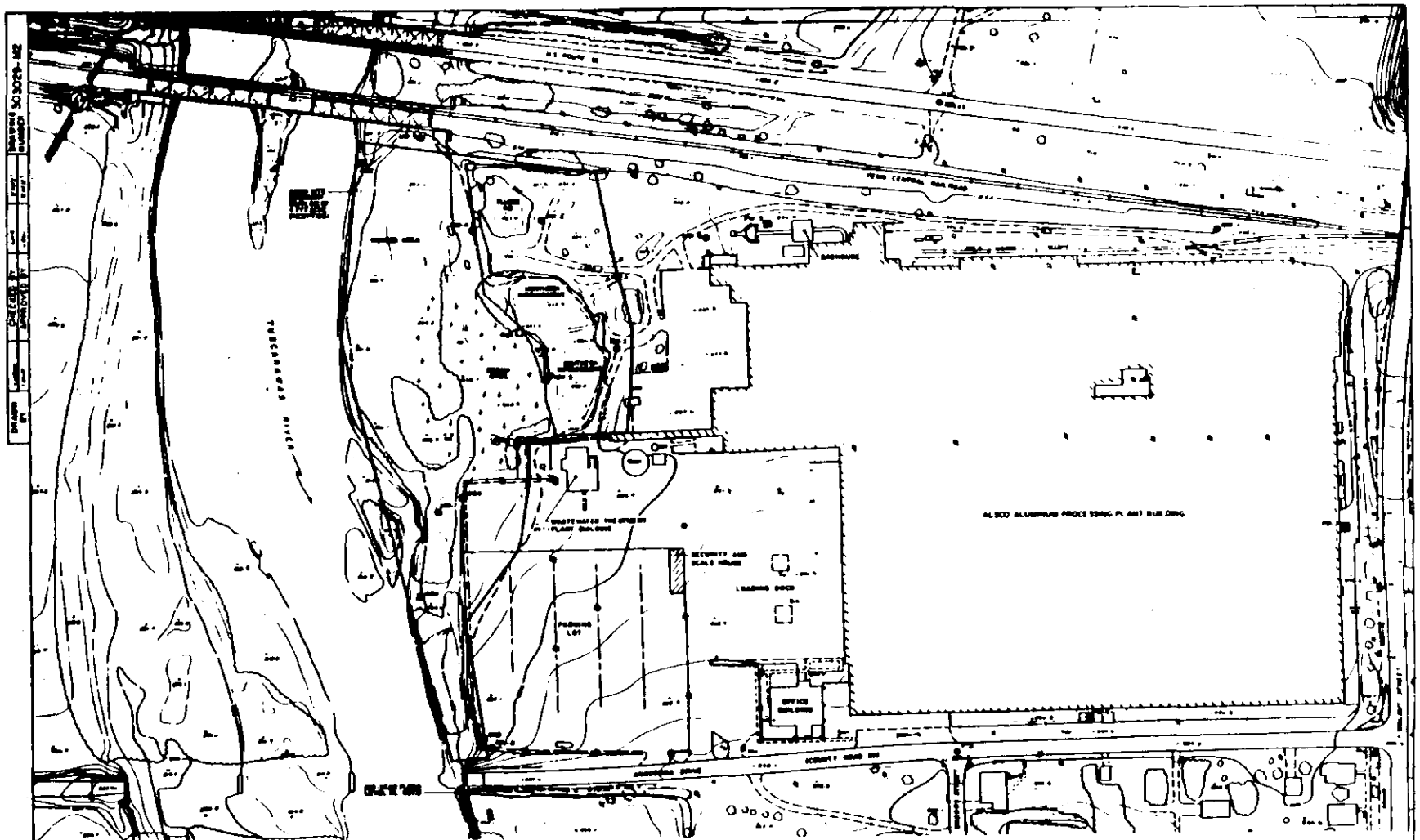

FIGURE 1-2

ALSCO-ANACONDA NPL
SITE VICINITY

GNADENHUTTEN, OHIO

PREPARED FOR

ATLANTIC RICHFIELD COMPANY
LOS ANGLES, CALIFORNIA

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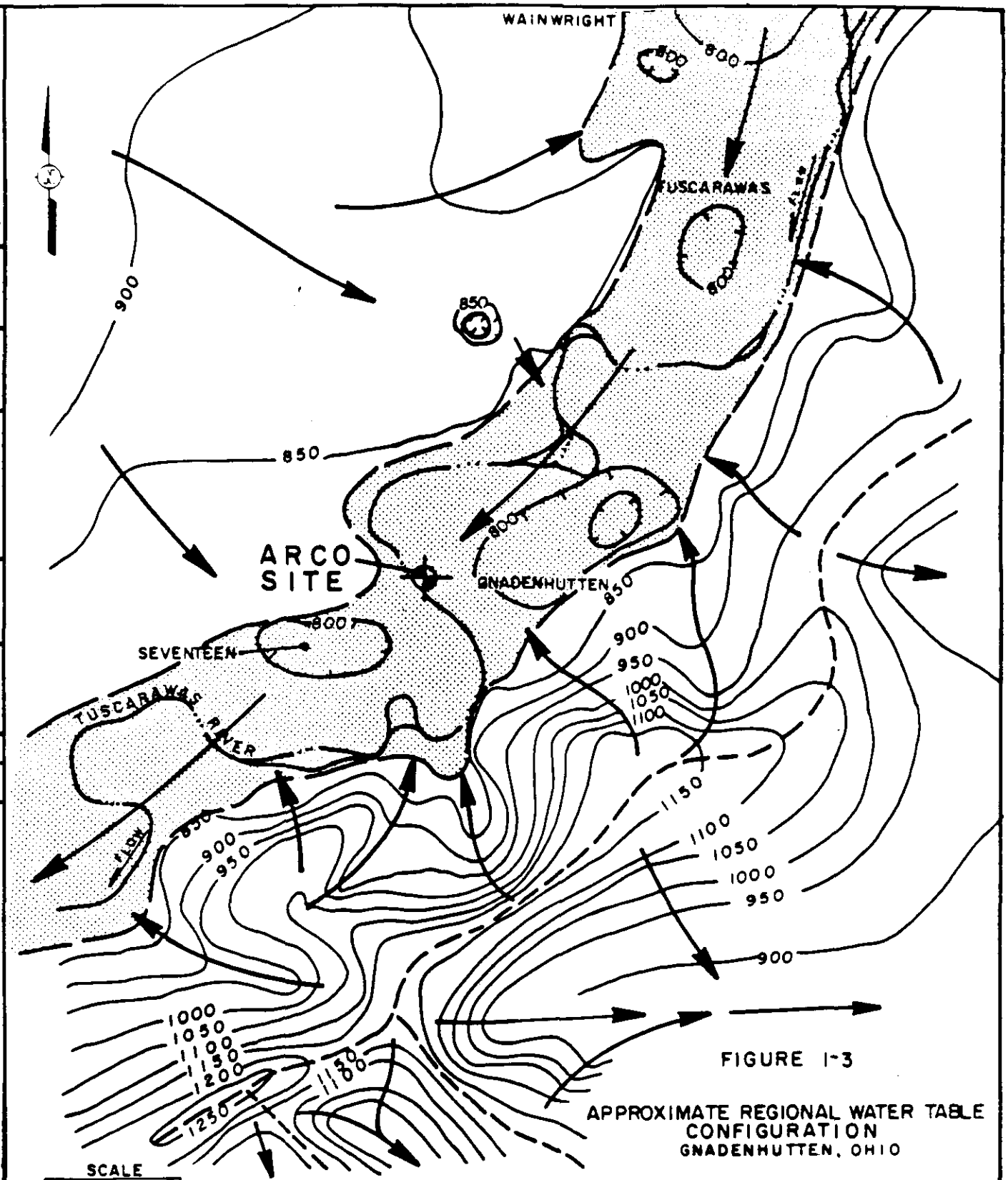

FIGURE 1-3

APPROXIMATE REGIONAL WATER TABLE CONFIGURATION
GNADENHUTTEN, OHIO

PREPARED FOR

ATLANTIC RICHFIELD COMPANY
LOS ANGELES, CALIFORNIA

SCALE
0 1 2 MILES

REFERENCE:
OHIO DEPARTMENT OF NATURAL RESOURCES, UNDATED, TUSCARAWAS COUNTY WATER WELL INVENTORY DATA.

LEGEND
APPROXIMATE EXTENT OF BURIED VALLEY
1000 APPROXIMATE WATER TABLE POTENTIOMETRIC CONTOUR; ELEVATION IN FEET ABOVE MEAN SEA LEVEL
APPROXIMATE GROUND WATER DIVIDE
APPROXIMATE GROUND WATER FLOW LINE

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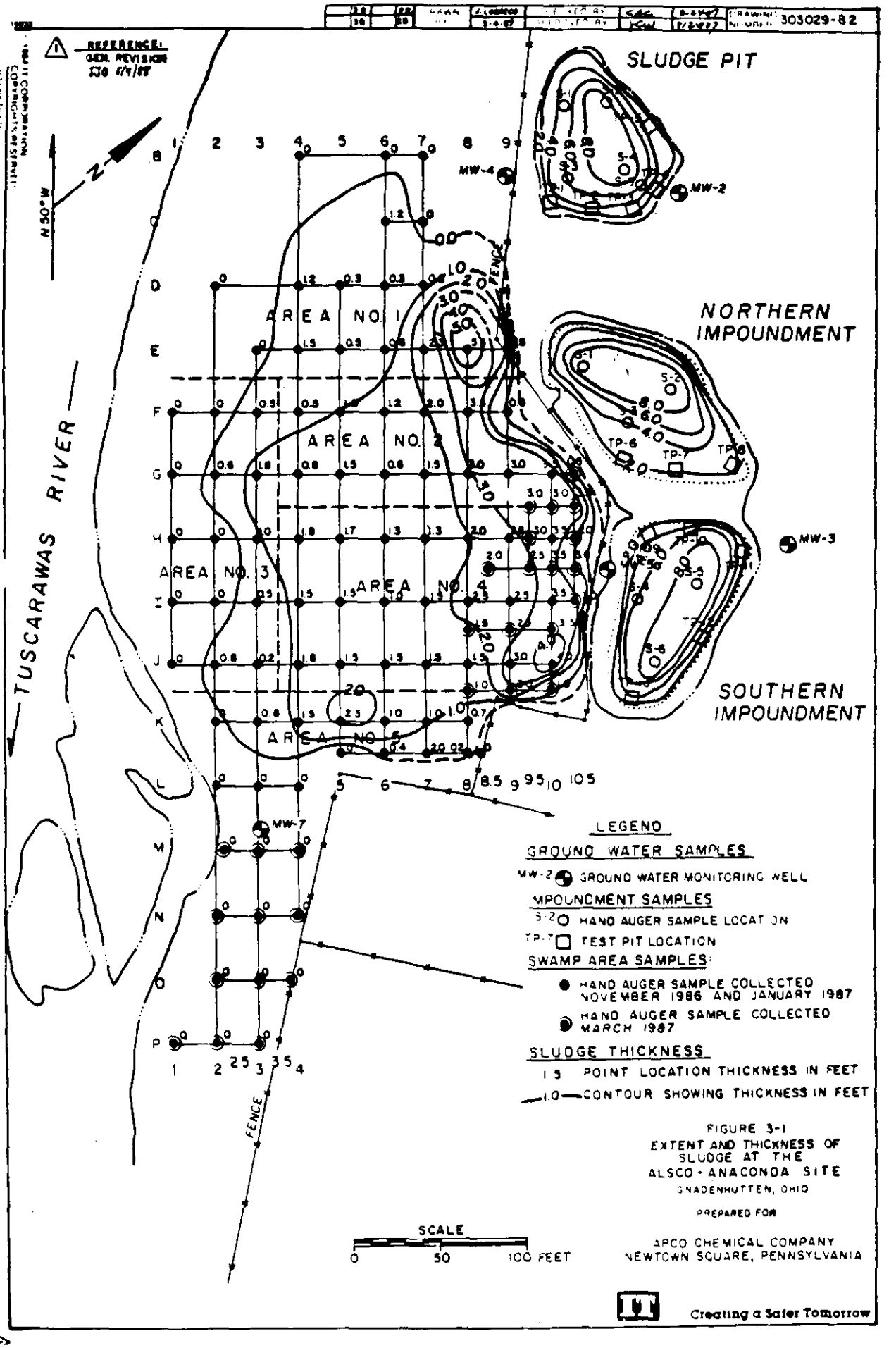


FIGURE 3-1
EXTENT AND THICKNESS OF SLUDGE AT THE ALSCO - ANACONDA SITE
GNADENHUTTEN, OHIO

PREPARED FOR

APCO CHEMICAL COMPANY
NEWTOWN SQUARE, PENNSYLVANIA

00001836

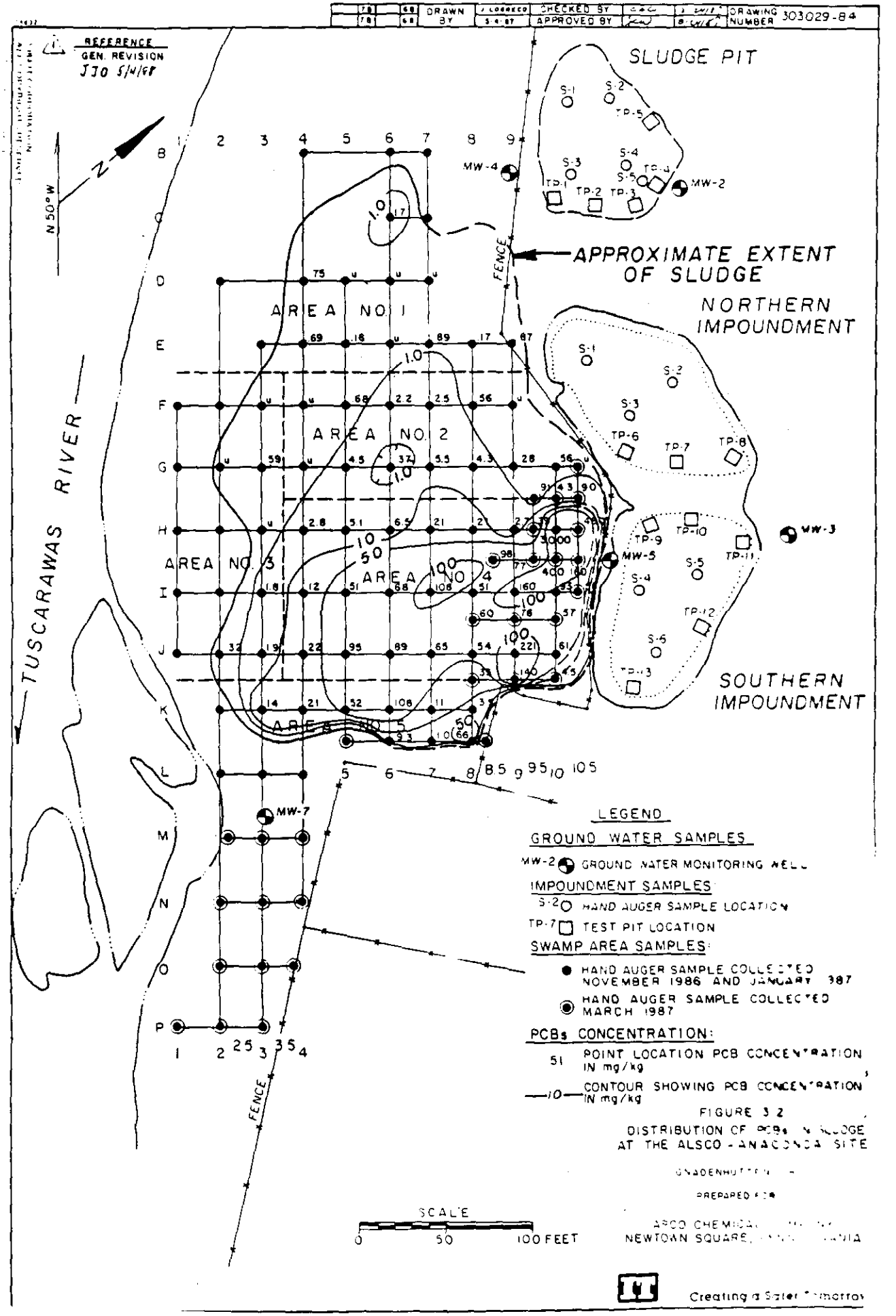


FIGURE 3.2
DISTRIBUTION OF PCBs IN SLUDGE AT THE ALSCO - ANACONDA SITE

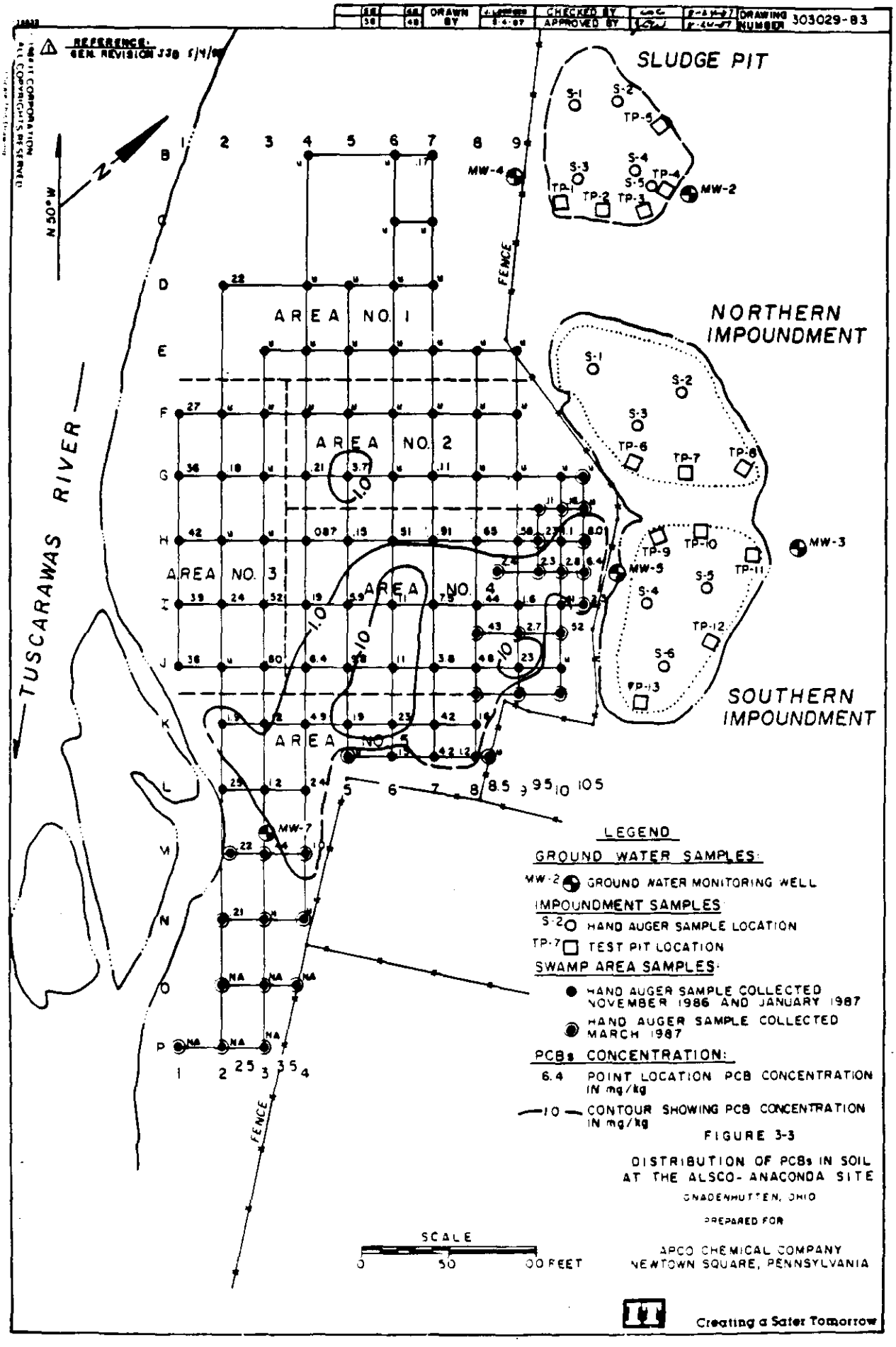
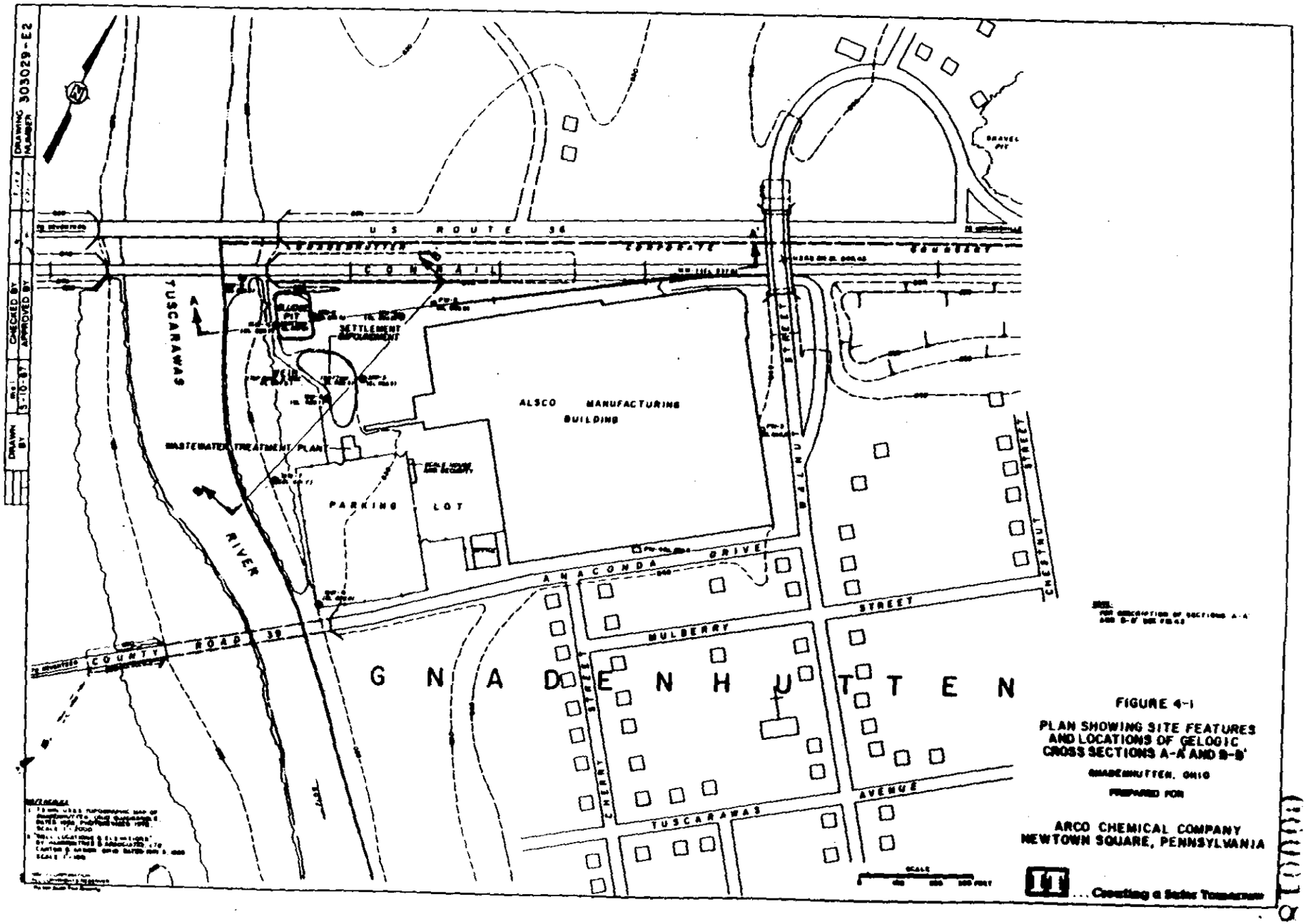


FIGURE 3-3

DISTRIBUTION OF PCBs IN SOIL AT THE ALSCO-ANACONDA SITE

GNADENHUTTEN, OHIO

PREPARED FOR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DATE 5-10-87
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U S ROUTE 36
CONRAIL
TUSCARAWAS
RIVER
SETTLEMENT EMPLACEMENT
WASTEWATER TREATMENT PLANT
PARKING LOT
ALSCO MANUFACTURING BUILDING
WALNUT STREET
CHESTNUT STREET
ANACONDA DRIVE
MULBERRY STREET
CHERRY STREET
TUSCARAWAS AVENUE
COUNTY ROAD 39
GNADENHUTTEN
FIGURE 4-1
PLAN SHOWING SITE FEATURES AND LOCATIONS OF GELOGIC CROSS SECTIONS A-A' AND B-B'
GNADENHUTTEN, OHIO
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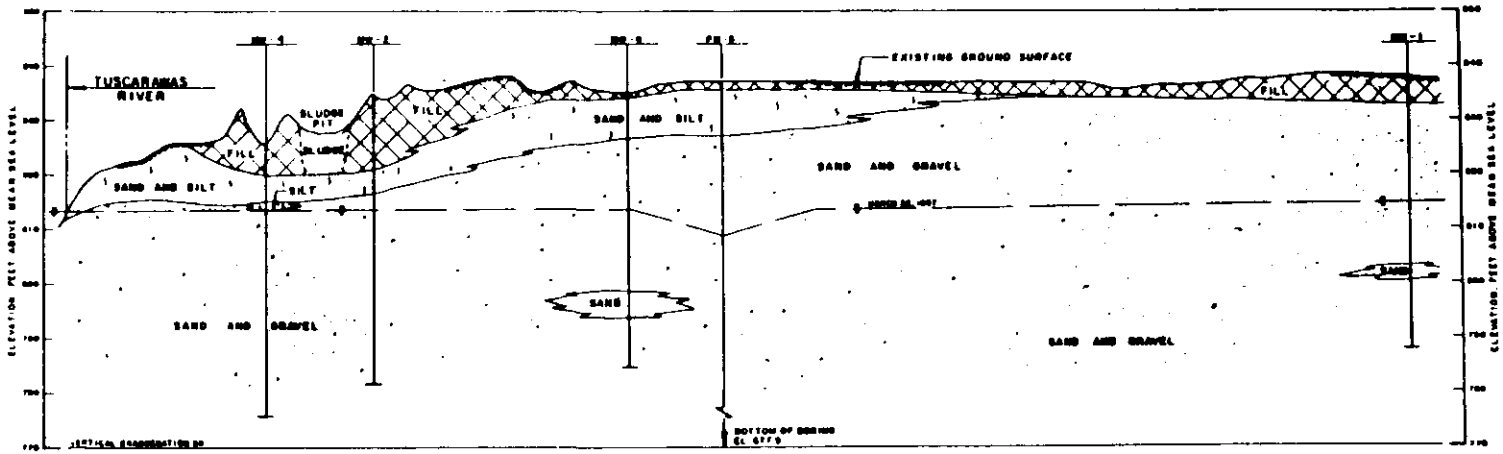
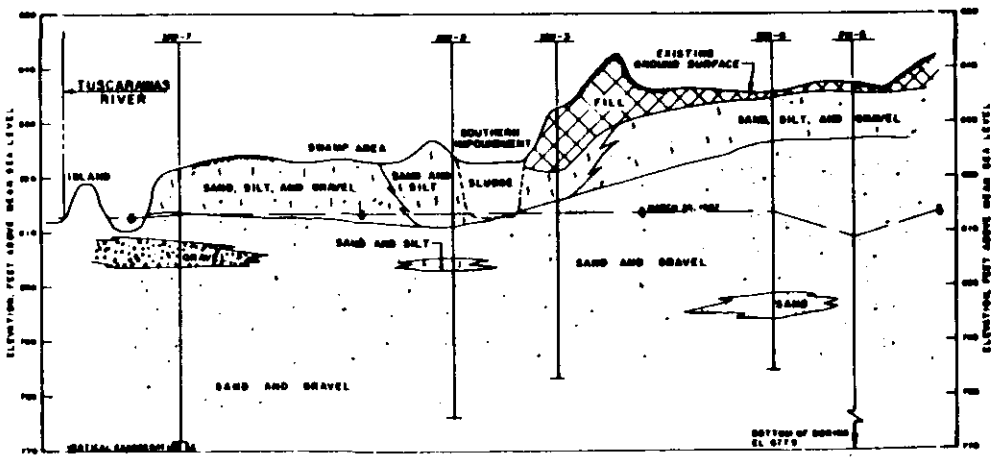


SECTION A-A'



SECTION B-B'

NOTE

FOR PLAN AND LOCATION OF BORINGS AND CROSS SECTIONS SEE FIGURE 4-1

THE BORING LOGS AND RELATED INFORMATION DEPICT SUBSURFACE CONDITIONS ONLY AT THE SPECIFIC LOCATIONS AND DATES INDICATED. SOIL CONDITIONS AND WATER LEVELS AT OTHER LOCATIONS MAY DIFFER FROM CONDITIONS ENCOUNTERED AT THESE BORING LOCATIONS. ALSO THE PASSAGE OF TIME MAY RESULT IN A CHANGE IN THE CONDITIONS AT THESE BORING LOCATIONS.

THE DEPTH AND THICKNESS OF THE SUBSURFACE STRATA INDICATED ON THE SECTIONS WERE GENERALIZED FROM AND INTERPOLATED BETWEEN THE TEST BORINGS. INFORMATION FROM ON ACTUAL SUBSURFACE CONDITIONS EXISTS ONLY AT THE LOCATION OF THE TEST BORINGS AND IT IS POSSIBLE THAT SUBSURFACE CONDITIONS BETWEEN THE TEST BORINGS MAY VARY FROM THOSE INDICATED.

FIGURE 4-2

GEOLOGIC CROSS SECTIONS
THROUGH THE SLUDGE PIT AND IMPOUNDMENT
SHADEMUTTEN, OHIO

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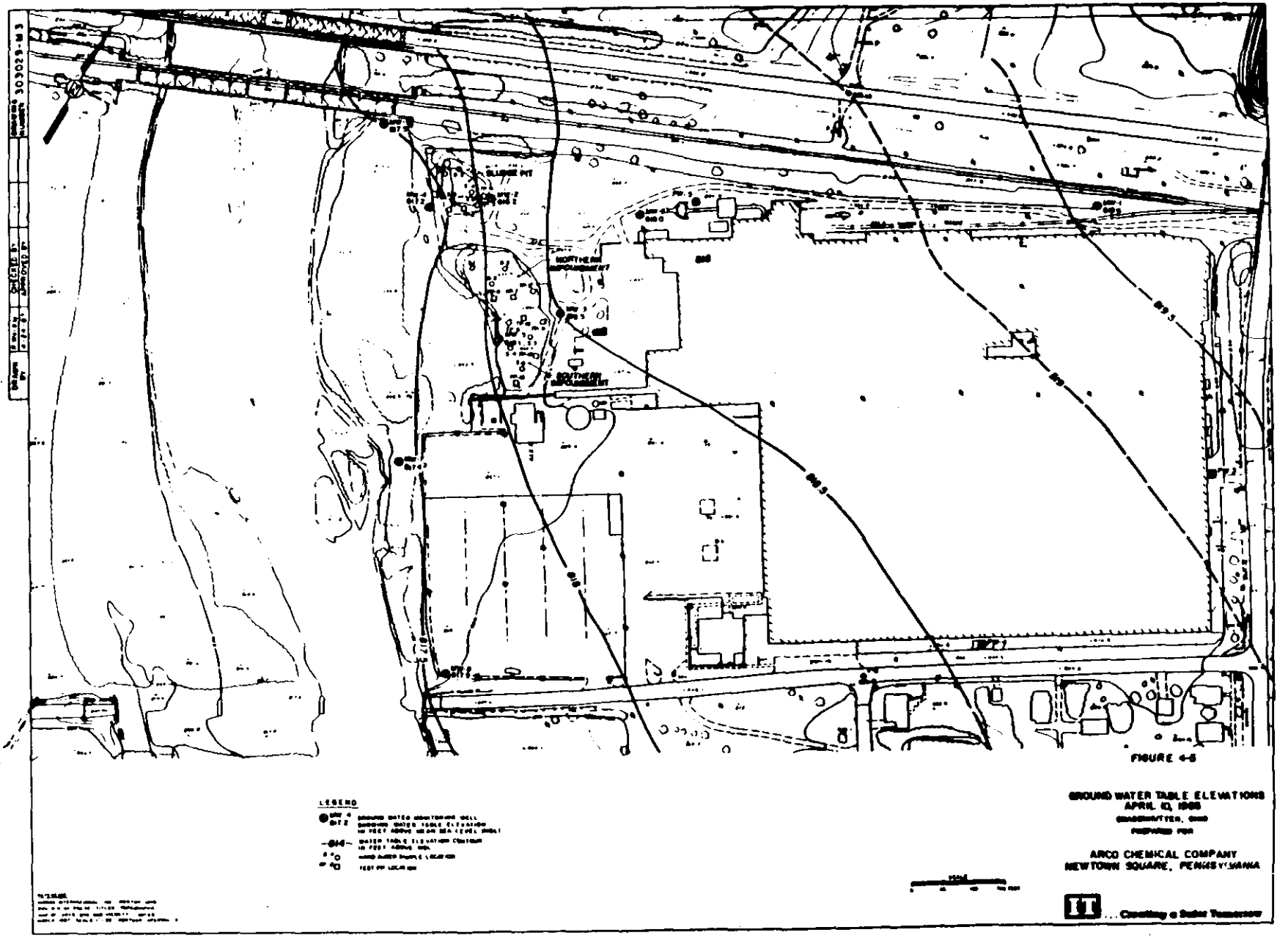

FIGURE 4-5

GROUND WATER TABLE ELEVATIONS
APRIL 10, 1986

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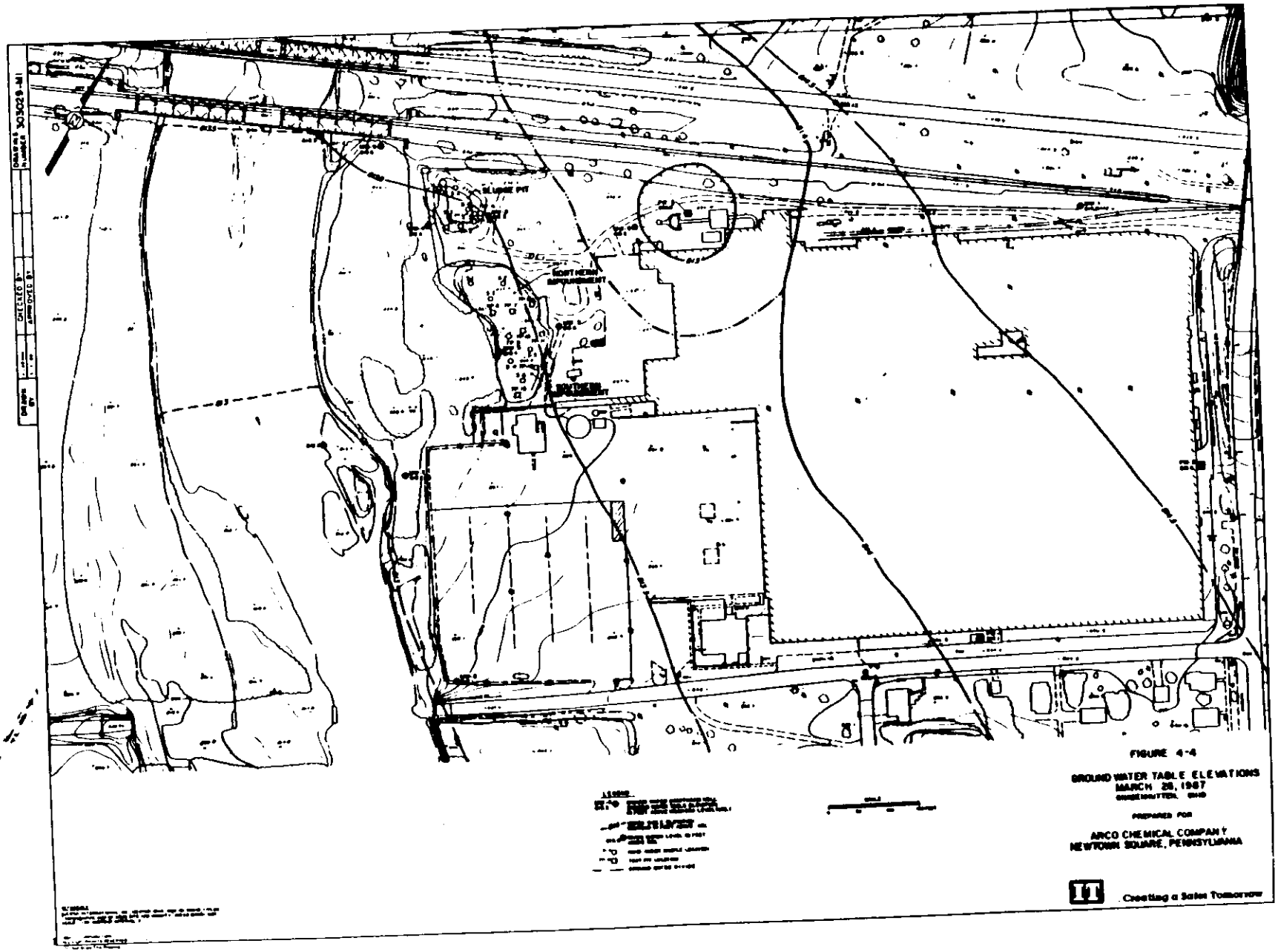

FIGURE 4-4

GROUND WATER TABLE ELEVATIONS
MARCH 26, 1987
CHASEMUTTEN, OHIO

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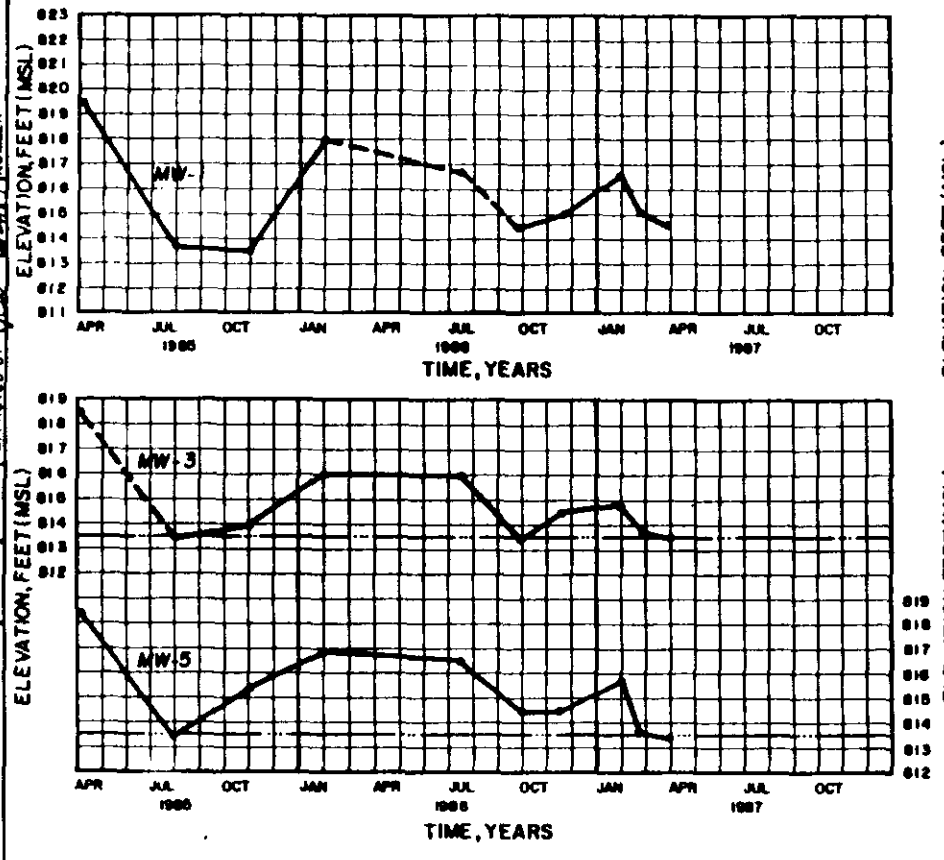

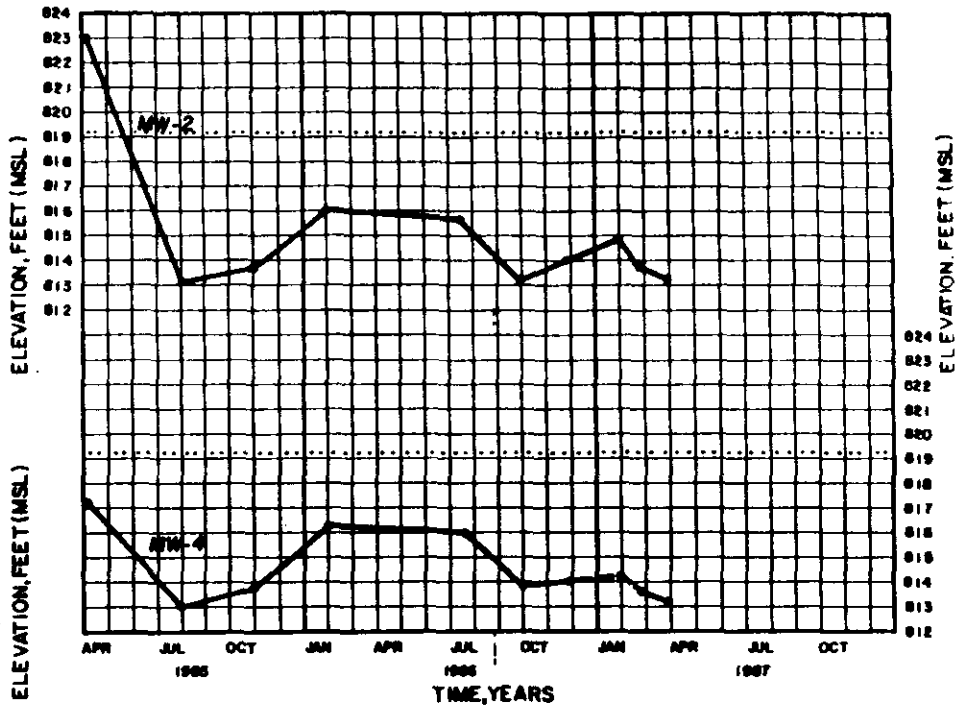

LEGEND

- INTERPOLATED TREND
- INFERRED TREND
- BASE OF IMPOUNDMENT
- BASE OF SLUDGE PIT

FIGURE 4-5A

TIME SERIES PLOTS OF WATER LEVEL IN WELLS AT THE ALSCO-ANACONDA SITE
GRADENHUTTEN, OHIO

PREPARED FOR

ARCO CHEMICAL COMPANY
NEWTOWN SQUARE, PENNSYLVANIA

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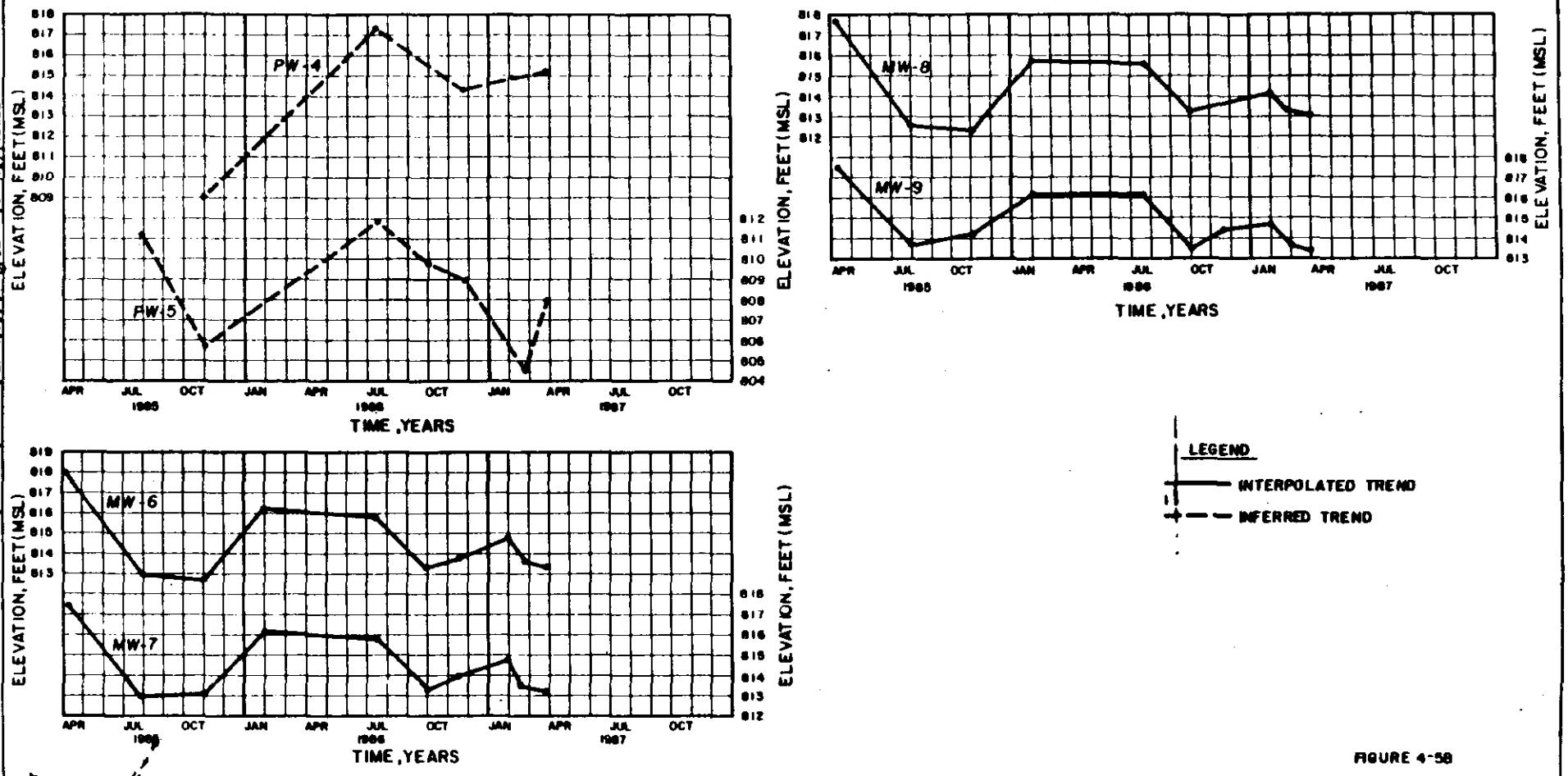

FIGURE 4-58

TIME SERIES PLOTS OF WATER LEVELS IN WELLS AT THE ALSCO-ANACONDA SITE
GNADENHUTTEN, OHIO

PREPARED FOR

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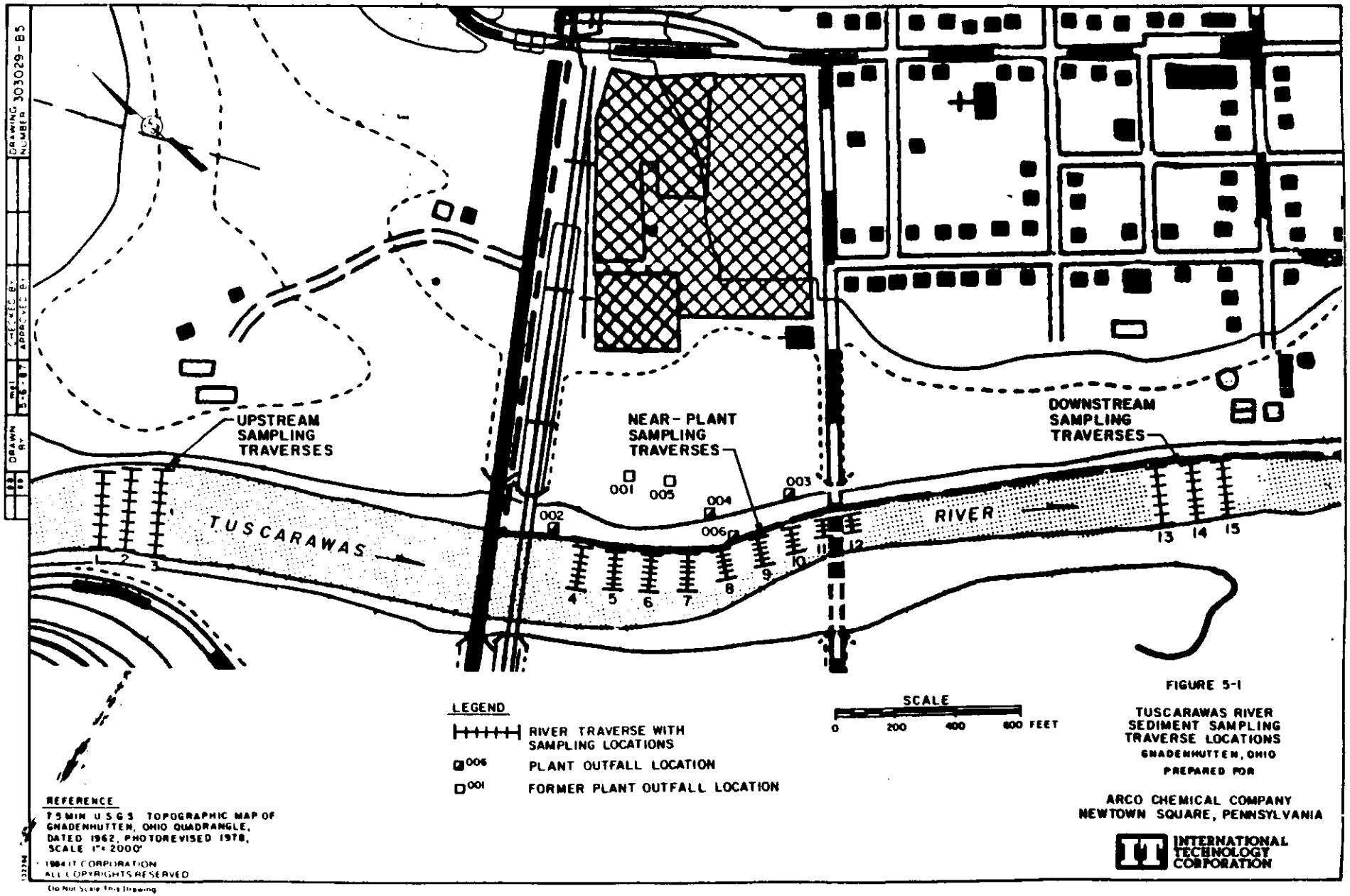

FIGURE 5-1

TUSCARAWAS RIVER SEDIMENT SAMPLING TRAVERSE LOCATIONS

GNADENHUTTEN, OHIO

PREPARED FOR

ARCO CHEMICAL COMPANY
NEWTOWN SQUARE, PENNSYLVANIA

00001845

APPENDIX

APPENDIX A

ANALYTICAL RESULTS FOR SLUDGE AND SOIL

APPENDIX A
LIST OF TABLES

TABLE NO.	TITLE
A-1	Summary of Volatile Hazardous Substance List Compound Results, April 1985 Impoundment, Sludge Pit, and Swamp Composites, ARCO Chemical Company, Gnadenhutten, Ohio
A-2	Summary of Acid and Base-Neutral Extractable Hazardous Substance List Compound Results, April 1985 Impoundment, Sludge Pit, and Swamp Composites, ARCO Chemical Company, Gnadenhutten, Ohio
A-3	Summary of Pesticide Hazardous Substance List Compound Results, April 1985 Impoundment, Sludge Pit, and Swamp Composites, ARCO Chemical Company, Gnadenhutten, Ohio
A-4	Summary of November 1986 Volatile Hazardous Substance List Compound Results, Northern and Southern Impoundment Areas, ARCO Chemical Company, Gnadenhutten, Ohio
A-5	Summary of November 1986 Acid and Base-Neutral Extractable Hazardous Substance List Compound Results, Northern and Southern Impoundment Areas, ARCO Chemical Company, Gnadenhutten, Ohio
A-6	Summary of November 1986 Pesticide Hazardous Substance List Compound Results, Northern and Southern Impoundment Areas, ARCO Chemical Company, Gnadenhutten, Ohio
A-7	Summary of January 1987 Vertical Sludge Composite Volatile Hazardous Substance List (HSL) Compound Results, Northern and Southern Impoundment Areas, ARCO Chemical Company, Gnadenhutten, Ohio
A-8	Summary of January 1987 Vertical Sludge Composite Volatile Hazardous Substance List (HSL) Compound Results, Sludge Pit Area, ARCO Chemical Company, Gnadenhutten, Ohio
A-9	Summary of January 1987 Southern Impoundment Soil Volatile Hazardous Substance List (HSL) Compound Results, ARCO Chemical Company, Gnadenhutten, Ohio
A-10	Summary of January 1987 Vertical Sludge Composite Acid and Base-Neutral Extractable Hazardous Substance List (HSL) Compound Results, Northern and Southern Impoundment Areas, ARCO Chemical Company, Gnadenhutten, Ohio
A-11	Summary of January 1987 Vertical Sludge Composite Acid and Base-Neutral Extractable Hazardous Substance List (HSL) Compound Results, Sludge Pit Area, ARCO Chemical Company, Gnadenhutten, Ohio
A-12	Summary of January 1987 Southern Impoundment Soil Acid and Base-Neutral Extractable Hazardous Substance List (HSL) Compound Results, ARCO Chemical Company, Gnadenhutten, Ohio

APPENDIX A

LIST OF TABLES
(Continued)

TABLE NO.	TITLE
A-13	Summary of January 1987 Vertical Sludge Composite Pesticide Hazardous Substance List (HSL) Compound Results, Northern and Southern Impoundment Areas, ARCO Chemical Company, Gnadenhutten, Ohio
A-14	Summary of January 1987 Vertical Sludge Composite Pesticide Hazardous Substance List (HSL) Compound Results, Sludge Pit Area, ARCO Chemical Company, Gnadenhutten, Ohio
A-15	Summary of January 1987 Southern Impoundment Soil Volatile Hazardous Substance List (HSL) Compound Results, ARCO Chemical Company, Gnadenhutten, Ohio

TABLE A-1

SUMMARY OF VOLATILE HAZARDOUS SUBSTANCE LIST
COMPOUND RESULTS
APRIL 1985 IMPOUNDMENT, SLUDGE PIT, AND SWAMP COMPOSITES(a)
ARCO CHEMICAL COMPANY
GRADENHUTTEN, OHIO

PARAMETERS	CAS NUMBER(b)	CONCENTRATION UNITS	SAMPLE IDENTIFICATION				
			N. IMPOUNDMENT SLUDGE COMPOSITE	S. IMPOUNDMENT SLUDGE COMPOSITE	SLUDGE PIT SLUDGE COMPOSITE	SWAMP SLUDGE COMPOSITE	SWAMP SOIL COMPOSITE
Acetone	67-64-1	ug/kg(c)	100U(d)	100U	100U	100U	100U
Acrolein	107-02-8	ug/kg	100U	100U	100U	100U	100U
Acrylonitrile	107-13-1	ug/kg	100U	100U	100U	100U	100U
Benzene	71-43-2	ug/kg	10U	10U	10U	10U	10U
Bromoform	75-25-2	ug/kg	10U	10U	10U	10U	10U
2-Butanone	78-93-3	ug/kg	100U	100U	100U	100U	100U
Carbon disulfide	75-15-0	ug/kg	100U	100U	100U	100U	100U
Carbon tetrachloride	56-23-5	ug/kg	10U	10U	10U	10U	10U
Chlorobenzene	108-90-7	ug/kg	10U	10U	10U	10U	10U
Chlorodibromomethane	124-48-1	ug/kg	10U	10U	10U	10U	10U
Chloroethane	75-00-3	ug/kg	10U	10U	10U	10U	10U
2-Chloroethylvinyl ether	110-75-8	ug/kg	100U	100U	100U	100U	100U
Chloroform	67-66-3	ug/kg	10U	10U	10U	10U	10U
Dichlorobromomethane	75-27-4	ug/kg	10U	10U	10U	10U	10U
1,1-Dichloroethane	75-34-3	ug/kg	10U	10U	10U	10U	10U
1,2-Dichloroethane	107-06-2	ug/kg	10U	10U	10U	10U	10U
1,1-Dichloroethylene	75-35-4	ug/kg	10U	10U	10U	10U	10U
1,2-Dichloropropane	78-87-5	ug/kg	10U	10U	10U	10U	10U
1,3-Dichloropropylene	542-75-6	ug/kg	10U	10U	10U	10U	10U
Ethylbenzene	100-41-4	ug/kg	10U	110,000	10U	10U	10U
2-Hexanone	591-78-6	ug/kg	100U	43,000	100U	100U	100U
Methyl bromide	74-83-9	ug/kg	100U	100U	100U	100U	100U
Methyl chloride	74-87-3	ug/kg	100U	100U	100U	100U	100U
Methylene chloride	75-09-2	ug/kg	100U	100U	100U	100U	100U
4-Methyl-2-pentanone	108-10-1	ug/kg	100U	100U	100U	100U	100U
Styrene	100-42-5	ug/kg	10U	10U	10U	10U	10U
1,1,2,2-Tetrachloroethane	79-34-5	ug/kg	10U	10U	10U	10U	10U
Tetrachloroethylene	127-18-4	ug/kg	10U	280	10U	10U	10U
Toluene	108-88-3	ug/kg	10U	5,300	10U	10U	10U
trans-1,2-Dichloroethylene	156-60-5	ug/kg	10U	10U	10U	10U	10U
1,1,1-Trichloroethane	71-55-6	ug/kg	10U	10U	10U	10U	10U
1,1,2-Trichloroethane	79-00-5	ug/kg	10U	10U	10U	10U	10U
Trichloroethylene	79-01-6	ug/kg	10U	10U	10U	10U	10U
Trichlorofluoromethane	75-69-4	ug/kg	10U	10U	10U	10U	10U
Vinyl acetate	108-05-4	ug/kg	100U	100U	100U	100U	100U
Vinyl chloride	75-01-4	ug/kg	100U	100U	100U	100U	100U
Total Xylenes	1330-02-7(e)	ug/kg	10U	410,000	12	10U	10U

(a)Samples were collected from April 1, 1985 to April 8, 1985.
(b)The numbers presented in this column are the Chemical Abstracts Service (CAS) numbers used for cataloging the indicated compounds in the Chemical Abstracts Index.

(c)"ug/kg" = micrograms per kilogram or parts per billion (ppb).

(d)"U" = analyzed for but not detected. The corresponding number represents the method detection limit for the sample.

(e)Total xylene includes the ortho-, meta-, and para-xylene isomers.

TABLE A-2

SUMMARY OF ACID AND BASE-NEUTRAL EXTRACTABLE
HAZARDOUS SUBSTANCE LIST COMPOUND RESULTS
APRIL 1985 IMPOUNDMENT, SLUDGE PIT, AND SWAMP COMPOSITES(a)
ARCO CHEMICAL COMPANY
CHARLESTOWN, OHIO

PARAMETERS	CAS NUMBER(b)	CONCENTRATION UNITS	SAMPLE IDENTIFICATION				
			N. IMPOUNDMENT SLUDGE COMPOSITE	S. IMPOUNDMENT SLUDGE COMPOSITE	SLUDGE PIT SLUDGE COMPOSITE	SWAMP SLUDGE COMPOSITE	SWAMP SOIL COMPOSITE
Acenaphthene	83-32-9	mg/kg(c)	0.10U(d)	0.10U	0.10U	0.10U	0.10U
Acenaphthylene	208-96-8	mg/kg	0.10U	0.10U	0.10U	0.10U	0.10U
Aniline	62-53-3	mg/kg	0.10U	0.10U	0.10U	0.10U	0.10U
Anthracene	120-12-7	mg/kg	0.10U	0.10U	0.10U	0.10U	0.10U
Benzidine	92-87-5	mg/kg	0.40U	0.40U	0.40U	0.40U	0.40U
Benzo(a)anthracene	56-55-3	mg/kg	0.10U	0.10U	0.10U	0.10U	0.10U
Benzoic acid	65-85-0	mg/kg	0.10U	0.10U	0.10U	0.10U	0.10U
Benzo(a)pyrene	50-32-8	mg/kg	0.10U	0.10U	0.10U	0.10U	0.10U
3,4-Benzofluoranthene	205-99-2	mg/kg	0.10U	0.10U	0.10U	0.10U	0.10U
Benzo(g,h,i)perylene	191-24-2	mg/kg	0.10U	0.10U	0.10U	0.10U	0.10U
Benzo(k)fluoranthene	207-08-9	mg/kg	0.10U	0.10U	0.10U	0.10U	0.10U
Benzyl alcohol	100-51-6	mg/kg	0.10U	0.10U	0.10U	0.10U	0.10U
Bis(2-chloroethoxy)methane	111-91-1	mg/kg	0.10U	0.10U	0.10U	0.10U	0.10U
Bis(2-chloroethyl)ether	111-44-4	mg/kg	0.10U	0.10U	0.10U	0.10U	0.10U
Bis(2-chloroisopropyl)ether	39638-32-9	mg/kg	0.10U	0.10U	0.10U	0.10U	0.10U
Bis(chloromethyl)ether(e)	542-88-1	mg/kg	0.40U	0.40U	0.40U	0.40U	0.40U
Bis(2-ethylhexyl)phthalate	117-81-7	mg/kg	1.5	1.1	2.6	2.9	0.75
4-Bromophenylphenylether	101-55-3	mg/kg	0.10U	0.10U	0.10U	0.10U	0.10U
Butylbenzylphthalate	85-68-7	mg/kg	0.10U	0.10U	0.10U	0.10U	0.10U
4-Chloroaniline	106-47-8	mg/kg	0.10U	0.10U	0.10U	0.10U	0.10U
p-Chloro-m-cresol	59-50-7	mg/kg	0.10U	0.10U	0.10U	0.10U	0.10U
2-Chloronaphthalene	91-58-7	mg/kg	0.10U	0.10U	0.10U	0.10U	0.10U
2-Chlorophenol	95-57-8	mg/kg	0.10U	0.10U	0.10U	0.10U	0.10U
4-Chlorophenylphenylether	7005-72-3	mg/kg	0.10U	0.10U	0.10U	0.10U	0.10U
Chrysene	218-01-9	mg/kg	0.10U	0.10U	0.10U	0.13	0.29
Dibenzo(a,h)anthracene	53-70-3	mg/kg	0.10U	0.10U	0.10U	0.10U	0.10U
Dibenzofuran	132-64-9	mg/kg	0.10U	0.10U	0.10U	0.10U	0.10U
1,2-Dichlorobenzene	95-50-1	mg/kg	0.10U	0.10U	0.10U	0.10U	0.10U
1,3-Dichlorobenzene	541-73-1	mg/kg	0.10U	0.10U	0.10U	0.10U	0.10U
1,4-Dichlorobenzene	106-46-7	mg/kg	0.10U	0.10U	0.10U	0.10U	0.10U
3,3'-Dichlorobenzidine	91-94-1	mg/kg	0.10U	0.10U	0.10U	0.10U	0.10U
2,4-Dichlorophenol	120-83-2	mg/kg	0.10U	0.10U	0.10U	0.10U	0.10U
Diethylphthalate	84-66-2	mg/kg	0.10	0.13	0.15	0.27	0.10U
2,4-Dimethylphenol	105-67-9	mg/kg	0.10U	0.10U	0.10U	0.10U	0.10U
Dimethyl phthalate	131-11-3	mg/kg	0.10U	0.10U	0.10U	0.10U	0.10U
-n-butylphthalate	84-74-2	mg/kg	0.31	0.80	0.35	0.52	0.29
6-Dinitro-o-cresol	534-52-1	mg/kg	1.0U	1.0U	1.0U	1.0U	1.0U
,4-Dinitrophenol	51-28-5	mg/kg	1.0U	1.0U	1.0U	1.0U	1.0U
2,4-Dinitrotoluene	121-14-2	mg/kg	0.10U	0.10U	0.10U	0.10U	0.10U
2,6-Dinitrotoluene	606-20-2	mg/kg	0.10U	0.10U	0.10U	0.10U	0.10U
Di-n-octylphthalate	117-84-0	mg/kg	0.10U	0.10U	0.10U	0.10U	0.10U
1,2-Diphenylhydrazine (Azobenzene)(f)	122-66-7	mg/kg	0.10U	0.10U	0.10U	0.10U	0.10U
Fluoranthene	206-44-0	mg/kg	0.10U	0.10U	0.10U	0.27	0.51
Fluorene	86-73-7	mg/kg	0.10U	0.10U	0.10U	0.10U	0.10U
Hexachlorobenzene	118-71-1	mg/kg	0.10U	0.10U	0.10U	0.10U	0.10U
Hexachlorobutadiene	87-68-3	mg/kg	0.10U	0.10U	0.10U	0.10U	0.10U
Hexachlorocyclopentadiene	77-47-4	mg/kg	0.10U	0.10U	0.10U	0.10U	0.10U
Hexachloroethane	67-72-1	mg/kg	0.10U	0.10U	0.10U	0.10U	0.10U
Indeno(1,2,3-cd)pyrene	193-39-5	mg/kg	0.10U	0.10U	0.10U	0.10U	0.10U
Isophorone	78-59-1	mg/kg	0.40U	16	0.40U	0.40U	0.40U
2-Methylnaphthalene	91-57-6	mg/kg	0.10U	0.10U	0.10U	0.18	0.19
2-Methylphenol	95-48-7	mg/kg	0.10U	0.10U	0.10U	0.10U	0.10U
4-Methylphenol	106-44-5	mg/kg	0.10U	0.10U	0.10U	0.10U	0.10U
Naphthalene	91-20-3	mg/kg	0.10U	200	0.10U	0.17	0.21
2-Nitroaniline	88-74-4	mg/kg	0.10U	0.10U	0.10U	0.10U	0.10U
3-Nitroaniline	99-09-2	mg/kg	0.10U	0.10U	0.10U	0.10U	0.10U
4-Nitroaniline	100-01-6	mg/kg	0.10U	0.10U	0.10U	0.10U	0.10U
Nitrobenzene	98-95-3	mg/kg	0.10U	0.10U	0.10U	0.10U	0.10U
2-Nitrophenol	88-75-5	mg/kg	0.10U	0.10U	0.10U	0.10U	0.10U
4-Nitrophenol	100-02-7	mg/kg	0.10U	1.5	0.10U	0.10U	0.10U
N-Nitrosodimethylamine	62-75-9	mg/kg	0.10U	0.10U	0.10U	0.10U	0.10U
N-Nitrosodi-n-propylamine	621-64-7	mg/kg	0.10U	0.10U	0.10U	0.10U	0.10U
N-Nitrosodiphenylamine (Diphenylamine)(f)	86-30-6	mg/kg	0.10U	0.65	0.12	0.67	0.32
Pentachlorophenol	87-86-5	mg/kg	0.10U	0.10U	0.10U	0.10U	0.10U
Phenanthrene	85-01-8	mg/kg	0.10U	0.12	0.10U	0.32	0.38
Phenol	108-95-2	mg/kg	0.10U	0.16	0.16	0.10U	0.10U
Pyrene	129-00-0	mg/kg	0.10U	0.10U	0.10U	0.38	0.66
1,2,4-Trichlorobenzene	120-82-1	mg/kg	0.10U	0.10U	0.10U	0.10U	0.10U
2,3,7,8-Tetrachlorodibenzo-p-dioxin	1746-01-6	mg/kg	0.10U	0.10U	0.10U	0.10U	0.10U
2,4,5-Trichlorophenol	95-95-4	mg/kg	0.10U	0.10U	0.10U	0.10U	0.10U
2,4,6-Trichlorophenol	88-06-2	mg/kg	0.10U	0.10U	0.10U	0.10U	0.10U

(a)Samples were collected from April 1, 1985 to April 8, 1985.

(b)The numbers presented in this column are the Chemical Abstracts Service (CAS) numbers used for cataloging the indicated compounds in the Chemical Abstracts Index.

)"mg/kg" = milligrams per kilogram or parts per million (ppm).

d)"U" = analyzed for but not detected. The corresponding number represents the method detection limit for the sample.

(e)The indicated compound decomposes rapidly in water.

(f)The indicated compound is detected as the compound in parentheses.

TABLE A-3

SUMMARY OF PESTICIDE HAZARDOUS SUBSTANCE LIST
COMPOUND RESULTS
APRIL 1985 IMPOUNDMENT, SLUDGE PIT, AND SWAMP COMPOSITES(a)
ARCO CHEMICAL COMPANY
CHAGRIN FALLS, OHIO

PARAMETERS	CAS NUMBER(b)	CONCENTRATION UNITS	SAMPLE IDENTIFICATION				
			N. IMPOUNDMENT SLUDGE COMPOSITE	S. IMPOUNDMENT SLUDGE COMPOSITE	SLUDGE PIT SLUDGE COMPOSITE	SWAMP SLUDGE COMPOSITE	SWAMP SOIL COMPOSITE
alpha-BHC	319-84-6	mg/kg(c)	0.010U(d)	0.010U	0.010U	0.010U	0.010U
gamma-BHC (lindane)	58-89-9	mg/kg	0.010U	0.010U	0.010U	0.010U	0.010U
beta-BHC	319-85-7	mg/kg	0.010U	0.010U	0.010U	0.010U	0.010U
Heptachlor	76-44-8	mg/kg	0.010U	0.010U	0.010U	0.010U	0.010U
delta-BHC	319-86-8	mg/kg	0.010U	0.010U	0.010U	0.010U	0.010U
Aldrin	309-00-2	mg/kg	0.010U	0.010U	0.010U	0.010U	0.010U
Heptaclor epoxide	1024-57-3	mg/kg	0.010U	0.010U	0.010U	0.010U	0.010U
Endosulfan I	115-29-7	mg/kg	0.010U	0.010U	0.010U	0.010U	0.010U
Dieldrin	60-57-1	mg/kg	0.020U	0.020U	0.020U	0.020U	0.020U
4,4'-DDE	72-55-9	mg/kg	0.020U	0.020U	0.020U	0.020U	0.020U
Endrin	72-20-8	mg/kg	0.020U	0.066	0.032	0.020U	0.020U
Endosulfan II	115-29-7	mg/kg	0.020U	0.020U	0.020U	0.020U	0.020U
4,4'-DDD	72-54-8	mg/kg	0.020U	0.020U	0.020U	0.020U	0.020U
4,4'-DDT	50-29-3	mg/kg	0.020U	0.020U	0.020U	0.020U	0.020U
Endrin aldehyde	7421-93-4	mg/kg	0.020U	0.020U	0.020U	0.020U	0.020U
Endosulfan sulfate	1031-07-8	mg/kg	0.020U	0.020U	0.020U	0.020U	0.020U
Methoxychlor	72-43-5	mg/kg	0.10U	0.10U	0.10U	0.10U	0.10U
Chlordane	57-74-9	mg/kg	0.10U	0.10U	0.10U	0.10U	0.10U
Toxaphene	8001-35-2	mg/kg	0.20U	0.20U	0.20U	0.20U	0.20U
Aroclor 1016	12674-11-2	mg/kg	1.0U	1.0U	1.0U	1.0U	1.0U
Aroclor 1221	11104-28-2	mg/kg	1.0U	1.0U	1.0U	1.0U	1.0U
Aroclor 1232	11141-16-5	mg/kg	1.0U	1.0U	1.0U	1.0U	1.0U
Aroclor 1242	53469-21-9	mg/kg	1.0U	1.0U	1.0U	1.0U	1.0U
Aroclor 1248	12672-29-6	mg/kg	1.0U	1.0U	1.0U	1.2	10
Aroclor 1254	11097-69-1	mg/kg	1.0U	1.0U	1.0U	1.0U	1.0U
Aroclor 1260	11096-82-5	mg/kg	1.0U	1.0U	1.0U	1.0U	1.0U

(a) Samples were collected from April 1, 1985 to April 8, 1985.

(b) The numbers presented in this column are the Chemical Abstracts Service (CAS) numbers used for cataloging the indicated compounds in the Chemical Abstracts Index.

(c) "mg/kg" = milligrams per kilogram or parts per million (ppm).

(d) "U" = analyzed for but not detected. The corresponding number represents the method detection limit for the sample.

TABLE A-4

SUMMARY OF NOVEMBER 1986 VOLATILE HAZARDOUS SUBSTANCE LIST
COMPOUND RESULTS
NORTHERN AND SOUTHERN IMPOUNDMENT AREAS(a)
ARCO CHADENHUTTEN PLANT
CHADENHUTTEN, OHIO

PARAMETERS	CAS REGISTRY NUMBER(b)	CONCENTRATION UNITS(c)	SLUDGE COMPOSITE	SAMPLE IDENTIFICATION NORTHERN IMPOUNDMENT AREA S-1 SOIL (9.4-10.0')	S-1 SOIL (10.0-10.6')	S-3 SOIL (3.8-5.5')	S-3 SOIL (5.5-6.5')
Chloromethane	74-87-3	ug/kg	450U(d)	100U	100U	110U	110U
Bromomethane	74-83-9	ug/kg	450U	100U	100U	110U	110U
Vinyl chloride	75-01-4	ug/kg	450U	100U	100U	110U	110U
Chloroethane	75-00-3	ug/kg	450U	100U	100U	110U	110U
Methylene chloride	75-09-2	ug/kg	630B(e)	75B	210B	190B	290B
Acetone	67-64-1	ug/kg	350JB(f)	310B	100B	75JB	94JB
Carbon disulfide	75-15-0	ug/kg	225U	50U	50U	55U	55U
1,1-Dichloroethene	75-35-4	ug/kg	225U	50U	50U	55U	55U
1,1-Dichloroethane	75-34-3	ug/kg	225U	50U	50U	55U	55U
trans-1,2-Dichloroethene	156-60-5	ug/kg	225U	50U	50U	55U	55U
Chloroform	67-66-3	ug/kg	330B	75B	62B	99B	79B
1,2-Dichloroethane	107-06-2	ug/kg	225U	8.4J	20J	30J	40J
2-Butanone	78-93-3	ug/kg	210JB	37JB	23JB	32JB	39JB
1,1,1-Trichloroethane	71-55-6	ug/kg	225U	50U	50U	55U	55U
Carbon tetrachloride	56-23-5	ug/kg	225U	50U	50U	55U	55U
Vinyl acetate	108-05-4	ug/kg	450U	100U	100U	110U	110U
Bromodichloromethane	75-27-4	ug/kg	225U	50U	50U	55U	55U
1,2-Dichloropropane	78-87-5	ug/kg	225U	50U	50U	55U	55U
trans-1,3-Dichloropropene	10061-02-6	ug/kg	225U	50U	50U	55U	55U
Trichloroethene	79-01-6	ug/kg	225U	50U	50U	55U	55U
Dibromochloromethane	124-48-1	ug/kg	225U	50U	50U	55U	55U
1,1,2-Trichloromethane	79-00-5	ug/kg	225U	50U	50U	55U	55U
Benzene	71-43-2	ug/kg	225U	50U	5.4J	55U	7.3J
cis-1,3-Dichloropropene	10061-01-05	ug/kg	225U	50U	50U	55U	55U
2-Chloroethylvinylether	110-75-8	ug/kg	450U	100U	100U	110U	110U
Bromoform	75-25-2	ug/kg	225U	50U	50U	55U	55U
4-Methyl-2-pentanone	591-78-6	ug/kg	450U	100U	100U	110U	110U
2-Hexanone	108-10-1	ug/kg	54J	33J	100U	110U	110U
Tetrachloroethene	127-18-4	ug/kg	225U	50U	50U	55U	55U
1,1,2,2-Tetrachloroethane	79-34-5	ug/kg	225U	50U	50U	55U	55U
Toluene	108-88-3	ug/kg	32JB	9.2JB	10JB	8.5JB	8.6JB
Chlorobenzene	108-90-7	ug/kg	225U	50U	50U	55U	55U
Ethylbenzene	100-41-4	ug/kg	29JB	11JB	11JB	8.8JB	6.5JB
Styrene	100-42-5	ug/kg	225U	50U	4.5JB	5.8JB	55U
Total Xylene(g)	1330-20-7	ug/kg	62JB	31JB	18JB	12JB	21JB

See footnotes at end of table.

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TABLE A-4
(Continued)

PARAMETERS	CAS REGISTRY NUMBER(b)	CONCENTRATION UNITS(c)	SLUDGE COMPOSITE	SAMPLE IDENTIFICATION SOUTHERN IMPOUNDMENT AREA S-4 SOIL (6.0-8.0')	S-5 SOIL (9.5-11')	S-6 SOIL (10.1-11.4')
Chloromethane	74-87-3	ug/kg	380U	100U	100U	100U
Bromomethane	74-83-9	ug/kg	380U	100U	100U	100U
Vinyl Chloride	75-01-4	ug/kg	380U	100U	100U	100U
Chloroethane	75-00-3	ug/kg	380U	100U	100U	100U
Methylene Chloride	75-09-2	ug/kg	780B	250B	25JB	21JB
Acetone	67-64-1	ug/kg	480B	77JB	200B	120B
Carbon Disulfide	75-15-0	ug/kg	190U	50U	50U	50U
1,1-Dichloroethene	75-35-4	ug/kg	190U	50U	50U	50U
1,1-Dichloroethane	75-34-3	ug/kg	190U	50U	50U	50U
trans-1,2-Dichloroethene	156-60-5	ug/kg	190U	50U	50U	50U
Chloroform	67-66-3	ug/kg	290B	72B	35JB	34JB
1,2-Dichloroethane	107-06-2	ug/kg	190U	18J	6.9J	19J
2-Butanone	78-93-3	ug/kg	140JB	45JB	13JB	16JB
1,1,1-Trichloroethane	71-55-6	ug/kg	190U	50U	50U	50U
Carbon Tetrachloride	56-23-5	ug/kg	190U	50U	50U	50U
Vinyl Acetate	108-05-4	ug/kg	380U	100U	100U	100U
Bromodichloromethane	75-27-4	ug/kg	190U	50U	50U	50U
1,2-Dichloropropane	78-87-5	ug/kg	190U	50U	50U	50U
trans-1,3-Dichloropropene	10061-02-6	ug/kg	190U	50U	50U	50U
Trichloroethene	79-01-6	ug/kg	190U	50U	50U	50U
Dibromochloromethane	124-48-1	ug/kg	190U	50U	50U	50U
1,1,2-Trichloroethane	79-00-5	ug/kg	190U	50U	50U	50U
Benzene	71-43-2	ug/kg	190U	6.6J	50U	50U
cis-1,3-Dichloropropene	10061-01-05	ug/kg	190U	50U	50U	50U
2-Chloroethylvinylether	110-75-8	ug/kg	380U	100U	100U	100U
Bromoform	75-25-2	ug/kg	190U	50U	50U	50U
4-Methyl-2-Pentanone	591-78-6	ug/kg	380U	100U	100U	100U
2-Hexanone	108-10-1	ug/kg	380U	100U	100U	100U
Tetrachloroethene	127-18-4	ug/kg	190U	50U	50U	7.0J
1,1,2,2-Tetrachloroethane	79-34-5	ug/kg	190U	50U	50U	50U
Toluene	108-88-3	ug/kg	43JB	8.1JB	50U	50U
Chlorobenzene	108-90-7	ug/kg	190U	50U	50U	50U
Ethylbenzene	100-41-4	ug/kg	170JB	15JB	5.4J	7.1JB
Styrene	100-42-5	ug/kg	190U	50U	50U	50U
Total Xylene(g)	1330-20-7	ug/kg	880B	62B	15J	18J

(a)Samples were collected from November 17, 1986 to November 25, 1986.

(b)The numbers presented in this column are the Chemical Abstracts Service (CAS) Registry Numbers used for cataloging the indicated compounds in the Chemical Abstracts Index.

(c)"ug/kg" equals micrograms per kilogram or parts per billion (ppb).

(d)"U" indicates that the compound was analyzed, but not detected. The corresponding number represents the method detection limit for the sample.

(e)"B" indicates that the corresponding compound was found in the blank as well as the sample.

(f)"J" indicates that the corresponding compound is present, but the calculated concentration is less than the specified detection limit.

(g)Total xylene includes the ortho-, meta-, and para-xylene isomers.

00001853

TABLE A-5

SUMMARY OF NOVEMBER 1986 ACID AND BASE-NEUTRAL EXTRACTABLE
HAZARDOUS SUBSTANCE LIST COMPOUND RESULTS
NORTHERN AND SOUTHERN IMPOUNDMENT AREAS(a)
ARCO CHARDEMUTTER PLANT
CHARDEMUTTER, OHIO

PARAMETERS	CAS REGISTRY NUMBER(b)	CONCENTRATION UNITS(c)	SAMPLE IDENTIFICATION NORTHERN IMPOUNDMENT AREA S-1 SOIL (9.4-10.0')	S-1 SOIL (10.0-10.6')	S-3 SOIL (3.8-5.5')	S-3 SOIL (5.5-6.5')
Phenol	108-95-2	ug/kg	390U(d)	365U	410U	410U
bis(2-Chloroethyl)ether	111-44-4	ug/kg	390U	365U	410U	410U
2-Chlorophenol	95-57-8	ug/kg	390U	365U	410U	410U
1,3-Dichlorobenzene	541-73-1	ug/kg	54JB(e,f)	62JB	260JB	180JB
1,4-Dichlorobenzene	106-46-7	ug/kg	390U	365U	410U	410U
Benzyl Alcohol	100-51-6	ug/kg	390U	365U	410U	410U
1,2-Dichlorobenzene	95-50-1	ug/kg	390U	365U	160J	410U
2-Methylphenol	95-48-7	ug/kg	390U	365U	410U	410U
bis(2-Chloroisopropyl)Ether	39638-32-9	ug/kg	390U	365U	410U	410U
4-Methylphenol	106-44-5	ug/kg	390U	365U	410U	410U
N-Nitroso-di-n-propylamine	621-64-7	ug/kg	390U	365U	410U	410U
Hexachloroethane	67-72-1	ug/kg	390U	365U	410U	410U
Nitrobenzene	98-95-3	ug/kg	390U	365U	410U	410U
Isophorone	78-59-1	ug/kg	390U	365U	410U	410U
2-Nitrophenol	88-75-5	ug/kg	390U	365U	410U	410U
2,4-Dimethylphenol	105-67-9	ug/kg	390U	365U	410U	410U
Benzoic Acid	65-85-0	ug/kg	1,900U	1,800U	2,000U	2,000U
bis(2-Chloroethoxy)methane	111-91-1	ug/kg	390U	365U	410U	410U
2,4-Dichlorophenol	120-83-2	ug/kg	390U	365U	410U	410U
1,2,4-Trichlorobenzene	120-82-1	ug/kg	390U	365U	410U	410U
Naphthalene	91-20-3	ug/kg	390U	365U	410U	410U
4-Chloroaniline	106-47-8	ug/kg	390U	365U	410U	410U
Hexachlorobutadiene	87-68-3	ug/kg	390U	365U	410U	410U
4-Chloro-3-methylphenol	59-50-7	ug/kg	390U	365U	410U	410U
2-Methylnaphthalene	91-57-6	ug/kg	390U	365U	410U	410U
Hexachlorocyclopentadiene	77-47-4	ug/kg	390U	365U	410U	410U
2,4,6-Trichlorophenol	88-06-2	ug/kg	390U	365U	410U	410U
2,4,5-Trichlorophenol	95-95-4	ug/kg	1,900U	1,800U	2,000U	2,000U
2-Chloronaphthalene	91-58-7	ug/kg	390U	365U	410U	410U
2-Nitroaniline	88-74-4	ug/kg	1,900U	1,800U	2,000U	2,000U
Dimethylphthalate	131-11-3	ug/kg	390U	365U	410U	410U
Acenaphthylene	208-96-8	ug/kg	390U	365U	410U	410U
3-Nitroaniline	99-09-2	ug/kg	1,900U	1,800U	2,000U	2,000U
Acenaphthene	83-32-9	ug/kg	390U	365U	410U	50U
2,4-Dinitrophenol	51-28-5	ug/kg	1,900U	1,800U	2,000U	2,000U
4-Nitrophenol	100-02-7	ug/kg	1,900U	1,800U	2,000U	2,000U
Dibenzofuran	132-64-9	ug/kg	390U	365U	410U	410U
2,4-Dinitrotoluene	121-14-2	ug/kg	390U	365U	410U	410U
2,6-Dinitrotoluene	606-20-2	ug/kg	390U	365U	410U	410U
Diethylphthalate	84-66-2	ug/kg	390U	365U	410U	410U
4-Chlorophenylphenylether	7005-72-3	ug/kg	390U	365U	410U	410U
Fluorene	86-73-7	ug/kg	390U	365U	410U	410U
4-Nitroaniline	100-01-6	ug/kg	1,900U	1,800U	2,000U	2,000U
4,6-Dinitro-2-methylphenol	534-52-1	ug/kg	1,900U	1,800U	2,000U	2,000U
N-Nitrosodiphenylamine(g)	86-30-6	ug/kg	61J	57J	72J	51J
4-Bromophenylphenylether	101-55-3	ug/kg	390U	365U	410U	410U
Hexachlorobenzene	118-74-1	ug/kg	390U	365U	410U	410U
Pentachlorophenol	87-86-5	ug/kg	1,900U	1,800U	410U	2,000U
Phenanthrene	85-01-8	ug/kg	390U	365U	410U	410U
Anthracene	120-12-7	ug/kg	390U	365U	410U	410U
Di-n-butylphthalate	84-74-2	ug/kg	390U	365U	410U	410U
Fluoranthene	206-44-0	ug/kg	390U	365U	410U	410U
Pyrene	129-00-0	ug/kg	390U	365U	410U	410U
Butylbenzylphthalate	85-68-7	ug/kg	390U	365U	410U	410U
3,3'-Dichlorobenzidine	91-94-1	ug/kg	780U	730U	820U	820U
Benzo(a)anthracene	56-55-3	ug/kg	390U	365U	410U	410U
bis(2-Ethylhexyl)phthalate	117-81-7	ug/kg	39J	53J	410U	410U
Chrysene	218-01-9	ug/kg	390U	365U	410U	410U
Di-n-octylphthalate	117-84-0	ug/kg	390U	365U	410U	410U
Benzo(b)fluoranthene	205-99-2	ug/kg	390U	365U	410U	410U
Benzo(k)fluoranthene	207-08-9	ug/kg	390U	365U	410U	410U
Benzo(a)pyrene	50-32-8	ug/kg	390U	365U	410U	410U
Indeno(1,2,3-cd)pyrene	193-39-5	ug/kg	390U	365U	410U	410U
Dibenz(a,h)anthracene	53-70-3	ug/kg	390U	365U	410U	410U
Benzo(g,h,i)perylene	191-24-2	ug/kg	390U	365U	410U	410U

See footnotes at end of table.

TABLE 4-5
(Continued)

PARAMETERS	CAS REGISTRY NUMBER(b)	CONCENTRATION UNITS(c)	SAMPLE IDENTIFICATION SOUTHERN IMPOUNDMENT AREA S-4 SLUDGE COMPOSITE	S-5 SLUDGE COMPOSITE	S-4 SLUDGE COMPOSITE	S-4 SOIL (6.0-8.0')	S-5 SOIL 9.5-11.0')	S-4 SOIL (10.1-11.[illegible]
Phenol	108-95-2	ug/kg	410U	385U	390U	410U	385U	385U
bis(2-Chloroethyl)ether	111-44-4	ug/kg	410U	385U	390U	410U	385U	385U
2-Chlorophenol	95-57-8	ug/kg	410U	385U	390U	410U	385U	385U
1,3-Dichlorobenzene	541-73-1	ug/kg	410U	385U	390U	180JB	130JB	210JB
1,4-Dichlorobenzene	106-46-7	ug/kg	410U	385U	390U	410U	385U	385U
Benzyl Alcohol	100-51-6	ug/kg	410U	385U	390U	410U	385U	385U
1,2-Dichlorobenzene	95-50-1	ug/kg	410U	385U	390U	410U	385U	385U
2-Methylphenol	95-48-7	ug/kg	410U	385U	390U	410U	385U	385U
bis(2-Chloroisopropyl)Ether	39638-32-9	ug/kg	410U	385U	390U	410U	385U	385U
4-Methylphenol	106-44-5	ug/kg	410U	385U	390U	410U	385U	385U
N-Nitroso-di-n-propylamine	621-64-7	ug/kg	410U	385U	390U	410U	385U	385U
Hexachloroethane	67-72-1	ug/kg	410U	385U	390U	410U	385U	385U
Nitrobenzene	98-95-3	ug/kg	410U	385U	390U	410U	385U	385U
Isophorone	78-59-1	ug/kg	410U	385U	390U	410U	385U	385U
2-Nitrophenol	88-75-5	ug/kg	410U	385U	390U	410U	385U	385U
2,4-Dimethylphenol	105-67-9	ug/kg	410U	385U	390U	410U	385U	385U
Benzoic Acid	65-85-0	ug/kg	2,000U	1,900U	1,900U	2,000U	1,900U	1,900U
bis(2-Chloroethoxy)methane	111-91-1	ug/kg	410U	385U	390U	410U	385U	385U
2,4-Dichlorophenol	120-83-2	ug/kg	410U	385U	390U	410U	385U	385U
1,2,4-Trichlorobenzene	120-82-1	ug/kg	410U	385U	390U	410U	385U	385U
Naphthalene	91-20-3	ug/kg	410U	385U	390U	410U	385U	385U
4-Chloroaniline	106-47-8	ug/kg	410U	385U	390U	410U	385U	385U
Hexachlorobutadiene	87-68-3	ug/kg	410U	385U	390U	410U	385U	385U
4-Chloro-3-methylphenol	59-50-7	ug/kg	410U	385U	390U	410U	385U	385U
2-Methylnaphthalene	91-57-6	ug/kg	410U	385U	390U	410U	385U	385U
Hexachlorocyclopentadiene	77-47-4	ug/kg	410U	385U	390U	410U	385U	385U
2,4,6-Trichlorophenol	88-06-2	ug/kg	410U	385U	390U	410U	385U	385U
2,4,5-Trichlorophenol	95-95-4	ug/kg	2,000U	1,900U	1,900U	2,000U	1,900U	1,900U
2-Chloronaphthalene	91-58-7	ug/kg	410U	385U	390U	410U	385U	385U
2-Nitroaniline	88-74-4	ug/kg	2,000U	1,900U	1,900U	2,000U	1,900U	1,900U
Dimethylphthalate	131-11-3	ug/kg	410U	385U	390U	410U	385U	385U
Acenaphthylene	208-96-8	ug/kg	410U	385U	390U	410U	385U	385U
3-Nitroaniline	99-09-2	ug/kg	2,000U	1,900U	1,900U	2,000U	1,900U	1,900U
Acenaphthene	83-32-9	ug/kg	410U	385U	390U	410U	385U	385U
2,4-Dinitrophenol	51-28-5	ug/kg	2,000U	1,900U	1,900U	2,000U	1,900U	1,900U
4-Nitrophenol	100-02-7	ug/kg	2,000U	1,900U	1,900U	2,000U	1,900U	1,900U
Dibenzofuran	132-64-9	ug/kg	410U	385U	390U	410U	385U	385U
2,4-Dinitrotoluene	121-14-2	ug/kg	410U	385U	390U	410U	385U	385U
2,6-Dinitrotoluene	606-20-2	ug/kg	410U	385U	390U	410U	385U	385U
Diethylphthalate	84-66-2	ug/kg	410U	385U	390U	410U	385U	385U
4-Chlorophenylphenylether	7005-72-3	ug/kg	410U	385U	390U	410U	385U	385U
Fluorene	86-73-7	ug/kg	410U	385U	390U	410U	385U	385U
4-Nitroaniline	100-01-6	ug/kg	2,000U	1,900U	1,900U	2,000U	1,900U	1,900U
4,6-Dinitro-2-methylphenol	534-52-1	ug/kg	2,000U	1,900U	1,900U	2,000U	1,900U	1,900U
N-Nitrosodiphenylamine(g)	86-30-6	ug/kg	43JB	54JB	54JB	54J	53J	55J
4-Bromophenylphenylether	101-55-3	ug/kg	410U	385U	390U	410U	385U	385U
Hexachlorobenzene	118-74-1	ug/kg	410U	385U	390U	410U	385U	385U
Pentachlorophenol	87-86-5	ug/kg	2,000U	1,900U	1,900U	2,000U	1,900U	1,900U
Phenanthrene	85-01-8	ug/kg	410U	385U	390U	410U	385U	385U
Anthracene	120-12-7	ug/kg	410U	385U	390U	410U	385U	385U
Di-n-butylphthalate	84-74-2	ug/kg	61JB	53JB	61JB	410U	385U	385U
Fluoranthene	206-44-0	ug/kg	410U	385U	390U	410U	385U	385U
Pyrene	129-00-0	ug/kg	410U	385U	390U	410U	385U	385U
Butylbenzylphthalate	85-68-7	ug/kg	410U	385U	390U	410U	385U	385U
3,3'-Dichlorobenzidine	91-94-1	ug/kg	820U	770U	790U	820U	770U	770U
Benzo(a)Anthracene	56-55-3	ug/kg	410U	385U	390U	410U	385U	385U
bis(2-Ethylhexyl)phthalate	117-81-7	ug/kg	410U	385U	390U	410U	385U	385U
Chrysene	218-01-9	ug/kg	410U	385U	390U	410U	385U	385U
Di-n-octylphthalate	117-84-0	ug/kg	410U	385U	390U	410U	385U	385U
Benzo(b)fluoranthene	205-99-2	ug/kg	410U	385U	390U	410U	385U	385U
Benzo(k)fluoranthene	207-08-9	ug/kg	410U	385U	390U	410U	385U	385U
Benzo(a)pyrene	50-32-8	ug/kg	410U	385U	390U	410U	385U	385U
Indeno(1,2,3-cd)pyrene	193-39-5	ug/kg	410U	385U	390U	410U	385U	385U
Dibenz(a,h)anthracene	53-70-3	ug/kg	410U	385U	390U	410U	385U	385U
Benzo(g,h,i)perylene	191-24-2	ug/kg	410U	385U	390U	410U	385U	385U

(a)Samples were collected from November 17, 1986 to November 25, 1986.

(b)The numbers presented in this column are the Chemical Abstracts Service (CAS) Registry Numbers used for cataloging the indicated compounds in the Chemical Abstracts Index.

(c)"ug/kg" equals micrograms per kilogram or parts per billion (ppb).

(d)"U" indicates that the compound was analyzed, but not detected. The corresponding number represents the method detection limit for the sample.

(e)"J" indicates that the corresponding compound is present, but the calculated concentration is less than the specified detection limit.

(f)"B" indicates that the corresponding compound was found in the blank as well as the sample.

(g)The indicated compound is detected as diphenylamine.

TABLE A-6

SUMMARY OF NOVEMBER 1986 PESTICIDE HAZARDOUS SUBSTANCE LIST
COMPOUND RESULTS
NORTHERN AND SOUTHERN IMPOUNDMENT AREAS(a)
ARCO CHADENHUTTEN PLANT
CHADENHUTTEN, OHIO

PARAMETERS	CAS REGISTRY NUMBER(b)	CONCENTRATION UNITS(c)	SAMPLE IDENTIFICATION NORTHERN IMPOUNDMENT AREA S-1 SOIL (9.4-10.0')	S-1 SOIL (10.0-10.6')	S-3 SOIL (3.8-5.5')	S-3 SOIL (5.5-6.5')
alpha-BHC	319-84-6	ug/kg	8.0U(d)	8.0U	8.0U	8.0U
beta-BHC	319-85-7	ug/kg	8.0U	8.0U	8.0U	8.0U
delta-BHC	319-86-8	ug/kg	8.0U	8.0U	8.0U	8.0U
gamma-BHC(Lindane)	58-89-9	ug/kg	8.0U	8.0U	8.0U	8.0U
Heptachlor	76-44-8	ug/kg	8.0U	8.0U	8.0U	8.0U
Aldrin	309-00-2	ug/kg	8.0U	8.0U	8.0U	8.0U
Heptachlor epoxide	1024-57-3	ug/kg	8.0U	8.0U	8.0U	8.0U
Endosulfan I	959-98-8	ug/kg	8.0U	8.0U	8.0U	8.0U
Dieldrin	60-57-1	ug/kg	16U	16U	16U	16U
4,4'-DDE	72-55-9	ug/kg	16U	16U	16U	16U
Endrin	72-20-8	ug/kg	16U	16U	16U	16U
Endosulfan II	33213-65-9	ug/kg	16U	16U	16U	16U
4,4'-DDD	72-54-8	ug/kg	16U	16U	16U	16U
Endosulfan sulfate	1031-07-8	ug/kg	16U	16U	16U	16U
4,4'-DDT	50-29-3	ug/kg	16U	16U	16U	16U
Methoxychlor	72-43-5	ug/kg	80U	80U	80U	80U
Endrin ketone	53494-70-5	ug/kg	16U	16U	16U	16U
Chlordane	57-74-9	ug/kg	80U	80U	80U	80U
Toxaphene	8001-35-2	ug/kg	160U	160U	160U	160U
Aroclor 1016	12674-11-2	ug/kg	80U	80U	80U	80U
Aroclor 1221	11104-28-2	ug/kg	80U	80U	80U	80U
Aroclor 1232	11141-16-5	ug/kg	80U	80U	80U	80U
Aroclor 1242	53469-21-9	ug/kg	80U	80U	80U	80U
Aroclor 1248	12672-29-6	ug/kg	80U	80U	80U	80U
Aroclor 1254	11097-69-1	ug/kg	160U	160U	160U	160U
Aroclor 1260	11096-82-5	ug/kg	160U	160U	160U	160U

See footnotes at end of table.

G0001856

TABLE A
(Continued)

PARAMETERS	CAS REGISTRY NUMBER(b)	CONCENTRATION UNITS(c)	SAMPLE IDENTIFICATION SOUTHERN IMPOUNDMENT AREA S-4 SOIL (6.0-8.0')	S-5 SOIL (9.5-11.0')	S-6 SOIL (10.1-11.4')
alpha-BHC	319-84-6	ug/kg	8.0U	8.0U	8.0U
beta-BHC	319-85-7	ug/kg	8.0U	8.0U	8.0U
delta-BHC	319-86-8	ug/kg	8.0U	8.0U	8.0U
gamma-BHC(Lindane)	58-89-9	ug/kg	8.0U	8.0U	8.0U
Heptachlor	76-44-8	ug/kg	8.0U	8.0U	8.0U
Aldrin	309-00-2	ug/kg	8.0U	8.0U	8.0U
Heptachlor epoxide	1024-57-3	ug/kg	8.0U	8.0U	8.0U
Endosulfan I	959-98-8	ug/kg	8.0U	8.0U	8.0U
Dieldrin	60-57-1	ug/kg	16U	16U	16U
4,4'-DDE	72-55-9	ug/kg	16U	16U	16U
Endrin	72-20-8	ug/kg	16U	16U	16U
Endosulfan II	33213-65-9	ug/kg	16U	16U	16U
4,4'-DDD	72-54-8	ug/kg	16U	16U	16U
Endosulfan sulfate	1031-07-8	ug/kg	16U	16U	16U
4,4'-DDT	50-29-3	ug/kg	16U	16U	16U
Methoxychlor	72-43-5	ug/kg	80U	80U	80U
Endrin ketone	53494-70-5	ug/kg	16U	16U	16U
Chlordane	57-74-9	ug/kg	80U	80U	80U
Toxaphene	8001-35-2	ug/kg	160U	160U	160U
Aroclor 1016	12674-11-2	ug/kg	80U	80U	80U
Aroclor 1221	11104-28-2	ug/kg	80U	80U	80U
Aroclor 1232	11141-16-5	ug/kg	80U	80U	80U
Aroclor 1242	53469-21-9	ug/kg	80U	80U	80U
Aroclor 1248	12672-29-6	ug/kg	80U	80U	80U
Aroclor 1254	11097-69-1	ug/kg	160U	160U	160U
Aroclor 1260	11096-82-5	ug/kg	160U	160U	160U

(a)Samples were collected from November 17, 1986 to November 25, 1986.

(b)The numbers presented in this column are the Chemical Abstracts Service Register Numbers used for cataloging the indicated compounds in the Chemical Abstracts Index.

(c)"ug/kg" equals micrograms per kilogram or parts per billion (ppb).

(d)"U" indicates that the compound was analyzed, but not detected. The corresponding number represents the method detection limit for the sample.

00001857

TABLE A-7

SUMMARY OF JANUARY 1987 VERTICAL SLUDGE COMPOSITE VOLATILE
HAZARDOUS SUBSTANCE LIST (HSL) COMPOUND RESULTS
NORTHERN AND SOUTHERN IMPOUNDMENT AREAS(a)
ARCO CHEMICAL COMPANY
CHARLESTOWN, OHIO

PARAMETERS	CAS REGISTRY NUMBER(b)	CONCENTRATION UNITS(c)	SAMPLE IDENTIFICATION: NORTHERN IMPOUNDMENT AREA S-1 VERTICAL COMPOSITE	S-2 VERTICAL COMPOSITE	S-3 VERTICAL COMPOSITE	SOUTHERN IMPOUNDMENT AREA S-4 VERTICAL COMPOSITE	S-5 VERTICAL COMPOSITE	S-6 VERTICAL COMPOSITE
Chloromethane	74-87-3	ug/kg	560U(d)	450U	480U	560U	740U	760U
Bromomethane	74-83-9	ug/kg	560U	450U	480U	560U	740U	760U
Vinyl chloride	75-01-4	ug/kg	560U	450U	480U	560U	740U	760U
Chloroethane	75-00-3	ug/kg	560U	450U	480U	560U	740U	760U
Methylene chloride	75-09-2	ug/kg	840B(e)	460B	770B	1,100B	950B	1,300B
Acetone	67-64-1	ug/kg	1,200B	220JB(f)	6,900B	280JB	1,200B	300JB
Carbon disulfide	75-15-0	ug/kg	280U	220U	240U	280U	370U	380U
1,1-Dichloroethene	75-35-4	ug/kg	280U	220U	240U	280U	370U	380U
1,1-Dichloroethane	75-34-3	ug/kg	280U	220U	240U	280U	370U	380U
trans-1,2-Dichloroethene	156-60-5	ug/kg	280U	220U	240U	280U	370U	380U
Chloroform	67-66-3	ug/kg	370B	310B	330B	320B	530B	480B
1,2-Dichloroethane	107-06-2	ug/kg	280U	220U	240U	280U	370U	380U
2-Butanone	78-93-3	ug/kg	210JB	100JB	220JB	92JB	150JB	170JB
1,1,1-Trichloroethane	71-55-6	ug/kg	280U	220U	240U	280U	370U	380U
Carbon tetrachloride	56-23-5	ug/kg	280U	220U	240U	280U	370U	380U
Vinyl acetate	108-05-4	ug/kg	560U	450U	480U	560U	740U	760U
Bromodichloromethane	75-27-4	ug/kg	280U	220U	240U	280U	370U	380U
1,2-Dichloropropane	78-87-5	ug/kg	280U	220U	240U	280U	370U	380U
trans-1,3-Dichloropropene	10061-02-6	ug/kg	280U	220U	240U	280U	370U	380U
Trichloroethene	79-01-6	ug/kg	280U	220U	240U	280U	370U	380U
Dibromochloromethane	124-48-1	ug/kg	280U	220U	240U	280U	370U	380U
1,1,2-Trichloroethane	79-00-5	ug/kg	280U	220U	240U	280U	370U	380U
Benzene	71-43-2	ug/kg	280U	220U	240U	280U	370U	380U
cis-1,3-Dichloropropene	10061-01-05	ug/kg	280U	220U	240U	280U	370U	380U
2-Chloroethylvinylether	110-75-8	ug/kg	560U	450U	480U	560U	740U	760U
Bromoform	75-25-2	ug/kg	280U	220U	240U	280U	370U	380U
4-Methyl-2-pentanone	591-78-6	ug/kg	560U	450U	480U	73J	740U	760U
2-Hexanone	108-10-1	ug/kg	560U	450U	480U	560U	740U	760U
Tetrachloroethene	127-18-4	ug/kg	280U	220U	240U	280U	370U	380U
1,1,2,2-Tetrachloroethane	79-34-5	ug/kg	280U	220U	240U	280U	370U	380U
Toluene	108-88-3	ug/kg	57JB	220U	49JB	93J	75J	260J
Chlorobenzene	108-90-7	ug/kg	280U	220U	240U	280U	370U	380U
Ethylbenzene	100-41-4	ug/kg	280U	220U	240U	170J	370U	160J
Styrene	100-42-5	ug/kg	280U	220U	240U	280U	370U	380U
Total xylene(g)	1330-02-7	ug/kg	72JB	220U	130JB	1,700	190J	500

(a)Samples were collected from January 26, 1987 through January 28, 1987.

(b)The numbers presented in this column are the Chemical Abstracts Service Registry Numbers used for cataloging the indicated compounds in the Chemical Abstracts Index.

(c)"ug/kg" equals micrograms per kilogram or parts per billion (ppb).

(d)"U" indicates that the compound was analyzed but not detected. The corresponding number represents the method detection limit for the sample.

(e)"B" indicates that the corresponding compound was found in the blank as well as the sample.

(f)"J" indicates that the corresponding compound is present, but the calculated concentration is less than the specified detection limit.

(g)Total xylene includes the ortho-, meta-, and para-xylene isomers.

TABLE A-6

SUMMARY OF JANUARY 1987 VERTICAL SLUDGE COMPOSITE VOLATILE
HAZARDOUS SUBSTANCE LIST (HSL) COMPOUND RESULTS
SLUDGE PIT AREA(a)
ARCO CHEMICAL COMPANY
CHARDEMUTTER, OHIO

PARAMETERS	CAS REGISTRY NUMBER(b)	CONCENTRATION UNITS(c)	SAMPLE IDENTIFICATION SLUDGE PIT S-1 VERTICAL COMPOSITE	S-2 VERTICAL COMPOSITE	S-3 VERTICAL COMPOSITE	S-4 VERTICAL COMPOSITE	S-5 VERTICAL COMPOSITE
Chloromethane	74-87-3	ug/kg	220U(d)	240U	230U	270U	280U
Bromomethane	74-83-9	ug/kg	220U	240U	230U	270U	280U
Vinyl chloride	75-01-4	ug/kg	220U	240U	230U	270U	280U
Chloroethane	75-00-3	ug/kg	220U	240U	230U	270U	280U
Methylene chloride	75-09-2	ug/kg	210B(e)	220B	190B	240B	350B
Acetone	67-64-1	ug/kg	440B	720B	510B	940B	500B
Carbon disulfide	75-15-0	ug/kg	110U	120U	120U	140U	140U
1,1-Dichloroethene	75-35-4	ug/kg	110U	120U	120U	140U	140U
1,1-Dichloroethane	75-34-3	ug/kg	110U	120U	120U	140U	140U
trans-1,2-Dichloroethene	156-60-5	ug/kg	110U	120U	120U	140U	140U
Chloroform	67-66-3	ug/kg	170B	190B	160B	170B	190B
1,2-Dichloroethane	107-06-2	ug/kg	110U	120U	120U	140U	140U
2-Butanone	78-93-3	ug/kg	180JB(f)	77JB	120U	61JB	120JB
1,1,1-Trichloroethane	71-55-6	ug/kg	110U	120U	120U	140U	140U
Carbon tetrachloride	56-23-5	ug/kg	110U	120U	120U	140U	140U
Vinyl acetate	108-05-4	ug/kg	220U	240U	230U	270U	280U
Bromodichloromethane	75-27-4	ug/kg	110U	120U	120U	140U	140U
1,2-Dichloropropane	78-87-5	ug/kg	110U	120U	120U	140U	140U
trans-1,3-Dichloropropene	10061-02-6	ug/kg	110U	120U	120U	140U	140U
Trichloroethene	79-01-6	ug/kg	110U	120U	24J	52J	43J
Dibromochloromethane	124-48-1	ug/kg	110U	120U	120U	140U	140U
1,1,2-Trichloroethane	79-00-5	ug/kg	110U	120U	120U	140U	140U
Benzene	71-43-2	ug/kg	110U	120U	120U	140U	140U
cis-1,3-Dichloropropene	10061-01-05	ug/kg	110U	120U	120U	140U	140U
2-Chloroethylvinylether	110-75-8	ug/kg	220U	240U	230U	270U	280U
Bromoform	75-25-2	ug/kg	110U	120U	120U	140U	140U
4-Methyl-2-pentanone	591-78-6	ug/kg	220U	240U	230U	270U	280U
2-Hexanone	108-10-1	ug/kg	220U	240U	230U	270U	280U
Tetrachloroethene	127-18-4	ug/kg	110U	120U	120U	140U	140U
1,1,2,2-Tetrachloroethane	79-34-5	ug/kg	110U	120U	120U	140U	140U
Toluene	108-88-3	ug/kg	38J	29J	25J	28J	140U
Chlorobenzene	108-90-7	ug/kg	39J	120U	120U	140U	140U
Ethylbenzene	100-41-4	ug/kg	110U	120U	120U	140U	140U
Styrene	100-42-5	ug/kg	110U	120U	120U	140U	140U
Total xylene(g)	1330-02-7	ug/kg	110U	120U	66JB	28JB	140U

(a)Samples were collected on January 27, 1987.

(b)The numbers presented in this column are the Chemical Abstracts Service Registry Numbers used for cataloging the indicated compounds in the Chemical Abstracts Index.

(c)"ug/kg" equals micrograms per kilogram or parts per billion (ppb).

(d)"U" indicates that the compound was analyzed but not detected. The corresponding number represents the method detection limit for the sample.

(e)"B" indicates that the corresponding compound was found in the blank as well as the sample.

(f)"J" indicates that the corresponding compound is present, but the calculated concentration is less than the specified detection limit.

(g)Total xylene includes the ortho-, meta-, and para-xylene isomers.

TABLE A-9

SUMMARY OF JANUARY 1987 SOUTHERN IMPOUNDMENT SOIL VOLATILE HAZARDOUS SUBSTANCE LIST (HSL) COMPOUND RESULTS(a)
ARCO CHEMICAL COMPANY
GNADENHUTTEN, OHIO

PARAMETERS	CAS REGISTRY NUMBER(b)	CONCENTRATION UNITS(c)	SAMPLE IDENTIFICATION S-4 SOIL (8.0-9.0 ft)	S-5 SOIL (8.5-9.0 ft)	S-6 SOIL (9.5-10.1 ft)
Chloromethane	74-87-3	ug/kg	120U(d)	100U	130U
Bromomethane	74-83-9	ug/kg	120U	100U	130U
Vinyl chloride	75-01-4	ug/kg	120U	100U	130U
Chloroethane	75-00-3	ug/kg	120U	100U	130U
Methylene chloride	75-09-2	ug/kg	110B(e)	120B	160B
Acetone	67-64-1	ug/kg	1,500B	650B	370B
Carbon disulfide	75-15-0	ug/kg	60U	50U	63U
1,1-Dichloroethene	75-35-4	ug/kg	60U	50U	63U
1,1-Dichloroethane	75-34-3	ug/kg	60U	50U	63U
trans-1,2-Dichloroethene	156-60-5	ug/kg	60U	50U	63U
Chloroform	67-66-3	ug/kg	80B	88B	100B
1,2-Dichloroethane	107-06-2	ug/kg	60U	50U	63U
2-Butanone	78-93-3	ug/kg	61JB(f)	54JB	58JB
1,1,1-Trichloroethane	71-55-6	ug/kg	60U	50U	63U
Carbon tetrachloride	56-23-5	ug/kg	60U	50U	63U
Vinyl acetate	108-05-4	ug/kg	120U	100U	130U
Bromodichloromethane	75-27-4	ug/kg	60U	50U	63U
1,2-Dichloropropane	78-87-5	ug/kg	60U	50U	63U
trans-1,3-Dichloropropene	10061-02-6	ug/kg	60U	50U	63U
Trichloroethene	79-01-6	ug/kg	60U	50U	63U
Dibromochloromethane	124-48-1	ug/kg	60U	50U	63U
1,1,2-Trichloroethane	79-00-5	ug/kg	60U	50U	63U
Benzene	71-43-2	ug/kg	60U	50U	63U
cis-1,3-Dichloroporpene	10061-01-05	ug/kg	60U	50U	63U
2-Chloroethylvinylether	110-75-8	ug/kg	120U	100U	130U
Bromoform	75-25-2	ug/kg	60U	50U	63U
4-Methyl-2-pentanone	591-78-6	ug/kg	120U	100U	130U
2-Hexanone	108-10-1	ug/kg	120U	100U	130U
Tetrachloroethene	127-18-4	ug/kg	60U	50U	63U
1,1,2,2-Tetrachloroethane	79-34-5	ug/kg	60U	50U	63U
Toluene	108-88-3	ug/kg	14JB	50U	13JB
Chlorobenzene	108-90-7	ug/kg	60U	50U	63U
Ethylbenzene	100-41-4	ug/kg	47J	50U	63U
Styrene	100-42-5	ug/kg	60U	50U	63U
Total xylene(g)	1330-02-7	ug/kg	60B	50U	22JB

(a)Samples were collected on January 26, 1987 and January 28, 1987.

(b)The numbers presented in this column are the Chemical Abstracts Service Registry Numbers used for cataloging the indicated compounds in the Chemical Abstracts Index.

(c)"ug/kg" equals micrograms per kilogram or parts per billion (ppb).

(d)"U" indicates that the compound was analyzed but not detected. The corresponding number represents the method detection limit for the sample.

(e)"B" indicates that the corresponding compound was found in the blank as well as the sample.

(f)"J" indicates that the corresponding compound is present, but the calculated concentration is less than the specified detection limit.

(g)Total xylene includes the ortho-, meta-, and para-xylene isomers.

TABLE 4-10

SUMMARY OF JANUARY 1987 VERTICAL SLUDGE COMPOSITE ACID AND BASE-NEUTRAL EXTRACTABLE
HAZARDOUS SUBSTANCE LIST (HSL) COMPOUND RESULTS
NORTHERN AND SOUTHERN IMPOUNDMENT AREAS(a)
ARCO CHEMICAL COMPANY
GRANDMUTTER, OHIO

PARAMETERS	CAS REGISTRY NUMBER(b)	CONCENTRATION UNITS(c)	SAMPLE IDENTIFICATION: NORTHERN IMPOUNDMENT AREA: S-1 SLUDGE COMPOSITE	S-2 SLUDGE COMPOSITE	S-3 SLUDGE COMPOSITE	SOUTHERN IMPOUNDMENT AREA: S-4 SLUDGE COMPOSITE	S-5 SLUDGE COMPOSITE	S-6 SLUDGE COMPOSITE
Phenol	108-95-2	ug/kg	2,000U(d)	1,700U	1,500U	2,000U	1,700U	1,500U
bis(2-Chloroethyl)ether	111-44-4	ug/kg	2,000U	1,700U	1,500U	2,000U	1,700U	1,500U
2-Chlorophenol	95-57-8	ug/kg	2,000U	1,700U	1,500U	2,000U	1,700U	1,500U
1,3-Dichlorobenzene	541-73-1	ug/kg	2,000U	1,700U	1,500U	2,000U	1,700U	1,500U
1,4-Dichlorobenzene	106-46-7	ug/kg	2,000U	1,700U	1,500U	2,000U	1,700U	1,500U
Benzyl alcohol	100-51-6	ug/kg	2,000U	1,700U	1,500U	2,000U	1,700U	1,500U
1,2-Dichlorobenzene	95-50-1	ug/kg	2,000U	1,700U	1,500U	2,000U	1,700U	1,500U
2-Methylphenol	95-48-7	ug/kg	2,000U	1,700U	1,500U	2,000U	1,700U	1,500U
bis(2-Chloroisopropyl)ether	39638-32-9	ug/kg	2,000U	1,700U	1,500U	2,000U	1,700U	1,500U
4-Methylphenol	106-44-5	ug/kg	2,000U	1,700U	1,500U	2,000U	1,700U	1,500U
N-Nitroso-di-n-propylamine	621-64-7	ug/kg	2,000U	1,700U	1,500U	2,000U	1,700U	1,500U
Hexachloroethane	67-72-1	ug/kg	2,000U	1,700U	1,500U	2,000U	1,700U	1,500U
Nitrobenzene	98-95-3	ug/kg	2,000U	1,700U	1,500U	2,000U	1,700U	1,500U
Isophorone	78-59-1	ug/kg	2,000U	1,700U	1,500U	2,000U	1,700U	1,500U
2-Nitrophenol	88-75-5	ug/kg	2,000U	1,700U	1,500U	2,000U	1,700U	1,500U
2,4-Dimethylphenol	105-67-9	ug/kg	2,000U	1,700U	1,500U	2,000U	1,700U	1,500U
Benzoic acid	65-85-0	ug/kg	10,000U	8,700U	7,700U	9,800U	8,500U	7,300U
bis(2-Chloroethoxy)methane	111-91-1	ug/kg	2,000U	1,700U	1,500U	2,000U	1,700U	1,500U
2,4-Dichlorophenol	120-83-2	ug/kg	2,000U	1,700U	1,500U	2,000U	1,700U	1,500U
1,2,4-Trichlorobenzene	120-82-1	ug/kg	2,000U	1,700U	1,500U	2,000U	1,700U	1,500U
Naphthalene	91-20-3	ug/kg	2,000U	1,700U	1,500U	2,000U	1,700U	1,500U
4-Chloroaniline	106-47-8	ug/kg	2,000U	1,700U	1,500U	2,000U	1,700U	1,500U
Hexachlorobutadiene	87-68-3	ug/kg	2,000U	1,700U	1,500U	2,000U	1,700U	1,500U
4-Chloro-3-methylphenol	59-50-7	ug/kg	2,000U	1,700U	1,500U	2,000U	1,700U	1,500U
2-Methylnaphthalene	91-57-6	ug/kg	2,000U	1,700U	1,500U	2,000U	1,700U	1,500U
Hexachlorocyclopentadiene	77-47-4	ug/kg	2,000U	1,700U	1,500U	2,000U	1,700U	1,500U
2,4,6-Trichlorophenol	88-06-2	ug/kg	2,000U	1,700U	1,500U	2,000U	1,700U	1,500U
2,4,5-Trichlorophenol	95-95-4	ug/kg	10,000U	8,700U	7,700U	9,800U	8,500U	7,300U
2-Chloronaphthalene	91-58-7	ug/kg	2,000U	1,700U	1,500U	2,000U	1,700U	1,500U
2-Nitroaniline	88-74-4	ug/kg	10,000U	8,700U	7,700U	9,800U	8,500U	7,300U
Dimethylphthalate	131-11-3	ug/kg	2,000U	1,700U	1,500U	2,000U	1,700U	1,500U
Acenaphthylene	208-96-8	ug/kg	2,000U	1,700U	1,500U	2,000U	1,700U	1,500U
3-Nitroaniline	99-09-2	ug/kg	10,000U	8,700U	7,700U	9,800U	8,500U	7,300U
Acenaphthene	83-32-9	ug/kg	2,000U	1,700U	1,500U	2,000U	1,700U	1,500U
2,4-Dinitrophenol	51-28-5	ug/kg	10,000U	8,700U	7,700U	9,800U	8,500U	7,300U
4-Nitrophenol	100-02-7	ug/kg	10,000U	8,700U	7,700U	9,800U	8,500U	7,300U
Dibenzofuran	132-64-9	ug/kg	2,000U	1,700U	1,500U	2,000U	1,700U	1,500U
2,4-Dinitrotoluene	121-14-2	ug/kg	2,000U	1,700U	1,500U	2,000U	1,700U	1,500U
2,6-Dinitrotoluene	606-20-2	ug/kg	2,000U	1,700U	1,500U	2,000U	1,700U	1,500U
Diethylphthalate	84-66-2	ug/kg	2,000U	1,700U	1,500U	2,000U	1,700U	1,500U
4-Chlorophenylphenylether	7005-72-3	ug/kg	2,000U	1,700U	1,500U	2,000U	1,700U	1,500U
Fluorene	86-73-7	ug/kg	2,000U	1,700U	1,500U	2,000U	1,700U	1,500U
4-Nitroaniline	100-01-6	ug/kg	10,000U	8,700U	7,700U	9,800U	8,500U	7,300U
4,6-Dinitro-2-methylphenol	534-52-1	ug/kg	10,000U	8,700U	7,700U	9,800U	8,500U	7,300U
N-Nitrosodiphenylamine(e)	86-30-6	ug/kg	240J(f)	1,700U	1,500U	390J	1,700U	1,500U
4-Bromophenylphenylether	101-55-3	ug/kg	2,000U	1,700U	1,500U	2,000U	1,700U	1,500U
Hexachlorobenzene	118-74-1	ug/kg	2,000U	1,700U	1,500U	2,000U	1,700U	1,500U
Pentachlorophenol	87-86-5	ug/kg	10,000U	8,700U	7,700U	9,800U	8,500U	7,300U
Phenanthrene	85-01-8	ug/kg	2,000U	1,700U	1,500U	2,000U	1,700U	170J
Anthracene	120-12-7	ug/kg	2,000U	1,700U	1,500U	2,000U	1,700U	1,500U
Di-n-butylphthalate	84-74-2	ug/kg	490JB(g)	1,700U	1,500U	420JB	380JB	600JB
Fluoranthene	206-44-0	ug/kg	2,000U	1,700U	1,500U	2,000U	1,700U	1,500U
Pyrene	129-00-0	ug/kg	2,000U	1,700U	1,500U	2,000U	1,700U	1,500U
Butylbenzylphthalate	85-68-7	ug/kg	2,000U	1,700U	1,500U	2,000U	1,700U	1,500U
3,3'-Dichlorobenzidine	91-94-1	ug/kg	4,000U	3,500U	3,100U	3,900U	3,400U	2,900U
Benzo(a)anthracene	56-55-3	ug/kg	2,000U	1,700U	1,500U	2,000U	1,700U	1,500U
bis(2-Ethylhexyl)phthalate	117-81-7	ug/kg	480J	1,100J	740J	470J	270J	710J
Chrysene	218-01-9	ug/kg	2,000U	1,700U	1,500U	2,000U	1,700U	1,500U
Di-n-octylphthalate	117-84-0	ug/kg	2,000U	1,700U	1,500U	2,000U	1,700U	1,500U
Benzo(b)fluoranthene	205-99-2	ug/kg	2,000U	1,700U	1,500U	2,000U	1,700U	1,500U
Benzo(k)fluoranthene	207-08-9	ug/kg	2,000U	1,700U	1,500U	2,000U	1,700U	1,500U
Benzo(a)pyrene	50-32-8	ug/kg	2,000U	1,700U	1,500U	2,000U	1,700U	1,500U
Indeno(1,2,3-cd)pyrene	193-39-5	ug/kg	2,000U	1,700U	1,500U	2,000U	1,700U	1,500U
Dibenz(a,h)anthracene	53-70-3	ug/kg	2,000U	1,700U	1,500U	2,000U	1,700U	1,500U
Benzo(g,h,i)perylene	191-24-2	ug/kg	2,000U	1,700U	1,500U	2,000U	1,700U	1,500U

(a)Samples were collected from January 26, 1987 through January 28, 1987.

(b)The numbers presented in this column are the Chemical Abstracts Service Registry Numbers used for cataloging the indicated compounds in the Chemical Abstracts Index.

(c)"ug/kg" equals micrograms per kilogram or parts per billion (ppb).

(d)"U" indicates that the compound was analysed but not detected. The corresponding number represents the method detection limit for the sample

(e)The indicated compound is detected as diphenylamine.

(f)"J" indicates that the corresponding compound is present, but the calculated concentration is less than the specified detection limit

(g)"B" indicates that the corresponding compound was found in the blank as well as the sample.

TABLE A-11

SUMMARY OF JANUARY 1987 VERTICAL SLUDGE COMPOSITE ACID AND BASE-NEUTRAL EXTRACTABLE HAZARDOUS SUBSTANCE LIST (HSL) COMPOUND RESULTS
SLUDGE PIT AREA(a)
ARCO CHEMICAL COMPANY
CHARDEMUTTER, OHIO

C00001862

PARAMETERS	CAS REGISTRY NUMBER(b)	CONCENTRATION UNITS(c)	SAMPLE IDENTIFICATION S-1 SLUDGE COMPOSITE	S-2 SLUDGE COMPOSITE	S-3 SLUDGE COMPOSITE	S-4 SLUDGE COMPOSITE	S-5 SLUDGE COMPOSITE
Phenol	108-95-2	ug/kg	900U(d)	940U	770U	930U	970U
bis(2-Chloroethyl)ether	111-44-4	ug/kg	900U	940U	770U	930U	970U
2-Chlorophenol	95-57-8	ug/kg	900U	940U	770U	930U	970U
1,3-Dichlorobenzene	541-73-1	ug/kg	900U	940U	770U	930U	970U
1,4-Dichlorobenzene	106-46-7	ug/kg	900U	940U	770U	930U	970U
Benzyl alcohol	100-51-6	ug/kg	900U	940U	770U	930U	970U
1,2-Dichlorobenzene	95-50-1	ug/kg	900U	940U	770U	930U	970U
2-Methylphenol	95-48-7	ug/kg	900U	940U	770U	930U	970U
bis(2-Chloroisopropyl)ether	39638-32-9	ug/kg	900U	940U	770U	930U	970U
4-Methylphenol	106-44-5	ug/kg	900U	940U	770U	930U	970U
N-Nitroso-di-n-propylamine	621-64-7	ug/kg	900U	940U	770U	930U	970U
Hexachloroethane	67-72-1	ug/kg	900U	940U	770U	930U	970U
Nitrobenzene	98-95-3	ug/kg	900U	940U	770U	930U	970U
Isophorone	78-59-1	ug/kg	900U	940U	770U	930U	970U
2-Nitrophenol	88-75-5	ug/kg	900U	940U	770U	930U	970U
2,4-Dimethylphenol	105-67-9	ug/kg	900U	940U	770U	930U	970U
Benzoic acid	65-85-0	ug/kg	4,500U	4,700U	3,900U	4,700U	4,900U
bis(2-Chloroethoxy)methane	111-91-1	ug/kg	900U	940U	770U	930U	970U
2,4-Dichlorophenol	120-83-2	ug/kg	900U	940U	770U	930U	970U
1,2,4-Trichlorobenzene	120-82-1	ug/kg	900U	940U	770U	930U	970U
Naphthalene	91-20-3	ug/kg	900U	940U	770U	930U	970U
4-Chloroaniline	106-47-8	ug/kg	900U	940U	770U	930U	970U
Hexachlorobutadiene	87-68-3	ug/kg	900U	940U	770U	930U	970U
4-Chloro-3-methylphenol	59-50-7	ug/kg	900U	940U	770U	930U	970U
2-Methylnaphthalene	91-57-6	ug/kg	900U	940U	770U	930U	970U
Hexachlorocyclopentadiene	77-47-4	ug/kg	900U	940U	770U	930U	970U
2,4,6-Trichlorophenol	88-06-2	ug/kg	900U	940U	770U	930U	970U
2,4,5-Trichlorophenol	95-95-4	ug/kg	4,500U	4,700U	3,900U	4,700U	4,900U
2-Chloronaphthalene	91-58-7	ug/kg	900U	940U	770U	930U	970U
2-Nitroaniline	88-74-4	ug/kg	4,500U	4,700U	3,900U	4,700U	4,900U
Dimethylphthalate	131-11-3	ug/kg	900U	940U	770U	930U	970U
Acenaphthylene	208-96-8	ug/kg	900U	940U	770U	930U	970U
3-Nitroaniline	99-09-2	ug/kg	4,500U	4,700U	3,900U	4,700U	4,900U
Acenaphthene	83-32-9	ug/kg	900U	940U	770U	930U	970U
2,4-Dinitrophenol	51-28-5	ug/kg	4,500U	4,700U	3,900U	4,700U	4,900U
4-Nitrophenol	100-02-7	ug/kg	4,500U	4,700U	3,900U	4,700U	4,900U
Dibenzofuran	132-64-9	ug/kg	900U	940U	770U	930U	970U
2,4-Dinitrotoluene	121-14-2	ug/kg	900U	940U	770U	930U	970U
2,6-Dinitrotoluene	606-20-2	ug/kg	900U	940U	770U	930U	970U
Diethylphthalate	84-66-2	ug/kg	900U	940U	770U	930U	970U
4-Chlorophenylphenylether	7005-72-3	ug/kg	900U	940U	770U	930U	970U
Fluorene	86-73-7	ug/kg	900U	940U	770U	930U	970U
4-Nitroaniline	100-01-6	ug/kg	4,500U	4,700U	3,900U	4,700U	4,900U
4,6-Dinitro-2-methylphenol	534-52-1	ug/kg	4,500U	4,700U	3,900U	4,700U	4,900U
N-Nitrosodiphenylamine(e)	86-30-6	ug/kg	900U	940U	770U	930U	970U
4-Bromophenylphenylether	101-55-3	ug/kg	900U	940U	770U	930U	970U
Hexachlorobenzene	118-74-1	ug/kg	900U	940U	770U	930U	970U
Pentachlorophenol	87-86-5	ug/kg	4,500U	4,700U	3,900U	4,700U	4,900U
Phenanthrene	85-01-8	ug/kg	900U	940U	770U	930U	970U
Anthracene	120-12-7	ug/kg	900U	940U	770U	930U	970U
Di-n-butylphthalate	84-74-2	ug/kg	900U	940U	770U	930U	180JB
Fluoranthene	206-44-0	ug/kg	900U	940U	770U	930U	970U
Pyrene	129-00-0	ug/kg	900U	940U	770U	930U	970U
Butylbenzylphthalate	85-68-7	ug/kg	900U	940U	770U	930U	970U
3,3'-Dichlorobenzidine	91-94-1	ug/kg	1,800U	1,900U	1,600U	1,900U	1,900U
Benzo(a)anthracene	56-55-3	ug/kg	900U	940U	770U	930U	970U
bis(2-Ethylhexyl)phthalate	117-81-7	ug/kg	690J(f)	920J	2,100	210J	550J
Chrysene	218-01-9	ug/kg	900U	940U	770U	930U	970U
Di-n-octylphthalate	117-84-0	ug/kg	900U	940U	770U	930U	970U
Benzo(b)fluoranthene	205-99-2	ug/kg	900U	940U	770U	930U	970U
Benzo(k)fluoranthene	207-08-9	ug/kg	900U	940U	770U	930U	970U
Benzo(a)pyrene	50-32-8	ug/kg	900U	940U	770U	930U	100J
Indeno(1,2,3-cd)pyrene	193-39-5	ug/kg	900U	940U	770U	930U	970U
Dibenz(a,h)anthracene	53-70-3	ug/kg	900U	940U	770U	930U	970U
Benzo(g,h,i)perylene	191-24-2	ug/kg	900U	940U	770U	930U	970U

(a)Samples were collected on January 27, 1987.

(b)The numbers presented in this column are the Chemical Abstracts Service Registry Numbers used for cataloging the indicated compounds in the Chemical Abstracts Index.

(c)"ug/kg" equals micrograms per kilogram or parts per billion (ppb).

(d)"U" indicates that the compound was analyzed but not detected. The corresponding number represents the method detection limit for the sample.

(e)The indicated compound is detected as diphenylamine.

(f)"J" indicates that the corresponding compound is present, but the calculated concentration is less than the specified detection limit.

TABLE A-12

SUMMARY OF JANUARY 1987 SOUTHERN DEPOUNDMENT SOIL ACID AND BASE-NEUTRAL EXTRACTABLE HAZARDOUS SUBSTANCE LIST (BSL) COMPOUND RESULTS(a)
ARCO CHEMICAL COMPANY
CHAGRINSUTTER, OHIO

PARAMETERS	CAS REGISTRY NUMBER(b)	CONCENTRATION UNITS(c)	SAMPLE IDENTIFICATION S-4 SOIL (8.0-9.0 ft)	S-5 SOIL (8.5-9.0 ft)	S-6 SOIL (9.5-10.1 ft)
Phenol	108-95-2	ug/kg	470U(d)	400U	450U
bis(2-Chloroethyl)ether	111-44-4	ug/kg	470U	400U	450U
2-Chlorophenol	95-57-8	ug/kg	470U	400U	450U
1,3-Dichlorobenzene	541-73-1	ug/kg	470U	400U	450U
1,4-Dichlorobenzene	106-46-7	ug/kg	470U	400U	450U
Benzyl alcohol	100-51-6	ug/kg	470U	400U	450U
1,2-Dichlorobenzene	95-50-1	ug/kg	470U	400U	450U
2-Methylphenol	95-48-7	ug/kg	470U	400U	450U
bis(2-Chloroisopropyl)ether	39638-32-9	ug/kg	470U	400U	450U
4-Methylphenol	106-44-5	ug/kg	470U	400U	450U
N-Nitroso-di-n-propylamine	621-64-7	ug/kg	470U	400U	450U
Hexachloroethane	67-72-1	ug/kg	470U	400U	450U
Nitrobenzene	98-95-3	ug/kg	470U	400U	450U
Isophorone	78-59-1	ug/kg	470U	400U	450U
2-Nitrophenol	88-75-5	ug/kg	470U	400U	450U
2,4-Dimethylphenol	105-67-9	ug/kg	470U	400U	450U
Benzoic acid	65-85-0	ug/kg	2,300U	2,000U	2,200U
bis(2-Chloroethoxy)methane	111-91-1	ug/kg	470U	400U	450U
2,4-Dichlorophenol	120-83-2	ug/kg	470U	400U	450U
1,2,4-Trichlorobenzene	120-82-1	ug/kg	470U	400U	450U
Naphthalene	91-20-3	ug/kg	360J(e)	400U	450U
4-Chloroaniline	106-47-8	ug/kg	470U	400U	450U
Hexachlorobutadiene	87-68-3	ug/kg	470U	400U	450U
4-Chloro-3-methylphenol	59-50-7	ug/kg	470U	400U	450U
2-Methylnaphthalene	91-57-6	ug/kg	470U	400U	450U
Hexachlorocyclopentadiene	77-47-4	ug/kg	470U	400U	450U
2,4,6-Trichlorophenol	88-06-2	ug/kg	470U	400U	450U
2,4,5-Trichlorophenol	95-95-4	ug/kg	2,300U	2,000U	2,200U
2-Chloronaphthalene	91-58-7	ug/kg	470U	400U	450U
2-Nitroaniline	88-74-4	ug/kg	2,300U	2,000U	2,200U
Dimethylphthalate	131-11-3	ug/kg	470U	400U	450U
Acenaphthylene	208-96-8	ug/kg	470U	400U	450U
3-Nitroaniline	99-09-2	ug/kg	2,300U	2,000U	2,200U
Acenaphthene	83-32-9	ug/kg	470U	400U	450U
2,4-Dinitrophenol	51-28-5	ug/kg	2,300U	2,000U	2,200U
4-Nitrophenol	100-02-7	ug/kg	2,300U	2,000U	2,200U
Dibenzofuran	132-64-9	ug/kg	470U	400U	450U
2,4-Dinitrotoluene	121-14-2	ug/kg	470U	400U	450U
2,6-Dinitrotoluene	606-20-2	ug/kg	470U	400U	450U
Diethylphthalate	84-66-2	ug/kg	470U	400U	450U
4-Chlorophenylphenylether	7005-72-3	ug/kg	470U	400U	450U
Fluorene	86-73-7	ug/kg	470U	400U	450U
4-Nitroaniline	100-01-6	ug/kg	2,300U	2,000U	2,200U
4,6-Dinitro-2-methylphenol	534-52-1	ug/kg	2,300U	2,000U	2,200U
N-Nitrosodiphenylamine(f)	86-30-6	ug/kg	470U	63J	450U
4-Bromophenylphenylether	101-55-3	ug/kg	470U	400U	450U
Hexachlorobenzene	118-74-1	ug/kg	470U	400U	450U
Pentachlorophenol	87-86-5	ug/kg	2,300U	2,000U	2,200U
Phenanthrene	85-01-8	ug/kg	470U	130J	66J
Anthracene	120-12-7	ug/kg	470U	400U	450U
Di-n-butylphthalate	84-74-2	ug/kg	88JB(g)	110JB	110JB
Fluoranthene	206-44-0	ug/kg	470U	400U	450U
Pyrene	129-00-0	ug/kg	470U	400U	450U
Butylbenzylphthalate	85-68-7	ug/kg	470U	400U	450U
3,3'-Dichlorobenzidine	91-94-1	ug/kg	470U	400U	450U
Benzo(a)anthracene	56-55-3	ug/kg	940U	800U	890U
bis(2-Ethylhexyl)phthalate	117-81-7	ug/kg	470U	93J	120J
Chrysene	218-01-9	ug/kg	470U	400U	450U
Di-n-octylphthalate	117-84-0	ug/kg	470U	400U	450U
Benzo(b)fluoranthene	205-99-2	ug/kg	470U	400U	450U
Benzo(k)fluoranthene	207-08-9	ug/kg	470U	400U	450U
Benzo(a)pyrene	50-32-8	ug/kg	470U	400U	450U
Indeno(1,2,3-cd)pyrene	193-39-5	ug/kg	470U	400U	450U
Dibenz(a,h)anthracene	53-70-3	ug/kg	470U	400U	450U
Benzo(g,h,i)perylene	191-24-2	ug/kg	470U	400U	450U

(a)Samples were collected on January 26, 1987 and January 28, 1987.

(b)The numbers presented in this column are the Chemical Abstracts Service Registry Numbers used for cataloging the indicated compounds in the Chemical Abstracts Index.

(c)"ug/kg" equals micrograms per kilogram or parts per billion (ppb).

(d)"U" indicates that the compound was analyzed but not detected. The corresponding number represents the method detection limit for the sample.

(e)"J" indicates that the corresponding compound is present, but the calculated concentration is less than the specified detection limit.

(f)The indicated compound is detected as diphenylamine.

(g)"B" indicates that the corresponding compound was found in the blank as well as the sample.

TABLE A-13

SUMMARY OF JANUARY 1987 VERTICAL SLUDGE COMPOSITE PESTICIDE
HAZARDOUS SUBSTANCE LIST (HSL) COMPOUND RESULTS
NORTHERN AND SOUTHERN IMPOUNDMENT AREAS(a)
ARCO CHEMICAL COMPANY
GNADENHUTTEN, OHIO

			SAMPLE IDENTIFICATION					
			NORTHERN IMPOUNDMENT AREA			SOUTHERN IMPOUNDMENT AREA		
PARAMETERS	CAS REGISTRY NUMBER(b)	CONCENTRATION UNITS(c)	S-1 VERTICAL COMPOSITE	S-2 VERTICAL COMPOSITE	S-3 VERTICAL COMPOSITE	S-4 VERTICAL COMPOSITE	S-5 VERTICAL COMPOSITE	S-6 VERTICAL COMPOSITE
alpha-BHC	319-84-6	ug/kg	51U(d)	43U	39U	49U	43U	37U
beta-BHC	319-85-7	ug/kg	51U	43U	39U	49U	43U	37U
delta-BHC	319-86-8	ug/kg	51U	43U	39U	49U	43U	37U
gamma-BHC (Lindane)	58-89-9	ug/kg	51U	43U	39U	49U	43U	37U
Heptachlor	76-44-8	ug/kg	51U	43U	39U	49U	43U	37U
Aldrin	309-00-2	ug/kg	51U	43U	39U	49U	43U	37U
Heptachlor epoxide	1024-57-3	ug/kg	51U	43U	39U	49U	43U	37U
Endosulfan I	959-98-8	ug/kg	51U	43U	39U	49U	43U	37U
Dieldrin	60-57-1	ug/kg	100U	87U	77U	98U	85U	73U
4,4'-DDE	72-55-9	ug/kg	100U	87U	77U	98U	85U	73U
Endrin	72-20-8	ug/kg	100U	87U	77U	98U	85U	73U
Endosulfan II	33213-65-9	ug/kg	100U	87U	77U	98U	85U	73U
4,4'-DDD	72-54-8	ug/kg	100U	87U	77U	98U	85U	73U
Endosulfan sulfate	1031-07-8	ug/kg	100U	87U	77U	98U	85U	73U
4,4'-DDT	50-29-3	ug/kg	100U	87U	77U	98U	85U	73U
Methoxychlor	72-43-5	ug/kg	510U	430U	390U	490U	430U	370U
Endrin ketone	53494-70-5	ug/kg	100U	87U	77U	98U	85U	73U
Chlordane	57-74-9	ug/kg	510U	430U	390U	490U	430U	370U
Toxaphene	8001-35-2	ug/kg	1,000U	870U	770U	980U	850U	730U
Aroclor 1016	12674-11-2	ug/kg	510U	430U	390U	490U	430U	370U
Aroclor 1221	11104-28-2	ug/kg	510U	430U	390U	490U	430U	370U
Aroclor 1232	11141-16-5	ug/kg	510U	430U	390U	490U	430U	370U
Aroclor 1242	53469-21-9	ug/kg	510U	430U	390U	490U	430U	370U
Aroclor 1248	12672-29-6	ug/kg	510U	430U	390U	490U	430U	370U
Aroclor 1254	11097-69-1	ug/kg	1,000U	870U	770U	980U	850U	730U
Aroclor 1260	11096-82-5	ug/kg	1,000U	870U	770U	980U	850U	730U

(a)Samples were collected from January 26, 1987 through January 28, 1987.

(b)The numbers presented in this column are the Chemical Abstracts Service Registry Numbers used for cataloging the indicated compounds in the Chemical Abstracts Index.

(c)"ug/kg" equals micrograms per kilogram or parts per billion (ppb).

(d)"U" indicates that the compound was analyzed but not detected. The corresponding number represents the method detection limit for the sample.

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TABLE A-14

SUMMARY OF JANUARY 1987 VERTICAL SLUDGE COMPOSITE PESTICIDE
HAZARDOUS SUBSTANCE LIST (HSL) COMPOUND RESULTS
SLUDGE PIT AREA(a)
ARCO CHEMICAL COMPANY
CHAGRINFALLS, OHIO

PARAMETERS	CAS REGISTRY NUMBER(b)	CONCENTRATION UNITS(c)	SAMPLE IDENTIFICATION S-1 VERTICAL COMPOSITE	S-2 VERTICAL COMPOSITE	S-3 VERTICAL COMPOSITE	S-4 VERTICAL COMPOSITE	S-5 VERTICAL COMPOSITE
alpha-BHC	319-84-6	ug/kg	22U(d)	23U	19U	23U	24U
beta-BHC	319-85-7	ug/kg	22U	23U	19U	23U	24U
delta-BHC	319-86-8	ug/kg	22U	23U	19U	23U	24U
gamma-BHC (Lindane)	58-89-9	ug/kg	22U	23U	19U	23U	24U
Heptachlor	76-44-8	ug/kg	22U	23U	19U	23U	24U
Aldrin	309-00-2	ug/kg	22U	23U	19U	23U	24U
Heptachlor epoxide	1024-57-3	ug/kg	22U	23U	19U	23U	24U
Endosulfan I	959-98-8	ug/kg	22U	23U	19U	23U	24U
Dieldrin	60-57-1	ug/kg	45U	47U	39U	47U	48U
4,4'-DDE	72-55-9	ug/kg	45U	47U	39U	47U	48U
Endrin	72-20-8	ug/kg	45U	47U	39U	47U	48U
Endosulfan II	33213-65-9	ug/kg	45U	47U	39U	47U	48U
4,4'-DDD	72-54-8	ug/kg	45U	47U	39U	47U	48U
Endosulfan sulfate	1031-07-8	ug/kg	45U	47U	39U	47U	48U
4,4'-DDT	50-29-3	ug/kg	45U	47U	39U	47U	48U
Methoxychlor	72-43-5	ug/kg	220U	230U	190U	230U	240U
Endrin ketone	53494-70-5	ug/kg	45U	47U	39U	47U	48U
Chlordane	57-74-9	ug/kg	220U	230U	190U	230U	240U
Toxaphene	8001-35-2	ug/kg	450U	470U	390U	470U	480U
Aroclor 1016	12674-11-2	ug/kg	220U	230U	190U	230U	240U
Aroclor 1221	11104-28-2	ug/kg	220U	230U	190U	230U	240U
Aroclor 1232	11141-16-5	ug/kg	220U	230U	190U	230U	240U
Aroclor 1242	53469-21-9	ug/kg	220U	230U	190U	230U	240U
Aroclor 1248	12672-29-6	ug/kg	220U	230U	190U	230U	240U
Aroclor 1254	11097-69-1	ug/kg	450U	470U	390U	470U	480U
\roclor 1260	11096-82-5	ug/kg	450U	470U	390U	470U	480U

(a)Samples were collected on January 27, 1987.

(b)The numbers presented in this column are the Chemical Abstracts Service Registry Numbers used for cataloging the indicated compounds in the Chemical Abstracts Index.

(c)"ug/kg" equals micrograms per kilogram or parts per billion (ppb).

(d)"U" indicates that the compound was analyzed but not detected. The corresponding number represents the method detection limit for the sample.

TABLE A-15

SUMMARY OF JANUARY 1987 SOUTHERN IMPOUNDMENT SOIL VOLATILE HAZARDOUS SUBSTANCE LIST (HSL) COMPOUND RESULTS(a)
ARCO CHEMICAL COMPANY
GNADENHUTTEN, OHIO

PARAMETERS	CAS REGISTRY NUMBER(b)	CONCENTRATION UNITS(c)	SAMPLE IDENTIFICATION S-4 SOIL (8.0-9.0 ft)	S-5 SOIL (8.5-9.0 ft)	S-6 SOIL (9.5-10.1 ft)
alpha-BHC	319-84-6	ug/kg	12U(d)	10U	11U
beta-BHC	319-85-7	ug/kg	12U	10U	11U
delta-BHC	319-86-8	ug/kg	12U	10U	11U
gamma-BHC (Lindane)	58-89-9	ug/kg	12U	10U	11U
Heptachlor	76-44-8	ug/kg	12U	10U	11U
Aldrin	309-00-2	ug/kg	12U	10U	11U
Heptachlor epoxide	1024-57-3	ug/kg	12U	10U	11U
Endosulfan I	959-98-8	ug/kg	12U	10U	11U
Dieldrin	60-57-1	ug/kg	24U	20U	22U
4,4'-DDE	72-55-9	ug/kg	24U	20U	22U
Endrin	72-20-8	ug/kg	24U	20U	22U
Endosulfan II	33213-65-9	ug/kg	24U	20U	22U
4,4'-DDD	72-54-8	ug/kg	24U	20U	22U
Endosulfan sulfate	1031-07-8	ug/kg	24U	20U	22U
4,4'-DDT	50-29-3	ug/kg	24U	20U	22U
Methoxychlor	72-43-5	ug/kg	120U	100U	110U
Endrin ketone	53494-70-5	ug/kg	24U	20U	22U
Chlordane	57-74-9	ug/kg	120U	100U	110U
Toxaphene	8001-35-2	ug/kg	240U	200U	220U
Aroclor 1016	12674-11-2	ug/kg	120U	100U	110U
Aroclor 1221	11104-28-2	ug/kg	120U	100U	110U
Aroclor 1232	11141-16-5	ug/kg	120U	100U	110U
Aroclor 1242	53469-21-9	ug/kg	120U	100U	110U
Aroclor 1248	12672-29-6	ug/kg	120U	100U	110U
Aroclor 1254	11097-69-1	ug/kg	240U	200U	220U
Aroclor 1260	11096-82-5	ug/kg	240U	200U	220U

(a)Samples were collected on January 26, 1987 and January 28, 1987.

(b)The numbers presented in this column are the Chemical Abstracts Service Registry Numbers used for cataloging the indicated compounds in the Chemical Abstracts Index.

(c)"ug/kg" equals micrograms per kilogram or parts per billion (ppb).

(d)"U" indicates that the compound was analyzed but not detected. The corresponding number represents the method detection limit for the sample.

APPENDIX
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APPENDIX B

GROUND WATER HYDRAULIC PARAMETER CALCULATIONS

APPENDIX B

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- B.3.4 LEAKAGE RATE

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- B.4.1 U.S. EPA VERTICAL AND HORIZONTAL SPREAD MODEL
- B.4.2 VHS MODEL RESULTS FOR 50-METER RECEPTOR

B.1.0 GROUND WATER DISCHARGE RATES AND TUSCARAWAS RIVER DILUTION FACTORS

Assuming that the ground water beneath the ARCO site flows to the Tuscarawas River, and assuming isotropic flow conditions (hydraulic properties are equal in all directions), the dilution factor, or ratio of the volumetric flux (discharge rates) of ground water entering the river to river discharging past the site, may be derived using Darcy's equation (Freeze and Cherry, 1979, p. 28):

$Q_G = K \cdot I \cdot A$ where Q_G = ground water discharge rate

K = hydraulic conductivity

I = hydraulic gradient

A = cross-sectional area perpendicular to flow

$I = \frac{dh}{dl}$ dh = hydraulic head drop

dl = horizontal distance of drop

$A = (m \cdot b)$ m = width of flow tube

b = saturated thickness

The dilution factor, DF, is the proportion of ground water discharge into the river, Q_G, relative to river discharge, Q_R, such that:

$$DF = Q_G/Q_R$$

B.1.1 HYDRAULIC CONDUCTIVITY

For the Gnadenhutten site, the aquifer of concern consists of unconsolidated sediments including fine-grained silt and sand and coarse-grained sandy gravel. Considering these materials have different abilities to transmit water, the hydraulic conductivities are expected to vary over a wide range of values, from about 10^{-5} to 1 centimeter per second (cm/s) (Freeze and Cherry, 1979, p. 29). Laboratory tests indicate hydraulic conductivities of about 10^{-5} cm/s for silty sand collected from excavations (test pits) in the sludge pit (Table 3-2). Aquifer pumping tests, conducted in the Tuscarawas River

valley about 2.7-miles southwest of the site (Ohio Drilling Company, 1972), indicated a coefficient of transmissivity, T, of 685,000 gallons per day per foot (gpd/ft), which is proportional to a hydraulic conductivity of 0.0061 feet per second (ft/s) (0.185 centimeters per second [cm/s]) for a 175-foot-thick saturated aquifer thickness. Hydraulic conductivity calculations for the site production well, PW-5, result in a hydraulic conductivity estimate of about 0.0041 ft/s (0.125 cm/s) assuming representative values for the well pumping rate, drawdowns, and aquifer thickness as indicated below.

In 1979, Well PW-5 was pumped at a rate of 1,000 gallons per minute (gpm), causing a drawdown of 6 feet (ft) (Ohio Drilling Company, 1980). However, the well is probably inefficient because the slotted screen extends only through a portion of the aquifer causing the drawdown to be accentuated.

Driscoll (1986, p. 1021) presents an empirical equation that enables the calculation of transmissivity, or hydraulic conductivity, for an unconfined aquifer from the pumping rate and drawdown in a well:

$$T = \frac{Q}{s}(1500)$$ where T = transmissivity (gpd/ft)

Q = well pumping rate (gpm)

s = drawdown (ft)

Taking well efficiency into account:

$$T = \frac{Q}{s \cdot e}(1500)$$

e = well efficiency (unitless from 0 to 1.0)

And then taking the saturated thickness of the aquifer into account:

$$K = \frac{T}{b \cdot (7.48)(86,400)}$$

K = hydraulic conductivity (ft/s)

b = saturated thickness (ft)

Now the hydraulic conductivity of the aquifer developed by the site production well, PW-5, may be estimated with values for the above parameters as reported on the Ohio Drilling Company (1980) well completion record. Assuming the well

efficiency is 60 percent and the saturated thickness of the aquifer is 157 feet (static water level is 23 feet and bedrock is 180 feet below the ground surface), the hydraulic conductivity is estimated for a pumping rate of 1,000 gpm and a drawdown of six feet:

$$T = \frac{(1,000)(1,500)}{(6)\cdot(.6)} = 416,667 \text{ gpd/ft}$$

$$K = \frac{416,667}{(157)(646,272)} = 0.00411 \text{ ft/s}$$

$$K = (0.00411 \text{ ft/s})(30.48 \text{ cm/ft}) = 0.125 \text{ cm/s}$$

B.1.2 HYDRAULIC GRADIENT

The ground water hydraulic gradient slopes moderately toward the Tuscarawas River except in the area where pumping of well PW-5 creates a cone of depression (Figure 4.5, March 26, 1987 data). In general, the gradient from Monitoring Well MW-1 to Monitoring Wells MW-7 and MW-8 is perpendicular to the water table elevation contours of the data (Figure 4.5). These wells provide an average gradient of 0.00135 ft/ft:

	dl (ft)	dh (ft)	$I = \frac{dh}{dl}$ (ft/ft)
MW-1 → MW-7	1,175	1.60	0.00136
MW-1 → MW-8	1,269	1.70	0.00134
			0.00135 average

B.1.3 CROSS-SECTIONAL AREA

The cross-sectional area through which site ground water flows, A, is defined by the length of the river segment bounding the site and by the saturated thickness of the aquifer. Assuming isotropic hydraulic conductivities in the horizontal plane ($K_x = K_y$), the horizontal plane of the flow tube may be defined as approximately square, with the river segment as one side of the square including the ARCO and Alsco site areas. The dimensions of the square are defined by the distance from MW-1 to MW-7 and to MW-8, which is approximately 1,200 feet, such that the length of the river segment is assumed to be 1,200 feet, which is about the distance of the site boundary. The vertical dimension that defines the cross-sectional area is the saturated

thickness of the aquifer. Assuming the total thickness of unconsolidated materials is 180 feet (depth to bedrock), and an average depth to ground water of 20 feet, the saturated thickness is 160 feet. Thus, the assumed cross-sectional area through which site ground water flows is 192,000 ft^2:

$$A = m \cdot b = (1{,}200\ ft) \cdot (160\ ft) = 192{,}000\ ft^2$$

B.1.4 GROUND WATER DISCHARGE RATES

For ground water flow beneath the site, the volumetric flux, or discharge rate, Q, may be derived using Darcy's equation and the above estimates for values of hydraulic conductivity, K, hydraulic gradient, I, and cross-sectional area, A. The widest ranging parameter is the hydraulic conductivity. Because the discharge rate is directly proportional to K, and if A and I remain constant, the following conversion becomes useful:

$$Q_G = K \cdot I \cdot A = K\ (0.00135)(192{,}000\ ft^2) = K \cdot (259.2\ ft^2)$$

A range of estimates for ground water flow rates through the aquifer cross section can be made using the above values. For example, using an estimated value of K for coarse gravel encountered by Well PW-5, a "high" discharge rate is obtained:

$$Q_G = (K)(I \cdot A) = (0.00411\ ft/s)(259.2\ ft^2) = 1.07\ ft^3/s$$

and then using an empirically derived value of K for fine-grained, silty sands encountered near the surface, a "low" discharge rate is derived:

$$Q_G = (10^{-5} cm/s)(0.0328\ ft/cm)(226.8\ ft^2) = 7.44 \times 10^{-5}\ ft^3/s$$

B.1.5 TUSCARAWAS RIVER DISCHARGE RATES

The nearest gaging station on the Tuscarawas River, which flows past the site (stream mile 37.7), is at Newcomerstown (stream mile 21.4), about 16.3 miles downriver from Gnadenhutten (Army Corps of Engineers, 1973). No major tributaries enter the Tuscarawas between the site and the gaging station, such that river discharge rates for the Newcomerstown gage as published by the Ohio Department of Natural Resources (1968, p. 27, 134) should be useful. The

drainage area at the Newcomerstown gage is 2,432 square miles (mi^2), and the following discharge rates apply:

EVENT	DISCHARGE RATE
Largest flood, historical record (1913)	82,931 ft^3/s
Largest flood, after regulation (1940)	22,100 ft^3/s
Median flow	1,190 ft^3/s
Low flow (exceeded 90 percent of time)	365 ft^3/s

The Corps of Engineers (Herndon, 1985) estimated the flood flow rates at stream-mile 37.7 for the 100-year and 50-year floods to be:

100-year	30,400 ft^3/s
50-year	16,800 ft^3/s

B.1.6 RIVER DILUTION FACTOR

The river dilution factor is a coefficient that depends on the ground water flow rate entering the river, Q_{GI}, and the river discharge rate, Q_R, which is the sum of the influent ground water and river water at the point of concern. Assuming the river water is "clean," the dilution factor, DF, is simply the ratio of the discharge rates of influent ground water to river water:

$$DF = Q_{GI}/Q_R$$

Assuming 100 percent of the ground water flow beneath the site enters the river during low flow, the most conservative dilution factor estimate is derived using a high ground water discharge rate estimate:

$$DF_{\text{LOW FLOW}} = \frac{1.07\ ft^3/s}{365\ ft^3/s} = 0.0029$$

Such a dilution factor, DF = 0.003, indicates that a constituent found at levels of 1,000 parts per billion (ppb) in ground water entering the river

would be diluted by the river to a concentration of 3 ppb. However, this dilution factor estimate may be unrealistically low because a large fraction of the ground water probably does not enter the river, but flows beneath the river and down the valley. If the influent ground water (discharge to the river) is assumed to be proportional to that part of the aquifer thickness intersected by the river, a lower dilution factor results. Assuming the river is 5 feet deep, such that the total aquifer thickness (saturated) is 160 feet, and the aquifer is dissected in the upper 5 feet, the proportion of influent ground water to "down-valley" ground water, Q_{GI}, is:

$$Q_{GI} = \frac{5}{160} Q_G = (0.031)\ Q_G$$

such that

$$Q_{GI} = (0.031)(1.07\ ft^3/s) = 0.033\ ft^3/s$$

The dilution factor for an influent ground water discharge rate of 0.033 ft/s entering the low flow river is:

$$\text{Proportional } DF_{LOW\ FLOW} = (0.031)(0.0029) = \frac{0.033\ ft^3/s}{365\ ft^3/s} = 0.0001$$

This "proportional" dilution factor indicates that a constituent found at 1,000 ppb in ground water entering the river would be diluted to a concentration of 0.1 ppb, but that most ground water does not flow into the river adjacent to the site.

The above estimates for the river dilution factor are "conservative" assuming high rates of ground water discharge and low rates of river discharge. Concentrations of contaminants in ground water entering a "clean" river will be reduced by at least three orders of magnitude during low flow and by a greater amount during normal to high flow.

B.2.0 GROUND WATER VELOCITY

Ground water flow through a representative volume of the aquifer may be evaluated through Darcy's equation and derivative relations that define such parameters as specific discharge, q, and the average linear velocity, v, of ground water. For the average cross-sectional area, A, including voids and solids, the specific discharge, q, is defined as (Freeze and Cherry, 1979, p. 16) :

$$q = Q/A$$

where the volumetric flux, Q, is derived from Darcy's equation and is defined as the product of the hydraulic conductivity, K, the hydraulic gradient, I, and the cross-sectional area, A, such that

$$q = K \cdot I$$

However, flow actually occurs only through that portion of the aquifer area occupied by interconnected voids, and for the typical cross-sectional area, the average linear velocity, v, is defined (Freeze and Cherry, 1979, p. 71) as:

$$v = Q/n \cdot A = K \cdot I/n = q/n$$

where n is the effective volumetric porosity or the average of the various possible cross-sectional area porosities.

B.2.1 SPECIFIC DISCHARGE

For the Gnadenhutten site ground water system, previous estimates indicate values for the hydraulic conductivity and the hydraulic gradient are K = 0.00411 ft/s and I = 0.00135 ft/ft, which results in a specific discharge of 0.44 ft/day:

$$q = (0.00411 \text{ ft/s})(0.00135 \text{ ft/ft}) = 5.55 \times 10^{-6} \text{ ft/s}$$
$$= 0.44 \text{ ft/day}$$

B.2.2 AQUIFER POROSITY AND AVERAGE LINEAR VELOCITY

For the unconsolidated sand and gravel aquifer media, porosity values are expected to range from n = 0.25 to n = 0.40 (Freeze and Cherry, 1979, p. 37). Assuming a low effective porosity, a high (conservative) estimate of the average linear ground water velocity is obtained. So if n = 0.25,

$$v = (5.55 \times 10^{-6} \text{ ft/s})/(0.25) = 2.22 \times 10^{-5} \text{ ft/s}$$
$$= 1.92 \text{ ft/day}$$

The above calculations indicate that the average linear velocity of ground water outside of the influence of the pumping well, PW-5, is about 1.2 feet per day, which is a relatively high rate reflecting the relatively conductive aquifer materials.

B.3.0 VERTICAL LEAKAGE FROM SITE IMPOUNDMENTS

The vertical leakage rate from the sludge impoundments also may be calculated using Darcy's equation:

$$Q = K \cdot I \cdot A$$

where Q = leakage flow rate
K = hydraulic conductivity
I = hydraulic gradient
A = cross-sectional area

Values for the above variables have been estimated previously as summarized below.

B.3.1 HYDRAULIC CONDUCTIVITY

Laboratory measurements of sludge and undersoil hydraulic conductivities range from 10^{-5} to 10^{-7} centimeters per second (cm/s) (Table 3-3). A typical value of $K = 10^{-6}$ cm/s $\approx 10^{-7.5}$ ft/s may be used in Darcy's equation.

B.3.2 HYDRAULIC GRADIENT

The water content of the sludge is approximately 80 percent (Table 3-14), such that the sludge is assumed to be saturated. A conservative approach assumes the average thickness of the sludge represents both the head drop (dh) and the

vertical distance across which the drop occurs (dl), such that the hydraulic gradient becomes unity:

$$I = \frac{dh}{dl}$$

$$I = 1.0 \qquad \text{where } dh = dl$$

and the flow rate equation becomes:

$$Q = K \cdot A$$

B.3.3 CROSS-SECTIONAL AREA

The cross-sectional areas of the impoundments (Table 3-1) as listed below have been estimated using the 1 inch = 50 feet site survey contoured at two-foot intervals:

IMPOUNDMENT	AREA (ft^2)
Sludge disposal pit	5,775
Northern settlement basin	6,400
Southern settlement basin	5,900

B.3.4 LEAKAGE RATE

Using the simplified flow rate equation, $Q = K \cdot A$, derived from Darcy's equation, the vertical leakage rates can be calculated:

Sludge Disposal Pit: $Q_{sp} = (10^{-7.5}\ ft/s)(5{,}775\ ft^2)$
$= 0.00018\ ft^3/s$
$= 0.00517\ \ell/s$

Northern Settlement Basin: $Q_{nb} = (10^{-7.5}\ ft/s)(6{,}400\ ft^2)$
$= 0.00020\ ft^3/s$
$= 0.00573\ \ell/s$

Southern Settlement Basin: $Q_{sb} = (10^{-7.5}\ ft/s)(5{,}900\ ft^2)$
$= 0.00019\ ft^3/s$
$= 0.00528\ \ell/s$

B.4.0 GROUND WATER CONTAMINANT DILUTION

The contaminants in leachate from the waste sources (sludge in impoundments, pit, and swamp) will be diluted by mixing with the ground water so long as the ground water concentrations are less than leachate concentrations. The effects of advection, hydrodynamic dispersion, and chemical diffusion are to dilute (reduce) contaminant concentrations with increasing distance from a finite source (Batu, 1987). Monitoring wells nearest the continuously leaching contaminant sources, therefore, will yield ground water with higher concentrations of contaminants than wells further downgradient. Several different approaches for evaluating downgradient dilution are possible. However, for the purpose of estimating the contaminant levels at finite distances from the ARCO site, the U.S. EPA Vertical and Horizontal Spread (VHS) model was used because it is considered to be conservative [Federal Register, Vol. 50, No. 229, Wednesday, November 27, 1985, pp. 48886-48966 (50 FR 48886-48966)].

B.4.1 U.S. EPA VERTICAL AND HORIZONTAL SPREAD MODEL

The VHS model is an analytical approach to evaluate the potential hazard of inorganic wastes that may leach into ground water from an overlying landfill. The model assumes reasonable worst-case conditions to model ground water transport of toxicants from disposal sites to nearby receptors. More specifically, the model estimates the ability of an aquifer to dilute the toxicants from a specific volume of waste and predicts toxicant levels at a receptor well any distance from the waste source. The VHS model equation is as follows (50 FR 48900):

$$C = C_o \text{ erf } \{[Y'/4Y]^{0.5}\} \text{ erf } \{X/[4(d_t Y)^{0.5}]\}$$

where

C = concentration at receptor [mg/ℓ]

C_o = leachate concentration [mg/ℓ]

Y' = width of single trench taken as 12.2 m

Y = distance to receptor point [m]

X = length of disposal trench perpendicular to ground water flow [m]

d_t = transverse dispersivity taken as 2m

The dimensions of the model define a trench-shaped landfill with a volume taken to be that of the waste (sludge). The length of the trench may be calculated as follows:

Volume = X (Y') depth

Then, given the initial leachate concentrations (e.g., EP Toxicity results), the estimated concentration at a receptor point any distance (Y) perpendicular from the trench may be calculated.

B.4.2 VHS MODEL RESULTS FOR 50-METER RECEPTOR

The VHS equation as presented above is used to estimate the dilution of leachate to a receptor 50 meters from the waste sludge. Maximum observed ground water concentrations for total chromium (Cr), cyanide (CN), fluoride (F), and arsenic (As) are used to compute the expected worst case concentrations at a receptor point 50 meters from the sludge assuming a total sludge volume of 8,850 cubic yards (yd^3) (6,766 m^3) and taking an average sludge thickness of 2.5 m (~7.9 feet), as indicated in Table 3-1.

The model trench length, X, can thus be computed as:

$$X = \text{volume}/[(Y')(\text{depth})]$$
$$= (6{,}766\ m^3)/[(12.2\ m)(2.5m)]$$
$$= 221.8\ m$$

Then for a receptor at a distance of 50 m:

$$C = C_o \text{ erf } \{[12.2/[(4)(50))]^{0.5}\} \text{ erf } \{221.8/(4[(2)(221.8)]^{0.5})\}$$
$$= C_o \text{ erf } (0.247) \text{ erf } (0.745)$$
$$= C_o\ (0.276)\ (0.708)$$
$$= C_o\ (0.195)$$

For Cr, CN, F, and As, the maximum EP Toxicity leachate concentrations in mg/ℓ are 0.14, 0.70, 8.7, and 0.047, respectively. Therefore, the concentrations at the receptor well 50 meters from the source are computed by the VHS model as follows:

$$C_{50}(Cr) = 0.14\ (0.195) = 0.027\ mg/\ell\ Cr$$
$$C_{50}(CN) = 0.70\ (0.195) = 0.137\ mg/\ell\ CN$$
$$C_{50}(F) = 8.7\ (0.195) = 1.70\ mg/\ell\ F$$
$$C_{50}(As) = 0.047\ (0.195) = 0.009\ mg/\ell\ As$$

The computed concentrations at a receptor well 50 meters from the source are less than the SDWA Standards and Water Quality Criteria*.

	VHS MODEL 50-m CONCENTRATION (mg/ℓ)		SDWA PRIMARY STANDARD (mg/ℓ)
Cr	0.027	<	0.05
CN	0.137	<	0.2*
F	1.70	<	4.0
As	0.009	<	0.05

*U.S. EPA Water Quality Criteria for the Protection of Human Health as reported in the Superfund Public Health Evaluation Manual (U.S. EPA, 1986, EPA 540/1-86/060).

APPENDIX
C

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APPENDIX C

BORING LOGS AND WELL COMPLETION DIAGRAMS
ARCO GNADENHUTTEN, OHIO SITE
AND SURROUNDING AREA

APPENDIX C

OUTLINE OF CONTENTS

- Boring logs and well completion diagrams for the ARCO Gnadenhutten, Ohio site
- Water well inventory of surrounding area
- Boring logs of water wells in surrounding area of the ARCO Gnadenhutten, Ohio site.

APPENDIX C

LIST OF TABLES

TABLE NO.	TITLE
C-1	Water Well Inventory, ARCO Chemical Company, Gnadenhutten, Ohio

LIST OF FIGURES

FIGURE NO.	TITLE
C.1	Regional Map Showing Water and Oil/Gas Well Locations

BORING LOGS AND WELL COMPLETION DIAGRAMS FOR THE ARCO GNADENHUTTEN, OHIO SITE

GENERAL NOTES AND LEGEND

Symbols to be used for designation of subsurface materials on all boring logs and subsurface sections

GRAVEL
SAND
SILT
CLAY
LIMESTONE
SILTSTONE
SANDSTONE
MASSIVE MUDSTONE OR CLAYSTONE
SHALE
VOID (INDICATES SIZE OF VOID)
WATER
APPROXIMATE EXISTING GROUND
APPROXIMATE TOP OF ROCK

2 O D SPLIT BARREL SAMPLE

75/0 5 PENETRATION REFUSAL RESISTANCE AND FRACTIONAL INCREMENT DRIVEN IN FEET

GROUND WATER LEVEL AND DATE

U S C S UNIFIED SOIL CLASSIFICATION SYSTEM (CAPITAL LETTERS INDICATE LAB TEST CLASSIFICATION LOWER CASE LETTERS INDICATE VISUAL FIELD CLASSIFICATION)

(60) RQD (ROCK QUALITY DESIGNATION PERCENT) LENGTH OF NUMBER OF PIECES GREATER THAN 4 INCHES DIVIDED BY THE LENGTH OF THE CORE RUN)

90 INDICATES PERCENT OF CORE RECOVERED (LENGTH OF CORE RECOVERED DIVIDED BY LENGTH OF CORE RUN)

STANDARD PENETRATION RESISTANCE IS THE NUMBER OF BLOWS REQUIRED TO DRIVE A 2 INCH O. D SPLIT BARREL SAMPLER 12 INCHES USING A 140 POUND HAMMER FALLING FREELY THROUGH 30 INCHES. THE SAMPLER WAS DRIVEN 18 INCHES AND THE NUMBER OF BLOWS RECORDED FOR EACH 6 INCH INTERVAL. THE RESISTANCE TO PENETRATION IS INDICATED ON THE DRAWING AS BLOWS PER FOOT.

TRACE – INDICATES PRESENCE OF 5 TO 12% OF SUBJECT MATERIAL BY WEIGHT
SOME – INDICATES PRESENCE OF 12 TO 30% OF SUBJECT MATERIAL BY WEIGHT
AND – INDICATES APPROXIMATELY EQUAL PORTIONS OF SUBJECT MATERIAL BY WEIGHT

CONSISTENCY OF COHESIVE SOILS

CONSISTENCY	UNCONFINED COMPRESSIVE STRENGTH TONS PER SQUARE FOOT
VERY SOFT	LESS THAN 0 25
SOFT	0 25 TO 0 50
MEDIUM STIFF	0 50 TO 1 0
STIFF	1 0 TO 2 0
VERY STIFF	2 0 TO 4 0
HARD	MORE THAN 4 0

DENSITY OF GRANULAR SOILS

DESIGNATION	BLOWS PER FOOT
VERY LOOSE	0 4
LOOSE	5 10
MEDIUM DENSE	11 30
DENSE	31 50
VERY DENSE	OVER 50

THE BORING LOGS AND RELATED INFORMATION DEPICT SUBSURFACE CONDITIONS ONLY AT THE SPECIFIC LOCATIONS AND DATES INDICATED SOIL CONDITIONS AND WATER LEVELS AT OTHER LOCATIONS MAY DIFFER FROM CONDITIONS OCCURRING AT THESE BORING LOCATIONS ALSO THE PASSAGE OF TIME MAY RESULT IN A CHANGE IN THE CONDITIONS AT THESE BORING LOCATIONS

U S C S CLASSIFICATION FOR SOILS

WENTWORTH SCALE FOR ROCK

TERMS USED TO DESCRIBE THE RELATIVE DEGREES OF ROCK CORE HARDNESS

DESCRIPTIVE TERMS	DEFINING CHARACTERISTICS
VERY SOFT	CRUSHES UNDER PRESSURE OF FINGERS AND/OR THUMB
SOFT	CRUSHES UNDER PRESSURE OF PRESSED HAMMER
MEDIUM HARD	BREAKS EASILY UNDER SINGLE HAMMER BLOW BUT WITH CRUMBLY EDGES
HARD	BREAKS UNDER ONE OR TWO STRONG HAMMER BLOWS BUT WITH RESISTANT SHARP EDGES
VERY HARD	BREAKS UNDER SEVERAL STRONG HAMMER BLOWS BUT WITH VERY RESISTANT SHARP EDGES AND MAY SPALL LEAVING CONCHOIDAL FRACTURES

THE SPACING OF THE DISCONTINUITIES IN THE ROCK MAY BE DESCRIBED BY ONE OF THE FOLLOWING TERMS

DESCRIPTIVE TERMS	SPACING
VERY BROKEN	LESS THAN 1 IN
BROKEN	1 IN TO 3 IN
SLIGHTLY BROKEN	3 IN TO 6 IN
UNBROKEN	6 IN AND GREATER

DATE BEGAN 3-13-85
DATE FINISHED 3-13-85
GROUND SURFACE EL. 837.8

BORING NO. MW-1

N _____ E _____

FIELD ENGINEER D. BRUNNER
CHECKED BY D. BRUNNER

EV (FET)	DEPTH (FEET)	SAMPLE TYPE	PROFILE	DESCRIPTION	USCS	PENETRATION RESISTANCE (BLOWS PER FOOT) 10 30 60	REMARKS
		S 1, S 2		FILL MATERIAL: BROWN AND BLACK, LOOSE, SAND, CINDERS, GRAVEL, MOIST 4.5'			
	5.0	S 3		BROWN, LOOSE, MEDIUM TO FINE SAND, SOME FINE GRAVEL, TRACE SILT, MOIST TO WET			
830.0	10.0	S 4		GRADES TO			
	15.0	S 5					
820.0							
3-13-85	20.0	S 6		BROWN, MEDIUM DENSE, MEDIUM TO FINE SAND, SOME MEDIUM TO FINE GRAVEL, TRACE SILT, WET	sp		
	25.0	S 7					
810.0	30.0	S 8					
	35.0	S 9		34.5' BROWN, MEDIUM DENSE, MEDIUM TO FINE, SAND SEAM 35.0-35.7 37.0'	sw		
800.0	40.0	S 10		BROWN, MEDIUM DENSE, COARSE TO FINE SAND, SOME MEDIUM TO FINE GRAVEL, TRACE SILT, WET	sp		
	45.0	S 11		NO RECOVERY			
790.0							
787.8	50.5						

PROJECT NO. 846697

BOTTOM OF BORING 50.0'

BORING NO. MW-1
SHEET 1 OF 1

DATE BEGAN 4-5-85
DATE FINISHED 4-5-85
GROUND SURFACE EL. 831.6

BORING NO. MW-2

N _____ E _____

FIELD ENGINEER D. BRUNNER
CHECKED BY D. BRUNNER

ELEV (FEET)	DEPTH (FEET)	SAMPLE TYPE	PROFILE	DESCRIPTION	USCS	PENETRATION RESISTANCE (BLOWS PER FOOT) 10 30 50	REMARKS
830.0	5.0	S 1		FILL MATERIAL: MOTTLED BROWN GRAY AND BLACK, VERY LOOSE, FINE SAND AND SILT, TRACE BLUE SLUDGE, WET			
	10.0	S 2		11.0'			
820.0				BROWN, LOOSE TO MEDIUM DENSE, MEDIUM TO FINE SAND, TRACE SILT, WET 13.5'	sw		
4-5-85	15.0	S 3		BROWN, LOOSE, FINE SAND AND SILT, WET 15.5'	sm		
	20.0	S 4					
10.0	25.0	S 5					
	30.0	S 6		BROWN, MEDIUM DENSE, COARSE TO FINE SAND, SOME MEDIUM TO FINE GRAVEL, TRACE SILT, WET	sp		
800.0	35.0	S 7		NO RECOVERY			
	40.0	S 8					
790.0	45.0	S 9		NO RECOVERY			
781.6	50.0						

PROJECT NO. 846697

BOTTOM OF BORING 50.0'

BORING NO. MW-2
SHEET 1 OF 1

DATE BEGAN 4-4-85
DATE FINISHED 4-4-85
GROUND SURFACE EL 833.3

BORING NO. MW-3

N _____ E _____

FIELD ENGINEER D. BRUNNER
CHECKED BY D. BRUNNER

EV (FEET)	DEPTH (FEET)	SAMPLE TYPE	PROFILE	DESCRIPTION	USCS	PENETRATION RESISTANCE (BLOWS PER FOOT) 10 30 50	REMARKS
830.0	5.0	S1		FILL MATERIAL: BROWN, MEDIUM DENSE, SAND, TRACE SILT, CINDERS, WOOD, GRAVEL, BRICK AND ROCK FRAGMENTS, WET			AUGERED THRU FILL MATERIAL 0.0 - 5.5'
	10.0	S2		12.0'			
820.0	15.0	S3		MOTTLED BROWN AND GRAY, VERY LOOSE, FINE SAND, SOME SILT, WET 17.0'	sm		
4-4-85	20.0						
810.0	25.0	S4					SPOON SUNK TO 22.5 FEET BY ITS OWN WEIGHT
	30.0	S5		BROWN, MEDIUM DENSE, COARSE TO FINE SAND, SOME MEDIUM TO FINE GRAVEL, TRACE SILT, WET	sp		
800.0	35.0	S6					
	40.0	S7		INTERBEDDED WITH SOME BROWN, MEDIUM TO FINE SAND SEAMS			
790.0	45.0	S8		NO RECOVERY			
783.3	50.0	S9		NO RECOVERY			

PROJECT NO. 846697

BOTTOM OF BORING 50.0'

BORING NO. MW-3
SHEET 1 OF 1

DATE BEGAN 3-22-85
DATE FINISHED 3-22-85
GROUND SURFACE EL. 825.7

BORING NO. MW-4

N _____ E _____

FIELD ENGINEER D. BRUNNER
CHECKED BY D. BRUNNER

EV (FEET)	DEPTH (FEET)	SAMPLE TYPE	PROFILE	DESCRIPTION	USCS	PENETRATION RESISTANCE (BLOWS PER FOOT) 10 30 50	REMARKS
		S 1		FILL MATERIAL: BROWN TO DARK BROWN, MEDIUM DENSE, FINE SAND AND SILT, TRACE CINDERS, ORGANICS, BRICK AND ROCK FRAGMENTS, MOIST 6.0'			
820.0	5.0	S 2		BROWN, LOOSE, MEDIUM TO FINE SAND, TRACE SILT, MOIST, GRADES TO GRAY COLOR 11.0'	sw		
	10.0	S 3		GRAY, SOFT, SILT, SOME CLAY, TRACE FINE SAND, WET 12.5'	ml		
3-22-85							
810.0	15.0	S 4		BROWN, MEDIUM DENSE, MEDIUM TO FINE SAND, SOME MEDIUM TO FINE GRAVEL, WET 20.5'	sp		
	20.0	S 5		GRAY, MEDIUM DENSE, MEDIUM TO FINE SAND, SOME MEDIUM TO FINE GRAVEL, TRACE SILT, WET 22.5'	sp		
800.0	25.0	S 6		BROWN, MEDIUM DENSE, MEDIUM TO FINE SAND, SOME MEDIUM TO FINE GRAVEL, TRACE SILT, WET 31.0'	sp		
	30.0	S 7		BROWN, MEDIUM DENSE, MEDIUM TO FINE SAND, TRACE SILT, WET 32.5'	sw		
790.0	35.0	S 8					
	40.0	S 9		BROWN, MEDIUM DENSE, MEDIUM TO FINE SAND, SOME MEDIUM TO FINE GRAVEL, TRACE SILT, WET	sp		
780.0	45.0	S 10					
775.7	50.0						

PROJECT NO. 846697

BOTTOM OF BORING 50.0'

BORING NO. MW-4
SHEET 1 OF 1

DATE BEGAN 4-8-85
DATE FINISHED 4-8-85
GROUND SURFACE EL. 826.1

BORING NO. MW-5

N _____ E _____

FIELD ENGINEER D. BRUNNER
CHECKED BY D. BRUNNER

ELEV (FEET)	DEPTH (FEET)	SAMPLE TYPE	PROFILE	DESCRIPTION	USCS	PENETRATION RESISTANCE (BLOWS PER FOOT) 10 30 50	REMARKS
820.0	5.0	S 1		BROWN, VERY LOOSE, FINE SAND AND SILT, WET 7.0'	sp		
4-8-85	10.0	S 2		GRAY, VERY LOOSE, FINE SAND, TRACE SILT, WET 13.0'	sw		
810.0	15.0	S 3		BROWN, MEDIUM DENSE, COARSE TO FINE SAND, WITH MEDIUM TO FINE GRAVEL, TRACE BLACK ORGANICS, WET 19.0'	sp		
	20.0	S 4		BROWN, MEDIUM DENSE, MEDIUM TO FINE SAND, WET 20.5'	sw		
				BROWN, MEDIUM DENSE, MEDIUM TO FINE SAND AND SILT, SOME MEDIUM TO FINE GRAVEL, WET 21.0'	sm / sp		
800.0	25.0	S 5		BROWN, MEDIUM DENSE, MEDIUM TO FINE SAND, TRACE FINE GRAVEL, WET 24.5'	sw		
	30.0	S 6		BROWN, MEDIUM DENSE, MEDIUM TO FINE SAND, TRACE FINE GRAVEL, WET 36.0'			
790.0	35.0	S 7					
	40.0	S 8		BROWN, MEDIUM DENSE, COARSE TO FINE SAND, SOME MEDIUM TO FINE GRAVEL, WET	sp		
780.0	45.0	S 9					
776.1	50.0						

PROJECT NO. 846697

BOTTOM OF BORING 50.0'

BORING NO. MW-5
SHEET 1 OF 1

DATE BEGAN 3-18-85
DATE FINISHED 3-19-85
GROUND SURFACE EL. 834.8

BORING NO. MW-6

N _____ E _____

FIELD ENGINEER T.M. JOHNSON
CHECKED BY D. BRUNNER

EV (FEET)	DEPTH (FEET)	SAMPLE TYPE	PROFILE	DESCRIPTION	USCS	PENETRATION RESISTANCE (BLOWS PER FOOT) 10 30 50	REMARKS
				SLAG AND CINDER FILL 0.5'			
830.0	5.0	S 1		BROWN, LOOSE, MEDIUM TO FINE SAND, SOME MEDIUM TO FINE GRAVEL, TRACE SILT, WET	sp		
	10.0			10.0'			
820.0	15.0	S 2		BROWN, LOOSE, MEDIUM TO COARSE SAND, SOME FINE TO COARSE GRAVEL, WET			SLIGHT REDDISH COLOR IN SAMPLE S-5 FOLLOWING ADDITION OF DIPHENYL CARBIZIDE
3-18-85		S 3		18.0'			
	20.0	S 4			sp		SLIGHT REDDISH COLOR IN SAMPLE S-7 FOLLOWING ADDITION OF DIPHENYL CARBIZIDE
810.0	25.0	S 5			sp		
	30.0	S 6		BROWN, LOOSE TO MEDIUM DENSE, FINE TO COARSE SAND, SOME FINE TO COARSE GRAVEL, WET	sp		SLIGHT REDDISH COLOR IN SAMPLE S-8 FOLLOWING ADDITION OF DIPHENYL CARBIZIDE
800.0	35.0	S 7			sp		SLIGHT REDDISH COLOR IN SAMPLE S-9 FOLLOWING ADDITION OF DIPHENYL CARBAZAIDE AUGERED FROM 46.5' TO 500' WITHOUT SAMPLING
				GRADES TO 38.0'			
	40.0	S 8		BROWN, MEDIUM DENSE, MEDIUM TO COARSE SAND, WET	sw		
				GRADES TO 43.0'			
790.0	45.0	S 9		BROWN, MEDIUM DENSE, FINE TO COARSE SAND, SOME FINE GRAVEL, WET	sp		
84.8	50.0						

PROJECT NO. 846697

BOTTOM OF BORING 50.0'

BORING NO. MW-6
SHEET 1 OF 1

DATE BEGAN 4-8-85
DATE FINISHED 4-9-85
GROUND SURFACE EL. 821.7

BORING NO. MW-7

N _____ E _____

FIELD ENGINEER D. BRUNNER
CHECKED BY D. BRUNNER

ELEV (FEET)	DEPTH (FEET)	SAMPLE TYPE	PROFILE	DESCRIPTION	USCS	PENETRATION RESISTANCE (BLOWS PER FOOT) 10 30 50	REMARKS
820.0				BROWN, VERY LOOSE, MEDIUM TO FINE SAND, TRACE SILT AND GRAVEL, WET	sp		
4-9-85	5.0	S 1					
				8.5'			
810.0	10.0	S 2		BROWN, MEDIUM DENSE, COARSE TO FINE SAND, WITH MEDIUM TO FINE GRAVEL, WET	sp		
				14.0'			
	15.0	S 3		BROWN, LOOSE, MEDIUM TO FINE GRAVEL, WITH COARSE TO FINE SAND, WET	gp		
				18.5'			
800.0	20.0	S 4					
	25.0	S 5					
	30.0	S 6		BROWN, MEDIUM DENSE, MEDIUM TO FINE SAND, SAME MEDIUM TO FINE GRAVEL, WET	sp		
790.0	35.0	S 7					
	40.0	S 8		NO RECOVERY			
780.0	45.0	S 9					
771.7	50.0						

PROJECT NO. 846697

BOTTOM OF BORING 50.0'

BORING NO. MW-7
SHEET 1 OF 1

DATE BEGAN 3-15-85
DATE FINISHED 3-15-85
GROUND SURFACE EL. 829.8

BORING NO. MW-8

N _____ E _____

FIELD ENGINEER D. BRUNNER
CHECKED BY D. BRUNNER

ELEV (FEET)	DEPTH (FEET)	SAMPLE TYPE	PROFILE	DESCRIPTION	USCS	PENETRATION RESISTANCE (BLOWS PER FOOT) 10 30 50	REMARKS
				ASPHALT AND SUBGRADE 0.5'			
				FILL MATERIAL: GRAY, LOOSE, MEDIUM TO FINE SAND, SOME FINE GRAVEL, TRACE SILT, TRACE ORGANICS, WET 3.0'	sp		
	5.0	S 1		FILL MATERIAL: BROWN, LOOSE, COARSE TO FINE SAND, SOME MEDIUM TO FINE GRAVEL, TRACE SILT, TRACE SHELL FRAGMENTS, MOIST 9.0'	sp		
820.0	10.0	S 2		GRAY TO BROWN, SOFT, SILT, TRACE FINE SAND AND CLAY, MOIST (RIVER SEDIMENT) 13.5'	sm		
3-15-85	15.0	S 3		BROWN, MEDIUM DENSE, SILT, SOME FINE SAND AND MEDIUM TO FINE GRAVEL, WET 14.5'	sm		
810.0	20.0	S 4		BROWN, DENSE TO MEDIUM DENSE, COARSE TO FINE SAND, SOME MEDIUM TO FINE GRAVEL, TRACE SILT, WET 20.0'	sp		
	25.0	S 5		BROWN, MEDIUM DENSE, COARSE TO MEDIUM SAND WITH MEDIUM GRAVEL, WET 25.0'	sw		
800.0	30.0	S 6		BROWN, DENSE, COARSE TO MEDIUM SAND, SOME MEDIUM TO FINE GRAVEL, TRACE SILT, WET 35.0'	sp		
	35.0	S 7					
790.0	40.0	S 8		BROWN, MEDIUM DENSE, FINE SAND, TRACE FINE GRAVEL, WET	sw		
	45.0	S 9					
780.0	50.0						
779.8							

PROJECT NO. 846697

BOTTOM OF BORING 50.0'

BORING NO. MW-8
SHEET 1 OF 1

DATE BEGAN 3-20-85
DATE FINISHED 3-20-85
GROUND SURFACE EL. 822.3

BORING NO. MW-9

N _____ E _____

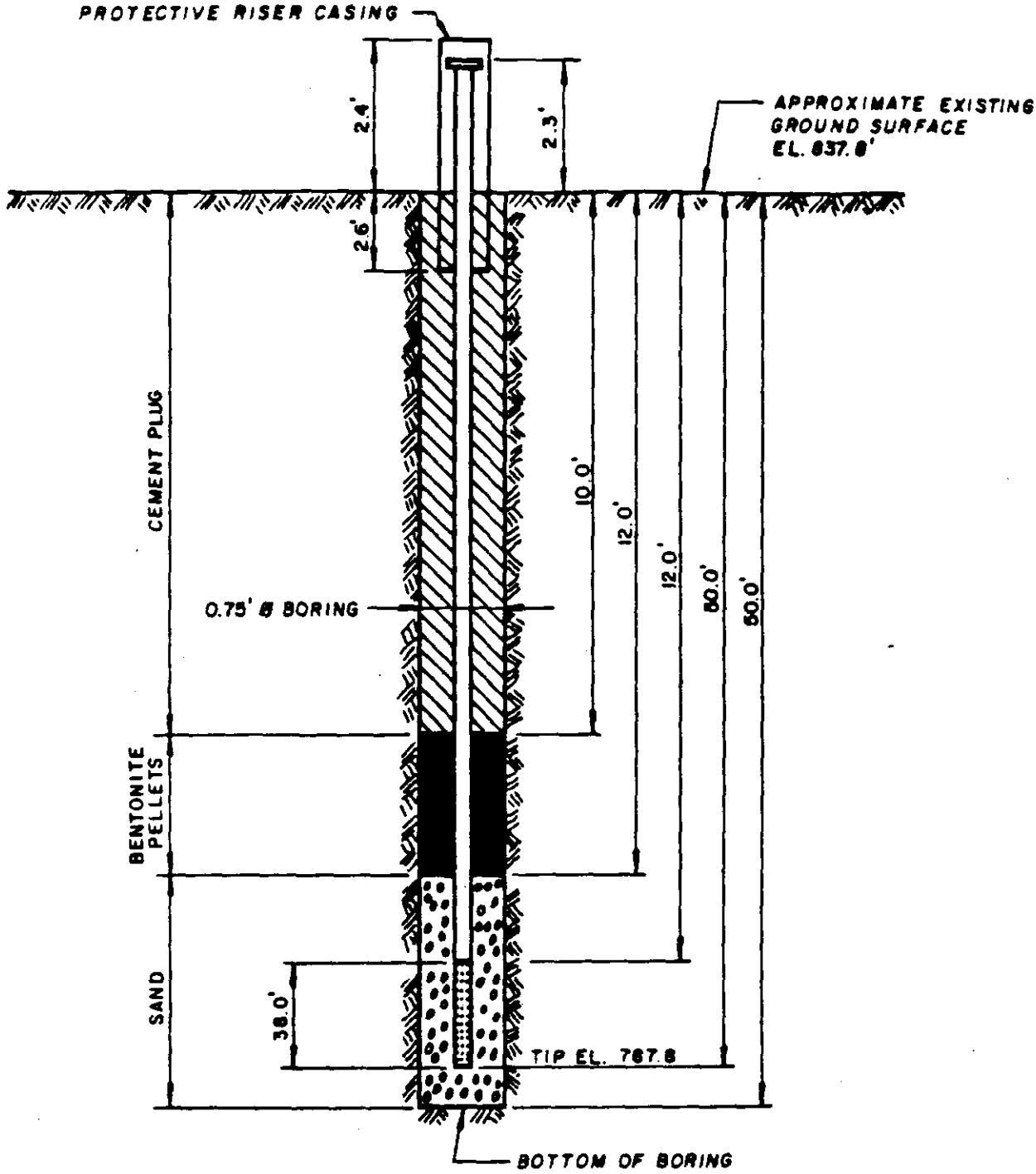
FIELD ENGINEER T.M. JOHNSON
CHECKED BY D. BRUNNER

ELEV (FEET)	DEPTH (FEET)	SAMPLE TYPE	PROFILE	DESCRIPTION	USCS	PENETRATION RESISTANCE (BLOWS PER FOOT) 10 30 50	REMARKS
820.0		S 1		DARK BROWN TO BLACK, VERY LOOSE, SILT, TRACE CLAY AND FINE SAND, MOIST	ml		NO COLORATION WITH ADDITION OF DIPLENYL CARBIZIDE
				GRADES TO			
3-20-85	5.0	S 2		LIGHT BROWN, VERY LOOSE, FINE SAND, TRACE TO SOME CLAY AND SILT, MOIST	sm		NO APPARENT COLORATION WITH ADDITION OF DIPHENYL CARBIZIDE
				GRADES TO			
	10.0			LIGHT BROWN TO GRAY, SOFT SILTY, CLAY, TRACE FINE SAND, WET 10.5'	cl		NO APPARENT COLORATION WITH ADDITION OF DIPLENYL CARBIZIDE
810.0	15.0	S 3		BROWN, LOOSE, COARSE TO FINE, SANDY GRAVEL, WET	gw		DROVE COBBLE IN S-4
		S 4			gw		NO APPARENT COLORATION WITH ADDITION OF DIPHENYL CARBIZIDE
				GRADES TO			
	20.0	S 5		BROWN, MEDIUM DENSE, FINE TO MEDIUM SAND, TRACE FINE GRAVEL, WET	sp		
0.0	25.0	S 6		BROWN, MEDIUM DENSE, FINE TO COARSE SAND, TRACE FINE GRAVEL, WET	sw		SLIGHT REDDISH COLORATION WITH ADDITION OF DIPHENYL CARBIZIDE
	30.0						
790.0		S 7		BROWN, MEDIUM DENSE, MEDIUM TO COARSE SAND, TRACE FINE GRAVEL, WET	sw		
	35.0	S 8			sw		REDDISH COLORATION WITH ADDITION OF DIPHENYL CARBIZIDE
	40.0	S 9		BROWN, DENSE, MEDIUM TO COARSE SAND, SOME FINE TO COARSE GRAVEL, WET	sw		
780.0	45.0	S 10		BROWN, DENSE, MEDIUM TO COARSE SAND, SOME FINE GRAVEL, WET	sw		VERY SLIGHT REDDISH COLORATION WITH ADDITION OF DIPHENYL CARBIZIDE
772.3	50.0						AUGERED FROM 46.5 to 50.0' WITHOUT SAMPLING TO COMPLETE BORING DEPTH

PROJECT NO. 846697

BOTTOM OF BORING 50.0'

BORING NO. MW-9
SHEET 1 OF 1



NOTES:

1. RISER PIPE IS 2 IN. I.D. SCHEDULE 40 PVC PIPE, THREADED, FLUSH-JOINTED.
2. SCREEN IS 2 IN. I.D. PVC PIPE CONTINUOUS SLOT SCREEN (0.010 IN. SLOT SIZE).
3. LOWER END OF SCREEN IS CAPPED.
4. ELEVATION OF WATER LEVEL 818.3'
5. WATER LEVEL MEASURED ON 3-14-85.

INSTALLATION DETAILS
MONITORING WELL MW-1
GNADENHUTTEN, OHIO

PREPARED FOR

ARCO CHEMICAL COMPANY
NEWTOWN SQUARE, PENNSYLVANIA

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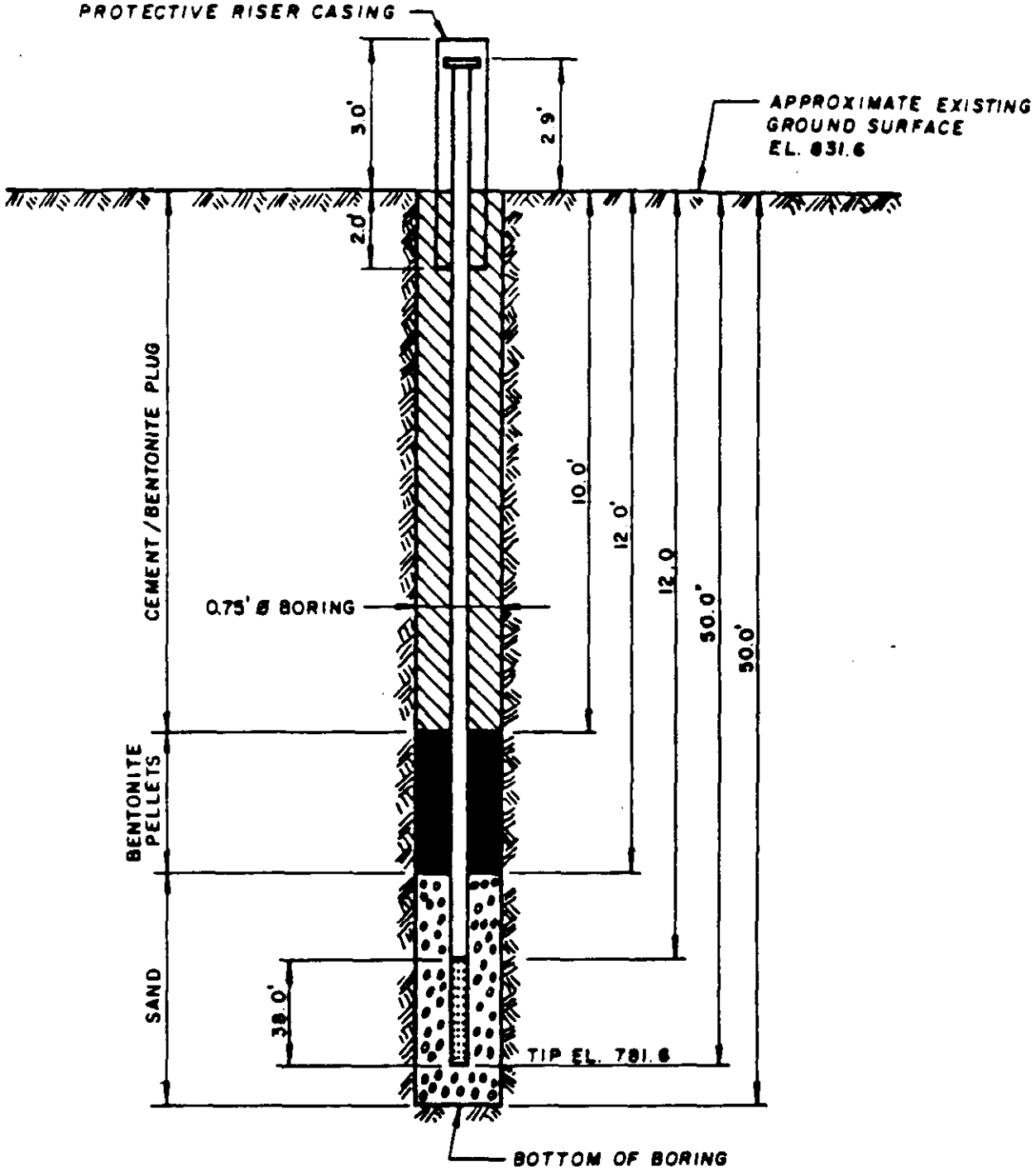

NOTES:

1. RISER PIPE IS 2 IN. I.D. SCHEDULE 40 PVC PIPE, THREADED, FLUSH-JOINTED.
2. SCREEN IS 2 IN. I.D. PVC PIPE CONTINUOUS SLOT SCREEN (0.010 IN. SLOT SIZE).
3. LOWER END OF SCREEN IS CAPPED.
4. ELEVATION OF WATER LEVEL 817.6'.
5. WATER LEVEL MEASURED ON 4-5-85.

INSTALLATION DETAILS
MONITORING WELL MW-2
GNADENHUTTEN, OHIO

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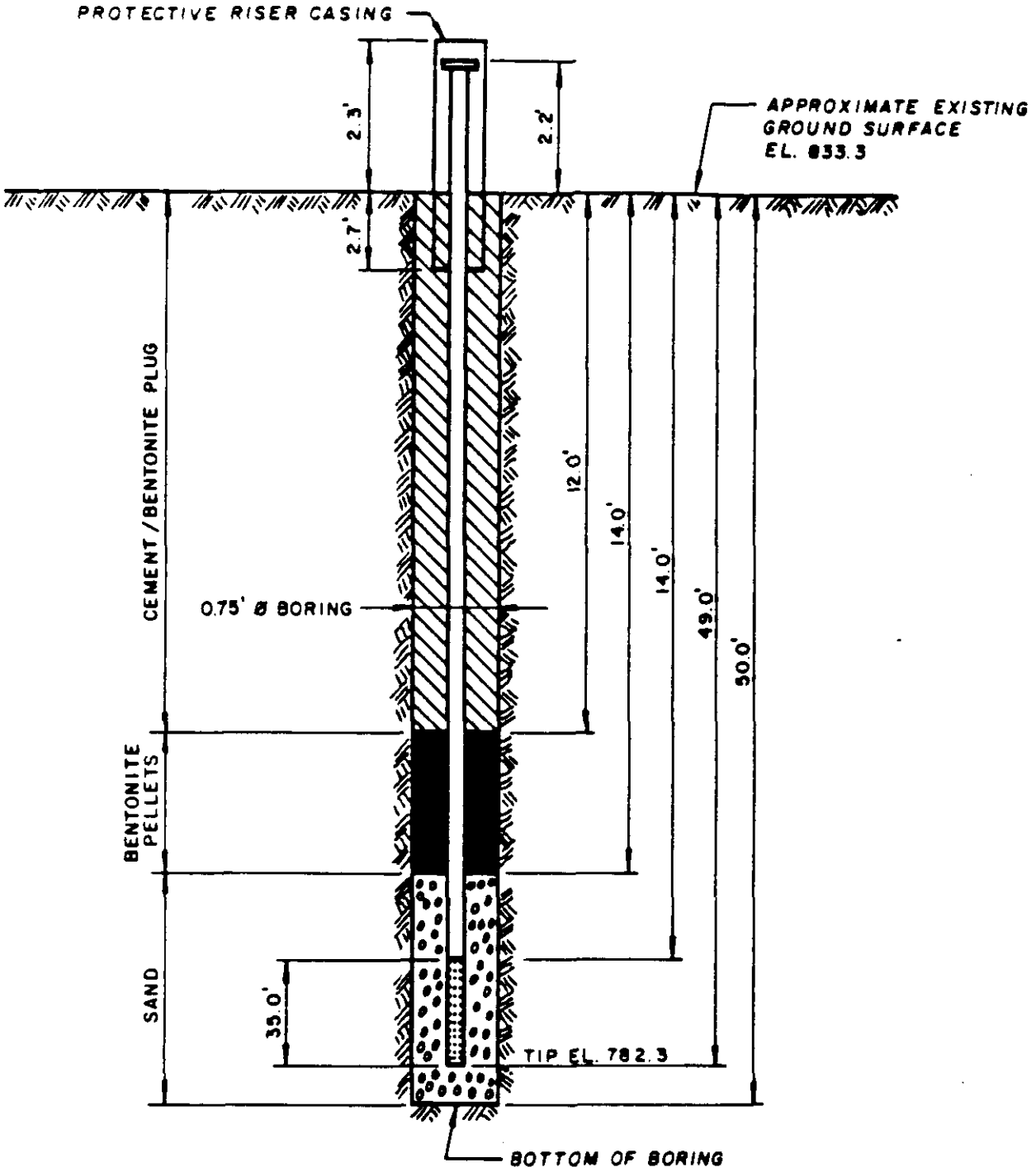
DR R. Weible 3-10-87 | CHECKED BY CAC | APPROVED BY | DRAWING NUMBER 029-A3

R Weible 3-10-87	CHECKED BY	CAC	3-17-87
	APPROVED BY		

DRAWING NUMBER 3029 – A4

D'



NOTES:

1. RISER PIPE IS 2 IN. I.D. SCHEDULE 40 PVC PIPE, THREADED, FLUSH-JOINTED.
2. SCREEN IS 2 IN. I.D. PVC PIPE CONTINUOUS SLOT SCREEN (0.010 IN. SLOT SIZE).
3. LOWER END OF SCREEN IS CAPPED.
4. ELEVATION OF WATER LEVEL 813.8'.
5. WATER LEVEL MEASURED ON 4-4-85.

INSTALLATION DETAILS
MONITORING WELL MW-3
GNADENHUTTEN, OHIO

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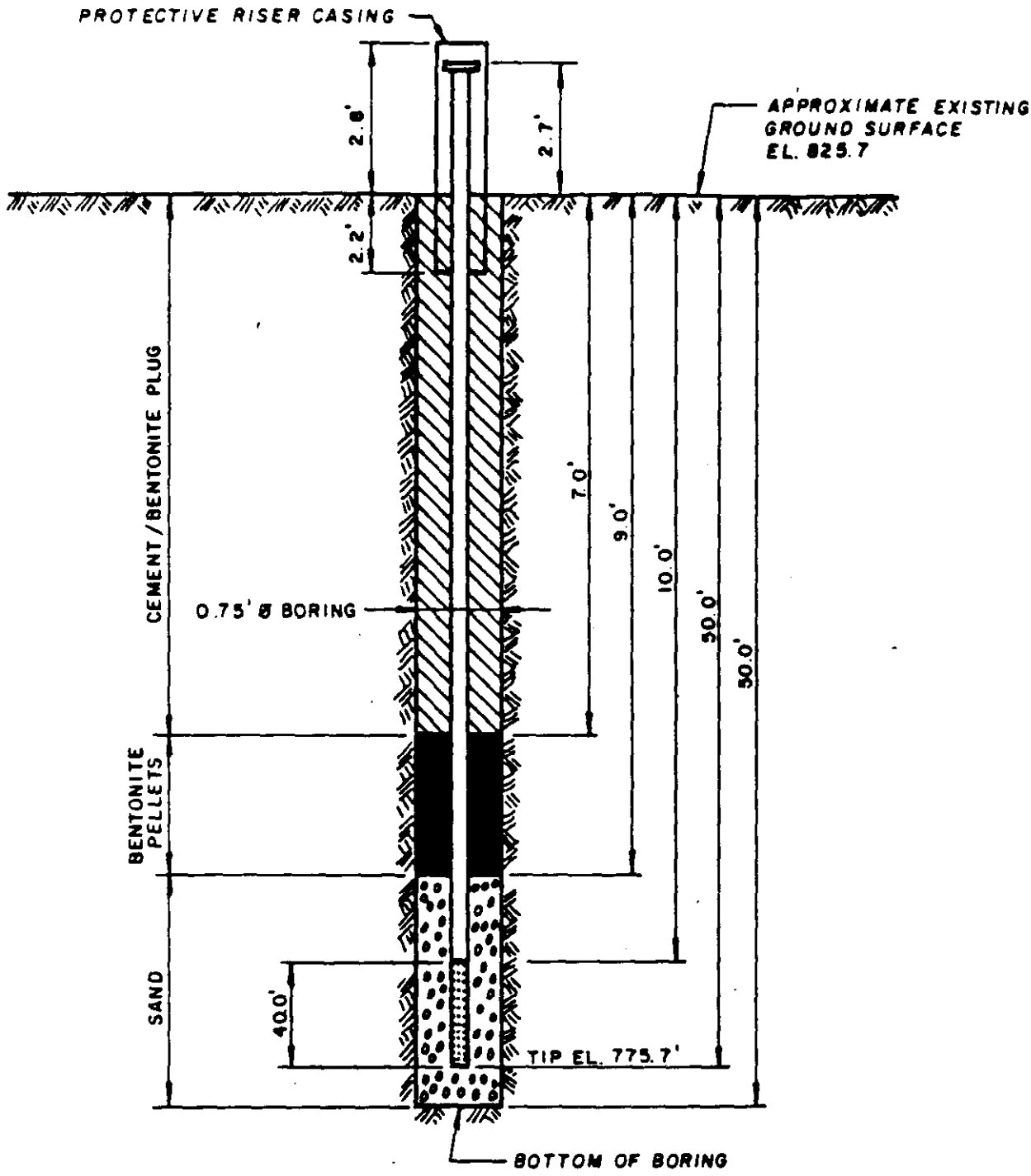
DR. BY	JES 3-14-87	CHECKED BY / APPROVED BY	CAC	8-24-87	DRAWING NUMBER	J29-A5



NOTES:

1. RISER PIPE IS 2 IN. I.D. SCHEDULE 40 PVC PIPE, THREADED, FLUSH-JOINTED.
2. SCREEN IS 2 IN. I.D. PVC PIPE CONTINUOUS SLOT SCREEN (0.010 IN. SLOT SIZE).
3. LOWER END OF SCREEN IS CAPPED.
4. ELEVATION OF WATER LEVEL 811.7'
5. WATER LEVEL MEASURED ON 3-22-85

INSTALLATION DETAILS
MONITORING WELL MW-4
GNADENHUTTEN, OHIO

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29-A6

DRAWING NUMBER

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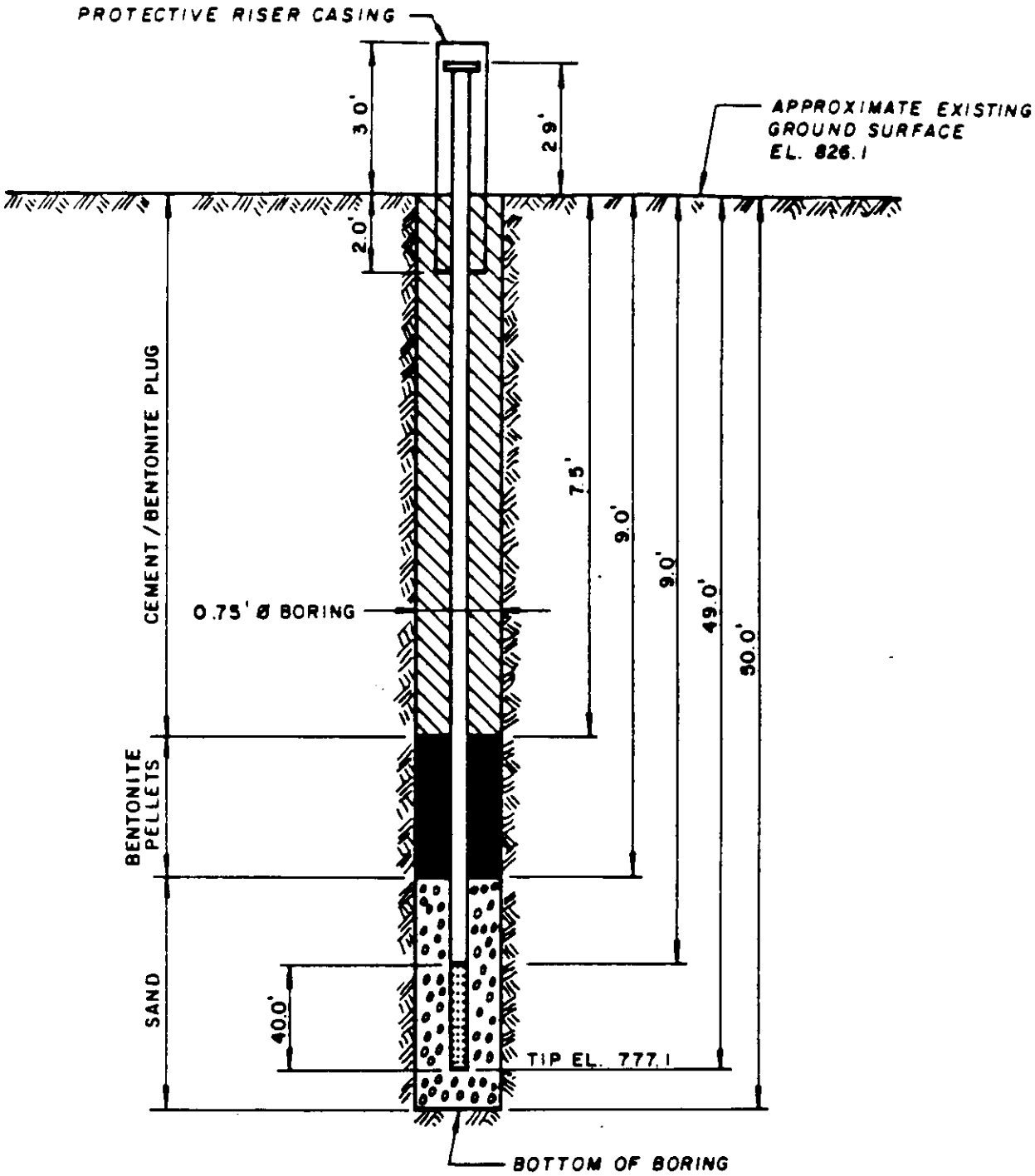
APPROVED BY

JES 3-14-87

DRA B.



NOTES:

1. RISER PIPE IS 2 IN. I.D. SCHEDULE 40 PVC PIPE, THREADED, FLUSH-JOINTED.
2. SCREEN IS 2 IN. I.D. PVC PIPE CONTINUOUS SLOT SCREEN (0.010 IN. SLOT SIZE).
3. LOWER END OF SCREEN IS CAPPED.
4. ELEVATION OF WATER LEVEL 813.1'
5. WATER LEVEL MEASURED ON 4-8-85

INSTALLATION DETAILS
MONITORING WELL MW-5
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29-A7

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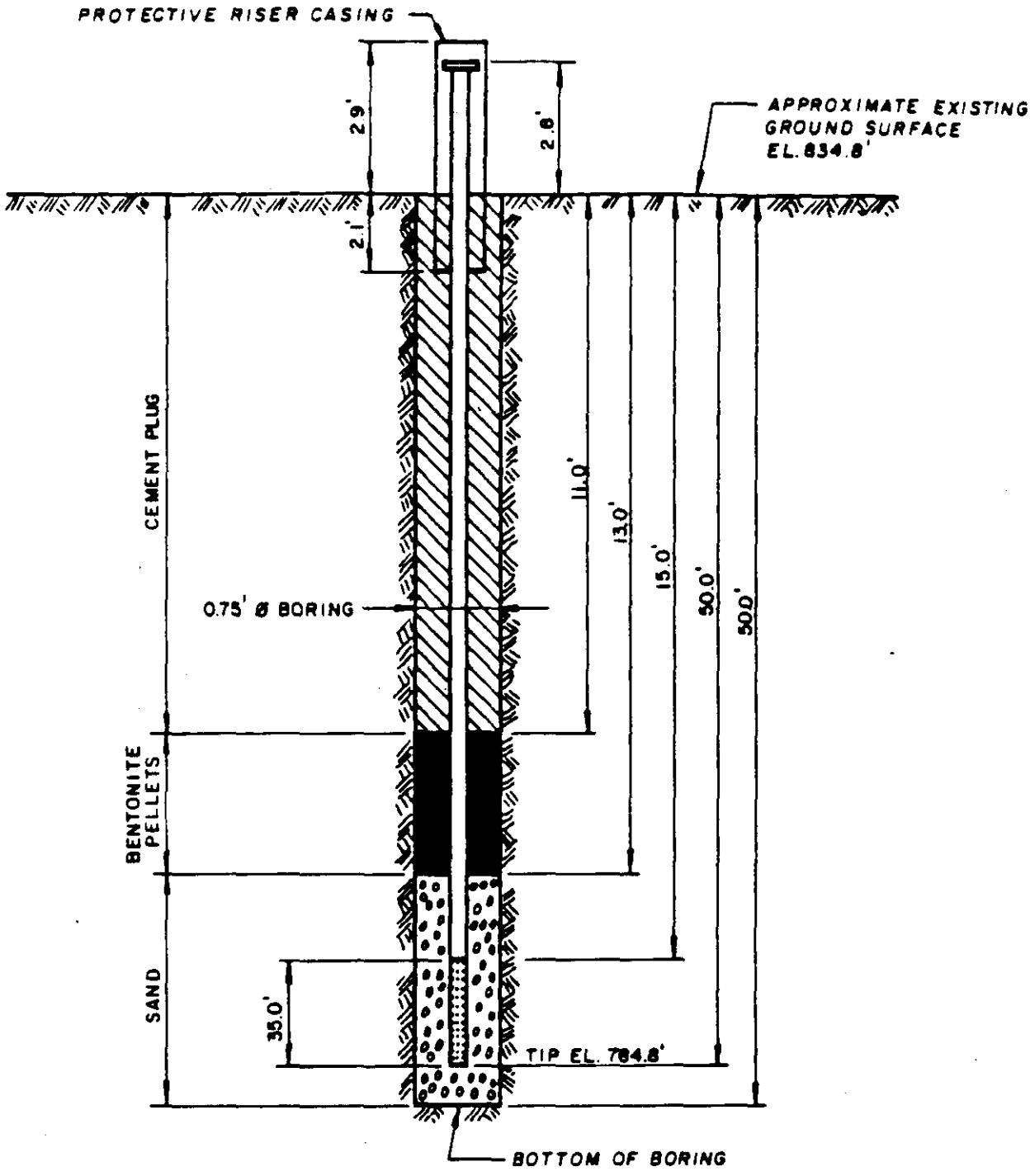
DR. B. GSJ 4 20 87



NOTES:

1. RISER PIPE IS 2 IN. I.D. SCHEDULE 40 PVC PIPE, THREADED, FLUSH-JOINTED.
2. SCREEN IS 2 IN. I.D. PVC PIPE CONTINUOUS SLOT SCREEN (0.010 IN. SLOT SIZE).
3. LOWER END OF SCREEN IS CAPPED.
4. ELEVATION OF WATER LEVEL 816.3'
5. WATER LEVEL MEASURED ON 3-19-85.

INSTALLATION DETAILS
MONITORING WELL MW-6
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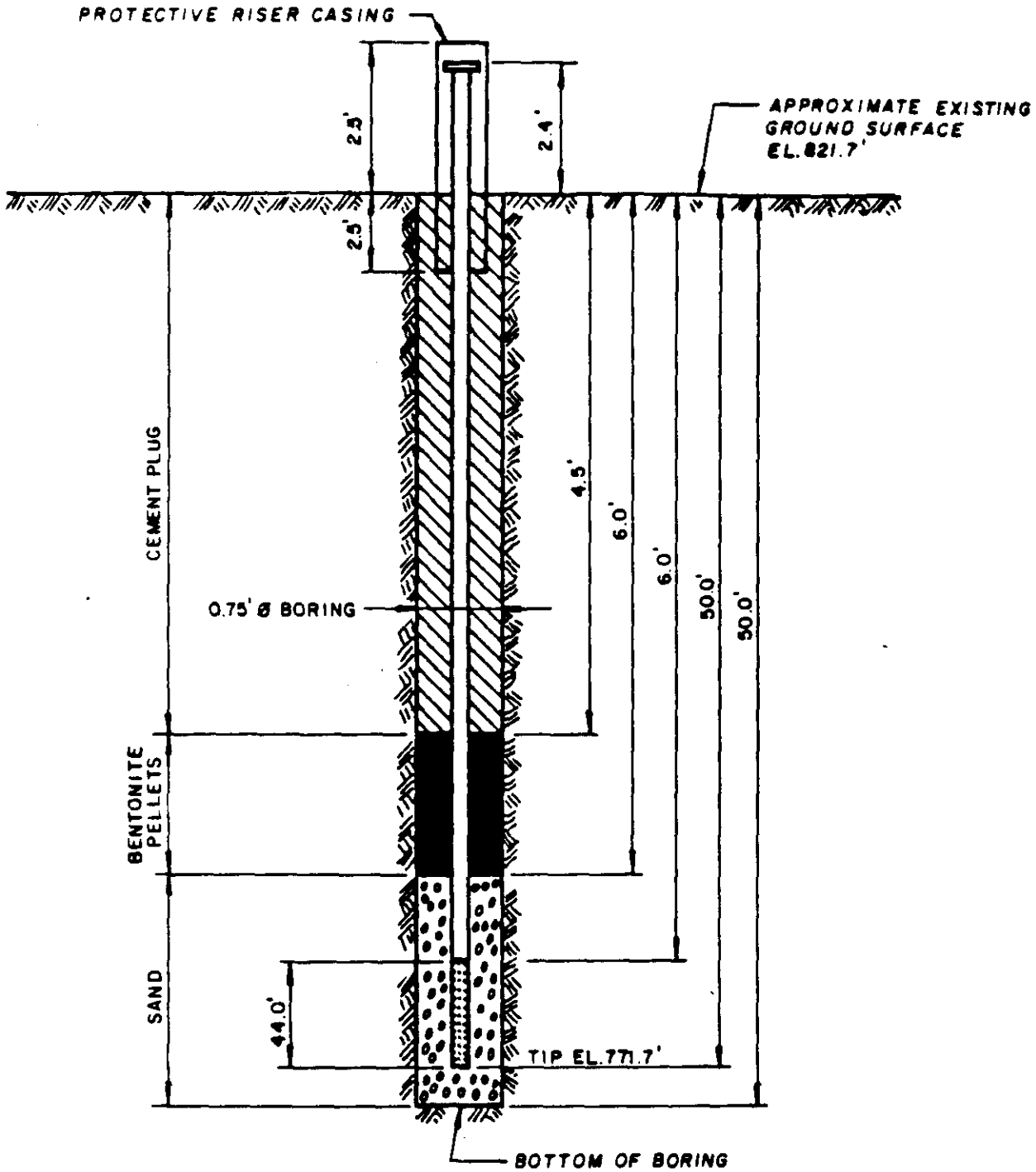

NOTES:

1. RISER PIPE IS 2 IN. I.D. SCHEDULE 40 PVC PIPE, THREADED, FLUSH-JOINTED.
2. SCREEN IS 2 IN. I.D. PVC PIPE CONTINUOUS SLOT SCREEN (0.010 IN. SLOT SIZE).
3. LOWER END OF SCREEN IS CAPPED.
4. ELEVATION OF WATER LEVEL 815.7'
5. WATER LEVEL MEASURED ON 4-9-85.

INSTALLATION DETAILS
MONITORING WELL MW-7
GNADENHUTTEN, OHIO
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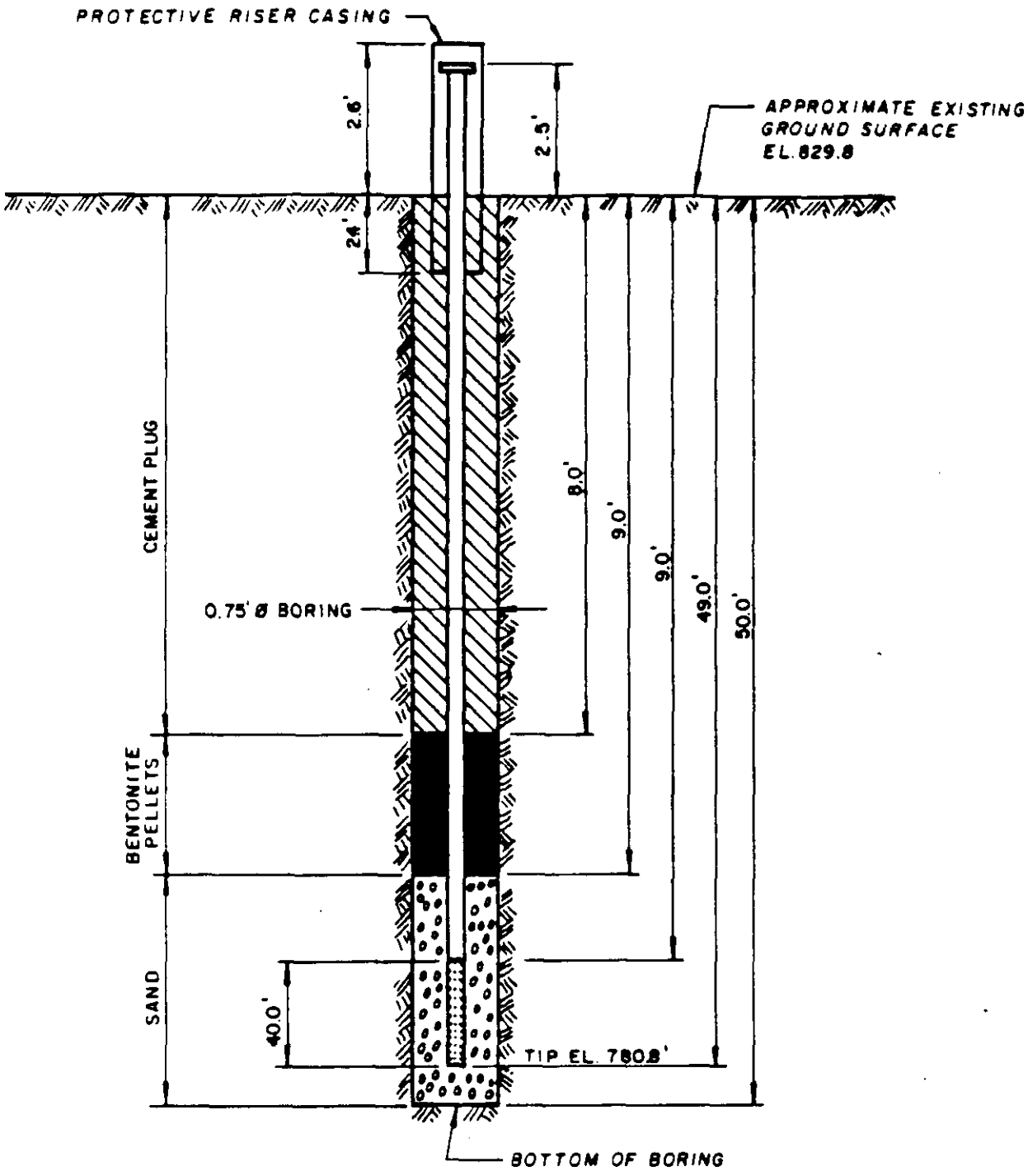

NOTES:

1. RISER PIPE IS 2 IN. I.D. SCHEDULE 40 PVC PIPE, THREADED, FLUSH-JOINTED.
2. SCREEN IS 2 IN. I.D. PVC PIPE CONTINUOUS SLOT SCREEN (0.010 IN. SLOT SIZE).
3. LOWER END OF SCREEN IS CAPPED.
4. ELEVATION OF WATER LEVEL 817.2
5. WATER LEVEL MEASURED ON 3-15-85

INSTALLATION DETAILS
MONITORING WELL MW-8
GNADENHUTTEN, OHIO
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DRAWN BY GSJ 4-20-87

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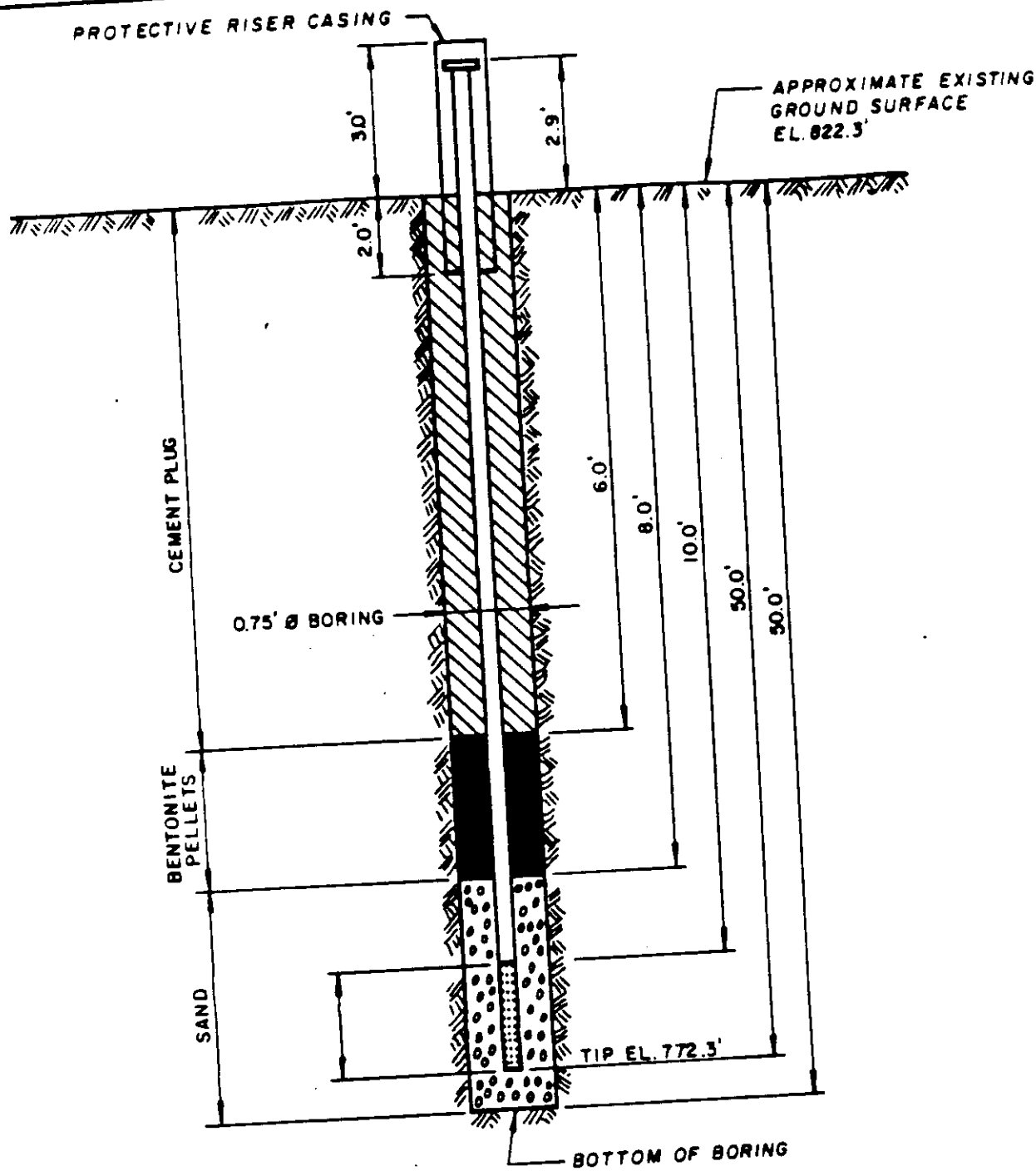
GEV 4-20-87	APPROVED BY	3C



NOTES:

1. RISER PIPE IS 2 IN. I.D. SCHEDULE 40 PVC PIPE, THREADED, FLUSH-JOINTED.
2. SCREEN IS 2 IN. I.D. PVC PIPE CONTINUOUS SLOT SCREEN (0.010 IN. SLOT SIZE).
3. LOWER END OF SCREEN IS CAPPED.
4. ELEVATION OF WATER LEVEL 815.8'
5. WATER LEVEL MEASURED ON 3-20-85.

INSTALLATION DETAILS
MONITORING WELL MW-9
GNADENHUTTEN, OHIO

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WATER WELL INVENTORY OF SURROUNDING AREA

TABLE C-1

WATER WELL INVENTORY, ARCO CHEMICAL COMPANY, CNADENHUTTEN, OHIO

1-MILE RADIUS(a)

RI REPT. WELL NO.(a)	BURGESS & NIPLE WELL NO.(b)	ODNR WELL INVENTORY NO.(c)	ODNR WELL REPT. NO.(d)	YEAR DRILLED	TOTAL DEPTH(e)	APPROXIMATE SURFACE ELEVATION(f)	STATIC WATER LEVEL DEPTH(e)	STATIC WATER LEVEL ELEV.(g)
PW-1	WW-19	-	-	1952	80	840	23	817
PW-2	WW-20	-	133882	1956	80	840	15	825
PW-3	WW-21	-	192486	1960	101	845	30	815
PW-4	WW-22	31	432186	1974	143	840	23.5	817
PW-5	WW-23	31	556533	1979	159	835	23	812
WW-1	WW-15	28	492812	1976	53	840	24	816
WW-2	-	27	406669	1970	65	845	-	-
WW-3	-	29	650895	1985	53	845	35	810
WW-4	WW-17	30	358126	1966	102	830	25	805
WW-5	WW-4	-	206837	1959	47.5	830	12	818
WW-6	-	30	390483	1969	51	835	20	815
WW-7	-	30	494148	1975	92	835	17	828
WW-8	-	32	487411	1976	91	835	9.5	825
WW-9	WW-18	33	332772	1966	116	845	32	813
WW-10	-	-	(15)	1945	100	845	30	815
WW-11	-	34	266676	1961	40	845	28	817
WW-12	WW-16	-	350181	1966	330*	845	-	-
WW-13	-	35	344039	1968	54	840	35	805
WW-14	WW-5	-	250344	1960	45	855	34	821
WW-15	WW-12	-	175483	1956	44	855	29	826
WW-16	WW-11	-	175482	1956	44	855	29	826
WW-17	WW-13	-	162333	1955	44	850	29	821
WW-18	-	37	523217	1977	61	850	35	815
WW-19	-	36	639273	1984	50	845	30	815
WW-20	-	36	370185	1968	45	845	24	821

C0001907

TABLE C-1
(Continued)

1-MILE RADIUS (Cont'd)

RI REPT. WELL NO.(a)	BURGESS & NIPLE WELL NO.(b)	ODNR WELL INVENTORY NO.(c)	ODNR WELL REPT. NO.(d)	YEAR DRILLED	TOTAL DEPTH(e)	APPROXIMATE SURFACE ELEVATION(f)	STATIC WATER LEVEL DEPTH(e)	STATIC WATER LEVEL ELEV.(g)
WW-21	-	38	390241	1969	55	850	30	820
WW-22	-	43	644417	1984	45	865	29	836
WW-23	-	44	392390	1969	150*	865	60	805
WW-24	-	39	500981	1977	160*	865	35	830
WW-25	-	40	472301	1974	157*	870	40	830
WW-26	-	41	490477	1977	80*	875	25	850
WW-27	-	41	481816	1976	148*	875	85	790
WW-28	-	42	306331	1964	178*	900	100	800
WW-29	WW-3	-	213215	1959	65*	870	(31)	839
WW-30	WW-2	-	213223	1960	83*	870	(28)	842
WW-31	WW-8	-	207244	1958	47	830	21	809
WW-32	WW-7	-	207245	1958	48	830	20	810
WW-33	WW-10	-	200230	1957	165*	840	50	790
WW-34	WW-9	-	200155	1957	120*	840	63	777
WW-35	-	26	596837	1982	145*	840	20	820
WW-36	-	26	471148	1974	143*	840	30	810
WW-37	WW-1	-	138374	1954	49	850	9	841
WW-38	-	110	321620	1965	130*	850	30	820
WW-39	-	111	266658	1961	107*	850	40	810
WW-40	-	112	478602	1974	80*	820	50	770

00001908

TABLE C-1
(Continued)

1.5-MILE RADIUS

RI REPT. WELL NO.(a)	BURGESS & NIPLE WELL NO.(b)	ODNR WELL INVENTORY NO.(c)	ODNR WELL REPT. NO.(d)	YEAR DRILLED	TOTAL DEPTH(e)	APPROXIMATE SURFACE ELEVATION(f)	STATIC WATER LEVEL DEPTH(e)	STATIC WATER LEVEL ELEV.(g)
WW-41	-	113	385719	1968	89*	870	35	835
WW-42	-	114	478627	1974	30	835	16	819
WW-43	-	115	266688	1962	23	835	8	827
WW-44	-	115	620886	1983	47	835	10	825
WW-45	-	115	280680	1962	33	835	10	825
WW-46	WW-6	-	215997	1958	96*	850	32	818
WW-47	WW-14	-	361391	1967	67	845	30	815
WW-48	-	45	288847	1965	155*	885	75	810
WW-49	-	46	288842	1965	260*	885	93	792
WW-50	-	6	399292	1970	81*	1,145	42	1,103
WW-51	-	63	365341	1970	102*	880	40	840
WW-52	-	64	490498	1978	75*	840	40	800
WW-53	-	56	266687	1961	68*	840	48	792
WW-54	-	56	288265	1962	80*	840	45	795
WW-55	-	55	523242	1977	79*	860	50	810
WW-56	-	60	497630	1975	74*	850	-	-
WW-57	-	25	330164	1965	58*	850	28	822

Footnotes

(a)Figure C.1 shows concentric 0.5-, 1.0-, and 1.5-mile radius circles around the ARCO site and well locations as identified by the RI report Well Nos. The RI Report Well Nos. were assiged such that locations nearest the ARCO site generally have lower numbers than the locations further from the site, and numbers generally increase in a clockwise sequence.

00001909

TABLE C-1
(Continued)

Footnotes (Continued)

(b)Twenty-three water well logs were presented in Burgess and Niple, Ltd., 1984, "Hydrogeologic Study, ARCO Metals Company, Gnadenhutten, Ohio."

(c)Forty-nine logs for water wells within 1.5 miles from the ARCO site were obtained from the Ohio Department of Natural Resources (ODNR), Division of Water; a total of 59 logs were obtained from the ODNR for wells within two miles from the site.

(d)The logs for wells drilled after 1952 have unique six-digit ODNR Well Report Nos. printed on the forms.

(e)Depth is reported as feet below the ground surface. Wells completed in bedrock--not in glacial valley fill--are indicated by an asterisk (*) after the total depth value.

(f)Surface elevations, in feet above mean sea level (MSL), were estimated from the U.S. Geological Survey 7.5-minute series Gnadenhutten and New Philadelphia, Ohio topographic maps (Figure 1.1).

(g)Static water level elevations, in feet above MSL, were estimated from the difference between the static water depth and the approximate surface elevation. Because the dates of measurement vary, these data should not be compared critically.

C00C1910

29-A13

DRAWING NUMBER

CHECKED BY

APPROVED BY

DRAWN BY

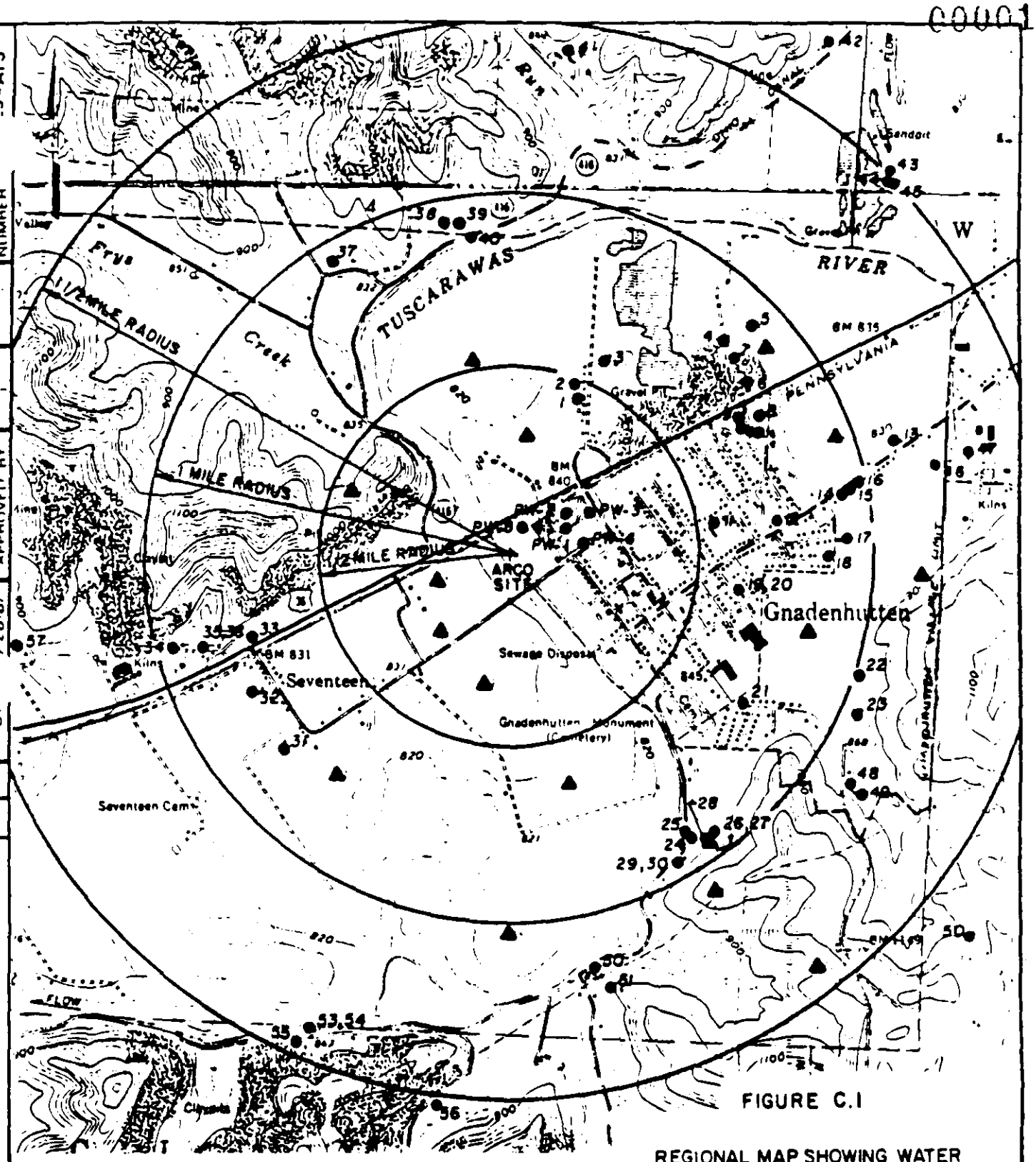


FIGURE C.I

REGIONAL MAP SHOWING WATER AND OIL/GAS WELL LOCATIONS
GNADENHUTTEN, OHIO

PREPARED FOR

ARCO CHEMICAL COMPANY
NEWTOWN SQUARE, PENNSYLVANIA

SCALE

0 2000 4000 FEET

REFERENCES:

1. U.S.G.S. 7.5-MINUTE SERIES GNADENHUTTEN AND NEW PHILADELPHIA, OHIO QUADRANGLES DATED 1962, SCALE 1" = 2000'
2. ODNR DIVISION OF WATER, 1945-1985 WELL LOGS AND DRILLING REPORTS
3. BURGESS & NIPLE LTD. 1984 HYDROGEOLOGIC STUDY, ARCO METALS CO. GNADENHUTTEN, OHIO.

LEGEND

10● WATER WELL (LOG IN APPENDIX C)

▲ OIL / GAS WELL

© 1984 IT CORPORATION
ALL COPYRIGHTS RESERVED

IT Creating a Safer Tomorrow

Do Not Scale This Drawing

BORING LOGS OF WATER WELLS IN SURROUNDING AREA
OF THE ARCO GNADENHUTTEN, OHIO SITE

Well Log WW-19

Well 1

Drillers Well Log

Owner - Arco Metals Company/Alsco

Drilled - 1952

Location - South side of Building

Well Diameter - 10 inches

Static Water Level - 23 feet

Test Pumping Rate -

Drawdown -

Formation	
0 - 80 feet	Sand and gravel

Well Driller - Ohio Drilling Company

WELL LOG AND DRILLING REPORT

State of Ohio
DEPARTMENT OF NATURAL RESOURCES
Division of Water
Columbus, Ohio

0000191

Well Log No.
N? 133852
Well 2

County Tuscarawas Township Clay Section or Lot Number

Owner Alumiwal Co. Address Uhrichsville Ohio

Location of property 200 Ft South of Penn RR and 525 West of Main St

CONSTRUCTION DETAILS

Casing diameter 12" Length of casing 42

Type of screen Bronze Length of screen 38'

Type of pump

Capacity of pump

Depth of pump setting

PUMPING TEST

Pumping rate G.P.M. Duration of test 8 hrs

Drawdown 10 ft. Date June 7-1956

Developed capacity 400 G.P.M.

Static level—depth to water 15 ft

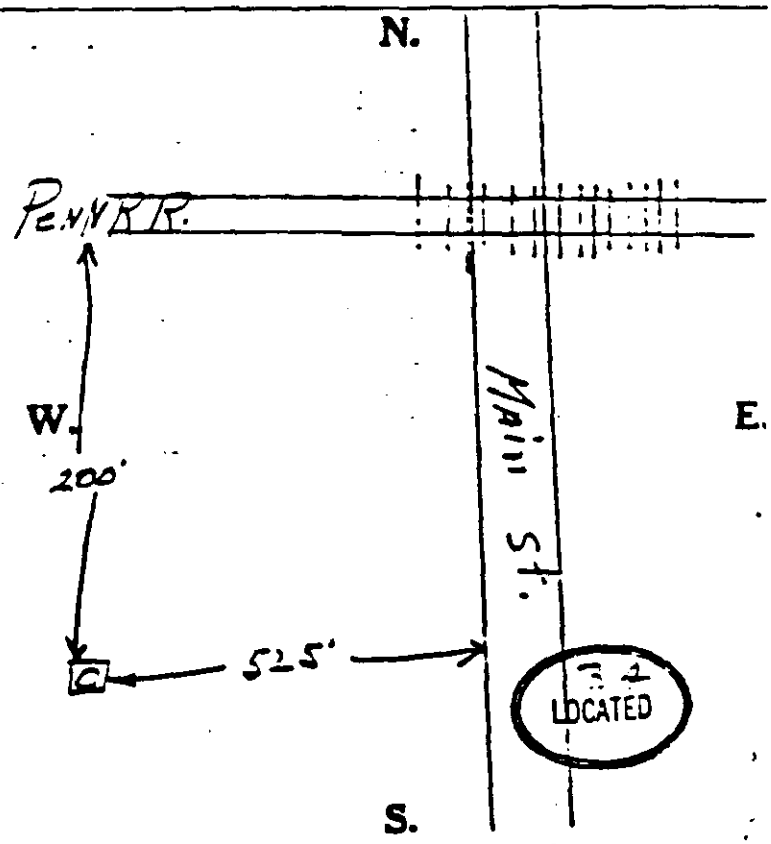
Pump installed by

WELL LOG

Formations Sandstone, shale, limestone, gravel and clay	From	To
Large Stones	0 Feet	20 Ft.
Gravel + Sand	20	40 "
Sand + Gravel	40	47 "
Gravel + Sand	47	55 "
Sand	55	64 "
Sand + Gravel	64	50 "

SKETCH SHOWING LOCATION

Locate in reference to numbered State Highways, St. Intersections, County roads, etc.



See reverse side for instructions

Drilling Firm The Ohio Drilling Co. Date June 15 - 1956

Address Mesopotamia Ohio Signed

PW-3

00001915

WELL LOG AND DRILLING REPORT

State of Ohio
DEPARTMENT OF NATURAL RESOURCES
Division of Water
1500 Dublin Road
Columbus, Ohio

No. 192486
Well 3

County Tuscarawas Township Clay Section of Township

Owner FLSCO Inc Address Gnadenhutten Ohio

Location of property 1000 ft South of R 36 and 50 West of Main St.

CONSTRUCTION DETAILS

Casing diameter 16" Length of casing 71
Type of screen Bonze Length of screen 30
Type of pump Deep Well
Capacity of pump
Depth of pump setting
Date of completion

BAILING OR PUMPING TEST

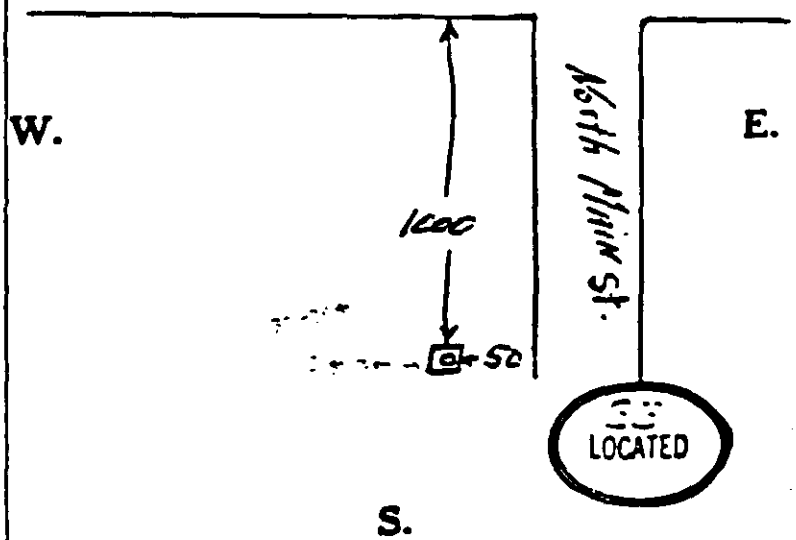
Pumping rate 1000 G.P.M. Duration of test 8 hrs.
Drawdown 24 ft. Date Nov 30
Developed capacity 1000 GPM
Static level—depth to water 30 ft.
Pump installed by Bob Harrold
[illegible]

WELL LOG

Formations dstone, shale, limestone, gravel and clay	From	To
Clay	0 Feet	5 Ft.
Clay + Gravel	5	10 "
Gravel + Clay	10	20 "
Gravel, Clay + Sand	20	45 "
Sand + Little Gravel	45	55 "
Sand	55	60 "
Gravel + Sand	60	85 "
Sand + Gravel	85	101 "

SKETCH SHOWING LOCATION

Locate in reference to numbered State Highways, St. Intersections, County roads, etc.



See reverse side for instructions

Drilling Firm The Ohio Drilling Co Date Dec. 9 - 1960
Address Wellsville Ohio Signed [illegible]

WE[illegible] LOG AND DRILLING R[illegible]ORT

ORIGINAL

(47) PW-4

432186 0001916

NO CARBON PAPER NECESSARY— [illegible]-TRANSCRIBING

State of Ohio
DEPARTMENT OF NATURAL RESOURCES
Division of Water
65 S. Front St., Rm. 815 Phone (614) 469-2646
Columbus, Ohio 43215

County Tuscarawas Township Clay. Section of Township

Owner Alsco Anaconda Inc Address Gnadenhutten, Ohio

Location of property South Side of Plant Approx 1000' South SR 36

CONSTRUCTION DETAILS

Casing diameter 26"x14" Length of casing 96'8"

Type of screen SISH Keystone Length of screen 40'

Type of pump Turbine Test.

Capacity of pump 3000 GPM

Depth of pump setting 100'

Date of completion Sept 16, 1974.

BAILING OR PUMPING TEST
(Specify one by circling)

Test Rate 2200 G.P.M. Duration of test 8 hrs

Drawdown 26'6" ft. Date Sept 16, 1974

Static level-depth to water 23'6" ft.

Quality (clear, cloudy, taste, odor) Clear.

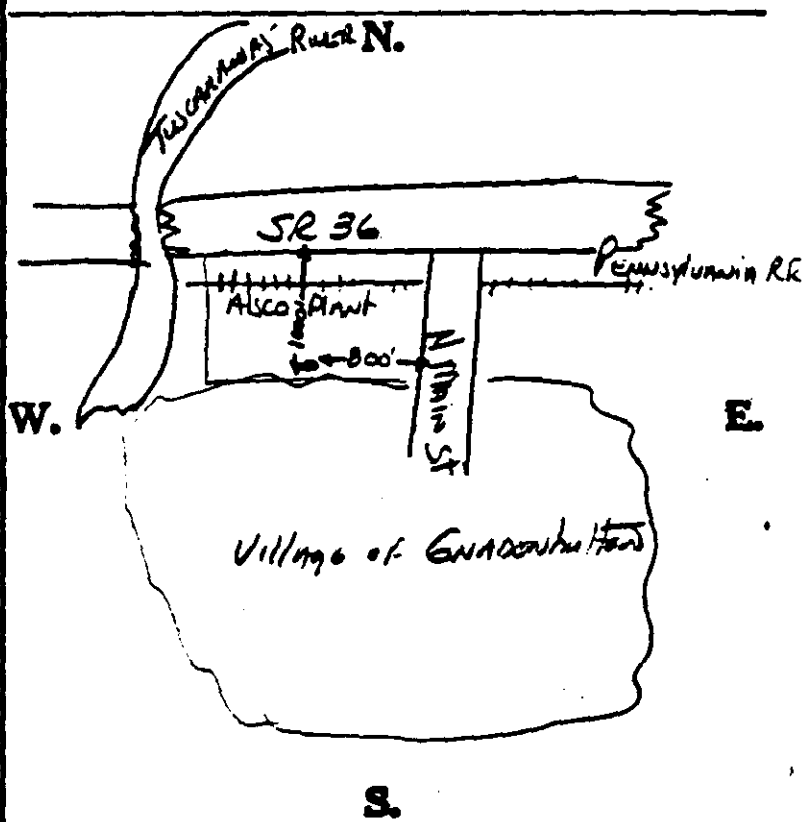
Pump installed by Aislinn

WELL LOG*

Formations [illegible]dstone, shale, limestone, gravel and clay	From	To
[illegible]ay + Sand	0 Feet	10 Ft.
Sand, Gravel + Clay	10	50
Sand, Gravel, little clay	50	65
Sand, Gravel, clay (Stratified)	65	79
Sand + Gravel	79	93
Sand, little gravel, little clay	93	100
Sand, Gravel little clay	100	131
Sand, Gravel, little Clay	131	137
Sand, Gravel, little Clay	137	143

SKETCH SHOWING LOCATION

Locate in reference to numbered State Highways, St. Intersections, County roads, etc.



Drilling Firm The Ohio Drilling Co

Address 113-3rd NW Massillon, O.

Date [illegible]

Signed [illegible]

(31)

*If additional space is needed to complete well log, use next consecutive numbered form.

County Permit No. _____

NO CARBON PAPER NECESSARY– SELF-TRANSCRIBING

WELL LOG AND DRILLING REPORT

State of Ohio
DEPARTMENT OF NATURAL RESOURCES
Division of Water
Fountain Square
Columbus, Ohio 43224

FW-3 (77) 556538 0000191

COUNTY Tuscarawas TOWNSHIP Warwick Twp SECTION OF TOWNSHIP _____

OWNER Alsco-Anaconda, Inc ADDRESS Gnadenhutten, Oh.

LOCATION OF PROPERTY Well #5 at T.H. #1

CONSTRUCTION DETAILS

Casing diameter 16" x 26" Length of casing 110'

Type of screen 200-slot st. stl. Length of screen 30'

Type of pump Peerless Vertical turbine

Capacity of pump 1000 gpm @ 290' TDH

Depth of pump setting 80.4 ft.

Date of completion Feb. 27, 1980

BAILING OR PUMPING TEST
(specify one by circling)

Test rate 1000 gpm Duration of test _____ hrs

Drawdown 6 ft Date _____

Static level (depth to water) 23 ft

Quality (clear, cloudy, taste, odor) _____

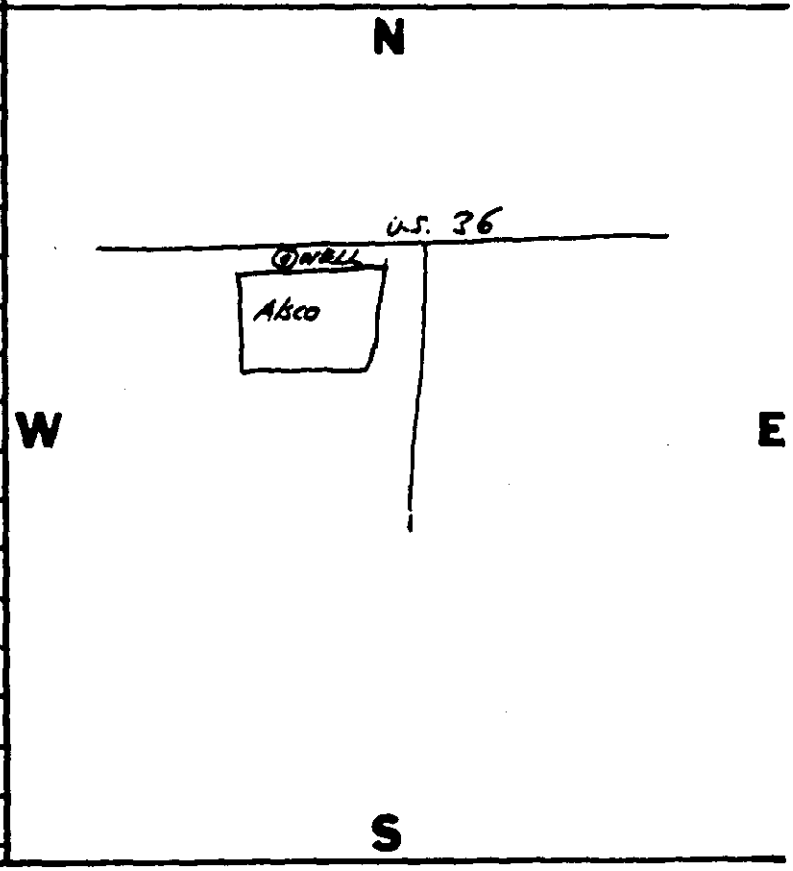
Pump installed by Ohio Drilling Co

WELL LOG*

Formations: sandstone, shale, limestone, gravel, clay	From	To
Fill, clay & fill	0 ft	3 ft
Sand, clay & stones	3	10
Sand, gravel & clay	10	40
Sand & gravel	40	102
Sand, gravel, little clay	102	115
Sand & gravel	115	140
Sand, gravel & little clay	140	146
Sand, gravel & little clay	146	152
Sand, some gravel & clay	152	159

SKETCH SHOWING LOCATION

Locate in reference to numbered state highways, street intersections, county roads, etc.



DRILLING FIRM Ohio Drilling Co DATE 3-13-81

ADDRESS Massillon, Ohio SIGNED Tom Perkins

(31)

*If additional space is needed to complete well log, use next consecutive numbered form.

PW-5

00001918

Well 5

THE OHIO DRILLING CO.

INCORPORATED

MASSILLON, OHIO

DRILLED FOR Alsco Annaconda - Gnadenhutten, Ohio HOLE NO. 1 - 3" Test Hol.

DRILLED BY Clarence Gardner DRILLER COMPLETED November 16 19 79

LOCATION

THICKNESS OF STRATA	STRATA	TOTAL DEPTH	SEAVED	WATER FROM SURFACE
3'	Ash, Clay & Fill	3'		
7'	Sandy Clay & Stones	10'		
10'	Sand, Gravel & Clay	20'		
10'	Sand, Gravel & Clay	30'		
10'	Sand, Gravel & Little Clay	40'		
8'	Sand & Gravel	48'		
8'	Sand & Gravel	56'		
6'	Sand & Gravel	62'		
7'	Sand & Gravel	69'		
6'	Sand & Gravel	75'		
7'	Sand & Gravel	82'		
7'	Sand & Gravel	89'		
6'	Sand & Gravel	95'		
7'	Sand & Gravel	102'		
7'	Sand, Gravel & Little Clay	109'		
6'	Sand, Gravel & Little Clay	115'		
6'	Sand & Gravel	121'		
5'	Sand & Gravel	127'		
7'	Sand & Gravel	134'		
6'	Sand & Gravel	140'		
6'	Sand, Gravel & Little Clay	146'		
6'	Sand, Gravel & Little Clay	152'		
7'	Sand, Some Gravel & Clay	159'		

#31

SIEVE ANALYSIS

OF

STRATA SAMPLES FROM NO. 1 - 3" TEST HOLE

ALSCO ANACONDA

GNADENHUTTEN, OHIO

Depth of Strata	Percentage Retained .131 Slot	Percentage Retained .097 Slot	Percentage Retained .078 Slot	Percentage Retained .060 Slot	Percentage Retained .0390 Slot	Percentage Retained .0203 Slot	Percentage Retained .0116 Slot	Percentage Retained .0041 Slot	Percentage Passed
102' - 109'	25%	7%	3%	3%	6%	10%	20%	16%	10%
109' - 115'	41%	8%	4%	4%	8%	13%	11%	5%	6%
115' - 121'	20%	6%	6%	5%	17%	26%	10%	3%	7%
121' - 127'	26%	9%	4%	9%	13%	13%	11%	8%	8%
127' - 134'	29%	6%	5%	6%	13%	16%	9%	6%	8%
134' - 140'	42%	10%	6%	6%	12%	12%	5%	3%	4%
140' - 146'	37%	9%	5%	8%	13%	12%	6%	2%	8%
146' - 152'	28%	8%	6%	6%	12%	15%	10%	7%	8%

PM-5

0000191

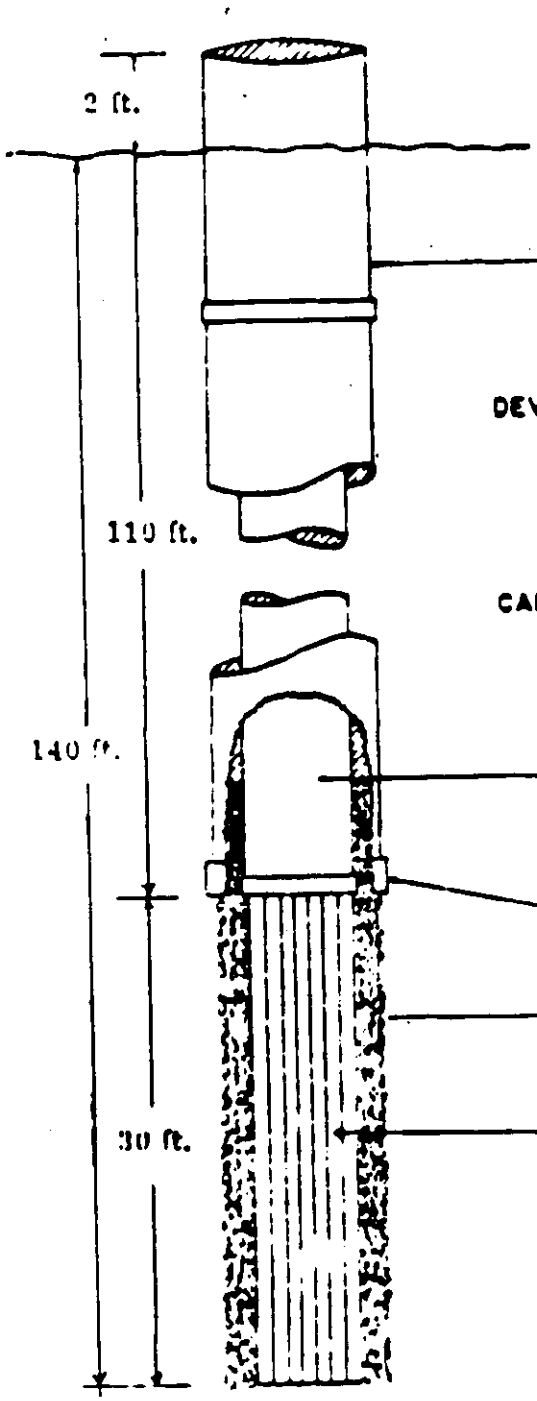
00001920

THE OHIO DRILLING COMPANY

MASSILLON, OHIO

Alsco-Anaconda, Inc.
Gnadenhutten, Ohio

Well No. 5
(Drilled at test hole #1 - 1979)



GROUND SURFACE

OUTER CASING 26" diameter, 3/8" wall, steel pipe with banded & welded joints.

DEVELOPMENT Swabbed & bailed, treated with phosphates & chlorine, pumped & back-washed.

CAPACITY 1000 gpm with 6 feet of drawdown.

INNER CASING 16" diameter, 3/8" wall steel pipe, butt welded.

DRIVE SHOE 1/2 x 5" steel shoe.

GRAVEL PACK Rounded silica gravel (sealpings) from R.W. Sidley Co.

SCREEN Ohio Drilling Co. Type II stainless steel, .200" slots.

DRILLED BY: James Brahm

COMPLETED: February 27, 1980

Static water level = 23 ft.

PW-5

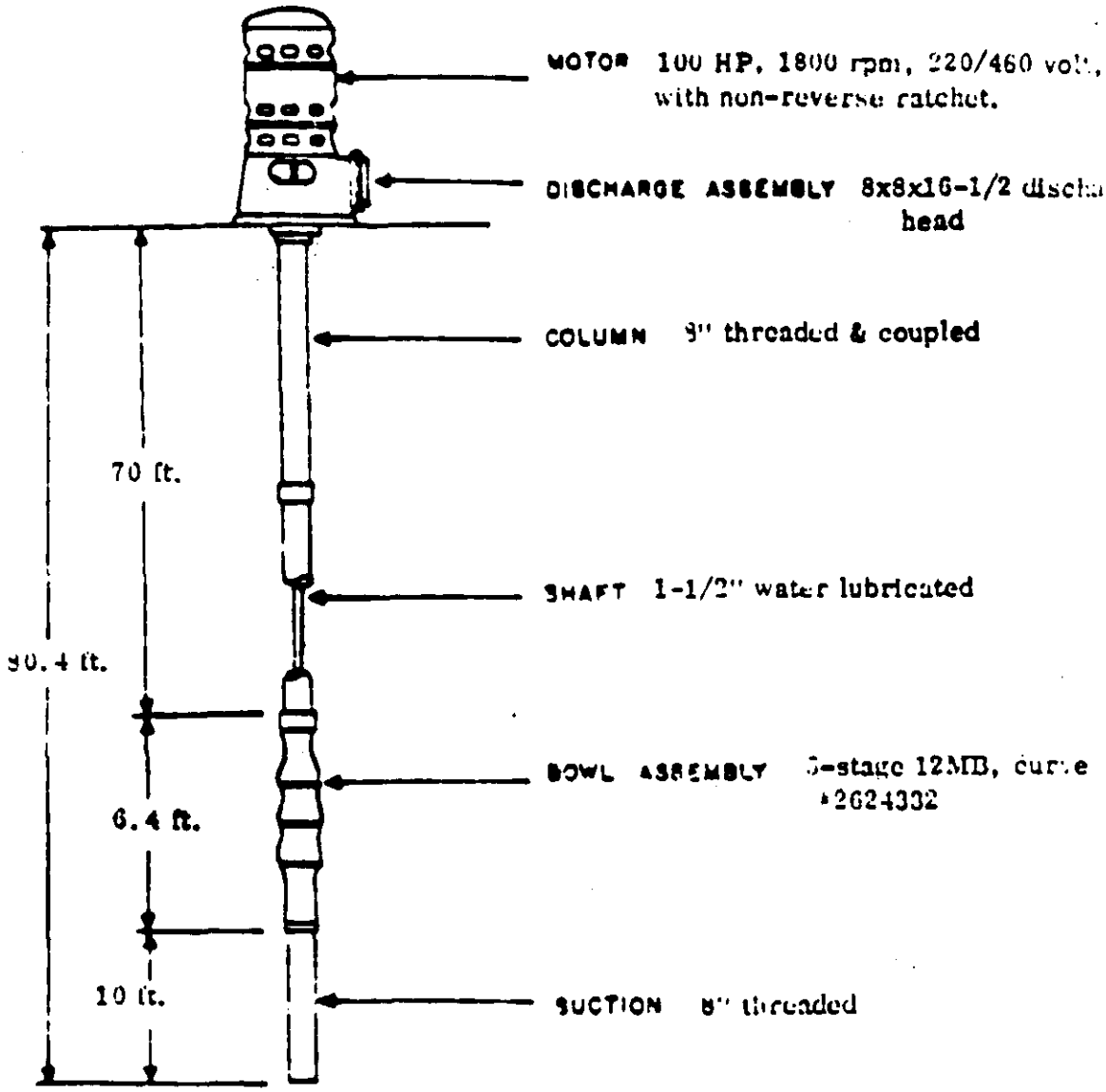
00001921

THE OHIO DRILLING COMPANY

MASSILLON, OHIO

PEERLESS PUMP INSTALLED AT: Well No. 5

Alsco-Anaconda, Inc.
Gnadenhutten, Ohio



PUMP RATED 1000 GPM AT 290 ftTDH

WELL LOG AND DRILLING REPORT

State of Ohio
DEPARTMENT OF NATURAL RESOURCES
Division of Geological Survey
Fountain Square
Columbus, Ohio 43224 Phone (614) 466-5344

NO CARBON PAPER NECESSARY– SELF-TRANSCRIBING

WW-1 ORIGINAL

492812 (69)

00001922

COUNTY TUSCARAWAS TOWNSHIP CLAY SECTION OF TOWNSHIP OR LOT NUMBER

OWNER JAMES EGLER ADDRESS BOX 291 GNADENHUTTEN, OHIO

LOCATION OF PROPERTY N. WALNUT EXT. GREEN HOUSE ON LEFT TURN IN AT GREEN ACRES BAR

CONSTRUCTION DETAILS

Casing diameter 5" Length of casing 55'

Type of screen PERFORATED Length of screen

Type of pump MYERS SUB 1/3 h.p.

Capacity of pump 10 gals

Depth of pump setting ~~55'~~ 47'

Date of completion 5-10-76

BAILING OR PUMPING TEST
(specify one by circling)

Test rate 20 gpm Duration of test 1 hrs

Drawdown 10 ft Date ~~5/3/76~~ 5-3-76

Static level (depth to water) 24 ft

Quality (clear, cloudy, taste, odor) 18 Grain Hard 7.5 PH 1.5 PPM IRON

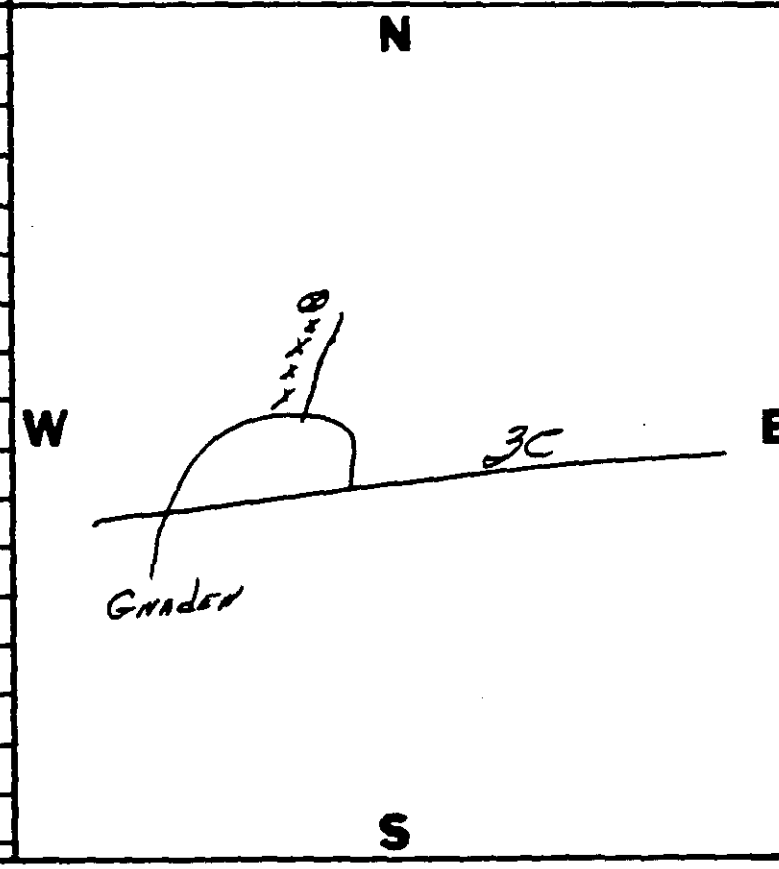
Pump installed by STOCKERT DRILLING CO.

WELL LOG*

Formations: sandstone, shale, limestone, gravel, clay	From	To
ND & GRAVEL	0 ft	53 ft

SKETCH SHOWING LOCATION

Locate in reference to numbered state highways, street intersections, county roads, etc.



DRILLING FIRM STOCKERT DRILLING CO. DATE MAY 17, 1976

ADDRESS STRASBURG, OHIO SIGNED M G Greenwalt Sec.

(28)

*If additional space is needed to complete well log, use next consecutive numbered form.

WELL LOG AND DRILLING REPORT

WW-2 ORIGINAL

NO CARBON PAPER NECESSARY— SELF-TRANSCRIBING

State of Ohio
DEPARTMENT OF NATURAL RESOURCES
Division of Water
65 S. Front St., Rm. 815 Phone (614) 469-2646
Columbus, Ohio 43215

No. 406669 (68)
00001923

County Tusc. Township CLAY Section of Township

Owner Gary Reed Address R. D. 2, Uhrichsville

Location of property

CONSTRUCTION DETAILS

Casing diameter 5" Length of casing 67'5"
Type of screen Length of screen
Type of pump
Capacity of pump
Depth of pump setting
Date of completion

BAILING OR PUMPING TEST
(Specify one by circling)

Test Rate 20 G.P.M. Duration of test 1 hrs.
Drawdown ft. Date Aug. 1970
Static level-depth to water ft.
Quality (clear, cloudy, taste, odor) clear

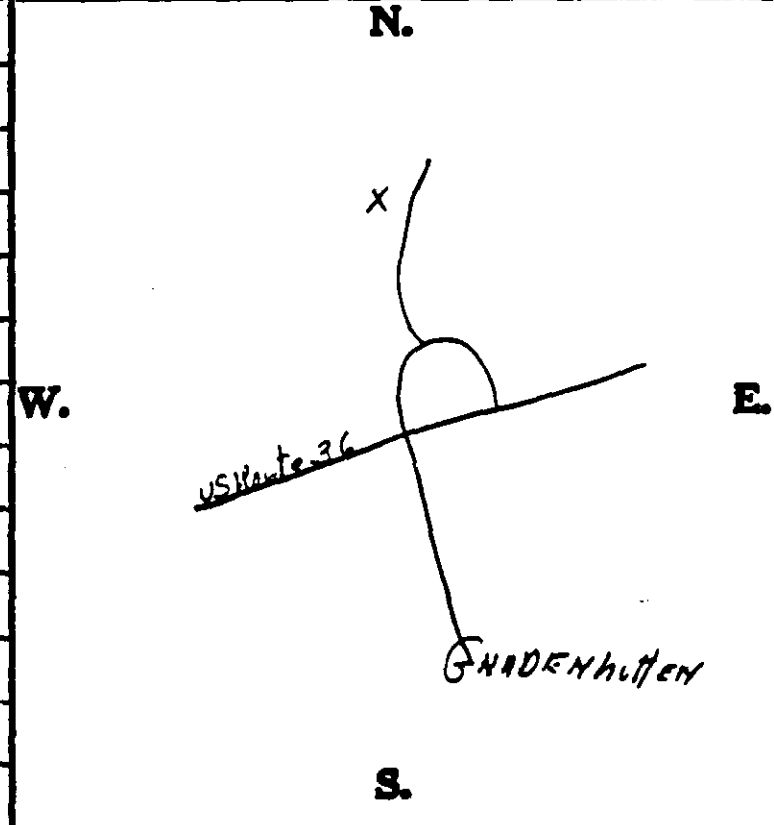
Pump installed by

WELL LOG*

Formations Sandstone, shale, limestone, gravel and clay	From	To
[illegible] & Gravel	0 Feet	65 Ft.

SKETCH SHOWING LOCATION

Locate in reference to numbered State Highways, St. Intersections, County roads, etc.



Drilling Firm D. M. Waltz Drilling Date September 22, 1970

Address R.D. 1, Strasburg, 44680 Signed Paul H. Kates (27)

*If additional space is needed to complete well log, use next consecutive numbered form.

WE . LOG AND DRILLING RI ORT

WW-
00001924
650895
(44)

State of Ohio
DEPARTMENT OF NATURAL RESOURCES
Division of Water
Fountain Square
Columbus, Ohio 43224

NO CARBON PAPER
NECESSARY-
SELF-TRANSCRIBING

L PERMIT 39466
ISTRATION NUMBER 31

COUNTY TUSCARAWAS TOWNSHIP ~~XXXXX~~ CLAY SECTION OF TOWNSHIP

OWNER STOCKER SAND AND GRAVEL ADDRESS BOX 176 - GNADENHUTTEN, OHIO

LOCATION OF PROPERTY NORTH WALNUT STREET EXTENSION -GNADENHUTTEN, OHIO

CONSTRUCTION DETAILS

Casing diameter 5" Length of casing 55'3"

Type of screen Length of screen

Type of pump SUBMERSIBLE

Capacity of pump 10 G.P.M.

Depth of pump setting 45'

Date of completion (9-16-85)

BAILING OR PUMPING TEST
(specify one by circling)

Test rate 24 gpm Duration of test 1½ hrs

Drawdown 0 ft Date 9-16-85

Static level (depth to water) 35 ft

Quality (clear, cloudy, taste, odor)

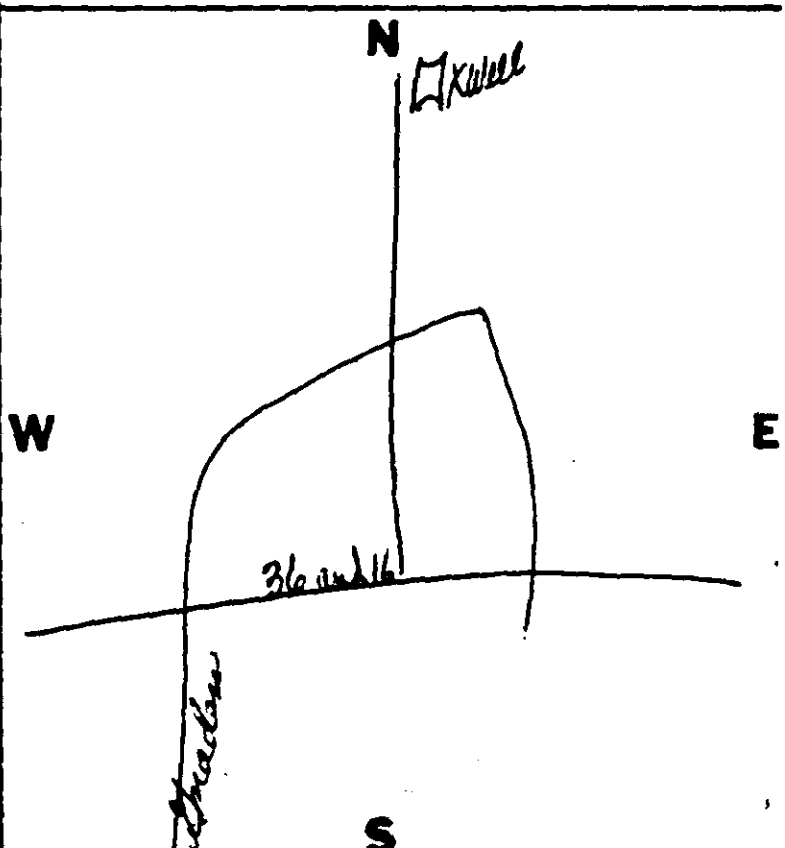
Pump installed by JENEI DRILLING CO., INC.

WELL LOG*

Formations: sandstone, shale, limestone, gravel, clay	From	To
AND GRAVEL	0 ft	53 ft
made water at 40'		

SKETCH SHOWING LOCATION

Locate in reference to numbered state highways, street intersections, county roads, etc.



DRILLING FIRM JENEI DRILLING CO., INC. DATE 9-16-85

ADDRESS ROUTE # 1 P. O. BOX 67 STRASBURG, OHIO 44680 SIGNED Robert L. Jenei

*If additional space is needed to complete well log, use next consecutive numbered form.

(29)

ORIGINAL COPY - ODNR, DIVISION OF WATER, FOUNTAIN SQ., COLS., OHIO 43224

WELL LOG AND DRILLING REPORT

WW-4 (4)00001925

State of Ohio
DEPARTMENT OF NATURAL RESOURCES
Division of Water
1562 W. First Avenue
Columbus, Ohio 43212

LEASE USE PENCIL OR TYPEWRITER
DO NOT USE INK

№ 358126

County Tuscarawas Township Clay Section of Township —

Owner Stocker Sand + Gravel Co. Address Gnadenhutten, Ohio

Location of property Rt. 36 gravel Plant.

CONSTRUCTION DETAILS

Casing diameter 12 Length of casing 102

Type of screen Slot Length of screen 30'

Type of pump Deming Turbine

Capacity of pump 1080 G.P.M.

Depth of pump setting 50'

Date of completion 8-2-66

BAILING OR PUMPING TEST

Pumping Rate 900 G.P.M. Duration of test 10 hrs.

Drawdown 15 ft. Date 8-10-66

Static level-depth to water 25 ft.

Quality (clear, cloudy, taste, odor) good

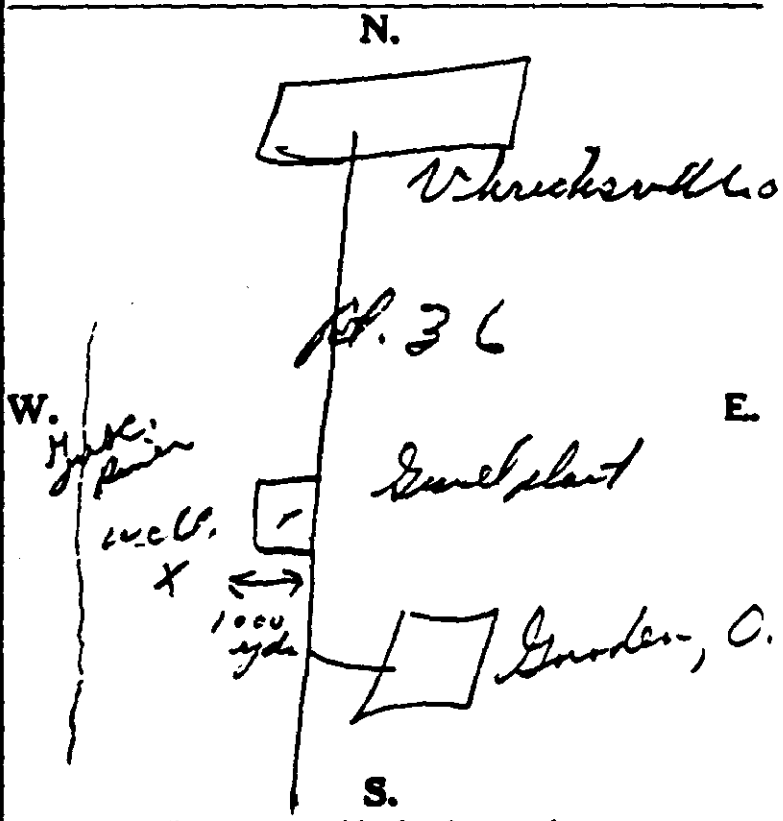
Pump installed by Feaver + Felle.

WELL LOG*

Formations Sandstone, shale, limestone, gravel and clay	From	To
sand + gravel	0 Feet	102 Ft.

SKETCH SHOWING LOCATION

Locate in reference to numbered State Highways, St. Intersections, County roads, etc.



See reverse side for instructions

Drilling Firm Feaver + Felfer Date 8-3-66

Address Beach City, Ohio Signed Pat Felfer

(30)

*If additional space is needed to complete well log, use next consecutive numbered form.

WELL LOG AND DRILLING

State of Ohio
DEPARTMENT OF NATURAL RESOURCES
Division of Water
1500 Dublin Road
Columbus, Ohio

WW-5 00001926

Well Log and Record
No. 206837

County Tuscarawas Township Clay Section or Township

Owner Ohio Valley Mining Co Address Sugarcreek O.

Location of property at Stoke Sand & Gravel Gnadenhutten Co

CONSTRUCTION DETAILS	BAILING OR PUMPING TEST
Casing diameter 4" Length of casing 47'6"	Pumping rate ..... G.P.M. Duration of test ..... hrs.
Type of screen Perforation Length of screen	Drawdown none ft. Date
Type of pump	Developed capacity 20 T/Pm. Bailer Test
Capacity of pump	Static level—depth to water 18' ft.
Depth of pump setting	Pump installed by
Date of completion	[illegible] 2-5

WELL LOG			SKETCH SHOWING LOCATION
Formations Sandstone, shale, limestone, gravel and clay	From	To	Locate in reference to numbered State Highways, St. Intersections, County roads, etc.
Gravel	0 Feet	47'6" Ft.	N. W. E. S. Gnadenhutten Ohio; Pen. R.R.; STATE RT 36; 35 LOCATED

See reverse side for instructions

Drilling Firm E. H. Stelle & Son Date April 20 - 59

Address Strasburg O Signed E. H. Stelle

WELL LOG AND DRILLING REPORT

WW-6 ORIGINAL (45)

NO CARBON PAPER NECESSARY— DO NOT TRANSCRIBING

State of Ohio
DEPARTMENT OF NATURAL RESOURCES
Division of Water
65 S. Front St., Rm. 815 Phone (614) 469-2646
Columbus, Ohio 43215

No. 390483 09001927

County Tuscarawas Township Clay Section of Township

Owner Ohio Valley Pipe Corp. Address St. Clairsville, O.

Location of property Rt. 36 at Gnadenhutten Ohio

CONSTRUCTION DETAILS

Casing diameter 4" Length of casing 51'

Type of screen perf. Length of screen 18"

Type of pump 5 hp. sub-

Capacity of pump 10 G.P.M.

Depth of pump setting 40'

Date of completion 9-5-69

BAILING OR PUMPING TEST
(Specify one by circling)

Test Rate 15+ G.P.M. Duration of test 1 hrs.

Drawdown 20' ft. Date 9-5-69

Static level-depth to water 15' ft.

Quality (clear, cloudy, taste, odor) Good - Clear

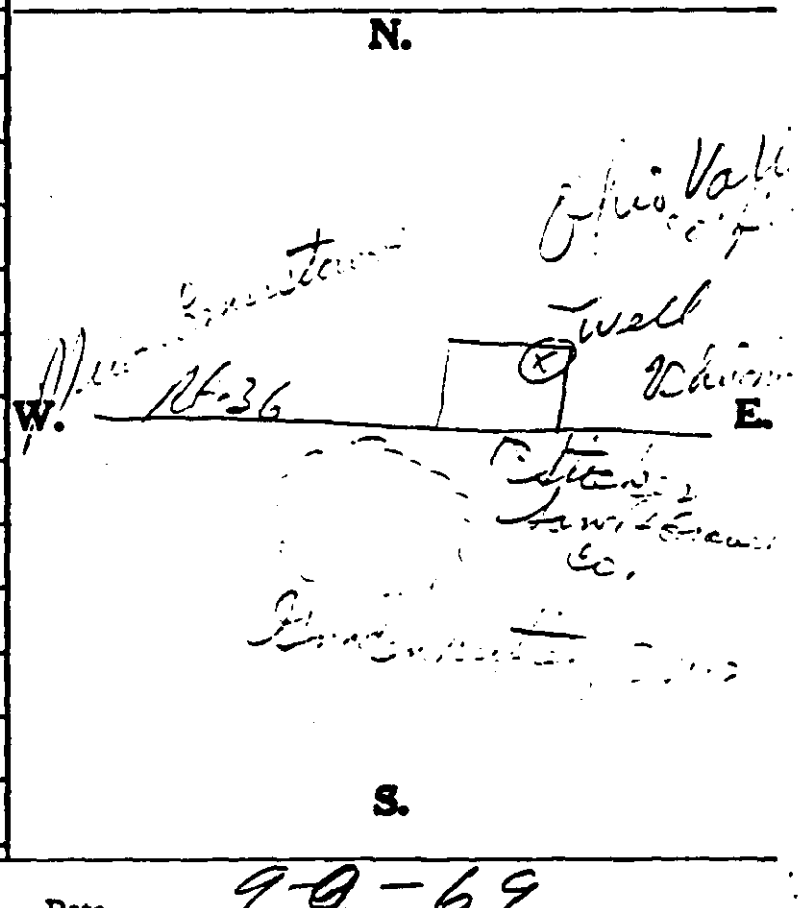
Pump installed by Pearson & Fuller

WELL LOG*

Formations Sandstone, shale, limestone, gravel and clay	From	To
Sand & gravel -	0 Feet	Ft.

SKETCH SHOWING LOCATION

Locate in reference to numbered State Highways, St. Intersections, County roads, etc.



Drilling Firm Pearson & Fuller Date 9-9-69

Address Beach City, Ohio Signed Pat Pearson

*If additional space is needed to complete well log, use next consecutive numbered form.

(3)

WE[illegible] LOG AND DRILLING RE[illegible]ORT

WW-7 ORIGINAL

75 00001928

494148

NO CARBON PAPER NECESSARY— [illegible]LF-TRANSCRIBING

State of Ohio
DEPARTMENT OF NATURAL RESOURCES
Division of Geological Survey
Fountain Square
Columbus, Ohio 43224 Phone (614) 466-5344

COUNTY TUSCARAWAS TOWNSHIP ~~WARWICK~~ clay SECTION OF TOWNSHIP OR LOT NUMBER

OWNER STOCKER SAND & GRAVEL CO. ADDRESS GNADENHUTTEN, OHIO

LOCATION OF PROPERTY OFF OF RT.36 L MILE EAST OF GNADENHUTTEN, OHIO

CONSTRUCTION DETAILS

Casing diameter ~~100~~ 10" Length of casing 81'

Type of screen 6" CONE SCREEN Length of screen 10x15

Type of pump FAIRBANK MORSE TURBIN 40 h.p. 10M7000

Capacity of pump 450 g.p.m.

Depth of pump setting 55'

Date of completion FEB. 29-76

BAILING OR PUMPING TEST
(specify one by circling)

Test rate 100 gpm Duration of test 1 hrs

Drawdown 3 ft Date 12-9-75

Static level (depth to water) 17 ft

Quality (clear, cloudy, taste, odor) clear

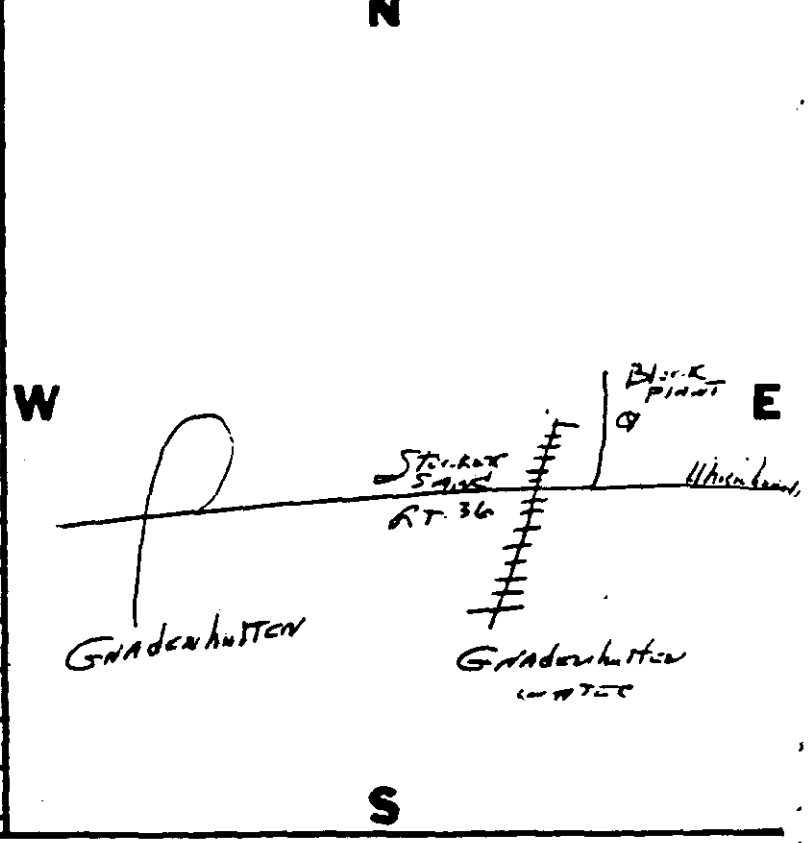
Pump installed by STOCKERT DRILLING CO.

WELL LOG*

Formations: sandstone, shale, limestone, gravel, clay	From	To
[illegible]OWN SAND & MUD	0 ft	70 ft
BROWN CLEAN GRAVEL		
VERY SMALL GRAVEL	70	92

SKETCH SHOWING LOCATION

Locate in reference to numbered state highways, street intersections, county roads, etc.



DRILLING FIRM STOCKERT DRILLING CO.

ADDRESS STRASBURG, OHIO.

DATE MARCH 31, 1976

SIGNED M O Greenwalt Sec

30

*If additional space is needed to complete well log, use next consecutive numbered form.

WE[illegible] LOG AND DRILLING RE[illegible]ORT

WW-8 ORIGINAL 00001929

79

487411

NO CARBON PAPER NECESSARY – SELF-TRANSCRIBING

State of Ohio
DEPARTMENT OF NATURAL RESOURCES
Division of Geological Survey
Fountain Square
Columbus, Ohio 43224 Phone (614) 466-5344

OFFSRSU

COUNTY Tuscarawas TOWNSHIP ~~Warwick~~ clay SECTION OF TOWNSHIP OR LOT NUMBER 34

OWNER Village of Gnadenhutten ADDRESS Gnadenhutten, O.

LOCATION OF PROPERTY Village Park - 325' East Treatment Plant - 300' South SR 36

CONSTRUCTION DETAILS

asing diameter 20" X 12" Length of casing 71'

ype of screen SISH Bar. Length of screen 20'

ype of pump Turbine Test Pump

apacity of pump 1500 gpm

epth of pump setting 70'

ate of completion Jan. 28, 1976

BAILING OR PUMPING TEST
(specify one by circling)

Test rate 1000 gpm Duration of test 8 hrs

Drawdown 16' 8" ft Date Jan 28, 1976

Static level (depth to water) 9'6" ft

Quality (clear, cloudy, taste, odor) Clear.

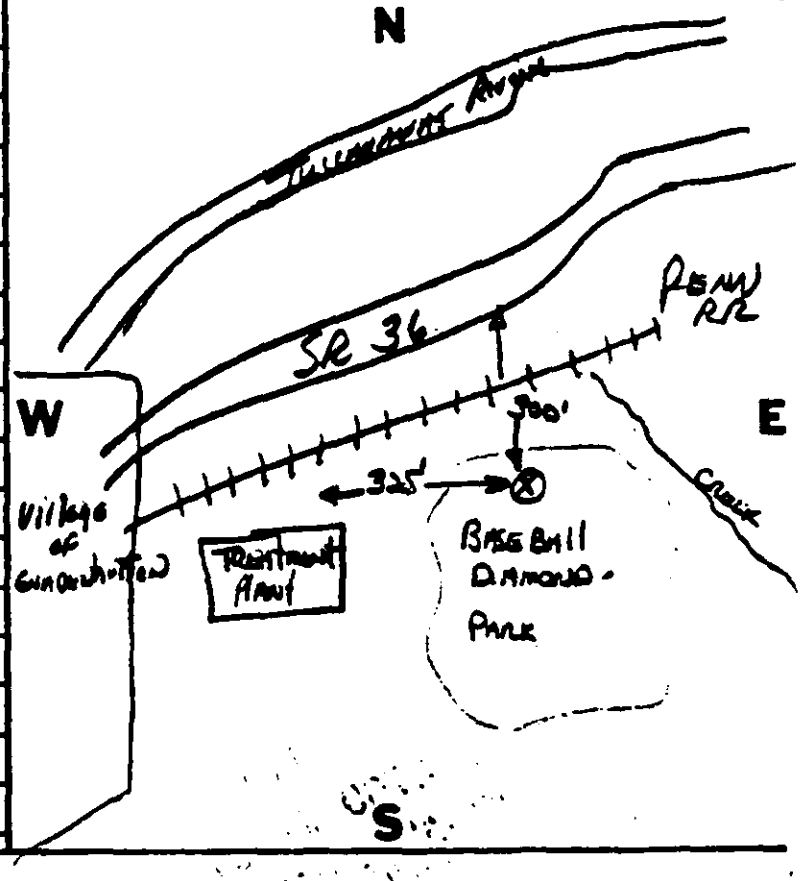
Pump installed by [illegible]

WELL LOG*

Formations: sandstone, shale, limestone, gravel, clay	From	To
[illegible] dw, Clay + Sand	0 ft	20 ft
Sand, gravel + clay	20	31'
Sand, Gravel, little Clay.	31	91'

SKETCH SHOWING LOCATION

Locate in reference to numbered state highways, street intersections, county roads, etc.



DRILLING FIRM The Ohio Drilling Co DATE

ADDRESS 113 3rd NW Massillon, O SIGNED [illegible]

32

*If additional space is needed to complete well log, use next consecutive numbered form.

WELL LOG AND DRILLING REPORT

State of Ohio
DEPARTMENT OF NATURAL RESOURCES
Division of Water
1562 W. First Avenue
Columbus, Ohio 43212

PLEASE USE PENCIL OR TYPEWRITER
DO NOT USE INK.

ORIGINAL
(43) WW-9
No. 332772
00001930

County TUSCARAWAS Township CLAY Section of Township N.E.

Owner Gnadenhutten Water Works Address Gnadenhutten Ohio

Location of property City Park.

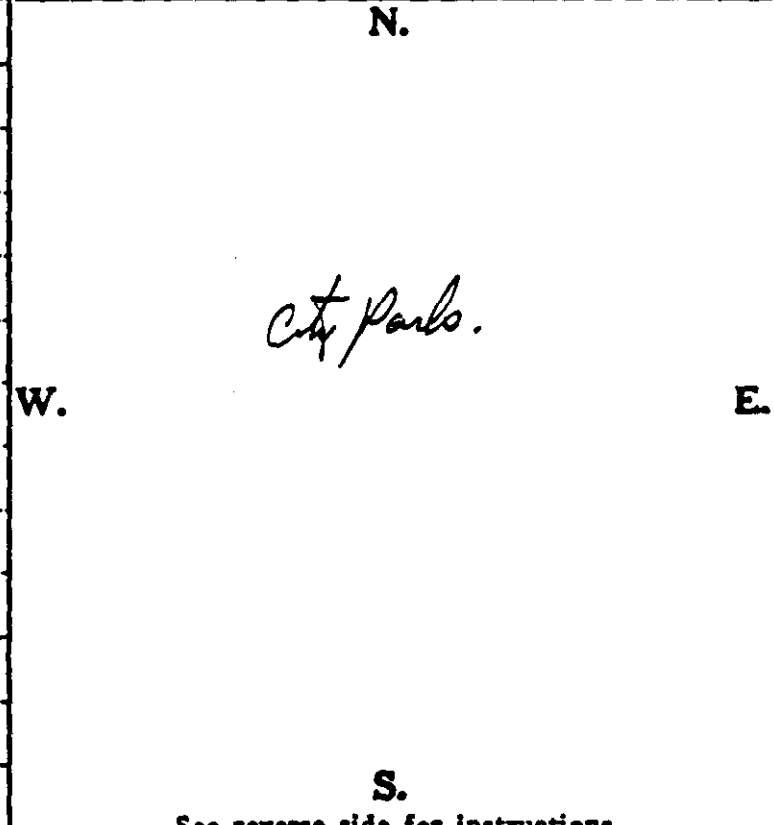
CONSTRUCTION DETAILS	BAILING OR PUMPING TEST
Casing diameter 10" Length of casing 116'16"	Pumping Rate 870 G.P.M. Duration of test 3 hrs.
Type of screen Perforated Pipe Length of screen 30'	Drawdown 32 ft. Date July 19
Type of pump Turbine	Static level-depth to water 32 ft.
Capacity of pump 650 GPM.	Quality (clear, cloudy, taste, odor) CLEAR
Depth of pump setting 80'	
Date of completion July 30/66	Pump installed by D. M. Waltz Drilling Co

WELL LOG*

Formations Sandstone, shale, limestone, gravel and clay	From	To
SURFACE	0 Feet	5 Ft.
Gravel & Sand	5'	35'
Sand	35'	70'
Sand Small Gravel	70'	80'
Gravel sand	80'	116'

SKETCH SHOWING LOCATION

Locate in reference to numbered State Highways, St. Intersections, County roads, etc.



See reverse side for instructions

Drilling Firm D. M. Waltz Drilling Co Date July 30/66

Address Kitel Strasburg Ohio Signed Paul Waltz.

(33)

*If additional space is needed to complete well log, use next consecutive numbered form.

OHIO WATER SUPPLY BOARD

Well Record No. 15

79

Co. Tuscarawas Twp. Clay 3 Sec.

Well Location 200' S. of #1 Pump Size

house located in village. Map Uhrichsville

Owner Village of Gnadenhuttenrose

Driller Ohio Drilling Co. Date 10/6/45

Well Head Elev. or M. P.

Elev. of Ground at Well

Pumping Test:

Static Level 30 ft. Date 10/16/45

Normal Pumpage

Quality Use

Adequacy of supply x = 2,297,000
y = N 255,500
1000 x 1000

Owner's Well No. or Other Designation

Source of Data Ohio Drilling Co.

Collected by Date 2/27/46

STRATA	DEPTH From	DEPTH To
Surface	0	5
Sand and gravel	5	70
Gravel and sand	70	100

* Chief Aquifer

WW-10.
00001931

WELL LOG AND DRILLING REPORT

State of Ohio
DEPARTMENT OF NATURAL RESOURCES
Division of Water
1562 W. First Avenue
Columbus, Ohio

WW-1100001932

(75)

No. 266676

PLEASE USE PENCIL OR TYPEWRITER. DO NOT USE INK.

County Tusc. Township Clay Section of Township 2

Owner James Bosley Address Gnadenhutten, O.

Location of property In village on Tusc. St.

CONSTRUCTION DETAILS	BAILING OR PUMPING TEST
Casing diameter 4" Length of casing 40'-10"	Pumping rate 12 G.P.M. Duration of test 2 hrs.
Type of screen point Length of screen	Drawdown 0 ft. Date 10-4-61
Type of pump none	Developed capacity
Capacity of pump	Static level—depth to water 28 ft.
Depth of pump setting	Pump installed by
Date of completion	

WELL LOG

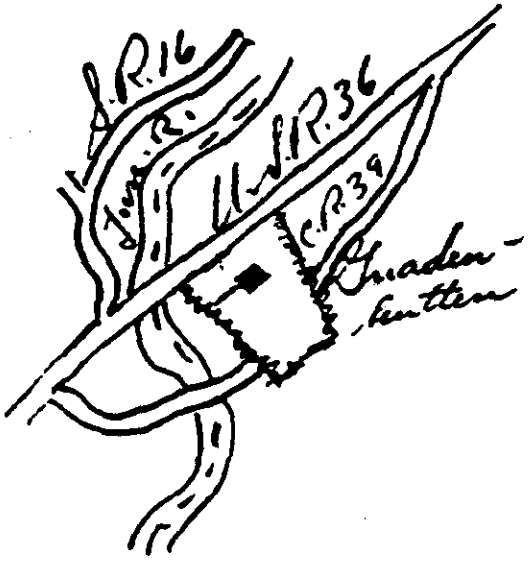
Formations Sandstone, shale, limestone, gravel and clay	From	To
d & gravel	0 Feet	40 Ft.

SKETCH SHOWING LOCATION

Locate in reference to numbered State Highways, St. Intersections, County roads, etc.

N.

W. E.



S.

See reverse side for instructions

Drilling Firm Burgess Drilling Date 10-19-61

Address R. 3 Dover, O. Signed J.W. Burgess

(34)

WW 00001933

WELL LOG AND DRILLING REPORT

State of Ohio
DEPARTMENT OF NATURAL RESOURCES
Division of Water
1562 W. First Avenue
Columbus, Ohio 43212

PLEASE USE PENCIL OR TYPEWRITER
NOT USE INK

No. 350181

County Tuscarawas Township Ch. Section of Township

Owner Columbia Gas of Ohio Inc Address Gnaden Hutten Ohio

Location of property East End of main st in Gnadenhutten

CONSTRUCTION DETAILS

Casing diameter 8" Length of casing 228'

Type of screen none Length of screen

Type of pump none

Capacity of pump

Depth of pump setting

Date of completion 8-27-66

BAILING OR PUMPING TEST

*Pumping Rate G.P.M. Duration of test hrs.

Drawdown ft. Date

Static level-depth to water ft.

Quality (clear, cloudy, taste, odor)

Pump installed by

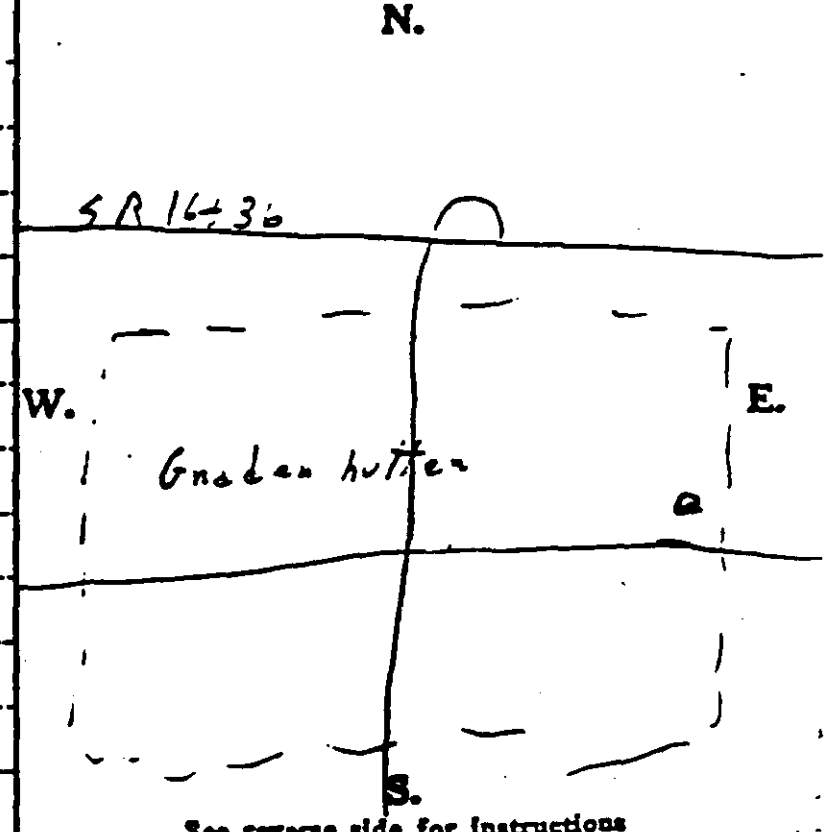
WELL LOG*

Formations Sandstone, shale, limestone, gravel and clay	From	To
Lty sand & gravel	0 Feet	13.0 Ft.
Boulders & cobblestone	13.0	18.0
Sand & gravel	18.0	210.0
Shale	210.0	214.0
Sandstone	214.0	257.0
Shale w/sandstone Beds	257.0	330.0

* well drilled for anodes did not check water

SKETCH SHOWING LOCATION

Locate in reference to numbered State Highways, St. Intersections, County roads, etc.



See reverse side for instructions

Drilling Firm Ellis & Harris drilling Date 8-31 66

Address Albany Ohio Signed K D Ellis

*If additional space is needed to complete well log, use next consecutive numbered form.

WELL LOG AND DRILLING REPORT

(73) 000[illegible]34
WW-13

State of Ohio
DEPARTMENT OF NATURAL RESOURCES
Division of Water
1562 W. First Avenue
Columbus, Ohio 43212

PLEASE USE PENCIL OR TYPEWRITER
DO NOT USE INK

Nº 344039

County Tuscarawas Township Clay Section of Township

Owner Robert Baker Address New Comerstown Ohio

Location of property East of Gnaton ¼ mile

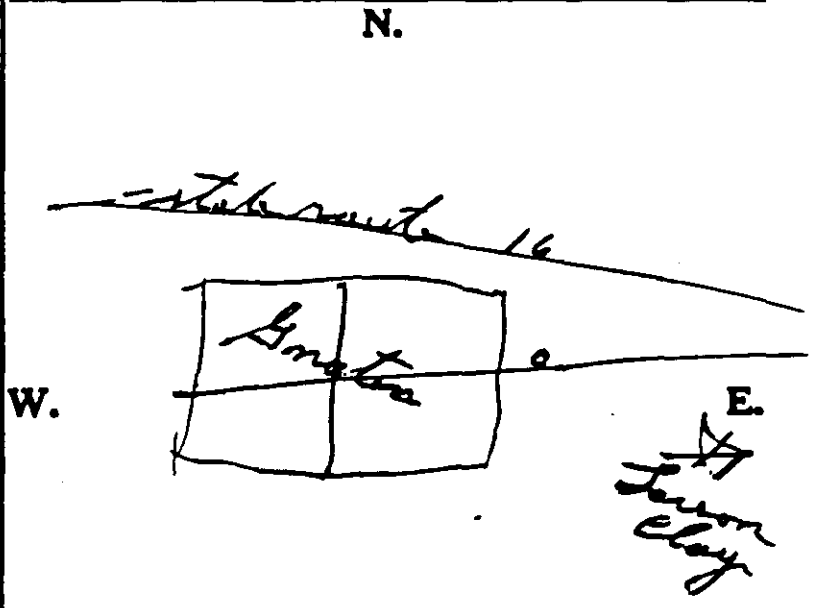
CONSTRUCTION DETAILS	BAILING OR PUMPING TEST
Casing diameter 5" Length of casing 54	Pumping Rate 25 G.P.M. Duration of test 2 hrs.
Type of screen Length of screen	Drawdown ft. Date
Type of pump	Static level-depth to water 35 ft.
Capacity of pump	Quality (clear, cloudy, taste, odor)
Depth of pump setting	
Date of completion	Pump installed by

WELL LOG*

Formations Sandstone, shale, limestone, gravel and clay	From	To
Sand and Gravel	0 Feet	54 Ft.

SKETCH SHOWING LOCATION

Locate in reference to numbered State Highways, St. Intersections, County roads, etc.



See reverse side for instructions

Drilling Firm Harry England Date April 10 1968

Address New Comerstown Signed Harry England

(35)

*If additional space is needed to complete well log, use next consecutive numbered form.

WW-14 00001935 ORIGINAL

WELL LOG AND DRILLING REPORT

State of Ohio
DEPARTMENT OF NATURAL RESOURCES
Division of Water
1562 W. First Avenue
Columbus, Ohio

PLEASE USE PENCIL OR TYPEWRITER. DO NOT USE INK.

Well Log No. 250344

County Tusc. Township Clay Section of Township 20

Owner James [illegible] Address R. 1 [illegible] O.

Location of property [illegible] (Co. Rd. #39)

CONSTRUCTION DETAILS

Casing diameter 4" Length of casing 45'-1

Type of screen [illegible] Length of screen 2'

Type of pump [illegible]

Capacity of pump

Depth of pump setting

Date of completion

BAILING OR PUMPING TEST

Pumping rate 10 G.P.M. Duration of test 2 hrs.

Drawdown 0 ft. Date 9-10-60

Developed capacity

Static level—depth to water 34 ft.

Pump installed by

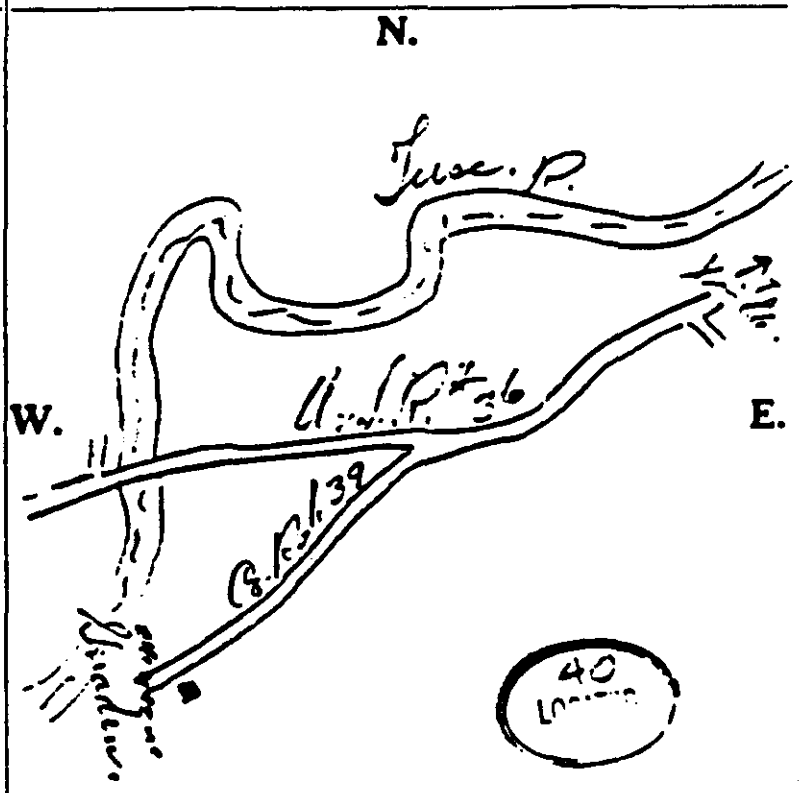
[illegible] - 820

WELL LOG

Formations [illegible]dstone, shale, limestone, gravel and clay	From	To
[illegible] and gravel	0 Feet	45 Ft.

SKETCH SHOWING LOCATION

Locate in reference to numbered State Highways, St. Intersections, County roads, etc.



See reverse side for instructions

Drilling Firm [illegible] Drilling Date 9-13-60

Address R 3 [illegible] Signed [illegible]

WELL LOG AND DRILLING REPORT

State of Ohio
DEPARTMENT OF NATURAL RESOURCES
Division of Water
1500 Dublin Road
Columbus, Ohio

WW-15 ORIGINAL
C0001936
Well Log WW-12
No. 175483

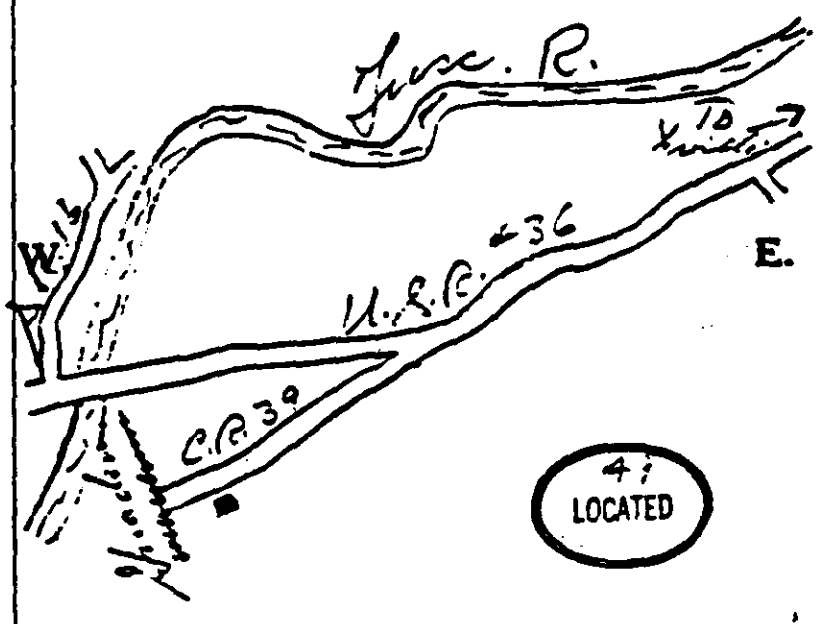
County Tusc. Township Clay Section of Township 20

Owner Bosley Bros. Co. Address R. 1 Gnadenhutten, O

Location of property Lot #1 on Co Rd. #39 - 1/4 mi. N.E. of corp.

CONSTRUCTION DETAILS	BAILING OR PUMPING TEST
Casing diameter 4" Length of casing 45'	Pumping rate 10 G.P.M. Duration of test 1 hrs.
Type of screen point Length of screen 2½'	Drawdown 0 ft. Date 6-21-56
Type of pump none	Developed capacity
Capacity of pump	Static level—depth to water 29 ft.
Depth of pump setting	Pump installed by
Date of completion	Elec - 820

WELL LOG			SKETCH SHOWING LOCATION
Formations Sandstone, shale, limestone, gravel and clay	From	To	Locate in reference to numbered State Highways, St. Intersections, County roads, etc.
sand & gravel	0 Feet	44 Ft.	N.



S.

See reverse side for instructions

Drilling Firm Geo. Kinnes Date 6-23-56

Address R. 3 Dover, O. Signed J. W. Kinnes

WW-06001937

Well Log

No. 175482

DEPARTMENT OF NATURAL RESOURCES
Division of Water
1500 Dublin Road
Columbus, Ohio

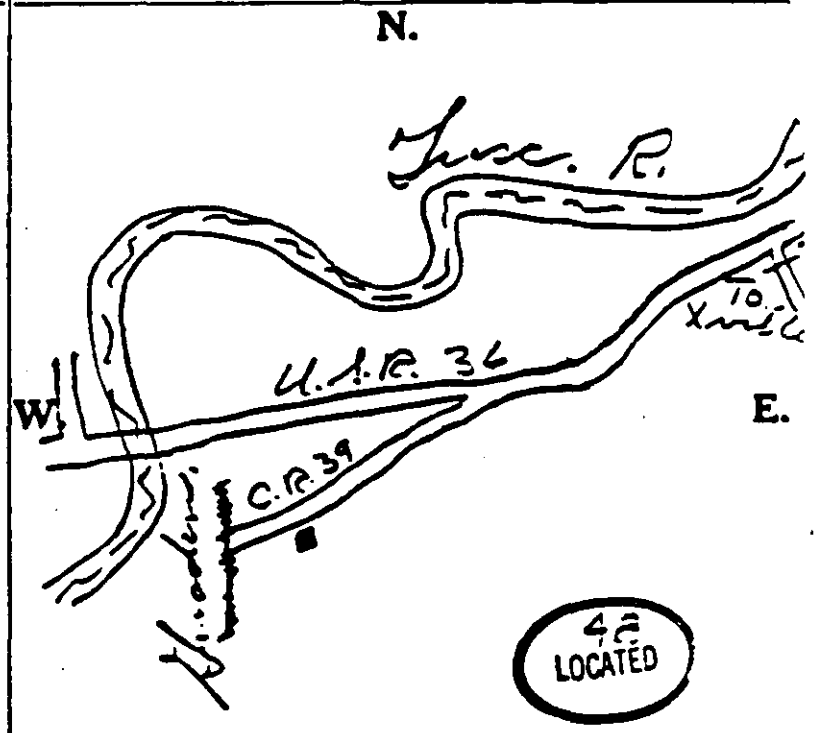
ty Tusc. Township Clay Section of Township 20

Owner Bosler Bros. Co. Address R.1 Gnadenhutten, O.

Location of property Lot #5 on Co. Rd. #39 - 1/4 mi. N.E. of corp.

CONSTRUCTION DETAILS	BAILING OR PUMPING TEST
Casing diameter 4" Length of casing 45'	Pumping rate 10 G.P.M. Duration of test 1 hrs.
Type of screen point Length of screen 2½'	Drawdown 0 ft. Date 6-20-56
Type of pump none	Developed capacity
Capacity of pump	Static level—depth to water 29 ft.
Depth of pump setting	Pump installed by
Date of completion	Elev - 820

WELL LOG			SKETCH SHOWING LOCATION
Formations Sandstone, shale, limestone, gravel and clay	From	To	Locate in reference to numbered State Highways, St. Intersections, County roads, etc.
[illegible] d & gravel	0 Feet	44 Ft.	



See reverse side for instructions

ng Firm Geo. Burgess Date 6-23-56

Address R 3 Dover, O. Signed J. W. Burgess

WW 1700001938

State of Ohio
DEPARTMENT OF NATURAL RESOURCES
Division of Water
Columbus, Ohio

Well Log

Nº 162333

County Jefferson Township Clay Section of Township or Lot Number

Owner Kohl Lumber Address Gnadenhutten

Location of property East Edge old Rt + 36 Gnadenhutten

CONSTRUCTION DETAILS	Bailer ~~PUMPING~~ TEST
Casing diameter 4 Length of casing 45 1	Pumping rate ____ G.P.M. Duration of test ____ hrs.
Type of screen ____ Length of screen ____	Drawdown 0 ft. Date Aug 23 [illegible]
Type of pump ____	Developed capacity 15 GPM
Capacity of pump ____	Static level—depth to water 29 ft.
Depth of pump setting ____	Pump installed by ____

WELL LOG			SKETCH SHOWING LOCATION
Formations Sandstone, shale, limestone, gravel and clay	From	To	Locate in reference to numbered State Highways, St. Intersections, County roads, etc.
	0 Feet	____ Ft.	N.
Gravel		44	Well
			W. Gnadenhutten E.
			LOCATED
			S.

See reverse side for instructions

Drilling Firm Everett Water & Co Inc Date Oct 19 1955

Address Strasburg Signed [illegible]

WELL LOG AND DRILLING REPORT

WW-18 ORIGINAL 193

523217

NO CARBON PAPER NECESSARY - SELF-TRANSCRIBING

State of Ohio
DEPARTMENT OF NATURAL RESOURCES
Division of Water
Fountain Square
Columbus, Ohio 43224

COUNTY Tuscarawas TOWNSHIP Clay SECTION OF TOWNSHIP

OWNER Charles Smith ADDRESS Tomahawk Road

LOCATION OF PROPERTY same

CONSTRUCTION DETAILS

Casing diameter 5" Length of casing 62'5"

Type of screen Length of screen

Type of pump

Capacity of pump

Depth of pump setting

Date of completion 9-7-77

BAILING OR PUMPING TEST
(specify one by circling)

Test rate 36 gpm Duration of test 4 hrs

Drawdown 18' ft Date 9-7-77

Static level (depth to water) 35' ft

Quality (clear, cloudy, taste, odor) clear

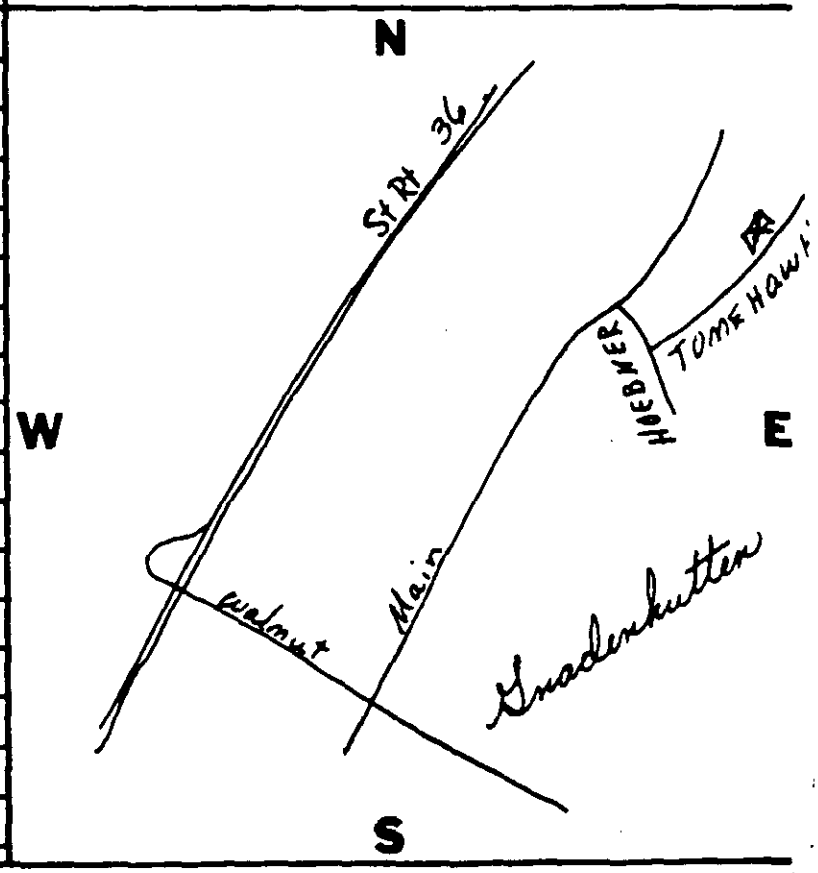
Pump installed by

WELL LOG*

Formations: sandstone, shale, limestone, gravel, clay	From	To
" wx clay	0 ft	10 ft
sand & gravel	10	61
closed end perforation		

SKETCH SHOWING LOCATION

Locate in reference to numbered state highways, street intersections, county roads, etc.



DRILLING FIRM Jenei Drilling Co. DATE 9-8-77

ADDRESS 1431 Front St N.E. SIGNED Karen Jenei

New Philadelphia Ohio

37

*If additional space is needed to complete well log, use next consecutive numbered form.

WELL LOG AND DRILLING REPORT

WW-19

53

639273

00001940

State of Ohio
DEPARTMENT OF NATURAL RESOURCES
Division of Water
Fountain Square
Columbus, Ohio 43224

NO CARBON PAPER NECESSARY— SELF-TRANSCRIBING

COUNTY [illegible] TOWNSHIP [illegible] SECTION OF TOWNSHIP [illegible]

OWNER [illegible] ADDRESS 141 S. Plum St.

LOCATION OF PROPERTY [illegible]

CONSTRUCTION DETAILS

Casing diameter [illegible] Length of casing [illegible]

Type of screen [illegible] Length of screen 4'

Type of pump [illegible]

Capacity of pump

Depth of pump setting

Date of completion

BAILING OR PUMPING TEST
(specify one by circling)

Test rate [illegible] gpm Duration of test 2 hrs

Drawdown [illegible] ft Date 1-6-74

Static level (depth to water) [illegible] ft

Quality (clear, cloudy, taste, odor) [illegible]

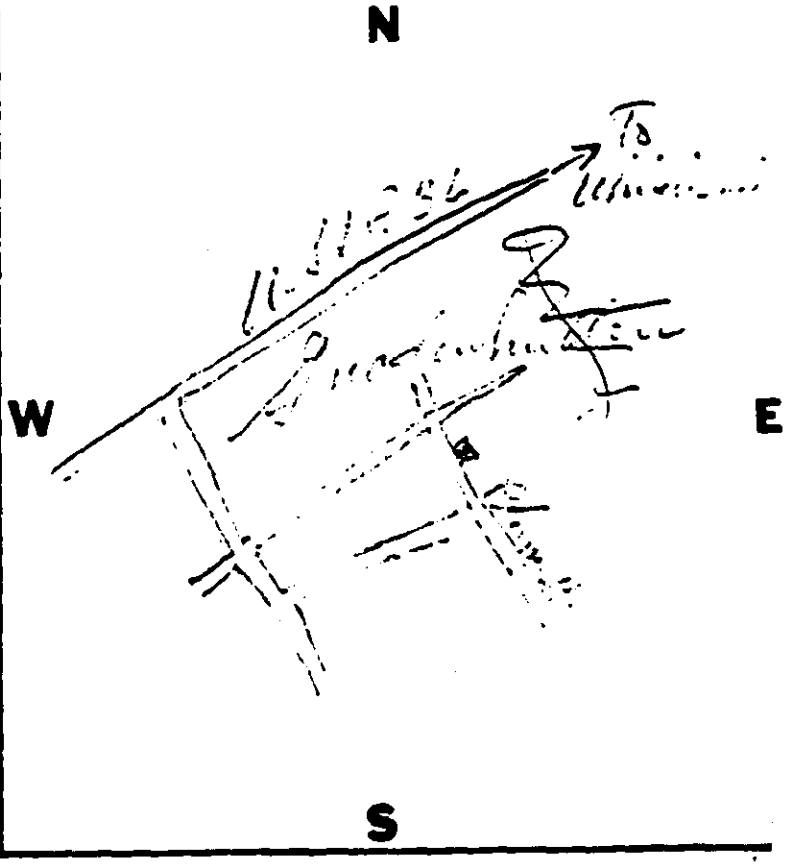
Pump installed by

WELL LOG*

Formations: sandstone, shale, limestone, gravel, clay	From	To
[illegible]	0 ft	50 ft

SKETCH SHOWING LOCATION

Locate in reference to numbered state highways, street intersections, county roads, etc.



DRILLING FIRM [illegible] DATE 1-10-74

ADDRESS [illegible] SIGNED [illegible]

*If additional space is needed to complete well log, use next consecutive numbered form.

36

ORIGINAL COPY - ODNR, DIVISION OF WATER, FOUNTAIN SQ., COLS., OHIO 43224

WELL LOG AND DRILLING ...

State of Ohio
DEPARTMENT OF NATURAL RESOURCES
Division of Water
1562 W. First Avenue
Columbus, Ohio 43212

PLEASE USE PENCIL OR TYPEWRITER
DO NOT USE INK

Nº 370~~185~~ (53)
00001941

C Tuse. Township Clay Section of Township 20

Owner Robert Shinaberry Address 141 S. Plum St.

Location of property In village of Gnadenhutten, O.

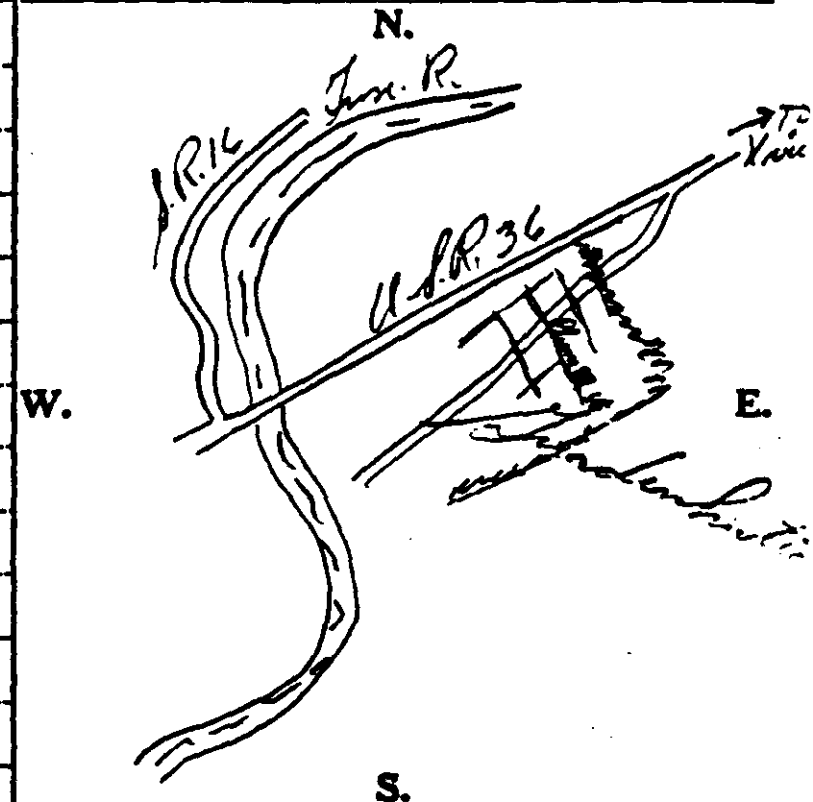
CONSTRUCTION DETAILS	BAILING OR PUMPING TEST
Casing diameter 5" Length of casing 45'-10"	Pumping Rate 20 G.P.M. Duration of test 2 hrs.
Type of screen point Length of screen 2'	Drawdown 0 ft. Date 2-14-68
Type of pump none	Static level-depth to water 24 ft.
Capacity of pump	Quality (clear, cloudy, taste, odor) clear
Depth of pump setting	
Date of completion	Pump installed by

WELL LOG*

Formations Sandstone, shale, limestone, gravel and clay	From	To
d + gravel	0 Feet	45 Ft.

SKETCH SHOWING LOCATION

Locate in reference to numbered State Highways, St. Intersections, County roads, etc.



See reverse side for instructions

...ing Firm Burgess Drilling Date 2-17-68

Address R3 Dover O. Signed J.W. Burgess

*If additional space is needed to complete well log, use next consecutive numbered form.

(36)

WELL LOG AND DRILLING REPORT

WW-21

NO CARBON PAPER NECESSARY— SELF-TRANSCRIBING

State of Ohio
DEPARTMENT OF NATURAL RESOURCES
Division of Water
65 S. Front St., Rm. 815 Phone (614) 469-2646
Columbus, Ohio 43215

No. 390241 (74) 00001942

y Tusc. Township Clay Section of Township

Owner Dr. M. A. Williamson Address Gnadenhuttah Gnadenhutten, Ohio

Location of property

CONSTRUCTION DETAILS

Casing diameter 4" Length of casing 56'7"
Type of screen Length of screen
Type of pump
Capacity of pump
Depth of pump setting
Date of completion

BAILING OR PUMPING TEST
(Specify one by circling)

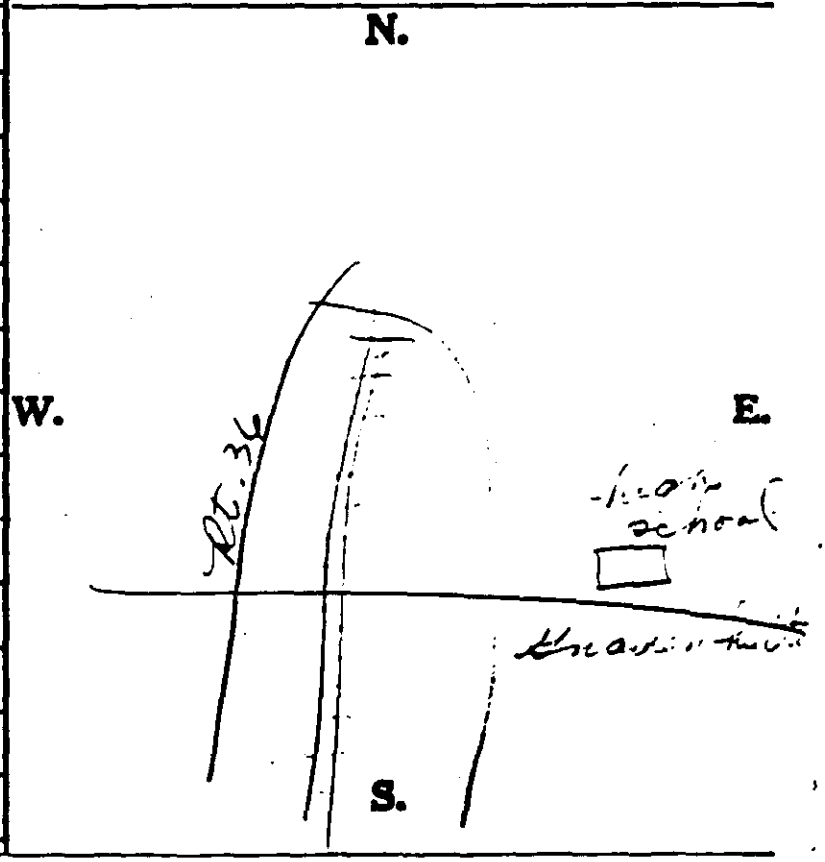
Test Rate 15 G.P.M. Duration of test hrs.
Drawdown 0 ft. Date 4/9/69-4/10/69
Static level-depth to water 30' ft.
Quality (clear, cloudy, taste, odor) 18 grain ha
8.0 PH 2.0 PPM iron
Pump installed by

WELL LOG*

Formations Sandstone, shale, limestone, gravel and clay	From	To
gravel	0 Feet	32' Ft.
Small granel (water)	32'	40'
Brown sand	40'	46'
Claean gravel	46'	55'

SKETCH SHOWING LOCATION

Locate in reference to numbered State Highways, St. Intersections, County roads, etc.



ing Firm Stockert Drilling Co. Date May 14, 1969
Address R. D. # 1 Strasburg, Ohio Signed Walter A. Stockert (38)

*If additional space is needed to complete well log, use next consecutive numbered form.

WELL LOG AND DRILLING REPORT

WW-22 (71)

State of Ohio
DEPARTMENT OF NATURAL RESOURCES
Division of Water
Fountain Square
Columbus, Ohio 43224

NO CARBON PAPER NECESSARY - SELF-TRANSCRIBING

644401001943

COUNTY Tuscarawas TOWNSHIP Clay SECTION OF TOWNSHIP

OWNER Tom Stocker ADDRESS 364 S. Walnut St., Gnadenhutten, Ohio

LOCATION OF PROPERTY S. Walnut St., Gnadenhutten, Ohio

CONSTRUCTION DETAILS

Casing diameter 8" Length of casing 45'

Type of screen Stainless Steel Length of screen 3'

Type of pump Sub.

Capacity of pump 10 GPM

Depth of pump setting 40'

Date of completion Aug. 22, 1984

BAILING OR PUMPING TEST
(specify one by circling)

Test rate 15 gpm Duration of test 2 hrs

Drawdown 1 ft Date Aug. 17, 1984

Static level (depth to water) 29 ft

Quality (clear, cloudy, taste, odor) Clear 10 Grain Hard 7.5 PH .5 PPM Iron

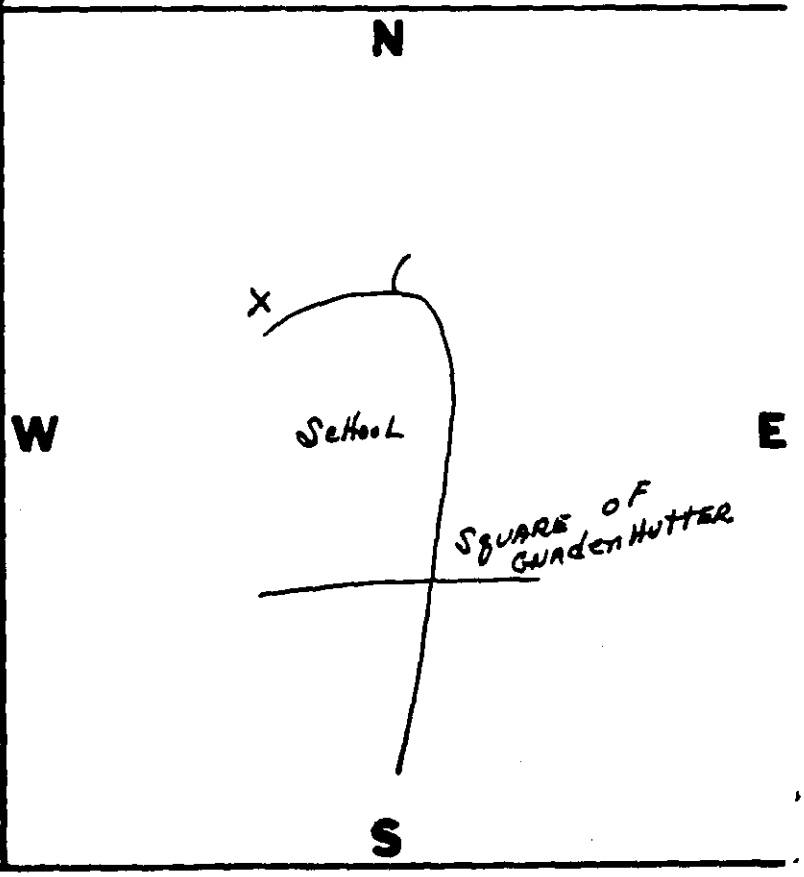
Pump installed by Stockert Drilling Co.

WELL LOG*

Formations: sandstone, shale, limestone, gravel, clay	From	To
Top soil and silt	0 ft	10 ft
[illegible]	10	25
Sand & Gravel	25	45

SKETCH SHOWING LOCATION

Locate in reference to numbered state highways, street intersections, county roads, etc.



DRILLING FIRM Stockert Drilling Company DATE August 23, 1984

ADDRESS 1425 N. Wooster AVe., Strasburg, O. SIGNED Doris E. Heid - S.O.C.

*If additional space is needed to complete well log, use next consecutive numbered form.

(43)

ORIGINAL COPY - ODNR, DIVISION OF WATER, FOUNTAIN SQ., COLS., OHIO 43224

WELL LOG AND DRILLING RECORD

WW-23

NO CARBON PAPER NECESSARY— SELF-TRANSCRIBING

State of Ohio
DEPARTMENT OF NATURAL RESOURCES
Division of Water
65 S. Front St., Rm. 815 Phone (614) 469-2646
Columbus, Ohio 43215

No. 392390 (72) 00001944

ty. TUSCARAWAS Township CLAY Section of Township

Owner ROBERT WOLF Address GNADENHUTTEN Ohio

Location of property OFF COUNTY RD-10 EAST of GNADENHUTTEN Ohio

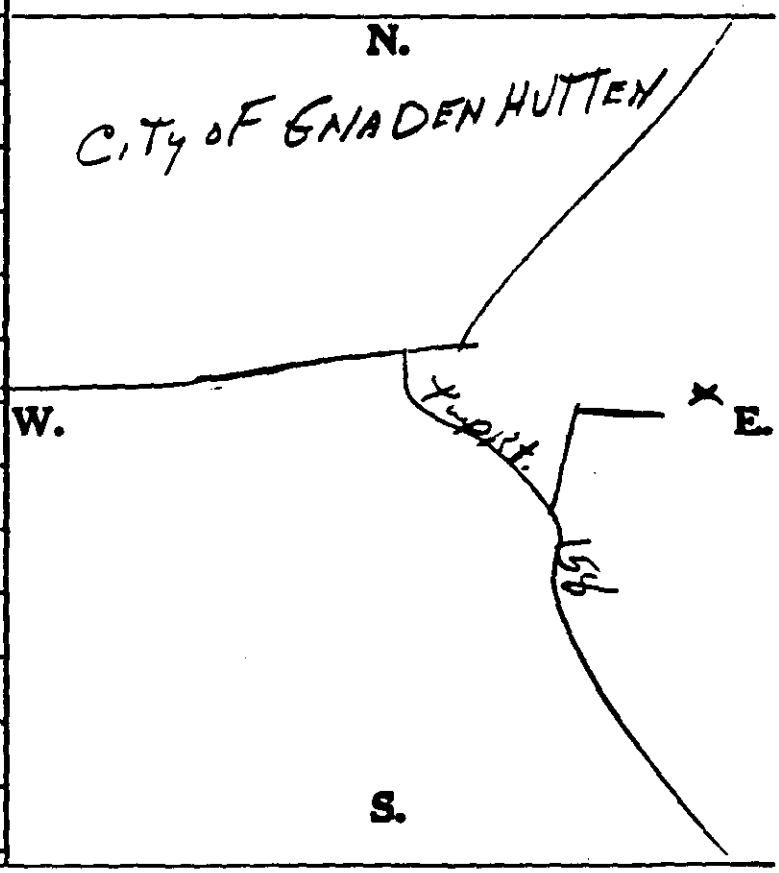
CONSTRUCTION DETAILS	BAILING OR PUMPING TEST (Specify one by circling)
Casing diameter 5" Length of casing 100'	Test Rate 18 G.P.M. Duration of test 1 hrs.
Type of screen — Length of screen —	Drawdown 10 ft. Date 9-13-69
Type of pump Sub.	Static level-depth to water 60' ft.
Capacity of pump 12 GPM.	Quality (clear, cloudy, taste, odor) CLEAR
Depth of pump setting 84'	
Date of completion Sept 16 69	Pump installed by D.M. WALTZ DRILLING CO.

WELL LOG*

Formations Sandstone, shale, limestone, gravel and clay	From	To
SAND	0 Feet	20 Ft.
MUD	20'	40'
LIME	40'	48
COAL & Clay	48'	55'
Shale	55'	92'
LIME	92'	95'
CLAY	95'	97'
Shale	97'	125'
LIME	125'	127'
Shale	127'	150'

SKETCH SHOWING LOCATION

Locate in reference to numbered State Highways, St. Intersections, County roads, etc.



illing Firm D.M. WALTZ DRILLING CO Date Sept 17 69

Address RD 1 STRASBURG Ohio Signed [illegible]

(44)

*If additional space is needed to complete well log, use next consecutive numbered form.

NO CARBON PAPER
NECESSARY—
SELF-TRANSCRIBING

State of Ohio
DEPARTMENT OF NATURAL RESOURCES
Division of Water
Fountain Square
Columbus, Ohio 43224

500981 (66) 00001945

CO TUSCARAWAS TOWNSHIP CLAY SECTION OF TOWNSHIP

OWNER JACK HEAVILIN ADDRESS R.D.# 1, GNADENHUTTEN, OHIO

LOCATION OF PROPERTY THIRD HOUSE OUT OF CORPORATION ON CO.RD. # 10

CONSTRUCTION DETAILS

sing diameter 5" Length of casing 118'

pe of screen Length of screen

pe of pump

pacity of pump

pth of pump setting

te of completion

BAILING OR PUMPING TEST
(specify one by circling)

Test rate 10 gpm Duration of test 1 hrs

Drawdown 115 ft Date 4-26-77

Static level (depth to water) 35 ft

Quality (clear, cloudy, taste, odor) 6 grain hard

7.5. PH .5 PPM IRON

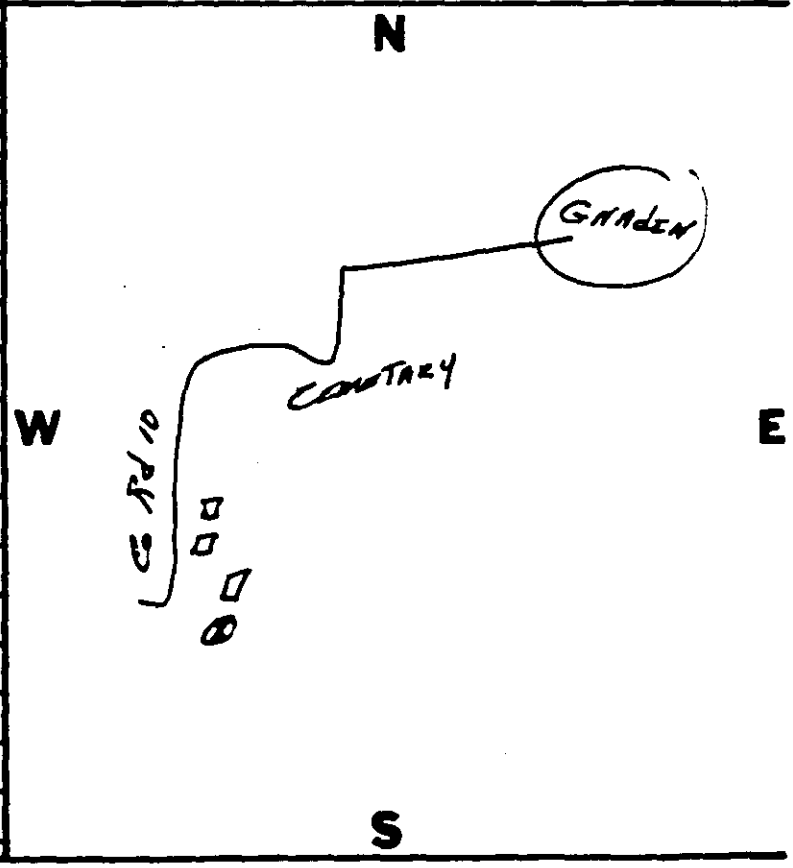
Pump installed by

WELL LOG*

Formations: sandstone, shale, limestone, gravel, clay	From	To
SAND & GRAVEL	0 ft	100 ft
SHALE	100	112
L[illegible]STONE	112	114'6"
COAL	114'6"	115
CLAY	115	121
SANDROCK	121	160

SKETCH SHOWING LOCATION

Locate in reference to numbered state highways, street intersections, county roads, etc.



LING FIRM STOCKERT DRILLING CO. DATE MAY 4, 1977

ESS STRASBURG, OHIO SIGNED M.A. Greenwalt, Sec

39

*If additional space is needed to complete well log, use next consecutive numbered form.

WELL LOG AND DRILLER'S RECORD

NO CARBON PAPER NECESSARY– SELF-TRANSCRIBING

State of Ohio
DEPARTMENT OF NATURAL RESOURCES
Division of Geological Survey
Fountain Square
Columbus, Ohio 43224 Phone (614) 466-5344

472301 (65) 00001946

COUNTY TUSCARAWAS TOWNSHIP CLAY SECTION OF TOWNSHIP OR LOT NUMBER

OWNER ROBERT ARTHUR ADDRESS GNADENHUTTEN, OHIO

LOCATION OF PROPERTY CO. RD. 10 ½ MILE SOUTH OF GNADENHUTTEN, OHIO

CONSTRUCTION DETAILS

Casing diameter 5" Length of casing 85

Type of screen _____ Length of screen _____

Type of pump _____

Capacity of pump _____

Depth of pump setting _____

Date of completion _____

BAILING OR PUMPING TEST
(specify one by circling)

Test rate 7 gpm Duration of test 2 hrs

Drawdown 117 ft Date 3-27-74

Static level (depth to water) 40 ft

Quality (clear, cloudy, taste, odor) TEST 6

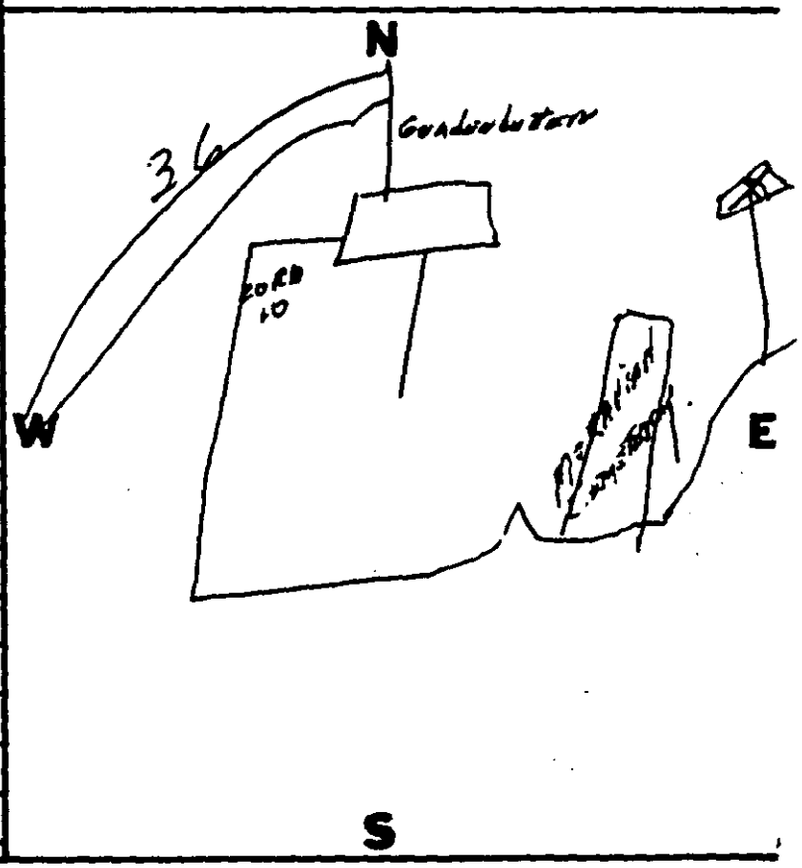
Pump installed by _____

WELL LOG*

Formations: sandstone, shale, limestone, gravel, clay	From	To
SAND & GRAVEL	0 ft	65 ft
Y BROWN MUD	65	74
COAL	74	76
CLAY	76	80
DARK PLASTIC SHALE	80 ~~93~~	93 ~~96~~
LIMESTONe	96	96'6"
COAL	96'6"	98
CLAY	98	110
GRAY SHALE	110	114
LIMESTONE	114	114'6"
COAL	114'6"	118
CLAY	118	157
SANDY SHALE SANDROCK		

SKETCH SHOWING LOCATION

Locate in reference to numbered state highways, street intersections, county roads, etc.



DRILLING FIRM STOCKERT DRILLING CO. DATE MAY 9, 1974

ADDRESS STRASBURG, OHIO SIGNED Albert Greenwalt Sec. (40)

*If additional space is needed to complete well log, use next consecutive numbered form.

WELL LOG AND DRILLING REPORT

WW-26

ORIGINAL

(78)

490477

0000194'

NO CARBON PAPER NECESSARY– SELF-TRANSCRIBING

State of Ohio
DEPARTMENT OF NATURAL RESOURCES
Division of Geological Survey
Fountain Square
Columbus, Ohio 43224 Phone (614) 466-5344

6-21-1977

COUNTY Tuscarawas TOWNSHIP Clay SECTION OF TOWNSHIP OR LOT NUMBER

OWNER Roger Hendman ADDRESS Rt Wrickmille

LOCATION OF PROPERTY on county Road 10 Gnadenhutten

CONSTRUCTION DETAILS

Casing diameter 5 Length of casing 40

Type of screen none Length of screen

Type of pump

Capacity of pump no Pump installed

Depth of pump setting

Date of completion 5-21-1977

BAILING OR PUMPING TEST
(specify one by circling)

Test rate 30 gpm Duration of test 1 hrs

Drawdown none ft Date 6-21-1977

Static level (depth to water) 25 ft

Quality (clear, cloudy, taste, odor) Clear no Pump installed

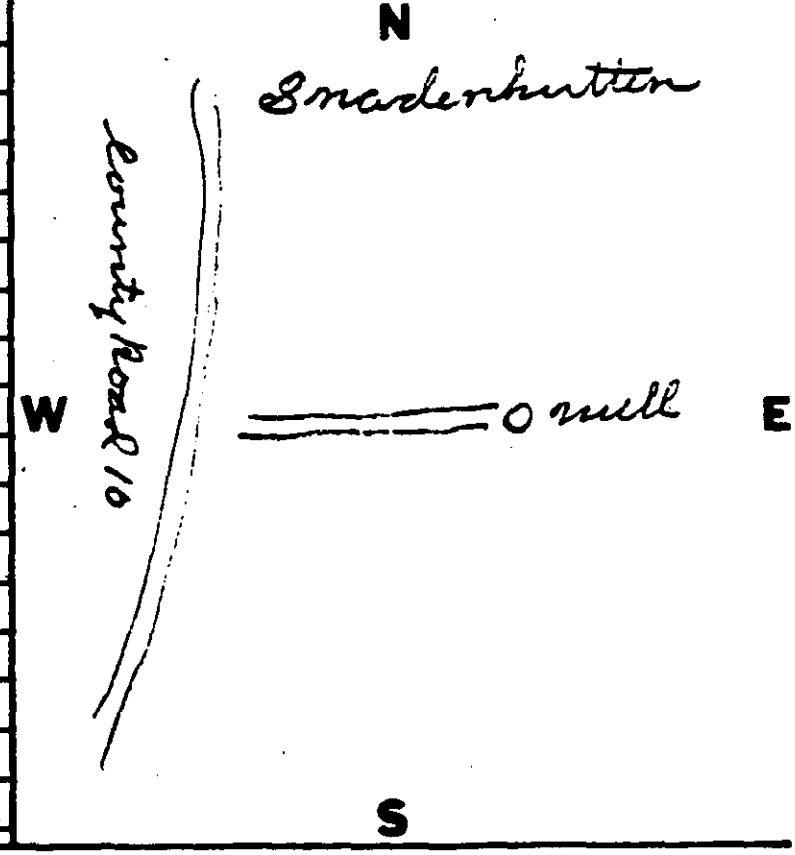
Pump installed by

WELL LOG*

Formations: sandstone, shale, limestone, gravel, clay	From	To
	0 ft	Soil 1 ft
clay	1	15
shale	15	18
sandy shale	18	61
shale	61	72
sand stone	72	80
matter at 70		

SKETCH SHOWING LOCATION

Locate in reference to numbered state highways, street intersections, county roads, etc.



DRILLING FIRM Tobin DATE 6-21-77

ADDRESS Port Washington, Pa SIGNED C. E. Tobin

*If additional space is needed to complete well log, use next consecutive numbered form.

(41)

WELL LOG AND DRILLER'S RECORD

NO CARBON PAPER NECESSARY– SELF-TRANSCRIBING

State of Ohio
DEPARTMENT OF NATURAL RESOURCES
Division of Geological Survey
Fountain Square
Columbus, Ohio 43224 Phone (614) 466-5344

48181[redacted]0001948

COUNTY Tuscarawas TOWNSHIP Clay SECTION OF TOWNSHIP OR LOT NUMBER

OWNER Roger Hindman ADDRESS RR 2 Uhrichsville

LOCATION OF PROPERTY on County Rt 10 Dresdenhutton

CONSTRUCTION DETAILS

Casing diameter 6" Length of casing 25

Type of screen Length of screen

Type of pump

Capacity of pump

Depth of pump setting

Date of completion

BAILING OR PUMPING TEST
(specify one by circling)

Test rate 12 gpm Duration of test 1 hrs

Drawdown ft Date 6/18/76

Static level (depth to water) 85 ft

Quality (clear, cloudy, taste, odor)

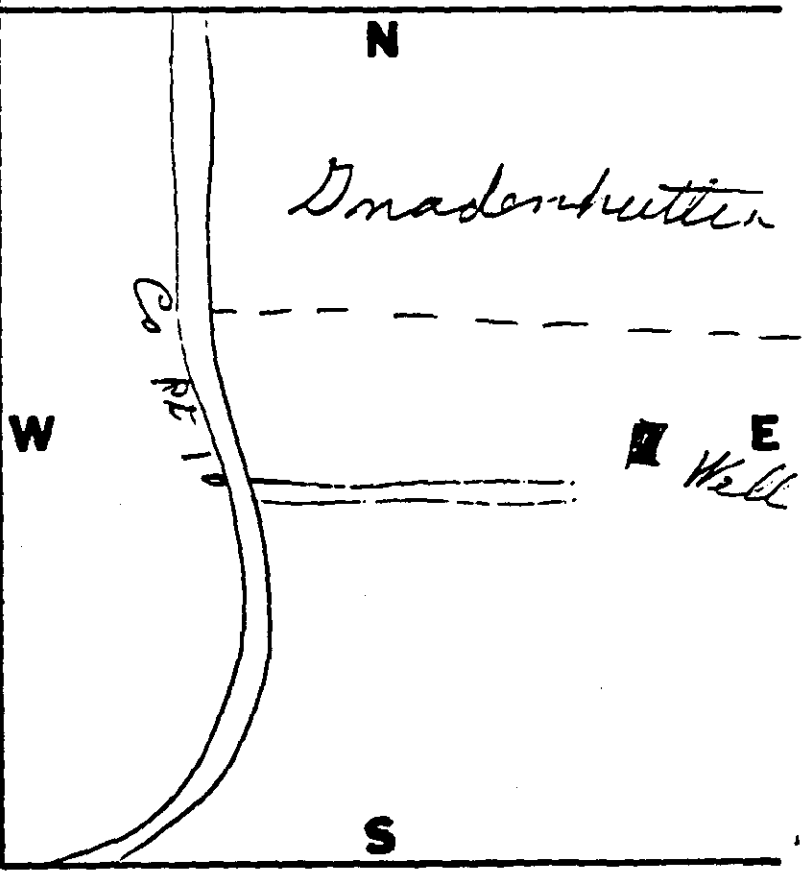
Pump installed by

WELL LOG*

Formations: sandstone, shale, limestone, gravel, clay	From	To
Clay	0 ft	15 ft
Sand	15	18
Shale	18	23
Clay	23	25
Sandy shale	25	40
Shale	40	79
Limestone	79	81
Coal	81	82
Shale	82	121
Limestone	121	126
Shale	126	148
Water at 126		

SKETCH SHOWING LOCATION

Locate in reference to numbered state highways, street intersections, county roads, etc.



DRILLING FIRM Unger Drilling DATE 6/19/76

ADDRESS RD # Dennison SIGNED [illegible]

*If additional space is needed to complete well log, use next consecutive numbered form.

(11)

WELL LOG AND DRILLERS REPORT

State of Ohio
DEPARTMENT OF NATURAL RESOURCES
Division of Water
1562 W. First Avenue
Columbus 12, Ohio

WW-20

(79)

No. ~~306331~~ 00001949

PLEASE USE PENCIL OR TYPEWRITER DO NOT USE INK

County Tusc. Township Clay Section of Township

Owner Jim R White Address Gnadenhutten O Box 533

Location of property 1/2 mile South of County Rd 10

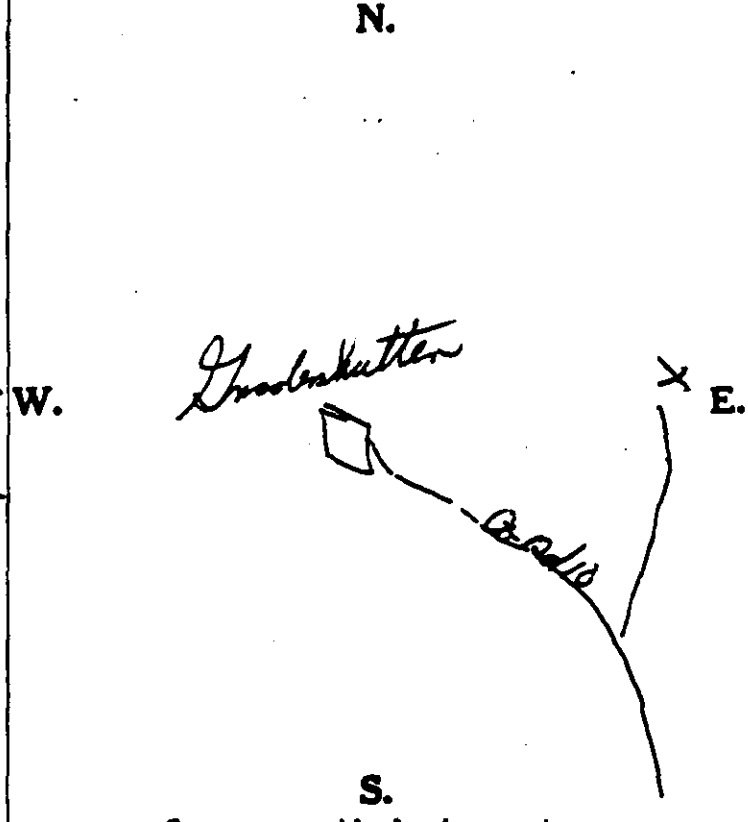
CONSTRUCTION DETAILS	BAILING OR PUMPING TEST
Casing diameter 5 Length of casing 44	Pumping Rate 24 G.P.M. Duration of test 1/2 hrs.
Type of screen Length of screen	Drawdown None ft. Date
Type of pump	Static level-depth to water 100 ft ft.
Capacity of pump	Quality (clear, cloudy, taste, odor)
Depth of pump setting	
Date of completion	Pump installed by

WELL LOG

Formations Sandstone, shale, limestone, gravel and clay	From	To
Bg shale	0 Feet	30 Ft.
fire Clay	30	32
gray shale	32	90
lime rock	90	92
gray shale	92	95
coal	95	96
sandy shale	96	133
lime rock	133	138
gray shale	138	162
lime rock	162	164
gray shale	164	178

SKETCH SHOWING LOCATION

Locate in reference to numbered State Highways, St. Intersections, County roads, etc.



See reverse side for instructions

Drilling Firm Sugar Creek Drilling Date July 7-64

Address Sugar Creek O Signed Nelson L Miller

(42)

WELL LOG AND DRILLING REPORT

State of Ohio
DEPARTMENT OF NATURAL RESOURCES
Division of Water
1500 Dublin Road
Columbus, Ohio

Well Log No. 0900195

No. 213215

County Tuscarawas Township Clay Section of Township

Owner James R White Address Canadian Hutton, Ohio

Location of property 1/2 mile south of Canadian Hutton on Gilmore Road

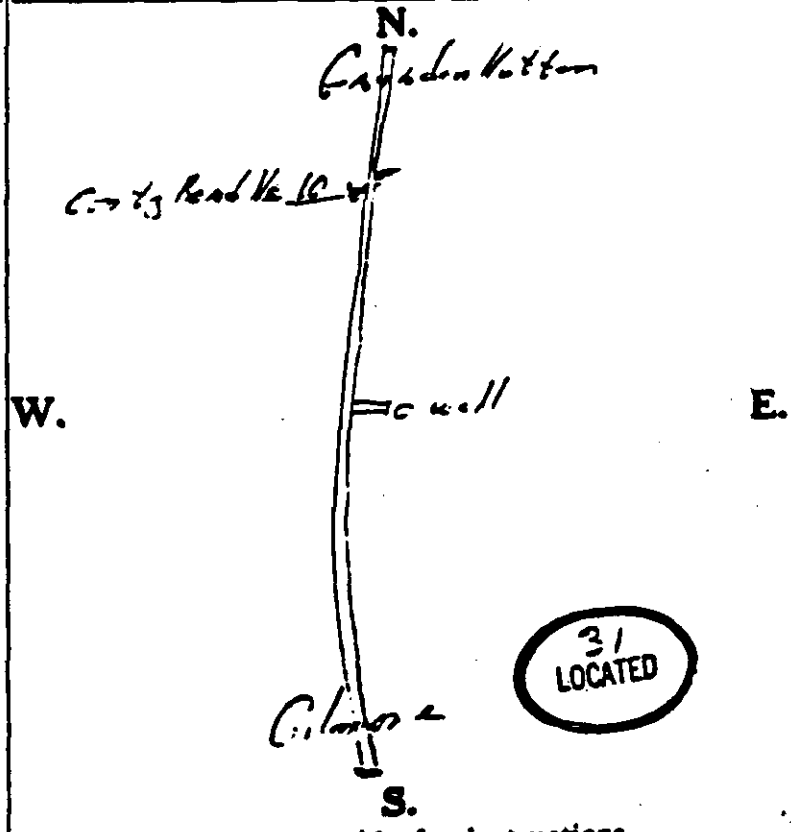
CONSTRUCTION DETAILS	BAILING OR PUMPING TEST
Casing diameter 6 Length of casing 33	Pumping rate ____ G.P.M. Duration of test ____ hrs.
Type of screen ____ Length of screen ____	Drawdown ____ ft. Date ____
Type of pump ____	Developed capacity 28 gal per Min
Capacity of pump ____	Static level—depth to water ____ ft.
Depth of pump setting ____	Pump installed by ____
Date of completion ____	- 860

WELL LOG

Formations Sandstone, shale, limestone, gravel and clay	From	To
Clay	0 Feet	9 Ft.
Sand & some clay	9	31
Gravel	31	33
Dark Shale	33	46
Light Shale	46	50
Dark Shale	50	65
Water at 50 ft.		

SKETCH SHOWING LOCATION

Locate in reference to numbered State Highways, St. Intersections, County roads, etc.



See reverse side for instructions

Drilling Firm Harry England Date Aug 6, 59

Address New Cumberland Ohio Signed [signature]

WELL LOG AND DRILLING REPORT

State of Ohio
DEPARTMENT OF NATURAL RESOURCES
Division of Water
1500 Dublin Road
Columbus, Ohio

WW-30 ORIGINAL

0000195

Well Log WW-2

No. 213223

County [illegible] Township [illegible] Section of Township

Owner [illegible] Address [illegible]

Location of property [illegible]

CONSTRUCTION DETAILS

Casing diameter 6" Length of casing [illegible]

Type of screen Length of screen

Type of pump

Capacity of pump

Depth of pump setting

Date of completion

BAILING OR PUMPING TEST

Pumping rate G.P.M. Duration of test hrs.

Drawdown ft. Date

Developed capacity 20 gal [illegible]

Static level—depth to water ft.

Pump installed by

[illegible]

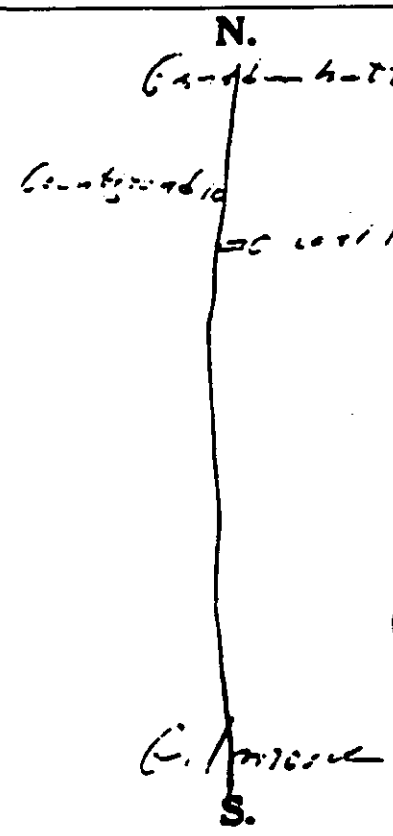
WELL LOG

Formations Sandstone, shale, limestone, gravel and clay	From	To
Clay	0 Feet	11 Ft.
Limerock	11	13
Fire Clay	13	37
Light Shale	37	51
Dark Shale	51	70
Light Shale	70	83

Water at 70

SKETCH SHOWING LOCATION

Locate in reference to numbered State Highways, St. Intersections, County roads, etc.



LOCATED

See reverse side for instructions

Drilling Firm [illegible] Date Nov 17 1960

Address [illegible] Signed [illegible]

WELL LOG AND DRILLING REPORT

State of Ohio
DEPARTMENT OF NATURAL RESOURCES
Division of Water
1500 Dublin Road
Columbus, Ohio

WW-31 ORIGINAL
00001952
Well Log WW-8
No. 207244

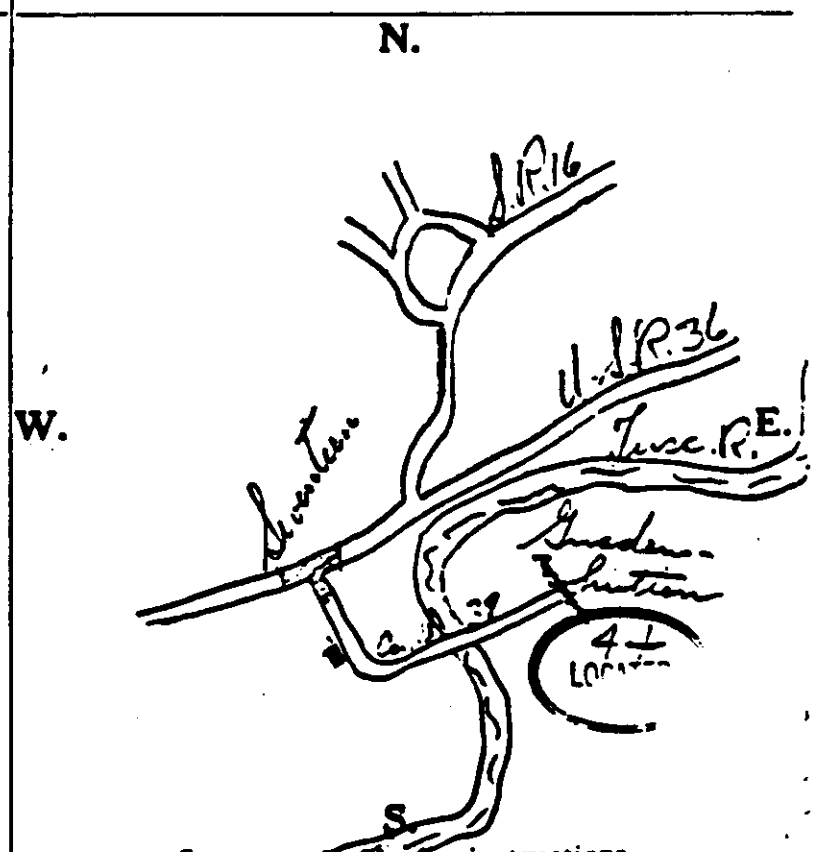
County Tusc. Township Clay Section of Township 27

Owner [illegible] Address R.1 Gnadenhutten E.

Location of property Village of Seventeen - on Co. Rd. 39 - 1 block E of U.S.R. 36

CONSTRUCTION DETAILS	BAILING OR PUMPING TEST
Casing diameter 4" Length of casing 47½	Pumping rate 15 G.P.M. Duration of test 2 hrs.
Type of screen point Length of screen 2	Drawdown 0 ft. Date 6-14-58
Type of pump none	Developed capacity
Capacity of pump	Static level—depth to water 21 ft.
Depth of pump setting	Pump installed by
Date of completion	835

WELL LOG			SKETCH SHOWING LOCATION
Formations dstone, shale, limestone, gravel and clay	From	To	Locate in reference to numbered State Highways, St. Intersections, County roads, etc.
sand & gravel	0 Feet	47 Ft.	



See reverse side for instructions

Drilling Firm [illegible] Date 6-16-58

Address R3 [illegible] Signed [illegible]

WELL LOG AND DRILLING REPORT

WW-32

State of Ohio
DEPARTMENT OF NATURAL RESOURCES
Division of Water
1500 Dublin Road
Columbus, Ohio

00001953
No. 207245

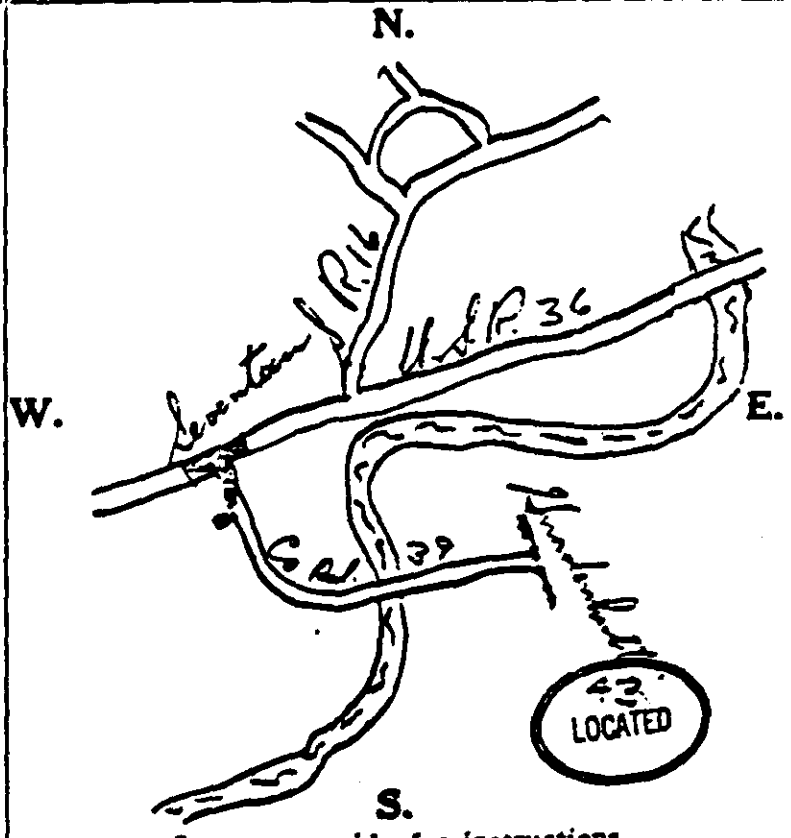
County Tusc. Township Clay Section of Township 27

Owner Warren V. Linden Address R.1 Gnadenhutten, E.

Location of property Village of Seventeen ½ Block E. of U.S.R. 36 - on Co. Rd. 39

CONSTRUCTION DETAILS	BAILING OR PUMPING TEST
Casing diameter 4" Length of casing 48½'	Pumping rate 15 G.P.M. Duration of test 2 hrs.
Type of screen Joint Length of screen 2'	Drawdown 0 ft. Date 6-16-58
Type of pump	Developed capacity
Capacity of pump	Static level—depth to water 20 ft.
Depth of pump setting	Pump installed by
Date of completion	[illegible]

WELL LOG			SKETCH SHOWING LOCATION
Formations Sandstone, shale, limestone, gravel and clay	From	To	Locate in reference to numbered State Highways, St. Intersections, County roads, etc.
dry gravel	0 Feet	48 Ft.	



See reverse side for instructions

Drilling Firm Burgess Drilling Contr. Date 6-16-58

Address R.2 Dover O. Signed J. W. Burgess

WELL LOG AND DRILLING REPORT

State of Ohio
DEPARTMENT OF NATURAL RESOURCES
Division of Water
1500 Dublin Road
Columbus, Ohio

WW-33
Well Log 00001954
No. 200[illegible]

County Tuscarawas Township Clay Section of Township —

Owner Frank Schupp Address R D #1 - Gnadenhutten, Ohio

Location of property at Loch Seventeen west of Gnadenhutten

CONSTRUCTION DETAILS	BAILING ~~OR PUMPING~~ TEST
Casing diameter 5" Length of casing 90'	Pumping rate ____ G.P.M. Duration of test ____ hrs.
Type of screen ____ Length of screen ____	Drawdown 40 ft. Date 4-17-57
Type of pump ____	Developed capacity 8 G.P.M.
Capacity of pump ____	Static level—depth to water 50 ft.
Depth of pump setting ____	Pump installed by ____
Date of completion ____	Elev - 860

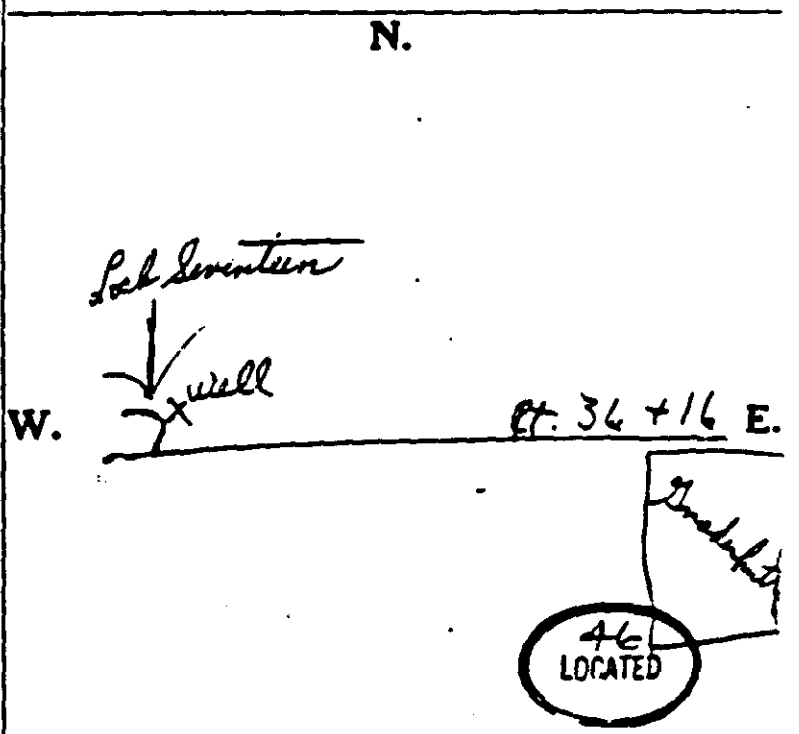
WELL LOG

Formations ...ndstone, shale, limestone, gravel and clay	From	To
Surface	0 Feet	10 Ft.
Dark Elastic shale	10'	15'
Coal	15'	15½'
Clay	15½	24'
Gray plastic shale	24'	48'
Gray sand rock	48'	72'
Gray plastic shale	72'	80'
#4 limestone	80'	83'
Coal	83'	83½'
Clay	83½'	89'
sandrock	89'	165'

water at 135' + 158'

SKETCH SHOWING LOCATION

Locate in reference to numbered State Highways, St. Intersections, County roads, etc.



See reverse side for instructions

Drilling Firm Everett Weltz + Co. Inc. Date 7-11-57

Address Strasburg, Ohio Signed A. D. Carr

WELL LOG AND DRILLING R...

State of Ohio
DEPARTMENT OF NATURAL RESOURCES
Division of Water
1500 Dublin Road
Columbus, Ohio

WW-34
00001955
Well Log WW-9
No. 200155

County Tuscarawas Township Clay Section of Township

Owner Walter Wohlwend Address RD #1 - Gnadenhutten, Ohio

Location of property at Lock Seventeen west of Gnadenhutten

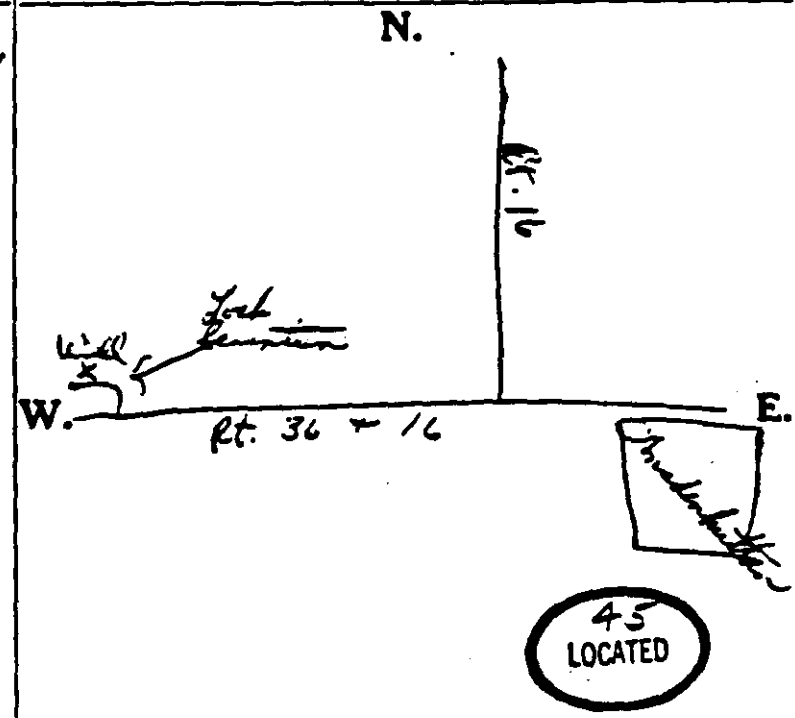
CONSTRUCTION DETAILS	BAILING ~~OR PUMPING~~ TEST
Casing diameter 5" Length of casing ?	Pumping rate ____ G.P.M. Duration of test ____ hrs.
Type of screen ____ Length of screen ____	Drawdown 57 ft. Date 12-6-56
Type of pump ____	Developed capacity 5 G.P.M.
Capacity of pump ____	Static level—depth to water 63 ft.
Depth of pump setting ____	Pump installed by ____
Date of completion ____	[illegible] - 8 + 0

WELL LOG

Formations dstone, shale, limestone, gravel and clay	From	To
well was	0 Feet	67' Ft.
sand rock	67'	115'
gray plastic shale	115'	118'
sand rock	118'	120'
water at 115'		

SKETCH SHOWING LOCATION

Locate in reference to numbered State Highways, St. Intersections, County roads, etc.



See reverse side for instructions

Drilling Firm Everett Waltz + Co., Inc. Date 7-3-57

Address Strasburg, Ohio Signed A. D. Carr

WELL LOG AND DRILLING REPORT

State of Ohio
DEPARTMENT OF NATURAL RESOURCES
Division of Water
Fountain Square
Columbus, Ohio 43224

NO CARBON PAPER NECESSARY - SELF-TRANSCRIBING

WW-35 (51)
5968370001956
Seventeen

COUNTY TUSCARAWAS TOWNSHIP CLAY SECTION OF TOWNSHIP

OWNER ALICE AND D.E. WILSON ADDRESS RT. #1 - BOX 31

LOCATION OF PROPERTY GNADENHUTTEN, OHIO - LOCK #17

CONSTRUCTION DETAILS

Casing diameter 5" Length of casing 68'
Type of screen — Length of screen —
Type of pump
Capacity of pump
Depth of pump setting
Date of completion 1-7-82

BAILING OR PUMPING TEST
(Specify one by circling)

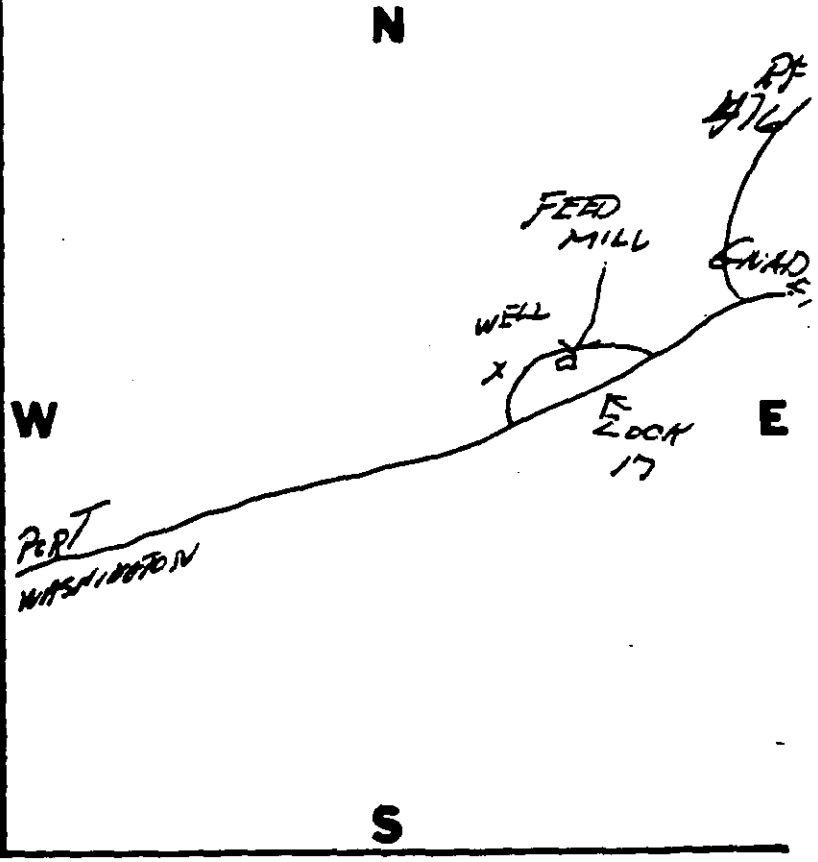
Test rate 30 gpm Duration of test 1 hrs
Drawdown 70' ft Date 1-7-82
Static level (depth to water) 20' ft
Quality (clear, cloudy, taste, odor) GOOD - CLEAR
2 GRAINS - 7.4 P.H - 1.0 P.P.M.
Pump installed by OWNER

WELL LOG*

Formations: sandstone, shale, limestone, gravel, clay	From	To
SURFACE	0 ft	2' ft
CLAY PLAS - CLAY	2'	20'
BROWN SHALE - SANDY STRS -	30'	45'
GREY SHALE - STRS	45'	
OF FLINT		53'
SHOW OF COAL - CLAY	53'	63'
GREY SANDY SHALE AND SANDROCK	63'	80'
LITE GREY SANDROCK	80'	120'
WHITE SANDROCK	120'	145'

SKETCH SHOWING LOCATION

Locate in reference to numbered state highways, street intersections, county roads, etc.



DRILLING FIRM FEARON - FELLER, INC. DATE 1-12-82
ADDRESS BEACH CITY, OHIO SIGNED [illegible]

*If additional space is needed to complete well log, use next consecutive numbered form.

ORIGINAL COPY - ODNR, DIVISION OF WATER, FOUNTAIN SQ., COLS., OHIO 43224 (26)

WEL LOG AND DRILLING RE

State of Ohio
DEPARTMENT OF NATURAL RESOURCES
Division of Geological Survey
Fountain Square
Columbus, Ohio 43224 Phone (614) 466-5344

NO CARBON PAPER NECESSARY- SELF-TRANSCRIBING

471148 (51)
00001957

COUNTY Tuscarawas TOWNSHIP Clay SECTION OF TOWNSHIP OR LOT NUMBER

OWNER Mr. J. Wilson ADDRESS Rt. 1 Gnadenhutten, O

LOCATION OF PROPERTY Rt. 36 at Lock Seventeen

CONSTRUCTION DETAILS

Casing diameter 5 3/8 O.D. Length of casing 68'

Type of screen — Length of screen —

Type of pump Jet

Capacity of pump 6-8 G.P.M.

Depth of pump setting

Date of completion July 20, 1974

BAILING OR PUMPING TEST (Specify one by circling)

Test rate 12+ gpm Duration of test 1 hrs

Drawdown 50 ft Date 7-20-74

Static level (depth to water) 30 ft

Quality (clear, cloudy, taste, odor) Good - clear - 4 grains hard - 7.4 P.H. - .5 iron

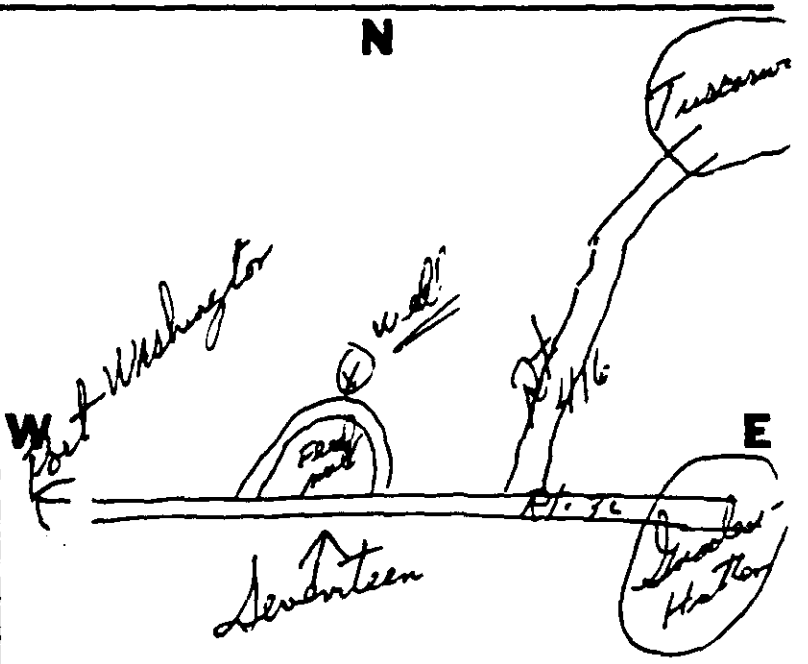
Pump installed by Owner -

WELL LOG*

Formations: sandstone, shale, limestone, gravel, clay	From	To
Surface	0 ft	2' ft
Green shale	2'	50'
Flint	50'	57'
Coal & clay	57'	65'
Bedrock	65'	143'

SKETCH SHOWING LOCATION

Locate in reference to numbered state highways, street intersections, county roads, etc.



DRILLING FIRM Faron & Feller. DATE July 24, 1974

ADDRESS Beach City, Ohio SIGNED [illegible]

(26)

*If additional space is needed to complete well log, use next consecutive numbered form.

WELL LOG AND DRILLING REPORT

WW-51

00001958

State of Ohio
DEPARTMENT OF NATURAL RESOURCES
Division of Water
Columbus, Ohio

Well Log WW-1

Nº 138374

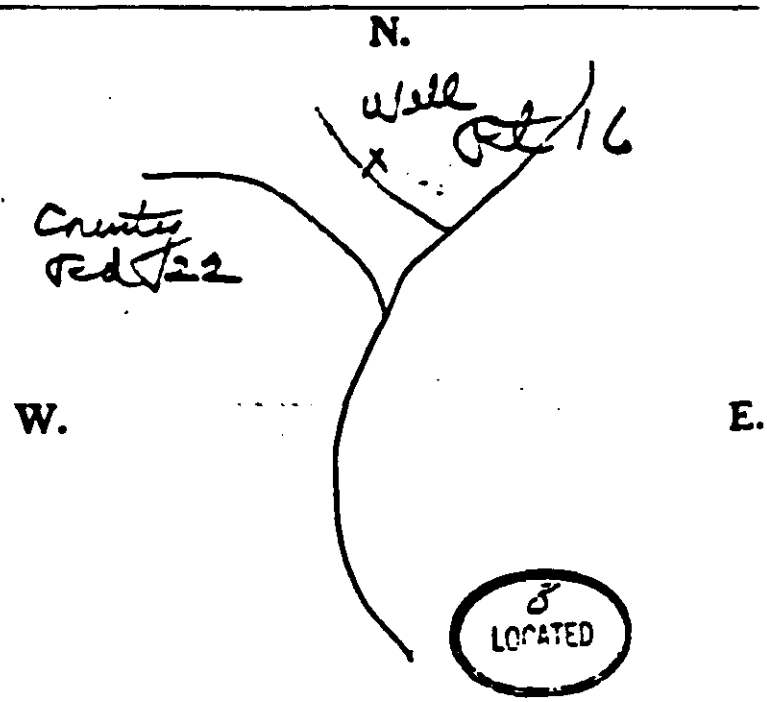
County Tuscarawas Township Clay Section of Township or Lot Number none

Owner Robert Rank Address R#1 Gnadenhutten

Location of property 1/4 mile no Route 16

CONSTRUCTION DETAILS	Bailer ~~PUMPING~~ TEST
Casing diameter 5 Length of casing 53	Pumping rate ____ G.P.M. Duration of test ____ hr
Type of screen ____ Length of screen ____	Drawdown 1 ft. Date Jan 22 195
Type of pump ____	Developed capacity 18 GPM
Capacity of pump ____	Static level—depth to water 9 f
Depth of pump setting ____	Pump installed by ____

WELL LOG			SKETCH SHOWING LOCATION
Formations Sandstone, shale, limestone, gravel and clay	From	To	Locate in reference to numbered State Highways, St. Intersections, County roads, etc.
	0 Feet	____ Ft.	
Gravel		49	



See reverse side for instructions

Drilling Firm Everett Waltz & Co Inc Date Aug 10 1954

Address Strasburg Signed C C Stimmer

WELL LOG AND DRILLING REPORT

(117) ORIGINAL

WW-38

PLEASE USE PENCIL OR TYPEWRITER DO NOT USE INK.

State of Ohio
DEPARTMENT OF NATURAL RESOURCES
Division of Water
1562 W. First Avenue
Columbus 12, Ohio

Nº 321620 00001959

County Tuscarawas Township Warwick Section of Township Southern

Owner George Preston Address Route #1 Gnaden-Hutten

Location of property Between Tuscarawas + Gnaden Hutten on Route #16

CONSTRUCTION DETAILS

Casing diameter 5" Length of casing 89'

Type of screen _____ Length of screen _____

Type of pump _____

Capacity of pump _____

Depth of pump setting _____

Date of completion _____

BAILING OR PUMPING TEST

Pumping Rate 15 G.P.M. Duration of test 3½ hrs.

Drawdown 125 ft. Date 10/9/65

Static level-depth to water 30' ft.

Quality (clear, cloudy, taste, odor) clear

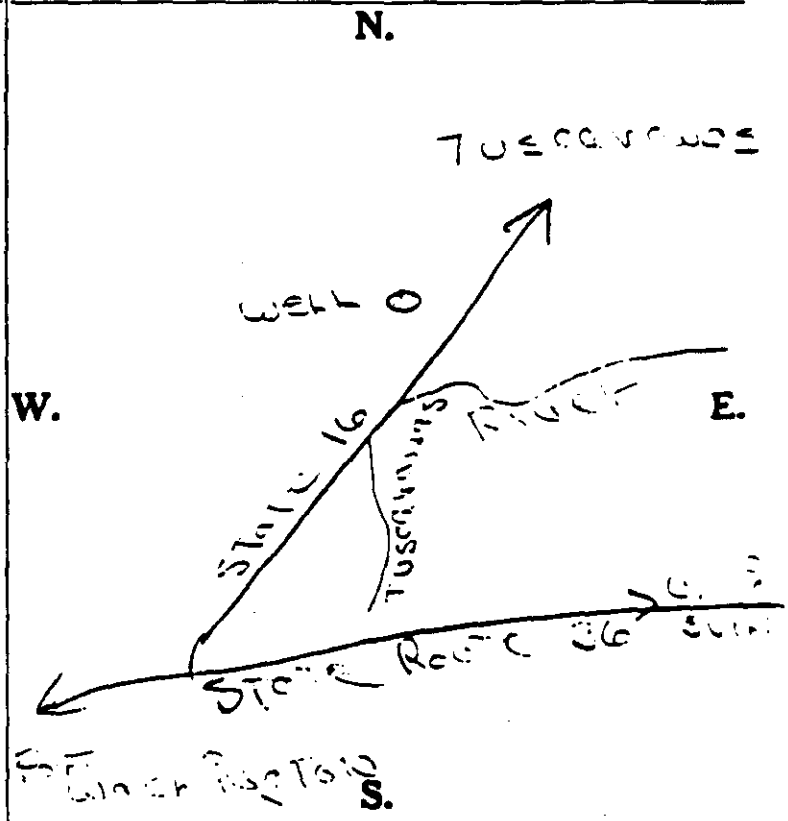
Pump installed by Owner

WELL LOG

Formations Sandstone, shale, limestone, gravel and clay	From	To
Ash Formation	0 Feet	20 Ft.
Sand + clay	20	40
Clay	40	80
~~Sand~~ Shale	80'	89'
Sandy Shale	89'	97'
Sandstone	97'	100'
Gray Shale	100'	117'
Limestone	117'	120'
Shale	120'	130'
Water at 94'		

SKETCH SHOWING LOCATION

Locate in reference to numbered State Highways, St. Intersections, County roads, etc.



See reverse side for instructions

Drilling Firm Johns Bros

Address Route #1 Uhrichsville

Date 10/9/65

Signed [signature]

(110)

WELL LOG AND DRILLING REPORT

State of Ohio
DEPARTMENT OF NATURAL RESOURCES
Division of Water
1562 W. First Avenue
Columbus, Ohio

PLEASE USE PENCIL OR TYPEWRITER. DO NOT USE INK.

WW-39
00001960
No. 266658

County Tusc. Township Warwick Section of Township 2

Owner Benjamin Metzger Address R.1 Gnadenhutten, O.

Location of property 1/2 mi. S of Tuscarawas on S.R. #16

CONSTRUCTION DETAILS

Casing diameter 5" Length of casing 42'-7"

Type of screen none Length of screen

Type of pump none

Capacity of pump

Depth of pump setting

Date of completion

BAILING OR PUMPING TEST

Pumping rate G.P.M. Duration of test 2 hrs.

Drawdown ft. Date 8-10-61

Developed capacity 250 gal per hour

Static level—depth to water 40 ft.

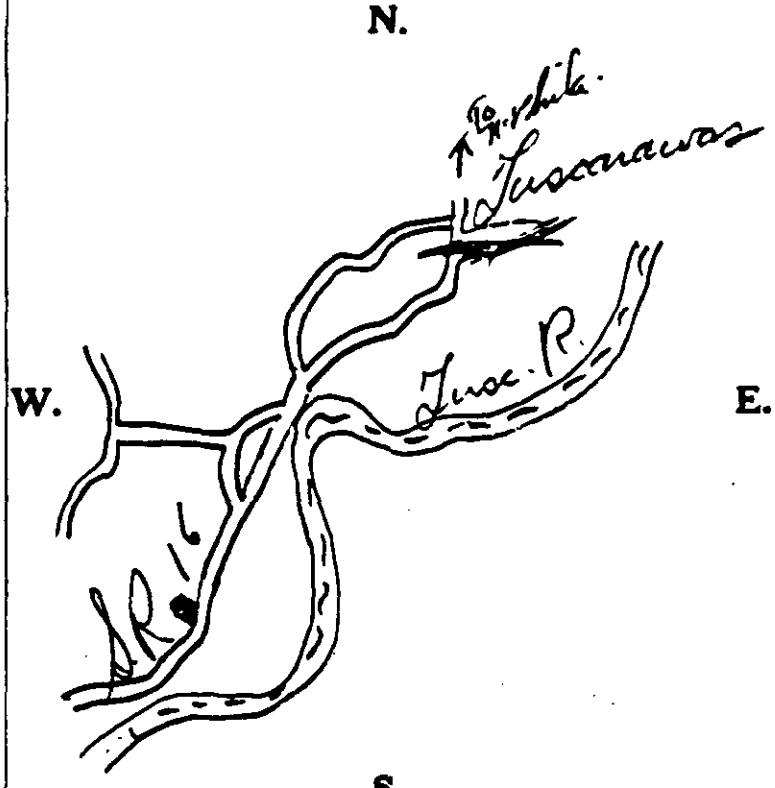
Pump installed by

WELL LOG

Formations Sandstone, shale, limestone, gravel and clay	From	To
dry fill	0 Feet	32 Ft.
yellow shale	32	38
grayshale, stony	38	60
sandstone, white	68	87
blue shale	87	89
coal	89	91
clay, white	91	93
blue shale	93	98
grayshale, stony	98	107
water at 68' & 87'		

SKETCH SHOWING LOCATION

Locate in reference to numbered State Highways, St. Intersections, County roads, etc.



See reverse side for instructions

Drilling Firm Burgess Drilling Date 8-15-61

Address R.3 Akron, O. Signed J.W. Burgess

111

WELL LOG AND DRILLING REPORT

WW-40

478602 (52)

00001961

State of Ohio
DEPARTMENT OF NATURAL RESOURCES
Division of Geological Survey
Fountain Square
Columbus, Ohio 43224 Phone (614) 466-5344

NO CARBON PAPER NECESSARY— SELF-TRANSCRIBING

COUNTY Tuscarwas TOWNSHIP Clay Warwick SECTION OF TOWNSHIP OR LOT NUMBER

OWNER John Metzger ADDRESS Rt. 1 - Gnadenhutten, O

LOCATION OF PROPERTY Rt 416 - 1 mile North of Rt. 36

CONSTRUCTION DETAILS

Casing diameter 5" Length of casing 55

Type of screen — Length of screen —

Type of pump

Capacity of pump

Depth of pump setting

Date of completion July 25-1974

BAILING OR PUMPING TEST
(specify one by circling)

Test rate 12+ gpm Duration of test 1 hrs

Drawdown 10' ft Date July 25-1974

Static level (depth to water) 50' ft

Quality (clear, cloudy, taste, odor) good - clear - 9 grains - 7 P.H. - 1 P.P.M

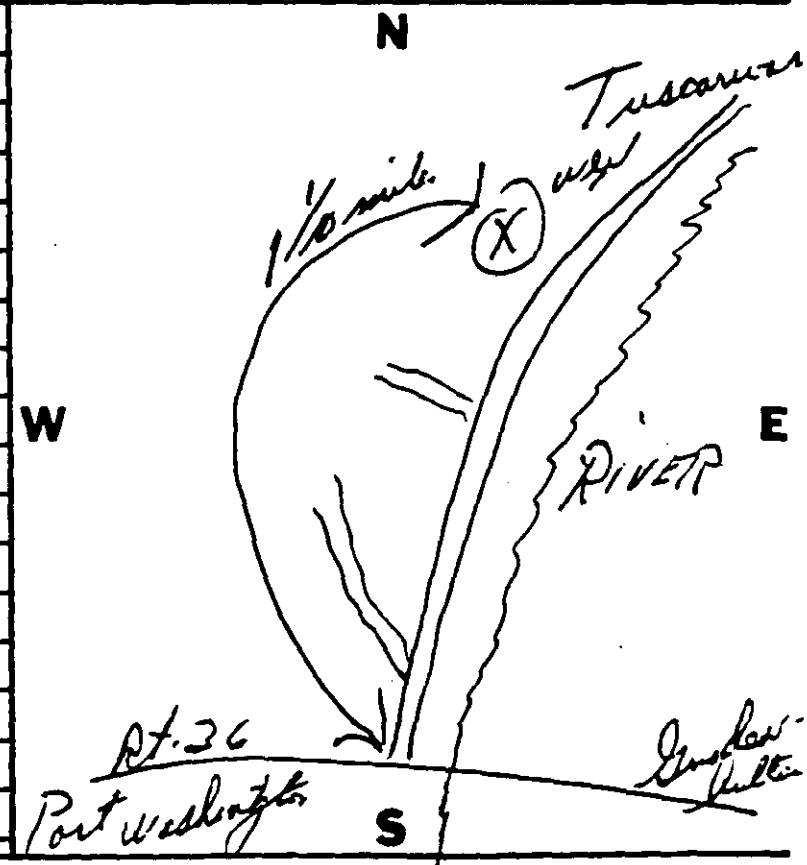
Pump installed by Owner

WELL LOG*

Formations: sandstone, shale, limestone, gravel, clay	From	To
sand	0 ft	10' ft
gray shale	10'	33'
lime	33'	34'
Coal & clay	34'	37'
gray shale	37'	49'
gray sandy shale	49'	80'

SKETCH SHOWING LOCATION

Locate in reference to numbered state highways, street intersections, county roads, etc.



DRILLING FIRM Fearon & Feller DATE Aug 19 1974

ADDRESS Beach City, Ohio SIGNED J. Fearon

112

*If additional space is needed to complete well log, use next consecutive numbered form.

WELL LOG AND DRILLING REPORT

WW-41

(35)

NO CARBON PAPER NECESSARY— SELF-TRANSCRIBING

State of Ohio
DEPARTMENT OF NATURAL RESOURCES
Division of Water
65 S. Front St., Rm. 815 Phone (614) 469-2646
Columbus, Ohio 43215

No. 385719000196[illegible]

CR 57

Co[illegible] Township Warwick Section of Township

Owner [illegible] Address [illegible]

Location of property

CONSTRUCTION DETAILS

asing diameter Length of casing

ype of screen Length of screen

ype of pump

apacity of pump

pth of pump setting

te of completion

BAILING OR PUMPING TEST
(Specify one by circling)

Test Rate G.P.M. Duration of test hrs.

Drawdown ft. Date

Static level-depth to water ft.

Quality (clear, cloudy, taste, odor)

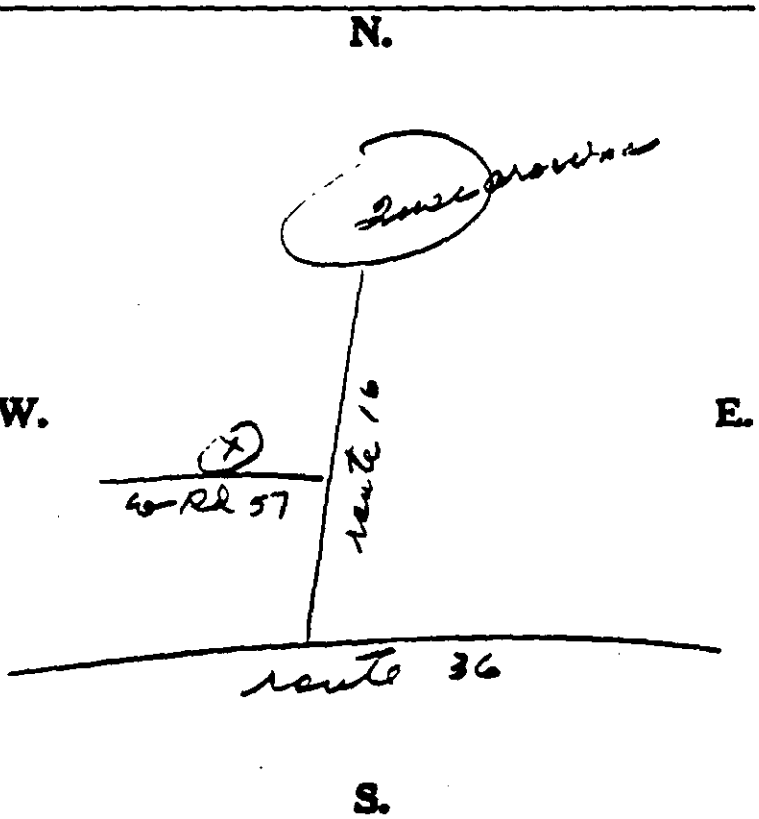
Pump installed by

WELL LOG*

Formations Sandstone, shale, limestone, gravel and clay	From	To
	0 Feet	Ft.
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]

SKETCH SHOWING LOCATION

Locate in reference to numbered State Highways, St. Intersections, County roads, etc.



ing Firm [illegible] Date [illegible]

Address [illegible] Signed [illegible]

113

*If additional space is needed to complete well log, use next consecutive numbered form.

WELL LOG AND DRILLING REPORT

State of Ohio
DEPARTMENT OF NATURAL RESOURCES
Division of Geological Survey
Fountain Square
Columbus, Ohio 43224 Phone (614) 466-5344

NO CARBON PAPER NECESSARY– SELF-TRANSCRIBING

ORIGINAL
147 WW-42
478627
0000196

COUNTY Tuscarawas TOWNSHIP Warwick SECTION OF TOWNSHIP OR LOT NUMBER

OWNER Mrs J Sullivan ADDRESS Box 76

LOCATION OF PROPERTY Tuscarawas, Ohio off Rt. 416

CONSTRUCTION DETAILS

Casing diameter 5" Length of casing 31'5

Type of screen Perf. Length of screen 18"

Type of pump Wards Jet ½ hs.

Capacity of pump 6-8 gpm

Depth of pump setting 23

Date of completion 11/7/74

BAILING OR PUMPING TEST
(specify one by circling)

Test rate 12 gpm Duration of test 1 hrs

Drawdown 2' ft Date 11/7/74

Static level (depth to water) 16 ft

Quality (clear, cloudy, taste, odor) 26 hard, 6.8 PH. 5 ppm Iron

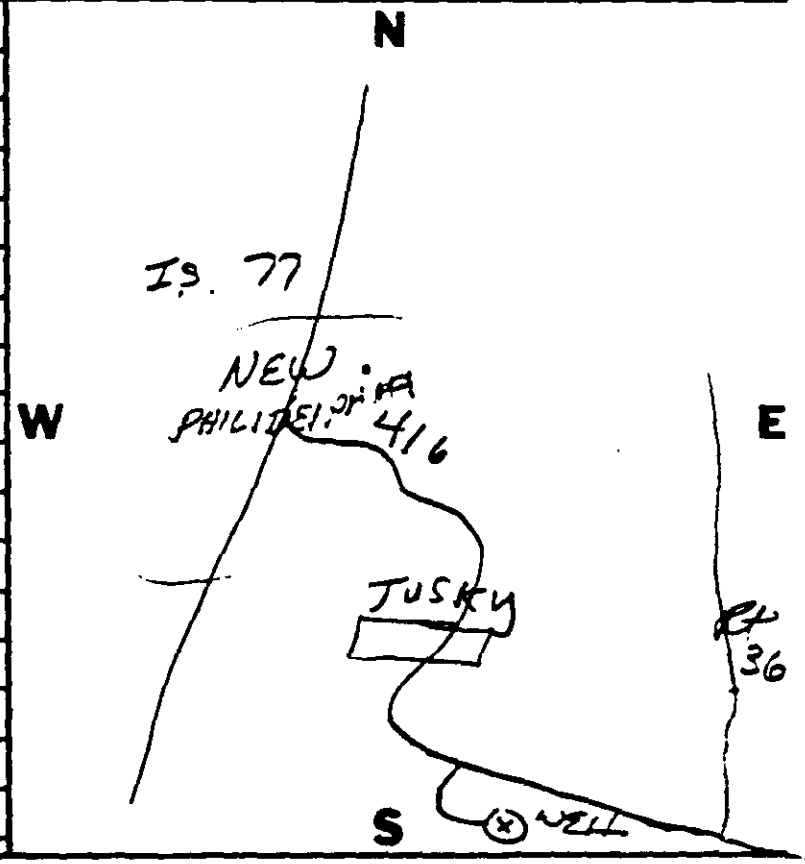
Pump installed by Fearon & Fellen

WELL LOG*

Formations: sandstone, shale, limestone, gravel, clay	From	To
Mud	0 ft	20 ft
Sand Gravel	20	30'

SKETCH SHOWING LOCATION

Locate in reference to numbered state highways, street intersections, county roads, etc.



DRILLING FIRM Fearon & Fellen DATE 11/7/74

ADDRESS Rt 1 Beach City, O SIGNED Wm. Fellen

114

*If additional space is needed to complete well log, use next consecutive numbered form.

State of Ohio
DEPARTMENT OF NATURAL RESOURCES
Division of Water
1562 W. First Avenue
Columbus, Ohio

PLEASE USE PENCIL OR TYPEWRITER. DO NOT USE INK.

WW 15 0000196

No. 266688

ty Tusc. Township Warwick Section of Township 1

Owner Stewart-Lodge gravel Co. Address R. 1, Gnadenhutten, O.

Location of property 2 mi. S.W. of Tuscarawas, O. just off S.R. #16

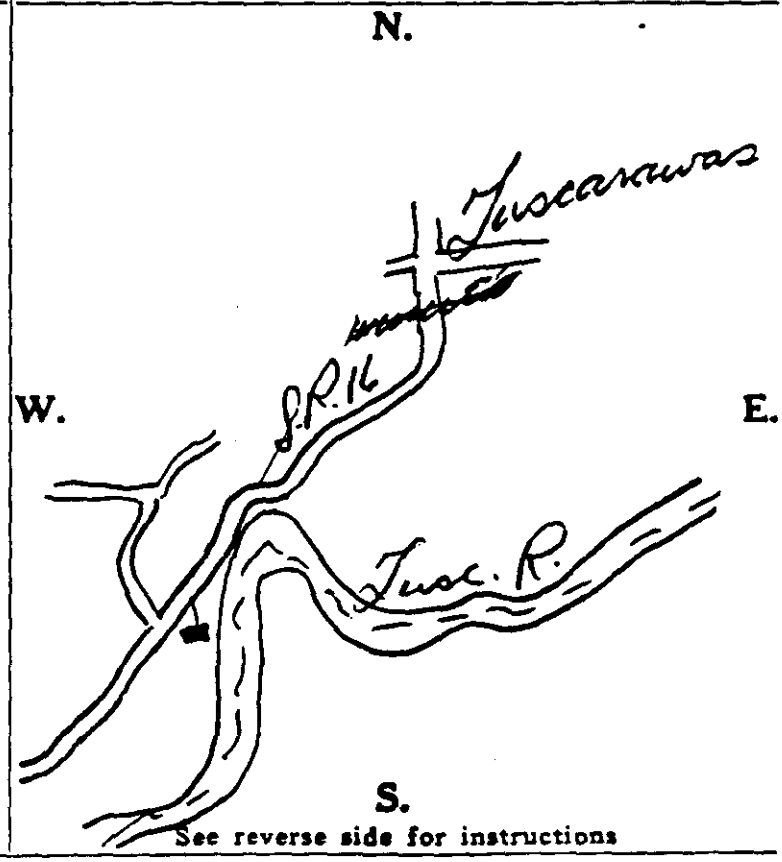
CONSTRUCTION DETAILS	BAILING OR PUMPING TEST
Casing diameter 12" Length of casing 23½'	Pumping rate 35 G.P.M. Duration of test 2 hrs.
Type of screen none Length of screen	Drawdown 0 ft. Date 1-11-62
Type of pump none	Developed capacity
Capacity of pump	Static level—depth to water 8 ft.
Depth of pump setting	Pump installed by
Date of completion	

WELL LOG

Formations Sandstone, shale, limestone, gravel and clay	From	To
1 & gravel	0 Feet	23 Ft.

SKETCH SHOWING LOCATION

Locate in reference to numbered State Highways, St. Intersections, County roads, etc.



See reverse side for instructions

illing Firm Burgess & Drilling Date 1-15-62

Address R. 3 Dover, O. Signed J. W. Burgess

115

WELL LOG AND DRILLING REPORT

WW-44 (82)

620886 00001965

State of Ohio
DEPARTMENT OF NATURAL RESOURCES
Division of Water
Fountain Square
Columbus, Ohio 43224

NO CARBON PAPER NECESSARY – SELF-TRANSCRIBING

COUNTY: Tusc. TOWNSHIP: Warwick SECTION OF TOWNSHIP: T7R1

OWNER: Paul Burgess ADDRESS: R#1 Gnadenhutten O.

LOCATION OF PROPERTY: 1½ mi. S of Tuscarawas O. off S.R. #1116 (Stewart-Bucher [illegible])

CONSTRUCTION DETAILS

Casing diameter: 12 in. Length of casing: 47'

Type of screen: [illegible] Length of screen: 30'

Type of pump: [illegible]

Capacity of pump:

Depth of pump setting:

Date of completion:

BAILING OR PUMPING TEST
(specify one by circling)

Test rate: 50 gpm Duration of test: 2 hrs

Drawdown: 5 ft Date: 6-6-93

Static level (depth to water): 10 ft

Quality (clear, cloudy, taste, odor): clear

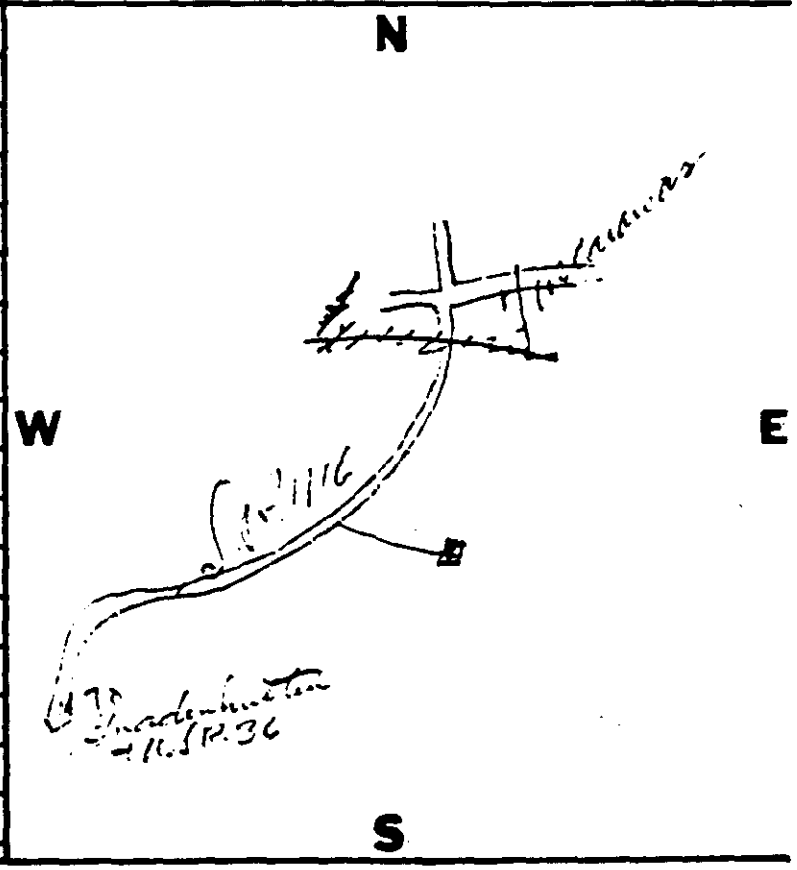
Pump installed by:

WELL LOG*

Formations: sandstone, shale, limestone, gravel, clay	From	To
dry gravel	0 ft	47 ft

SKETCH SHOWING LOCATION

Locate in reference to numbered state highways, street intersections, county roads, etc.



DRILLING FIRM: Burgess Drilling DATE: 6-7-93

ADDRESS: R3 Harvey Ct. SIGNED: [illegible]

*If additional space is needed to complete well log, use next consecutive numbered form.

ORIGINAL COPY - ODNR, DIVISION OF WATER, FOUNTAIN SQ., COLS., OHIO 43224 (115)

WELL LOG AND DRILLING REPORT

State of Ohio
DEPARTMENT OF NATURAL RESOURCES
Division of Water
1562 W. First Avenue
Columbus 12, Ohio

PLEASE USE PENCIL OR TYPEWRITER DO NOT USE INK.

(81) WW-45

Nº 280680

00001966

County Tusc. Township Warwick Section of Township 1

Owner Stewart-Fedge gravel Co. Address R. 1 Gnadenhutten O.

Location of property 1½ mi. S.W. of Tuscarawas O. off S.R. #16

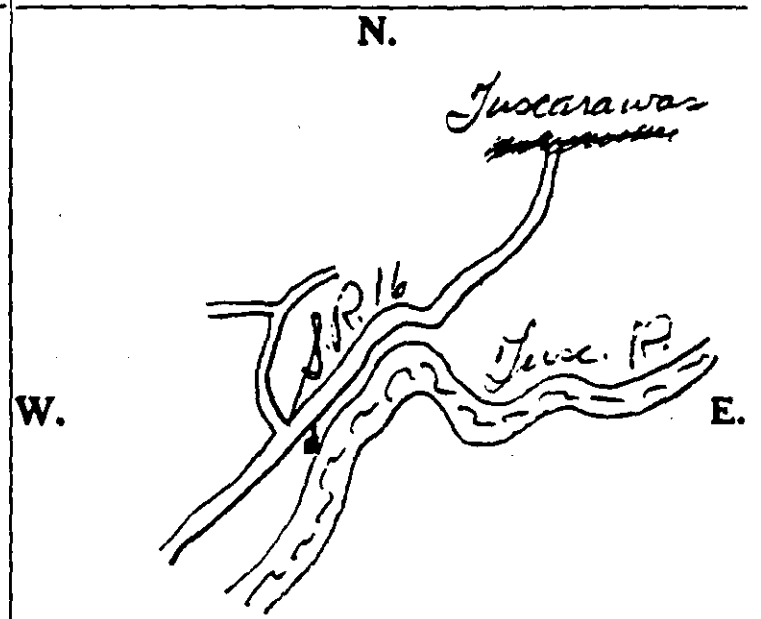
CONSTRUCTION DETAILS	BAILING OR PUMPING TEST
Casing diameter 12" Length of casing 33½'	Pumping Rate 100 G.P.M. Duration of test 2 hrs.
Type of screen wood Length of screen 15'	Drawdown 9 ft. Date 7-27-62
Type of pump centrifugal	Static level-depth to water 10 ft.
Capacity of pump 100 g/p.m.	Quality (clear, cloudy, taste, odor) clear
Depth of pump setting 28'	
Date of completion 7-27-62	Pump installed by owner

WELL LOG

Formations Sandstone, shale, limestone, gravel and clay	From	To
2 d/4 gravel	0 Feet	33 Ft.

SKETCH SHOWING LOCATION

Locate in reference to numbered State Highways, St. Intersections, County roads, etc.



See reverse side for instructions

Drilling Firm Burgess Drilling Date 7-28-62

Address R. B. Dover, Ex. Signed J. W. Burgess

115

WELL LOG AND DRILLING REPORT

WW-46 ORIGINAL

State of Ohio
DEPARTMENT OF NATURAL RESOURCES
Division of Water
1500 Dublin Road
Columbus, Ohio

0000196

Well Log No. 215997

County Tuscarawas Township Clay Section of Township —

Owner Larson Clay Pipe Co. Address Box 431 Uhrichsville, O.

Location of property at their plant just east of Gnadenhutten

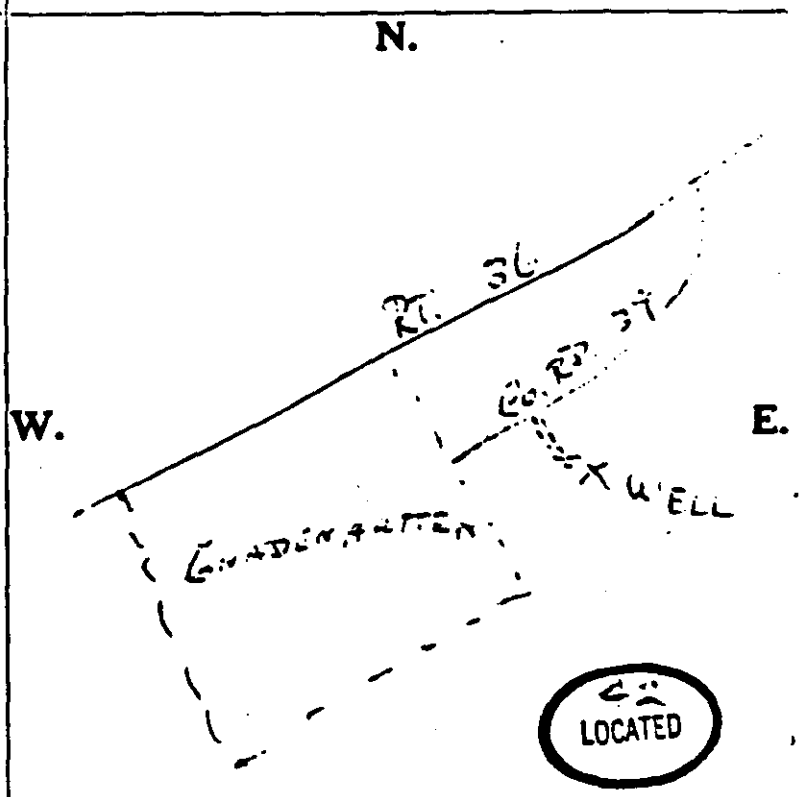
CONSTRUCTION DETAILS	BAILING ~~OR PUMPING~~ TEST
Casing diameter 8" Length of casing 75'11"	Pumping rate ____ G.P.M. Duration of test ____ hrs.
Type of screen ____ Length of screen ____	Drawdown 0 ft. Date 7-31-58
Type of pump ____	Developed capacity 22 gpm [illegible]
Capacity of pump ____	Static level—depth to water 32 ft.
Depth of pump setting ____	Pump installed by ____
Date of completion ____	[illegible] - 820

WELL LOG

Formations sandstone, shale, limestone, gravel and clay	From	To
	0 Feet	62 Ft.
Washed	62'	70'
Clay	70'	90'
Sandy shale & Sandrock	90'	96'
Fray Plastic Shale		
Water at 83'6"		

SKETCH SHOWING LOCATION

Locate in reference to numbered State Highways, St. Intersections, County roads, etc.



See reverse side for instructions

Drilling Firm Everett Waltz & Co., Inc. Date 5-21-55

Address Strasburg, Ohio Signed [illegible]

WW-47

Well 00001968

Nº 361031

WELL LOG AND DRILLING REPORT

State of Ohio
DEPARTMENT OF NATURAL RESOURCES
Division of Water
1532 W. First Avenue
Columbus, Ohio 43212

PLEASE USE PENCIL OR TYPEWRITER
DO NOT USE INK

County Tusc. Township Clay Section of Township

Owner Larson Sewwe Pipe Address Gnadenhutten, Ohio

Location of property

CONSTRUCTION DETAILS

Casing diameter 8" Length of casing 69'1"

Type of screen Perforation Length of screen 18'

Type of pump Sub.

Capacity of pump 100 G.P.M.

Depth of pump setting 36'

Date of completion 6/19/67

BAILING OR PUMPING TEST

Pumping Rate 110 G.P.M. Duration of test 5 hrs.

Drawdown 11 ft. Date 6/1/67-6/9/67

Static level-depth to water 30' ft.

Quality (clear, cloudy, taste, odor)

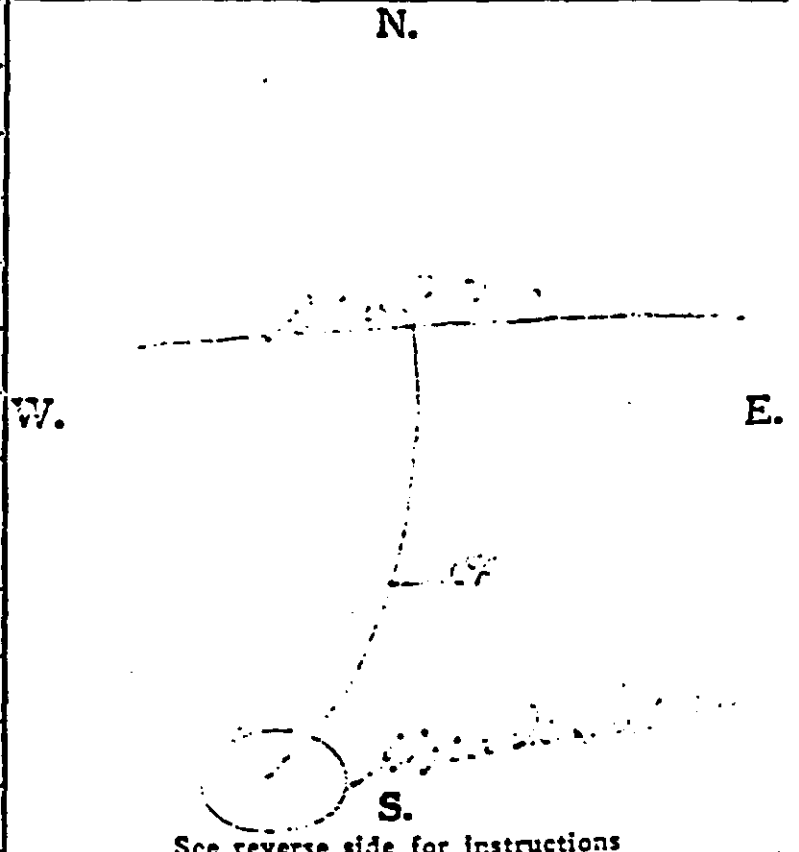
Pump installed by

WELL LOG*

Formations Sandstone, shale, limestone, gravel and clay	From	To
0 to 6' top soil	0 Feet	6' Ft.
sand & gravel	6'	67'

SKETCH SHOWING LOCATION

Locate in reference to numbered State Highways, St. Intersections, County roads, etc.



See reverse side for instructions

Drilling Firm Stockert Drilling Co. Date June 20, 1967

Address R. D. #1 Strasburg, Ohio Signed Walter A. Stockert

*If additional space is needed to complete well log, use next consecutive numbered form.

WELL LOG AND DRILLING REPORT

WW-48 (58) 0001969

ORIGINAL

State of Ohio
DEPARTMENT OF NATURAL RESOURCES
Division of Water
1562 W. First Avenue
Columbus 12, Ohio

PLEASE USE PENCIL OR TYPEWRITER DO NOT USE INK.

Nº 288847

County TUSCARAWAS Township CLAY Section of Township NORTH EAST

Owner TUSCARAWAS POWLTY Address GNADENHUTTEN

Location of property GNADEHUTTEN EAGE OF TOWN

CONSTRUCTION DETAILS

Casing diameter 5 Length of casing 55

Type of screen NONE Length of screen NONE

Type of pump 1/2 HP Sub.

Capacity of pump 8 GPM

Depth of pump setting 120'

Date of completion Feb 12 1965

BAILING OR PUMPING TEST

Pumping Rate 10 G.P.M. Duration of test 1 hrs.

Drawdown 20 ft. Date Feb 12, 65

Static level-depth to water 75 ft.

Quality (clear, cloudy, taste, odor) CLEAR

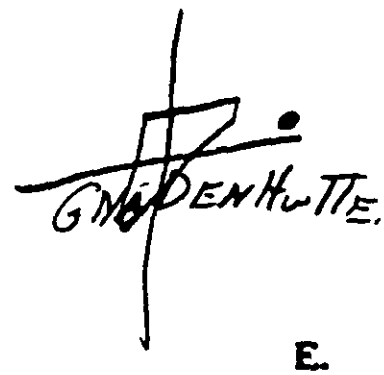
Pump installed by D.M. WALTZ DRILLING CO

WELL LOG

Formations Sandstone, shale, limestone, gravel and clay	From	To
WASH	0 Feet	60 Ft.
SHALE	60	106
LIME	106	108
CLAY	108	113
SHALE	113	121
LIME	121	123
CLAY	123	129
SHALE	129	149
LIME	149	154
SHALE	154	155

SKETCH SHOWING LOCATION

Locate in reference to numbered State Highways, St. Intersections, County roads, etc.



See reverse side for instructions

Drilling Firm D.M. WALTZ DRILLING CO Date APRIL 14/65

Address STRASBURG OHIO Signed Paul Kates

45

WELL LOG AND DRILLING REPORT

PLEASE USE PENCIL
OR TYPEWRITER
DO NOT USE INK

State of Ohio
DEPARTMENT OF NATURAL RESOURCES
Division of Water
1562 W. First Avenue
Columbus 12, Ohio

57 WW-49 0500197
No. 288842

County TUSCARAWAS Township CLAY Section of Township NORTH · EAST

Owner TUSCARAWAS POULTY Address GNADENHUTTEN OHIO

Location of property GNADENHUTTEN 2 AGE OFF TOWN

CONSTRUCTION DETAILS

Casing diameter 10' Length of casing 65'

Type of screen NONE Length of screen NONE

Type of pump 3HP Sub.

Capacity of pump 50 GPM.

Depth of pump setting 200'

Date of completion MAY 16 64

BAILING OR PUMPING TEST

Pumping Rate 54 G.P.M. Duration of test 2 hrs.

Drawdown 78 ft. Date MAY 16 64

Static level-depth to water 93 ft.

Quality (clear, cloudy, taste, odor) CLEAR SALTY

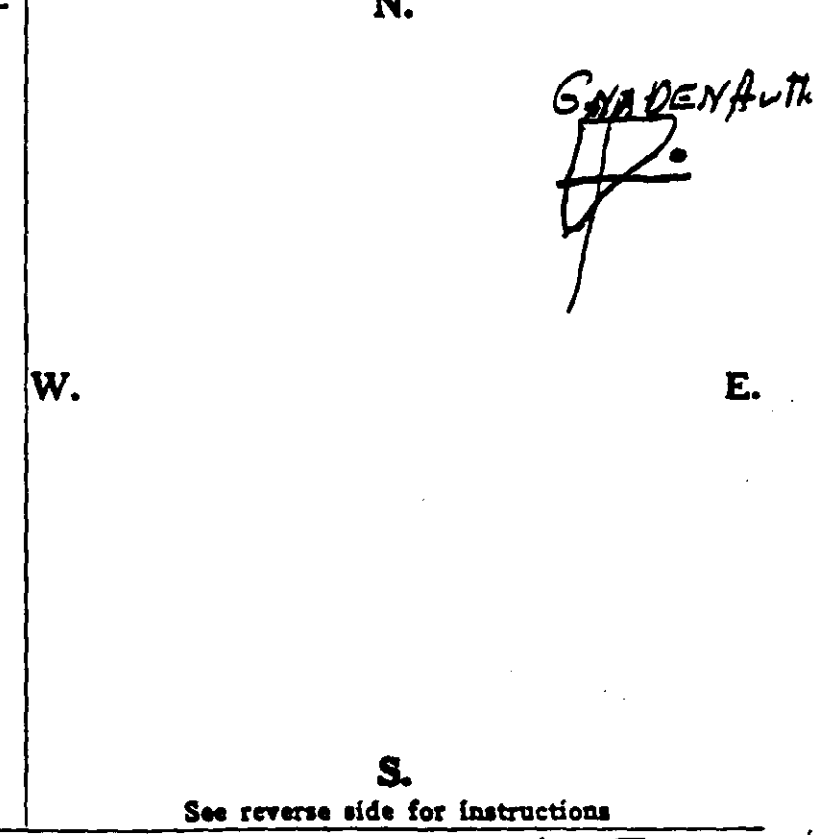
Pump installed by D.M. WALTZ DRILLING CO

WELL LOG

Formations Sandstone, shale, limestone, gravel and clay	From	To
WASH	0 Feet	32 Ft.
CLAY	32	35
SHALE	35	129
LIME	129	131
CLAY	131	140
SHALE	140	171
LIME	171	176
CLAY	176	183
SHALE	183	206
SAND ROCK	206	217
SHALE	217	231
SAND ROCK	231	236
SHALE	236	242
SAND ROCK	242	260

SKETCH SHOWING LOCATION

Locate in reference to numbered State Highways, St. Intersections, County roads, etc.



See reverse side for instructions

Drilling Firm D.M. WALTZ DRILLING CO Date APRIL 14 65

Address STRASBURG O. Signed Paul Waltz

46

WELL LOG AND DRILLING REPORT

WW-50 (6)

No. 399292 00001971

NO CARBON PAPER NECESSARY— SELF-TRANSCRIBING

State of Ohio
DEPARTMENT OF NATURAL RESOURCES
Division of Water
65 S. Front St., Rm. 815 Phone (614) 469-2646
Columbus, Ohio 43215

C Tuse Township Rush Section of Township 35

Owner Dean Fatchell Address R. 3 Wheelsville O.

Location of property 1/4 mi. S.E. of Gradenhutten O. on T.R. 158

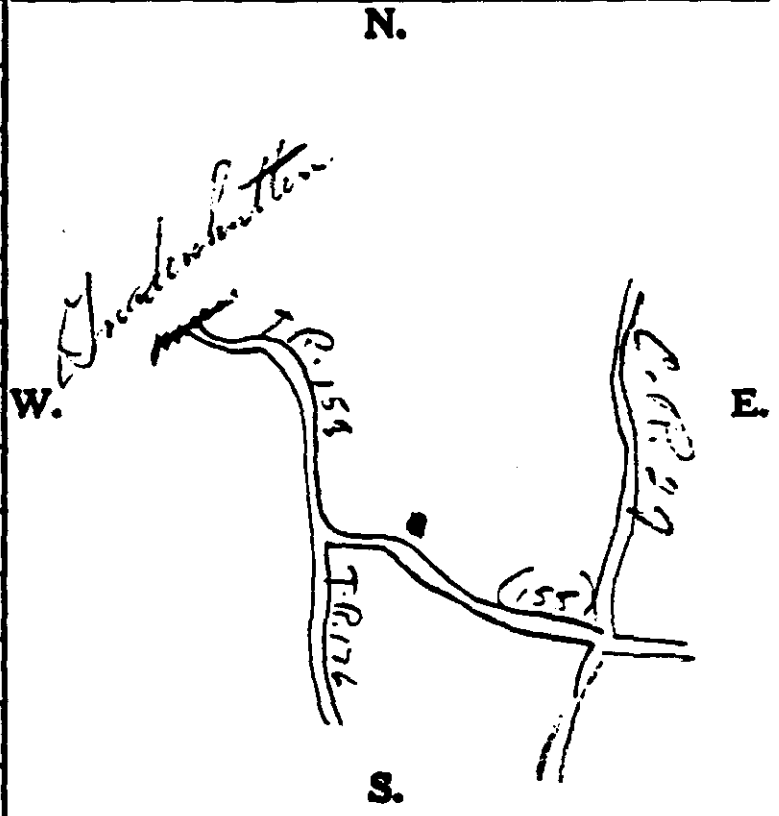
CONSTRUCTION DETAILS	BAILING OR PUMPING TEST (Specify one by circling)
Casing diameter 6" Length of casing 67'3"	Test Rate 10 G.P.M. Duration of test 2 hrs.
Type of screen none Length of screen	Drawdown 20 ft. Date 2-27-70
Type of pump none	Static level-depth to water 42 ft.
Capacity of pump	Quality (clear, cloudy, taste, odor) clear
Depth of pump setting	
Date of completion	Pump installed by

WELL LOG*

Formations Sandstone, shale, limestone, gravel and clay	From	To
[illegible] shale	0 Feet	20 Ft.
[illegible] shale	20	58
[illegible] shale	58	67
[illegible] shale stone	67	81

SKETCH SHOWING LOCATION

Locate in reference to numbered State Highways, St. Intersections, County roads, etc.



ng Firm Burgess Drilling Date 3-2-70

Address R. 3 Dover E. O. Signed J. W. Burgess (6)

*If additional space is needed to complete well log, use next consecutive numbered form.

WELL LOG AND DRILLING REPORT

State of Ohio
DEPARTMENT OF NATURAL RESOURCES
Division of Water
1562 W. First Avenue
Columbus, Ohio 43212

PLEASE USE PENCIL OR TYPEWRITER
DO NOT USE INK

WW-51 (64)
Nº 365341
00001972

County: Tuscarawas Township: Clay Section of Township: north east

Owner: Mike Miller Address: R.T. #I, Gnadenhutten

Location of property: Intersection of county roads I0 and I6 at mobile home

CONSTRUCTION DETAILS

Casing diameter: 5" Length of casing: 47'
Type of screen: Length of screen:
Type of pump:
Capacity of pump:
Depth of pump setting:
Date of completion:

owner

BAILING OR PUMPING TEST

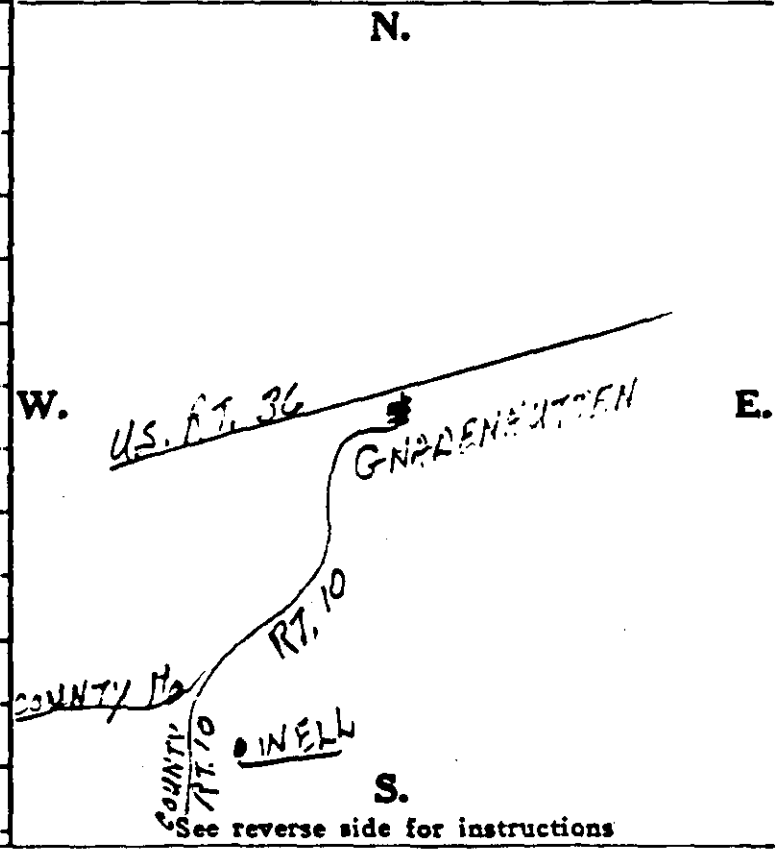
Pumping Rate: 2 G.P.M. Duration of test: 3 hrs.
Drawdown: 62 ft. Date: II* I7- 70
Static level-depth to water: 40 ft.
Quality (clear, cloudy, taste, odor): cloudy
Pump installed by: OWNER

WELL LOG*

Formations Sandstone, shale, limestone, gravel and clay	From	To
sandy loam	0 Feet	I2 Ft.
brown clay	I2	4I
gray shale	4I	70
limestone	70	76
coal	76	78
shale	78	84
limestone	84	98
shale	98	I02
water at 70 and 84		

SKETCH SHOWING LOCATION

Locate in reference to numbered State Highways, St. Intersections, County roads, etc.



See reverse side for instructions

Drilling Firm: Fisher's drilling Date: II-I9- 70
Address: Rt#I Tippecanoe, Ohio Signed: Charles Fisher

(63)

*If additional space is needed to complete well log, use next consecutive numbered form.

WEL' LOG AND DRILLING REF^RT

WW-52

(63)

490494

00001973

NO CARBON PAPER NECESSARY – SELF-TRANSCRIBING

State of Ohio
DEPARTMENT OF NATURAL RESOURCES
Division of Geological Survey
Fountain Square
Columbus, Ohio 43224 Phone (614) 466-5344

6-10-78

COUNTY Tuscarawas TOWNSHIP Clay SECTION OF TOWNSHIP OR LOT NUMBER

OWNER [illegible] ADDRESS [illegible]

LOCATION OF PROPERTY Clay Township Tuscarawas County

CONSTRUCTION DETAILS

ising diameter 5 Length of casing [illegible]

pe of screen Length of screen

pe of pump [illegible]

apacity of pump [illegible]

epth of pump setting [illegible]

ate of completion 6-6-1978

BAILING OR PUMPING TEST
(specify one by circling)

Test rate [illegible] gpm Duration of test hrs

Drawdown [illegible] ft Date [illegible]

Static level (depth to water) [illegible] ft

Quality (clear, cloudy, taste, odor) [illegible]

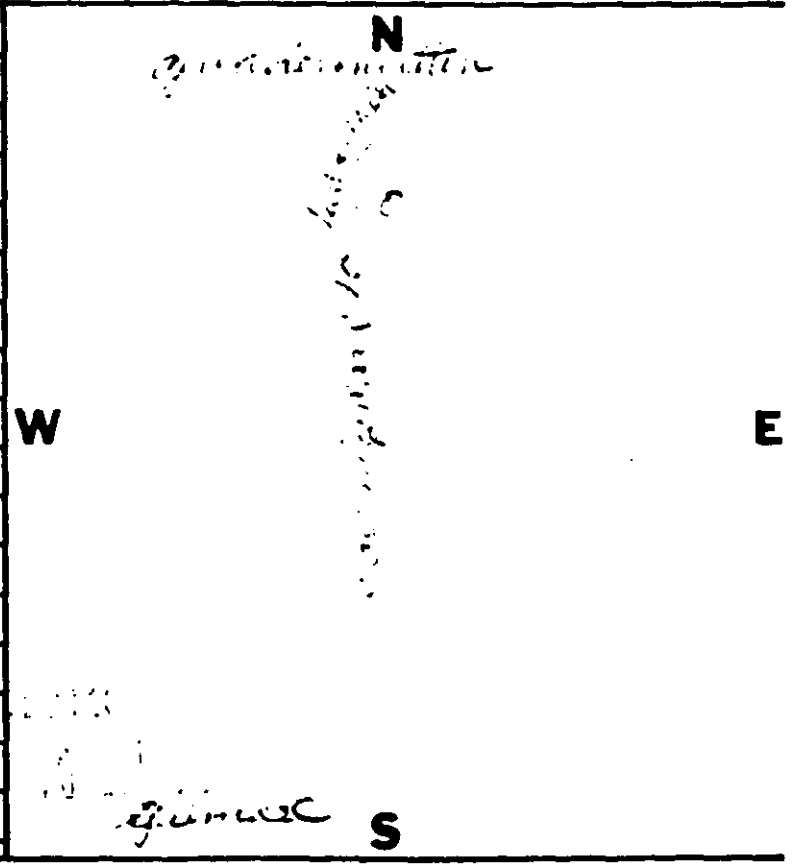
Pump installed by [illegible]

WELL LOG*

Formations: sandstone, shale, limestone, gravel, clay	From	To
	0 ft	ft
[illegible]	1	19
[illegible]	19	30
[illegible]	30	71
[illegible]	71	75

SKETCH SHOWING LOCATION

Locate in reference to numbered state highways, street intersections, county roads, etc.



ING FIRM Tahin DATE 6-10-1978

ADDRESS Port Washington Ohio SIGNED [illegible] Tahin

(64)

*If additional space is needed to complete well log, use next consecutive numbered form.

WELL LOG AND DRILLING REPORT

State of Ohio
DEPARTMENT OF NATURAL RESOURCES
Division of Water
1562 W. First Avenue
Columbus, Ohio

ORIGINAL

WW-53 (42)
00001974
No. 266687

PLEASE USE PENCIL OR TYPEWRITER. DO NOT USE INK.

County Tuscarawas Township Clay Section of Township 25

Owner Mrs. Norman Crome Address R.1 Gnadenhutten, O.

Location of property 1½ mi. S. of Gnadenhutten O. on Co. road #16

CONSTRUCTION DETAILS

Casing diameter 4" Length of casing

Type of screen Length of screen

Type of pump

Capacity of pump

Depth of pump setting

Date of completion

BAILING OR PUMPING TEST

Pumping rate 5 G.P.M. Duration of test 1 hrs.

Drawdown 0 ft. Date 12-11-61

Developed capacity

Static level—depth to water 48 ft.

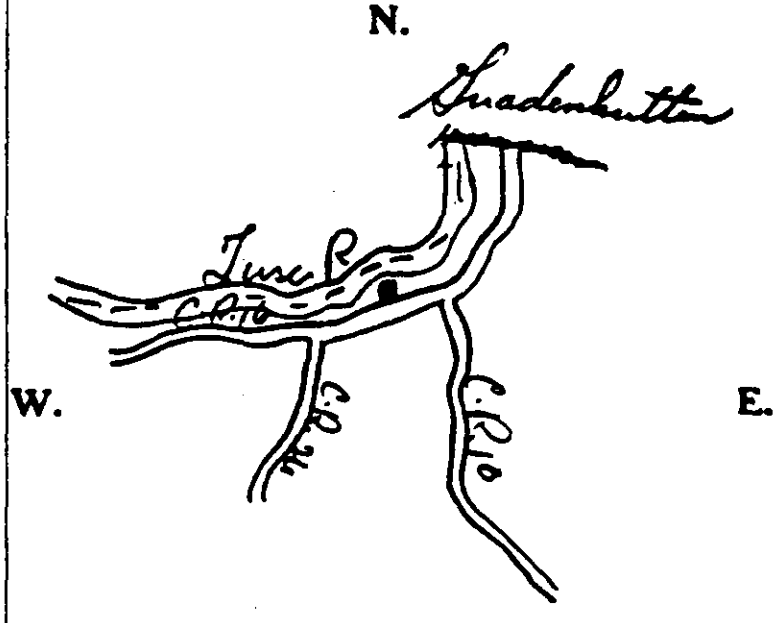
Pump installed by

WELL LOG

Formations Sandstone, shale, limestone, gravel and clay	From	To
3. top gravel	0 Feet	14 Ft.
sandstone, yellow	14	16
blue shale	16	23
limestone gray	23	30
blue shale	30	44
limestone gray	44	47
clay, white	47	52
sandstone, gray	52	68
salt water at 66' (3700 ppm.) well sealed with fire clay.		

SKETCH SHOWING LOCATION

Locate in reference to numbered State Highways, St. Intersections, County roads, etc.



See reverse side for instructions

Drilling Firm Burgess Drilling Date 12-13-61

Address R.3 Dover O. Signed J. W. Burgess

(56)

WELL LOG AND DRILLING REPORT

ORIGINAL

WW-5 00001975

No 288265

PLEASE USE PENCIL
OR TYPEWRITER
DO NOT USE INK.

State of Ohio
DEPARTMENT OF NATURAL RESOURCES
Division of Water
1562 W. First Avenue
Columbus 12, Ohio

County Tuscarawas Township Clay Section of Township 25

Owner Norman Crouse Address R.1 Gnadenhutten O.

Location of property 1/2 mi. S. of Gnadenhutten on Co. road #16

CONSTRUCTION DETAILS

Casing diameter 4" Length of casing 20'-9"

Type of screen none Length of screen

Type of pump none

Capacity of pump

Depth of pump setting

Date of completion

BAILING OR PUMPING TEST

Pumping Rate 150 G.P.H. Duration of test 2 hrs.

Drawdown ft. Date 12-4-62

Static level-depth to water 45 ft.

Quality (clear, cloudy, taste, odor) clear

Pump installed by

WELL LOG

Formations Sandstone, shale, limestone, gravel and clay	From	To
s & gravel	0 Feet	18 Ft.
limestone	18	21
gray shale	21	42
limestone	42	45
gray shale	45	70
sandstone, white	70	80

water at 21', 42 & 78'

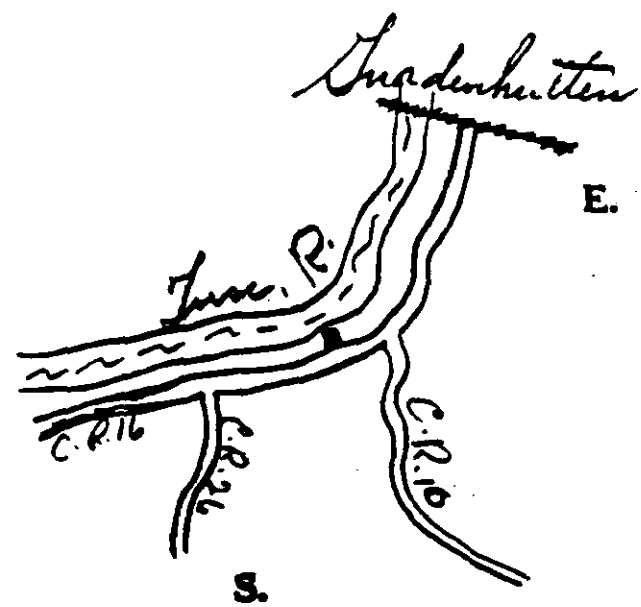
NOTE: We drilled a salt well 12-11-61 at the Crouse property, 3700 ppm shown on log No. 266687. We needed all the water we could find in this last well, hence only one length of casing.

SKETCH SHOWING LOCATION

Locate in reference to numbered State Highways, St. Intersections, County roads, etc.

N.

W. E.



S.

See reverse side for instructions

Drilling Firm Burgess Drilling

Address R.3 B Tower O.

Date 12-14-62

Signed J. W. Burgess

56

WELL LOG AND DRILLING REPORT

WW-35

(35)

523242 0001976

NO CARBON PAPER NECESSARY - SELF-TRANSCRIBING

State of Ohio
DEPARTMENT OF NATURAL RESOURCES
Division of Water
Fountain Square
Columbus, Ohio 43224

COUNTY TUSCARAWAS TOWNSHIP CLAY SECTION OF TOWNSHIP 26

OWNER EMPIRE COAL CO. (DOROTHY DYER) ADDRESS U.S. ROUTE # 36 - GNADENHUTTEN, OHIO

LOCATION OF PROPERTY ON COUNTY RD. 16 OFF OF COUNTY RD. 10

CONSTRUCTION DETAILS

Casing diameter 5" Length of casing 40"

Type of screen _____ Length of screen _____

Type of pump _____

Capacity of pump _____

Depth of pump setting _____

Date of completion 10-4-77

BAILING OR PUMPING TEST
(specify one by circling)

Test rate ½ gpm Duration of test 1 hrs

Drawdown 20 ft Date 10-4-77

Static level (depth to water) 50' ft

Quality (clear, cloudy, taste, odor) clear - water salty

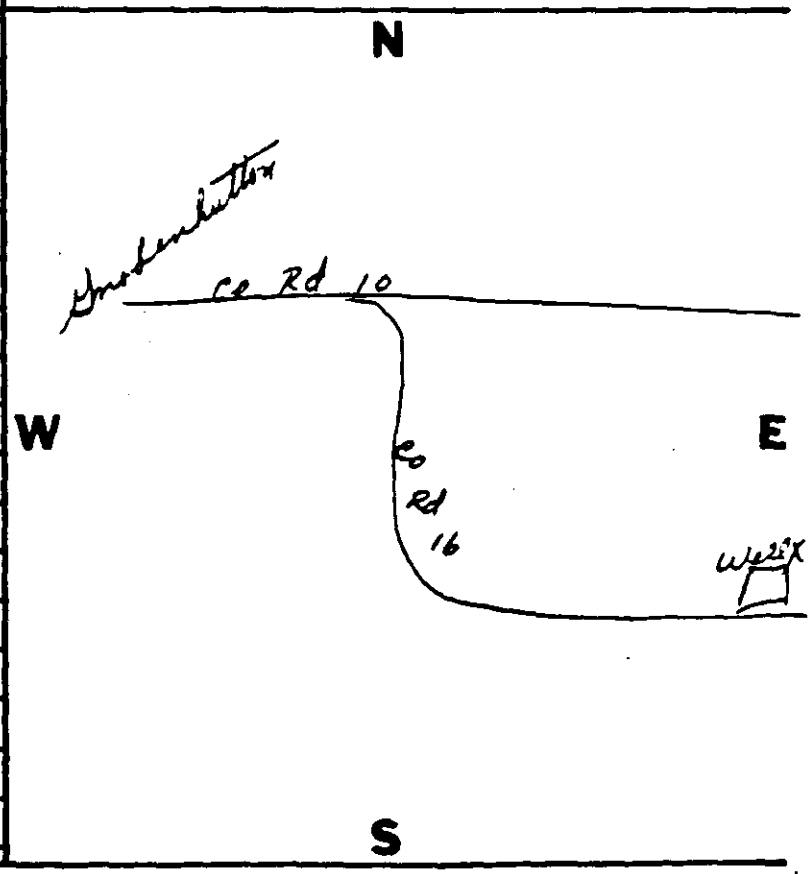
Pump installed by _____

WELL LOG*

Formations: sandstone, shale, limestone, gravel, clay	From	To
BROWN SHALE	0 ft	14 ft
GREY PLASTIC SHALE	14'	32'
LIMESTONE	32'	35'
COAL	35'	36'
CLAY	36'	40'
GREY PLASTIC SHALE	40'	59'
SANDROCK	59'	79'

SKETCH SHOWING LOCATION

Locate in reference to numbered state highways, street intersections, county roads, etc.



DRILLING FIRM JENEI DRILLING CO., INC. DATE 12-23-77

ADDRESS 431 FRONT ST. S.W SIGNED Robert L Jenei

NEW PHILADELPHIA, OHIO 44663

(55)

*If additional space is needed to complete well log, use next consecutive numbered form.

WELL LOG AND DRILLING REPORT

WW-56 ORIGINAL

28

497630

00001977

NO CARBON PAPER NECESSARY – SELF-TRANSCRIBING

State of Ohio
DEPARTMENT OF NATURAL RESOURCES
Division of Geological Survey
Fountain Square
Columbus, Ohio 43224 Phone (614) 466-5344

COUNTY Tuscarawas TOWNSHIP Clay SECTION OF TOWNSHIP OR LOT NUMBER Clay twp

OWNER William Shull ADDRESS Gnadenhutten

LOCATION OF PROPERTY

CONSTRUCTION DETAILS

Casing diameter 7 OD Length of casing 72

Type of screen Length of screen

Type of pump

Capacity of pump

Depth of pump setting

Date of completion

BAILING OR PUMPING TEST
(specify one by circling)

Test rate 3 gpm Duration of test 1 hrs

Drawdown 20 ft Date Aug 15 1975

Static level (depth to water) ft

Quality (clear, cloudy, taste, odor) clear

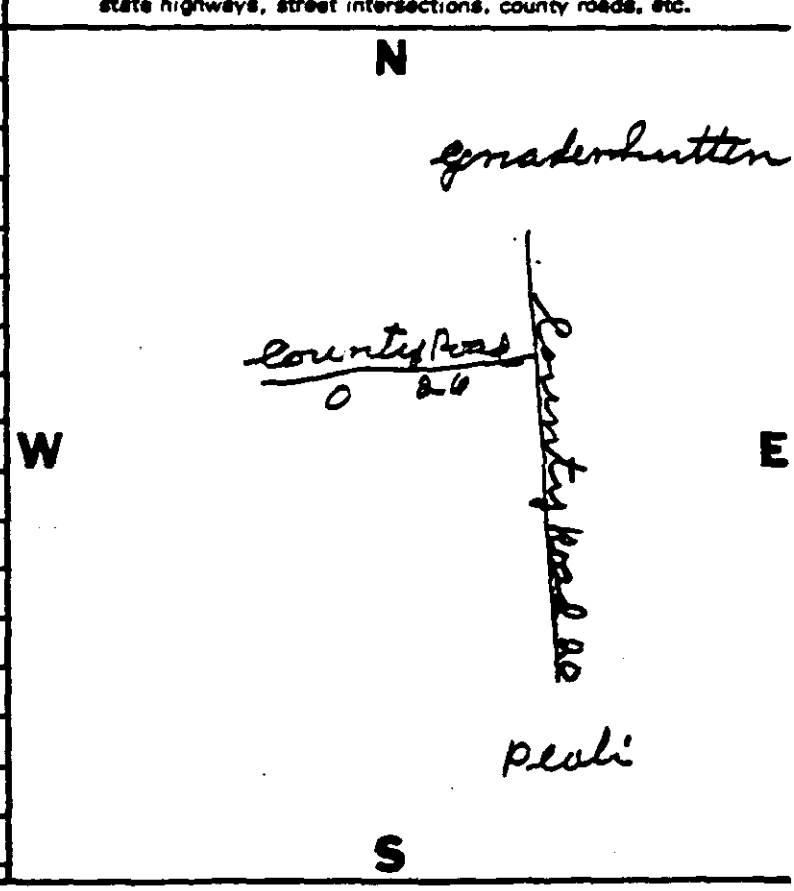
Pump installed by

WELL LOG*

Formations: sandstone, shale, limestone, gravel, clay	From	To
top soil	0 ft	10 ft
mud	10	70
lime stone	70	74

SKETCH SHOWING LOCATION

Locate in reference to numbered state highways, street intersections, county roads, etc.



LLING FIRM Tobin DATE Aug 15 1975

ADDRESS Port Washington Ohio SIGNED L. B. Tobin

*If additional space is needed to complete well log, use next consecutive numbered form.

(8)

WELL LOG AND DRILLING RECORD

State of Ohio
DEPARTMENT OF NATURAL RESOURCES
Division of Water
1562 W. First Avenue
Columbus, Ohio 43212

PLEASE USE PENCIL OR TYPEWRITER
DO NOT USE INK

(50) WW-57
№ 330164
00001978

County Tuscarawas Township Clay Section of Township

Owner Robert Deweese Address R.D. #1 Gnadenhutten, O.

Location of property Next to Ross Clay - West side

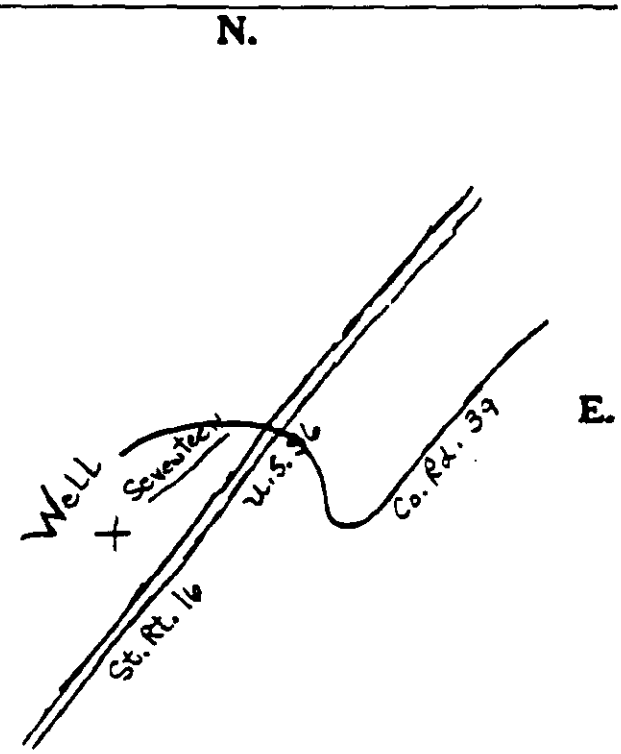
CONSTRUCTION DETAILS	BAILING OR PUMPING TEST
Casing diameter 5" Length of casing 24'9"	Pumping Rate 8 G.P.M. Duration of test hrs.
Type of screen Length of screen	Drawdown 38' ft. Date Jan. 21, 1964
Type of pump Submersible	Static level-depth to water 28' ft.
Capacity of pump 9 gpm	Quality (clear, cloudy, taste, odor)
Depth of pump setting 67'	No Iron, Good
Date of completion 1-28-64	Pump installed by Everett Waltz & Co.

WELL LOG*

Formations Sandstone, shale, limestone, gravel and clay	From	To
Erase	0 Feet	5 Ft.
Brown shale	5'	9'
Gray shale	9'	12'
Coal	12'	13'
Clay	13'	18'
Sandy shale	18'	29'
Sandrock	29'	58'
Water at 40'		

SKETCH SHOWING LOCATION

Locate in reference to numbered State Highways, St. Intersections, County roads, etc.



See reverse side for instructions

Drilling Firm EVERETT WALTZ & CO. Inc.
DRILLING CONTRACTORS
Address STRASBURG, OHIO

Date Jan. 30, 1965
Signed Ron Haswell

(75)

*If additional space is needed to complete well log, use next consecutive numbered form.

00001979

APPENDIX D

APPENDIX D

ANALYTICAL RESULTS FOR GROUND WATER

APPENDIX D
LIST OF TABLES

TABLE NO.	TITLE
D-1	Summary of General Chemical Results, April 1985 First Quarterly Ground Water Monitoring, ARCO Chemical Company, Gnadenhutten, Ohio
D-2	Summary of Volatile Hazardous Substance List Compound Results, April 1985 First Quarterly Ground Water Monitoring, ARCO Chemical Company, Gnadenhutten, Ohio
D-3	Summary of Acid and Base-Neutral Extractable Hazardous Substance List Compound Results, April 1985 First Quarterly Ground Water Monitoring, ARCO Chemical Company, Gnadenhutten, Ohio
D-4	Summary of Pesticide Hazardous Substance List Compound Results, April 1985 First Quarterly Ground Water Monitoring, ARCO Chemical Company, Gnadenhutten, Ohio
D-5	Summary of General Chemical Results, July 1985 Second Quarter Ground Water Monitoring, ARCO Chemical Company, Gnadenhutten, Ohio
D-6	Summary of Volatile Hazardous Substance List Compound Results, July 1985 Second Quarterly Ground Water Monitoring, ARCO Chemical Company, Gnadenhutten, Ohio
D-7	Summary of Acid and Base-Neutral Extractable Hazardous Substance List Compound Results, July 1985 Second Quarterly Ground Water Monitoring, ARCO Chemical Company, Gnadenhutten, Ohio
D-8	Summary of General Chemical Results, November 1985 Third Quarterly Ground Water Monitoring, ARCO Chemical Company, Gnadenhutten, Ohio
D-9	Summary of Polychlorinated Biphenyl Results, November 1985 Third Quarter Ground Water Monitoring, ARCO Chemical Company, Gnadenhutten, Ohio
D-10	Summary of General Chemical Results, January 1986 Fourth Quarter Ground Water Monitoring, ARCO Chemical Company, Gnadenhutten, Ohio
D-11	Summary of General Chemical Results, November 1986 Final Quarter Ground Water Monitoring, ARCO Chemical Company, Gnadenhutten, Ohio
D-12	Summary of Volatile Hazardous Substance List Compound Results, November 1986 Final Quarter Ground Water Monitoring, ARCO Chemical Company, Gnadenhutten, Ohio

APPENDIX D

LIST OF TABLES
(Continued)

D-13 Summary of Acid and Base-Neutral Extractable Hazardous Substance List Compound Results, November 1986 Final Quarter Ground Water Monitoring, ARCO Chemical Company, Gnadenhutten, Ohio

D-14 Summary of Pesticide Hazardous Substance List Compound Results, November 1986 Final Quarter Ground Water Monitoring, ARCO Chemical Company, Gnadenhutten, Ohio

D-15 Summary of General Chemical Results, January 1987 Final Quarter Ground Water Monitoring, ARCO Chemical Company, Gnadenhutten, Ohio

TABLE D-1

SUMMARY OF GENERAL CHEMICAL RESULTS
APRIL 1985 FIRST QUARTERLY GROUND WATER MONITORING(a)
ARCO CHEMICAL COMPANY
CHADENHUTTEN, OHIO

PARAMETERS	CONCENTRATION UNITS	SAMPLE IDENTIFICATION							
		MW-1, 20 feet	MW-1, 37.5 feet	MW-2, 18 feet	MW-2, 37.5 feet	MW-3, 16 feet	MW-3, 37.5 feet	MW-4, 17 feet	MW-4, 37.5 feet
pH	pH Units	7.19	7.19	6.82	6.90	6.85	6.81	6.85	6.90
Specific Conductance	umhos/cm @ 25°C	600	590	1320	1380	1220	1130	1770	1760
Temperature	° Celsius	13	13	16	16	12	12	ND(d)	ND
Cyanide, Amenable	mg/l(b)	0.02U(c)	0.02U	0.02U	0.07	0.02U	0.03	0.02U	0.02U
Cyanide, Total	mg/l	0.02U	0.02U	0.22	0.23	0.36	0.29	0.35	0.26
Fluoride	mg/l	0.1	0.1	0.6	0.6	5.9	5.7	8.0	7.8
Nitrate	mg/l NO_3-N	1.6	1.0	1.7	1.3	9.1	11	0.1U	0.1U
Metals:									
Aluminum	mg/l	0.01	0.01	0.03	0.03	0.07	0.05	0.03	0.02
Arsenic	mg/l	0.002	0.001	0.001	0.001	0.001	0.001	0.006	0.005
Barium	mg/l	0.11	0.10	0.11	0.12	0.07	0.07	0.10	0.10
Cadmium	mg/l	0.001U	0.001U	0.001U	0.001U	0.001U	0.001U	0.001U	0.001U
Chromium, Hexavalent	mg/l	0.01U	0.01U	0.01U	0.01U	0.01U	0.01U	0.01U	0.01U
Chromium, Total	mg/l	0.02	0.02	0.02	0.01U	0.04	0.01U	0.01U	0.02
Copper	mg/l	0.01U	0.01U	0.01U	0.01U	0.01	0.01	0.01U	0.01
Iron	mg/l	0.01U	0.05	0.14	0.17	0.20	0.22	6.0	5.3
Lead	mg/l	0.01U	0.01U	0.01U	0.01U	0.01U	0.01U	0.01U	0.01U
Manganese	mg/l	0.21	0.21	2.9	2.7	7.4	7.0	4.7	5.2
Mercury	mg/l	0.0002U	0.0002U	0.0002U	0.0002U	0.0002U	0.0002U	0.0002U	0.0002U
Selenium	mg/l	0.007	0.008	0.014	0.015	0.010	0.007	0.002	0.002
Silver	mg/l	0.001U	0.001U	0.001U	0.001U	0.001U	0.001U	0.001U	0.001U
Zinc	mg/l	0.01U	0.03	0.03	0.04	0.03	0.03	0.04	0.04

00001983

TABLE D-1
(Continued)

PARAMETERS	CONCENTRATION UNITS	SAMPLE IDENTIFICATION							
		MW-5, 17 feet	MW-5, 37.5 feet	MW-6, 19 feet	MW-6, 37.5 feet	MW-7, 15 feet	MW-7, 37.5 feet	MW-8, 18 feet	MW-8, 37.5 feet
pH	pH Units	7.19	6.90	7.01	7.02	7.00	7.1	7.00	7.00
Specific Conductance	umhos/cm @ 25°C	820	810	780	790	1000	1050	720	700
Temperature	° Celsius	13	13	12	12	16	16	16	14
Cyanide, Amenable	mg/l	0.02U	0.02U	0.02U	0.02U	0.02U	0.02U	0.02U	0.02U
Cyanide, Total	mg/l	0.04	0.05	0.02U	0.02U	0.02U	0.02U	0.02U	0.02U
Fluoride	mg/l	4.2	4.4	0.1	0.1	2.0	1.6	0.1	0.1
Nitrate	mg/l NO_3-N	0.1U	0.1U	19	21	0.8	0.3	0.1U	0.1U
Metals:									
Aluminum	mg/l	0.01	0.01	0.01U	0.01U	0.17	0.03	0.01	0.01
Arsenic	mg/l	0.001	0.001	0.001	0.001U	0.023	0.047	0.001U	0.001
Barium	mg/l	0.11	0.11	0.17	0.16	0.10	0.10	0.12	0.12
Cadmium	mg/l	0.001U	0.001U	0.001U	0.001U	0.001U	0.001U	0.001U	0.001U
Chromium, Hexavalent	mg/l	0.01U	0.01U	0.01U	0.01U	0.01	0.01U	0.01U	0.01U
Chromium, Total	mg/l	0.02	0.03	0.02	0.02	0.11	0.01U	0.03	0.02
Copper	mg/l	0.01	0.02	0.01	0.02	0.01	0.02	0.02	0.02
Iron	mg/l	0.06	0.08	0.04	0.01	0.45	1.6	0.01	0.03
Lead	mg/l	0.01U	0.01U	0.01U	0.01U	0.01U	0.01U	0.01U	0.01U
Manganese	mg/l	4.3	4.4	0.01U	0.01U	0.62	1.3	0.04	0.04
Mercury	mg/l	0.0002U	0.0002U	0.0002U	0.0002U	0.0002U	0.0002U	0.0002U	0.0002U
Selenium	mg/l	0.001	0.001U	0.004	0.004	0.002	0.002	0.002	0.001
Silver	mg/l	0.001U	0.001U	0.001U	0.001U	0.001U	0.001U	0.001U	0.001U
Zinc	mg/l	0.03	0.03	0.03	0.03	0.06	0.03	0.04	0.03

00001984

TABLE D-1
(Continued)

PARAMETERS	CONCENTRATION UNITS	SAMPLE IDENTIFICATION				
		MW-9, 15 feet	MW-9, 37.5 feet	PW-4	PW-5	TP-11
pH	pH Units	6.90	6.92	7.30	7.12	NR(e)
Specific Conductance	umhos/cm @ 25°C	690	700	690	750	NR
Temperature	° Celsius	14	14	14	13	NR
Cyanide, Amenable	mg/l	0.02	0.02U	0.02U	0.02U	NR
Cyanide, Total	mg/l	0.08	0.07	0.02U	0.02U	NR
Fluoride	mg/l	7.2	6.8	0.1	0.1	NR
Nitrate	mg/l	2.1	2.4	0.1U	0.1U	NR
Metals:						
Aluminum	mg/l	0.01U	0.01	0.12	0.01	NR
Arsenic	mg/l	0.001	0.001	0.009	0.004	NR
Barium	mg/l	0.05	0.05	0.19	0.06	NR
Cadmium	mg/l	0.001U	0.001U	0.001U	0.001U	NR
Chromium, Hexavalent	mg/l	0.14	0.14	0.01U	0.01U	0.14
Chromium, Total	mg/l	0.14	0.14	0.08	0.01U	0.75
Copper	mg/l	0.02	0.03	0.03	0.03	NR
Iron	mg/l	0.07	0.07	0.47	0.31	NR
Lead	mg/l	0.01U	0.01U	0.01U	0.01U	NR
Magnesium	mg/l	0.02	0.03	0.53	0.62	NR
Mercury	mg/l	0.0002U	0.0002U	0.0002U	0.0002U	NR
Selenium	mg/l	0.001	0.001	0.002	0.001	NR
Silver	mg/l	0.001U	0.001U	0.001U	0.001U	NR
Zinc	mg/l	0.04	0.04	0.06	0.04	NR

(a)First quarterly ground water monitoring samples were collected from April 9, 1985 to April 12, 1985.

(b)"mg/l" = milligrams per liter or parts per million (ppm).

(c)"U" = analyzed for but not detected. The corresponding number represents the method detection limit for the sample.

(d)"ND" = the indicated parameter was not determined.

(e)"NR" = the indicated analysis was not required.

00001985

TABLE D-2

SUMMARY OF VOLATILE HAZARDOUS SUBSTANCE LIST
COMPOUND RESULTS
APRIL 1985 FIRST QUARTERLY GROUND WATER MONITORING(a)
ARCO CHEMICAL COMPANY
CHAGRINFALLS, OHIO

PARAMETERS	CAS NUMBER(b)	CONCENTRATION UNITS	SAMPLE IDENTIFICATION MW-1, 20 feet	MW-2, 18 feet	MW-3, 16 feet	MW-5, 17 feet	MW-6, 19 feet	PW-5
Acetone	67-64-1	ug/l(c)	10U(d)	10U	10U	10U	10U	10U
Acrolein	107-02-8	ug/l	10U	10U	10U	10U	10U	10U
Acrylonitrile	107-13-1	ug/l	10U	10U	10U	10U	10U	10U
Benzene	71-43-2	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
Bromoform	75-25-2	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
2-Butanone	78-93-3	ug/l	10U	10U	10U	10U	10U	10U
Carbon disulfide	75-15-0	ug/l	10U	10U	10U	10U	10U	10U
Carbon tetrachloride	56-23-5	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
Chlorobenzene	108-90-7	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
Chlorodibromomethane	124-48-1	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
Chloroethane	75-00-3	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
2-Chloroethylvinyl ether	110-75-8	ug/l	10U	10U	10U	10U	10U	10U
Chloroform	67-66-3	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
Dichlorobromomethane	75-27-4	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
1,1-Dichloroethane	75-34-3	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
1,2-Dichloroethane	107-06-2	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
1,1-Dichloroethylene	75-35-4	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
1,2-Dichloropropane	78-87-5	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
1,3-Dichloropropylene	542-75-6	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
Ethylbenzene	100-41-4	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
2-Hexanone	591-78-6	ug/l	10U	10U	10U	10U	10U	10U
Methyl bromide	74-83-9	ug/l	10U	10U	10U	10U	10U	10U
Methyl chloride	74-87-3	ug/l	10U	10U	10U	10U	10U	10U
Methylene chloride	75-09-2	ug/l	10U	10U	10U	10U	10U	10U
4-Methyl-2-pentanone	108-10-1	ug/l	10U	10U	10U	10U	10U	10U
Styrene	100-42-5	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
1,1,2,2-Tetrachloroethane	79-34-5	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
Tetrachloroethylene	127-18-4	ug/l	6.8	5.3	9.7	4.7	4.7	1.0U
Toluene	108-88-3	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
trans-1,2-Dichloroethylene	156-60-5	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
1,1,1-Trichloroethane	71-55-6	ug/l	1.0U	1.0U	1.0U	1.0U	1.5	1.0U
1,1,2-Trichloroethane	79-00-5	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
Trichloroethylene	79-01-6	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
Trichlorofluoromethane	75-69-4	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
Vinyl acetate	108-05-4	ug/l	10U	10U	10U	10U	10U	10U
Vinyl chloride	75-01-4	ug/l	10U	10U	10U	10U	10U	10U
Total xylene(e)	1330-02-7	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U

(a)First quarterly ground water monitoring samples were collected from April 9, 1985 to April 12, 1985.

(b)The numbers presented in this column are the Chemical Abstracts Service (CAS) numbers used for cataloging the indicated compounds in the Chemical Abstracts Index.

(c)"ug/l" = micrograms per liter or parts per billion (ppb).

(d)"U" = analyzed for but not detected. The corresponding number represents the method detection limit for the sample.

(e)Total xylene includes the ortho-, meta-, and para-xylene isomers.

TABLE D-3

SUMMARY OF ACID AND BASE-NEUTRAL EXTRACTABLE
HAZARDOUS SUBSTANCE LIST COMPOUND RESULTS
APRIL 1985 FIRST QUARTERLY GROUND WATER MONITORING(a)
ARCO CHEMICAL COMPANY
GRANDMUTTER, OHIO

PARAMETERS	CAS NUMBER(b)	CONCENTRATION UNITS	SAMPLE IDENTIFICATION					
			MW-1, 20 feet	MW-2, 18 feet	MW-3, 16 feet	MW-5, 17 feet	MW-6, 19 feet	FW-5
Acenaphthene	83-32-9	ug/l(c)	1.0U(d)	1.0U	1.0U	1.0U	1.0U	1.0U
Acenaphthylene	208-96-8	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
Aniline	62-53-3	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
Anthracene	120-12-7	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
Benzidine	92-87-5	ug/l	4.0U	4.0U	4.0U	4.0U	4.0U	4.0U
Benzo(a)anthracene	56-55-3	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
Benzoic acid	65-85-0	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
Benzo(a)pyrene	50-32-8	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
3,4-Benzofluoranthene	205-99-2	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
Benzo(g,h,i)perylene	191-24-2	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
Benzo(k)fluoranthene	207-08-9	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
Benzyl alcohol	100-51-6	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
Bis(2-chloroethoxy)methane	111-91-1	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
Bis(2-chloroethyl)ether	111-44-4	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
Bis(2-chloroisopropyl)ether	39638-32-9	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
Bis(chloromethyl)ether(e)	542-88-1	ug/l	4.0U	4.0U	4.0U	4.0U	4.0U	4.0U
Bis(2-ethylhexyl)phthalate	117-81-7	ug/l	1.0U	1.2	3.0	2.6	3.4	1.0
4-Bromophenylphenylether	101-55-3	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
Butylbenzylphthalate	85-68-7	ug/l	1.0U	1.0U	1.1	1.0U	1.0U	1.0U
4-Chloroaniline	106-47-8	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
p-Chloro-m-cresol	59-50-7	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
2-Chloronaphthalene	91-58-7	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
2-Chlorophenol	95-57-8	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
4-Chlorophenylphenylether	7005-72-3	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
Chrysene	218-01-9	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
Dibenzo(a,h)anthracene	53-70-3	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
Dibenzofuran	132-64-9	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
1,2-Dichlorobenzene	95-50-1	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
1,3-Dichlorobenzene	541-73-1	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
1,4-Dichlorobenzene	106-46-7	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
3,3'-Dichlorobenzidine	91-94-1	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
2,4-Dichlorophenol	120-83-2	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
Diethylphthalate	84-66-2	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
2,4-Dimethylphenol	105-67-9	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
Dimethylphthalate	131-11-3	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
Di-n-butylphthalate	84-74-2	ug/l	1.0U	2.4	2.8	4.7	1.3	2.6
4,6-Dinitro-o-cresol	534-52-1	ug/l	10U	10U	10U	10U	10U	10U
2,4-Dinitrophenol	51-28-5	ug/l	10U	10U	10U	10U	10U	10U
2,4-Dinitrotoluene	121-14-2	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
2,6-Dinitrotoluene	606-20-2	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
Di-n-octylphthalate	117-84-0	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
1,2-Diphenylhydrazine (Azobenzene)(f)	122-66-7	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
Fluoranthene	206-44-0	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
Fluorene	86-73-7	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
Hexachlorobenzene	118-71-1	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
Hexachlorobutadiene	87-68-3	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
Hexachlorocyclopentadiene	77-47-4	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
Hexachloroethane	67-72-1	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
Indeno(1,2,3-cd)pyrene	193-39-5	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
Isophorone	78-59-1	ug/l	4.0U	4.0U	4.0U	4.0U	4.0U	4.0U
2-Methylnaphthalene	91-57-6	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
2-Methylphenol	95-48-7	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
4-Methylphenol	106-44-5	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
Naphthalene	91-20-3	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
2-Nitroaniline	88-74-4	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
3-Nitroaniline	99-09-2	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
4-Nitroaniline	100-01-6	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
Nitrobenzene	98-95-3	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
2-Nitrophenol	88-75-5	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
4-Nitrophenol	100-02-7	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
N-Nitrosodimethylamine	62-75-9	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
N-Nitrosodi-n-propylamine	621-64-7	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
N-Nitrosodiphenylamine (Diphenylamine)(f)	86-30-6	ug/l	1.3	1.0U	1.0U	7.5	1.0U	1.0U
Pentachlorophenol	87-86-5	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
Phenanthrene	85-01-8	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
Phenol	108-95-2	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
Pyrene	129-00-0	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
1,2,4-Trichlorobenzene	120-82-1	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
2,3,7,8-Tetrachlorodibenzo-p-dioxin	1746-01-6	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
2,4,5-Trichlorophenol	95-95-4	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
2,4,6-Trichlorophenol	88-06-2	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U

(a) First quarterly ground water monitoring samples were collected from April 9, 1985 to April 12, 1985.

(b) The numbers presented in this column are the Chemical Abstracts Service (CAS) numbers used for cataloging the indicated compounds in the Chemical Abstracts Index.

(c) "ug/l" = micrograms per liter or parts per billion (ppb).

(d) "U" = analyzed for but not detected. The corresponding number represents the method detection limit for the sample.

(e) The indicated compound decomposes rapidly in water.

(f) The indicated compound is detected as the compound in parentheses.

TABLE D-4

SUMMARY OF PESTICIDE HAZARDOUS SUBSTANCE LIST COMPOUND RESULTS
APRIL 1985 FIRST QUARTERLY GROUND WATER MONITORING(a)
ARCO CHEMICAL COMPANY
CHAGRINUTTER, OHIO

PARAMETERS	CAS NUMBER(b)	CONCENTRATION UNITS	SAMPLE IDENTIFICATION					
			MW-1, 20 feet	MW-2, 18 feet	MW-3, 16 feet	MW-5, 17 feet	MW-6, 19 feet	MW-5
a-BHC	319-84-6	ug/l(c)	0.05U(d)	0.05U	0.05U	0.05U	0.05U	0.05U
g-BHC (lindane)	58-89-9	ug/l	0.05U	0.05U	0.05U	0.05U	0.05U	0.05U
b-BHC	319-85-7	ug/l	0.05U	0.05U	0.05U	0.05U	0.05U	0.05U
Heptachlor	76-44-8	ug/l	0.05U	0.05U	0.05U	0.05U	0.05U	0.05U
d-BHC	319-86-8	ug/l	0.05U	0.05U	0.05U	0.05U	0.05U	0.05U
Aldrin	309-00-2	ug/l	0.05U	0.05U	0.05U	0.05U	0.05U	0.05U
Heptachlor epoxide	1024-57-3	ug/l	0.05U	0.05U	0.05U	0.05U	0.05U	0.05U
Endosulfan I	115-29-7	ug/l	0.05U	0.05U	0.05U	0.05U	0.05U	0.05U
Dieldrin	60-57-1	ug/l	0.10U	0.10U	0.10U	0.10U	0.10U	0.10U
4,4'-DDE	72-55-9	ug/l	0.10U	0.10U	0.10U	0.10U	0.10U	0.10U
Endrin	72-20-8	ug/l	0.10U	0.10U	0.10U	0.10U	0.10U	0.10U
Endosulfan II	115-29-7	ug/l	0.10U	0.10U	0.10U	0.10U	0.10U	0.10U
4,4'-DDD	72-54-8	ug/l	0.10U	0.10U	0.10U	0.10U	0.10U	0.10U
4,4'-DDT	50-29-3	ug/l	0.10U	0.10U	0.10U	0.10U	0.10U	0.10U
Endrin aldehyde	7421-93-4	ug/l	0.10U	0.10U	0.10U	0.10U	0.10U	0.10U
Endosulfan sulfate	1031-07-8	ug/l	0.10U	0.10U	0.10U	0.10U	0.10U	0.10U
Methoxychlor	72-43-5	ug/l	0.50U	0.50U	0.50U	0.50U	0.50U	0.50U
Chlordane	57-74-9	ug/l	0.50U	0.50U	0.50U	0.50U	0.50U	0.50U
Toxaphene	8001-35-2	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
Aroclor 1016	12674-11-2	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
Aroclor 1221	11104-28-2	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
Aroclor 1232	11141-16-5	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
Aroclor 1242	53469-21-9	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
Aroclor 1248	12672-29-6	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
Aroclor 1254	11097-69-1	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
Aroclor 1260	11096-82-5	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U

(a) First quarterly ground water monitoring samples were collected from April 9, 1985 to April 12, 1985.

(b) The numbers presented in this column are the Chemical Abstracts Service (CAS) numbers used for cataloging the indicated compounds in the Chemical Abstracts Index.

(c) "ug/l" = micrograms per liter or parts per billion (ppb).

(d) "U" = analyzed for but not detected. The corresponding number represents the method detection limit for the sample.

TABLE D-5

SUMMARY OF GENERAL CHEMICAL RESULTS
JULY 1985 SECOND QUARTERLY GROUND WATER MONITORING(a)
ARCO CHEMICAL COMPANY
CHADENHUTTEN, OHIO

PARAMETERS	CONCENTRATION UNITS	SAMPLE IDENTIFICATION									
		MW-1 29 feet	MW-1 37 feet	MW-2 23 feet	MW-2 37 feet	MW-3 24 feet	MW-3 37 feet	MW-4 17 feet	MW-4 37 feet	MW-5 18 feet	MW-5 37 feet
pH	pH Units	7.05	6.92	6.70	6.65	6.92	6.90	6.95	7.15	7.10	7.05
Specific Conductance	umhos/cm @ 25°C	500	510	660	790	780	800	1100	1000	700	700
Temperature	°C	15	15	14	16	16	16	15	15	18	18
Cyanide, Amenable	mg/l(b)	0.02U(c)	0.02U	0.02U	0.02U	0.02U	0.02U	0.02U	0.04	0.02U	0.02U
Cyanide, Total	mg/l	0.02U	0.02U	0.07	0.11	0.02U	0.06	0.17	0.21	0.07	0.05
Fluoride	mg/l	0.1	0.1	0.2	0.2	1.8	1.8	8.7	8.6	3.8	3.7
Nitrate	mg/l	2.9	4.4	3.3	3.6	8.2	6.1	0.7	0.2	0.4	0.2
Total Organic Carbon (TOC)	mg/l	4	ND(d)	7	ND	5	ND	6	ND	7	ND
Metals:											
Chromium, Hexavalent	mg/l	0.01U	0.01U	0.01U	0.01U	0.13	0.13	0.01U	0.01U	0.01U	0.01U
Chromium, Total	mg/l	0.01U	0.01U	0.01U	0.01U	0.11	0.13	0.01U	0.01U	0.01U	0.01U
Iron	mg/l	0.39	0.45	0.07	0.09	0.03	0.04	4.5	4.3	0.09	0.09
Manganese	mg/l	0.09	0.07	2.2	2.6	1.5	1.5	2.3	2.3	3.2	3.3
Selenium	mg/l	0.01U	0.01U	0.01U	0.01U	0.01U	0.01U	0.01U	0.01U	0.01U	0.01U

00001989

TABLE D-5
(Continued)

PARAMETERS	CONCENTRATION UNITS	SAMPLE IDENTIFICATION									
		MW-6 25 feet	MW-6 37 feet	MW-7 17 feet	MW-7 37 feet	MW-8 22 feet	MW-8 37 feet	MW-9 17 feet	MW-9 37 feet	PW-4 PUMP ZONE	PW-5 PUMP ZONE
pH	pH Units	7.00	6.90	6.70	6.80	6.90	6.80	6.90	6.90	7.00	7.45
Specific Conductance	umhos/cm @ 25°C	510	560	1350	1040	510	340	700	680	600	550
Temperature	°C	ND	13	20	20	16	16	15	14	15	14
Cyanide, Amenable	mg/l	0.02U	0.02U	0.02U	0.02U	0.02U	0.02U	0.10	0.02	0.02U	0.02U
Cyanide, Total	mg/l	0.02U	0.02U	0.02U	0.02U	0.02U	0.02U	0.10	0.08	0.02U	0.02U
Fluoride	mg/l	0.1	0.1	2.0	2.2	0.1	0.1	5.6	4.8	0.1	0.1
Nitrate	mg/l	5.0	5.6	6.4	7.4	0.8	0.1U	2.0	1.5	0.4	0.2
Total Organic Carbon (TOC)	mg/l	3	ND	3	ND	2	ND	5	ND	2	2
Metals:											
Chromium, Hexavalent	mg/l	0.01U	0.01U	0.10	0.10	0.01U	0.01U	0.14	0.10	0.01U	0.01U
Chromium, Total	mg/l	0.01U	0.01U	0.05	0.05	0.01U	0.01U	0.10	0.06	0.01U	0.01U
Iron	mg/l	0.01U	0.01U	0.01U	0.01U	0.01U	0.01U	0.05	0.04	0.27	0.35
Manganese	mg/l	0.01U	0.01U	0.01U	0.01U	0.16	0.18	0.26	0.60	0.43	0.61
Selenium	mg/l	0.01U	0.01U	0.01U	0.01U	0.01U	0.01U	0.01U	0.01U	0.01U	0.01U

(a)Second quarter ground water monitoring samples were collected from July 30, 1985 to July 31, 1985.

(b)"mg/l" = milligrams per liter or parts per million (ppm).

(c)"U" = analyzed for but not detected. The corresponding number represents the method detection limit for the sample.

(d)"ND" indicates not determined.

0001960

TABLE .

SUMMARY OF VOLATILE HAZARDOUS SUBSTANCE LIST
COMPOUND RESULTS
JULY 1985 SECOND QUARTERLY GROUND WATER MONITORING(a)
ARCO CHEMICAL COMPANY
CHADERHUTTEN, OHIO

PARAMETERS	CAS NUMBER(b)	CONCENTRATION UNITS	SAMPLE IDENTIFICATION										
			MW-1, 29 feet	MW-2, 23 feet	MW-3, 24 feet	MW-4, 17 feet	MW-5, 18 feet	MW-6, 25 feet	MW-7, 17 feet	MW-8, 22 feet	MW-9, 17 feet	PW-4	PW-5
Acetone	67-64-1	ug/l(c)	10U(d)	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U
Acrolein	107-02-8	ug/l	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U
Acrylonitrile	107-13-1	ug/l	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U
Benzene	71-43-2	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
Bromoform	75-25-2	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
2-Butanone	78-93-3	ug/l	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U
Carbon disulfide	75-15-0	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
Carbon tetrachloride	56-23-5	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
Chlorobenzene	108-90-7	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
Chlorodibromomethane	124-48-1	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
Chloroethane	75-00-3	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
2-Chloroethylvinyl ether	110-75-8	ug/l	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U
Chloroform	67-66-3	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.1	1.0U	1.0U
Dichlorobromomethane	75-27-4	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
1,1-Dichloroethane	75-34-3	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
1,2-Dichloroethane	107-06-2	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
1,1-Dichloroethylene	75-35-4	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
1,2-Dichloropropane	78-87-5	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
1,3-Dichloropropylene	542-75-6	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
Ethylbenzene	100-41-4	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
2-Hexanone	591-78-6	ug/l	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U
Methyl bromide	74-83-9	ug/l	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U
Methyl chloride	74-87-3	ug/l	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U
Methylene chloride	75-09-2	ug/l	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U
4-Methyl-2-pentanone	108-10-1	ug/l	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U
Styrene	100-42-5	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
1,1,2,2-Tetrachloroethane	79-34-5	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
Tetrachloroethylene	127-18-4	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
Toluene	108-88-3	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
trans-1,2-Dichloroethylene	156-60-5	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
1,1,1-Trichloroethane	71-55-6	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
1,1,2-Trichloroethane	79-00-5	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
Trichloroethylene	79-01-6	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
Trichlorofluoromethane	75-69-4	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
Vinyl acetate	108-05-4	ug/l	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U
Vinyl chloride	75-01-4	ug/l	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U
Total xylene(e)	1330-0-27	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U

(a)Second quarterly ground water monitoring samples were collected from July 30, 1985 to July 31, 1985.

(b)The numbers presented in this column are the Chemical Abstracts Service (CAS) numbers used for cataloging the indicated compounds in the Chemical Abstracts Index.

(c)"ug/l" = micrograms per liter or parts per billion (ppb).

(d)"U" = analyzed for but not detected. The corresponding number represents the method detection limit for the sample.

(e)Total xylene includes the ortho-, meta-, and para-xylene isomers.

C0001991

TABLE D-7

SUMMARY OF ACID AND BASE-NEUTRAL EXTRACTABLE
HAZARDOUS SUBSTANCE LIST COMPOUND RESULTS
JULY 1985 SECOND QUARTERLY GROUND WATER MONITORING(a)
ARCO CHEMICAL COMPANY
CHARLESTOWN, OHIO

PARAMETERS	CAS NUMBER(b)	CONCENTRATION UNITS	SAMPLE IDENTIFICATION MW-1, 29 feet	MW-2, 23 feet	MW-3, 24 feet	MW-4, 17 feet	MW-5, 18 feet	MW-6, 25 feet	MW-7, 17 feet	MW-8, 22 feet	MW-9, 17 feet	PW-4	PW-5
Acenaphthene	83-32-9	ug/l(c)	1.0U(d)	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
Acenaphthylene	208-96-8	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
Aniline	62-53-3	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
Anthracene	120-12-7	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
Benzidine	92-87-5	ug/l	4.0U	4.0U	4.0U	4.0U	4.0U	4.0U	4.0U	4.0U	4.0U	4.0U	4.0U
Benzo(a)anthracene	56-55-3	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.4	1.0U	1.0U	1.0U
Benzoic acid	65-85-0	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
Benzo(a)pyrene	50-32-8	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	9.2	1.0U
3,4-Benzofluoranthene	205-99-2	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
Benzo(g,h,i)perylene	191-24-2	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.8	1.0U	1.0U	1.0U
Benzo(k)fluoranthene	207-08-9	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.2	2.0	1.0U	1.0U	1.0U
Benzyl alcohol	100-51-6	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
Bis(2-chloroethoxy)methane	111-91-1	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
Bis(2-chloroethyl)ether	111-44-4	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
Bis(2-chloroisopropyl)ether	39638-32-9	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
Bis(chloromethyl)ether(e)	542-88-1	ug/l	4.0U	4.0U	4.0U	4.0U	4.0U	4.0U	4.0U	4.0U	4.0U	4.0U	4.0U
Bis(2-ethylhexyl)phthalate	117-81-7	ug/l	1.0U	2.5	1.0U	1.0U	1.8	1.0U	1.4	1.0U	1.0U	2.6	1.0U
4-Bromophenylphenylether	101-55-3	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
Butylbenzylphthalate	85-68-7	ug/l	1.0U	1.0	1.0U	1.0U	1.0U	1.0U	1.6	1.7	2.6	1.0U	1.0U
4-Chloroaniline	106-47-8	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
p-Chloro-m-cresol	59-50-7	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
2-Chloronaphthalene	91-58-7	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
2-Chlorophenol	95-57-8	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
4-Chlorophenylphenylether	7005-72-3	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
Chrysene	218-01-9	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.6	1.0U	1.0U	1.0U
Dibenzo(a,h)anthracene	53-70-3	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
Dibenzofuran	132-64-9	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
1,2-Dichlorobenzene	95-50-1	ug/l	4.2	1.2	1.0U	1.0U	1.0U	1.0U	1.0U	1.4	1.4	1.1	1.0U
1,3-Dichlorobenzene	541-73-1	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
1,4-Dichlorobenzene	106-46-7	ug/l	1.9	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
Dichlorobenzidine	91-94-1	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
chlorophenol	120-83-2	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
ylphthalate	84-66-2	ug/l	1.0U	1.9	1.0U	1.7	1.0U	1.0U	1.0U	1.2	1.3	1.0U	1.0U
imethylphenol	105-67-9	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
Dimethylphthalate	131-11-3	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
Di-n-butylphthalate	84-74-2	ug/l	3.4	4.3	1.0	1.6	5.3	4.0	4.0	2.7	3.9	1.0U	2.5
4,6-Dinitro-o-cresol	534-52-1	ug/l	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U
2,4-Dinitrophenol	51-28-5	ug/l	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U
2,4-Dinitrotoluene	121-14-2	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
2,6-Dinitrotoluene	606-20-2	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
Di-n-octylphthalate	117-84-0	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
1,2-Diphenylhydrazine (Azobenzene)(f)	122-66-7	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
Fluoranthene	206-44-0	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
Fluorene	86-73-7	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
Hexachlorobenzene	118-71-1	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
Hexachlorobutadiene	87-68-3	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
Hexachlorocyclopentadiene	77-47-4	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
Hexachloroethane	67-72-1	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
Indeno(1,2,3-cd)pyrene	193-39-5	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
Isophorone	78-59-1	ug/l	4.0U	4.0U	4.0U	4.0U	4.0U	4.0U	4.0U	4.0U	4.0U	4.0U	4.0U
2-Methylnaphthalene	91-57-6	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
2-Methylphenol	95-48-7	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
4-Methylphenol	106-44-5	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
Naphthalene	91-20-3	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
2-Nitroaniline	88-74-4	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
3-Nitroaniline	99-09-2	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
4-Nitroaniline	100-01-6	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
Nitrobenzene	98-95-3	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
2-Nitrophenol	88-75-5	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
4-Nitrophenol	100-02-7	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
N-Nitrosodimethylamine	62-75-9	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
N-Nitrosodi-n-propylamine	621-64-7	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
N-Nitrosodiphenylamine (Diphenylamine)(f)	86-30-6	ug/l	1.0U	1.9	1.0U	1.0U	3.5	2.1	1.0U	1.2	1.0U	1.2	1.4
Pentachlorophenol	87-86-5	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
Phenanthrene	85-01-8	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
Phenol	108-95-2	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
Pyrene	129-00-0	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
1,2,4-Trichlorobenzene	120-82-1	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
2,3,7,8-Tetrachlorodibenzo-p-dioxin	1746-01-6	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
2,4,5-Trichlorophenol	95-95-4	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
2,4,6-Trichlorophenol	88-06-2	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U

(a)Second quarterly ground water monitoring samples were collected from July 30, 1985 to July 31,1985.

(b)The numbers presented in this column are the Chemical Abstracts Service (CAS) numbers used for cataloging the indicated compounds in the Chemical Abstracts Index.

"1" = micrograms per liter or parts per billion (ppb).

"U" = analyzed for but not detected. The corresponding number represents the method detection limit for the sample.

(e)The indicated compound decomposes rapidly in water.

(f)The indicated compound is detected as the compound in parentheses.

TABLE D-8

SUMMARY OF GENERAL CHEMICAL RESULTS
NOVEMBER 1985 THIRD QUARTERLY GROUND WATER MONITORING(a)
ARCO CHEMICAL COMPANY
GNADENHUTTEN, OHIO

PARAMETERS	CONCENTRATION UNITS	SAMPLE IDENTIFICATION									
		MW-1 27 feet	MW-1 37 feet	MW-2 23 feet	MW-2 37 feet	MW-3 23 feet	MW-3 37 feet	MW-4 17 feet	MW-4 37 feet	MW-5 17 feet	MW-5 37 feet
pH	pH Units	7.30	7.35	7.10	7.05	6.75	6.75	7.05	7.00	7.20	7.20
Specific Conductance	umhos/cm @ 25°C	480	400	590	620	1230	1300	910	910	730	800
Temperature	° Celsius	15	15	15	15	18	18	17	ND(b)	ND	ND
Cyanide Amenable	mg/l(c)	0.02U(d)	0.02U	0.02U	0.03	0.02U	0.37	0.02U	0.05	0.02U	0.02U
Cyanide, Total	mg/l	0.02U	0.02U	0.03	0.03	0.23	0.47	0.09	0.08	0.08	0.05
Fluoride	mg/l	0.1	0.1	0.1	0.1	4.0	4.4	8.3	8.2	3.6	3.7
Nitrate	mg/l NO_3-N	2.4	1.3	5.0	4.8	3.0	2.7	0.1U	0.1U	0.1U	0.1U
Total Organic Carbon	mg/l	1U	ND	3	ND	12	ND	5	ND	4	ND
Total Organic Halogen	mg/l	ND	ND	ND	ND	ND	ND	0.06	ND	0.05U	ND
Metals:											
Chromium, Hexavalent	mg/l	0.01U	0.01U	0.01U	0.01U	0.02	0.01	0.01U	0.01U	0.01U	0.01U
Chromium, Total	mg/l	0.01U	0.01U	0.05	0.01U	0.04	0.03	0.01U	0.01	0.01U	0.01U
Selenium	mg/l	0.001U	0.001U	0.001U	0.001U	0.001U	0.001U	0.001U	0.001U	0.001U	0.001U

C00001993

TABLE D-8
(Continued)

PARAMETERS	CONCENTRATION UNITS	SAMPLE IDENTIFICATION										
		MW-6 27 feet	MW-6 37 feet	MW-7 17 feet	MW-7 37 feet	MW-8 20 feet	MW-8 37 feet	MW-9 17 feet	MW-9 37 feet	PW-4	PW-5	SURFACE WATER OUTFALL NO. 2
pH	pH Units	7.30	7.25	7.05	7.10	7.17	7.20	7.00	7.00	7.80	7.55	ND
Specific Conductance	umhos/cm @ 25°C	400	450	680	710	525	600	720	810	560	480	ND
Temperature	° Celsius	ND	16	16	16	14	14	18	18	16	16	ND
Cyanide Amenable	mg/l(c)	0.02U	0.02U	0.02U	0.02U	0.02U	0.02U	0.02U	0.02U	0.02U	0.02U	ND
Cyanide, Total	mg/l	0.02U	0.02U	0.02U	0.02U	0.02U	0.02U	0.05	0.03	0.02U	0.02U	ND
Fluoride	mg/l	0.1	0.1	2.3	2.3	0.1	0.1	7.2	7.2	0.1	0.1	ND
Nitrate	mg/l NO_3-N	6.4	6.6	7.2	7.3	1.6	1.0	1.0	1.0	0.1U	0.1U	ND
Total Organic Carbon	mg/l	2	ND	2	ND	2	ND	3	ND	1	1	ND
Total Organic Halogen	mg/l	ND	ND	0.05U	ND	0.08	ND	0.05U	ND	ND	ND	ND
Metals:												
Chromium, Hexavalent	mg/l	0.01U	0.01	0.08	0.07	0.01U	0.01U	0.10	0.10	0.01U	0.01U	ND
Chromium, Total	mg/l	0.01U	0.01U	0.06	0.06	0.01U	0.01U	0.10	0.08	0.01U	0.01U	0.01U
Selenium	mg/l	0.001U	0.001U	0.001U	0.001U	0.001U	0.001U	0.001U	0.001U	0.001U	0.001U	0.001U

(a)Third quarterly ground water monitoring samples were collected from November 4, 1985 to November 5, 1985.

(b)"ND" = the indicated parameter was not determined.

(c)"mg/l" = milligrams per liter or parts per million (ppm).

(d)"U" = *analyzed for but not detected. The corresponding number represents the method detection limit for the sample.*

00001994

TABLE D-9

SUMMARY OF POLYCHLORINATED BIPHENYL RESULTS
NOVEMBER 1985 THIRD QUARTER GROUND WATER MONITORING(a)
ARCO CHEMICAL COMPANY
GNADENHUTTEN, OHIO

SAMPLE IDENTIFICATION	POLYCHLORINATED BIPHENYLS	
	ug/l(b)	SOURCE AROCLOR(c)
MW-4, 17 feet	1.0U(d)	--(e)
MW-5, 17 feet	1.0U	--
MW-7, 17 feet	1.0U	--
MW-8, 20 feet	1.0U	--
MW-9, 17 feet	1.0U	--

(a)Third quarter ground water monitoring samples were collected from November 4, 1985 to November 5, 1985.

(b)"ug/l" = micrograms per liter per parts per billion (ppb).

(c)The indicated commercial aroclor mixture represents the source of the polychlorinated biphenyl contamination and the standard used for instrument calibration and analysis. All samples were screened for Aroclors 1016, 1221, 1232, 1242, 1248, 1254, and 1260 to determine which aroclors are present in the sample and, therefore, should be used for instrument calibration.

(d)"U" indicates that the compound was analyzed, but not detected. The corresponding number represents the method detection limit for the sample.

(e)"-" indicates that polychlorinated biphenyls were not detected in the corresponding sample. Therefore, no source aroclor is given.

TABLE D-10

SUMMARY OF GENERAL CHEMICAL RESULTS
JANUARY 1986 FOURTH QUARTER GROUND WATER MONITORING(a)
ARCO CHEMICAL COMPANY
GNADENHUTTEN, OHIO

PARAMETERS	CONCENTRATION UNITS	SAMPLE IDENTIFICATION MW-1 22 feet	MW-1 37 feet	MW-2 20 feet	MW-2 37 feet	MW-3 22 feet	MW-3 37 feet	MW-4 15 feet	MW-4 37 feet	MW-5 15 feet	MW-5 37 feet
pH	pH Units	7.10	7.25	7.00	7.00	6.80	6.80	7.05	7.10	7.25	7.30
Specific Conductance	umhos/cm @ 25°C	981	825	1,610	1,849	1,716	1,596	2,416	2,389	1,107	1,064
Temperature	°C	10	12	12	12	12	12	11	11	10	12
Cyanide Amenable	mg/l(b)	0.02U(c)	0.02U	0.03	0.04	0.02U	0.16	0.02U	0.02U	0.09	0.02U
Cyanide, Total	mg/l	0.02U	0.02U	0.21	0.27	0.25	0.33	0.17	0.13	0.09	0.12
Fluoride	mg/l	0.1	0.1	0.5	0.5	6.0	5.9	7.3	7.4	3.4	3.6
Nitrate	mg/l NO_3-N	3.4	2.9	4.2	3.0	5.9	5.4	0.2	0.2	0.1U	0.4
Total Organic Carbon	mg/l	4	ND(d)	11	ND	16	ND	15	ND	5	ND
Total Organic Halogen	mg/l	ND	ND	ND	ND	ND	ND	0.05U	ND	0.12	ND
Metals:											
Chromium, Hexavalent	mg/l	0.01	0.01U	0.01U	0.03	0.04	0.03	0.01	0.01	0.01U	0.01
Chromium, Total	mg/l	0.01U	0.01U	0.02	0.02	0.02	0.02	0.01U	0.01U	0.01U	0.01U
Selenium	mg/l	0.001U	0.001U	0.001U	0.001U	0.001	0.001U	0.001U	0.001U	0.001U	0.001U

C00001996

TABLE D-10
(Continued)

PARAMETERS	CONCENTRATION UNITS	SAMPLE IDENTIFICATION MW-6 23 feet	MW-6 37 feet	MW-7 17 feet	MW-7 37 feet	MW-8 20 feet	MW-8 37 feet	MW-9 15 feet	MW-9 37 feet	PW-4 PUMP ZONE	PW-5 PUMP ZONE
pH	pH Units	7.20	7.20	7.20	7.20	7.20	7.10	7.20	7.20	7.80	7.50
Specific Conductance	umhos/cm @ 25°C	967	942	1,624	1,596	915	945	1,160	1,160	1,107	1,121
Temperature	°C	10	11	11	12	11	12	11	11	10	10
Cyanide Amenable	mg/l	0.02U	0.02U	0.02U	0.02U	0.02U	0.02U	0.02U	0.02	0.02U	0.02U
Cyanide, Total	mg/l	0.02U	0.02U	0.02U	0.02U	0.02U	0.02U	0.15	0.18	0.02U	0.02U
Fluoride	mg/l	0.1	0.1	2.6	2.6	0.1	0.2	7.1	7.0	0.1	0.1
Nitrate	mg/l NO_3-N	8.2	8.1	3.4	3.2	0.9	0.7	1.0	1.0	0.1	0.1U
Total Organic Carbon	mg/l	3	ND	2	ND	5	ND	7	ND	3	4
Total Organic Halogen	mg/l	ND	ND	0.07	ND	0.06	ND	0.06	ND	ND	ND
Metals:											
Chromium, Hexavalent	mg/l	0.01	0.01U	0.08	0.05	0.01U	0.01U	0.13	0.13	0.02	0.01U
Chromium, Total	mg/l	0.01U	0.01U	0.04	0.04	0.01U	0.01U	0.11	0.11	0.02	0.01U
Selenium	mg/l	0.004	0.004	0.001U	0.001U	0.001U	0.001U	0.001U	0.001U	0.001U	0.001U

(a)Fourth quarter ground water monitoring samples were collected from January 29, 1986 to January 30, 1986.

(b)"mg/l" = milligrams per liter or parts per million (ppm).

(c)"U" = analyzed for but not detected. The corresponding number represents the method detection limit for the sample.

(d)"ND" indicates not determined.

00001997

TABLE D-11

SUMMARY OF GENERAL CHEMICAL RESULTS
NOVEMBER 1986 FINAL QUARTER GROUND WATER MONITORING(a)
ARCO CHEMICAL COMPANY
CHADEMHUTTEN, OHIO

PARAMETERS	CONCENTRATION UNITS	MW-1 27 ft	MW-1 37 ft	MW-2 23 ft	MW-2 37 ft	MW-3 24 ft	MW-3 37 ft	MW-4 20 ft	MW-4 37 ft	MW-5 19 ft	MW-5 37 ft
pH	pH Units	6.7	6.7	6.7	6.7	6.55	6.55	6.75	6.75	6.55	6.55
Specific Conductance	umhos/cm @ 25°C	800	800	1,425	1,400	1,890	1,850	1,700	1,495	1,505	1,490
Temperature	°C	10	10	12	12	12	12	12	12	12	12
Cyanide, Total	mg/l(b)	0.02U(d)	0.02U	0.17	0.13	0.28	0.21	0.25	0.14	0.11	0.12
Fluoride	mg/l	0.1U	0.1	0.3	0.3	6.4	5.6	6.0	6.4	3.5	3.8
Nitrate	mg/l NO_3-N	3.6	3.8	2.8	2.7	4.0	4.3	1.7	1.4	0.3	0.3
Metals:											
Aluminum	mg/l	0.10U	0.10U	0.10U	0.10U	0.10U	0.10U	0.10U	0.10U	0.10U	0.10U
Arsenic	mg/l	0.010U	0.010U	0.010	0.014	0.010U	0.010U	0.010U	0.010U	0.010U	0.010U
Barium	mg/l	0.086	0.085	0.030	0.028	0.033	0.032	0.039	0.040	0.050	0.056
Cadmium	mg/l	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U
Chromium, Hexavalent	mg/l	0.01U	0.01U	0.03	0.03	0.01	0.05	0.01U	0.01U	0.01U	0.01U
Chromium, Total	mg/l	0.010U	0.010U	0.015	0.018	0.012	0.010U	0.010U	0.010U	0.010U	0.010U
Copper	mg/l	0.010U	0.010U	0.010U	0.010U	0.010U	0.010U	0.010U	0.010U	0.010U	0.010U
Iron	mg/l	0.051	0.064	0.11	0.096	0.18	0.21	3.9	3.9	0.26	0.21
Lead	mg/l	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005	0.006
Manganese	mg/l	0.054	0.041	2.5	2.3	3.9	3.5	2.9	3.0	2.4	2.7
Mercury	mg/l	0.0002U	0.0002U	0.0002U	0.0002U	0.0002U	0.0002U	0.0002U	0.0002U	0.0002U	0.0002U
Selenium	mg/l	0.005	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.012	0.013
Silver	mg/l	0.010U	0.010U	0.010U	0.010U	0.010U	0.010U	0.010U	0.010U	0.010U	0.010U
Zinc	mg/l	0.024	0.096	0.065	0.12	0.22	0.14	0.019	0.13	0.085	0.092

See footnotes at end of table.

00001998

TABLE D-11
(Continued)

PARAMETERS	CONCENTRATION UNITS	MW-6 26 ft	MW-6 37 ft	MW-7 17 ft	MW-7 37.5 ft	MW-8 23 ft	MW-8 37 ft	MW-9 16 ft	MW-9 37 ft	PW-4	PW-5
pH	pH Units	6.8	6.8	6.7	6.7	6.7	6.7	6.4	6.4	7.2	6.8
Specific Conductance	umhos/cm @ 25°C	820	800	1,295	1,220	1,010	900	1,210	1,160	ND(c)	890
Temperature	°C	10	10	17	17	11.5	11.5	12	12	12	10
Cyanide, Total	mg/l(b)	0.02U	0.02U	0.02U	0.10	0.09	0.02U	0.06	0.05	0.02U	0.02U
Fluoride	mg/l	0.1	0.1	2.4	2.4	0.1	0.1	4.0	3.9	0.1	0.1
Nitrate	mg/l NO_3-N	6.4	6.6	1.0	0.6	0.9	0.3	0.7	1.2	0.1U	0.1U
Metals:											
Aluminum	mg/l	0.10U	0.10U	0.10U	0.10U	0.10U	0.10U	0.10U	0.10U	0.10U	0.10U
Arsenic	mg/l	0.010U	0.010U	0.013	0.012	0.018	0.010U	0.010U	0.010U	0.028	0.010U
Barium	mg/l	0.067	0.069	0.046	0.044	0.084	0.081	0.069	0.070	0.20	0.036
Cadmium	mg/l	0.005U	0.005U	0.005	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U
Chromium, Hexavalent	mg/l	0.01U	0.01U	0.03	0.01	0.03	0.01U	0.06	0.06	0.01U	0.01U
Chromium, Total	mg/l	0.010U	0.010U	0.024	0.010U	0.010U	0.010U	0.040	0.036	0.010U	0.010U
Copper	mg/l	0.010U	0.010U	0.010U	0.010U	0.010U	0.010U	0.010U	0.010U	0.010	0.010U
Iron	mg/l	0.025	0.020	0.024	0.018	0.022	0.019	0.090	0.068	1.2	0.21
Lead	mg/l	0.005	0.006	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U	0.005U
Manganese	mg/l	0.005U	0.005U	0.007	0.019	0.14	0.15	0.16	0.13	0.75	0.62
Mercury	mg/l	0.0002	0.0002U	0.0002U	0.0002U	0.0002U	0.0004	0.0004	0.0002U	0.0002U	0.0002U
Selenium	mg/l	0.005U	0.005U	0.006	0.007	0.008	0.005	0.005U	0.005U	0.008	0.007
Silver	mg/l	0.010U	0.010U	0.010U	0.010U	0.010U	0.010U	0.010U	0.010U	0.010U	0.010U
Zinc	mg/l	0.039	0.069	0.097	0.093	0.044	0.10	0.059	0.11	0.032	0.010U

(a)Samples were collected for November 18, 1986 to November 20, 1986.

(b)"mg/l" equals milligrams per liter or parts per million (ppm).

(c)The indicated specific conductance value was not determined.

(d)"U" indicates that the compound was analyzed but not detected. The corresponding number represents the method detection limit for the sample.

00001999

TABLE D-12

SUMMARY OF VOLATILE HAZARDOUS SUBSTANCE LIST
COMPOUND RESULTS
NOVEMBER 1986 FINAL QUARTER GROUND WATER MONITORING(a)
ARCO CHEMICAL COMPANY
CHARLESTOWN, OHIO

PARAMETERS	CAS REGISTRY NUMBER(b)	CONCENTRATION UNITS(c)	MW-1 27 ft	MW-2 23 ft	MW-3 24 ft	MW-4 20 ft	MW-5 19 ft	MW-6 26 ft	MW-7 17 ft	MW-8 23 ft	MW-9 16 ft	PW-4	PW-5
Chloromethane	74-87-3	ug/l	10U(d)	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U
Bromomethane	74-83-9	ug/l	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U
Vinyl Chloride	75-01-4	ug/l	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U
Chloroethane	75-00-3	ug/l	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U
Methylene Chloride	75-09-2	ug/l	13B(e)	17B	14B	11B	11B	12B	5.1B	8.3B	7.0B	15B	8.9B
Acetone	67-64-1	ug/l	13B	15B	46B	36B	31B	7.4JB(f)	52B	97B	26B	140B	8.9JB
Carbon Disulfide	75-15-0	ug/l	5U	5U	5U	5U	5U	2.4J	5U	5U	5U	5U	1.2J
1,1-Dichloroethene	75-35-4	ug/l	5U	3.6J	5U	5U	5U	5U	5U	5U	5U	5U	5U
1,1-Dichloroethane	75-34-3	ug/l	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U
trans-1,2-Dichloroethene	156-60-5	ug/l	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U
Chloroform	67-66-3	ug/l	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U
1,2-Dichloroethane	107-06-2	ug/l	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U
2-Butanone	78-93-3	ug/l	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U
1,1,1-Trichloroethane	71-55-6	ug/l	5U	5U	5U	5U	5U	2.3J	5U	5U	5U	5U	5U
Carbon Tetrachloride	56-23-5	ug/l	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U
Vinyl Acetate	108-05-4	ug/l	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U
Bromodichloromethane	75-27-4	ug/l	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U
1,2-Dichloropropane	78-87-5	ug/l	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U
trans-1,3-Dichloropropene	10061-02-6	ug/l	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U
Trichloroethene	79-01-6	ug/l	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U
Dibromochloromethane	124-48-1	ug/l	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U
1,1,2-Trichloroethane	79-00-5	ug/l	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U
Benzene	71-43-2	ug/l	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U
cis-1,3-Dichloropropene	10061-01-05	ug/l	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U
2-Chloroethylvinylether	110-75-8	ug/l	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U
Bromoform	75-25-2	ug/l	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U
4-Methyl-2-Pentanone	591-78-6	ug/l	10U	10U	10U	10U	10U	10U	10U	10U	10U	3.5J	10U
2-Hexanone	108-10-1	ug/l	10U	10U	10U	4.3J	10U	10U	10U	2.1J	10U	10U	10U
Tetrachloroethene	127-18-4	ug/l	5U	5U	5U	5U	5U	5U	5U	5U	5U	1.2J	5U
1,1,2,2-Tetrachloroethane	79-34-5	ug/l	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U
Toluene	108-88-3	ug/l	1.1JB	5U	5U	5U	5U	1.0J	5U	5U	5U	6.9	5U
Chlorobenzene	108-90-7	ug/l	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U	5U
Ethylbenzene	100-41-4	ug/l	2.0JB	5U	5U	5U	5U	5U	1.0J	1.1J	5U	5U	5U
Styrene	100-42-5	ug/l	2.1JB	5U	5U	5U	5U	5U	1.0J	1.1J	5U	5U	5U
Total Xylene(g)	1330-20-7	ug/l	6.2B	1.7JB	5U	1.3JB	1.6JB	1.6JB	1.5JB	1.6JB	5U	13B	1.4JB

(a)Samples were collected from November 18, 1986 to November 20, 1986.

(b)The numbers presented in this column are the Chemical Abstracts Service (CAS) Registry Numbers used for cataloging the indicated compounds in the Chemical Abstracts Index.

(c)"ug/l" equals micrograms per liter or parts per billion (ppb).

(d)"U" indicates that the compound was analyzed, but not detected. The corresponding number represents the method detection limit for the sample.

(e)"B" indicates that the corresponding compound was found in the blank as well as the sample.

(f)"J" indicates that the corresponding compound is present, but the calculated concentration is less than the specified detection limit.

(g)Total xylene includes the ortho-, meta-, and para-xylene isomers.

TABLE 9-13

SUMMARY OF ACID AND BASE-NEUTRAL EXTRACTABLE
HAZARDOUS SUBSTANCE LIST COMPOUND RESULTS
NOVEMBER 1986 FINAL QUARTER GROUND WATER MONITORING(a)
ARCO CHEMICAL COMPANY
GRADEMUTTER, OHIO

PARAMETERS	CAS REGISTRY NUMBER(b)	CONCENTRATION UNITS(c)	MW-1 27 ft	MW-2 23 ft	MW-3 24 ft	MW-4 20 ft	MW-5 19 ft	MW-6 26 ft	MW-7 17 ft	MW-8 23 ft	MW-9 16 ft	PW-4	PW-5
Phenol	108-95-2	ug/l	10U(d)	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U
bis(2-Chloroethyl)ether	111-44-4	ug/l	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U
2-Chlorophenol	95-57-8	ug/l	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U
1,3-Dichlorobenzene	541-73-1	ug/l	10U	10U	10U	10U	10U	10U	2.2JB(e)	13B(f)	10U	10U	10U
1,4-Dichlorobenzene	106-46-7	ug/l	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U
Benzyl alcohol	100-51-6	ug/l	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U
1,2-Dichlorobenzene	95-50-1	ug/l	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U
2-Methylphenol	95-48-7	ug/l	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U
bis(2-Chloroisopropyl)ether	39638-32-9	ug/l	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U
4-Methylphenol	106-44-5	ug/l	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U
N-Nitroso-di-n-propylamine	621-64-7	ug/l	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U
Hexachloroethane	67-72-1	ug/l	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U
Nitrobenzene	98-95-3	ug/l	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U
Isophorone	78-59-1	ug/l	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U
2-Nitrophenol	88-75-5	ug/l	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U
2,4-Dimethylphenol	105-67-9	ug/l	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U
Benzoic acid	65-85-0	ug/l	50U	50U	50U	50U	50U	50U	50U	50U	50U	50U	50U
bis(-2-Chloroethoxy)methane	111-91-1	ug/l	10U	10U	10U	10U	10U	10U	10	10U	10U	10U	10U
2,4-Dichlorophenol	120-83-2	ug/l	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U
1,2,4-Trichlorobenzene	120-82-1	ug/l	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U
Naphthalene	91-20-3	ug/l	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U
4-Chloroaniline	106-47-8	ug/l	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U
Hexachlorobutadiene	87-68-3	ug/l	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U
4-Chloro-3-methylphenol	59-50-7	ug/l	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U
2-Methylnaphthalene	91-57-6	ug/l	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U
Hexachlorocyclopentadiene	77-47-4	ug/l	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U
2,4,6-Trichlorophenol	88-06-2	ug/l	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U
2,4,5-Trichlorophenol	95-95-4	ug/l	50U	50U	50U	50U	50U	50U	50U	50U	50U	50U	50U
2-Chloronaphthalene	91-58-7	ug/l	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U
2-Nitroaniline	88-74-4	ug/l	50U	50U	50U	50U	50U	50U	50U	50U	50U	50U	50U
Dimethylphthalate	131-11-3	ug/l	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U
Acenaphthylene	208-96-8	ug/l	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U
3-Nitroaniline	99-09-2	ug/l	50U	50U	50U	50U	50U	50U	50U	50U	50U	50U	50U
Acenaphthene	83-32-9	ug/l	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U
2,4-Dinitrophenol	51-28-5	ug/l	50U	50U	50U	50U	50U	50U	50U	50U	50U	50U	50U
4-Nitrophenol	100-02-7	ug/l	50U	50U	50U	50U	50U	50U	50U	50U	50U	50U	50U
Dibenzofuran	132-64-9	ug/l	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U
2,4-Dinitrotoluene	121-14-2	ug/l	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U
2,6-Dinitrotoluene	606-20-2	ug/l	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U
Diethylphthalate	84-66-2	ug/l	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U
4-Chlorophenylphenylether	7005-72-3	ug/l	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U
Fluorene	86-73-7	ug/l	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U
4-Nitroaniline	100-01-6	ug/l	50U	50U	50U	50U	50U	50U	50U	50U	50U	50U	50U
4,6-Dinitro-2-methylphenol	534-52-1	ug/l	50U	50U	50U	50U	50U	50U	50U	50U	50U	50U	50U
N-Nitrosodiphenylamine(g)	86-30-6	ug/l	2.4JB	10U	3.2JB	3.0JB	3.1JB	10U	10U	10U	2.6JB	2.8JB	2.2JB
4-Bromophenylphenylether	101-55-3	ug/l	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U
Hexachlorobenzene	118-74-1	ug/l	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U
Pentachlorophenol	87-86-5	ug/l	50U	50U	2.2J	50U	50U	50U	50U	50U	50U	50U	50U
Phenanthrene	85-01-8	ug/l	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U
Anthracene	120-12-7	ug/l	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U
Di-n-butylphthalate	84-74-2	ug/l	10U	10U	2.1J	2.1J	10U	2.5J	10U	10U	10U	10U	2.2J
Fluoranthene	206-44-0	ug/l	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U
Pyrene	129-00-0	ug/l	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U
Butylbenzylphthalate	85-68-7	ug/l	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U
3,3'-Dichlorobenzidine	91-94-1	ug/l	20U	20U	20U	20U	20U	20U	20U	20U	20U	20U	20U
Benzo(a)anthracene	56-55-3	ug/l	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U
bis(2-Ethylhexyl)phthalate	117-81-7	ug/l	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U
Chrysene	218-01-9	ug/l	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U
Di-n-octylphthalate	117-84-0	ug/l	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U
Benzo(b)fluoranthene	205-99-2	ug/l	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U
Benzo(k)fluoranthene	207-08-9	ug/l	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U
Benzo(a)pyrene	50-32-8	ug/l	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U
Indeno(1,2,3-cd)pyrene	193-39-5	ug/l	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U
Dibenz(a,h)anthracene	53-70-3	ug/l	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U
Benzo(g,h,i)perylene	191-24-2	ug/l	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U	10U

(a)Samples were collected from November 18, 1986 to November 20, 1986.

(b)The numbers presented in this column are the Chemical Abstracts Service (CAS) Registry Numbers used for cataloging the indicated compounds in the Chemical Abstracts Index.

(c)"ug/l" equals micrograms per liter or parts per billion (ppb).

(d)"U" indicates that the compound was analyzed, but not detected. The corresponding number represents the method detection limit for the sample.

(e)"J" indicates that the corresponding compound is present, but the calculated concentration is less than the specified detection limit.

(f)"B" indicates that the corresponding compound was found in the blank as well as the sample.

(g)The indicated compound is detected as diphenylamine.

TABLE D-14

SUMMARY OF PESTICIDE HAZARDOUS SUBSTANCE LIST
COMPOUND RESULTS
NOVEMBER 1986 FINAL QUARTER GROUND WATER MONITORING(a)
ARCO CHEMICAL COMPANY
CHADENHUTTEN, OHIO

PARAMETERS	CAS REGISTRY NUMBER (b)	CONCENTRATION UNITS(c)	MW-1 27 ft	MW-2 23 ft	MW-3 24 ft	MW-4 20 ft	MW-5 19 ft	MW-6 26 ft	MW-7 17 ft	MW-8 23 ft	MW-9 16 ft	PW-4	PW-5
alpha-BHC	319-84-6	ug/l	0.05U(d)	0.05U	0.05U	0.05U	0.05U	0.05U	0.05U	0.05U	0.05U	0.05U	0.05U
beta-BHC	319-85-7	ug/l	0.05U	0.05U	0.05U	0.05U	0.05U	0.05U	0.05U	0.05U	0.05U	0.05U	0.05U
delta-BHC	319-86-8	ug/l	0.05U	0.05U	0.05U	0.05U	0.05U	0.05U	0.05U	0.05U	0.05U	0.05U	0.05U
gamma-BHC(Lindane)	58-89-9	ug/l	0.05U	0.05U	0.05U	0.05U	0.05U	0.05U	0.05U	0.05U	0.05U	0.05U	0.05U
Heptachlor	76-44-8	ug/l	0.05U	0.05U	0.05U	0.05U	0.05U	0.05U	0.05U	0.05U	0.05U	0.05U	0.05U
Aldrin	309-00-2	ug/l	0.05U	0.05U	0.05U	0.05U	0.05U	0.05U	0.05U	0.05U	0.05U	0.05U	0.05U
Heptachlor epoxide	1024-57-3	ug/l	0.05U	0.05U	0.05U	0.05U	0.05U	0.05U	0.05U	0.05U	0.05U	0.05U	0.05U
Endosulfan I	959-98-8	ug/l	0.05U	0.05U	0.05U	0.05U	0.05U	0.05U	0.05U	0.05U	0.05U	0.05U	0.05U
Dieldrin	60-57-1	ug/l	0.10U	0.10U	0.10U	0.10U	0.10U	0.10U	0.10U	0.10U	0.10U	0.10U	0.10U
4,4'-DDE	72-55-9	ug/l	0.10U	0.10U	0.10U	0.10U	0.10U	0.10U	0.10U	0.10U	0.10U	0.10U	0.10U
Endrin	72-20-8	ug/l	0.10U	0.10U	0.10U	0.10U	0.10U	0.10U	0.10U	0.10U	0.10U	0.10U	0.10U
Endosulfan II	33213-65-9	ug/l	0.10U	0.10U	0.10U	0.10U	0.10U	0.10U	0.10U	0.10U	0.10U	0.10U	0.10U
4,4'-DDD	72-54-8	ug/l	0.10U	0.10U	0.10U	0.10U	0.10U	0.10U	0.10U	0.10U	0.10U	0.10U	0.10U
Endosulfan sulfate	1031-07-8	ug/l	0.10U	0.10U	0.10U	0.10U	0.10U	0.10U	0.10U	0.10U	0.10U	0.10U	0.10U
4,4'-DDT	50-29-3	ug/l	0.10U	0.10U	0.10U	0.10U	0.10U	0.10U	0.10U	0.10U	0.10U	0.10U	0.10U
Methoxychlor	72-43-5	ug/l	0.50U	0.50U	0.50U	0.50U	0.50U	0.50U	0.50U	0.50U	0.50U	0.50U	0.50U
Endrin ketone	53494-70-5	ug/l	0.10U	0.10U	0.10U	0.10U	0.10U	0.10U	0.10U	0.10U	0.10U	0.10U	0.10U
Chlordane	57-74-9	ug/l	0.50U	0.50U	0.50U	0.50U	0.50U	0.50U	0.50U	0.50U	0.50U	0.50U	0.50U
Toxaphene	8001-35-2	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
Aroclor 1016	12674-11-2	ug/l	0.50U	0.50U	0.50U	0.50U	0.50U	0.50U	0.50U	0.50U	0.50U	0.50U	0.50U
Aroclor 1221	11104-28-2	ug/l	0.50U	0.50U	0.50U	0.50U	0.50U	0.50U	0.50U	0.50U	0.50U	0.50U	0.50U
Aroclor 1232	11141-16-5	ug/l	0.50U	0.50U	0.50U	0.50U	0.50U	0.50U	0.50U	0.50U	0.50U	0.50U	0.50U
Aroclor 1242	53469-21-9	ug/l	0.50U	0.50U	0.50U	0.50U	0.50U	0.50U	0.50U	0.50U	0.50U	0.50U	0.50U
Aroclor 1248	12672-29-6	ug/l	0.50U	0.50U	0.50U	0.50U	0.50U	0.50U	0.50U	0.50U	0.50U	0.50U	0.50U
Aroclor 1254	11097-69-1	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U
Aroclor 1260	11096-82-5	ug/l	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U	1.0U

(a)Samples were collected from November 18, 1986 to November 20, 1986.

(b)The numbers presented in this column are the Chemical Abstracts Service Registry Numbers used for cataloging the indicated compounds in the Chemical Abstracts Index.

(c)"ug/l" equals micrograms per liter or parts per billion (ppb).

(d)"U" indicates that the compound was analyzed, but not detected. The corresponding number represents the method detection limit for the sample.

000002

TABLE D-15

SUMMARY OF GENERAL CHEMICAL RESULTS
JANUARY 1987 FINAL QUARTER GROUND WATER MONITORING(a)
ARCO CHEMICAL COMPANY
GNADENHUTTEN, OHIO

PARAMETERS	CONCENTRATION UNITS	MW-1 28.8 ft	MW-1 37 ft	MW-2 24.4 ft	MW-2 37 ft	MW-3 24.8 ft	MW-3 37 ft	MW-4 20.8 ft	MW-4 37 ft	MW-5 18.4 ft	MW-5 37 ft
pH	pH Units	7.0	7.0	6.9	6.8	6.7	6.6	6.8	7.0	6.7	6.7
Specific Conductance	umhos/cm@25°C	700	700	1,000	1,000	1,240	1,220	930	900	1,650	1,250
Temperature	°C	8	9	11	11	13	13	15	15	10	11
Cyanide, Total	mg/l(b)	0.02U(c)	0.02U	0.18	0.23	0.39	0.39	0.05	0.12	0.70	0.50
Metals:											
Chromium, Hexavalent	mg/l	0.01U	0.01U	0.02	0.01U	0.02	0.03	0.01U	0.01U	0.01U	0.01U

See footnotes at end of table.

00003008

TABLE D-15
(Continued)

PARAMETERS	CONCENTRATION UNITS	MW-6 27.5 ft	MW-6 37 ft	MW-7 14.4 ft	MW-7 37 ft	MW-8 22.7 ft	MW-8 37 ft	MW-9 15.3 ft	MW-9 37 ft	PW-4	PW-5
pH	pH Units	6.9	7.0	6.7	7.2	6.9	6.7	6.7	6.7	6.5	6.6
Specific Conductance	umhos/cm@25°C	700	650	710	700	625	650	625	650	725	750
Temperature	°C	10	11	9	8	6	7	10	10	14	14
Cyanide, Total	mg/l(b)	0.02U	0.02U	0.02U	0.02U	0.02U	0.02U	0.02	0.02	0.02U	0.02U
Metals:											
Chromium, Hexavalent	mg/l	0.01U	0.01U	0.01U	0.01U	0.01U	0.01U	0.02	0.01U	0.01U	0.01U

(a)Samples were collected from January 27, 1987 to January 29, 1987.

(b)"mg/l" equals milligrams per liter or parts per million (ppm).

(c)"U" indicates that the compound was analyzed but not detected. The corresponding number represents the method detection limit for the sample.

00009004

APPENDIX
E

00002005

APPENDIX E

EXTRACTION PROCEDURE (EP) TOXICITY LEACHATE ANALYSIS METHODS DATA

APPENDIX E
LIST OF TABLES

TABLE NO.	TITLE
E-1	E.P. Toxicity Leachate Analysis Methods Data, March through April 1985 Samples, ARCO Chemical Company, Gnadenhutten, Ohio
E-2	E.P. Toxicity Leachate Analysis Method Data, April 1985 Samples, ARCO Chemical Company, Gnadenhutten, Ohio
E-3	E.P. Toxicity Leachate Analysis Methods Data for Metals, November through December 1986 Samples, ARCO Chemical Company, Gnadenhutten, Ohio
E-4	E.P. Toxicity Leachate Analysis Methods Data for General Chemistry, November through December 1986 Samples, ARCO Chemical Company, Gnadenhutten, Ohio
E-5	E.P. Toxicity Leachate Analysis Methods Data for Metals, January 1987 Samples, ARCO Chemical Company Company, Gnadenhutten, Ohio
E-6	E.P. Toxicity Leachate Analysis Methods Data for General Chemistry January 1987 Samples, ARCO Chemical Company, Gnadenhutten, Ohio

TABLE E-1

EP TOXICITY LEACHATE ANALYSIS
METHODS DATA
MARCH THROUGH APRIL 1985 SAMPLES(a)
ARCO CHEMICAL COMPANY
GNADENHUTTEN, OHIO

SAMPLE I.D.	INITIAL PH	FINAL PH	TOTAL VOLUME ACID ADDED (ml)
MW-1			
S-5	9.10	5.20	200
S-9	9.70	4.80	250
MW-2			
S-1	8.60	4.70	200
S-4	8.60	4.80	20
S-6	9.40	5.35	200
MW-3			
S-1	8.75	4.75	225
S-3	7.00	5.10	10
S-7	9.65	5.00	200
MW-4			
S-1	8.10	4.80	160
S-1 Duplicate	8.20	4.80	155
S-4	8.80	4.90	40
S-10	9.50	4.95	200
S-10 Duplicate	9.60	5.00	200
MW-5			
S-1	7.15	4.90	10
S-1 Duplicate	7.20	4.95	10
S-3	8.70	4.85	20
S-7	9.40	5.10	110
MW-6			
S-4	9.10	5.10	125
S-7	9.30	5.10	200
S-8	9.40	5.05	175

TABLE E-1
(Continued)

SAMPLE I.D.	INITIAL PH	FINAL PH	TOTAL VOLUME ACID ADDED (ml)
MW-7			
S-1	6.85	4.70	16
S-3	8.45	4.90	55
S-5	9.20	5.25	200
MW-8			
S-3	8.45	5.10	10
S-4	9.40	5.20	25
S-6	9.50	5.30	200
MW-9			
S-2	7.20	5.10	13
S-3	7.70	4.75	110
S-3 Duplicate	7.60	5.20	75
S-6	9.80	5.20	200
S-6 Duplicate	10.10	5.05	170
S-8	9.60	5.15	200

(a)Monitoring well soil boring samples were collected from March 18 to April 9, 1985.

TABLE E-2

EP TOXICITY LEACHATE ANALYSIS
METHODS DATA
APRIL 1985 SAMPLES(a)
ARCO CHEMICAL COMPANY
GNADENHUTTEN, OHIO

SAMPLE I.D.	INITIAL PH	FINAL PH	TOTAL VOLUME ACID ADDED (ml)
TP-1 Composite	7.90	5.10	400
TP-2 Composite	7.70	5.50	400
TP-3 Composite	7.30	5.50	400
TP-4 Composite	7.00	5.40	400
TP-5 Composite	7.00	5.00	400
TP-6 Composite	6.90	4.60	250
TP-7 Composite	7.50	5.00	400
TP-8 Composite	9.50	5.30	400
TP-9 Composite	9.50	4.60	400
TP-10 Composite	7.20	5.35	400
TP-11 Composite	9.70	6.00	400
TP-12 Composite	8.10	6.10	400
TP-13 Composite	10.50	5.70	400
Lagoon Soil Composite	9.00	4.15	100
Sludge Pit Soil Composite	7.10	4.90	50
Sludge Pit Sludge Composite	7.50	5.10	400
B Series Soil Composite	7.00	4.60	100
B Series Sludge Composite	7.00	5.00	400
North Lagoon Sludge Composite	7.50	4.70	400
South Lagoon Sludge Composite	7.20	5.10	400

(a)Samples were collected from April 1 to April 8, 1985.

TABLE E-3

EP TOXICITY LEACHATE ANALYSIS
METHODS DATA FOR METALS
NOVEMBER THROUGH DECEMBER 1986 SAMPLES(a)
ARCO CHEMICAL COMPANY
GNADENHUTTEN, OHIO

SAMPLE I.D.	INITIAL pH	FINAL pH	TOTAL VOLUME ACID ADDED (ml)
Northern Impoundment Area Sludge Composite	8.5	7.40	100
S-1 Soil (9.4 - 10.0 ft.)	8.80	5.20	35
S-1 Soil Duplicate (9.4 - 10.0 ft.)	8.85	5.20	34
S-1 Soil (10.0 - 10.6 ft.)	8.80	5.05	11
S-3 Soil (3.8 - 5.5 ft.)	7.30	5.15	9
S-3 Soil (5.5 - 6.5 ft.)	6.80	5.20	6
Southern Impoundment Area Sludge Composite	8.70	7.80	100
S-4 Soil (6.0 - 8.0 ft.)	8.95	5.20	12
S-5 Soil (9.5 - 11.0 ft.)	8.90	5.00	20
S-6 Soil (10.1 - 11.4 ft.)	9.00	5.15	40
Blank	7.40	5.00	<1.0

See footnote at end of table.

TABLE E-3
(Continued)

SAMPLE I.D.	INITIAL pH	FINAL pH	TOTAL VOLUME ACID ADDED (ml)
Area 1 Composite			
Sludge	8.10	6.30	100
Soil	6.80	5.20	10
Area 2 Composite			
Sludge	8.00	6.10	100
Soil	6.90	5.00	10
Area 3 Composite			
Sludge	7.90	6.10	80
Soil	7.20	5.20	10
Soil Duplicate	7.40	5.20	11
Area 4 Composite			
Sludge	7.80	6.10	80
Soil	6.60	5.10	6
Area 5 Composite			
Sludge	7.60	5.20	80
Soil	7.30	4.80	22
Sludge Pit			
Sludge Composite	8.00	6.50	100
Soil Composite	7.65	5.00	8
Soil Composite Duplicate	7.60	5.00	8
Blank	7.20	4.45	<1.0

(a)Samples were collected from November 17, 1986 to December 2, 1986.

TABLE E-4

EP TOXICITY LEACHATE ANALYSIS
METHODS DATA FOR GENERAL CHEMISTRY
NOVEMBER THROUGH DECEMBER 1986 SAMPLES(a)
ARCO CHEMICAL COMPANY
GNADENHUTTEN, OHIO

SAMPLE I.D.	INITIAL pH	FINAL pH	TOTAL VOLUME ACID ADDED (ml)
Northern Impoundment Area Sludge Composite	8.50	5.95	200
Northern Impoundment Area Sludge Composite Duplicate	8.40	5.80	200
S-1 Soil (9.4 - 10.0 ft.)	8.20	5.15	30
S-1 Soil (10.0 - 10.6 ft)	7.00	5.20	6
S-3 Soil (3.8 - 5.5 ft.)	6.40	5.05	4
S-3 Soil Duplicate (3.8 - 5.5 ft.)	6.60	5.00	4
S-3 Soil (5.5 - 6.5 ft.)	6.70	5.15	2
Southern Impoundment Area Sludge Composite	9.70	7.10	200
S-4 Soil (6.0 - 8.0 ft.)	8.40	4.90	6
S-5 Soil (9.5 - 11.0 ft.)	8.00	5.00	12
S-6 Soil (10.1 - 11.4 ft.)	8.10	4.85	21
Blank	5.80	4.20	1

See footnote at end of table.

TABLE E-4
(Continued)

SAMPLE I.D.	INITIAL pH	FINAL pH	TOTAL VOLUME ACID ADDED (ml)
Area No. 1 Composite			
Sludge	7.30	5.10	100
Soil	6.30	5.20	8
Area 2 Composite			
Sludge	6.80	5.20	100
Soil	6.50	5.10	7
Area 3 Composite			
Sludge	7.00	5.10	80
Soil	6.60	5.05	10
Soil Duplicate	6.65	5.00	10
Area 4 Composite			
Sludge	6.80	5.15	80
Soil	6.30	4.80	7
Area 5 Composite			
Sludge	7.20	5.20	50
Soil	6.75	4.75	10
Sludge Pit			
Sludge Composite	7.00	5.45	200
Soil Composite	7.00	4.50	25
Blank	5.95	5.00	<1

(a)Samples were collected from November 17 to December 2, 1986.

TABLE E-5

EP TOXICITY LEACHATE ANALYSIS
METHODS DATA FOR METALS
JANUARY 1987 SAMPLES(a)
ARCO CHEMICAL COMPANY
GNADENHUTTEN, OHIO

SAMPLE I.D.	INITIAL pH	FINAL pH	TOTAL VOLUME ACID ADDED (ml)
Northern Impoundment Area Sludge Composite	8.60	7.40	100
S-1 Soil (8.0 - 8.8 ft.)	8.15	4.85	12
S-2 Soil (7.2 - 8.5 ft.)	7.50	4.70	12
S-3 Soil (7.0 - 7.8 ft.)	7.30	4.70	10
Southern Impoundment Area Sludge Composite	9.15	8.35	100
S-4 Soil (8.0 - 9.0 ft.)	7.70	4.75	12
S-4 Soil Duplicate	7.75	4.80	12
S-5 Soil (8.5 - 9.0 ft.)	8.40	5.20	35
S-6 Soil (9.5 - 10.1 ft.)	9.50	5.00	65
Blank	6.70	4.30	<1

See footnote at end of table.

TABLE E-5
(Continued)

SAMPLE I.D.	INITIAL pH	FINAL pH	TOTAL VOLUME ACID ADDED (ml)
Area 1 Composite			
Sludge	8.30	6.35	100
Soil	7.40	5.05	10
Area 2 Composite			
Sludge	8.30	6.15	100
Soil	7.50	4.95	15
Area 3 Composite			
Sludge	8.20	6.10	100
Soil	7.50	4.70	20
Area 4 Composite			
Sludge	8.15	6.15	100
Soil	7.60	4.85	15
Area 5 Composite			
Sludge	8.10	5.20	70
Soil	7.40	4.80	15
Sludge Pit			
Sludge Composite	8.40	6.80	100
Soil Composite	8.00	4.85	17
Blank	5.20	4.15	1

(a)Samples were collected from January 19 to January 28, 1987.

TABLE E-6

EP TOXICITY LEACHATE ANALYSIS
METHODS DATA FOR GENERAL CHEMISTRY
JANUARY 1987 SAMPLES(a)
ARCO CHEMICAL COMPANY
GNADENHUTTEN, OHIO

SAMPLE I.D.	INITIAL pH	FINAL pH	TOTAL VOLUME ACID ADDED (ml)
Northern Impoundment Area Sludge Composite	9.20	5.4	100
S-1 Soil (8.0 - 8.8 ft.)	8.70	4.10	20
S-2 Soil (7.2 - 8.5 ft.)	7.80	4.60	10
S-3 Soil (7.0 - 7.8 ft.)	7.60	4.50	10
Southern Impoundment Area Sludge Composite	10.60	6.70	100
S-4 Soil (8.0 - 9.0 ft.)	7.90	4.55	10
S-4 Soil Duplicate	8.50	5.20	10
S-5 Soil (8.5 - 9.0 ft.)	8.90	5.10	27
S-6 Soil (9.5 - 10.1 ft.)	9.50	5.10	29
Blank	5.50	4.80	<1.0

See footnote at end of table.

TABLE E-6
(Continued)

SAMPLE I.D.	INITIAL pH	FINAL pH	TOTAL VOLUME ACID ADDED (ml)
Area 1 Composite			
Sludge	7.50	5.10	100
Soil	6.70	5.00	8
Area 2 Composite			
Sludge	8.05	5.30	100
Soil	7.00	4.95	10
Area 3 Composite			
Sludge	7.25	5.00	65
Soil	7.30	5.10	10
Area 4 Composite			
Sludge	6.85	5.15	6
Soil	7.20	4.80	10
Area 5 Composite			
Sludge	7.40	5.00	40
Soil	6.60	5.20	6
Soil Duplicate	6.50	5.05	6
Sludge Pit			
Sludge Composite	8.90	5.70	100
Soil Composite	8.00	4.50	15
Blank	5.15	5.15	<1

(a)Samples were collected from January 19 to January 28, 1987.