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CONCEPTUAL WORKPLAN FOR ADDITIONAL FIELD INVESTIGATIONS AT NAVAL INDUSTRIAL RESERVE ORDNANCE PLANT FRIDLEY, MINNESOTA

JUNE 1987

RMT INC.

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CONCEPTUAL WORKPLAN
FOR
ADDITIONAL FIELD INVESTIGATIONS
AT
NAVAL INDUSTRIAL RESERVE ORDNANCE PLANT
FRIDLEY, MINNESOTA

JUNE 1987

CONTRACT NO. DACA45-86-C-0015

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I hereby certify that this plan, specification, or report was prepared by me or under my direct supervision and that I am a duly Registered Professional Engineer under the laws of the State of Minnesota.

Thomas P. Kunes

Date 6-23-87 Registration No. 013728

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President, Northern Region
RMT, Inc.

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TABLE OF CONTENTS

Title	Page
1. INTRODUCTION	1
1.1 Background	1
1.2 Site Description and History	1
1.3 Purpose and Scope	5
2. TECHNICAL APPROACH	6
2.1 Background	6
2.2 Plans and Management	7
2.3 Site Investigations	10
2.4 Data Use	20
2.5 Reports	21
3. PROJECT MANAGEMENT	23
3.1 Project Organization	23
3.2 Progress Reports	25
3.3 Correspondence	26
3.4 Documents	26
3.5 Conference Notes and Confirmation Notices	27
3.6 Notification of Site Visits	28
3.7 Project Records	28
3.8 Contract Progress Reports	29
4. PROJECT SCHEDULE	30
5. REFERENCES	32

List of Figures

Figure 1 - General Vicinities Map	3
Figure 2 - Proposed Pore Gas Survey Areas	12
Figure 3 - Proposed Monitoring and Production Well Locations	14
Figure 4 - Project Organization	24
Figure 5 - Preliminary Schedule for Proposed Activities	31

List of Tables

Table 2-1 - List of Analytical Parameters	19

1. INTRODUCTION

1.1 Background

RMT, Inc., has been retained by the Omaha District of the U.S. Army Corps of Engineers (COE) to complete a Remedial Investigation/ Feasibility Study (RI/FS) for the Naval Industrial Reserve Ordnance Plant (NIROP) located in Fridley, Minnesota. The data collected by the COE and RMT through the fall of 1986 was assembled into an Interim Report (RMT, 1987a) and a draft RI Report (RMT 1987b). Evaluation of the data suggests several additional field investigations that could contribute to a better understanding of hazardous constituent distributions and sources, and that could provide data on basic hydrogeologic parameters needed for evaluation of potential remedial alternatives. This workplan outlines the proposed field investigations, the objectives of the specific tasks, the general methods to be used, and the expected application of the data.

The proposed field activities will be undertaken concurrently with the development and writing of the FS Report under a subsequent contract modification. When possible, the data obtained in the proposed investigations will be incorporated into the evaluation and design of remedial alternatives during the development of the FS.

should we suggest that the work be done prior to FS

1.2 Site Description and History

The Naval Industrial Reserve Ordnance Plant (NIROP) is a government-owned, contractor-operated facility. The plant is operated by the Northern Ordnance Division of FMC Corporation. The NIROP manufactures advanced naval weapons systems. Operations include

development, design, engineering, and testing. The NIROP began production in 1941, making it the first plant to mass-produce naval guns during World War II. The NIROP has continued to produce naval guns and has expanded into the production of guided missile launching systems, torpedo tubes, and hydraulic and electric power drive and control systems.

The NIROP is located in the northern portion of the Minneapolis/St. Paul, Minnesota metropolitan area within the city limits of Fridley, Minnesota (see Figure 1). It is situated approximately one-half mile east of the Mississippi River and less than one mile south of Interstate 694. The facility is bordered on the west by East River Road and on the east by the Burlington Northern rail yard. The government-owned, contractor-operated portion of the plant occupies about 83 acres. The plant is located in an industrial area which has a number of adjacent manufacturing facilities.

In previous years, the storage yard in the northern quarter of the site had been used for the disposal of drummed waste by burial in 8- to 10-foot-deep trenches or in pits. The materials disposed were thought to include waste oil, plating sludge, paint sludge, cleaning solvents, and degreasing solvents, which may contain hazardous chemicals such as cyanide, trichloroethylene (TCE), methyl ethyl ketone (MEK), and 1,1,1-trichloroethane (RMT, 1987b).

Initial remedial action cleanup activities began in November 1983. Nine areas were excavated, and 43 drums and approximately 1,200 cubic yards of soils were removed. The majority of the drums contained inert solids; others contained PCB wastes, flammable solids, base solids, and

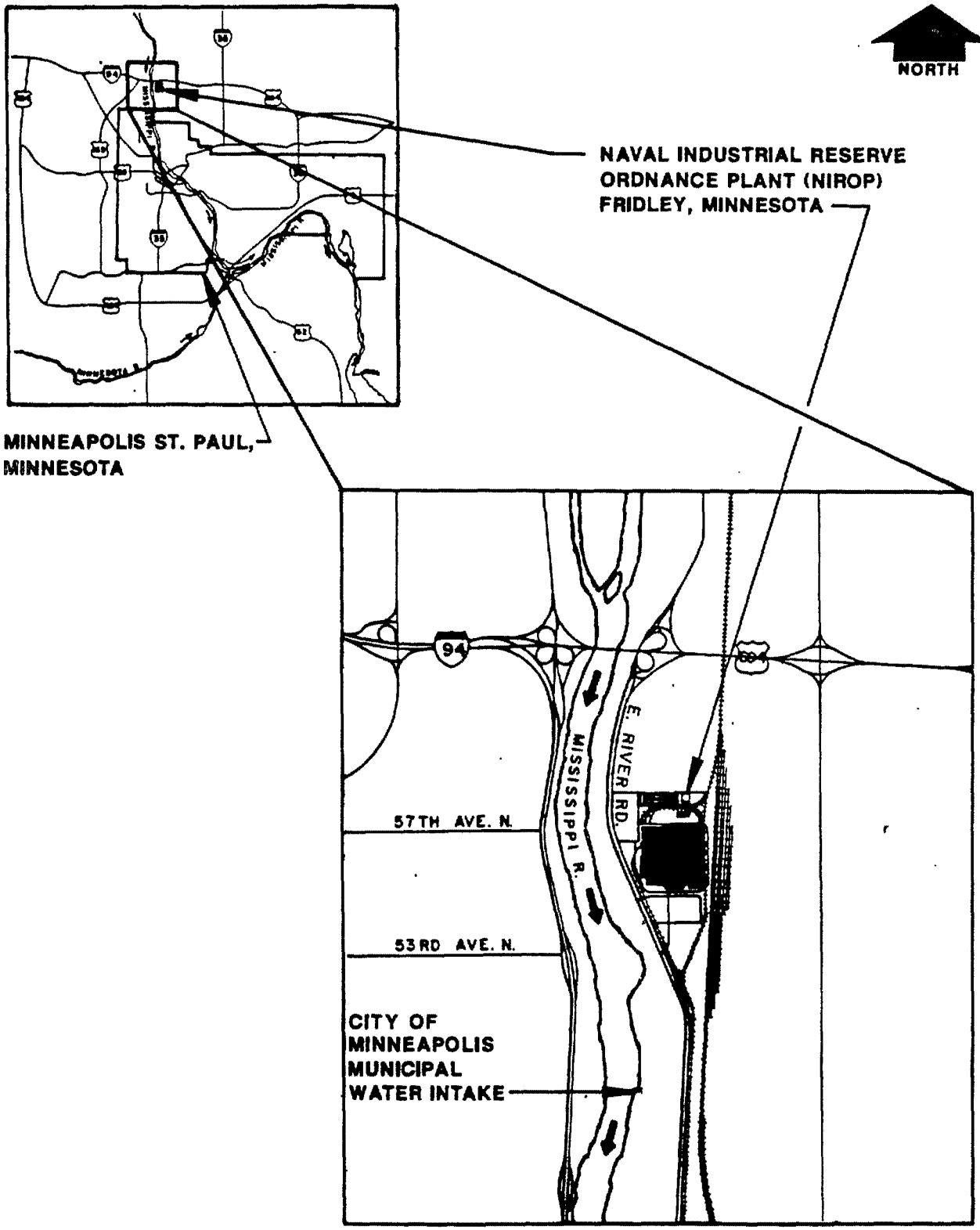

FIGURE 1

GENERAL VICINITIES MAP

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inert liquids; and some were empty. The hazardous soils and drums were disposed in an EPA-approved landfill. Samples were then taken in the excavations for volatile organics. Two trenches showed VOCs above one part per million; however, no further testing was done at that time. The trenches were backfilled with clean fill, and removal activities were completed in March 1984.

Fourteen monitoring wells were installed at the NIROP between May and August 1983. Seven additional on-site monitoring wells were installed in May and June 1985. Installation of 12 off-site monitoring wells was completed in February 1986. The purpose of these wells was to determine ground water flow direction and the general extent of ground water contamination. Water levels were measured biweekly until April 1985, and again biweekly from June 1986 to September 1986. Ground water quality samples were taken six times from the original 14 wells and analyzed at the U.S. Army Corp of Engineers Waterways Experiment Station. The 7 wells installed in May and June of 1985 have been sampled three times, and the 12 off-site wells have been sampled twice. The most recent ground water sampling occurred in November 1986.

RMT, Inc., has prepared an Interim Report (RMT, 1987a) and a Draft RI Report (RMT, 1987b) which presents and evaluates data collected by the Corps of Engineers for the Navy at the NIROP. The information contained in these documents forms the basis for the field investigations proposed in this workplan.

1.3 Purpose and Scope

The purpose of this workplan is to outline additional field investigations for the NIROP. This workplan presents outlines for two major field investigations: source characterization and evaluation of aquifer hydraulic properties. The source characterization includes pore gas evaluations, sewer outlet sampling, production well sampling, additional monitoring well installation, ground water sampling, and chemical time-series analyses during aquifer pumping tests. The aquifer evaluation includes a pumping test and some limited single-well response tests. This Conceptual Workplan presents the objective of each of these tasks, the general approach or implementation scheme, and a brief discussion of how the data generated by each task will be applied to the ongoing feasibility studies.

This Conceptual Workplan is not intended to be a substitute for the workplan described in the Model Statement of Work for Conducting Remedial Investigations (Task 2 - Plans and Management) contained in the USEPA document entitled Guidance on Remedial Investigations Under CERCLA (USEPA, 1985a). After the Conceptual Workplan has been reviewed and approved, RMT will prepare detailed workplans (per Task 2) for review and approval prior to commencement of subsequent activities.

2. TECHNICAL APPROACH

2.1 Background

The basis for this conceptual work is the Interim Report (RMT, 1987a) and the Draft RI Report (RMT, 1987b) which evaluated existing information for the NIROP facility and identified additional data needs to facilitate problem definition and evaluation of remedial action technologies. The following is a summary of the major recommendations for additional data needs at the NIROP facility that will be addressed in this workplan:

Source Characterization

- Additional work is needed to characterize potential contaminant sources at the NIROP facility. The potential sources that require further characterization include the following:

  - Underground utility lines which may convey solvents from bulk storage tanks into the plant.
  - Plant sewer system.
  - Upgradient (off-site) sources (i.e., located to the north and east of the NIROP facility).
  - TCE-contaminated, on-site soils.

  Better identification and evaluation of these potential contaminant sources will help to explain the observed occurrence of contaminants in the ground water. Identification of the potential source(s) is critical to proper evaluation of the No-Action Alternative and remedial alternatives.

Site Hydrogeology

- Selected aspects of the hydrogeology beneath the NIROP require further evaluation. These include the following:

  - Improved understanding of geology and flow patterns on the north and east sides of the NIROP.
  - Evaluation of aquifer hydraulic properties (e.g., hydraulic conductivity and storativity).

  Better understanding of hydrogeology will improve the accuracy of contaminant transport predictions and will provide some preliminary data with which to begin the assessment and design of remedial alternatives.

2.2 Plans and Management

Six documents (plans) will be developed before any field investigation begins. The six plans include the following:

- Project Workplan.
- Site Operations Plan.
- Sampling Plan.
- Quality Assurance/Quality Control Project Plan.
- Health and Safety Plan.
- Data Management and Documentation Plan.

Wherever possible, previously prepared plans (e.g., RMT, 1986a and 1986b) will be updated to meet the needs of the proposed activities.

Project Workplan

A Project Workplan will be developed after review and approval of the Conceptual Workplan have been obtained. The Project Workplan will provide detailed information regarding the technical and management approach and methods presented in this Conceptual Workplan.

Site Operations Plan

The Site Operations Plan will address the details for on-site activities including the following:

- Base operations (office) location.
- Decontamination zones.
- Sanitary facilities.
- Communication.

- Equipment storage.
- Security.

A decontamination pad currently exists at the site. This pad will be used in the proposed site investigations.

Sampling Plan

A site-specific Sampling Plan will be prepared. This plan will detail the type, location, and number of samples to be collected including proposed monitoring well locations and depths, sewer sampling locations, production well locations, pore gas sampling stations, and the ground water analytical program. The plan will also provide a description of techniques that are not part of the Quality Assurance/ Quality Control Project Plan. Guidance for the development of the Sampling Plan will be provided by the Guidance on Remedial Investigations Under CERCLA (USEPA, 1985a).

Quality Assurance/Quality Control Project Plan

The Quality Assurance/Quality Control (QA/QC) Project Plan will outline the procedures to be followed in order to maintain a high standard of quality for the data generated during the field investigations. The plan will include quality control techniques, quality assurance procedures, definitions of QA/QC responsibilities for investigation personnel, and descriptions of methods and procedures to be utilized during the investigation. A Standard Operating Procedures Manual will be cited for routine methods, while nonroutine methods will be described in detail in the plan. The Quality Assurance/Quality

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Control Project Plan will be developed with USEPA guidance documents (USEPA, 1985a) and Corps of Engineers guidance documents (U.S. Army, Corps of Engineers, 1984).

Health and Safety Plan

A site-specific Health and Safety Plan will be prepared. The plan will be based on the most recent regulations and guidelines available from agencies such as OSHA, NIOSH, EPA, U.S. Coast Guard, and the Corps of Engineers, and will include at a minimum the following topics:

- Chemical and physical hazard evaluation
- Air monitoring
- Levels of protection
- Work limitations
- Decontamination
- Contingencies
- Site security

The Health and Safety Plan will be developed from the existing plan written for the November 1986 ground water sampling. Additional information will be incorporated to cover hazards associated with the investigations described in this workplan. The existing plan included hazards known to be present and will be subject to revision if additional hazards become known.

Data Management and Documentation Plan

The purpose of this plan is to define the procedures to document and track investigation data and results. The plan will identify and set up laboratory and data documentation, project-related progress reporting procedures, and documents. A computer data base will be established for laboratory analytical results to facilitate use of the data.

2.3 Site Investigations

Further field investigations are required to improve the definition of the nature and extent of hazardous substance occurrence and to provide data for the assessment of remedial alternatives that include ground water pumping. The specific tasks proposed have been grouped into three stages which include the following:

Stage I - Soil pore gas evaluation for source identification.

Stage II - Well installation for source evaluation, improved definition of hazardous constituent occurrence, and improved definition of site geology and ground water flow systems.

Stage III - Aquifer testing for evaluation of design parameters needed for remedial alternative evaluation.

Stage I

Stage I of the proposed field investigations includes the in-field measurement of soil vapor volatile organic compounds in suspected source areas of TCE and associated VOCs. Soil vapor analysis will be performed during Stage I as a screening technique to determine potential sources of VOC contamination and to assist in the placement of monitoring wells during Stage II. The analysis consists of driving a hollow soil probe equipped with specially designed fittings into the ground, evacuating the probe and measuring organic vapor concentrations with a photoionization detector connected to the soil probe. The detector does not identify specific VOCs, but provides a rapid and inexpensive indication of the presence of VOCs such as TCE. The measurements would be taken at regular grid spacings over the proposed investigation areas (described below). The spacing would be reduced or modified in areas of specific

MAYBE? depending on [illegible] why not portable GC/MS?

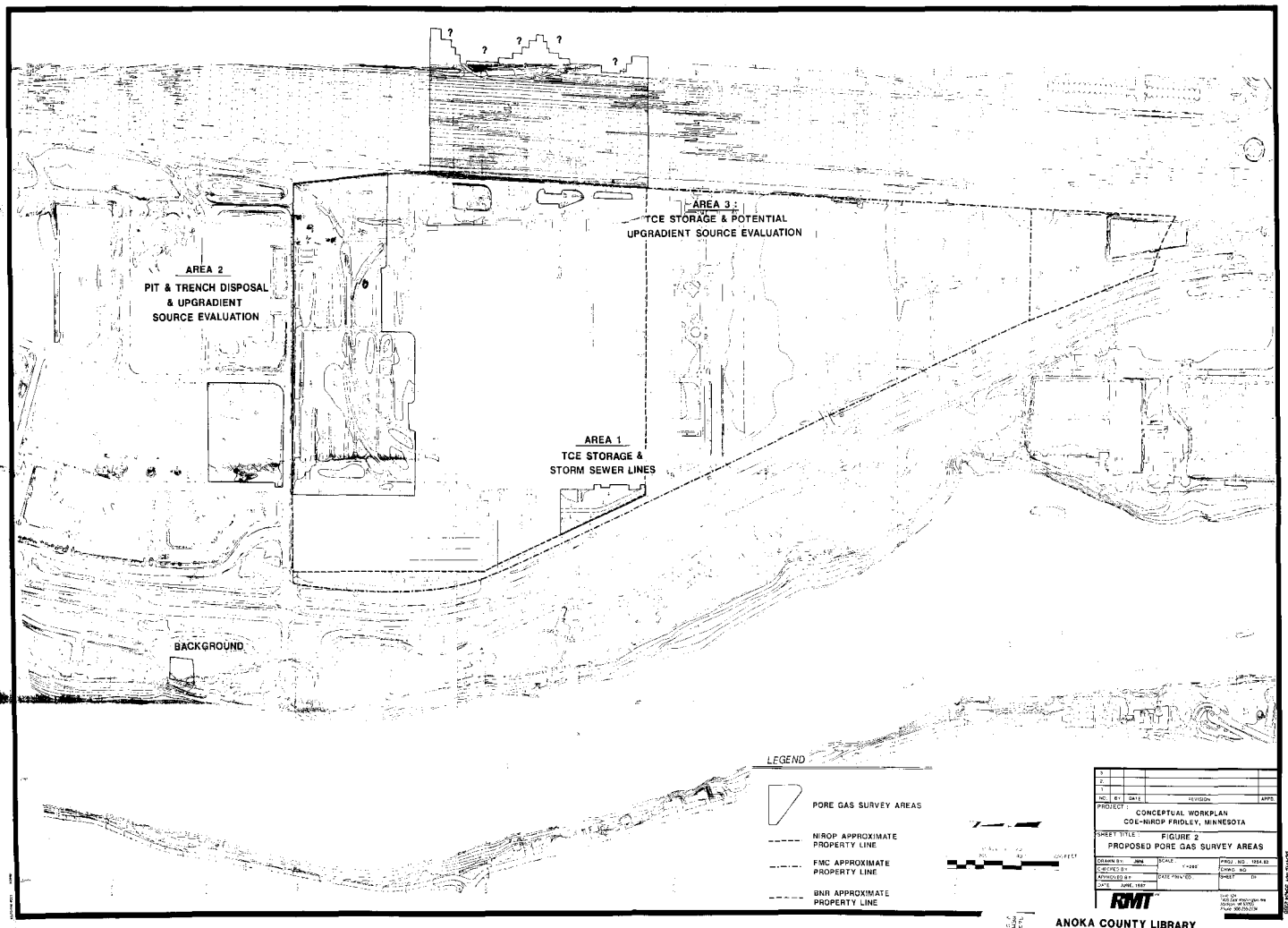
interest (e.g., burial sites, storm sewers, etc.) to provide data to assess the impact these areas may have on VOC occurrence.

Previous ground water monitoring indicates that there may be sources of VOCs east of the NIROP, as well as several sources on the NIROP property. The soil vapor analysis would be a rapid means of helping to determine potential source areas without interference to current activities. It has been assumed that the Navy will be able to obtain access to the adjacent properties for this purpose. The data generated by this investigation may form the basis for future investigations that could include soil analyses (surficial or borings) or monitoring well installation. The data could also be used to adjust the positions of some of the monitoring wells proposed for installation during Stage II.

Sampling stations that exhibit VOC concentrations well in excess of background values will be resampled in order to identify the type and concentration of VOCs present. The quantitative analyses will be performed with either a field gas chromatograph (head space analyses of soils) or static VOC trapping devices submitted for laboratory analyses.

The soil pore vapor analyses will focus on four areas (Figure 2). Previous reports have identified several potential VOC sources southwest of the NIROP building. The first area of proposed activity will concentrate on the TCE storage area used between 1966 and 1982, and the areas immediately over and adjacent to the storm sewers identified in the Draft RI Report (RMT, 1987b).

The second area of soil pore vapor analyses (Figure 2) is on the north side of the NIROP. Persistently high levels of TCE in samples



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PROJECT : CONCEPTUAL WORKPLAN
COE-NIROP FRIDLEY, MINNESOTA

SHEET TITLE : FIGURE 2
PROPOSED PORE GAS SURVEY AREAS

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from wells in the storage yard suggest that there is a continuing source of VOCs in the area. Wells on the north edge and immediately north of the storage yard have also yielded samples with significant concentrations of VOCs. The initial sampling will take place in the area of the pits and trenches and near monitoring well 16-S. The soil pore vapor sampling around well 16-S could be extended further north if the initial findings suggest the presence of significant concentrations of VOCs in the soil.

The third area to be included in the pore vapor investigation is east of the NIROP building (Figure 2). Specific areas of interest include the area around the current TCE storage tank, the area of underground tanks near well 9-S and the strip of land between the NIROP perimeter road and the Burlington Northern property. The survey will also extend eastward, across the Burlington Northern Railroad yard, in the direction of plume migration suggested by the hydrogeologic and water quality data presented in the Draft RI Report (RMT, 1987b).

A fourth area identified for soil pore gas monitoring will be used to ascertain background conditions. The background area is proposed northwest of the NIROP in the county park.

Stage II

Additional monitoring wells will be installed during Stage II of this investigation (Figure 3). The location and depths of the proposed monitoring wells are based on the hydrogeology and the extent of hazardous constituents defined in the Draft RI Report (RMT, 1987b). The results of the Stage I soil pore gas evaluations may suggest changes or

additions to the monitoring well network. These would be presented to the COE at the end of Stage I.

The installation of additional monitoring wells would serve two purposes. The first would be an improved understanding of the hydrogeology in several areas including the following:

- Geologic units and vertical flow components near the southeast corner of the NIROP building (near well 9-S).
- Geologic units and ground water flow north of the NIROP (near wells 15-S and 16-S).
- Geologic units and ground water flow on the west side of the NIROP (between wells 1-PC and 4-PC).

The information will be used to refine the understanding of the geology and the impact the geology has on ground water flow patterns.

The second purpose of the monitoring wells is to better delineate the extent of hazardous substances in the ground water. The studies to date still leave some uncertainty regarding sources of hazardous substances (both on-site and upgradient) and the extent of hazardous substances beneath and along the downgradient boundary of the NIROP.

Monitoring wells will be placed north of the NIROP facility to better assess the quality of upgradient ground water. Data collected to date indicates that 10 to 200 ug/L of TCE is already present at the water table upgradient of the northern boundary of the NIROP. This "input" needs to be assessed in order to determine the incremental contribution of NIROP sources. Three proposed wells (A, B, and C) will be completed adjacent to the existing monitoring well 15-S. TCE concentrations in samples from well 15-S have averaged 12 ug/L. The new wells will be placed in the middle and at the bottom of the aquifer in the unconsolidated sediments and near the top of the Prairie du Chien/Jordan

aquifer. A fourth well (D) will be placed at the base of the unconsolidated sediments adjacent to well 16-S (average TCE concentration of 133 ug/L).

New monitoring wells (E and F) will be placed immediately downgradient of Hazardous Waste Storage Area C. Area C is the location of a dry well that was found to contain 1,1,1 trichloroethane, 1,2 dichloroethylene, tetrachloroethylene, and 1,1,2 trichloroethane (RMT, 1987b). The wells will be placed at the water table and in the middle of the unconsolidated sediment aquifer to determine whether significant releases of hazardous constituents from the storage area have occurred and are contributing to the hazardous substances observed to be leaving the NIROP southwest of the plant.

Some of the highest TCE concentrations reported at the NIROP facility have come from monitoring well 9-S. It is uncertain whether the observed concentrations originate on the NIROP property or are the result of TCE migration from the east. The vertical extent of TCE is also unknown. Two additional wells (G and H) will be placed adjacent to well 9-S in the middle and bottom of the aquifer in the unconsolidated sediments to assess vertical concentration gradients and TCE extent. This is especially important in light of the very high TCE concentrations found at the base of the aquifer downgradient of well 9-S (at well 8-D). Monitoring wells I and J will be placed upgradient of well 9-S (on BNR property) to determine horizontal contaminant concentration gradients. Again, data from these new wells will help to differentiate the incremental increase in hazardous constituents resulting from possible source(s) at the NIROP facility from constituents that are migrating onto the NIROP from the east.

WHY? BECAUSE TCE IS HEAVIER THAN H_2O.

High concentrations of TCE (average of 6,600 ug/L) have also been measured at well 8-S, immediately downgradient of the disposal pits and trenches. The available data from well 8-S is only from near the water table. Therefore, additional wells (K and L), will be placed at the middle and bottom of the unconsolidated aquifer to help define the vertical distribution of hazardous constituents in this area.

Two proposed wells (M and N) will be installed on the downgradient (southwest) side of the NIROP facility, adjacent to existing wells 6-D and 18-S. Well M, near 6-D, would be completed at the water table. Doesn't 11-S MONITOR THIS ZONE Boring logs in this area indicate that clay layers or lenses may be present immediately north of this location. The proposed monitoring well M will be placed above the clay layer elevation to determine whether the layer has any control on the migration of TCE from the north. Proposed well N, adjacent to well 18-S, will be placed in the middle of the unconsolidated sediment aquifer, between the intakes for wells 18-S and 8-D. Data from this proposed well will be used to determine whether the entire thickness of the unconsolidated aquifer (120 feet) is affected by a single "plume" or whether there are two "plumes," one near the water table and a second at the base of the aquifer. Resolution of this question will allow for greater accuracy in assessing remedial alternatives.

A well nest consisting of a water table well (O) and a deep piezometer (P) at the base of the aquifer will be installed along the northern portion of the western property boundary. Data from this nest will be used to determine whether hazardous substances are migrating westward from the pit area as well as to determine hydrogeology along

the northwest property line. what about 20-S? would help in pump tests

A round of ground water sampling will be completed following the installation of the Stage II wells. This round of sampling will include both the new monitoring wells and the existing wells as well as the sewer outfalls and the on-site production wells (if possible). Parameters for analyses are shown on Table 2-1.

An additional round of ground water sampling (if necessary) will be limited to those wells whose analytical results do not meet QA/QC requirements or whose results appear to be in conflict with those of surrounding well samples. The analyses will again include VOCs, trace elements, major ions and field pH, conductance and temperature. INC. METALS? Pb, Fe,

Stage III

Two aquifer tests will be performed during Stage III. The first test will be performed east of the NIROP building (AT-1, Figure 3). The objective of the test is to assess the source(s) of VOCs observed in samples from well 9-S by analyzing chemical time series data. If preliminary findings from the proposed monitoring wells near 9-S and on BNR property (wells G, H, I, and J) provide strong evidence of a VOC source(s) upgradient of the NIROP, the test may not be conducted. If however, the data from these proposed wells proves to be inconclusive, a 4- to 6-inch diameter pumping well (AT-1) would be installed between monitoring wells 9-S and J. The well would be pumped for a period of 2 to 5 days, and ground water samples would be collected periodically from nearby monitoring wells. Changes in TCE concentrations with time from the various wells will be evaluated to determine whether the TCE source is west (NIROP) or east (upgradient) of the pumping well.

what is the rationale for this time period

- HOW DEEP WILL THE WELLS BE? - SHOULD KEEP IN MIND POSSIBLE VERTICAL MOVEMENT OF CONTAMINANTS.

TABLE 2-1

LIST OF ANALYTICAL PARAMETERS

PARAMETER

Volatile Organic Compounds[1]	Metals[2] (Dissolved)
Vinyl Chloride	Barium
Methylene Chloride	Selenium
Trichlorofluoromethane	Manganese
1,1 Dichloroethylene	Zinc
1,1 Dichloroethane	
Cis and Trans 1,2 Dichloroethylene	
Chloroform	
1,1,1 Trichloroethane	
Trichloroethylene	
Benzene	
Tetrachloroethylene	
Toluene	
Ethyl Benzene	
Xylene	

1 VOCs selected for analyses were based on the list of VOCs detected to date as reported in the Draft RI Report (RMT, 1987b); recommendations made in the Draft RI Report also included xylene due to its detection in pits/trenches; and, vinyl chloride which was added to the list due to being a breakdown product of TCE.

2 Metals selected for analyses were based on Table 7-2 of the Draft RI Report (RMT, 1987b). Parameters selected are those metals that exhibited a determinable off-site health risk. Selenium was added due to its detection at well 9-S at a concentration exceeding its MCL.

Preliminary review of remedial alternatives suggests that ground water pumping may play a major role in several alternatives. It would therefore be necessary to obtain information on the hydraulic properties (transmissivity, storativity, boundaries) of the unconsolidated sediments for designing an aquifer pumping system. A large-scale aquifer pumping test would be used to obtain the needed information. A 6- to 10-inch diameter well (AT-2, Figure 3) would be located on the southwest side of the facility, in the vicinity of monitoring wells 4-S, 4-PC, 5-S, 6-S, 7-D, 6-D, 10-S, 11-S, 17-S, L, M, and N. These monitoring wells will serve as observation wells during a 24- to 72-hour pumping test. It would also be appropriate to collect samples for chemical analysis during the test to aid in designing the ground water remediation program. Ground water removed during the pump test would be used to evaluate the chemical characteristics of the ground water which might affect the physical operation of remedial equipment (i.e., scaling or blinding due to precipitation of iron hydroxide or calcium carbonate). This evaluation would be a bench-scale evaluation. The pumping well will be located near where future ground water remediation wells may be installed. The well will be designed such that it could be converted from a test well to part of a ground water remediation system.

— where would the effluent be disposed of?

2.4 Data Use

After data from each stage of the proposed site investigation is completed, it will be analyzed to see that the data are sufficient in quality and quantity to support the feasibility study. Data gathered in the site investigations will be coupled with information from the RI

Report to refine the understanding of the nature and extent of hazardous substances in soil and ground water.

RMT will use many of the same methods presented in the Draft RI Report to analyze subsequent site investigations. These include the following:

- Evaluation of maximum, minimum, and mean constituent concentrations.
- Evaluation of time trends in constituent concentrations.
- Revision of geologic cross sections, water table and piezometric contour maps, ground water flow nets and contaminant concentration maps.
- Re-evaluation of the No-Action Alternative (Section 7, Interim Report, RMT 1987a) on the basis of new information collected during the proposed site investigations.

The data collected on aquifer properties will be incorporated into the Feasibility Study. The data will be used to specifically evaluate ground water extraction systems that could form part of several remedial alternatives (Section 8, Interim Report, RMT 1987a).

2.5 Reports

Following completion of each stage of site investigation and subsequent investigation analysis, RMT will prepare a summary report detailing the results of the investigation as well as recommendations for subsequent stages of site investigation (if any). Each of these summary reports will be distributed as outlined in Section 3.4 of this report.

Once the site investigation has been completed, RMT will prepare an Addendum Remedial Investigation Report covering tasks conducted as part of this investigation. The Addendum RI Report will also reassess the No-Action Alternative as presented in Section 7 of the Interim Report (RMT, 1987a) using the data obtained by the investigation. The Addendum RI will be distributed as outlined in Section 3.4.

-Seems like double work to me

3. PROJECT MANAGEMENT

3.1 Project Organization

An organizational chart for the Corps of Engineers and the RMT project team for the NIROP RI/FS is illustrated in Figure 4. The work proposed in this workplan will be treated as continuing phases of the RI. The designated Corps of Engineers' Project Manager is Tom Thiele, who will provide day-to-day management of the project and will serve as the primary contact between RMT and the Corps.

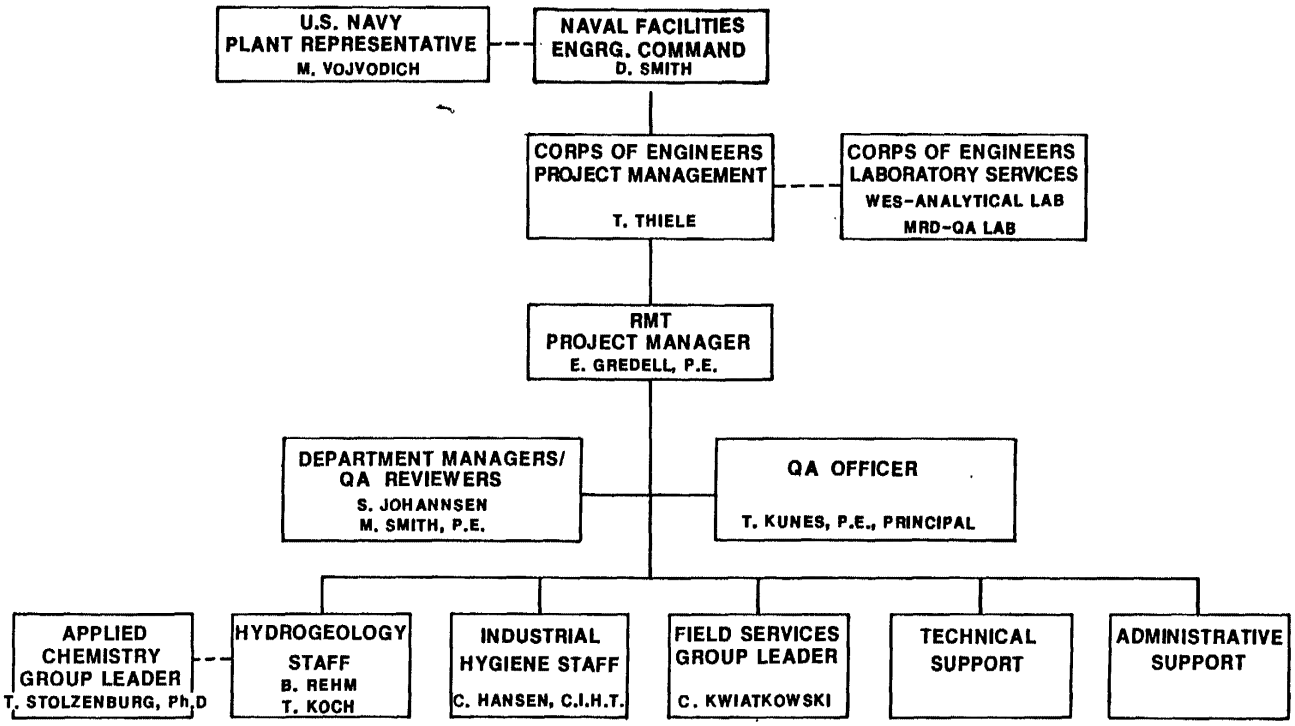
Eric Gredell will be the RMT Project Manager. RMT's project manager will provide day-to-day project oversight and will be the primary contact between RMT and the Corps. The remainder of the project team is composed of engineers, hydrogeologists, chemists, industrial hygienists, and support staff. This multi-disciplinary project team provides the mechanism for approaching this RI/FS in a systematic and comprehensive way.

In addition to the project team, RMT has developed quality assurance/quality control (QA/QC) procedures that provide a mechanism for a high quality product. The QA/QC procedure is integrated into the project at all staff levels. Quality control (QC) functions begin at the project team level where adherence to professional standards of practice are maintained.

The final level in the QA/QC program is quality assurance (QA) review. QA reviewers are senior consultants at RMT who are responsible for company-wide quality. The senior consultants' primary role is to provide consistency between different projects within the company. This is accomplished by making sure that proper QC review procedures have been followed throughout the project.

FIGURE 4

PROJECT ORGANIZATION



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3.2 Progress Reports

Monthly progress reports will be prepared by RMT to describe the technical progress of the project. These reports will include a discussion of the following items:

- Identification of site and activity.
- Status of work at the site and progress to date.
- Difficulties encountered during the reporting period.
- Actions being taken to rectify problems.
- Activities planned for the next month.
- Changes in personnel.

The progress report will list target and actual completion dates for each element or activity, including project completion, and will provide an explanation of deviations from the established schedule. The progress chart, which is developed in Section 4 of this report, will be updated and submitted each month in conjunction with the monthly progress report.

Monthly progress reports will be distributed according to the following Document Submittal List:

Corps of Engineers	Number of Copies
MROED-E Omaha, NE	4
MRDED-TG Omaha, NE	2
MRDED-L Omaha, NE	1
North Central Div. Chicago	2

U. S. Navy	
Philadelphia	4
Minneapolis	3
Minnesota Pollution Control Agency	
St. Paul	3

Monthly progress reports will be distributed by regular mail service.

3.3 Correspondence

Correspondence for this project will indicate the project name, project stage, and the contract number. A cover letter will accompany each document indicating not only the above information, but also the date comments are due, to whom the comments are to be submitted, and the date and location of the review conference, etc. as appropriate. The contents of cover letters associated with submittals will be coordinated with the Corps of Engineers' Project Manager prior to the submittal date.

3.4 Documents

Documents prepared as part of the RI/FS will be distributed as follows:

Corps of Engineers	Number of Copies
MROED-EA Omaha, NE	8
MRDED-TG Omaha, NE	3
MRDED-L Omaha, NE	1
North Central Div. Chicago	2

U. S. Navy	
Philadelphia	4
Minneapolis	3
Minnesota Pollution Control Agency	
St. Paul	3

Draft copies of reports will be distributed to the Corps of Engineers' Project Manager for review prior to distribution according to the above document submittal list.

Reports will be distributed by overnight delivery service. In addition, one reproducible, unbound copy of both reports will be provided to the Corps of Engineers.

3.5 Conference Notes and Confirmation Notices

Conference Notes

RMT will be responsible for taking and preparing notes from conferences. The notes will be typed and furnished to the Corps of Engineers within 5 working days after the date of the conference. After the Corps approves the conference notes, they will be distributed to attendees within 3 working days. Conference notes will include at a minimum the following:

- Date and location of the conference with a list of attendees. The roster of attendees will include name, organization, and telephone number.

- Written comments presented by attendees will be attached to each report with the conference action noted. Conference actions will be labeled as follows: "A" for approved comment; "D" for a disapproved comment; "W" for a comment that has been withdrawn; and "E" for a comment for which an exception has been noted. Technical comments annotated "T" are provided for consideration. Comments not incorporated are to be indicated as such with a brief explanation.

Confirmation Notices

RMT will provide a record of discussions, verbal directions, telephone conversations, etc. on contract matters. These records, which are entitled confirmation notices, will be numbered sequentially and will identify participating personnel, subject discussed, and conclusions reached. Once each week RMT will forward a reproducible copy of these confirmation notices to the Corps of Engineers' Project Manager. The government will distribute these notices. Staff at RMT will provide their individual copies of confirmation notices to the RMT Project Manager each week for submittal to the Corps of Engineers.

3.6 Notification of Site Visits

RMT will notify the Corps of Engineers' Project Manager at least 10 days prior to site visits or, when a 10-day notice is not possible, after deciding to visit the site. If RMT cannot contact the Corps of Engineers' Project Manager, the designated representative will be notified. RMT will also confirm site visits immediately beforehand. Telephone notification of both the site visit and confirmation of the site visit will be considered sufficient.

3.7 Project Records

At the completion of the project, RMT will provide the Corps of Engineers with a copy of records including correspondence, memoranda, trip reports, confirmation notices, sampling plans, test results, submittals, photographs, and other records or documents generated as a result of the project.

3.8 Contract Progress Reports

RMT will submit a progress report to the Corps of Engineers with each request for payment. The progress reports will indicate work performed, costs, and problems incurred during the payment period. Contract progress reports are for distribution to the Corps of Engineers only, and will not be distributed in the manner shown for the progress reports described in Section 3.2.

4. PROJECT SCHEDULE

The project schedule for the proposed field investigations is presented in Figure 5. This schedule will form the basis for the project progress chart which will be updated each month during the course of the project and will be submitted with the monthly progress reports. This progress chart will be revised to reflect any modifications or other approved changes in scheduling during investigations.

It is important that the first round of ground water monitoring in Stage II of the site investigation be conducted no later than early December. If the monitoring is conducted as scheduled, the analysis of the samples can be completed during the winter months. If the first round of samples cannot be collected as planned, the sample collection may have to be delayed until warmer weather returns to provide a reasonable probability that QC requirements for sampling can be met.

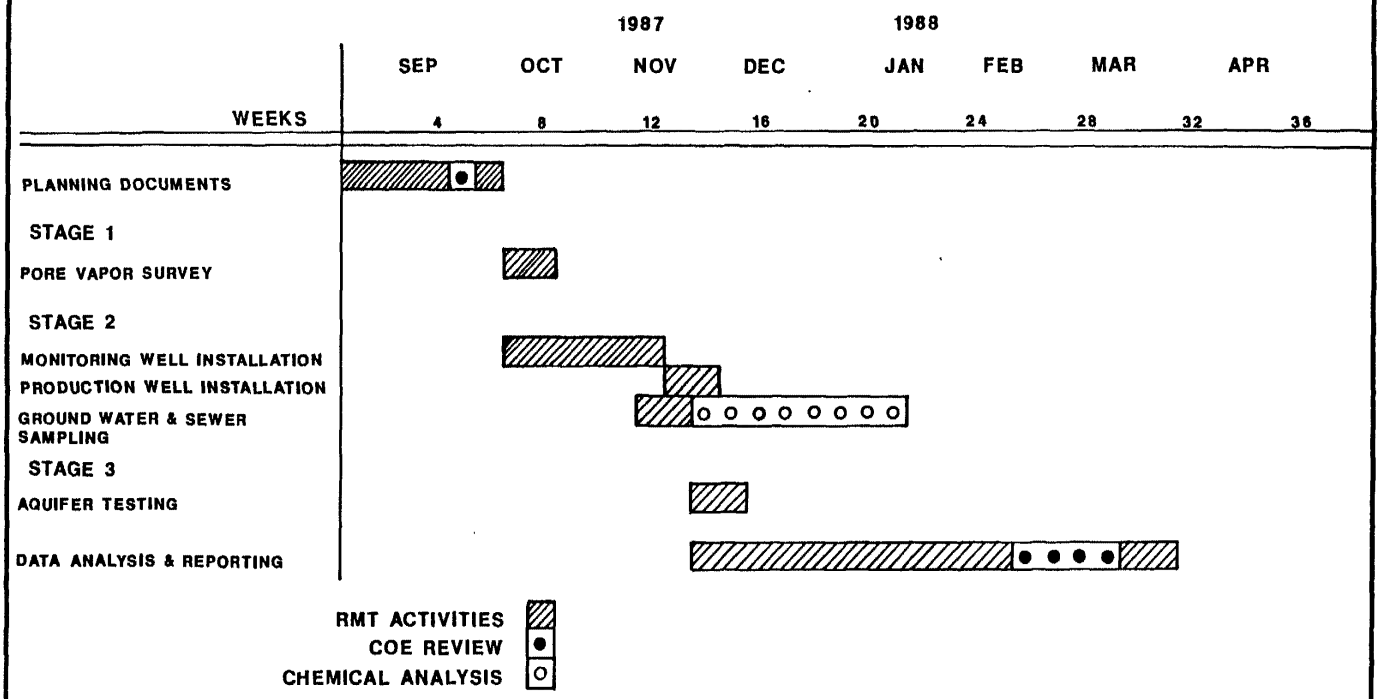

FIGURE 5 - PRELIMINARY SCHEDULE FOR PROPOSED ACTIVITIES

RMT INC

Dwn. by: MCS
Date: 6/87
Proj.#: 1254.02

5. REFERENCES

NIOSH. 1985. Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities. U.S. Department of Health and Human Services, Publ. No. 85-115.

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U.S. Army Corps of Engineers. 1985. Chemical Quality Management - Toxic and Hazardous Wastes. Draft ER 1110-1-263.

U.S. Army Corps of Engineers. 1983. Project Report of the Hazardous Waste Cleanup Site for the United States Navy at the Naval Industrial Reserve Ordnance Plant (NIROP) at Fridley, Minnesota.

U.S. Army Corps of Engineers. 1984. Safety and Occupational Health Document Requirements for Hazardous Waste Site Remedial Actions. ER 385-1-92.

USEPA. 1980. Interim Guidelines and Specifications for Implementing Quality Assurance Project Plans. QAMS-005/80, Office of Monitoring Systems and Quality Assurance, Washington, DC.

USEPA. 1983. Characterization of Hazardous Waste Sites - A Methods Manual, Volume II - Available Sampling Methods. EPA/600/4-83/040.

USEPA. 1984. Standard Operating Safety Guides. Office Energy and Remedial Response, Hazardous Response Division, Washington, DC.

USEPA. 1985a. Guidance on Remedial Investigations Under CERCLA. EPA/540/G-85/002.

USEPA. 1985b. Guidance on Feasibility Studies Under CERCLA. EPA/540/G-85/003.

USEPA. 1985c. Characterization of Hazardous Waste Sites - A Methods Manual, Volume I - Site Investigations. EPA/600/4-84/075.

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VOLUME I

REMEDIAL INVESTIGATION REPORT
FOR
REMEDIAL INVESTIGATION/FEASIBILITY STUDY
AT
NAVAL INDUSTRIAL RESERVE ORDNANCE PLANT
FRIDLEY, MINNESOTA

JUNE 1987

CONTRACT NO. DACA45-86-C-0015

Chris Hansen, CIHT
Industrial Hygienist

Thomas E. Koch
Project Hydrogeologist

Bernd W. Rehm
Hydrogeologist

Eric Gredell, P.E.
Project Manager

I hereby certify that this plan, specification, or report was prepared by me or under my direct supervision and that I am a duly Registered Professional Engineer under the laws of the State of Minnesota.

Date 6-24-87 Registration No. 013728

Thomas P. Kunes, P.E.
President, Northern Region

1254.03 139:RTA:frid0506a

EXECUTIVE SUMMARY

The Naval Industrial Reserve Ordnance Plant (NIROP) is located in an industrial area in the northern portion of the Minneapolis/St. Paul Metropolitan Area within the city limits of Fridley, Minnesota. Advanced naval weapons systems are designed and manufactured at the NIROP. The northern portion of the facility is government-owned and operated by a private contractor (FMC), and the remainder of the facility is owned independently by FMC.

The most significant natural resource near the facility is the Mississippi River. The City of Minneapolis water supply intake in the Mississippi River is less than one mile downstream from the NIROP. A portion of the Anoka County Islands of Peace Mississippi Riverfront Park is located west of the NIROP adjacent to the river.

Ground water use in the vicinity of the NIROP consists primarily of high capacity industrial production wells completed in the Prairie du Chien/Jordan (PCJ) aquifer system. The City of Fridley also maintains a backup well finished in the PCJ immediately north of the NIROP.

A highly permeable aquifer within unconsolidated Quaternary sediments overlies the PCJ in the vicinity of the NIROP. The unconsolidated aquifer is hydraulically separated from the PCJ by a silty to shaly basal bed of the St. Peter Sandstone except for an area where the St. Peter Sandstone has been eroded. The unconsolidated aquifer is in contact with the PCJ in the eroded area. The City of Minneapolis has plans to utilize the unconsolidated aquifer for a "Ranney" well system to serve as a backup to the Mississippi River surface water intake.

TABLE OF CONTENTS

Title	Page
EXECUTIVE SUMMARY	i
1. INTRODUCTION	1-1
1.1 Background	1-1
1.2 Purpose and Scope	1-1
2. INVESTIGATION SUMMARY	2-1
2.1 Site Background Information	2-1
2.1.1 Site Description	2-1
2.1.2 Chronology of Remedial Work and Investigations	2-4
2.1.3 Historical Description	2-6
2.1.4 Other Factors	2-9
2.2 Nature and Extent of the Problem	2-11
2.2.1 Special Waste Considerations	2-15
2.2.2 Effects of Contaminants from the Site	2-15
2.2.3 Near-Future Impacts of Site Conditions	2-15
2.3 Investigation Summary	2-16
2.4 Overview of Report	2-17
3. SITE FEATURES INVESTIGATION	3-1
3.1 Demography	3-1
3.2 Land Use	3-1
3.3 Natural Resources	3-1
3.4 Climatology	3-2
4. HAZARDOUS SUBSTANCES INVESTIGATION	4-1
4.1 Hazardous Substance Types	4-1
4.1.1 Raw Materials	4-2
4.1.2 Industrial Processes	4-5
4.1.3 Waste Storage Processing and Disposal Practices	4-7
4.2 Waste Component Characteristics and Behavior	4-30
4.2.1 Introduction	4-30
4.2.2 Behavior of Individual Compounds	4-31
4.2.3 Toxicology of Individual Compounds	4-35
5. SUBSURFACE INVESTIGATIONS	5-1
5.1 Soils	5-1
5.2 Geology	5-3
5.3 Ground Water	5-13
5.3.1 Ground Water Occurrence	5-13
5.3.2 Ground Water Flow	5-16
5.3.3 Data QA/QC Evaluation and Presentation	5-25
5.3.4 Evaluation of Constituents	5-34
5.3.5 Occurrence and Migration of Hazardous Substances in Ground Water	5-59

TABLE OF CONTENTS (Cont'd)

Title	Page
6. SURFACE WATER INVESTIGATION	6-1
6.1 Surface Water Characteristics	6-1
6.2 Ground Water/Surface Water Relationship	6-2
6.3 Surface Water Use	6-2
6.4 Surface Water Contamination	6-3
7. ASSESSMENT OF POTENTIAL IMPACT OF EXISTING GROUND WATER CONTAMINATION TO PUBLIC HEALTH	7-1
7.1 Introduction	7-1
7.2 Summary of Existing Conditions	7-1
7.3 Evaluation of the Impact of Existing Conditions to Public Health	7-4
7.3.1 Method of Evaluation	7-4
7.3.2 Deviations and Assumptions	7-4
7.3.3 Computation of Results	7-5
7.4 Evaluation of Possible Future Effects	7-7
8. REFERENCES	8-1
9. TERMINOLOGY GUIDE	9-1

List of Figures

Figure 2-1 - General Vicinities Map	2-2
Figure 2-2 - NIROP Facility Map	2-3
Figure 4-1 - Industrial Production Areas	4-6
Figure 4-2 - Soil Boring Locations Advanced in Trenches 3 and 6, June 1985	4-24
Figure 4-3 - Approximate Sanitary and Storm Sewer Systems at NIROP	4-26
Figure 5-1 - Geologic Cross Section A-A'	5-8
Figure 5-2 - Geologic Cross Sections B-B' and C-C'	5-9
Figure 5-3 - Approximate St. Peter Sandstone/ Prairie du Chien Contact	5-12
Figure 5-4 - Water Table in Unconsolidated Sediments	5-19
Figure 5-5 - Piezometric Surface Near the Base of the Unconsolidated Sediments	5-20
Figure 5-6 - Prairie du Chien Piezometric Surface	5-21
Figure 5-7 - Extent of TCE Contamination Shallow Alluvial Aquifer	5-61
Figure 5-8 - Decreases in TCE Since Excavation	5-66
Figure 7-1 - Risk Levels for Various Observed TCE Concentrations	7-6

TABLE OF CONTENTS

Title | Page

List of Tables

Table 4-1 - Summary of Waste Generated by Industrial Process Areas..... 4-8
Table 4-2 - Summary of Composite Analyses Performed on Drum Contents from Pit/Trench Area..... 4-15
Table 4-3 - Range of Constituent Values Detected in Soils from Pits and Trenches Upon Completion of Excavation..... 4-18
Table 4-4 - Summary of Concentration Ranges for MPCA-Required Volatile Organic Compound Analyses of Samples from One Foot Below Pit Bottoms.... 4-20
Table 4-5 - NIROP Soil Sampling Results of Borings Advanced at Pits 3 and 6, June 1985..... 4-22
Table 4-6 - Summary of Sanitary and Storm Sewer Effluent Analyses (from Hickok, 1981)..... 4-29
Table 4-7 - Water Solubilities and Densities of Selected Volatile Organic Compounds..... 4-33
Table 4-8 - Carcinogenicity of Volatile Organic Compounds..... 4-36
Table 4-9 - Acute Toxicities of Selected Volatile Organic Compoudns..... 4-37
Table 5-1 - General Geologic Column, Twin City Basin..... 5-4
Table 5-2 - NIROP Monitoring Well Construction Data..... 5-18
Table 5-3 - Vertical Gradients in NIROP Wells..... 5-23
Table 5-4 - Monitoring Well Installation and Sampling Dates..... 5-27
Table 5-5 - Percent Recovery for Spiked Samples from June 1985 and January-April 1986 Rounds..... 5-28
Table 5-6 - Relative Percent Difference (RPD) for Duplicate Samples from June 1985 and January-April 1986 Rounds..... 5-30
Table 5-7 - List of Constituents Detected in Monitoring Well Samples from the NIROP Site, Fridley, Minnesota..... 5-33
Table 5-8 - Concentrations of Dissolved Inorganic Constituents Detected in Ground Water Samples, November 1986..... 5-36
Table 5-9 - Summary of Inorganic Constituents Detected at Least One Time in Ground Water Samples from the NIROP Study Area..... 5-45
Table 5-10- Maximum and Mean Concentrations of Organic Constituents Detected in Ground Water Samples, October 1983 to November 1986..... 5-47
Table 5-11- Summary of Organic Constituents Detected at Least One Time in Ground Water at the NIROP Study Area..... 5-58

TABLE OF CONTENTS (Cont'd)

Title | Page

List of Tables (Cont'd)

Table 5-12- Summary of Constituents Detected or Reported on the NIROP Facility..... 5-63
Table 6-1 - Surface Water Trichloroethylene Analysis Results..... 6-4

List of Appendices

Appendix A - Chronological Summary of Constituents Detected in at Least One Sample from NIROP Water Chemical Analyses

Appendix B - Alphabetical Summary of Constituents Detected in at Least One Sample from NIROP Ground Water Analyses

Appendix C - Maximum and Mean Concentrations Detected in NIROP Ground Water Analyses

Appendix D - Constituents Added November 1986

In March 1981, an anonymous phone call to the MPCA led to the discovery of trichloroethylene (TCE) in three NIROP water supply wells finished in the PCJ. Grab samples obtained from NIROP storm sewer outfalls at the Mississippi River also showed contamination by TCE and other volatile organic compounds (VOCs) at that time. Subsequent sampling at the City of Minneapolis Mississippi River water intake also revealed measurable concentrations of TCE.

Investigations into potential problems at the NIROP began immediately by FMC Corporation. Two separate areas of concern were identified as the South Study Area (FMC-owned property) and the North Study Area (government-owned property) by Hickok and Associates (1981a). FMC pursued investigation of the south study area separately from the government-owned north study area. An agreement was recently reached between FMC and the MPCA for what Hickok had called the South Study Area. That agreement calls for pumping and discharging contaminated ground water to the Pig's Eye Waste Treatment Plant for treatment. Cleanup levels for the ground water have been set at 0.270 mg/l total VOCs. This Remedial Investigation Report details the Navy's efforts related to investigation of what Hickok (1981a) called the North Study Area, which is herein referred to as the NIROP.

On March 31, 1982, Naval officials implemented the Navy Assessment and Control of Installation Pollutants (NACIP) program to identify and control environmental contamination from past use and disposal practices. An Initial Assessment Study (IAS) was completed in June 1983 by Envirodyne Engineers, Inc. The IAS determined that drummed wastes had occasionally been buried in the northern portion of the NIROP and,

additionally, that the area beneath the NIROP building may be contributing to ground water problems. As a result of IAS recommendations, the Navy contracted the U.S. Army Corps of Engineers (COE) to continue investigations.

Through various geophysical and remote sensing techniques, nine areas were selected for excavation based on their liklihood for containing drummed wastes. These areas were excavated under COE direction in the fall of 1983. Forty-three excavated drums and underlying soils were found to contain VOCs, PCBs, oil and grease, pesticides, and metals. The 43 excavated drums and 1,200 cubic yards of soil were disposed at USEPA-approved landfills (U.S. Army Corps of Engineers, 1984).

Three phases of ground water monitoring well installation began in June 1983 under COE supervision. The current network consists of 33 monitoring wells installed under the COE's direction and 1 FMC-installed monitoring well. Wells have been finished in the shallow and deep portions of the unconsolidated aquifer as well as the PCJ aquifer. The monitoring well network has been used to determine physical and chemical characteristics of the unconsolidated and PCJ aquifers underlying the NIROP and some adjacent areas.

Analysis of information gathered during this investigation indicates the following:

- Ground water flow is from the northeast to the southwest across the NIROP site.
- Ground water in the shallow and deep portions of the unconsolidated aquifer at the NIROP has been contaminated by VOCs.

1. INTRODUCTION

1.1 Background

RMT, Inc., has been retained by the Omaha District of the U.S. Army Corps of Engineers to complete a Remedial Investigation Report for the Naval Industrial Reserve Ordnance Plant (NIROP) located in Fridley, Minnesota.

This Remedial Investigation Report is the culmination of the following specific tasks as described in the USEPA guidance documents on RI/FS under CERCLA:

- RI Task 1 - Description of Current Situation
- RI Task 4 - Analysis of Existing Data

Recommendations for additional data that need to be obtained to provide additional problem definition will be addressed in the Conceptual Workplan which outlines activities for the remainder of the RI/FS.

1.2 Purpose and Scope

The purpose of the Remedial Investigation Report is to use existing information to evaluate the impacts of past disposal practices on subsoils and ground water.

The scope of this report is limited to a review of existing information related to the NIROP site and surrounding areas which was developed by other consultants, the Corps of Engineers, and RMT. A list of previous investigations which formed the basis for this Remedial Investigation Report is as follows:

- Initial Assessment Study of Naval Industrial Reserve Ordnance Plant, Minneapolis, Minnesota, prepared by Envirodyne Engineers, Inc., for the Navy Assessment, June 1983.

- Draft NIROP Hazardous Waste Clean-Up Report prepared by the Corps of Engineers in October 1984, and finalized by RMT in September 1986.

- Ground water quality and ground water level measurement data collected by the Corps of Engineers from October 1983 to March 1986.

- Summary Report on Ground Water Conditions, FMC Northern Ordnance Division Plant, Minneapolis, Minnesota. 1983. S.S. Papadopulas and Associates, Inc.

- Final Report Phase I and Phase II Investigation Programs, Northern Ordnance Division FMC Corporation. 1984. S.S. Papadopulas and Associates, Inc.

- Evaluation of Remedial Action Alternatives, FMC and BNR Lands, Ground Water Regime, May 1985, Connestoga-Rovers & Associates Limited.

- Evaluation of Past Disposal Practices Phase I Intitial Assessment, April 1981, Eugiene A. Hickok and Associates.

- Evaluation of Past Disposal Practices Phase II Hydrogeological Investigation, Eugene A. Hickok and Associates, December 1981.

- Feasibility Study, FMC and BNR Lands, Ground Water Regime, January 1985, Connestoga-Rovers & Associates, Limited.

- Response Action Plan, Fridley, Minnesota, April 1985, Connestoga-Rovers & Associates, Limited.

2. INVESTIGATION SUMMARY

2.1 Site Background Information

2.1.1 Site Description

The Naval Industrial Reserve Ordnance Plant (NIROP) is operated by the Northern Ordnance Division of FMC Corporation and is involved with the manufacture of advanced naval weapon systems, including their development, design, engineering, and testing. The plant began production of naval guns in 1941. The plant has continued to produce naval guns and has expanded into the production of guided missile launching systems, torpedo tubes, and hydraulic and electric power drive and control systems.

The NIROP is located in the northern portion of the Minneapolis/St. Paul Metropolitan Area, within the city limits of Fridley, Minnesota. The plant is situated approximately one-quarter mile east of the Mississippi River and less than one mile south of Interstate 694. The plant is bordered on the west by the East River Road and on the east by the Burlington Northern railyard. A general vicinities map is included as Figure 2-1.

The government-owned, contractor-operated portion of the plant encompasses 82.61 acres. The remainder of the facility is owned and operated by FMC Corporation. Figure 2-2 shows the layout of the plant, delineating those areas owned by the Navy and those areas owned by FMC, as well as other site features referred to throughout the report. This report deals only with the government-owned portion of the facility.

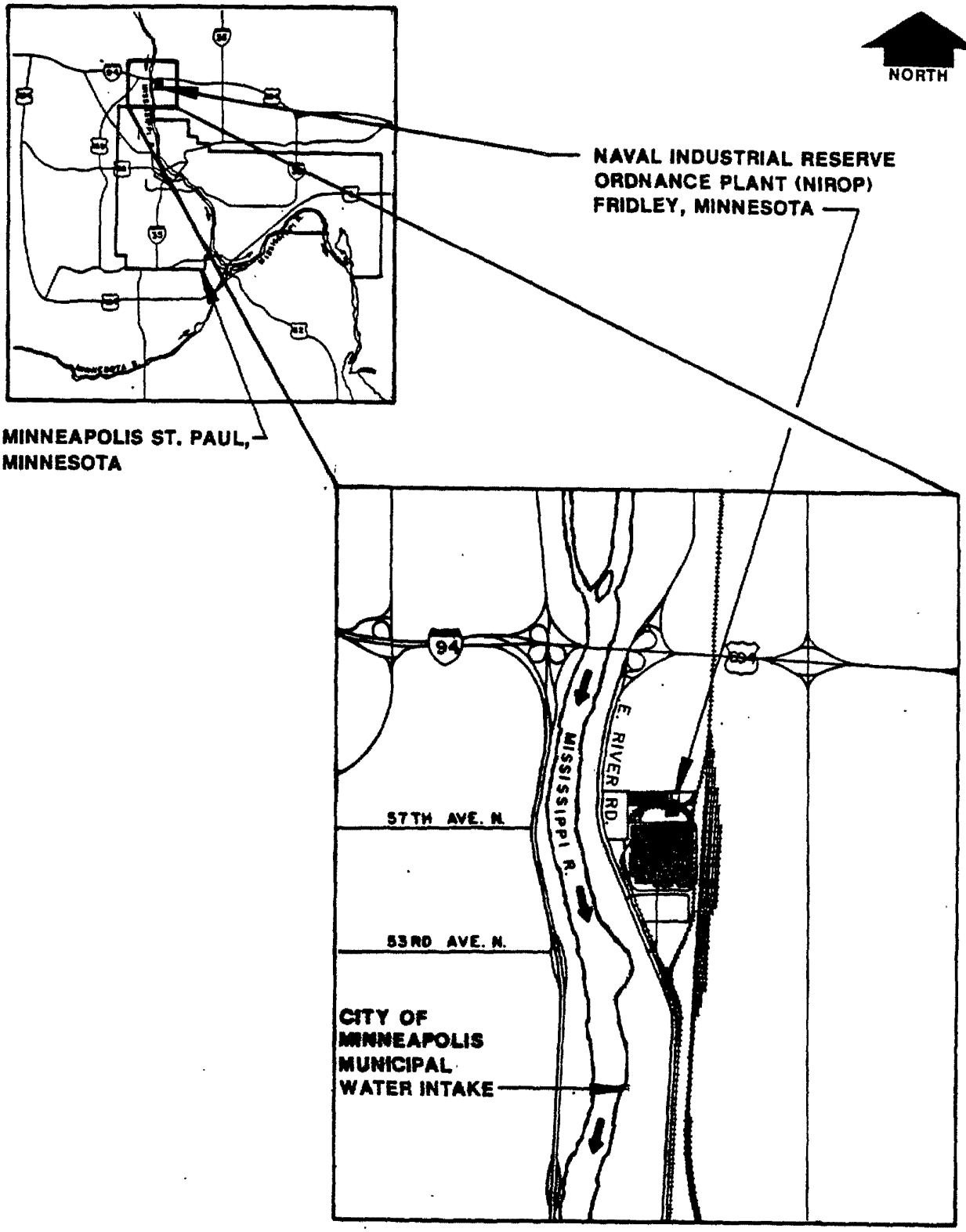

FIGURE 1

GENERAL VICINITIES MAP

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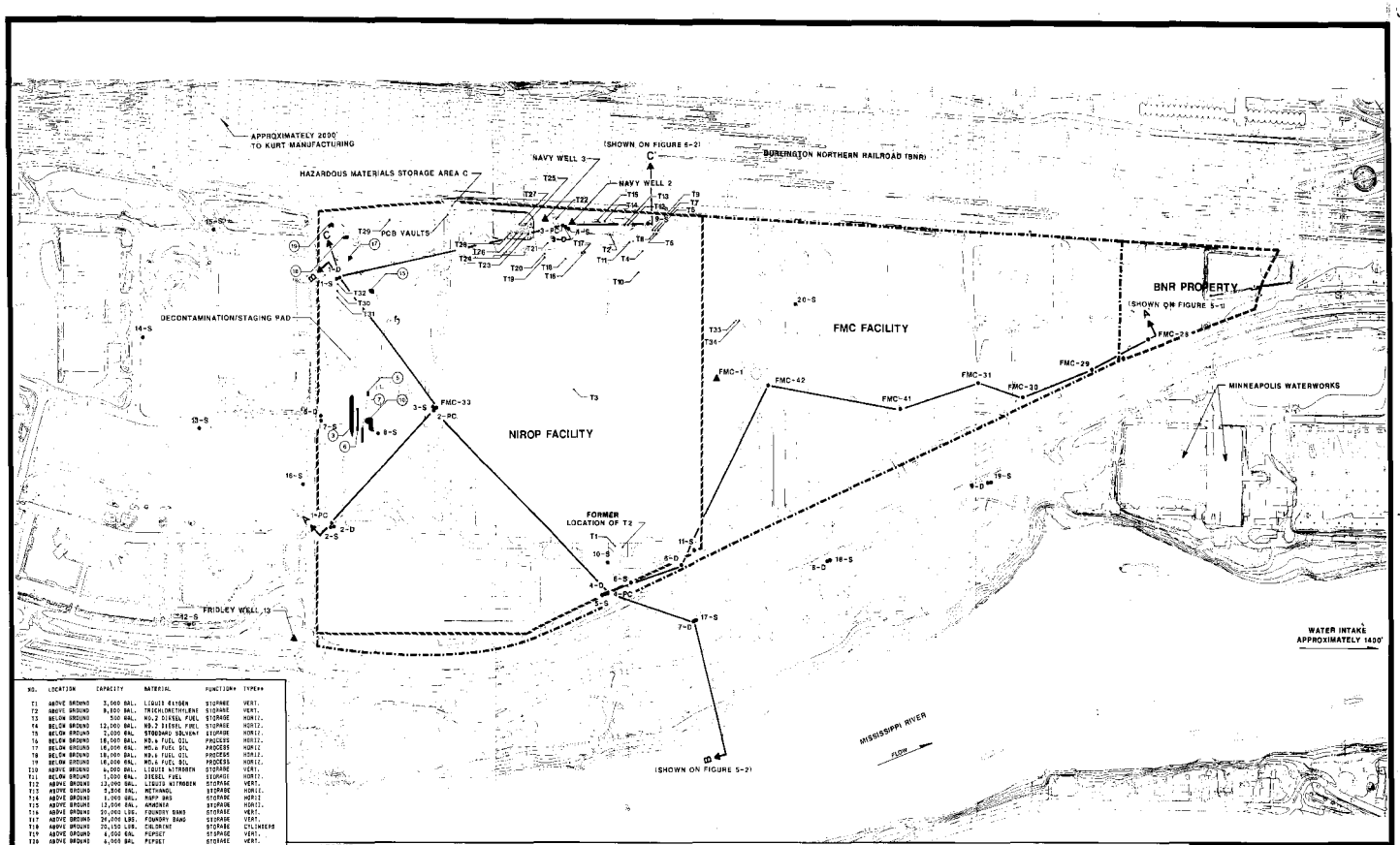

NO.	LOCATION	CAPACITY	MATERIAL	FUNCTION*	TYPE**
T1	ABOVE GROUND	3,000 GAL.	LIQUID NITROGEN	STORAGE	VERT.
T2	ABOVE GROUND	9,800 GAL.	TRICHLOROETHYLENE	STORAGE	VERT.
T3	BELOW GROUND	500 GAL.	NO.2 DIESEL FUEL	STORAGE	HORIZ.
T4	BELOW GROUND	12,000 GAL.	NO.2 DIESEL FUEL	STORAGE	HORIZ.
T5	BELOW GROUND	2,000 GAL.	STODDARD SOLVENT	STORAGE	HORIZ.
T6	BELOW GROUND	18,000 GAL.	NO.6 FUEL OIL	PROCESS	HORIZ.
T7	BELOW GROUND	18,000 GAL.	NO.6 FUEL OIL	PROCESS	HORIZ.
T8	BELOW GROUND	18,000 GAL.	NO.6 FUEL OIL	PROCESS	HORIZ.
T9	BELOW GROUND	18,000 GAL.	NO.6 FUEL OIL	PROCESS	HORIZ.
T10	ABOVE GROUND	4,000 GAL.	LIQUID NITROGEN	STORAGE	VERT.
T11	BELOW GROUND	1,000 GAL.	DIESEL FUEL	STORAGE	HORIZ.
T12	ABOVE GROUND	12,000 GAL.	LIQUID NITROGEN	STORAGE	VERT.
T13	ABOVE GROUND	3,800 GAL.	METHANOL	STORAGE	HORIZ.
T14	ABOVE GROUND	1,000 GAL.	RAFF BRS	STORAGE	HORIZ.
T15	ABOVE GROUND	12,000 GAL.	AMMONIA	STORAGE	HORIZ.
T16	ABOVE GROUND	30,000 LBS.	FOUNDRY SAND	STORAGE	VERT.
T17	ABOVE GROUND	30,000 LBS.	FOUNDRY SAND	STORAGE	VERT.
T18	ABOVE GROUND	20,150 LBS.	CHLORINE	STORAGE	CYLINDERS
T19	ABOVE GROUND	4,000 GAL.	PEPSIET	STORAGE	VERT.
T20	ABOVE GROUND	4,000 GAL.	PEPSIET	STORAGE	VERT.
T21	BELOW GROUND	2,000 GAL.	GASOLINE	STORAGE	HORIZ.
T22	ABOVE GROUND	100,000 GAL.	WATER	STORAGE	VERT.
T23	ABOVE GROUND	65,000 GAL.	NO.6 FUEL OIL	STORAGE	VERT.
T24	ABOVE GROUND	65,000 GAL.	NO.6 FUEL OIL	STORAGE	VERT.
T25	ABOVE GROUND	65,000 GAL.	NO.6 FUEL OIL	STORAGE	VERT.
T26	ABOVE GROUND	65,000 GAL.	NO.6 FUEL OIL	STORAGE	VERT.
T27	ABOVE GROUND	65,000 GAL.	NO.6 FUEL OIL	STORAGE	VERT.
T28	ABOVE GROUND	65,000 GAL.	NO.6 FUEL OIL	STORAGE	VERT.
T29	ABOVE GROUND	18,000 GAL.	PROPANE	STORAGE	HORIZ.
T30	ABOVE GROUND	17,303 GAL.	PROPANE	STORAGE	HORIZ.
T31	ABOVE GROUND	17,303 GAL.	PROPANE	STORAGE	HORIZ.
T32	ABOVE GROUND	17,303 GAL.	PROPANE	STORAGE	HORIZ.
T33	BELOW GROUND	1,000 GAL.	GASOLINE	STORAGE	HORIZ.
T34	BELOW GROUND	1,000 GAL.	GASOLINE	STORAGE	HORIZ.

* STORAGE, PROCESS, ETC.
** TANKS, BINS, SOUNDS, ETC.

TANK LOCATIONS FROM ENVIRODYNE, 1993

LEGEND

- EXISTING PAVED ROAD
- EXISTING UNPAVED ROAD
- EXISTING BUILDING
- EXISTING FENCE
- 935 EXISTING 5' CONTOUR
- EXISTING 1' CONTOUR
- 925' EXISTING SPOT ELEVATION
- TREES AND / OR BRUSH
- EDGE OF WATER
- WET AREA
- 16-S MONITORING WELL LOCATION
- WATER SUPPLY WELL
- T1 LOCATION AND NUMBER OF STORAGE TANKS (SEE SUMMARY TABLE)
- 3 EXCAVATED WASTE DISPOSAL PITS/TRENCHES
- NIROP PROPERTY LINE (APPROXIMATE)
- FMC PROPERTY LINE (APPROXIMATE)
- A A' GEOLOGIC CROSS SECTIONS

BASE MAP PROVIDED BY CORPS OF ENGINEERS, DATE OF SURVEY AND DATUM UNKNOWN. MONITORING WELL LOCATIONS ARE APPROXIMATE, BASED ON PROXIMITY TO LANDMARKS.

SCALE 1" = 200'
0 200 400 600 FEET

NO.	BY	DATE	REVISION	APPD.
1.				
2.				
3.				

PROJECT: INTERIM REPORT RI/FS AT NIROP FRIDLEY, MINNESOTA

SHEET TITLE: NIROP FACILITY MAP

DRAWN BY: JWM MDZ | SCALE: 1" = 200' | PROJ. NO. 1128.02
CHECKED BY: | DRAWG. NO.
APPROVED BY: | DATE PRINTED:
DATE: 4/19/97

FIGURE 2-2

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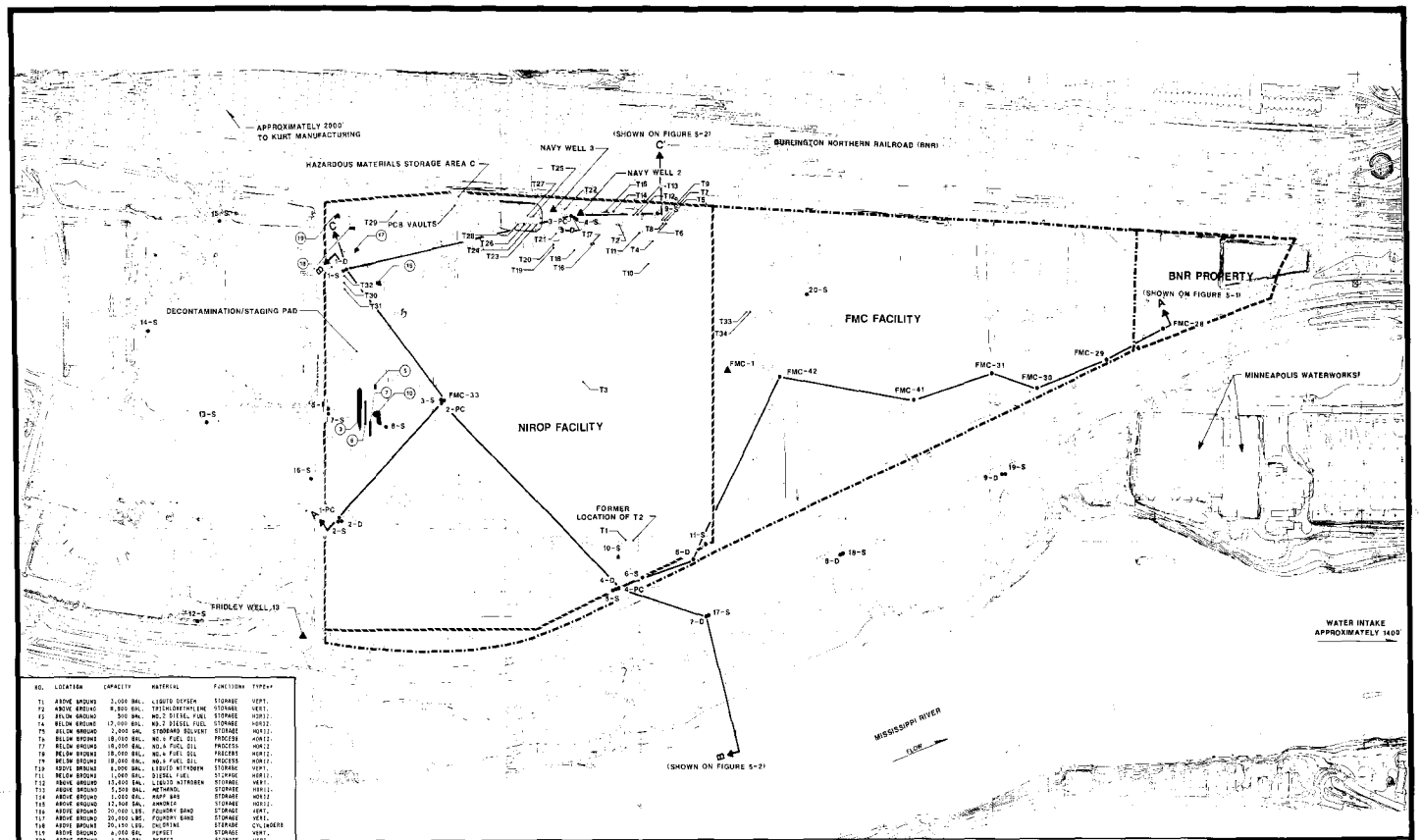
Madison, WI 53713
Phone: 608-251-4843

CONTRAC 3-86-C-0016

ANOKA COUNTY LIBRARY



NO.	LOCATION	CAPACITY	MATERIAL	FUNCTION*	TYPE**
T1	ABOVE GROUND	2,000 GAL.	LIQUID OXYGEN	STORAGE	VERT.
T2	ABOVE GROUND	8,000 GAL.	TRICHLOROETHYLENE	STORAGE	VERT.
T3	BELOW GROUND	300 GAL.	NO.2 DIESEL FUEL	STORAGE	HORIZ.
T4	BELOW GROUND	17,000 GAL.	NO.2 DIESEL FUEL	STORAGE	HORIZ.
T5	BELOW GROUND	2,000 GAL.	STODDARD SOLVENT	STORAGE	HORIZ.
T6	BELOW GROUND	18,000 GAL.	NO.6 FUEL OIL	PROCESS	HORIZ.
T7	BELOW GROUND	18,000 GAL.	NO.6 FUEL OIL	PROCESS	HORIZ.
T8	BELOW GROUND	18,000 GAL.	NO.6 FUEL OIL	PROCESS	HORIZ.
T9	BELOW GROUND	18,000 GAL.	NO.6 FUEL OIL	PROCESS	HORIZ.
T10	ABOVE GROUND	8,000 GAL.	LIQUID NITROGEN	STORAGE	VERT.
T11	BELOW GROUND	1,000 GAL.	DIESEL FUEL	STORAGE	HORIZ.
T12	ABOVE GROUND	13,600 GAL.	LIQUID NITROGEN	STORAGE	VERT.
T13	ABOVE GROUND	5,000 GAL.	METHANOL	STORAGE	HORIZ.
T14	ABOVE GROUND	1,000 GAL.	MAPP GAS	STORAGE	HORIZ.
T15	ABOVE GROUND	12,000 GAL.	AMMONIA	STORAGE	HORIZ.
T16	ABOVE GROUND	20,000 LBS.	FOUNDRY SAND	STORAGE	VERT.
T17	ABOVE GROUND	20,000 LBS.	FOUNDRY SAND	STORAGE	VERT.
T18	ABOVE GROUND	20,100 LBS.	CHLORINE	STORAGE	CYLINDERS
T19	ABOVE GROUND	4,000 GAL.	PEPSICI	STORAGE	VERT.
T20	ABOVE GROUND	4,000 GAL.	PEPSICI	STORAGE	VERT.
T21	BELOW GROUND	2,000 GAL.	GASOLINE	STORAGE	HORIZ.
T22	ABOVE GROUND	100,000 GAL.	WATER	STORAGE	VERT.
T23	ABOVE GROUND	65,000 GAL.	NO.4 FUEL OIL	STORAGE	VERT.
T24	ABOVE GROUND	65,000 GAL.	NO.4 FUEL OIL	STORAGE	VERT.
T25	ABOVE GROUND	65,000 GAL.	NO.6 FUEL OIL	STORAGE	VERT.
T26	ABOVE GROUND	65,000 GAL.	NO.6 FUEL OIL	STORAGE	VERT.
T27	ABOVE GROUND	65,000 GAL.	NO.6 FUEL OIL	STORAGE	VERT.
T28	ABOVE GROUND	65,000 GAL.	NO.6 FUEL OIL	STORAGE	VERT.
T29	ABOVE GROUND	90,000 GAL.	PROPANE	STORAGE	HORIZ.
T30	ABOVE GROUND	17,000 GAL.	PROPANE	STORAGE	HORIZ.
T31	ABOVE GROUND	17,000 GAL.	PROPANE	STORAGE	HORIZ.
T32	ABOVE GROUND	17,000 GAL.	PROPANE	STORAGE	HORIZ.
T33	BELOW GROUND	1,000 GAL.	GASOLINE	STORAGE	HORIZ.
T34	BELOW GROUND	1,000 GAL.	GASOLINE	STORAGE	HORIZ.

* STORAGE, PROCESS, ETC.
** TANKS, BINS, DRUMS, ETC.

TANK LOCATIONS FROM ENVIRODYNE, 1983

LEGEND

- EXISTING PAVED ROAD
- EXISTING UNPAVED ROAD
- EXISTING BUILDING
- EXISTING FENCE
- EXISTING 5' CONTOUR
- EXISTING 1' CONTOUR
- 4893 EXISTING SPOT ELEVATION
- TREES AND OR BRUSH
- EDGE OF WATER
- WET AREA
- 14-S MONITORING WELL LOCATION
- WATER SUPPLY WELL
- T1 LOCATION AND NUMBER OF STORAGE TANKS (SEE SUMMARY TABLE)
- 3 EXCAVATED WASTE DISPOSAL PITS/TRENCHES
- NIROP PROPERTY LINE (APPROXIMATE)
- FMC PROPERTY LINE (APPROXIMATE)
- A A' GEOLOGIC CROSS SECTIONS

BASE MAP PROVIDED BY COURT OF ENGINEERS, DATE OF PHOTO AND OVERLAY UNKNOWN. MONITORING WELL LOCATIONS ARE APPROXIMATE, BASED ON PROXIMITY TO LANDMARKS.

SCALE: 1" = 200'
0 200 400 800 FEET

NO.	BY	DATE	REVISION	APPR.
3				
2				
1				

PROJECT: RI/FS AT NIROP FRIDLEY, MINNESOTA

SHEET TITLE: NIROP FACILITY MAP

DRAWN BY: JMM MDZ | SCALE: 1"=200' | PROJ. NO. 1126.03
CHECKED BY: | DATE PRINTED: | DWNG. NO.
APPROVED BY:
DATE: 4/15/87

FIGURE 2-2

RMT

CONTRACT NO. DACA45-88-C-0055

ANOKA COUNTY LIBRARY

2.1.2 Chronology of Remedial Work and Investigations

In 1981, an anonymous phone call to the Minnesota Pollution Control Agency (MPCA) led to concern over waste disposal practices at the NIROP facility.

Subsequently, on March 16, 1981, and April 23, 1981, Navy water supply wells 2 and 3 and FMC well 1 (Figure 2-2) were tested and found to contain trichloroethylene (TCE) at concentrations ranging from 0.035 mg/l to 0.200 mg/l. The wells were finished in the Prairie du Chien/Jordan aquifer and were being used as a potable water supply. The wells were shut down on April 24, 1981.

Sampling in 1981 at the Minneapolis water supply intake, approximately 1 mile downstream in the Mississippi River (Figure 2-2), revealed the unquantifiable presence of TCE during 4 sampling rounds. On December 31, 1981, the first quantifiable concentration (0.0012 mg/l) of TCE was detected at the water supply intake (Envirodyne, 1983).

On March 31, 1982, naval officials implemented the Navy Assessment and Control of Installation Pollutants (NACIP) Program to identify and control environmental contamination from past use and disposal of hazardous substances at Navy and Marine Corps installations. The NACIP Program is part of the Department of Defense Installation Restoration Program, and is similar to the Environmental Protection Agency's "Superfund" Program authorized by the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 and the Superfund Amendments Reauthorization Act of 1986.

Under the NACIP Program, Envirodyne Engineers completed an Initial Assessment Study (IAS) in 1983. The IAS team collected and evaluated

evidence of contamination that could pose a potential threat to human health or the environment. The IAS included a review of archival and facility records, interviews with personnel, and an on-site survey of the facility.

The IAS team discovered that, in previous years, the storage yard in the northern portion of the site had been used for disposing of drummed waste by burial in 8- to 10-foot-deep trenches or in pits (Figure 2-2).

IAS recommendations for the NIROP included the following:

- The use of geophysical techniques to locate and define the boundaries of waste burial areas.
- Excavation and proper disposal of wastes from located waste disposal areas.
- Installation of numerous monitoring wells to detect the presence of ground water contamination emanating from suspected NIROP source areas.

Initial remedial action cleanup activities began in November, 1983 as a result of IAS recommendations. Under the supervision of the U.S. Army Corps. of Engineers, nine areas were excavated (Figure 2-2), and approximately 1,200 cubic yards of soil and 43 drums were removed. The majority of the drums contained inert solids; others contained PCB wastes, flammable solids, base solids and inert liquids. Four of the drums were empty (U.S. Army Corps of Engineers, 1984). The hazardous soils and drums were disposed in an EPA-approved landfill. Samples were then taken of the soils beneath the excavations and analyzed for volatile organic compounds (VOCs) and PCBs. Soil samples beneath three trenches contained total VOC's above 1 mg/l; however, no further testing

was done at that time. The trenches were backfilled with clean fill, and removal activities were completed in March, 1984.

Phased installation of ground water monitoring wells began in the fall of 1983. To date, 34 wells have been installed as part of the NIROP ground water monitoring network. Wells have been completed in the shallow and deep portions of an unconfined aquifer in the Quaternary sediments as well as in the Prairie du Chien bedrock aquifer. Eight rounds of ground water sampling have been conducted at the NIROP since October 1983.

2.1.3 Historical Description

Facility Type. The NIROP dates back to 1940 when Northern Pump Company negotiated with the Navy for the construction of a new manufacturing plant. Northern Pump had been under defense contracts to the Navy throughout the 1930's. These defense contracts eventually reached a level where Northern Pump's existing plant in Minneapolis was inadequate. An arrangement was made to construct a new plant. The arrangement was unique in that the plant was partly owned by the government and partly owned by Northern Pump Company. The site chosen for the plant was a corn field just north of the Minneapolis city limits, within the Township of Fridley. The new plant was completed in just 60 days, with machinery, office equipment, and records moved intact by flat car from the old plant. By January 1941, the plant was in full production.

In June 1942, Northern Pump Company established Northern Ordnance, Incorporated, as an operating subsidiary to conduct the government

early 1970s, small burnable material was processed in the NIROP incinerator. Incinerator ash was, in turn, hauled to a disposal area off Navy property.

Hazardous wastes are currently placed in 55-gallon drums for disposal off Navy property by a contractor. On the average, approximately 30 drums per month were disposed of since the early 1970s. Before 1973, industrial wastes such as paint sludge and chlorinated solvents were typically disposed in landfills off Navy property. Limited disposal of these materials also occurred on Navy property in the early 1970s. These materials were placed in on-site pits or trenches in the northern portion of the NIROP property.

The NIROP has one on-site industrial wastewater treatment plant for handling chemical wastes from the plating shop. Plant sanitary wastewater, and both treated and untreated industrial wastewater, are discharged to the sanitary sewer system.

Incidents. No serious incidents (fire, explosion, etc.) have been reported at the NIROP facility. Several spills of various materials including acids, paints, solvents, fuel oil, and gasoline have occurred in varying quantities. Records of spills which occurred in 1984, 1985, and 1986, have been incorporated into this report. Records were not available prior to 1984.

Site Investigations and Regulatory Violations. Investigations of the NIROP were instigated by the discovery of TCE in the Navy wells on the NIROP facility and at the City of Minneapolis water intake in the nearby Mississippi River. The investigation began with the Initial Assessment Study (Envirodyne Engineers, 1983). Subsequently, excavation

of on-site buried drummed wastes has been completed under COE supervision. Additionally, 34 monitoring wells have been installed to date and eight rounds of ground water sampling have been completed.

A Request for Response Action (RFRA) was issued to the Navy by the Minnesota Pollution Control Agency in May 1984. The obligation to take response action required a Remedial Investigation/Feasibility Study (RI/FS) be completed by the Navy.

2.1.4 Other Factors

Planned Use. The NIROP facility has been operating at its present location since 1941. No plans to change that operation are known at this time.

Conflicting or Missing Information. Certain areas of this investigation contain conflicting or missing information. Specific problem areas include the following:

- The IAS (Envirodyne, 1983) reported that between 50 to 100 drums of waste were disposed in two trenches on the northern portion of the NIROP facility. Two additional pits reportedly received 25 drums each. The number of drums disposed, as well as burial locations, was based on employee recollection and hearsay. After review of file information and aerial photographs, as well as completion of a field geophysical survey, nine areas were selected for excavation with MPCA concurrence. Subsequently, 43 drums were removed from 2 of the 9 excavated areas. Although a discrepency exists between the number of drums reportedly disposed and the number recovered, the COE is confident that the drum removal project was successful.

- Documentation of the excavation of Pit 5 as performed indicates that the true area to be excavated was approximately 40 feet east of the area indicated on Drawing 3 of 3 in the Project Report of the Hazardous Waste Cleanup Site (COE, 1986). This discrepancy was brought to the attention of the COE. Subsequent investigation by the COE indicated that Drawing 1 of 3 from the Project Report (COE, 1986) shows an incorrect planned location for Pit 5 excavation. The COE

indicated that the actual excavation area for Pit 5 was the correct location. No information is available regarding why the planned location for Pit 5 was shown incorrectly on Drawing 1 of 3. The decision to locate the actual Pit 5 excavation 40 feet west of the planned location was reportedly made in the field by the COE during the excavation work, based on additional field measurements.

- Total volatile organic compound concentrations detected in soils in Pit 7 exceeded 1 part per million (ppm). - The COE (1984) indicated that MPCA guidelines established backfilling requirements of 1 ppm and that only trenches number 3 and 6 exceeded the guideline. Subsequent review of soils analytical data show that TCE was detected in Pit 7 at 1.3 mg/kg (ppm).

- Conflicting information exists regarding underground tanks in the vicinity of well 9-S. - The Initial Assessment Study (IAS) (Envirodyne, 1983) shows the location of both above- and below-ground tank locations. Figure 2-2 of this report was adapted from IAS information. Recently received information from FMC labeled "Enclosure (15) One General Arrangement Plan Drawing - Present Status" (not otherwise labeled or dated) shows at least one and possibly two additional 2,000-gallon underground tanks in the vicinity of 9-S. An April 9, 1987, letter from the FMC Environmental Manager states that one of these two tanks currently contains mineral spirits and that the other tank was abandoned at an unknown date. Prior uses of these two tanks, which were installed in the 1950s, is unknown.

- Data regarding ground water quality in the deeper portions of the unconfined aquifer is lacking in some locations.

- Ground water data for xylene are sparse in the immediate area of the pits/trenches. Xylene was detected in a significant quantity (39 percent by weight) in drums removed from the pit/trench area. Xylene was not analyzed in soil samples obtained from the pits/trenches and has been analyzed only once (November, 1986) in ground water. Therefore, conclusions regarding the presence or absence of xylene in ground water cannot be made at this time.

- A subsurface investigation of the dry well in Hazardous Waste Storage Area C revealed VOCs and metals in soils and potentially in ground water. There are no monitoring wells located downgradient of Hazardous Waste Storage Area C.

- The only known sampling of the storm sewer outfalls to the Mississippi River were reported by Hickok (1981). Current sampling data would be useful to look at VOC loading to the Mississippi River.

2.2 Nature and Extent of the Problem

Results of this investigation indicate that multiple sources of ground water contamination exist in the vicinity of the NIROP, and that contaminant sources include NIROP activities as well as undefined off-site sources. The degree of off-site contribution has not been determined at this time but may be significant. Contaminated ground water from these sources apparently has migrated to the Mississippi River. Trichloroethylene (TCE) has been detected at the City of Minneapolis drinking water intake less than one mile downstream from the NIROP.

Contaminants detected in ground water are primarily volatile organic compounds (VOCs). This investigation has determined that TCE is the best indicator of ground water contamination within the study area.

The following key items which have been developed in Sections 4, 5, 6, and 7 are presented in support of the above statements:

1. Ground water use in the vicinity of the NIROP consists primarily of industrial production wells completed in the Prairie du Chien/Jordan bedrock aquifer. Shallow ground water use was reported by Papadopulos (1983) as consisting of two farm wells; one north and west of the NIROP (upgradient), and one about 900 feet south and west of the NIROP. The present condition of these wells is unknown; however, they appear to be located in what is now a county park and therefore, may no longer exist.

2. Thirty-three ground water monitoring wells have been installed at the NIROP site under the direction of the COE. One additional well (FMC-33), installed as part of the FMC Study, has been used for this study. Data from well borings have yielded the following geologic findings:

   - Unconsolidated silty sand, gravelly sand, sandy gravel or gravel was found in nearly all borings.

   - Clay, silty clay, sandy clay or clayey silt lenses were observed in several borings at various depths. These lenses appear to be discontinuous across the site. Underneath the adjacent FMC site these clay deposits are apparently continuous.

- Underneath the alluvial deposits is the St. Peter Sandstone which is 37 feet thick at the northern property line and not present near the southern property line. Where present, the St. Peter Sandstone acts as a confining layer above the underlying Prairie du Chien Dolomite. The lack of continuous confining layers in the alluvial aquifer and above the bedrock means that contaminants could potentially migrate throughout the alluvial aquifer and into the bedrock aquifer.

3. Numerous rounds of ground water elevations have been obtained from the NIROP monitoring wells. The following findings have been developed from this data.

   - Ground water flow in the shallow and deep portions of the alluvial aquifer is generally to the southwest or west toward the Mississippi River with horizontal hydraulic gradients that vary from 0.0005 ft/ft to 0.014 ft/ft. Average linear ground water velocities for these gradients would range from 40 to 1,100 ft/yr, assuming hydraulic conductivities estimated by Papadopulos (1984) and porosities from Freeze and Cherry (1979). This movement of contaminants in the shallow aquifer would take approximately 0.5 years to travel from the western property boundary of the NIROP site to the Mississippi River.

   - Flow in the bedrock (Prairie du Chien) aquifer is also to the southwest (toward the Mississippi River) with horizontal hydraulic gradients of 0.0008 ft/ft. The average linear ground water flow velocity for this gradient, assuming hydraulic conductivities estimated by Kanivetsky (1979) and a porosity from Freeze and Cherry (1979), is 67 feet/year. In the bedrock aquifer it would take approximately 15 years to travel the same distance. This evaluation assumes typical gradients and flow distances and no attenuation of the constituents.

   - In general, vertical hydraulic gradients in the alluvial aquifer are near zero, except in those areas where clay lenses exist and the vertical gradients are downward. Vertical gradients between the deep alluvial aquifer and the bedrock (Prairie du Chien) aquifer are generally upward and increase in the vicinity of the Mississippi River, which is the regional discharge for both the alluvial and bedrock aquifers.

4. Ground water quality on the basis of the eight sampling rounds and water quality analyses performed can be summarized as follows:

   - Inorganics - Prior to November 1986, only total concentrations (unfiltered samples) were reported and the data suggested that significant concentrations of inorganic constituents could be found in the ground water. The samples collected in November 1986 had total concentrations fairly consistent with previous results. However dissolved concentrations (filtered samples)

were analyzed for the first time and were considerably lower, indicative of the fact that much of the inorganic concentrations were associated with sediments in the samples. Sediment that is transported by ground water is not generally consumed. Of the dissolved inorganic concentrations detected only three constituents exceeded federal standards; manganese, sulfate and selenium. Of these constituents, manganese and sulfate both exhibited concentrations in excess of SMCLs in both background wells and downgradient wells and therefore are not associated with activities at the NIROP.

Selenium in a sample from well 9-S (0.49 mg/l) is the only dissolved inorganic constituent detected in ground water above an MCL. Since well 9-S is located along the eastern (upgradient) edge of the NIROP facility, it is possible that selenium detected in well 9-S is related to an off-site source.

- PCBs - PCBs were detected in several wells at concentrations near the detection limit. PCB Aroclors varied between sampling rounds as did the locations where PCBs were detected. Although PCBs were detected in drums and soils in the pit/trench disposal area, they were not detected in wells immediately downgradient. Low confidence in the reported values (near detection limits) and the lack of spatial or temporal patterns suggests that PCBs are not of concern in the ground water.

- Organics - The primary organic compound detected in ground water on the NIROP site is TCE. Other organic compounds occur at much lower concentrations than TCE. 1,2-Dichloroethylene isomers (breakdown products of TCE) appear to be correlated with the occurrence of TCE. Tetrachloroethylene, 1,1 dichloroethane, and 1,1,1 trichloroethane also generally occur in the same areas as TCE, but at much lower concentrations. TCE has been detected in background wells 15-S and 16-S (Figure 2-2) at concentrations as high as 0.017 mg/l and 0.17 mg/l, respectively.

  1,1 Dichloroethylene has been detected in well 9-S only, and thus, exhibits a distinctive distribution pattern. The balance of organic compounds detected in ground water were detected at insignificant concentrations or demonstrated no obvious source areas.

5. Raw materials used and thus wastes generated at the NIROP include chlorinated and non-chlorinated solvents, acids, bases, metal conditioners, stripping and cleaning agents, paints, and photographic chemicals.

6. Data for the years 1984 through 1986 indicate leaks and spills of various raw materials, including TCE, have occurred at the NIROP and that spilled materials have entered both the storm and sanitary sewer systems. It is likely that activities prior to 1984 resulted in a similar frequency of spills, type of spilled materials, and spill volume.

7. Past NIROP waste disposal practices included occasional burying of drummed wastes in pits and trenches in the northern portion of the facility property. Identification and removal of the drummed wastes were undertaken by the Navy to remediate conditions. Hazardous substances were detected in 39 of 43 drums excavated. Hazardous substances identified in drums and underlying soils in the pits and trenches included VOCs, PCBs, pesticides, and metals. VOCs were the only hazardous substance detected in drums and soils which have been detected in shallow ground water downgradient of the disposal area in significant concentrations. The mix of VOCs detected in wells immediately downgradient of the pit/trench drum disposal area (3-S, FMC-33, and 8-S) included TCE, 1,1,1 trichloroethane, 1,2 dichloroethylene and tetrachloroethylene. Of these VOCs, TCE was detected most often and in the highest concentrations. TCE concentrations declined dramatically upon completion of drum excavation and then leveled off in wells 3-S and FMC-33. However, an increase in TCE concentrations has been noted in well 8-S in the November 1986 sampling round. The cause of this increase is unknown. Evaluation of the deep alluvial aquifer in this area would require an additional well(s).

8. TCE-contaminated ground water was detected to the north and east (upgradient) of the NIROP in shallow alluvial wells 15-S and 16-S. Evaluation of the deep alluvial aquifer in this area was not possible since there are no deep wells. Detection of TCE upgradient of the facility at these locations suggests that a separate contaminant source exists which is not on the NIROP property.

9. Ground water contamination by a similar mix of contaminants as those detected in wells downgradient of the pit/trench area was detected in shallow alluvial well 9-S along the eastern NIROP property boundary. 1,1, Dichloroethane and selenium (in excess of the MCL) were also detected in well 9-S. Due to the location of well 9-S, relative to ground water flow and potential on-site sources, as well as the detection of 1,1 dichloroethane and selenium, an off-site source of contamination east or northeast of well 9-S is suggested. Evaluation of the deep alluvial aquifer near well 9-S would require an additional well(s).

10. A fourth area of contamination was indicated on the southwestern portion of the NIROP facility near wells 10-S, 6-S, 11-S, and 17-S. Constituents detected in well 10-S indicate a pure TCE source, while those in well 6-S indicate a mix similar to those previously discussed. An above-ground TCE tank formerly located near well

10-S or its distribution system may be the source of this problem. Over 13,000 gallons of TCE per year are used at the NIROP. Although the contaminants detected in well 6-S may be an extension of the plume from the pit/trench area, the building envelope including leaks from the storm and sanitary sewers are also potential sources.

11. Soil and water samples obtained from a dry well in Hazardous Waste Storage Area C (Figure 2-2) indicated the presence of TCE, 1,1,1 trichloroethane, 1,2 dichloroethylene, tetrachloroethylene, toluene, xylene, and ethylbenzene as well as chromium, lead, and cadmium. There are no monitoring wells downgradient of Hazardous Waste Storage Area C; thus, no conclusions regarding the possible spread of contaminants from this area can be made.

2.2.1 Special Waste Considerations

Production of naval ordnance has always been the primary focus at the NIROP. No ammunition production or loading operations were conducted at the facility. Additionally, the only radioactive source used at the facility was removed from service and shipped to the Barnwell Waste Management Facility, Barnwell, South Carolina, in December 1982.

2.2.2 Effects of Contaminants from the Site

Hazardous substances have migrated from the site to the surface waters of the Mississippi River. No adverse effects from these substances have been reported or observed. Likewise, no vegetative stress or aquatic problems have been reported or observed.

2.2.3 Near-Future Impacts of Site Conditions

The City of Minneapolis has proposed to install wells in the alluvial aquifer near the NIROP facility. These wells would supplement current sources during peak demand. A hydrogeologic investigation of

the alluvial aquifer has been completed by the Ranney Company (1978). Definitive plans and a completion date for this project are not known at this time.

2.3 Investigation Summary

The initial investigation of conditions at the NIROP was performed in 1981 by Hickok and Associates under contract to FMC Corporation. Hickock identified two separate areas of concern which they called the South Study Area and the North Study Area. Subsequently, FMC began investigation of the South Study Area in 1981, while investigation of the North Study Area was undertaken by the Navy.

The Navy's investigation at the NIROP facility began in March 1982, as part of the Navy Assessment and Control of Installation Pollution (NACIP) program. As part of the NACIP program, an Initial Assessment Study was performed to identify and assess site areas posing a potential threat to human health or the environment due to contamination from past operations including hazardous materials. The IAS concluded that three areas warranted further investigation. As a result of IAS recommendations, the Navy through the U.S Army Corps of Engineers (COE) initiated cleanup of the pit/trench disposal area and installed and sampled 34 ground water monitoring wells.

In June 1986, after seven rounds of ground water sampling and analysis, COE retained RMT, Inc., of Madison, Wisconsin, to complete this investigation. Subsequently, a comprehensive round of ground water sampling has been performed as well as preparation of this report.

Concurrent with this investigation, FMC Corporation, through various subcontractors, conducted the investigation of a separate ground water contamination problem on FMC property immediately to the south of the NIROP study. Based on studies completed by FMC, an agreement was reached with the MPCA. FMC has agreed to pump TCE-contaminated ground water and discharge it for treatment to the Pig's Eye Sewage Treatment Plant. FMC cleanup levels have been set at 0.270 parts per million (ppm) total VOCs.

2.4 Overview of Report

This report generally follows the basic Remedial Investigation Report format as outlined in the "Guidance on Remedial Investigations Under CERCLA," USEPA (1985).

The report has been divided into 7 major sections as well as references (Section 8), a terminology guide (Section 9), and Appendices. Raw data and supporting documents are included in Volume II.

Sections 3 through 7 provide information from the following project investigations:

- Site Features Investigation (Section 3).
- Hazardous Substances Investigation (Section 4).
- Subsurface Investigation (Section 5).
- Surface Water Investigation (Section 6).
- Assessment of Potential Impact of Existing Ground Water Contamination to Public Health (Section 7).

Appendices A through D included in Volume I are as follows:

- Chronological Summary of Constituents Detected in at Least One Sample from NIROP Ground Water Analyses (Appendix A).
- Alphabetical Summary of Constituents Detected in at Least One Sample from NIROP Ground Water Analyses (Appendix B).
- Maximum and Mean Concentrations of Constituents Detected in NIROP Ground Water Analyses (Appendix C).
- Constituents Added November 1986 (Appendix D).

3. SITE FEATURES INVESTIGATION

3.1 Demography

The Naval Industrial Reserve Ordnance Plant is in the City of Fridley, Anoka County, Minnesota. Population estimates for 1984 place Fridley's population at 29,270 residents. Anoka County's population, according to 1984 estimates, was 210,939 people.

The NIROP facility is located near the northern boundary of the metropolitan statistical area (as defined by the U.S. Bureau of Census) for Minneapolis-St. Paul, Minnesota-Wisconsin. The area was estimated to contain a population of 2,262,400 people in 1985. The facility is situated in the southern-most tip of Anoka County.

3.2 Land Use

The NIROP site and properties neighboring on the north, east, and south, are zoned "heavy industrial."

Also located between East River Road and the Mississippi River (west of the site) is the "Anoka County Islands of Peace Mississippi Riverfront Park." The park is a day-use recreation facility on the river's edge, consisting of approximately 60 acres.

3.3 Natural Resources

Two significant waterways are in the vicinity of the site: Rice Creek approximately 2 miles to the north and the Mississippi River to the west. Because of ground water and surface water flow directions (west and south), it is unlikely that the NIROP facility would impact Rice Creek.

The Mississippi River provides active recreational opportunities to boaters and anglers as well as passive recreation because of its aesthetics and historical significance. The river also serves as a source of public and private water supply. The City of Minneapolis waterworks facility is located approximately 2,000 feet south (downstream) of the NIROP (see Section 6.3 for further details).

The NIROP facility is situated over an aquifer capable of yielding significant quantities of water for residential or municipal supplies. The aquifer is generally restricted to the Mississippi River Valley.

3.4 Climatology

The climate in the area of the NIROP is characterized by warm summers with average temperatures ranging from the upper 70°F to the low 80°F, with moderate rainfall averaging about 17 inches. Winter temperatures average between 3 and 7°F for January and February. Winter precipitation (during the months of October through April) averages about 9 inches. Temperature extremes for the area range from -34° to 104°F (Envirodyne, 1983).

Wind directions vary throughout the year. Northwest winds prevail from November through April; southeast winds are dominant in May, June, August, and October; and southern winds dominate in July and September. Wind speeds are fairly constant throughout the year, averaging 10.5 miles per hour (Envirodyne, 1983).

4. HAZARDOUS SUBSTANCES INVESTIGATION

This section of the report summarizes the information RMT obtained from the COE and FMC regarding substances found at the NIROP. All of the documents reviewed were produced during the 1980s. The facility, however, has been in existence since 1941. Very little information is available for this forty-year period and most of what does exist is anecdotal, such as recollections of older employees, or indirect, such as air photo interpretation. Although the Initial Assessment Study (Envirodyne Engineers, 1983) was designed to provide a comprehensive evaluation of past hazardous waste generation or disposal, little is known about site activities prior to the 1960s. The information presented here, consequently, can only provide a "snap shot" of current practices that may not be representative of past practices nor lead to the identification of all past disposal areas or other potential sources of hazardous substance releases. This section is divided into two parts. The first part describes the hazardous substances that are used at the NIROP, the processes that utilize hazardous substances and generate hazardous wastes, and the disposition of the hazardous wastes. The second part of this section describes the physical and chemical behavior of the major hazardous substances found at the NIROP.

4.1 Hazardous Substance Types

This section addresses hazardous substance quantities, location, components, containment, composition, and management methods. It covers the materials at the site that may be potential sources of environmental contamination or public health threats, or which may be of importance during remediation.

4.1.1 Raw Materials

The NIROP uses a wide variety of raw materials for industrial operations. Tanks and stockrooms used for storage of raw materials are located throughout the facility. Most materials used for the various industrial operations are stored in stockrooms associated with individual departments. Only hazardous materials are stored in a central location (Figure 4-1). These materials are not dispensed from this location but are transported directly to the shops through the Maintenance Control Center.

Numerous hazardous materials including metal conditioners, stripping and cleaning agents, solvents, paints, acids, bases, and photographic chemicals are used at the NIROP. All fresh chemicals and machinery oils are kept in the central hazardous materials storage area. Materials are labeled upon receipt and stored in their shipping containers. Items are segregated by type (acids, bases, solvents, etc.) into individually diked rooms. The oil and solvent stockroom contains an explosion-proof ceiling.

Specific materials used at the NIROP for which material safety data sheets have been provided to RMT by the COE include the following:

Product	Ingredients	Use
Reliasolv 564	90% Tetrachloroethylene	Cleaner and resin flux remover
Diko	Mixed phenols	Molding sand binder (use has been discontinued)
23-75 Coreactant	Bisphenyl isocyanate Aromatic hydrocarbons	Phenolic based resin binder used in molding sands
Various Pepset Formulations	Aromatic and aliphatic hydrocarbons phenol, formaldehyde, polymeric diisocyante and pyridine	Phenolic based resin binder used in molding sands

Various Isocure Formulations	Aromatic and aliphatic hydrocarbons, triethylamine, polymeric diisocyanate, phenol, formaldehyde, alcohol, and aromatic acid derivatives	Foundry operations, resins, amines
Rust-Lick G-25-JA	Amines, nitrate, polyoxyethylene (dimethylimino) ethylene dichloride	Machine coolant
Trimsol	Petroleum oil, chlorinated wax, emulsifiers, odorants, and dye	Machine coolant

Trichloroethylene (TCE) is also used in the NIROP facility in large quantities. Commercial or technical grade TCE can contain other compounds that are also considered hazardous substances. These include chloroform and 1,1,1 trichloroethane. 1,1,1 Trichloroethane is also used in relatively large quantities in vapor degreasers. Material safety data sheets for TCE and 1,1,1 trichloroethane were not provided.

Both above-ground and underground tanks are located outside for bulk storage of oil and several other materials. Tanks used for materials storage at the NIROP, their locations and contents, are shown on Figure 2-2.

Due to the detection of trichloroethylene (TCE) and other volatile organic compounds (VOCs) in ground water, tanks containing VOCs are of primary concern to this investigation. The current TCE storage tank (T2 on Figure 2-2) was moved to its present location under permit number M-83-S, issued by the MPCA in May 1983. The 8,670-gallon steel TCE tank is above ground. Safeguards include a 5-foot-2-inch-high concrete wall surrounding and contiguous with a base slab constructed of 6 inches of reinforced concrete. There is no curbing or containment for trucks

delivering or receiving the TCE and there are no overflow prevention devices or alarms. The TCE is transported into the plant in "tote tanks" hauled on trucks. The trucks deliver the TCE to the various points of use.

Prior to May 1983, a steel TCE storage tank was located on the west side of the building (Figure 2-2). TCE distribution at that time was by piping laid in a covered concrete trench. The 10-foot-diameter, 15-foot-high tank was placed on a 7 1/2-inch-thick concrete pad. The original TCE storage and distribution system drawing (FMC Drawing Nos 2555F, 2558F, and 2574F October 1966) shows no spill containment provisions.

The principal oil used over the years at the NIROP has been #6 fuel oil. The oil is stored in six above-ground insulated steel tanks (65,000-gallon capacity) located outside in a drainless, diked area adjacent to the Plant Maintenance Department. All tanks are connected by equalizer lines at the top to guard against overflowing.

Four steel underground tanks (18,000-gallon capacity) are also used to store #6 fuel oil. These tanks are located in an area adjacent to the Boiler Room (Figure 2-2). The tanks are similarly connected by equalizer lines to prevent overflow. There are no sanitary or storm drain inlets in the vicinity of these tanks. Storm sewers have been sealed at the oil unloading stations to prevent leaking or spilled oil from entering the system.

Spills and leaks of stored materials have occurred at the NIROP, both indoors at storage areas and shipping and receiving areas, as well as outdoors at storage tanks. Records obtained from FMC for the years

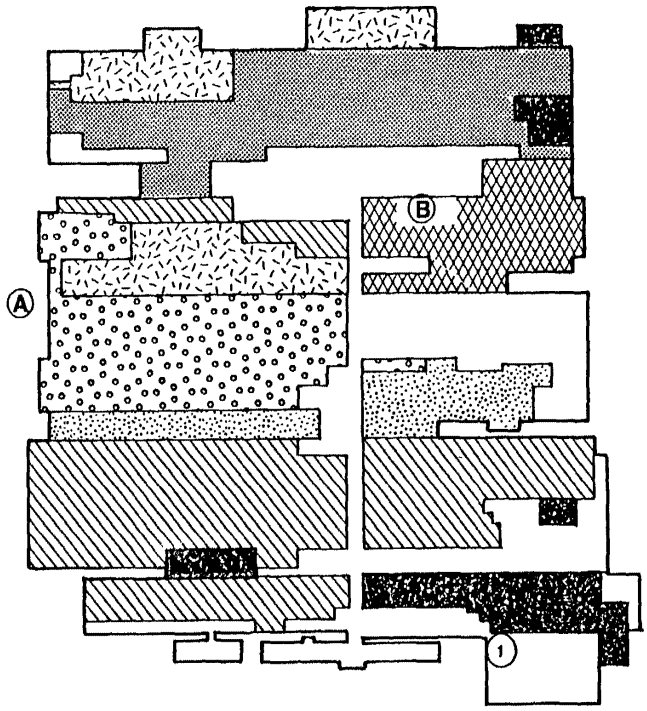
1984 to 1986 list 23 spills in these areas of acids, oils, solvents, and plating solutions in quantities ranging from less than 1 to 15 gallons per spill. Various methods were used to clean up these spills. Records for years prior to 1984 were not provided. The records for the years 1984 through 1986 are found in Volume II of this report. It is likely that previous facility activities resulted in a similar frequency of spills, type of spilled material, and spill volumes.

4.1.2 Industrial Processes

The processing and manufacturing operations associated with the facility include machine shop, metal plating shop, paint shop, assembly, foundry, heat treating, welding, and associated support facilities.

Locations of production areas at the NIROP have varied over the years. Figure 4-1 shows areas of the facility which were being used for various activities as defined by Envirodyne (1983).

Reports documenting spills and leaks that occurred in process areas during the period from 1984 to 1986 were provided by the COE. One hundred and thirty-three (133) spills were reported over the three-year period. Spilled materials included cyanide compounds, acids, oils, plating solutions, paint, ethylene glycol, paint thinner and solvents. Individual spill volumes ranged from less than 1 to 4,000 gallons. Approximately 780 gallons of TCE were also reported to have been spilled during the three-year period, including a 200-gallon spill in the plating area (April 1984) and a 520-gallon spill in the foundry area (September 1985). Generally, spilled material was recovered with absorbent material or vacuuming. Some of the spilled material,



LEGEND

- ASSEMBLY & PAINTING
- FOUNDRY
- WELDING
- HEAT TREAT & PLATING
- MACHINE SHOP
- TEST & INSPECTION & QA
- SHIPPING, RECEIVING & STORAGE
- (1) PHOTO LAB
- (A) (B) (C) APPROXIMATE LOCATIONS OF HAZARDOUS WASTE STORAGE AREAS IN 1986

NOTE: PROCESS AREA LOCATIONS ADAPTED FROM ENVIRODYNE (1983). LOCATIONS OF THE PRODUCTION AREAS HAVE VARIED OVER TIME. THE DATE OF THE PROCESS AREA LAYOUT SHOWN IS NOT KNOWN. ALTHOUGH HAZARDOUS WASTE STORAGE AREA A APPEARS TO BE OUTSIDE OF THE BUILDING, A RECENT ADDITION (NOT SHOWN) COVERS THIS AREA.

NORTH

APPROXIMATE SCALE 1"=300'

RMT NC

Dwn by	LLS
Date	4/87
Proj #	1254.03

FIGURE 4-1

INDUSTRIAL PROCESS AREAS WITHIN THE MAIN NIROP BUILDING

including part of the 200 gallons of TCE, was lost to floor drains or the sanitary sewer system. Some reported corrective measures included the sealing of floor grates to prevent future spill losses.

4.1.3 Waste Storage, Processing, and Disposal Practices

Hazardous Waste Storage Areas.

Table 4-1 summarizes findings regarding waste production in the industrial process areas. Much of the information reported in Table 4-1 has been taken from the Initial Assessment Study by Envirodyne Engineers, Inc., June 1983. Findings reflect conditions at the NIROP in the 1970's and early 1980's. Little information is available regarding practices during the 1940's and 1950's.

Three areas of hazardous waste storage, designated A, B, and C, are located at the facility. Areas A and B are located within the plant building. Area C is located in an outlying building near the northeast corner of the main plant building (see Figure 4-1).

The maximum number of drums that can be stored in the existing storage areas is 274 55-gallon drums distributed as follows:

Area A - Storage Shed - 52 drums
Area B - Storage Crib - 108 drums
Area C - Building - 114 drums

The three storage areas are currently being replaced by a new storage facility with a capacity of 288 55-gallon drums. Closure plans for Areas A, B, and C have been submitted for both state and federal approval.

During closure of Storage Area C, it was discovered that a sump in the building floor was actually a dry well. The dry well consisted of a

TABLE 4-1

SUMMARY OF WASTES GENERATED BY INDUSTRIAL PROCESS AREAS

Production Area	Waste Generated	Disposal Methods
Machine Shop	Metal scrap, shavings, water soluble coolants, lubricating and cutting oils, hydraulic oils	Some recycling, 50,000 to 150,000 gallons/year of liquids to sanitary sewer. Approximately 8 barrels/year of sludges disposed off-site.
Metal Plating	Acids, caustics, chromium and cyanide bearing liquids	Pre-1973 liquids pumped to sanitary sewer or disposed off-site. Post-1978 wastewater pretreatment then to sanitary sewer.
	Plating Sludges	Approximately 25 barrels/year disposed off-site. Some on-site disposal prior to 1973.
Cleaning/Degreasing (Plant-wide)	TCE	Approximately 40 barrels/year of TCE sold to reclaimer.
	Stoddard Solvent	Approximately 120 barrels/year of stoddard solvent disposed off-site.
	1,1,1 Trichloroethane	Approximately 75 barrels/year of 1,1,1 trichloroethane disposed off-site.
Paint Shop	Paint sludges, cleaners, phosphatizers, chromic acid, rinse water contaning naphtha or methylethyl ketone (MEK), and toluene	1960's - 2 to 3 barrels/year sludges disposed off-site with some presumed disposed on-site in pits and trenches. 1970's - filter system installed with filters disposed off-site. Cleaner, phosphatizers discharged to sanitary sewer. Chromic acid collected and processed with plating effluent pretreatment. Rinse water discharged to sanitary sewer. Cleaners containing MEK, toluene, or naphtha disposed off-site (approximately 20 gallons/day).

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TABLE 4-1 (Cont'd)

SUMMARY OF WASTES GENERATED BY INDUSTRIAL PROCESS AREAS

Assembly	Stoddard solvent, 1,1,1-trichloroethane, wash water, solvent-soaked rags	Stoddard solvent and 1,1,1 trichloroethane included with cleaning/degreasing (above). Wash water discharged to sanitary sewer. Solvent-soaked rags collected in closed containers and washed on-site.
Foundry	Sand	Most sand is reclaimed, however, non-reclaimable sand (core butts) disposed off-site. Some core butts reportedly disposed on-site at north property prior to 1970. After 1970 disposed by contract hauler.
Heat Treating	Quench oils, water-based oils, non-cyanide bearing salts, cyanide bearing salts, grit/bead blast	Quench oil burned in boilers. Water-based oils discharged to sanitary sewer. Approximately 1,200 pounds/year each of waste salts (non-cyanide and cyanide) disposed off-site. Grit/bead blast wastes disposed off-site.
Photo Shop	Fixer, developer, and silver bearing liquids	300,000 gallons of rinsewater discharged annually.
Welding Department	Rod stubs, flux, slag, lime carbide	Wastes collected and disposed off-site.
Boiler Plant	Condensate blowdown	300,000 gallons/year discharged to sanitary sewer.

section of 48-inch-diameter concrete pipe filled with crushed rock. The base of the concrete pipe was 10.83 feet below grade at an elevation of 825.17 feet according to the original Closure Plan submitted in the RCRA Part B Application (MSL). Core samples taken and analyzed from beneath the dry well indicated contamination by halogenated and aromatic solvents. As a result, actions have been taken to seal this dry well temporarily until final closure of the storage area.

Soil samples from beneath the dry well at Hazardous Waste Storage Area C were obtained on May 30, 1985, by Braun Engineering of Minneapolis. Samples were taken to a depth of 14.5 feet below the base of the dry well or to an approximate elevation of 810.7 feet (MSL). Since the water table elevation from the well closest to Hazardous Waste Storage Area C (4-S) was 814.95 feet on June 10, 1985, it is assumed that the samples obtained from greater than 10 feet below the dry well were below the water table. The samples contained chromium, cadmium, and lead at 24, 2.8, and 32 mg/kg, respectively, at the 4-foot to 6-foot level. Chromium, cadmium, and lead concentrations decreased to 7.2, 0.17, and 4.7 mg/kg, respectively, at the 10-foot to 12-foot levels. Organic compounds detected in the soil sample from the 4-foot to 6-foot level included ethyl benzene (7.9 mg/kg), m-xylene (19 mg/kg), o-xylene and p-xylene (28 mg/kg), toluene (6.9 mg/kg), 1,2-dichloroethylene (19 mg/kg), tetrachloroethylene (26 mg/kg), 1,1,1 trichloroethane (1.2 mg/kg), and trichloroethylene (430 mg/kg). Organic contaminants detected at the 10-foot to 12-foot level were tetrachloroethylene (66 mg/kg) and trichloroethylene (62 mg/kg).

A water sample was also obtained from the dry well in Hazardous Waste Storage Area C. Although one might not expect to see standing water in a dry well, water was observed during the July 25, 1986, site visit. It is unclear how water from the dry well was sampled, but sampling was performed by Braun Engineering in May 1985. It is doubtful that this sample represents ground water conditions at Area C, but rather represents spills of materials which occurred in the storage area combined with surface runoff.

Results of the water sample obtained by Braun Engineering showed the following organic contaminants: ethyl benzene (3.3 mg/l), m-xylene (11 mg/l), o-xylene and p-xylene (6.9 mg/l), toluene (2.4 mg/l), cis and trans 1,2-dichloroethene (63 mg/l), tetrachloroethene (49 mg/l), 1,1,1 trichloroethane (4.2 mg/l) and 1,1,2 trichloroethene (470 mg/l). Results of Braun Engineering laboratory testing are included in Volume II.

PCB Storage. PCBs were used as dielectric fluid in capacitors for induction furnace and hardening equipment located in the Foundry and Heat Treat Departments and in power capacitors throughout the NIROP.

The Maintenance Department notifies plant engineering when a PCB capacitor is to be removed from service. Plant engineering, in turn, coordinates disposal operations. The out-of-service units are placed in DOT-approved 17-H drums containing one foot of sorbent material. The 55-gallon drums are placed into an 800-gallon concrete vault constructed with 4-inch-thick walls and a 6-inch bottom. Each vault is ultimately filled with a 6-inch layer of sorbent material and sealed with a 4-inch-thick concrete cap.

Three sealed concrete PCB storage vaults are located outside of the plant in the northeast corner of the facility (Figure 2-2). The vaults are kept above the ground by placing them on wooden blocks.

On-Site Waste Disposal. The storage yard located in the northern portion of the NIROP facility was used for burial of waste materials in pits and trenches (Figure 2-2). Drums of wastes were buried in the pits or trenches at depths of 8 to 10 feet.

No records of buried materials were maintained; therefore, the exact amount and location of wastes could not be ascertained. The IAS (Envirodyne, 1983) reported that 50 to 100 drums of waste were disposed in two trenches on the northern portion of the facility. Two additional pits reportedly received 25 drums each. The number of drums disposed was based on employee recollection and hearsay. The materials disposed in the pits and trenches were thought to include waste oil, plating sludge, paint sludge, cleaning solvents, and degreasing solvents. These waste materials may have contained hazardous substances such as cyanide, trichloroethylene (TCE), methyl ethyl ketone (MEK), and 1,1,1-trichloroethane. Wastes were assumed to be in liquid, semi-liquid, or solid form.

The Navy, through the U.S. Army Corps of Engineers (COE), began cleanup of the pits and trenches in 1983. COE personnel conducted geophysical surveys of the suspected disposal areas. Prior to the geophysical survey, Navy and FMC officials arranged to relocate equipment and materials kept in the storage areas to delineate potential excavation areas to reduce interference with the surveys. The geophysical survey crew completed their task by using both magnetometer and terrain

conductivity surveys. As a result of these surveys, 20 areas were identified as potential disposal locations.

Data for the 20 areas where geophysical surveys took place was reviewed by the COE Missouri River Division Laboratory. Four of the 20 areas were found to have had anomolous "no reading" areas. These areas were found to correlate well with buried asphalt or concrete rubble and were not further considered as hazardous waste disposal areas. This reasoning was further supported by employee recollections. Seven additional areas were found to have had varying levels of conductivity. These seven areas corresponded to known areas of rubble disposal (no drummed wastes), or buried features such as electrical lines, propane lines, and a former ditch.

The nine remaining areas were selected for excavation (Figure 2-2). These areas were divided into high, medium, and low probability waste sites as follows:

High Probability Waste Sites - 3, 5, 18

Medium Probability Waste Sites - 6, 7, 10

Low Probability Waste Sites - 15, 17, 19

The criteria for these subdivisions included consideration of aerial photograph analyses and interviews with NIROP employees (COE, Exhibit Q, 1984).

Chemical Waste Management of Oakbrook, Illinois, began excavation of the nine pits in November 1983. A total of 43 drums were recovered (41 drums from Pit 3 and 2 drums from Pit 17) and stored temporarily on a staging pad until excavation of all pits was complete. Although the number of drums recovered differed from the original estimate, the COE is confident that the removal project was successful.

After excavation, composite samples were obtained from the drums and analyzed. Classification and a summary of analytical results for the 43 drums are shown in Table 4-2. Laboratory analytical results are included as Volume II of this report.

During review of data from the excavated areas it was noted that Pit 7 was originally excavated in the wrong location. A second excavation was made in the correct (as planned by geophysical data) location and sampled. A drawing prepared for the COE (U.S. Army Corps of Engineers, Drawing Control No. XF-215-30-01, Sheet 4, 1984) shows both the proposed locations of the excavations and the locations at which the excavations were actually made. This drawing also indicates that Pit 5, a high probability waste site, appears to have been excavated approximately 40 feet west of the planned location. The COE project manager has verified that the drawing showing areas to be excavated (Drawing 1 of 3, COE, 1984) is incorrect and that actual excavation took place in the corrct location (Thiele, 1987).

All empty drums were crushed and disposed with the contaminated soil at the Evergreen Landfill, Northwood, Ohio, USEPA I.D. OHD 68111327. The full or partially filled drums were trucked to Emelle, Alabama, and disposed at the Chemical Waste Management Facility, USEPA I.D. ALD 000622464.

The required depth of excavation was to be determined based on the results from the volatile organics testing of the soil at the base of the excavations. Guidance from Dave Richfield of the MPCA was that, if the total concentration of VOC analyzed was less than 1 part per million, backfilling could proceed. The project report of the hazardous

TABLE 4-2

SUMMARY OF COMPOSITE ANALYSES PERFORMED ON DRUM CONTENTS FROM PIT/TRENCH AREA
(Analyses Date, January 1984)

Classification*	Number of Drums	Oil and Grease (% by weight)	Metals	Total (mg/kg)	Leachable** (mg/l)	Volatile Organic Compounds (% by weight)		PCBs (mg/kg)
Empty	4	--		--		--		--
Inert Liquid	4	7.5	As	< 0.07		Isopropanol	0.3	ND
			Ba	5.78		Methyl Ethyl Ketone	0.6	
			Cd	142	7.21	Trichloroethylene	0.2	
			Cr	7,430	2.12	Ethyl Benzene	0.02	
			Cu	15.3		Xylenes	0.07	
			Hg	< 0.005		Hydrocarbons (C_{10}-20)	0.2	
			Ni	6.84				
			Pb	18.9	0.04			
			Se	0.15				
			Zn	2,560	95.7			
Base Solid	1	16	Ag	< 0.22		Methyl Ethyl Ketone	0.06	ND
			As	< 0.07		Trichloroethylene	0.4	
			Ba	119	1.70	Toluene	0.03	
			Cd	8.60	0.01	Ethylbenzene	0.07	
			Cr	427	< 0.01	Xylenes	0.3	
			Cu	71.5		Hydrocarbons (C_6-16)	0.5	
			Hg	< 0.005				
			Ni	22.8				
			Pb	312	< 0.01			
			Se	< 0.07				
			Zn	1,250	3.40			
PCB Waste	6	(a)		(a)		(a)		650 (as 1016)

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TABLE 4-2 (Cont'd)

SUMMARY OF COMPOSITE ANALYSES PERFORMED ON DRUM CONTENTS FROM PIT/TRENCH AREA
(Analyses Date, January 1984)

Classification*	Number of Drums	Oil and Grease (% by weight)	Metals	Total (mg/kg)	Leachable** (mg/l)	Volatile Organic Compounds (% by weight)		PCBs (mg/kg)
Flammable Solid	2	54.4	Ag	0.74		Trichloroethylene	0.06	ND
			As	< 0.08		Toluene	2	
			Ba	44.9		Ethylbenzene	12	
			Cd	2.87	0.01	Xylenes	39	
			Cr	1,020	0.31	Hydrocarbons (C_7-22)	12	
			Cu	24.5		Naphthalene	0.2	
			Hg	< 0.005		C_3 Benzenes	2	
			Ni	8.18		C_4 Benzenes	3	
			Pb	301	< 0.01	C_5 Benzenes	2	
			Se	0.16				
			Zn	32,500	97.3			
Inert Solid	26	6.92	Ag	1.46		Trichloroethylene	0.8	65
			As	1.49		Toluene	0.08	
			Ba	218	2.14	Ethylbenzene	0.2	
			Cd	4.90	0.03	Xylene	1	
			Cr	533	0.16	Hydrocarbons (C_{10}-23)	2	
			Cu	124		Cresols	0.8	
			Hg	0.0202		C_3 Benzenes	0.03	
			Ni	33.1				
			Pb	324	< 0.01			
			Se	< 0.08				
			Zn	1,250	3.16			

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* - Classifications by Chemical Waste Management Corp.
** - Leachable Concentrations by EP Test Procedure
(a) - Constituents Not Reported
ND - Not Detected

waste cleanup (COE, 1984) states that all pits except numbers 3 and 6 had VOC concentrations below the 1 ppm (1 mg/kg) guideline. Pit number 3 was also reported to have PCBs in the soil beneath the pit (COE, 1984). The data reviewed by RMT indicates that Pit 7 apparently also exceeded the 1 ppm guideline (see Section 5.1). The soil in Pit 7 containing more than 1 ppm of VOCs was not removed. The final depth of the excavations has not been reported. However, photographs of pit 3 indicate the depth to be 4 to 5 feet. Pit number 3 was lined with plastic sheeting prior to backfilling so that the clean backfill would not come into contact with the trench bottom soil that still contained organic compounds. The remaining 8 pits were filled with clean soil without any special provisions for segregating the fill from the underlying soil.

Upon completion of excavation, five soil sampling locations were identified at the bottom of each excavation. Split-spoon samples were obtained at each of the five locations at the pit bottom and at a 1-foot and 2-foot depth below the pit bottom level. The range of constituent values detected in soils from pits and trenches upon completion of excavation are shown in Table 4-3.

Results of metals reported in Table 4-3 have been compared to the composition of typical soils as reported by Bowen (1966). Results of the comparison indicate that the soils sampled below Pit 5 may be indicative of natural or background conditions. Comparing the Pit 5 soil data with samples from the other pits suggests that barium, chromium, copper, lead, manganese, nickel, and zinc may have been associated with past waste disposal particularly in Pits 7, 10, 15, and 17.

RANGE OF CONSTITUENT VALUES DETECTED IN SOILS FROM PITS AND TRENCHES UPON COMPLETION OF EXCAVATION*

Constituent	Pit/Trench								
	3	5	6	7**	10	15	17	18	19
Metals (mg/kg)									
Arsenic	< 0.06 - 2.50	< 0.06 - 27.7	< 0.06 - 6.15	< 4 - 6	< 0.7 - 9	< 3.2 - 6.1	< 3 - < 10	< 3.9 - < 16	< 2.7 - 11
Barium	5.01 - 83.8	8.28 - 78.2	7.16 - 169	< 5 - 270	7.5 - 300	(c)	22 - 72	(c)	(c)
Cadmium	0.88 - 2.06	0.90 - 2.91	1.3 - 4.29	< 0.5 - 2	< 0.3 - < 0.6	< 0.4 - 4.3	< 0.3 - < 0.3	< 0.3 - 1	< 0.2 - < 0.4
Chromium (Total)	6.82 - 48.7	9.94 - 16.4	9.00 - 19.3	5.3 - 74	2.2 - 28	(a)	< 2 - 130	(a)	(a)
Copper	5.67 - 334	6.57 - 45.5	5.58 - 80.2	4.1 - 14,000	< 0.7 - 19	1.8 - 4,300	1 - 32	6.4 - 39	7.1 - 36
Lead	12.4 - 48.3	14.3 - 49.4	19.9 - 74.2	< 8 - 550	< 1 - < 2	< 10 - 280	< 2 - 370	< 10 - 22	< 10 - 24
Manganese	(d)	(d)	(d)	< 0.04 - 14,000	39 - 3,000	(d)	100 - 740	(d)	(d)
Mercury	< 0.005 - 0.0363	< 0.005 - 0.0202	< 0.005 - 0.2231	< 0.07 - < 0.1	< 0.03 - < 0.1	< 8.1 - < 0.5	< 0.02 - < 0.8	< 0.1 - 2	< 0.1 - < 0.2
Nickel	9.2 - 18.3	7.98 - 19.2	0.8 - 27.1	7 - 110	< 10 - 25	(e)	4.5 - 37	(e)	(e)
Selenium	< 0.06 - 0.45	< 0.05 - 0.25	< 0.06 - 0.21	< 3.8 - < 6	< 0.8 - < 1	< 2	< 1 - < 2	< 2 - < 8	< 2
Silver	0.23 - 1.36	0.44 - 1.28	0.75 - 1.79	< 0.1 - 3.5	< 1 - 4	< 1	< 1 - < 4	< 1 - < 5	< 0.6 - < 1
Zinc	10.2 - 108	13.4 - 46.5	12.3 - 70.8	8.0 - 890	4.6 - 28	8.4 - 1,200	5.2 - 46	5.1 - 43	16 - 56
Organics (mg/kg)									
Aldrin	< 0.001	< 0.001	< 0.001	< 0.001	< 0.002	< 0.002	ND - < 0.015	< 0.002 - 0.0077	< 0.002
Chlordane	< 0.001	< 0.001	< 0.001	< 0.010	< 0.020	< 0.020 - 0.041	ND - < 0.015	< 0.002 -< 0.020	< 0.020 - 0.028
DDT	< 0.001	< 0.001	< 0.001	< 0.001 - 0.270	0.0025 - .100	0.0024 - 0.130	0.004 - 0.140	< 0.002 - 0.093	0.0048 - 0.126
Dieldrin	< 0.001	< 0.001	< 0.001	< 0.001 - 0.002	< 0.002 - .0063	< 0.002 - 0.0071	ND - 0.015	< 0.002 - 0.012	< 0.002 - 0.022
Endrin	< 0.001	< 0.001	< 0.001	< 0.001 - 0.002	< 0.002 - .0289	< 0.002 - 0.0058	ND - 0.082	< 0.002 - 0.086	< 0.002 -0.0071
Heptachlor	< 0.001	< 0.001	< 0.001	< 0.001	< 0.002 - .0081	< 0.002	0.0048 - 0.0086	< 0.002 - 0.0079	< 0.002
Lindane	< 0.001	< 0.001	< 0.001	< 0.001 - 0.002	< 0.002 - .0023	< 0.002	ND - 0.0025	< 0.002 - 0.0028	< 0.002
Methoxylchlor	< 0.001	< 0.001	< 0.001	< 0.005	< 0.010	< 0.002 - < 0.010	< 0.002 -< 0.010	ND	< 0.010
Toxaphene	< 0.005	< 0.005	< 0.005	< 0.020	< 0.050	< 0.050 - 0.280	< 0.050 - 0.280	ND - 0.690	< 0.050 - 0.250
Parathion	< 0.001	< 0.001	< 0.001	< 0.010	< 0.050	< 0.050	ND	< 0.050	< 0.050
PCBs (mg/kg)	< 0.001 - 0.03	< 0.001	< 0.001	< 0.042	< 0.020 - .130	< 0.0055 - 0.077	ND - 1.00	< 0.020	< 0.02 - 0.053
Industrial Solvents (% by weight)	< 1.0	< 1.0	< 1.0	(b)	(b)	< 0.1	(b)	< 0.1	< 0.1

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* Ranges indicated for each pit/trench include values for samples obtained from the surface of the pit bottom; 1 foot below the pit bottom, and 2 feet below the pit bottom. Duplicate sample results have been included in ranges shown where appropriate.

** Pit #7 was excavated and sampled twice due to a surveying error. Values shown represent the second (true) excavation location.

ND - Not Detected

(a) - Total chromium not reported for pits/trenches 15, 18, and 19.

(b) - Industrial solvents not reported for pits/trenches 7, 10, and 17.

(c) - Barium not reported for pits/trenches 15, 18, and 19.

(d) - Manganese not reported for pits/trenches 3, 5, 6, 15, 18, and 19.

(e) - Nickel not reported for pits/trenches 15, 18, and 19.

This round of soil sampling and analyses also indicates that pesticides are present below some of the excavated pits. None of the pesticide concentrations detected at the NIROP exceeded 1 mg/kg (1 part per million - ppm). Currently there are no standards for pesticides in soils. The United States Department of Agriculture (USDA) considers that 1 to 10 ppm of pesticide residue at three feet is normal in agricultural use. (USDA, 1987). Therefore, pesticide concentrations detected at the NIROP appear to be insignificant.

At the MPCA's request, a modification was issued to perform additional pit bottom sampling in order to quantify the presence of 15 volatile organic compounds. The previous analyses (Table 4-3) had reported "industrial solvents" on a percent by weight basis only. These additional samples were taken 1 foot below the pit bottoms. Additional samples were obtained as follows:

Pit Number	Number of Samples Analyzed
3	6
5	2
6	3
7	3
10	3
15	2
17	3
18	2
19	2
Total	26

The above testing was performed to a detection level of 10 parts per billion. Table 4-4 summarizes the range of concentrations of VOCs from one foot below the pit bottom as required by the MPCA.

At the request of the MPCA, soil from beneath trenches 3 and 6 was resampled in June 1985. Samples were collected during the installation

TABLE 4-4

SUMMARY OF CONCENTRATION RANGES FOR MPCA-REQUIRED VOLATILE ORGANIC COMPOUND ANALYSES OF SAMPLES FROM ONE FOOT BELOW PIT BOTTOMS

Constituent (mg/kg)	Pit/Trench								
	3*	5	6*	7**	10	15	17	18	19
Ethylbenzene	< 0.010 -< 0.100	< 0.010	NS	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Benzene	< 0.010 - < .100	< 0.010	NS	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Methylene Chloride	< 0.005 - 1.200	< 0.010	0.017 -0.033	< 0.005-0.056	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Tetrachloroethylene	0.022 - 6.300	< 0.010	0.042 -0.051	< 0.005-0.078	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
1,1,2-trichloroethane	< 0.010 - < 0.100	< 0.010	< 0.010	< 0.005	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Toluene	0.100 - 12.000	< 0.010	NS	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Chloroform	< 0.010 -< 0.100	< 0.010	< 0.010	< 0.005	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
1,1 dichloroethane	< 0.010 - 5.000	< 0.010	< 0.010	< 0.005	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
cis 1,2-dichloro-ethylene	< 0.010 - NS	< 0.010	< 0.010	< 0.005	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Trans 1,2-dichloro-ethylene	< 0.100 - (> 10.000 - < 100.000)	< 0.010	0.021 -0.064	< 0.005 - 0.057	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
1,1-dichloroethylene	< 0.005 - 1.300	< 0.010	< 0.010	< 0.005	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
1,1,2,2 tetrachloro-ethane	< 0.010 - < 0.100	< 0.010	< 0.010	< 0.005	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
1,1,1,2 tetrachloro-ethane	< 0.010 -< 0.100	< 0.010	< 0.010	< 0.005	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
1,1,1 trichloroethane	< 0.010 - 1.000	< 0.010	< 5.1 - 13	< 0.005-0.014	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Trichloroethylene	0.680 - 3,700	0.050 -0.280	0.160 -1.600	0.045 - 1.300	0.099 - 0.220	< 0.010	< 0.010	< 0.010	< 0.010

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* Due to high concentrations detected in pits/trenches 3 and 6 reanalysis was required by MPCA. Concentrations shown reflect reanalyzed samples.
** Pit #7 was excavated and sampled twice due to a surveying error. Concentrations shown represent the second (true) excavation location.
NS-Data not supplied.

of the second set of monitoring wells at the site. The drill rig was used to drive and obtain split-spoon samples. Samples were obtained at eleven locations in pit 3 and five locations in pit 6. Samples were collected beginning at 10 feet below ground surface to a depth of 20 feet below ground surface. All of the samples were, therefore, collected below the base of the pits. Data are presented in Volume II. A summary of these soil data is presented as Table 4-5 and boring locations are shown on Figure 4-2.

Three organic compounds were detected in 11 of 13 samples collected below Pit 6. Methylene chloride was found in two samples (0.39 and 0.14 mg/kg) and bis (2 ethylhexyl) phthalate was found in 9 samples (0.234 to 0.0200 mg/kg). Trichloroethylene was detected in only two samples; one from boring 4 between the 16.5-foot and 18.0-foot depth at 0.026 mg/kg and one from boring 5 between the 18.5-to 20.0-foot depth as present but not quantifiable.

Samples from below Pit 3 contained 8 organic compounds at concentrations greater than those in Pit 6. Trichloroethylene was detected in 75 percent of the samples and from all depths below Pit 3 and in concentrations ranging from present, but below detection limits, to 207 mg/kg. Trichloroethylene was most prevalent at the eastern end of pit 3. Other organic compounds detected included tetrachloroethylene (0.0987 mg/kg to 16.5 mg/kg); 1,1,1 trichloroethane (0.048 to 1.0 mg/kg); methylene chloride (0.10 to 0.039 mg/kg) toluene (0.032 mg/kg to 7.9 mg/kg); ethylbenzene (1.9 mg/kg to 10.6 mg/kg) bis (2 ethylhexyl) phthalate (0.0049 to 0.045 mg/kg) and trans 1,2 dichloroethylene (0.78 mg/kg).

Pit #	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Sample # Location	1	1	2	2	3	3	3	4	4	4	5	5	5	6	6	6	7	7	7
Depth	10.0-11.5	18.5-20.0	10.0-11.5	18.5-20.0	10.0-11.5	14.5-16.0	18.5-20.0	10.0-11.5	14.5-16.0	18.5-20.0	10.0-11.5	12.5-14.0	18.5-20.0	10.0-11.5	14.5-16.0	18.5-20.0	10.0-11.5	14.5-16.0	18.5-20.0
Lead	2.78	3.97	2.43	2.12	1.45	1.64	1.62	1.61	2.35	1.96	1.82	1.63	2.20	2.03	1.82	1.83	2.20	3.04	2.50
Manganese	679	485	328	166	350	194	218	285	340	205	376	357	445	387	226	419	460	390	343
Zinc	11.3	11.7	9.32	11.2	11.3	8.40	11.6	9.03	12.4	11.9	11.1	10.2	11.2	16.2	12.1	13.1	15.8	14.2	8.05
PCB 1242	< .002	< .002	< .002	< .002	< .002	< .002	< .002	< .002	< .002	< .002	< .002	< .002	< .002	< .002	< .002	< .002	< .002	< .002	< .002
PCB 1248	< .002	< .002	< .002	< .002	< .002	< .002	< .002	< .002	< .002	< .002	< .002	< .002	< .002	< .002	< .002	< .002	< .002	< .002	< .002
PCB 1254	< .002	< .002	< .002	< .002	< .002	< .002	< .002	< .002	< .002	< .002	< .002	< .002	< .002	< .002	< .002	< .002	< .002	< .002	< .002
PCB 1260	< .002	< .002	< .002	< .002	< .002	< .002	< .002	< .002	< .002	< .002	< .002	< .002	< .002	< .002	< .002	< .002	< .002	< .002	< .002
Methylene Chloride	< .025	< .025	.10	< .025	.035	< .025	< .025	.039	< .025	< .025	< .025	< .025	< .025	< .63	< .63	< .63	< .63	< .025	< .025
1,1-Dichloroethene	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .63	< .63	< .63	< .63	< .025	< .025
1,1-Dichloroethane	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .63	< .63	< .63	< .63	< .025	< .025
Trans 1,2-Dichloroethene	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .63	< .63	< .63	.78	< .025	< .025
1,1,1 Trichloroethane	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	.88	< .63	< .63	1.0	.048	< .025
Trichloroethene	.19	< .025*	< .025*	< .025*	< .025	< .025	< .025	< .025	< .025	.41	< .025	< .025	.042	207	127	78.8	139	6.7	.53
Benzene	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .63	< .63	< .63	< .63	< .025	< .025
Tetrachloroethene	.056	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	.073	< .025	< .025	< .025	16.5	13.0	3.9	13.9	.56	.097
Toluene	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	4.9	7.9	4.6	3.82	.73	.032
Ethylbenzene	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	1.9	10.6	6.4	4.85	2.38	< .025
Chloroform	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .63	< .63	< .63	< .63	< .025	< .025
Bis(2 ethylhexyl) Phthalate	< .0002	< .0002	< .0002	< .0002	.0110	.037	.022	.0085	.016	.022	< .0002	< .0002	.023	< .0002	< .0002	.045	< .0002	< .0002	.033

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Pit #	3	3	3	3	3	3	3	6	6	6	6	6	6	6	6	6	6	6	6	6
Sample # Location	8	8	9	9	10	10	11	1	1	1	2	2	2	3	3	3	4	4	4	5
Depth	12.5-14.0	18.5-20.0	10.0-11.5	18.5-20.0	14.5-16.0	18.5-20.0	18.5-20.0	10.0-11.5	14.5-16.0	18.5-20.0	10.0-11.5	14.5-16.0	16.5-18.0	10.0-11.5	14.5-16.0	16.5-18.0	10.0-11.5	14.5-16.0	16.5-18.0	18.5-20.0
Lead	1.85	2.50	2.47	1.89	1.79	2.78	2.69	1.57	1.81	2.59	1.68	2.10	1.49	1.09	1.86	1.80	1.56	2.27	3.30	2.44
Manganese	192	356	602	394	164	1820	331	357	215	345	1400	526	399	540	266	285	344	196	521	716
Zinc	9.65	10.2	14.2	9.85	9.12	10.7	10.2	9.36	11.8	14.5	11.8	9.10	9.27	11.3	8.27	12.1	12.9	10.1	11.7	12.2
PCB 1242	< .002	< .002	< .002	< .002	< .002	< .002	< .002	< .002	< .002	< .002	< .002	< .002	< .002	< .002	< .002	< .002	< .002	< .002	< .002	< .002
PCB 1248	< .002	< .002	< .002	< .002	< .002	< .002	< .002	< .002	< .002	< .002	< .002	< .002	< .002	< .002	< .002	< .002	< .002	< .002	< .002	< .002
PCB 1254	< .002	< .002	< .002	< .002	< .002	< .002	< .002	< .002	< .002	< .002	< .002	< .002	< .002	< .002	< .002	< .002	< .002	< .002	< .002	< .002
PCB 1260	< .002	< .002	< .002	< .002	< .002	< .002	< .002	< .002	< .002	< .002	< .002	< .002	< .002	< .002	< .002	< .002	< .002	< .002	< .002	< .002
Methylene Chloride	< .025	< .025	< .025	< .025	< .025	< .025	.042	.39	.14	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025
1,1-Dichloroethene	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025
1,1-Dichloroethane	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025
Trans 1,2-Dichloroethene	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025
1,1,1 Trichloroethane	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025
Trichloroethene	< .025	.30	.034	< .025*	< .025	< .025*	.15	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	.026	< .025*
Benzene	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025
Tetrachloroethene	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025
Toluene	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025
Ethylbenzene	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025
Chloroform	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025	< .025
Bis(2 ethylhexyl) Phthalate	.0049	.0051	< .0002	< .0002	< .0002	< .0002	< .0002	.031	.037	.0111	.0395	.0247	.0297	.234	.0732	.0200	< .0002	< .0002	< .0002	< .0002

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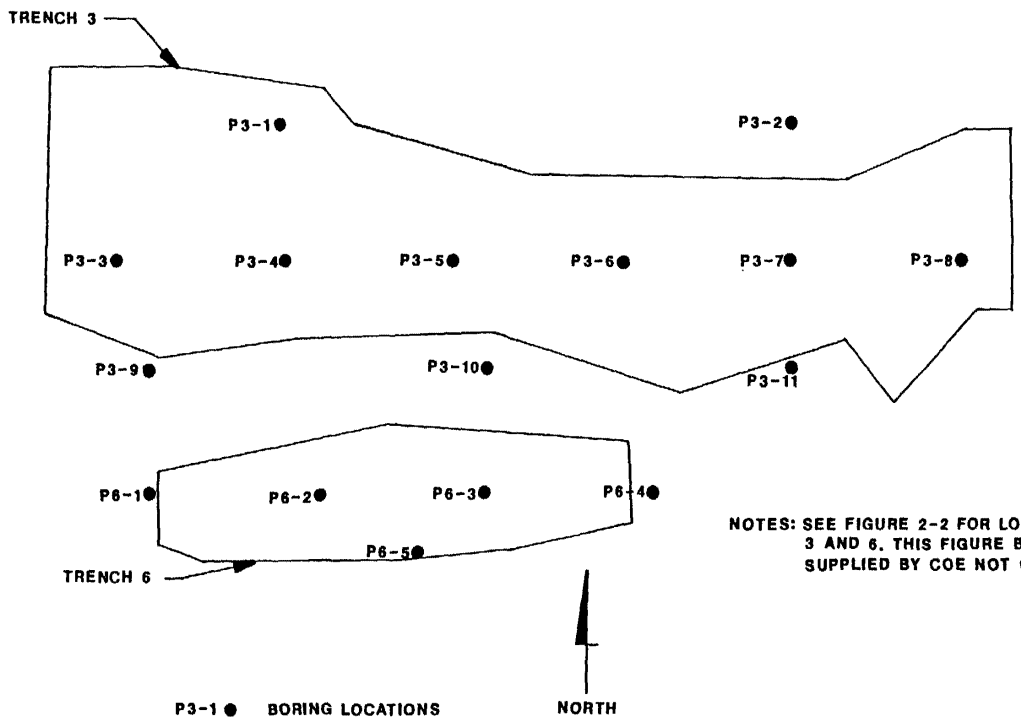


NOTES: SEE FIGURE 2-2 FOR LOCATIONS OF TRENCHES 3 AND 6. THIS FIGURE BASED ON DRAWING SUPPLIED BY COE NOT OTHERWISE LABELED.

SCALE 1"=APPROXIMATELY 20'

FIGURE 4-2

SOIL BORING LOCATIONS ADVANCED IN TRENCHES 3 AND 6 JUNE, 1985

RMT INC

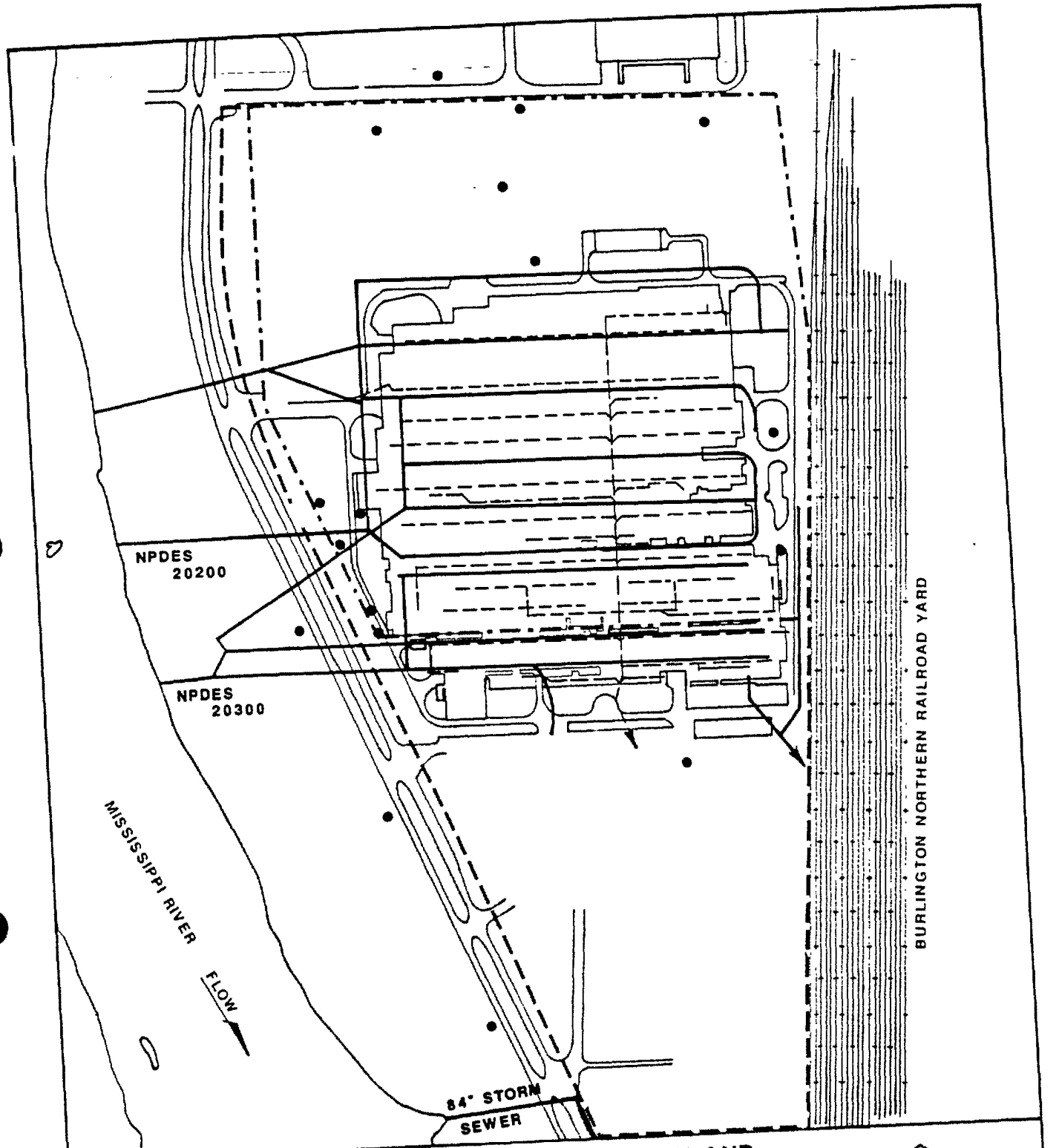
Dwn. by.: MCS

Date: 4/87

Proj #: 1254.01

The presence of high concentrations of VOCs below the pits indicates that an unknown quantity of these hazardous constituents were released from the disposal area. The VOCs also probably entered the ground water flow system since the water table is approximately 19 feet below the ground surface in the area of the pits. The disposal activities in some of the pits and trenches did result in releases of hazardous substances into the environment. The constituents left in the soil (Table 4-5) may also form continuing source to the ground water as precipitation infiltrates through the sandy soils.

Sewer Systems. Sewer systems in use at the NIROP include separate sanitary and storm sewers (Figure 4-3). The sanitary sewer system installation was begun during the original site development. As the facility expanded, so did the collection system. Various sizes of clay pipe were used for the original gravity flow system. The sanitary sewer is 4 to 6 feet below the ground surface at the northern end and 8 to 10 feet below the ground surface on the sourthern end of the facility. The sanitary sewer system from NIROP continues beneath FMC-owned property. The system carries plant sanitary wastewater and treated and untreated industrial wastewaters. It has a single 15-inch connection point to the metropolitan system. Total facility (NIROP and FMC) wastewater discharged to the metropolitan sewer system during 1983 ranged from 0.3 to 0.5 MGD. The wastewater discharge has varied over time, depending on the number of employees, which has ranged from 1,000 to 11,000. There are currently approximately 3,200 employees at the NIROP. The plant effluent is piped to the Pig's Eye Wastewater Treatment Plant, which is operated by the Metropolitan Waste Control Commission.



APPROXIMATE SANITARY AND STORM SEWER SYSTEMS AT NIROP

ADAPTED FROM FMC DRAWING 4251 (1984), ENVIRODYNE (1983) AND HICKOK (1981)

N

0 500

1" = 500'

- - - - SANITARY SEWER

——— STORM SEWER

● NIROP STUDY AREA MONITORING WELL OR WELL NEST LOCATION .

RMT

DWN BY:	JM
DATE:	4/10/87
PROJ.#	1254.01

FIGURE 4-3

Repairs to the FMC portion of the sanitary sewer system were initiated by FMC in October 1982, as reported by Papadopulos (1983). These repairs were needed because of unusually high ground water levels observed in a monitoring well located near the sewer. It was concluded that leakage from the sanitary sewer was probably causing the elevated ground water levels. This conclusion was also based on an inspection of the condition of the sewer in existing manholes and a television survey of the sewer between manholes. The wastewater contains several different types of wastes, and leakage from the sewer may have caused ground water contamination beneath the FMC-owned portion of the facility. The sewer was repaired in October 1982 by inserting a liner into the existing pipe. Inspection and repair of the lateral lines was not conducted. The condition of sanitary sewer lines beneath the NIROP is not known. The inspections and repairs described here occurred only beneath the FMC-owned portions of the facility.

The storm sewer system is also shown on Figure 4-3. Most of the storm sewer system exits the facility at the southwestern corner of the main plant building, near monitoring wells 10-S, 6-D, and 6-S. The storm sewer system is connected to roof drains, catch basins in roadways, and in the plant, as well as floor drains throughout the plant (FMC Drawing 4251, 1984). The drawing indicates that many of the floor drains have been plugged as of 1984. A separate sewer drains the southeastern portion of the facility near well 9-S, toward the south. An 84-inch line draining to the Mississippi River is located to the south, near monitoring wells 19-S and 19-D.

The sewer systems beneath the NIROP have the potential for releasing hazardous substances to the environment. Spills described earlier in this report, continue to occasionally find their way into floor drains and the sanitary sewer. It is likely that 20 to 40 years ago spills of liquid wastes, and intentional waste disposal practices, resulted in even greater discharges to the sewer system. Some section of the sewer lines are over 40 years old. It is not unlikely that small and large leaks may exist in parts of the system as was discovered beneath the adjoining FMC facility.

The integrity of the sewer systems have not been investigated. However, two outfalls on the Mississippi River and the sanitary sewer were sampled in March 1981 (Hickok, 1981a). The results are summarized on Table 4-6. The sample from storm sewer outfall 20200 contained substantial quantities of TCE (0.4 mg/l), acetone, methyl ethyl ketone, and isopropyl alcohol. The second storm sewer sample contained only acetone. The sanitary sewer sample contained at least seven organic compounds, including 0.35 mg/l of TCE. These data suggest that if the sewers are leaking, hazardous substances can be released to the shallow ground water flow system beneath the NIROP.

Industrial Wastewater Pretreatment Plant. The NIROP uses an industrial wastewater pretreatment system, constructed in 1973, for wastewater generated from metal plating operations. Before the pretreatment plant was constructed, plating wastes were discharged directly to the sanitary sewer (Envirodyne, 1983).

The continuous pretreatment system automatically treats approximately 100,000 gallons per day of liquid plating wastes (rinse

TABLE 4-6

SUMMARY OF SANITARY AND STORM SEWER EFFLUENT ANALYSES (FROM HICKOK, 1981). ALL CONCENTRATIONS IN mg/L.

	Sanitary Sewer	Storm Sewer Outfalls		
		NPDES 20200	NPDES 20300	84" Outfall
Acetone	0.15	0.3	0.060	< 0.025
n-Butyl alcohol	< 0.025	< 0.025	< 0.025	< 0.025
Isopropyl alcohol	0.3	0.1	< 0.025	< 0.025
Methyl ethyl ketone	< 0.025	0.3	< 0.025	< 0.025
Methyl isobutyl ketone	< 0.025	< 0.025	< 0.025	< 0.025
Methylene chloride	0.06	< 0.025	< 0.025	< 0.025
Mineral spirits	2.0	< 0.5	< 0.5	< 0.5
Naphthalene	< 0.025	< 0.025	< 0.025	< 0.025
Tetrachloroethylene	< 0.025	< 0.025	< 0.025	< 0.025
Toluene	< 0.025	< 0.025	< 0.025	< 0.025
Trichloroethylene	0.35	0.40	< 0.025	< 0.025
1,1,1 Trichloroethane	0.03	< 0.025	< 0.025	< 0.025
Xylene (meta)	0.030	< 0.025	< 0.025	
Xylene (ortho/para)	< 0.025	< 0.025	< 0.025	
Chromium	0.45	< 0.05	< 0.05	< 0.05
Cadmium	I*	< 0.01	< 0.01	< 0.01
Copper	< 0.05	< 0.05	I	< 0.05
Cyanide	0.023	< 0.006	< 0.006	0.006
Lead	0.05	< 0.05	< 0.05	< 0.05
Nickel	0.05	< 0.05	< 0.05	< 0.05
Oil/Grease	364	10	NR*	13
Zinc	0.14	0.03	0.02	0.01
pH	8.6	8.1	8.1	8.2
TOC	I	5	9	8.2
COD	16	< 4	16	20

* I = Illegible copy and NR = Not Reported

water and spent plating solutions). The pretreatment plant employs chemical treatment to destroy cyanide, reduce hexavalent chromium to the trivalent state, neutralize acids and alkalis, and precipitate heavy metals. The treatment sludge, a listed hazardous waste containing heavy metals, is drummed and stored in a NIROP hazardous waste staging area prior to final disposal in an approved landfill. The treatment operation during the 1980's generated approximately 12 to 24 barrels of sludge annually. Clarified wastewater is discharged to the sanitary sewer system.

4.2 Waste Component Characteristics and Behavior

4.2.1 Introduction

An evaluation was conducted by RMT to determine which chemical parameters at the NIROP site should be addressed more extensively in terms of environmental behavior and potential toxicity. The list of chemicals compiled in Section 4.1 was screened to select chemicals which satisfied one or more of the following general criteria:

- clear pattern of occurrence in on-site ground water samples
- clear pattern of occurrence in trench and pit soils
- known history of spills
- toxicologically important

The highest priority was given to those chemicals for which there was evidence of migration in ground water (discussed in detail in Section 5.3.3 and 5.3.4 of this report). The compounds which were reported frequently in samples of ground water are listed below:

Trichloroethylene
Methylene chloride
cis and trans 1,2-dichloroethylene
Tetrachloroethylene
1,1,1-trichloroethane
1,1-dichloroethane

No metals exhibited an obvious ground water occurrence pattern indicative of on-site operations. Two inorganics, manganese and sulfate, were frequently measured at concentrations exceeding the secondary drinking water regulations. However, these levels appear in wells throughout the site and are likely due to either upgradient sources or natural geochemical conditions.

Selenium was measured at a concentration over the primary drinking water standard in well 9-S during the last round of sampling in November, 1986. For this reason the behavior of selenium will be further discussed. In addition, because of the occurrence of xylene and ethylbenzene at high concentrations in one of the excavated drums and PCBs in soils beneath one of the trenches, these parameters warrant further discussion. Toluene was also found in two drums and in some ground water samples. Isocyanates will also be discussed because they are listed as a raw material and are potentially very toxic. These compounds have not been included in any waste, soil, or ground water analysis program. The environmental significance of isocyanates is therefore unknown at the NIROP site.

4.2.2 Behavior of Individual Compounds

The behavior of the compounds in the list in Section 4.2.1 can be discussed as a group. All these compounds are liquids at room temperature but are considered volatiles. Xylene, ethylbenzene, and toluene can also be included in this group. Therefore, they would tend to evaporate from surface spills. If buried or spilled in large quantities these compounds would become available for leaching by infiltrating rainfall.

In general these compounds are soluble in water so that ground water could cause significant translocation in the subsurface. Water solubilities for each compound are listed in Table 4-7.

If a spill or leak is large enough such that the solubility in ground water is exceeded, then these liquids would separate from water. Toluene, ethyl benzene and xylene are less dense than water and would float on the water's surface. The remaining volatile compounds are denser than water and would sink. It is possible that trichloroethylene may have sunk at the NIROP site because it appears to have been spilled or leaked in the largest concentrations.

A sinking plume of trichloroethylene will be slowed by layers of less permeable strata or by bedrock. Ground water flowing past a sinking plume will dissolve trichloroethylene from the plume edges and transport it in the direction of ground water flow at concentrations less than or equal to the solubility (i.e., approximately 1000 mg/l).

Trichloroethylene may also undergo biodegradation in the subsurface. The amount of degradation by microorganisms cannot be predicted at any particular site. It is dependent on concentrations of the compound, exposure time of the organisms to the compound, amount of oxygen present, other compounds present, and other hydrogeochemical factors. The breakdown products of trichloroethylene could include the three forms of dichloroethylene, vinyl chloride, chloroethane and carbon dioxide (Kleopfer et.a., 1985; Bario-Lage et.al., 1986). Dichloroethylene does appear in ground water samples. However, vinyl chloride has not been detected in ground water, indicating that degradation of trichloroethylene may not be occurring.

TABLE 4-7

WATER SOLUBILITIES AND DENSITIES OF SELECTED VOLATILE ORGANIC COMPOUNDS

Compound	Solubility* (mg/L)	Density (H_2O = 1)
Trichloroethylene	1,000	1.46
Methylene Chloride	20,000	1.3
trans 1,2-dichloroethylene	600	1.28
cis 1,2-dichloroethylene	800	1.26
Toluene	515	0.87
Tetrachloroethylene	150	1.63
1,1,1-trichloroethane	4,400	1.35
1,1-dichloroethane	5,500	1.17
Ethylbenzene	152	0.87
Xylene	180	0.88

*Solubility in water at 20°C

Polychlorinated biphenyls (PCBs) behave differently in soils. PCBs exhibit a much lower water solubility (less than 100 ppb.) PCBs also have an affinity for organic or other solid surfaces. Therefore, PCBs are not mobile in ground water, nor are they readily leached from the unsaturated zone. Migration can occur if other organic solvents are mixed with PCBs. However, at the NIROP site the soils in the pit/trench containing the highest concentration of PCBs did not contain detectable levels of organic solvents.

Isocyanates are generally highly reactive with both organic solvents and water. In both instances, the cyanate molecule is altered. In the case of reaction with water, substituted urea compounds and carbon dioxide are formed. It is unlikely that isocyanates would remain intact after exposure to rainfall or ground water.

The material safety data sheets at NIROP show that polymeric isocyanates are being used. Although this terminology is not definitive, it may refer to the polymeric form of MDI (diphenylmethane - 4,4'-diisocyanate). Synonyms for this material are methylene bisphenyl isocyanate and polymethylenepolyphenyl polyisocyanate. The vapor pressure of this material is low (0.00014 tarr at 25°C) which is significant because the toxicity of isocyanates is greater via inhalation than by dermal exposure.

Selenium occurs in several oxidation states in the environment (-2, +4, +6). In intermediate redox conditions and at pH values between 2.9 and 8.4, selenium normally exists as $HSeO_3^-$. In this oxidation state (+4) selenium is called selenite. Selenite is strongly adsorbed to solid surfaces containing iron below a pH of 9. Clay minerals with low

iron content may adsorb selenite less strongly. At higher pHs carbonate can prevent selenite adsoprtion. Other anions may reduce selenite adsorption, including phosphate and possibly sulfate.

4.2.3 Toxicology of Individual Compounds

Volatile Organic Compounds. The carcinogenic potential of the compounds listed in Table 4-7 has been studied. Table 4-8 classifies the compounds by carcinogenicity.

The acute and chronic toxicities of these compounds to humans is not well known. In order to compare these compounds, the oral LD_{50} values for rats are shown in Table 4-9. Data on mutagenicity and teratogenicity is even more scarce. The information which is available is often contradictory or for inhalation experiments only (WDHSS, 1985 and 1986). Therefore, an effective comparison of compounds cannot be made.

PCBs. PCBs are regarded as a potential human carcinogen by NIOSH (1986). According to NIOSH, exposure by humans to PCBs can also cause chloroacne, gastrointestinal disturbances, changes in blood chemistry and numbness in fingers and toes. EPA concluded that PCBs may also cause adverse reproductive effects (49 CFR 28176 Tuesday, July 10, 1984). However, PCBs have a low acute oral toxicity (> 1,000 mg/kg for rats and mice, NIOSH, 1986).

Isocyanates. The isocyanates exert toxic effects primarily in the vapor phase (ACGIH, 1986). Although both eye damage and respiratory problems have been documented, most reported incidents have been in the lungs and bronchial airways. The threshold limit value - time weighted

TABLE 4-8

CARCINOGENICITY OF VOLATILE ORGANIC COMPOUNDS

Compound	Carcinogenicity
Trichloroethylene	Known or probable carcinogen[1]
Methylene chloride	Some data to indicate non-carcinogen[2]
trans 1,2-dichloroethylene	Insufficient data[2]
cis 1,2-dichloroetylene	Insufficient data[2]
Toluene	Some data to indicate non-carcinogen[2]
Tetrachlorethene	Known or probable carcinogen[1]
1,1,1-trichloroethane	Non-carcinogen[1]
1,1-dichloroethane	Contradictory data[2]
Ethylbenzene	Insufficient data[2]
Xylene	Insufficient data[2]

1 50 FR 46886 Wednesday, November 13, 1985.

2 Public Health Related Groundwater Standards, September 1985 and June 1986. Wisconsin Department of Health and Social Services, Division of Health.

TABLE 4-9

ACUTE TOXICITIES OF SELECTED VOLATILE ORGANIC COMPOUNDS[1]

Compound	Oral LD_{50} for Rats (g/kg)
Trichloroethylene	4.9
Methylene chloride	2.0 - 3.0
cis and trans 1,2-dichloroethylene	0.77
Toluene	4.3 - 7.5
Tetrachloroethylene	No data
1,1,1-trichloroethane	11*
1,1-dichloroethane	14.1
Ethylbenzene	3.5
Xylene	0.0043

*LD_{50} for Mice

[1]Taken from Public Health Related Ground Water Standards, September 1985 and June 1986. Wisconsin Department of Health and Social Services, Division of Health.

average (TLV-TWA) is 0.02 ppm in air for MDI (ACGIH, 1986). MDI appears to have a low oral toxicity and is not a potent skin irritant.

Selenium. Selenium is considered a potential carcinogen based on tests with laboratory animals (USDHS, 1983). However, there is some evidence that selenite may actually inhibit tumor formation (Sittig, 1980). Other toxic effects of selenium are strongly dependent on the chemical form of selenium. Selenium is considered an essential nutrient for humans in the range of 0.01 to 0.1 mg/l in the diet (Sittig, 1980). For these reasons a Primary Drinking Water Standard of 0.01 mg/l has been set as a precautionary measure until human health effects are more clearly defined.

5. SUBSURFACE INVESTIGATIONS

The U.S. Army Corps of Engineers (COE) has installed 33 monitoring wells on the NIROP in three phases in May 1983, May 1985, and January 1986. The wells were designated with suffixes to identify the stratigraphic position of the monitoring well intakes: with "S" indicating a shallow (water table) well in the unconsolidated aquifer, "D" indicating a deep (piezometer) well near the base of the unconsolidated aquifer, and "PC" indicating a monitoring well (piezometer) near the top of the aquifer in the Prairie du Chien Formation. The wells were constructed of stainless steel, wire-wound well screens and galvanized well casing. The boreholes were grouted and lockable protective casings were cemented over the well casings. Individual well construction diagrams are provided in Volume II of this report.

This section of the report also compiles the regional information contained in published reports; unpublished data from previous investigations of the FMC Northern Ordnance Division Plant (Papadopulos, 1983; Conestoga Roovers, 1983 and 1985); unpublished reports of previous investigations at the NIROP facility (Envirodyne, 1983); and the November 1986 ground water sampling conducted by RMT.

5.1 Soils

Physical Properties of Soils. The soils in the area of the NIROP formed in sandy glacial deposits. The glacial deposits occurring at the site consist of coarse sand, medium sand, and some gravelly sand. These unconsolidated deposits are up to 150 feet thick in the vicinity of the NIROP (Envirodyne, 1983).

Alluvial deposits occur in areas immediately adjacent to the Mississippi River, west of the East River Road. These deposits are of recent origin, and the soils formed show little development. The texture of these alluvial deposits varies widely. These deposits are frequently subjected to flooding (Envirodyne, 1983).

The NIROP is located in the southwesternmost portion of Anoka County in a small strip of land referred to as the "Anoka County Boot." This portion of the county is not included in the present (1983) Anoka County Soil Survey. However, the Soil Conservation Service (SCS) was able to provide Envirodyne (1983) information as to the soils present at the NIROP. The SCS indicated that the NIROP was located within the Hubbard-Nymore soil association, which is characterized by nearly level to gently sloping, excessively drained, sandy soils. The majority of the area has Hubbard soils, while small areas close to the Mississippi River are occupied by Becker and Chaska soils.

The Hubbard series consists of nearly level to slightly sloping, excessively drained soils formed in broad outwash sands. These soils are located on broad flats adjacent to drainageways and large depressions in the sandy outwash plains. Hubbard soils have a black and very dark grayish-brown, coarse sandy surface layer about 20 inches thick. The subsoil is dark brown and yellowish-brown coarse sand. The underlying material at a depth of about 44 inches is pale brown, gravelly coarse sand. The permeability of these soils is rapid.

The Becker series consists of nearly level, moderately well drained to well drained soils formed in loamy sediments underlain by sand. These soils are found on bottomland along rivers and streams.

Permeability of these soils is moderately rapid, and the available water capacity is moderate. This soil is occasionally flooded for short periods. The surface layer is very dark brown, black or dark grayish-brown fine sandy loam about 27 inches thick. The subsoil is dark brown and dark yellowish-brown, friable, very sandy loam about 17 inches thick. The underlying material is mottled yellowish-brown, loose coarse sand. This soil differs from the Hubbard soils in that it has a thick A horizon and a thicker loamy sediment.

The Chaska series consists of deep, poorly and somewhat poorly drained soils formed in loamy alluvium on flood plains. The surface layer is very dark gray silt loam 8 inches thick. The substratum is 30 inches of very dark grayish-borwn and very dark gray mottled silt loams with strata of fine sand and very fine sandy loam over stratified and mottled dark grayish-brown and olive fine sandy loam and grayish-brown loamy fine sand. Slopes on these soils range from 0 to 2 percent. These soils are commonly subjected to periods of flooding. The permeability of these soils is moderate to moderately rapid.

5.2 Geology

The description of site geology is based upon published reports, NIROP monitoring well logs, and reports from the nearby FMC study area. A general geologic column (Hogberg, 1972) is presented in Table 5-1. The NIROP site lies on an alluvial terrace deposit which was formed during the Pleistocene Epoch, when glacial melt waters caused the nearby Mississippi River to flow at a higher elevation. The terrace deposits consist of a heterogeneous mixture of gravel, sand, silt, and clay.

TABLE 5-1 GENERAL GEOLOGIC COLUMN, TWIN CITY BASIN

System	Rock Unit	Approx. thickness (in feet)	General Description	Graphic Column	Water-Bearing Characteristics
Quaternary	Undifferentiated glacial deposits	0-500	Glacial till, outwash, and valley train sand and gravel; lake deposits; and alluvium of several ages and several provenances; vertical and horizontal distribution of units is complex		Distribution of aquifers and confining beds is poorly known; sand and gravel aquifers that yield moderate to large amounts of water are common in buried bedrock valleys
Ordovician	Decorah Shale	90	Shale, greenish-gray, fissile to blocky; includes thin discontinuous lenses of fossiliferous limestone that increase in abundance upward		Aquifer: low yields from fractures in shale and solution cavities in dolostone
	Platteville Formation	to 35	Dolostone, light-gray to buff, thin- to med.-bedded, shaly		
	Glenwood Formation	to 5	Shale, greenish-gray, fissile, sandy		Confining bed
	St. Peter Sandstone	150	Sandstone, light-gray, massively bedded, well sorted, med.-gr., poorly cemented, quartzose; approx. 20-ft-thick silty to shaly bed near base		Aquifer: moderate yields; Confining bed
	Prairie du Chien Group: Shakopee Formation	50	Dolostone, buff, thin- to thick-bedded, silt- and sand-rich, med.-gr. thin sandstone beds near base		Aquifer: high yields from fractures in dolostone and from poorly cemented sandstone; principal aquifer of the Twin City basin
	Prairie du Chien Group: Oneota Dolomite	100	Dolostone, buff, thin- to thick-bedded, vuggy, med.-gr., silt-rich dolomite marls		
Cambrian	Jordan Sandstone	90	Sandstone, light-gray, massively bedded, med.- to coarse-gr., well sorted, poorly cemented, quartzose		
	St. Lawrence Formation	50	Dolostone, gray to tan, silty or sandy, argillaceous, glauconitic in upper part		Confining bed
	Franconia Formation	155	Sandstone, greenish-gray, thin-bedded, fine- to coarse-gr., silty to dolomitic, commonly glauconitic; an upper aquifer (Ironton) is a fine-gr. sandstone		Aquifer: low yields; Confining bed
	Ironton Sandstone	30	Sandstone, light-gray, poorly to well sorted, med.-gr., silt-rich, quartzose		Aquifer: moderate to high yields
	Galesville Sandstone	35	Sandstone, light-gray, well sorted, fine- to med.-gr., quartzose		
	Eau Claire Formation	to 130	Sandstone, red, fine- to med.-gr., silty, glauconitic, interbedded with grayish-green to red, fissile shale		Confining bed
	Mt. Simon Sandstone	160	Sandstone, light-gray, fine- to coarse-gr., quartzose, thin shale beds in upper part		Aquifer: moderate to high yields; second most important aquifer of Twin City basin
Keweenawan	Hinckley Sandstone	75	Sandstone, tan, med.- to coarse-gr., arkosic		
	Fond du Lac Formation and older sedimentary rocks	to 4,000	Sandstone and siltstone, fine-gr., well cemented, arkosic, interbedded with red to green micaceous shale		Confining bed
	Metamorphic and Igneous Rocks	to 20,000	Mostly mafic, lava flows with thin interflow sediments		

FROM: HOGBERG, 1972

Soil samples (39) from borings 5-D, 6-D, 9-S, and 10-S were classified according to the Unified Soil Classification System following mechanical analyses. The predominant sediment type beneath the NIROP was found to be silty sand (SM). Gravelly sand (SP or SM-SP) occurred at boring 5-D, 6-D, and 9-S. Sandy clay was found in boring 5-D. Details of these analyses and depths of individual samples are presented in Volume II of this report.

The bedrock unit immediately underlying most of the Quaternary deposits at the NIROP is the St. Peter Sandstone. Successive units underlying the St. Peter sandstone are the Prairie du Chien Group and the Jordan, St. Lawrence, Franconia, and Dreshach Formations. This discussion extends to the base of the St. Lawrence due to its role as a regional confining unit.

The St. Peter Sandstone has been described by Thiel (1944) as consisting of a medium- to fine-grained, friable, white to yellow sandstone, with beds of siltstone and shale in the lower part of the formation. Because of the small size of its quartz grains, the formation is not highly permeable.

Much of the original thickness of the St. Peter Sandstone was eroded away before the overlying unconsolidated materials were deposited. Therefore, only the lower portion of the formation is present beneath the site. The base of the St. Peter Sandstone is typically silty to shaly. This low permeability unit therefore acts as a hydrogeologic confining unit within the ground water flow system, separating the Quaternary deposits from the underlying Prairie du Chien aquifer. Within the Mississippi River Valley, the St. Peter Sandstone

is often completely eroded away, exposing the underlying Prairie du Chien Group. Where the St. Peter is absent, or where "windows" occur, there is direct communication with the alluvium and hazardous substance migration into the Prairie du Chien Formation can occur.

The Prairie du Chien Group consists of the Shakopee and Oneota Dolomites. The Shakopee Dolomite is much less dolomitic than the Oneota (Thiel, 1944). Its basal beds are sandy and, in many places, the succeeding layers are thin-bedded. Much of the formation is a massive, drab, dolomitic limestone with cavities filled with white calcite. Calcareous oolites may be found throughout the Shakopee, and much of the flint that is common in this formation is also oolitic.

The Oneota Dolomite is thick-bedded, drab to buff, and in places pink, and may be sandy or shaly. The upper part may be cherty and in many locations it is porous to cavernous. Many of the cavities and joints are lined with quartz crystals, and huge calcite-lined pockets are common. In the southeastern counties where the dolomite is strongly developed in the bluffs of the Mississippi and its tributaries, there are extensive solution channels, some of which reach the dimensions of caves penetrable for some distance. Both the Shakopee and Oneota Dolomites are highly permeable and form a regional aquifer that is widely used for water supplies.

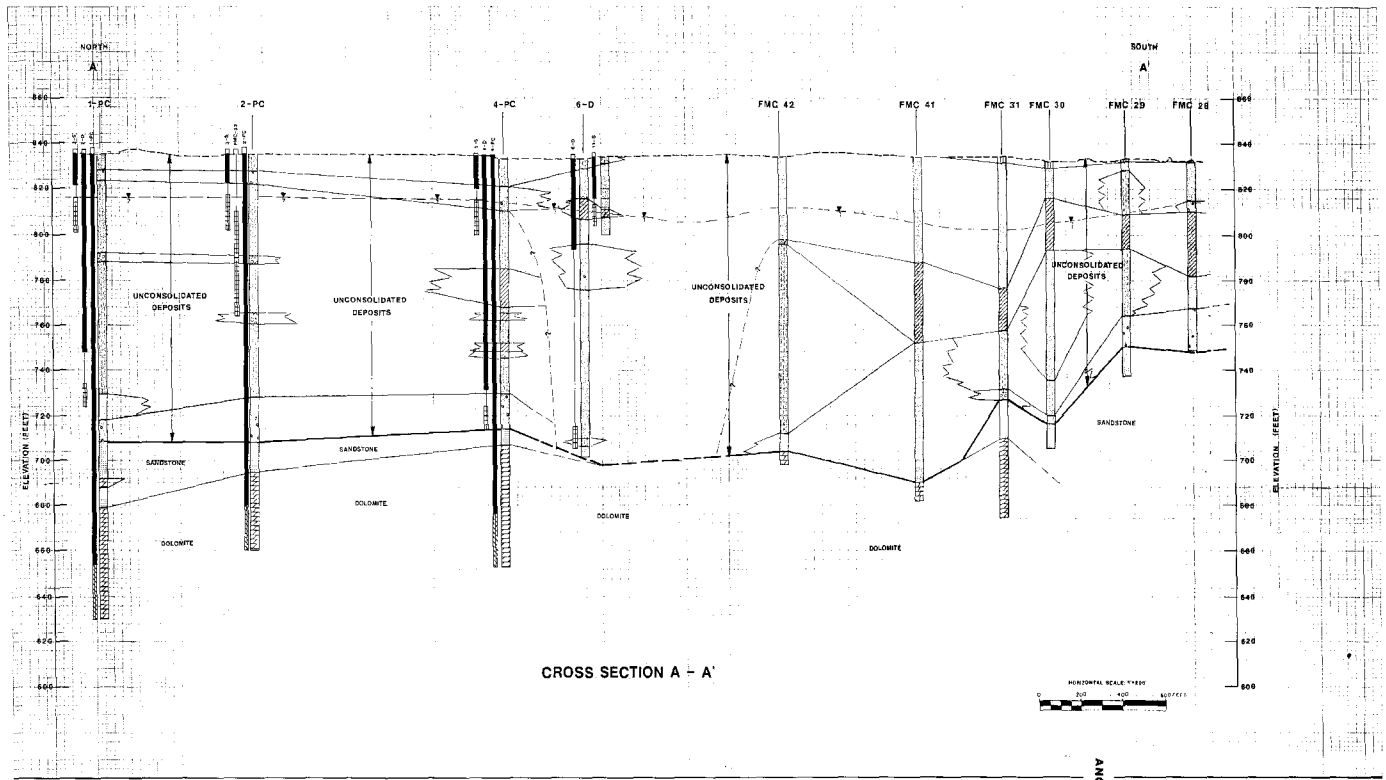
The Jordan Sandstone, which underlies the Prairie du Chien Group, has been described by Thiel (1944) as a loosely cemented medium- to coarse-grained white sandstone, which becomes yellow or brown, due to oxidation, along its outcrops and jointing planes. It ranges from 75 to nearly 175 feet thick and is exposed in the valleys of the Minnesota

River and tributary streams; it also appears in the lower part of the bluffs of the Mississippi and its branches from near Hastings southward to the Iowa state line. Elsewhere the Jordan Sandstone is deeply buried beneath younger rock. The Jordan Sandstone is made up of two members, the Norwalk and the Van Oser. The upper Van Oser member is the coarser. It consists of friable gray, white, pink, or brown sand grains. The lower Norwalk member is not present in the Twin Cities area. The Jordan sandstone is very permeable and acts as a regional aquifer.

The St. Lawrence Formation underlies the Jordan Formation. The St. Lawrence Formation consists of glauconitic, buff, dolomitic limestone (Thiel, 1944). Several conspicuous beds of gray to buff dolomitic siltstone occur near the base of the formation. The St. Lawrence consists of two members, the lower of which is the Nicolet Creek member, the upper, the Lodi shale.

Neither member of the St. Lawrence Formation is important as a source of ground water. The chief value of these members lies in their function as confining strata under the Jordan Sandstone aquifer. Contaminants which have migrated to this depth would be impeded from further migration by the St. Lawrence Formation.

Geologic Cross Sections. Geologic cross sections have been prepared to aid in the discussion of site geology at the NIROP study area. Cross-section locations are shown on Figure 2-2. Two north-south geologic cross sections and one east-west cross section are shown on Figures 5-1 and 5-2. Boring logs from the installation of NIROP monitoring wells and information from FMC reports were used in preparing Figures 5-1 and 5-2.



CROSS SECTION A - A'

LEGEND

- EXISTING GROUND SURFACE
- BEDROCK SURFACE
- STRATIGRAPHIC BOUNDARY
- INFERRED STRATIGRAPHIC BOUNDARY
- WATER TABLE (JULY 22, 1986)
- WELL STICK-UP ABOVE GROUND
- LOCATIONS OF WELL SEALS
- LOCATION OF WELL SCREEN
- OPEN BOREHOLE

SAND (SP)
GRAVELLY SAND (SP)
SILT (ML)
GRAVELLY SILT (ML-GM)
SILT & SAND (SM)
SANDY SILT (ML-SM)
CLAYEY SAND (SC)
CLAYEY SILT (ML-CL)
CLAY (CL)
GRAVEL (GP)
GRAVELLY CLAY (CL-GC)
SANDY GRAVEL (GW)
SILTY CLAY (CL-ML)
SILTY GRAVEL (GM)
SANDY CLAY (CL-SC)
CLAYEY GRAVEL (GC)
TOPSOIL
FILL-WANMADE
SANDSTONE
COBBLES & BOULDERS
LIMESTONE
PEAT OR MUCK
DOLOMITE
CRYSTALLINE ROCK
SHALE

NOTES:

- NIROP BORING LOCATIONS ARE APPROXIMATE, BASED ON FIELD CHECKS AGAINST CULTURAL FEATURES.
- LOCATIONS AND GEOLOGIC DATA FOR FMC BORINGS FROM POPADOPULOS (1983 AND 1984).
- SUFFIXES:
  - PC=MONITORING WELL COMPLETED IN THE PRAIRIE DU CHIEN FORMATION
  - D=MONITORING WELL COMPLETED IN THE BASE OF UNCONFINED AQUIFER IN THE UNCONSOLIDATED DEPOSITS
  - S=MONITORING WELL COMPLETED NEAR THE WATER TABLE IN THE UNCONFINED AQUIFER IN THE UNCONSOLIDATED DEPOSITS

NOTE:
ALL GEOLOGIC INFORMATION SHOWN ON THIS FIGURE IS A REPRESENTATION OF PROBABLE CONDITIONS EXISTING IN THE FIELD. ACTUAL CONDITIONS BETWEEN BORINGS MAY DIFFER FROM THIS REPRESENTATION.

NO.	BY	DATE	REVISION	APPD
3				
2				
1				

PROJECT:
RI/FS AT NIROP
FRIDLEY, MINNESOTA

SHEET TITLE:
GEOLOGIC CROSS SECTION A-A'

DRAWN BY	WDZ	SCALE: HORIZ. 1" = 200' VERT. 1" = 20'	PROJ. NO. 1225.01
CHECKED BY			DRWG. NO.
APPROVED BY		DATE PRINTED	FIGURE 3-1
DATE	4/16/87		

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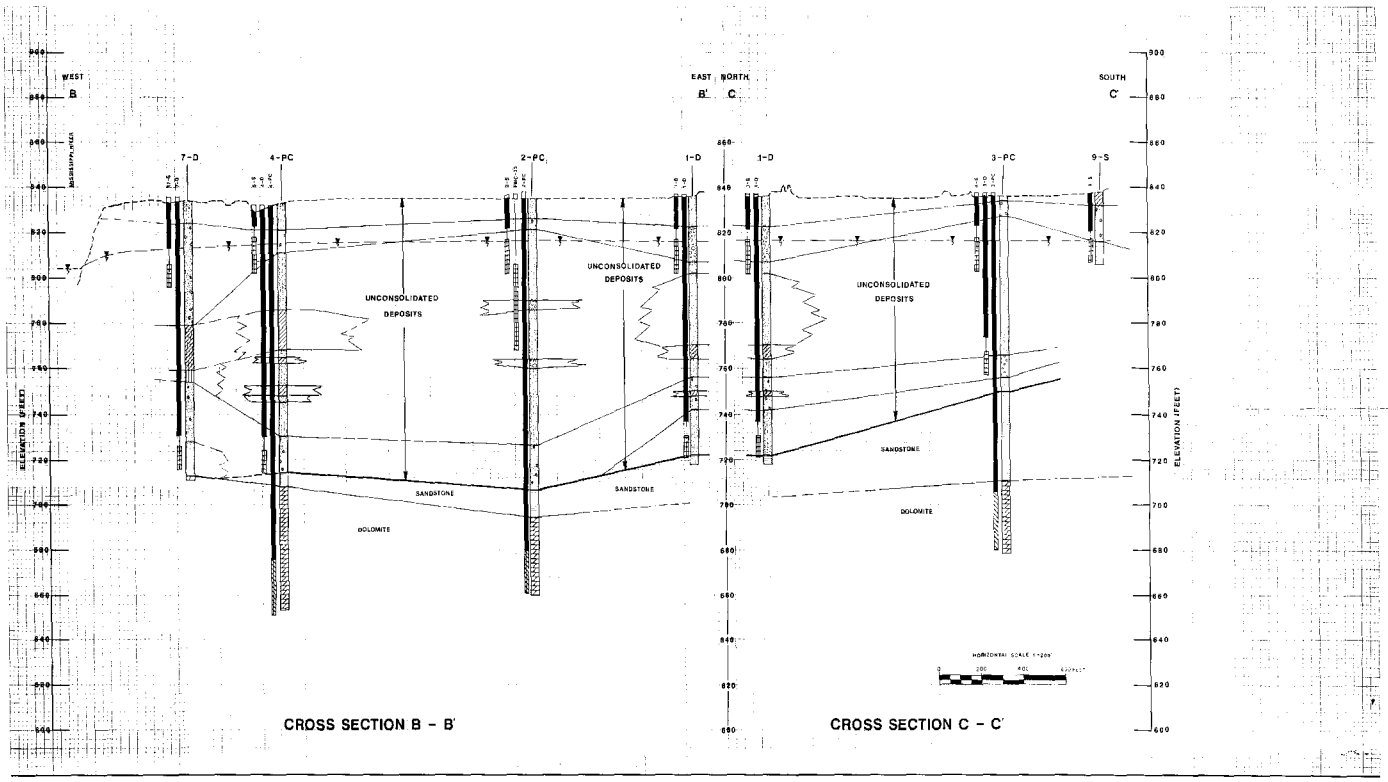

LEGEND

- EXISTING GROUND SURFACE
- BEDROCK SURFACE
- STRATIGRAPHIC BOUNDARY
- INFERRED STRATIGRAPHIC BOUNDARY
- WATER TABLE (JULY 22, 1986)
- WELL STICKUP ABOVE GROUND
- LOCATIONS OF WELL SEALS
- LOCATION OF WELL SCREEN
- OPEN BOREHOLE

SAND (SP) · GRAVELLY SAND (SP) · SILTY SAND (SM) · CLAYEY SAND (SC) · CLAY (CL) · GRAVELLY CLAY (GL-SC) · SILTY CLAY (CL-ML) · SANDY CLAY (CL-SC) · TOPSOIL · FILL-MANMADE · COBBLES & BOULDERS · PEAT OR MUCK · CRYSTALLINE ROCK · SILT (ML) · GRAVELLY SILT (ML-GM) · SANDY SILT (ML-SM) · CLAYEY SILT (ML-CL) · GRAVEL (GP) · SANDY GRAVEL (GW) · SILTY GRAVEL (GM) · CLAYEY GRAVEL (GC) · SANDSTONE · LIMESTONE · DOLOMITE · SHALE

NOTES:

- NIROP BORING LOCATIONS ARE APPROXIMATE, BASED ON FIELD CHECKS AGAINST CULTURAL FEATURES.
- LOCATIONS AND GEOLOGIC DATA FOR FMC BORINGS FROM PORADOPULOS (1983 AND 1984).
- SUFFIXES:
  - PC=MONITORING WELL COMPLETED IN THE PRAIRIE DU CHIEN FORMATION
  - D=MONITORING WELL COMPLETED IN THE BASE OF UNCONFINED AQUIFER IN THE UNCONSOLIDATED DEPOSITS
  - S=MONITORING WELL COMPLETED NEAR THE WATER TABLE IN THE UNCONFINED AQUIFER IN THE UNCONSOLIDATED DEPOSITS

NOTE:
ALL GEOLOGIC INFORMATION SHOWN ON THIS FIGURE IS A REPRESENTATION OF PLAUSIBLE CONDITIONS EXISTING IN THE FIELD. ACTUAL CONDITIONS BETWEEN BORINGS MAY DIFFER FROM THIS REPRESENTATION.

NO.	BY	DATE	REVISION	APPD.
3				
2				
1				

PROJECT:
RI/FS AT NIROP
FRIDLEY, MINNESOTA

SHEET TITLE:
GEOLOGIC CROSS SECTIONS
B-B' AND C-C'

DRAWN BY: JMM	SCALE: HORIZ. 1"=200' VERT. 1"=20'	PROJ. NO. 1284.03	
CHECKED BY:		DWG. NO.	
APPROVED BY:	DATE PRINTED:	FIGURE 5-2	
DATE: 8/1/88			

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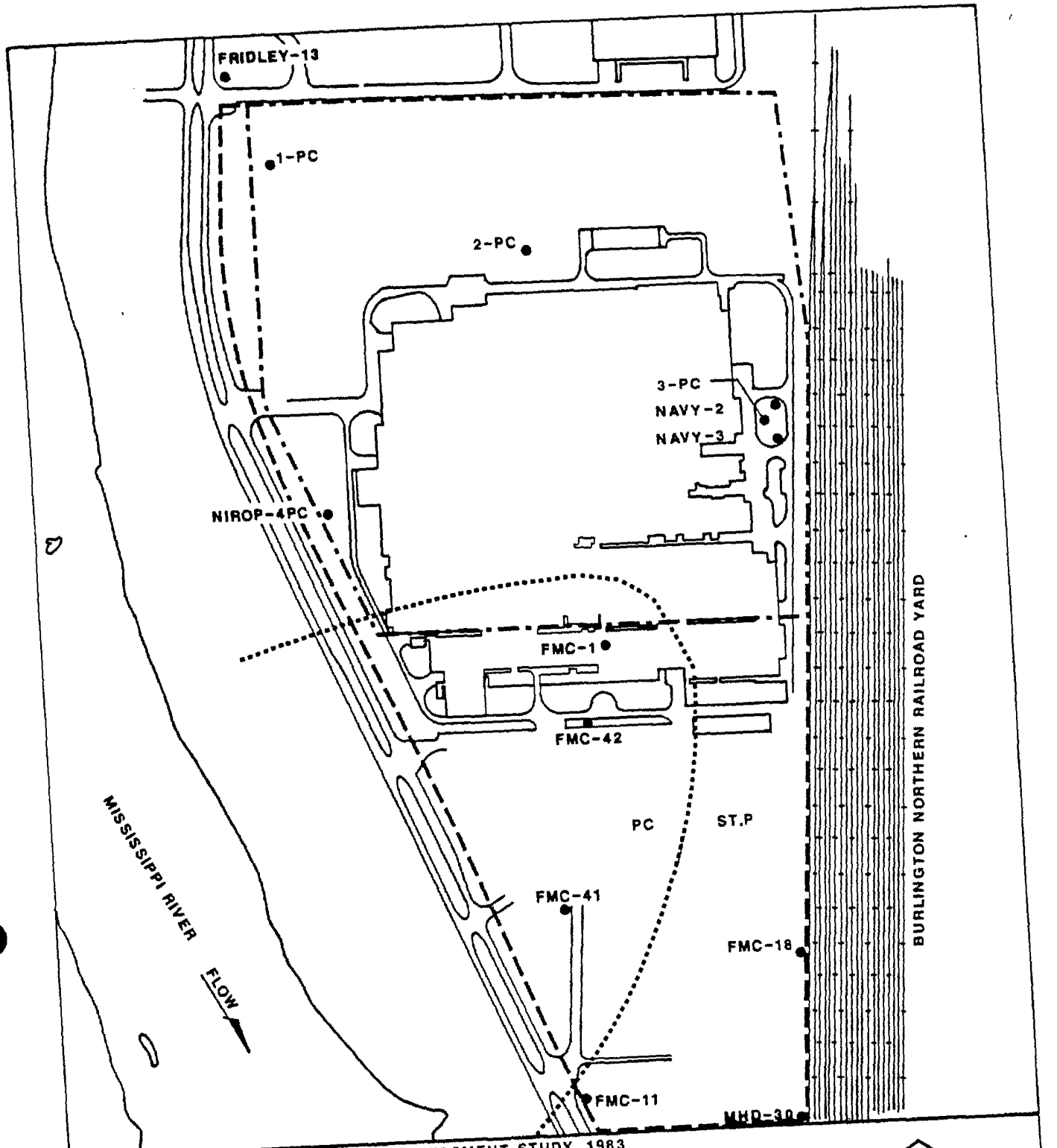
Several borings beneath the NIROP facility penetrate the bedrock formations. A distinct thinning of the St. Peter Sandstone occurs between wells 1-PC and 4-PC. The thickness decreases from approximately 37 feet to 7 feet between the wells. Further south, the St. Peter Sandstone is absent between borings 7-D and FMC 42 and 41 and appears again at FMC 31. In the area where the St. Peter Sandstone is absent, the Prairie du Chien Dolomite is in direct contact with the overlying alluvial deposits. The approximate areal extent of Prairie du Chien exposure is shown on Figure 5-3, which has been adapted from the Initial Assessment Study (1983). This area could allow vertical migration of contaminants into the Prairie du Chien Formation to occur. The contact area appears to be the mouth of a buried bedrock valley described by Payne (1965). Payne describes the valley as extending to the northeast, which would locate it under the southern portion of the NIROP facility.

In summary, the NIROP is underlain by a thick layer of unconsolidated sediments. The majority of the sediments are silty sand and form an extensive aquifer beneath the facility. There are coarser, gravelly sand layers near the top and the bottom of the unconsolidated sediments. Both layers are hydraulically connected to thick sand deposits that appear to extend from near the ground surface to the bedrock along the Mississippi River. The clay layer(s) which significantly affects ground water flow and contaminant migration beneath the FMC facility becomes thin and discontinuous beneath the NIROP. It probably does not have a significant impact below the NIROP.



PROPERTY ADAPTED FROM INITIAL ASSESSMENT STUDY, 1983

● WELL LOCATION & NUMBER. USED FOR DETERMINATION OF UPPER BEDROCK LITHOLOGY

CONTACT BETWEEN BEDROCK UNITS

NIROP PROPERTY — FMC PROPERTY

ST.P ST. PETER SANDSTONE PC PRAIRIE du CHIEN DOLOMITE

N

0 500'

1" = 500'

FIGURE 5-3
APPROXIMATE ST. PETER SANDSTONE/ PRAIRIE du CHIEN CONTACT

RMT

DWN. BY:	MDZ
DATE:	8/11/86
PROJ.#	1120.03

5.3 Ground Water

5.3.1 Aquifer Systems

Four aquifers underlie the NIROP site as defined by the Minnesota Geological Survey (Kanivetsky and Walton, 1979). These are (from youngest to oldest) the Quaternary aquifer, the Prairie du Chien/Jordan aquifer, the Franconia/Ironton/Galesville aquifer and the Mt. Simon/Hinckley/Fond du Lac aquifer. The upper two aquifers (Quaternary and Prairie du Chien/Jordan) are separated from the lower two units by the St. Lawrence Formation, which serves as a confining layer. Therefore, this investigation will focus on the upper two aquifers.

The Quaternary aquifer is found within Mississippi River alluvial deposits which consist primarily of sand with some gravel, varying thicknesses of silts, and occasional clay lenses. The Quaternary alluvial aquifer, though capable of yielding fairly high quantities of water to wells, is not commonly used for water supply purposes. The Quaternary aquifer is highly susceptibile to contamination; therefore, the underlying Prairie du Chien/Jordan aquifer is more commonly used (Envirodyne, 1983).

The Prairie du Chien/Jordan (PCJ) is composed of two units: dolomites of the Prairie du Chien Group and the Jordan Sandstone. The Prairie du Chien is primarily a highly fractured dolomite and contains solution cavities that increase its permeability. The Prairie du Chien Group is underlain by the poorly cemented Jordan Sandstone which, together with the Prairie du Chien, is capable of yielding 500 to 1,000 gpm.

In the NIROP study area, the PCJ aquifer is generally separated from the overlying Quaternary aquifer by a silty to shaly basal bed of the St. Peter Sandstone. However, under the southwestern portion of the plant, the St. Peter Sandstone is fully eroded and in contact with the unconfined Quaternary alluvial aquifer (see Figure 5-3). Where this condition occurs, the PCJ and the Quaternary deposits act as a single, hydraulically connected unit.

Ground Water Use. Only two area wells were reported by Papadopulos (1983) as being finished in the Quaternary alluvial aquifer in the vicinity of the NIROP. One well is north and west of the NIROP (upgradient), west of East River Road; and the other is about 900 feet south of the NIROP, west of East River Road. Both wells are in the area currently designated as a park. It is not known if either well is operational. The production from these wells was estimated by Papadopulos at less than a few hundred gallons per day. A high-capacity "Ranney" well system to augment the City of Minneapolis water supply has been proposed for the alluvial aquifer immediately west and south of the NIROP. These wells would be generally downgradient of the NIROP.

The PCJ aquifer is a major source of ground water for the Minneapolis-St. Paul area. Within and near the NIROP site, ground water production from the Prairie du Chien/Jordan aquifer either has occurred or does occur from several wells. Three high capacity production wells are located on NIROP property (FMC/Navy wells 1, 2, and 3 on Figure 2-2). These wells are no longer in use. The City of Fridley Municipal Well 13 (immediately northwest of the NIROP), two wells owned by Honeymead/Minnesota Linseed Oil Company (located southeast of the

facility), and two wells owned by Kurt Manufacturing Company (located about 2,500 feet northeast of the NIROP), continue to rely upon water from the PCJ aquifer.

Production from these wells has varied over the years. Navy wells 2 and 3 produced at an average annual rate of about 500 to 650 gallons per minute (gpm) or about 0.7 to 0.9 million gallons per day (Mgd) prior to their closure in April, 1981 (Papadopulos, 1983). FMC well 1 produced at an average rate of about 245 gpm (0.35 Mgd) in 1983. Prior to the closure of Navy wells 2 and 3, FMC well 1 was used only to supplement the production from wells 2 and 3. The average annual production rate of FMC well 1 prior to August 1981 was less than 10 gpm (0.01 Mgd). Fridley well 13 is used intermittently at a pumping rate of approximately 1,000 gpm and produces about 15 to 30 gpm (0.02 to 0.04 Mgd) on an average annual basis. The Honeymead wells average about 140 to 170 gpm (0.20 to 0.24 Mgd) of production annually (Papadopulos, 1983). Annual production from the wells owned by Kurt Manufacturing Company is unknown.

Other wells that produce ground water from the Prairie du Chien/Jordan aquifer are located in the main Fridley well field (about 2 miles north-northeast from the plant) and in the Brooklyn Center well field (about 2 miles north-northwest from the site). The production from these well fields in 1979 was about 4 and 3 Mgd, respectively (Papadopulos, 1983). However, in the Fridley well field, only about 40 percent of the total production was from the Prairie du Chien/Jordan aquifer.

Effects of Pumping. Little is known about the effects of pumping in the vicinity of the NIROP. One effort to determine the effects of nearby pumping wells was reported by Papadopulos (1984). Three local production wells were evaluated; Fridley Number 13 (Figure 2-2), Kurt Manufacturing (about 1/2 mile northeast of the NIROP), and Honeymead/ Minnesota Linseed Oil Company (Southeast of the NIROP). Efforts to develop accurate data for both the Kurt Manufacturing and Honeymead wells were unsuccessful.

The Fridley Well Number 13 test was more successful. Fridley Well Number 13 was pumped at a reported rate of 1,000 gallons per minute for 24 hours beginning at 1:00 p.m., January 4, 1984. Water in the pumping well declined nearly 30 feet over the test period. Water level declines of 0.1 to 0.9 feet were observed in bedrock monitoring wells beneath the NIROP and FMC facilities.

The short-term pumping test indicates that production from well 13 could potentially affect ground water flow directions in the Prairie du Chien beneath the NIROP facility. If hazardous constituents were to enter the Prairie du Chien, they could be drawn toward Fridley Well 13 during periods of intermittent use.

5.3.2 Ground Water Flow

Monitoring wells at the NIROP study area were installed in three phases. The U.S. Army Corps of Engineers supervised the installation of monitoring wells at the NIROP site. Fourteen monitoring wells were installed at the NIROP site between May and August 1983. Seven additional on-site monitoring wells were installed in May and June 1985.

Installation of twelve off-site monitoring wells was completed in February 1986. The purpose of these wells was to monitor the effectiveness of waste removal activities from the pits/trenches (described in Section 4 of this report), to determine ground water flow directions, and to determine the extent of ground water contamination. Water levels were measured how often regularly from October 1983 to April 1985, and from June to September 1986. Well construction logs and water level data are presented in Volume II of this report. Table 5-2 summarizes some of the monitoring well information.

Three separate water table or piezometric surface maps have been prepared to present horizontal ground water flow directions (Figures 5-4, 5-5, and 5-6). Water level data from the adjacent FMC study area has been incorporated where appropriate.

The water table surface within the unconsolidated deposits has been developed from water levels measured on July 22, 1986 (Figure 5.4). Generally, ground water flow is toward the southwest or west, to the Mississippi River. A horizontal hydraulic gradient of 0.0005 feet/foot beneath most of the site (well 7-S to well 10-S) steepens to between 0.014 feet/foot (well 10-S to well 11-S) and 0.010 feet/foot (well 20-S to 19-S) at the southern edge of the facility. The steepening occurs in the area of a broad "valley" within the water table surface between the NIROP and the Minneapolis Waterworks facility. The increased gradients and lower water levels may reflect the occurrence of the "clean" sand unit discussed in Section 5.2. This potentially more permeable unit would cause flow to converge in this area from the surrounding, less permeable silty sands. This low point in the water table may be

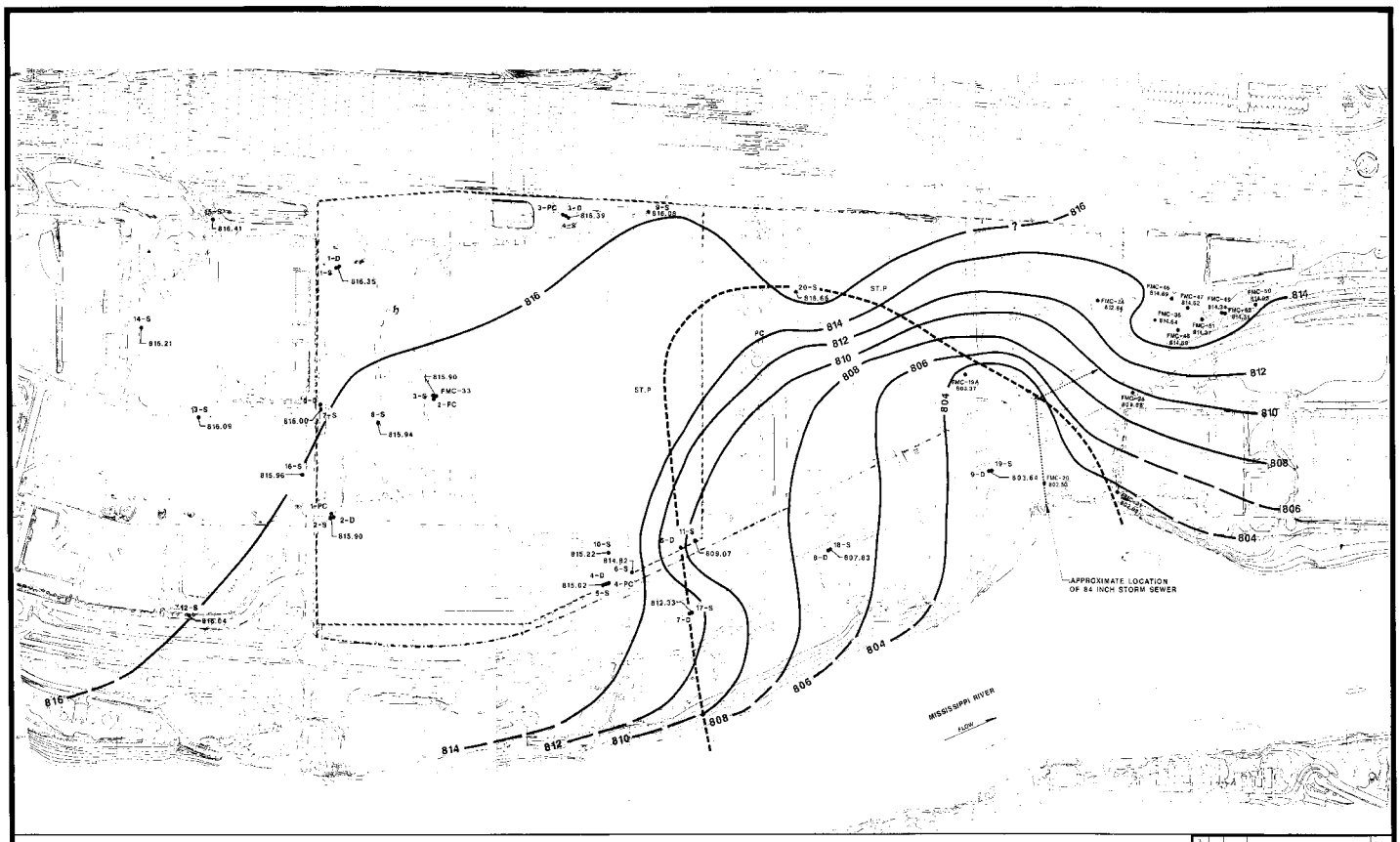
TABLE 5-2. NIROP MONITORING WELL CONSTRUCTION DATA

WELL NUMBER	TOP OF CASING ELEVATION	TOP OF SCREEN ELEVATION	BOTTOM OF SCREEN ELEVATION	WELL * DEPTH
1-S	837.14	817.24	802.16	34.98
1-D	836.75	731.31	721.21	115.54
1-PC	837.63	653.97**	628.97	208.66
2-S	836.07	816.62	801.42	34.65
2-D	836.04	733.93	723.74	112.3
2-PC	838.05	679.35**	659.76	178.28
3-S	836.75	817.06	802.00	34.75
3-D	837.48	766.79	756.61	80.87
3-PC	839.21	706.51**	679.81	159.4
4-S	837.45	817.67	802.60	34.85
4-D	834.79	723.94	713.86	120.93
4-PC	834.75	677.42**	652.42	182.33
5-S	835.06	815.38	800.35	34.71
5-D	836.00	729.1	718.9	117.1
6-S	835.73	816.28	801.08	34.65
6-D	835.69	715.71	705.74	129.95
7-S	835.97	816.23	806.03	29.94
7-D	835.63	727.63	717.63	118
8-S	835.76	815.96	805.86	29.9
8-D	834.02	716.02	706.02	128
9-S	836.68	817.38	807.38	29.3
9-D	834.30	720.03	710.30	124
10-S	835.89	814.59	804.59	31.3
11-S	835.89	814.79	804.59	31.3
12-S	838.51	812.61	802.61	35.9
13-S	834.59	810.69	800.69	33.9
14-S	835.99	811.59	801.59	34.4
15-S	834.83	810.33	800.33	34.5
16-S	837.26	811.46	801.46	35.8
17-S	835.75	806.75	796.75	39
18-S	834.08	803.33	793.33	40.75
19-S	834.56	799.56	789.56	45
20-S	837.62	812.02	802.02	35.6
FMC-33	837.05	806.05	760.05	77.0

* From top of casing

** Open hole

(1254.01 139:RTA:frid0506T3)



LEGEND

- EXISTING PAVED ROAD
- EXISTING UNPAVED ROAD
- EXISTING BUILDING
- EXISTING FENCE
- 808 EXISTING 2' CONTOUR
- EXISTING 1' CONTOUR
- x 890' EXISTING SPOT ELEVATION
- TREES AND / OR BRUSH
- EDGE OF WATER
- WET AREA
- 12-S MONITORING WELL LOCATION AND NUMBER
- 815.5 EQUIPOTENTIAL LINE
- CONTACT BETWEEN ST. PETER AND PRAIRIE du CHIEN FORMATIONS
- ST.P ST. PETER SANDSTONE
- PC PRAIRIE du CHIEN DOLOMITE
- NIROP FACILITY PROPERTY LINE (APPROXIMATE)
- FMC FACILITY PROPERTY LINE (APPROXIMATE)

NOTES:

LOCATIONS OF FMC WELLS ARE APPROXIMATE.

FMC WATER LEVEL READINGS TAKEN JULY 16, 1986.

NIROP WATER LEVEL READINGS TAKEN JULY 22, 1986.

0 50 100 200 300 400 500 600 700 800 900 1000 FEET

CONTRACT NO. DACA45-86-C-0015

NO.	BY	DATE	REVISION	APPR.
1.				
2.				
3.				

PROJECT:
RI/FS AT NIROP
FRIDLEY, MINNESOTA

SHEET TITLE:
WATER TABLE IN UNCONSOLIDATED SEDIMENTS
JULY, 1986

DRAWN BY JOHN MOO	SCALE 1" = 600'	PROJ. NO. 1884.41
CHECKED BY		DWNG. NO.
APPROVED BY	DATE PRINTED	SHEET OF
DATE 6/13/86		FIGURE 5- 4

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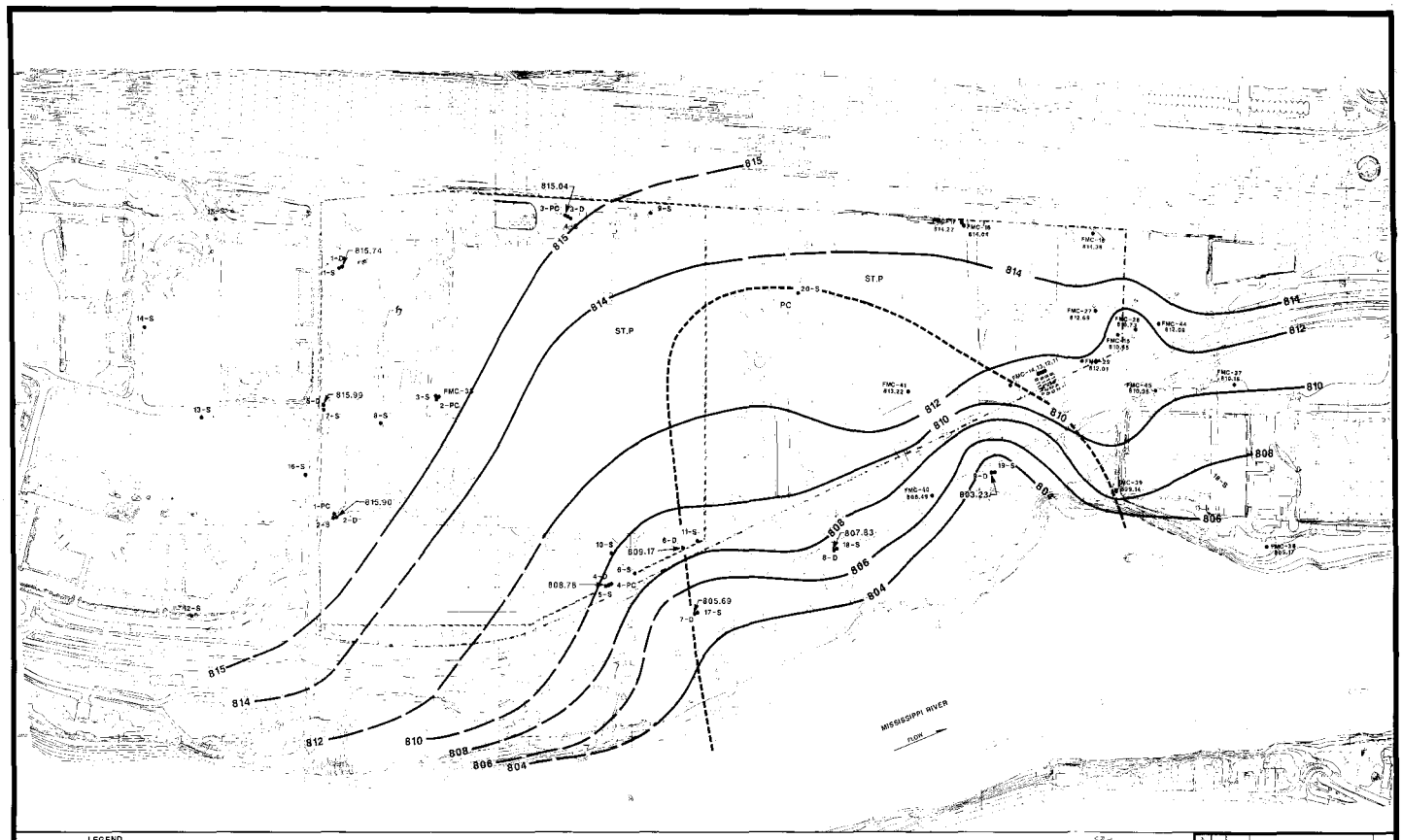

LEGEND

- EXISTING PAVED ROAD
- EXISTING UNPAVED ROAD
- EXISTING BUILDING
- EXISTING FENCE
- 600 EXISTING 5' CONTOUR
- 1 895 EXISTING SPOT ELEVATION
- TREES AND / OR BRUSH
- EDGE OF WATER
- WET AREA
- MW-22A MONITORING WELL LOCATION AND NUMBER
- 815.5 EQUIPOTENTIAL LINE
- CONTACT BETWEEN ST. PETER AND PRAIRIE du CHIEN FORMATIONS
- ST.P ST. PETER SANDSTONE
- PC PRAIRIE du CHIEN DOLOMITE
- NIROP FACILITY PROPERTY LINE (APPROXIMATE)
- FMC FACILITY PROPERTY LINE (APPROXIMATE)

NOTES:

LOCATIONS OF FMC WELLS ARE APPROXIMATE.

FPC WATER LEVEL READINGS TAKEN JULY 16, 1986.

NIROP WATER LEVEL READINGS TAKEN JULY 22, 1986.

S.A.
SPEC. CHK.

SCALE 1" = 200'
200 100 NO FEET

NO.	BY	DATE	REVISION	APPD
3.				
2.				
1.				

PROJECT:

RI/FS AT NIROP
FRIDLEY, MINNESOTA

SHEET TITLE:

PIEZOMETRIC SURFACE NEAR THE BASE OF THE UNCONSOLIDATED SEDIMENTS JULY, 1986

DRAWN BY: JMM MOZ	SCALE 1" = 200'	PROJ. NO. 1264.01
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DATE: 8-13-86		

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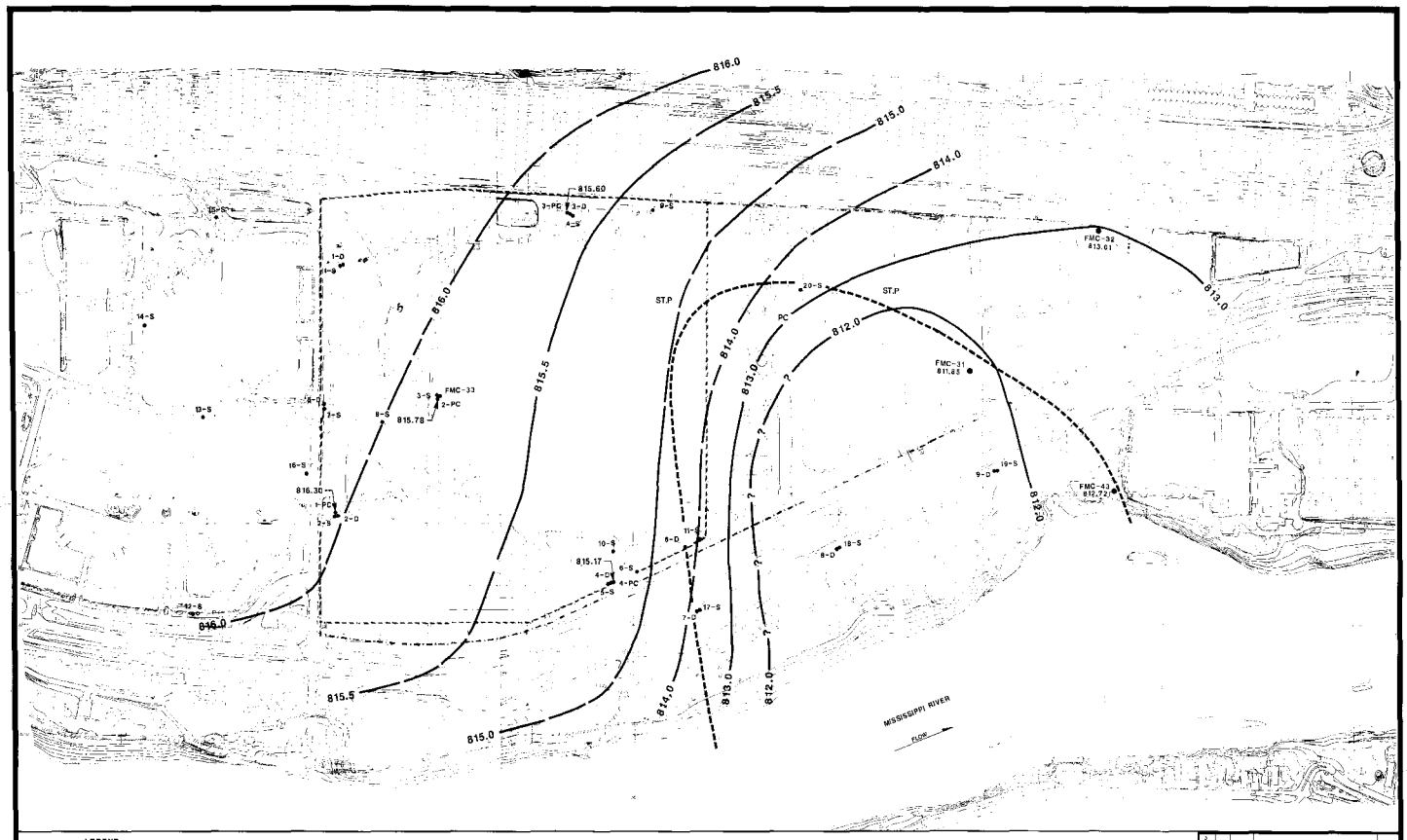

LEGEND

- EXISTING PAVED ROAD
- EXISTING UNPAVED ROAD
- EXISTING BUILDING
- EXISTING FENCE
- 809 EXISTING 5' CONTOUR
- EXISTING 1' CONTOUR
- 865 EXISTING SPOT ELEVATION
- TREES AND / OR BRUSH
- EDGE OF WATER
- WET AREA
- MW-12A MONITORING WELL LOCATION AND NUMBER
- 813.5 EQUIPOTENTIAL LINE
- CONTACT BETWEEN ST. PETER AND PRAIRIE du CHIEN FORMATIONS
- ST.P ST. PETER SANDSTONE
- PC PRAIRIE du CHIEN DOLOMITE
- NIROP FACILITY PROPERTY LINE (APPROXIMATE)
- FMC FACILITY PROPERTY LINE (APPROXIMATE)

NOTE:
LOCATIONS OF FMC WELLS ARE APPROXIMATE
FMC WATER LEVEL READINGS TAKEN JULY 16, 1986
NIROP WATER LEVEL READINGS TAKEN JULY 23, 1986

SCALE 1" = 200'
0 100 200 400 FEET

NO.	BY	DATE	REVISION	APPD.
3.				
2.				
1.				

PROJECT
RI/FS AT NIROP
FRIDLEY, MINNESOTA

SHEET TITLE:
PRAIRIE DU CHIEN
PIEZOMETRIC SURFACE JULY, 1986

DRAWN BY: JRM MDZ
SCALE: 1" = 200'
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APPROVED BY:
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DATE: 8/13/86
FIGURE 5-6

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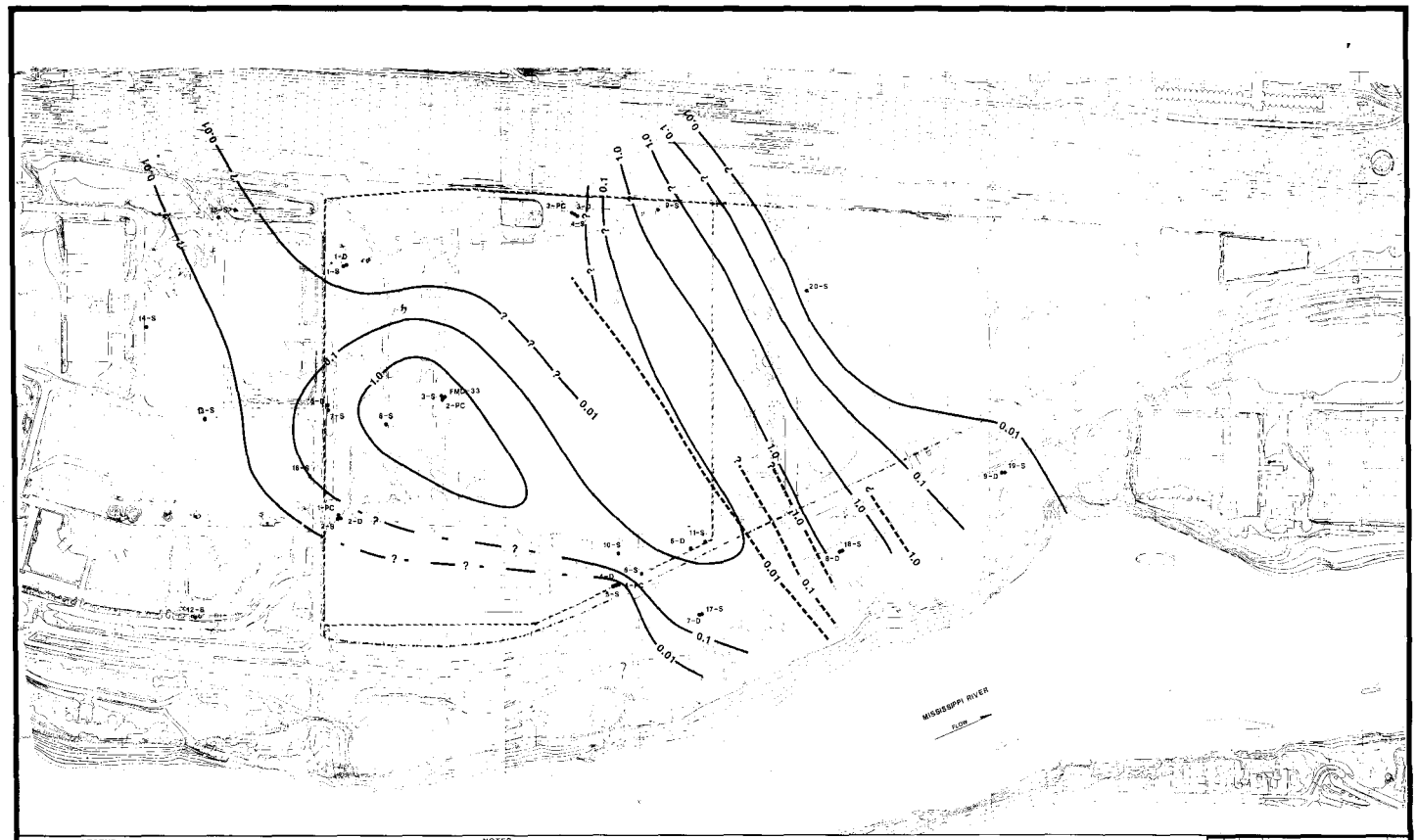

LEGEND

- EXISTING PAVED ROAD
- EXISTING UNPAVED ROAD
- EXISTING BUILDING
- EXISTING FENCE
- EXISTING 5' CONTOUR
- EXISTING 1' CONTOUR
- 865.1 EXISTING SPOT ELEVATION
- TREES AND / OR BRUSH
- EDGE OF WATER
- WET AREA
- 2-S MONITORING WELL LOCATION AND NUMBER
- TCE IN mg/L IN DEEP UNCONSOLIDATED AQUIFER
- TCE IN mg/L IN SHALLOW UNCONSOLIDATED AQUIFER
- APPROXIMATE NIROP FACILITY PROPERTY LINE
- APPROXIMATE FMC FACILITY PROPERTY LINE
- INFERRED TCE CONCENTRATION

NOTES

TRICHLORETHYLENE CONCENTRATIONS USED IN PREPARATION OF THIS PLATE ARE MEAN VALUES FOR DATA COLLECTED BETWEEN OCTOBER, 1983 AND NOVEMBER, 1986

SCALE: 1" = 200'
0 200 400 600 FEET

CONTRACT NO. DACA45-86-C-0015

NO.	BY	DATE	REVISION	APPD.
1				
2				
3				

PROJECT:
RI/FS AT NIROP
FRIDLEY, MINNESOTA

SHEET TITLE:
EXTENT OF TCE CONTAMINATION SHALLOW & DEEP UNCONSOLIDATED AQUIFER

DRAWN BY: JAN WAZ | SCALE: 1" = 200' | PROJ. NO. 1874.01
CHECKED BY: | DRWG. NO. 5-7
APPROVED BY: | DATE PLOTTED: | FIGURE 5-7
DATE: 8/1/88

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accentuated as a result of ground water leaking into the 84-inch storm sewer noted in Section 4.1 or, flowing laterally through very permeable bedding materials used in constructing the storm sewer system. The storm sewer may therefore intercept the southwestward ground water flow from the NIROP. Additionally, this area may be more subject to changes in stage of the Mississippi River.

The piezometric surface in the base of the unconsolidated sediments is shown in Figure 5-5. Ground water is again flowing southwestward toward the Mississippi River. The horizontal gradient beneath the northeastern two-thirds of the facility was calculated to be 0.0044 feet/foot. The horizontal gradient on the southern edge of the facility again increases to 0.012 feet/foot. The increased gradients and "valley" in the piezometric surface may again be reflecting the presence of more permeable sands in the vicinity of wells 6-D, 7-D, and 8-D.

The piezometric surface for the Prairie du Chien/Jordan aquifer system shown on Figure 5-6. Flow is toward the southwest. The horizontal gradient calculated between wells 1-PC and 2-PC was 0.0008 feet/foot. The gradient appears to remain flat across the site to the Mississippi River.

Vertical hydraulic gradients were calculated for eight NIROP well nests to allow a better understanding of the vertical components of ground water flow. The vertical gradients measured at the eight well nests on three different dates are summarized in Table 5-3. The dates were chosen to cover both high and low water table elevations.

In general, vertical gradients are downward or near zero within the alluvial aquifer. The gradients are slight, except for well nests

TABLE 5-3

VERTICAL GRADIENTS* IN NIROP WELLS

WELL	AQUIFER FINISHED IN	VERTICAL GRADIENT (ft/ft) 11/18-20/86	7/22/86	1/18/85
1-S 1-D	Shallow Alluvial Deep Alluvial	0.002	0.007	0.0001
2-S 2-D 1-PC	Shallow Alluvial Deep Alluvial Dolomite	-0.0005 -0.01	0 -0.005	-0.003 -0.009
3-S 2-PC	Shallow Alluvial Dolomite	-0.003	0.0008	-0.002
4-S 3-D 3-PC	Shallow Alluvial Deep Alluvial Dolomite	0.01 -0.01	0.03 -0.008	0.01 -0.009
5-S 4-D 4-PC	Shallow Alluvial Deep Alluvial Dolomite	0.05 -0.2	0.07 -0.1	0.07 -0.1
17-S 7-D	Shallow Alluvial Deep Alluvial	0.06	0.08	Wells Not Installed
18-S 8-D	Shallow Alluvial Deep Alluvial	-0.0002	0	Wells Not Installed
19-S 9-D	Shallow Alluvial Deep Alluvial	0.004	0.005	Wells Not Installed

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* Upward gradients are preceded by a negative sign.

5-S/4-D and 17-S/7-D, where gradients are nearly 0.1 feet/foot downward. These steeper gradients may be attributed to a drop in hydraulic head as ground water enters the potentially more permeable sands found in the vicinity of wells 6-D, 8-D, and 9-D.

Vertical gradients between the deep alluvial aquifer and the dolomite were calculated at three locations. Vertical gradients at these locations were upward. The strongest gradient (0.2 feet/foot) was measured at 4-D/4-PC, the well nest nearest the Mississippi River. The strong upward gradient may reflect ground water flow from the bedrock aquifer to a regional ground water discharge area, the Mississippi River.

No information is available regarding hydraulic conductivities for the NIROP study area. Hydraulic conductivities from slug tests reported by Papadopulos (1984) for the unconsolidated sediments ranged from 0.5 feet/day to 320 feet/day. The median value for 15 tests was 65 feet/day. Grain size analyses of sand and gravelly sand (SP) from NIROP borings 5-D and 6-D were performed by the COE (see Volume II). Representative analyses were used to estimate hydraulic conductivity values for the sand using the methods presented by Masch and Denny (1966). The estimated values ranged from 20 to 90 feet/day, the same order of magnitude as the field test values from FMC. The silty sands (SM) found beneath much of the NIROP have not been tested. It is likely that the hydraulic conductivity is less than that of the sand (SP).

Hydraulic conductivity values for the Prairie du Chien/Jordan aquifer have been estimated by Kanivetsky (1979). Values reported ranged from approximately 4.9 feet/day to nearly 66 feet/day. The modal value was approximately 46 feet/day.

The average linear ground water velocity ($\bar{V}$) can be determined from the modified Darcy's Law:

$$\bar{V} = \frac{Ki}{n}$$

where: K - hydraulic conductivity of aquifer
i - gradient
n - porosity of aquifer

The chart below has been prepared from hydraulic conductivities and gradients cited above. Values assumed for n are from Freeze and Cherry (1979).

Unit	K (ft/day)	i (ft/ft)	n (assumed)	$\bar{V}$ (ft/yr)
Shallow Unconsolidated Sediments	65	0.0005	0.30	40
Shallow Unconsolidated Sediments	65	0.014	0.30	1,100
Deep Unconsolidated Sediments	65	0.0044	0.30	350
Deep Unconsolidated Sediments	65	0.012	0.30	950
Prairie du Chien Aquifer	46	0.0008	0.20	67

These calculations indicate that flow rates near the water table over most of the NIROP are relatively slow, except in the southwest corner of the facility where gradients steepen. Ground water flow rates in the deeper portions of the unconsolidated sediments show less variability across the facility.

5.3.3 Data QA/QC Evaluation and Presentation

This section of the report documents the extent of hazardous substance occurrence in ground water as defined by the the monitoring well sampling program at the NIROP. Ground water samples have been taken six times from the original fourteen wells. The seven wells installed in May and June 1985 have been sampled three times, and the twelve off-site wells have been sampled twice. The latest sampling

round was in November 1986. Table 5-4 summarizes the history of ground water sampling from the NIROP wells. All samples were analyzed at the U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, Mississippi. The section has been divided into two parts: the first portion deals with QA/QC and evaluation of NIROP data; the second portion looks at the extent of hazardous substances beneath the facility.

This section evaluates data analyses for three of the eight sampling rounds performed by the COE between October 1983 and April 1986 and by RMT in November 1986. The first two rounds evaluated herein are a combination of the January and April 1986 sampling rounds and the June 1985 sampling round.

The quality control data for the June 1985 and January-April 1986 rounds of water quality analysis were examined by RMT in order to evaluate accuracy of analyses performed by the Waterways Experimental Station (WES). Data were evaluated on the basis of percent recovery in spiked samples, relative percent difference in duplicate or replicate samples, and results of analysis of field blank samples.

Percent recovery information for spiked samples from the June 1985 and January-April 1986 sampling rounds is summarized in Table 5-5. The number of samples for which percent recoveries were reported, the range of percent recovery, and the mean percent recovery are indicated for each constituent. The last column in the table contains ranges of acceptable percent recovery for each constituent based on method performance data from a number of different laboratories and published in the Federal Register (October 26, 1984, Part VIII). The Waterways Experiment Station percent recovery data is very good and falls well within the acceptable range for every constituent.

TABLE 5-4

MONITORING WELL INSTALLATION AND SAMPLING DATES

WELL NO.	INSTALLATION DATE	SAMPLING DATE 10/83	4/84	10/84	1/85	6/85	1/86	4/86	11/86
1-S	05/26/83	X	X	X	X	X			X
1-D	05/25/83	X	X	X	X	X			X
1-PC	08/25/83	X	X	X	X	X			X
2-S	06/28/83	X	X	X	X	X			X
2-D	06/22/83	X	X	X	X	X			X
2-PC	08/24/83	X	X	X	X	X			X
3-S	06/13/83	X	X	X	X	X			X
3-D	06/08/83	X	X	X	X	X			X
3-PC	08/15/83	X	X	X	X	X			X
4-S	06/09/83	X	X	X	X	X			X
4-D	06/02/83	X	X	X	X	X			X
4-PC	08/26/83	X				X			X
5-S	06/02/83	X	X	X	X	X			X
5-D	05/24/85					X		X	X
6-S	06/06/83	X	X	X	X	X			X
6-D	06/05/85					X		X	X
7-S	05/28/85					X	X		X
7-D	02/07/86							X	X
8-S	06/10/85					X			X
8-D	02/18/86							X	X
9-S	06/11/85					X	X		X
9-D	02/01/86							X	X
10-S	06/07/85					X	X		X
11-S	06/06/85					X	X		X
12-S	12/30/85							X	X
13-S	01/02/86							X	X
14-S	01/08/86							X	X
15-S	01/09/86							X	X
16-S	12/31/85							X	X
17-S	02/06/86							X	X
18-S	02/06/86							X	X
19-S	01/17/86							X	X
20-S	01/13/86							X	X
FMC-33	01/24/83	X	X	X	X	X			X

TABLE 5-5

PERCENT RECOVERY FOR SPIKED SAMPLES
FROM JUNE 1985 AND JANUARY-APRIL 1986 ROUNDS

CONSTITUENT	NO. OF SAMPLES	RANGE OF % RECOVERY	MEAN % RECOVERY	USEPA % RECOVERY ACCEPTANCE RANGE CRITERIA *
Zinc	7	92.2 to 104	98.8	75 to 125
Manganese	7	98.0769 to 105	101.9	75 to 125
PCB 1221	3	80 to 110	90.3	15 to 178
PCB 1248	2	112 to 114.4	—	38 to 158
Chloromethane	2	75.25 to 97.375	—	D to 273**
Bromomethane	2	66.375 to 103.25	—	D to 242
Vinyl Chloride	3	81.75 to 99.875	91.3	D to 251
Chloroethane	3	79.125 to 95.25	87.4	14 to 230
Methylene Chloride	4	78.8235 to 108.75	87.8	D to 221
1,1 Dichloroethylene	6	86.5 to 104.25	95.3	D to 234
1,1 Dichloroethane	6	63.25 to 105.5	90.6	59 to 155
1,2-Dichloroethylene	6	78.75 to 123.5	94.3	54 to 156
Chloroform	5	90.75 to 100.75	95.8	51 to 138
1,2 Dichloroethane	5	93.25 to 102.5	96.5	59 to 155
1,1,1 Trichloroethane	6	83.5 to 106.25	97.1	52 to 162
Carbon Tetrachloride	5	81.75 to 105.25	93.8	70 to 140
Bromodichloromethane	5	91.25 to 100	95.5	35 to 155
1,2 Dichloropropane	5	95 to 100.75	97.5	D to 210
Trans-1,3-dichloropropene	4	50.23 to 105.114	88.7	17 to 183
Trichloroethylene (TCE)	6	72.5 to 100.25	87.8	71 to 157
Dibromochloromethane	5	94 to 104	97.7	53 to 149
Cis-1,3-dichloropropene	2	94.8718 to 100.321	--	D to 227
1,1,2 Trichloroethane	5	79 to 107.25	97.1	52 to 150
Benzene	6	86.75 to 110.5	93.4	37 to 151
2-Chloroethylvinylether	3	91.75 to 108	98.1	D to 305
Bromoform	4	76.75 to 95.5	83.9	45 to 169
1,1,2,2 Tetrachloroethane	4	98.75 to 116.5	107.9	46 to 157
Tetrachloroethylene	5	87 to 112	96.9	64 to 148
Toluene	6	90 to 101.75	96.1	47 to 162
Chlorobenzene	5	90.75 to 132.75	107.5	37 to 160
Ethylbenzene	5	63.5 to 121.5	93.6	37 to 162
Acrolein	1	89.75	--	88 to 118
Acrylonitrile	3	109.5 to 118.5	111.4	71 to 135

* USEPA Percent Recovery Criteria for organic compounds were obtained from the Federal Register, Friday, October 26, 1984, Part VIII, 40 CFR, Part 136, Guidelines Establishing Test Procedures for the Analysis of Pollutants Under the Clean Water Act; Final Rule and Interim Final Rule and Proposed Rule. Criteria were obtained from tables for methods used by Waterways Experimental Station for water analyses: Volatile organic compounds, method 624 (p 43326), PCB's, method 608 (p. 43379); and acrolein and acrylonitrile, method 603 (p. 43285).

** D - Detected - results must be greater than zero.

Duplicate analyses were performed for some constituents for twelve of the June 22, 1985, samples and for 6 of 27 samples in the January-April 1986 round. Relative percent difference (as defined by Contract Lab Program Procedures) was calculated for each duplicate sample pair for which quantifiable concentrations of a constituent were detected in both samples. Relative percent difference (RPD) values were calculated according to the following Contract Lab Program definition.

$$RPD = \left| \frac{C_1 - C_2}{\frac{C_1 + C_2}{2}} \right| \times 100$$

C_1 = Concentration of constituent in sample
C_2 = Concentration of same constituent in replicate sample

The results of these calculations are summarized in Table 5-6.

The range of values and the mean relative percent difference for five organic compounds and two inorganic elements were calculated. Generally, laboratories maintain records of duplicate analysis data from which confidence limits are established. Confidence limits for relative percent difference for a limited number of constituents are published in the Contract Laboratory Program Procedures Manual. Of those constituents in Table 5-6, only trichloroethylene has such a published confidence limit. The published confidence limit of 90 percent is given for a relative percent difference of 14. This is a 90% confidence limit meaning that, in nine of ten duplicate analyses, a laboratory should obtain a relative percent difference value less than 14. Eight of the nine duplicate pairs analyzed by the Waterways Experiment Station which

TABLE 5-6

RELATIVE PERCENT DIFFERENCE (RPD) FOR DUPLICATE SAMPLES
FROM JUNE 1985 AND JANUARY-APRIL 1986 ROUNDS

CONSTITUENT	PAIRS*	RANGE RPD	MEAN RPD	USEPA 90% CONFIDENCE LIMIT OF RPD
Zinc	7	0.7 to 4.0	1.9	—
Manganese	7	0.0 to 1.7	0.9	--
Trans 1,2 dichloroethylene	8	0.0 to 14.6	5.1	—
Tetrachloroethylene	1	4.4	--	--
Trichloroethylene (TCE)	9	2.3 to 14.3	8.1	14
Methylene chloride	1	30.5	--	--
Bis(ethylhexyl) phthalate	2	33.3 to 33.8	33.6	--

*Indicates the number of replicate pairs for which quantifiable concentrations of the indicated constituent were detected in both samples.

contained quantifiable concentrations of TCE had relative percent difference values less than 14. The one value higher than the 90 percent confidence limit was 14.3.

One distilled water field blank sample was analyzed during the January-April 1986 round. The field blank was not of sufficient volume to analyze for all parameters. Therefore, the trip blank was not analyzed for lead, zinc, manganese, or any of the seven PCB Aroclors. Of the other constituents analyzed, only methylene chloride (0.013 mg/l) was detected in the field blank sample. Methylene chloride is a common contaminant resulting from laboratory analysis procedures.

An eighth ground water sampling round was conducted at the NIROP in November 1986 by RMT. A QA/QC evaluation of laboratory results similar to that presented here for COE data is described in detail in the A-E Quality Control Summary Report (RMT, 1987). Results of that evaluation indicated that the data quality was similar to the two rounds of data evaluated here. The analytical quality of the reviewed data was determined to be acceptable for use in the RI evaluations. The November 1986 sampling round also improved the overall quality of the data base since it was the first round in which all wells were sampled for a consistent set of constituents. Previous rounds had included only portions of the monitoring well network and the analytical program changed between rounds. This had made evaluations of spatial and temporal trends in constituent concentrations difficult.

Analysis of dissolved metals in the NIROP monitoring wells was performed for the first time in November 1986. Dissolved metals samples were prepared by filtering in the field in order to minimize chemical

changes to the ground water samples and to collect a more representative sample of the water moving through the ground. Three of the 34 ground water samples collected were analyzed for total metals as well as dissolved metals so that comparisons to previous sampling could be made.

Laboratory results for the eight rounds of sampling are included in Volume II. Interpretation of data directly from the analyses shown in Volume II proved difficult for the following reasons:

1. Due to the phased approach of well installation, various wells were sampled as they were installed.

2. Constituents included in the analytical program and individual constituent detection limits changed between sampling rounds.

3. The format shown does not allow for data manipulation and/or statistical analyses.

In order to provide for easier interpretation, the data shown in Volume II were first reduced to a list of constituents which were detected in any of the wells at least one time over the entire monitoring period. A list of these constituents is shown in Table 5-7. From the list of detected constituents, a second set of tables was derived which lists each constituent detected by sample round and by well. These tables are shown in Appendix A.

Reduction of data to the format shown in Appendix A allowed grouping of constituents alphabetically by well (Appendix B). Alphabetical grouping facilitated statistical analyses of detected constituents. Both manual and computer checks of data reduction were performed to ensure completeness and accuracy.

Statistical analyses chosen for data presentation included the selection of maximum and mean values of detected constituents. In order

TABLE 5-7

LIST OF CONSTITUENTS DETECTED IN MONITORING WELL SAMPLES FROM THE NIROP SITE, FRIDLEY, MINNESOTA

INORGANIC CONSTITUENTS	ORGANIC CONSTITUENTS
Arsenic	1,1,1 Trichloroethane
Barium	1,1-Dichloroethane
Cadmium	1,1-Dichloroethylene
Calcium	Benzene
Chloride	Bis (2 ethylhexyl) Phthalate
Chromium	Chloroform
Copper	1,2-Dichloroethylene
Lead	Ethylbenzene
Magnesium	Methylene Chloride
Manganese	PCB 1242
Mercury	PCB 1248
Nickel	PCB 1254
Silver	PCB 1260
Sodium	TOC
Sulfates	Tetrachloroethylene
Zinc	Toluene
Alkalinity	Trichloroethylene
Nitrate-N	Trichlorofluoromethane

to determine mean values of constituent concentrations, the following assumptions were made:

1. Data points were left blank in instances where individual wells were not sampled, samples were broken, or "insufficient sample" was present. Thus, the above instances are not included in the count for calculation of mean concentrations.

2. A value equal to one-half the detection limit was assigned to samples listed as not detected at concentrations less than the detection limit, or present, but below the detection limit.

3. Actual values were assigned to constituent concentrations detected as equal to or greater than the appropriate detection limit.

Results of statistical analyses of maximum and mean values of constituents detected are included in Appendix C. Statistical analyses of new constituents added in the November 1986 sampling round were not performed. Data for added constituents are shown in Appendix D.

5.3.4 Evaluation of Constituents

The purpose of this section is to evaluate constituents detected in monitoring wells at the NIROP site. This evaluation is aimed at determining which constituents are to be further considered as significant ground water contaminants. In order to facilitate discussion, constituents have been grouped together as inorganics and organics.

Inorganic Constituents. Until November 1986, most inorganic constituents were analyzed only once or twice. Only lead, manganese, and zinc analyses were performed in each of the first seven sampling rounds. Prior to November 1986, samples for analysis of inorganic constituents were unfiltered and preserved with acid prior to shipment (total concentration). Filtered samples (dissolved concentrations) as

well as three total concentration samples (for comparison), were obtained for analyses in November 1986.

Findings are presented below for individual constituents which were measured above detection limits in at least one sample. Constituents which have never been found above detection limits include antimony, beryllium, cyanide, and thallium. Dissolved constituent concentrations are discussed where appropriate in detail because it is the dissolved fraction that is potentially mobile in ground water, and it is the dissolved fraction in ground water that may result in exposures to humans or the environment. The dissolved concentrations are summarized on Table 5-8. Detected concentrations have been compared to Maximum Contaminant Levels (MCLs), Maximum Contaminant Level Goals (MCLGs) and Secondary Maximum Contaminant Levels (SCMLs) as defined by the Safe Drinking Water Act (as ammended).

Arsenic was analyzed in the second sampling round (April 1984) and in the last sampling round (November 1986). Measurable concentrations of total arsenic were reported in 1984 in only one well (1-S) at a concentration of 0.008 mg/l. Dissolved arsenic concentrations were reported in the November 1986 sampling round from wells 9-S and 15-S as well as duplicate samples from those wells. It was not detected in the well 1-S sample in November. The total arsenic concentration in well 9-S was 0.023 mg/l while the dissolved concentration was < 0.005 mg/l. Total and dissolved arsenic detected in 15-S was 0.045 mg/l and 0.014 mg/l, respectively. The dissolved arsenic values are below the MCL of 0.05 mg/l. Arsenic is not known to have been used in processes at the NIROP.

TABLE 5-8. CONCENTRATIONS OF DISSOLVED
INORGANIC CONSTITUENTS DETECTED IN GROUND WATER
SAMPLES, NOVEMBER 1986 (mg/l)

Date	Parameter	1-S	1-D	1-PC	2-S	2-D	2-PC	3-S	3-D	3-PC	4-S	4-D	4-PC	5-S	5-D	6-S	6-D	7-S
Nov-86	Alkalinity	333	231	234	369	268	8.5	481	302	239	242	258	233	497	383	456	260	533
Nov-86	Arsenic, Diss.	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Nov-86	Barium, Diss	0.080	0.040	0.119	0.105	0.075	0.051	0.185	0.074	0.034	0.058	0.099	0.093	0.061	0.080	0.077	0.092	0.060
Nov-86	Barium, Total							0.088										
Nov-86	Cadmium, Diss.	< 0.0001	0.0004	0.0008	0.0006	< 0.0001	0.0005	0.0003	0.0004	0.0005	0.0006	0.0002	0.0005	0.0009	< 0.0001	0.0004	< 0.0001	0.0008
Nov-86	Calcium, Diss.	101	86.0	81.5	169	110	21.1	157	115	110	64.9	99.3	90.4	186	117	145	102	216
Nov-86	Calcium, Total							169										
Nov-86	Chloride	19.5	30.9	58.4	4.5	41.7	59.7	4.8	22.6	31.7	4.2	72.6	75.6	50.0	3.2	32.7	72.5	18.7
Nov-86	Chromium, Diss.	0.005	0.002	0.002	0.003	0.001	0.002	0.003	0.001	0.002	0.002	0.001	< 0.001	0.002	0.002	< 0.001	< 0.001	0.002
Nov-86	Copper, Diss.	0.004	< 0.001	0.005	0.008	< 0.001	0.003	0.003	0.006	0.003	0.009	< 0.001	0.002	0.004	< 0.001	< 0.001	0.009	0.003
Nov-86	Lead, Diss.	< 0.001	< 0.001	0.002	0.001	< 0.001	0.003	0.002	< 0.001	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.002	0.003	0.002
Nov-86	Magnesium, Diss.	20.2	38.8	45.0	38.6	51.6	10.7	30.1	43.5	54.9	21.5	48.4	45.9	43.5	61.4	39.4	47.6	27.3
Nov-86	Manganese, Diss.	1.07	0.090	0.046	0.198	0.392	0.002	1.04	0.076	0.052	0.005	0.362	0.210	0.593	0.100	0.564	0.330	1.01
Nov-86	Mercury, Diss.	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004
Nov-86	Nickel, Diss.	0.009	0.003	< 0.001	0.005	0.002	0.007	< 0.001	0.004	< 0.001	0.009	< 0.001	0.014	0.012	< 0.001	0.025	0.043	0.072
Nov-86	Nitrate-Nitrogen			0.209	1.37		0.160	1.17		0.060	6.56		0.106	2.66			0.036	3.29
Nov-86	Potassium, Diss.	3.92	2.20	3.28	3.69	2.67	36.8	3.85	2.20	2.62	2.79	2.43	3.52	4.67	2.74	4.00	2.34	2.83
Nov-86	Selenium, Diss.	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Nov-86	Selenium, Total							< 0.005										
Nov-86	Silver, Diss.	0.005	0.003	0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.003	< 0.001	< 0.001	< 0.001
Nov-86	Sodium, Diss.	14.3	5.85	12.9	5.99	6.06	34.0	7.83	6.81	5.68	11.5	13.5	10.2	18.0	3.57	26.0	15.0	6.77
Nov-86	Sulfates	77.5	129	96.0	58.3	184	130	97.0	203	304	45.2	148	85.9	192	184	172	176	148
Nov-86	Zinc, Diss.	0.133	1.25	0.068	0.851	0.660	< 0.030	0.131	0.842	0.357	0.634	0.492	0.086	0.601	0.687	0.909	0.823	1.05

Date	Parameter	7-D	8-S	8-D	9-S	9-D	10-S	11-S	12-S	13-S	14-S	15-S	16-S	17-S	18-S	19-S	20-S	FRC-33
Nov-86	Alkalinity	303	469	267	436	362	493	426	417	374	383	477	395	458	302	264	190	504
Nov-86	Arsenic, Diss.	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.014	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Nov-86	Barium, Diss	0.111	0.072	0.090	0.109	0.061	0.079	0.106	0.064	0.093	0.093	0.136	0.068	0.050	0.095	0.032	0.055	0.128
Nov-86	Barium, Total				0.984							0.172						
Nov-86	Cadmium, Diss.	0.0002	0.0009	0.0003	0.0006	0.0007	0.0006	< 0.0001	0.0010	0.0011	0.0021	0.0008	0.0010	0.0006	0.0005	0.0024	0.0009	0.0004
Nov-86	Calcium, Diss.	113	134	113	133	122	143	158	126	154	190	159	108	170	157	66.0	66.0	208
Nov-86	Calcium, Total				154							207						
Nov-86	Chloride	36.0	5.9	47.7	15.2	42.9	36.6	23.2	45.7	13.7	58.8	15.0	4.6	25.6	26.6	54.6	15.3	12.9
Nov-86	Chromium, Diss.	0.002	0.002	0.002	0.003	0.002	0.003	0.001	< 0.001	< 0.001	< 0.001	0.002	0.001	0.003	0.002	0.002	0.001	0.001
Nov-86	Copper, Diss.	0.004	0.003	0.002	0.005	0.002	0.005	0.002	0.002	0.006	0.002	0.002	0.004	0.003	0.003	0.004	0.004	0.002
Nov-86	Lead, Diss.	0.002	< 0.001	0.002	0.003	0.011	0.005	< 0.001	0.001	0.005	0.004	0.003	0.003	0.005	0.004	0.009	0.004	0.003
Nov-86	Magnesium, Diss.	52.4	33.0	54.9	33.0	49.2	50.8	58.1	33.8	36.9	33.8	53.4	29.0	54.9	54.1	18.0	17.2	53.4
Nov-86	Manganese, Diss.	0.403	1.94	0.700	0.026	0.142	1.58	0.003	1.20	1.50	0.876	1.96	1.04	0.388	0.920	0.034	0.098	1.00
Nov-86	Mercury, Diss.	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004
Nov-86	Nickel, Diss.	< 0.001	0.054	< 0.001	< 0.001	0.001	0.032	0.004	0.006	0.013	0.037	< 0.001	0.005	0.003	< 0.001	< 0.001	0.004	< 0.001
Nov-86	Nitrate-Nitrogen	0.031	1.69	0.022	3.92	0.221	0.205	0.803	6.05	2.09	17.0	0.028	0.110	2.02	0.016	2.74	0.434	0.020
Nov-86	Potassium, Diss.	4.75	3.74	4.51	5.49	3.52	3.67	3.97	3.67	3.06	1.92	4.92	3.28	3.85	2.87	2.22	2.22	3.36
Nov-86	Selenium, Diss.	< 0.005	< 0.005	< 0.005	0.049	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.008	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Nov-86	Selenium, Total				0.076							< 0.005						
Nov-86	Silver, Diss.	< 0.001	0.002	< 0.001	< 0.001	0.002	< 0.001	< 0.001	0.001	< 0.001	< 0.001	< 0.001	0.003	< 0.001	0.002	0.002	< 0.001	< 0.001
Nov-86	Sodium, Diss.	9.36	6.89	11.0	28.2	19.5	16.5	7.44	17.1	6.50	5.77	10.6	4.14	16.8	8.18	41.1	9.45	7.19
Nov-86	Sulfates	251	183	272	91.7	189	224	363	56.4	218	164	318	59.5	333	422	26.8	72.4	321
Nov-86	Zinc, Diss.	1.23	4.42	1.03	0.184	1.07	0.735	0.246	3.81	3.03	3.25	1.84	2.87	2.21	4.71	3.78	3.10	0.526

Barium was analyzed only in the November 1986 sampling round. Total concentrations of barium measured in wells 3-S, 9-S, and 15-S were 0.088 mg/l, 0.086 mg/l and 0.172 mg/l, respectively. Quantifiable dissolved barium was found in all wells with concentrations ranging from 0.032 mg/l in downgradient well 19-S to 0.165 mg/l in on-site well 3-S. Background concentrations of barium are similar to downgradient concentrations and no sample exceeded the MCL for barium (1.0 mg/l).

Cadmium was analyzed in samples collected in October 1983, April 1984, and November 1986. The highest total cadmium concentration reported from NIROP samples was 0.0194 mg/l, in the November 1986 sample from upgradient well 15-S. This value is above the MCL for cadmium of 0.01 mg/l. The dissolved cadmium concentration for the sample from well 15-S (0.0008 mg/l), however, is more than one order of magnitude below the MCL. Dissolved cadmium was reported in 30 of 34 samples at concentrations of 0.0002 to 0.0024 mg/l.

Cadmium is used in NIROP plating processes and these sludges may have been disposed of on-site. EP Toxicity tests for cadmium were run on drummed wastes removed from the pits/trenches. The highest concentration detected was 7.21 mg/l (Volume II). However, EP Toxicity tests run on soils from pits 3, 5, and 6 showed 36 of 37 samples had no measurable cadmium concentrations above the detection limit of 0.01 mg/l. One sample had a reportable cadmium concentration of 0.002 mg/l. This data suggests that mobile (leachable) cadmium is not present in the soils beneath the sampled pits and trenches. The presence of similar cadmium concentrations in background and downgradient ground water samples also indicates that cadmium is not being released to the ground water from the NIROP.

Calcium was analyzed only in the November 1986 sampling round. Concentrations of total calcium measured for wells 3-S, 9-S, and 15-S were 169 mg/l, 154 mg/l and 207 mg/l, respectively. The dissolved calcium concentrations for these three samples were 8 to 48 mg/l less than their respective total concentration. Dissolved calcium concentrations ranged from 21.1 mg/l to 208 mg/l. Background and downgradient samples had similar calcium concentrations. No health-based or environmental standards have been established for calcium.

Chloride was analyzed only in the November 1986 sampling round. Chloride was detected in all 34 monitoring wells at concentrations ranging from 3.2 to 75.6 mg/l. The SMCL of 250 mg/l was not exceeded in any well.

Chromium was analyzed in samples collected in October 1983, April 1984, and November 1986. The MCL for chromium is 0.05 mg/l. It was exceeded by total chromium concentrations from well 2-S (0.057 mg/l) and well 9-S (0.267 mg/l) in October 1983 and November 1986, respectively. The dissolved and total chromium analyses from November 1986 indicated that total concentrations were 3 to 300 times higher than dissolved concentrations. The total values therefore do not accurately reflect potential hazardous constituent migration because much of chromium is associated with the sediment which is not transported with the slow-moving ground water. Dissolved chromium was detected in 28 of 34 monitoring wells, at concentrations ranging from 0.001 mg/l to 0.005 mg/l, during the November 1986 sampling round. The MCL for chromium was not exceeded by any dissolved chromium concentrations and there were no significant differences between background and downgradient dissolved chromium concentrations.

Chromium was used in the NIROP plating shop and may have been disposed on-site with plating sludges. EP Toxicity leaching test results of drummed samples from the pit/trench area indicated a maximum concentration of 0.31 mg/l (for legible results) (Volume II). These wastes were removed and soils at pit bottom, and at 1-foot and 2-feet below the pit bottom were subjected to EP Toxicity tests in pits 3, 5, and 6. Results from 26 of 42 samples showed no leachable chromium above the detection level of 0.01 mg/l. The highest leachable concentration was 0.02 mg/l in 4 of 42 samples (Volume II) suggesting that chromium is not present beneath the disposal areas sampled. The lack of significant chromium concentrations in ground water downgradient of disposal sites also suggests that chromium that may have been disposed on the NIROP facility does not appear to be migrating to, or with, ground water.

Copper was analyzed in samples collected in October 1983, April 1984, and November 1986. The MCLG for copper is 1.3 mg/l. The highest value of total copper detected in NIROP monitoring wells was 0.377 mg/l in well 9-S (November 1986). The dissolved copper concentration for well 9-S was 0.005 mg/l. Again, most of the copper is associated with sediment which is not transported by ground water. Dissolved copper concentrations range from 0.009 mg/l to < 0.001 mg/l. None of the dissolved copper concentrations exceeded the MCLG. Copper was used in the plating shop at the NIROP facility and may have been disposed on-site. The ground water data however, suggest that copper disposed on the facility is not entering, or migrating with, the ground water.

Lead has been analyzed in all sampling rounds. Total lead has been detected in numerous samples (both upgradient and downgradient of the

facility) at concentrations above the MCL of 0.05 mg/l. A comparison of dissolved and total concentrations from November 1986, however, show that total concentrations, on the order of 70 times greater than dissolved concentrations, reflect lead associated with sediment. None of the dissolved lead concentrations exceeded the MCL. Almost all the dissolved lead concentrations measured in November 1986 were less than or equal to 0.005 mg/l. The highest dissolved lead concentration detected in November 1986 came from well 9-D (0.011 mg/l) and the adjacent well 19-S (0.009 mg/l). Both wells are downgradient of the NIROP. It is not clear whether this is indicative of a release from the facility since other downgradient wells closer to the plant yielded samples with lower lead concentrations. Measureable lead concentrations (> 0.01 mg/l) were reported by Papadopolus (1984) in three water table wells and two piezometers installed for the FMC investigations. The concentrations ranged from 0.02 to 0.24 mg/l. It is not known if results reported by Papadopolus were for total or dissolved lead. It is therefore difficult to draw any conclusions regarding the relationship of the FMC data to the observed lead concentrations at wells 19-S and 9-D.

Magnesium was analyzed in only the November 1986 sampling round. The WES did not report analyses for total magnesium. Data for dissolved magnesium showed concentrations ranging from 10.7 mg/l to 61.4 mg/l. No health-based or environmental standards have been set for magnesium.

Manganese was analyzed in all eight sampling rounds. No MCL or MCLG has been set for manganese. However, total manganese concentrations have exceeded the SMCL of 0.05 mg/l in every well

sampled. Dissolved manganese was detected at concentrations exceeding the SMCL in all but 6 wells. In general, the highest dissolved manganese concentrations were detected in background wells (15-S, 12-S, 13-S, and 16-S). Based on these results, the observed manganese levels do not appear to be originating from on-site operations.

Mercury was analyzed in 14 well samples collected in April 1984 and in 34 well samples collected in November 1986. Total mercury was reported in 1984 at concentrations exceeding the detection limits in shallow wells 3-S, 4-S, and 6-S at 0.0013, 0.0007, and 0.0008 mg/l, respectively, and in the Prairie du Chien well 2-PC at 0.0008 mg/l. Neither dissolved mercury nor total mercury were reported above the detection limit of 0.0004 mg/l during the November 1986 sampling round. No concentration of mercury (total or dissolved) has exceeded the MCL of 0.002 mg/l. Mercury is not reported as having been used in NIROP processes.

Nickel was analyzed in 14 samples obtained in April 1984 and 34 samples collected in the November 1986. Total nickel was reported in all of the well samples collected during April 1984, between concentrations of 0.003 and 0.107 mg/l. The comparison of dissolved and total concentrations from three of the November 1986 samples indicates that much of the nickel is associated with suspended sediment that is not transported by ground water. Total concentrations ranged from 0.332 to 0.018 mg/l, while dissolved concentrations were less than 0.005 mg/l. Dissolved nickel concentrations ranging from 0.001 mg/l (9-D) to 0.072 mg/l (7-S) were reported in 22 of the 34 monitoring well samples collected in November 1986. Background well samples had the same range

of dissolved nickel concentrations as on-site or downgradient well samples. Nickel is used in the plating process at the NIROP facility, but is apparently not being released to the ground water. MCLs and MCLGs have not been set for nickel. The ambient water quality criterion for the protection of human health has been set at 0.0134 mg/l. The observed dissolved nickel concentrations are generally one-half the criterion.

Selenium was analyzed for the first time in samples collected during November 1986. Dissolved selenium and total selenium were approximately equal when detected (0.049 and 0.076 mg/l, respectively). This is typical since selenium is not generally associated with sediment. Only two wells showed concentrations of dissolved selenium above the detection limit of 0.005 mg/l: background well 14-S (0.008 mg/l) and on-site well 9-S (0.049 mg/l). The MCL for selenium is 0.010 mg/l and the MCLG is 0.045 mg/l. Concentrations of selenium detected in the sample from well 9-S exceeded the MCL. Well 9-S is near the NIROP property boundary on the eastern (upgradient) side of the facility. Sources of selenium are not apparent since it has not been reported as being used at the facility. The presence of selenium may be indicative of an as yet unidentified upgradient source.

Silver was analyzed in samples obtained at the NIROP facility in October 1983, April 1984, and November 1986. Silver was reported in only one sample (4-S) in April 1984 at the detection limit of 0.001 mg/l. Dissolved silver was detected in 10 of the 34 monitoring wells in November 1986. Concentrations ranged from 0.001 mg/l (12-S) to 0.005 mg/l (1-S). Both background and downgradient well samples had similar

concentrations. Silver was used in both the NIROP plating process and the photo lab but is apparently not being released to the ground water. The MCL of 0.05 mg/l was not exceeded by any sample.

Sodium was analyzed in only the November 1986 sampling round. Concentrations ranged from 3.57 mg/l to 14.1 mg/l in samples from wells 5-D and 19-S, respectively. There were no apparent spatial trends in sodium occurrence across the NIROP. No health-based environmental standards for sodium have been established.

Sulfate was analyzed in only the November 1986 sampling round. Concentrations ranged from 26.8 mg/l (19-S) to 422 mg/l (18-S). The SMCL for sulfate is 250 mg/l. The SMCL for sulfate was exceeded in eight wells, including one background well. Approximately two-thirds of the wells with high sulfate concentrations are downgradient of the southwest corner of the NIROP (7-D, 8-D, 11-S, 17-S, and 18-S). It is not clear if this spatial distribution is related to any particular source on the NIROP.

Zinc was analyzed in all eight sampling rounds at the NIROP facility. Total zinc concentrations, measured at all monitoring wells, have ranged from 0.086 to 29.8 mg/l. The SMCL of 5.0 mg/l was exceeded in 15 of 34 monitoring wells sampled. The high total zinc values appear to be associated with suspended sediment in the well samples. Comparison of dissolved and total concentrations from November 1986 show total values to be 12 to 17 times greater than dissolved concentrations. Dissolved zinc concentrations above the 5.0 mg/l standard were not observed in any well sampled during November 1986. The dissolved zinc concentrations ranged from 0.030 mg/l to 4.42 mg/l. There were no

significant differences between upgradient and on-site or downgradient dissolved zinc concentrations.

Some of the zinc detected in the well water at the NIROP facility may have leached from well casing materials. The highest dissolved and total zinc concentrations are found in those wells that have galvanized well casing in contact with the ground water. Galvanized well casings can reportedly leach zinc into well water (Barcelona et al., 1983). The leached zinc may precipitate at the bottom of the well or be absorbed by sediment at the well bottom. Zinc is not reported as being used in the plating process at the NIROP. Based on these results, the observed zinc levels do not appear to be originating from on-site operations.

Table 5-9 has been prepared to aid in summarizing the findings of the previous section. Prior to November 1986, only total concentration(unfiltered samples) were reported and the data suggested that significant concentrations of hazardous inorganic constituents could be found in the ground water. The samples collected in November 1986 had total concentrations fairly consistent with previous results. However, dissolved concentrations were considerably lower, indicative of the fact that much of the inorganic concentrations were associated with sediment in the samples. Sediment is not transported by ground water and is not generally consumed. In fact, only three constituents exceeded federal standards when dissolved concentrations were considered; manganese, sulfate, and selenium. Of these constituents, manganese and sulfate both exhibited concentrations in excess of SMCLs in both background wells and downgradient wells.

TABLE 5-9

SUMMARY OF INORGANIC CONSTITUENTS DETECTED AT LEAST ONE TIME IN GROUND WATER SAMPLES FROM THE NIROP STUDY AREA (mg/l)

Constituent	Maximum Total Concentration/Location		Maximum Dissolved Concentration/Location		SDWA Regulatory Level
Arsenic	0.045	15-S	0.014	15-S	MCL-0.05
Barium	Not Analyzed		0.165	3-S	MCL-1.0
Cadmium	0.0194	15-S	0.0024	19-S	MCL-0.01
Calcium	Not Analyzed		208	FMC-33	None
Chloride	Not Analyzed		75.6	4-PC	SMCL-250
Chromium	0.057	2-S	0.005	1-S	MCL-0.05
Copper	0.377	9-S	0.009	4-S	MCLG-1.3
Lead	0.366	12-S	0.011	9-D	MCL-0.05
Magnesium	Not Analyzed		61.4	5-D	None
Manganese	27.5	7-S	1.96	15-S	SMCL-0.05
Mercury	0.0013	3-S	< 0.0004	all wells	MCL-0.002
Nickel	0.107	2-S	0.072	7-S	None
Selenium	0.076	9-S	0.049	9-S	MCL-0.010
Silver	0.001	4-S	0.005	1-S	MCL-0.05
Sodium	Not Analyzed		41.4	19-S	None
Sulfate	Not Analyzed		422	18-S	SMCL-250
Zinc	29.8	10-S	4.71	18-S	SMCL-5.0

Selenium in a sample from well 9-S (0.049 mg/l) is the only dissolved inorganic constituent detected in ground water above an MCL. Well 9-S is located along the eastern (upgradient) edge of the NIROP facility. Thus, it is possible that the selenium detected in well 9-S may be related to an off-site source. Selenium has only been analyzed in a single sampling round (November 1986). Additional sampling would be required to increase the certainty in any interpretation of selenium occurrence.

Organic Constituents. Organic constituents have been analyzed in samples from all 8 sampling rounds. Most of the analysis has focused on volatile organic compounds. A number of these compounds have, and continue to be, used on the NIROP facility. Many are also used in large quantities. Previous investigations (see Section 4.1) have also found these compounds to be in past waste disposal areas. Some samples (14 collected in April 1984) have also been analyzed for the more extensive priority pollutant list.

A summary table (Table 5-10) has been prepared to clarify the occurrence of organic constituents in ground water samples. The table lists only those compounds that have been detected at least one time at the NIROP. The data is summarized as mean concentrations to simplify the presentation. The maximum reported value is also listed to provide a sense for the variability observed at a given monitoring well.

Bis (2 ethylhexyl) phthalate was analyzed in all but the April 1986 and November 1986 sampling rounds; therefore, no background wells have been analyzed. Bis (2 ethylhexyl) phthalate was detected in every round when analyzed and in nearly every well at least once. The occurrence of

TABLE 5-10 MAXIMUM AND MEAN CONCENTRATIONS OF ORGANIC CONSTITUENTS DETECTED IN GROUND WATER SAMPLES, OCTOBER 1983 to NOVEMBER 1986 (mg/1)

1254.01

Parameter		1-S	1-D	1-PC	2-S	2-D	2-PC	3-S	3-D	3-PC	4-S	4-D	4-PC	5-S	5-D	6-S	6-D	7-S	7-D
1,1,1-Trichloroethane	Count	6	6	6	6	6	6	6	6	6	6	6	3	6	3	6	3	3	2
	Maximum	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0025	0.1300	0.0025	0.0065	0.0025
	Mean	0.0038	0.0038	0.0038	0.0043	0.0038	0.0038	0.0038	0.0038	0.0038	0.0038	0.0038	0.0033	0.0038	0.0025	0.0616	0.0025	0.0047	0.0025
1,1-Dichloroethane	Count	6	6	6	6	6	6	6	6	6	6	6	3	6	3	6	3	3	2
	Maximum	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0260	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0025	0.0190	0.0025	0.0025	0.0025
	Mean	0.0038	0.0038	0.0038	0.0038	0.0038	0.0038	0.0093	0.0038	0.0038	0.0038	0.0038	0.0033	0.0038	0.0025	0.0065	0.0025	0.0025	0.0025
1,1-Dichloroethene	Count	6	6	6	6	6	6	6	6	6	6	6	3	6	3	6	3	3	2
	Maximum	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0025	0.0050	0.0025	0.0025	0.0025
	Mean	0.0038	0.0038	0.0038	0.0038	0.0038	0.0038	0.0038	0.0038	0.0038	0.0038	0.0038	0.0033	0.0038	0.0025	0.0038	0.0025	0.0025	0.0025
Benzene	Count	6	6	6	6	6	6	6	6	6	6	6	3	6	3	6	3	3	2
	Maximum	0.0050	0.0220	0.0210	0.0050	0.0050	0.0230	0.0050	0.0050	0.0140	0.0061	0.0050	0.0050	0.0057	0.0025	0.0100	0.0025	0.0025	0.0025
	Mean	0.0038	0.0066	0.0064	0.0038	0.0038	0.0072	0.0038	0.0038	0.0068	0.0044	0.0038	0.0033	0.0043	0.0025	0.0050	0.0025	0.0025	0.0025
Bis(2ethylhexyl)Phthalate	Count	4	4	4	4	4	4	4	4	4	4	4	1	4	1	4	1	1	0
	Maximum	0.0180	0.0050	0.0060	0.0840	0.0840	0.0300	0.1400	0.0580	0.0230	0.0180	0.0730	0.0059	0.0160	0.0036	0.2200	0.0030	0.0009	NA
	Mean	0.0056	0.0021	0.0028	0.0222	0.0226	0.0088	0.0379	0.0167	0.0081	0.0064	0.0200	0.0059	0.0074	0.0036	0.0564	0.0030	0.0009	NA
Chloroform	Count	6	6	6	6	6	6	6	6	6	6	6	3	6	3	6	3	3	2
	Maximum	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0025	0.0050	0.0025	0.0025	0.0025
	Mean	0.0036	0.0038	0.0038	0.0038	0.0038	0.0038	0.0038	0.0038	0.0038	0.0038	0.0038	0.0033	0.0038	0.0025	0.0038	0.0025	0.0025	0.0025
Cis 1,2-Dichloroethene	Count	3	3	3	3	3	3	3	3	3	3	3	1	3	1	3	1	1	1
	Maximum	0.0050	0.0050	0.0050	0.0050	0.0050	0.0240	0.2900	0.0050	0.0050	0.0050	0.0050	0.0025	0.0050	0.0025	0.5800	0.0025	0.0025	0.0025
	Mean	0.0042	0.0042	0.0042	0.0042	0.0042	0.0105	0.1500	0.0042	0.0042	0.0042	0.0042	0.0025	0.0042	0.0025	0.2490	0.0025	0.0025	0.0025
Ethylbenzene	Count	6	6	6	6	6	6	6	6	6	6	6	3	6	3	6	3	3	2
	Maximum	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0370	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0025	0.0050	0.0025	0.0025	0.0025
	Mean	0.0038	0.0038	0.0038	0.0038	0.0038	0.0038	0.0131	0.0038	0.0038	0.0038	0.0038	0.0033	0.0038	0.0025	0.0038	0.0025	0.0025	0.0025
Methylene Chloride	Count	6	6	6	6	6	6	6	6	6	6	6	3	6	3	6	3	3	2
	Maximum	0.3000	0.1100	0.1600	41.0000	0.8300	6.0000	0.1300	0.0300	0.1100	0.8000	0.4400	0.0190	0.0290	0.0025	0.0700	0.0025	0.0025	0.0025
	Mean	0.0551	0.0312	0.0328	6.8408	0.1435	1.0397	0.0397	0.0075	0.0241	0.1482	0.0772	0.0088	0.0092	0.0025	0.0185	0.0025	0.0025	0.0025

TABLE 5-10 (Cont'd). MAXIMUM AND MEAN CONCENTRATIONS OF ORGANIC CONSTITUENTS DETECTED IN GROUND WATER SAMPLES, OCTOBER 1983 to NOVEMBER 1986 (mg/l)

1254.01

Parameter		8-S	8-D	9-S	9-D	10-S	11-S	12-S	13-S	14-S	15-S	16-S	17-S	18-S	19-S	20-S	FMC-33
1,1,1-Trichloroethane	Count	2	2	3	2	3	3	2	2	2	2	2	2	2	2	2	6
	Maximum	0.0390	0.0025	0.3900	0.0086	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0050
	Mean	0.0295	0.0025	0.2667	0.0056	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0038
1,1-Dichloroethane	Count	2	2	3	2	3	3	2	2	2	2	2	2	2	2	2	6
	Maximum	0.0073	0.0025	0.0660	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0270
	Mean	0.0049	0.0025	0.0540	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0113
1,1-Dichloroethene	Count	2	2	3	2	3	3	2	2	2	2	2	2	2	2	2	6
	Maximum	0.0025	0.0025	0.0092	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0050
	Mean	0.0025	0.0025	0.0050	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0038
Benzene	Count	2	2	3	2	3	3	2	2	2	2	2	2	2	2	2	6
	Maximum	0.0025	0.0052	0.0025	0.0050	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0045	0.0025	0.0025	0.0025	0.0100
	Mean	0.0025	0.0039	0.0025	0.0038	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0045	0.0025	0.0025	0.0025	0.0053
Bis(2ethylhexyl)Phthalate	Count	1	0	1	0	1	1	0	0	0	0	0	0	0	0	0	4
	Maximum	0.0000	NA	0.0000	NA	0.0003	0.0008	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.0190
	Mean	0.0000	NA	0.0000	NA	0.0003	0.0008	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.0238
Chloroform	Count	2	2	3	2	3	3	2	2	2	2	2	2	2	2	2	6
	Maximum	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0050
	Mean	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0038
Cis 1,2-Dichloroethene	Count	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	3
	Maximum	0.2400	0.0480	0.3450	0.0280	0.0360	0.0276	0.0025	0.0025	0.0025	0.0025	0.0025	0.0270	0.3300	0.0025	0.0025	0.2300
	Mean	0.2400	0.0480	0.3450	0.0280	0.0360	0.0276	0.0025	0.0025	0.0025	0.0025	0.0025	0.0270	0.3300	0.0025	0.0025	0.1453
Ethylbenzene	Count	2	2	3	2	3	3	2	2	2	2	2	2	2	2	2	6
	Maximum	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.2100
	Mean	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0655
Methylene Chloride	Count	2	2	3	2	3	3	2	2	2	2	2	2	2	2	2	6
	Maximum	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0056	0.0025	0.0025	0.0025	0.0025	0.0025	0.1200
	Mean	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0041	0.0025	0.0025	0.0025	0.0025	0.0025	0.0311

TABLE 5-10 (Cont'd). MAXIMUM AND MEAN CONCENTRATIONS OF ORGANIC CONSTITUENTS DETECTED IN GROUND WATER SAMPLES, OCTOBER 1983 to NOVEMBER 1986 (mg/l)

1254.01

Parameter		1-S	1-D	1-PC	2-S	2-D	2-PC	3-S	3-D	3-PC	4-S	4-D	4-PC	5-S	5-D	6-S	6-D	7-S	7-D	8-S
	Count	5	5	5	5	5	5	5	5	5	5	5	2	5	2	5	2	2	1	1
PCB 1242	Maximum	0.00050	0.00020	0.00030	0.00010	0.00010	0.00050	0.00010	0.00020	0.00030	0.00020	0.00010	0.00010	0.00040	0.00010	0.00020	0.00010	0.00010	0.00010	0.00010
	Mean	0.00017	0.00011	0.00013	0.00009	0.00009	0.00017	0.00009	0.00011	0.00013	0.00011	0.00009	0.00008	0.00015	0.00010	0.00011	0.00010	0.00010	0.00010	0.00010
	Count	5	5	5	5	5	5	5	5	5	5	5	2	5	2	5	2	2	1	1
PCB 1248	Maximum	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00040	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010
	Mean	0.00009	0.00009	0.00009	0.00009	0.00009	0.00009	0.00009	0.00009	0.00017	0.00009	0.00009	0.00008	0.00009	0.00010	0.00009	0.00010	0.00010	0.00010	0.00010
	Count	5	5	5	5	5	5	5	5	5	5	5	2	5	2	5	2	2	1	1
PCB 1254	Maximum	0.00075	0.00050	0.00030	0.00110	0.00020	0.00050	0.00070	0.00030	0.00030	0.00040	0.00010	0.00010	0.00020	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010
	Mean	0.00023	0.00017	0.00013	0.00029	0.00011	0.00017	0.00021	0.00013	0.00013	0.00015	0.00009	0.00008	0.00011	0.00010	0.00009	0.00010	0.00010	0.00010	0.00010
	Count	5	5	5	5	5	5	5	5	5	5	5	2	5	2	5	2	2	1	1
PCB 1260	Maximum	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00055	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010
	Mean	0.00009	0.00009	0.00009	0.00009	0.00009	0.00009	0.00009	0.00009	0.00009	0.00009	0.00018	0.00008	0.00009	0.00010	0.00009	0.00010	0.00010	0.00010	0.00010
	Count	6	6	6	6	6	6	6	6	6	6	6	3	6	3	6	3	3	2	2
Tetrachloroethene	Maximum	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0170	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0025	0.2000	0.0025	0.0025	0.0025	0.0460
	Mean	0.0038	0.0038	0.0038	0.0038	0.0038	0.0038	0.0071	0.0038	0.0038	0.0038	0.0038	0.0033	0.0038	0.0025	0.0554	0.0025	0.0025	0.0025	0.0460
	Count	2	2	2	1	2	2	2	2	2	2	2	1	2	0	2	0	0	0	0
TOC	Maximum	22.80	642.00	51.80	57.00	7.40	15.90	16.10	3.50	6.60	10.10	30.70	2.30	649.00	NA	27.60	NA	NA	NA	NA
	Mean	16.25	322.35	30.85	57.00	6.10	9.45	15.65	2.60	4.90	9.60	15.85	2.30	331.25	NA	20.40	NA	NA	NA	NA
	Count	6	6	6	6	6	6	6	6	6	6	6	3	6	3	6	3	3	2	2
Toluene	Maximum	0.0050	0.0120	0.0110	0.0050	0.0050	0.0200	0.0050	0.0072	0.0140	0.0050	0.0061	0.0140	0.0050	0.0025	0.0050	0.0025	0.0025	0.0025	0.0025
	Mean	0.0038	0.0062	0.0052	0.0038	0.0038	0.0067	0.0038	0.0045	0.0063	0.0038	0.0044	0.0072	0.0038	0.0025	0.0038	0.0025	0.0025	0.0025	0.0025
	Count	6	6	6	6	6	6	6	6	6	6	6	3	6	3	6	3	3	2	2
Trans 1,2-Dichloroethene	Maximum	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.2900	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0025	0.5800	0.0025	0.0025	0.0025	0.2400
	Mean	0.0038	0.0038	0.0038	0.0038	0.0038	0.0038	0.1320	0.0038	0.0038	0.0038	0.0038	0.0033	0.0038	0.0025	0.1728	0.0025	0.0025	0.0025	0.2150
	Count	6	6	6	6	6	6	6	6	6	6	6	3	6	3	6	3	3	2	2
Trichloroethene	Maximum	0.0050	0.0050	0.0050	0.1300	0.0092	0.0620	28.0000	0.0230	0.0810	0.0190	0.0050	0.0050	0.0050	0.0025	3.8000	0.0110	0.1500	0.0025	9.2000
	Mean	0.0038	0.0038	0.0038	0.0755	0.0053	0.0208	6.0717	0.0140	0.0291	0.0065	0.0038	0.0033	0.0038	0.0025	1.3321	0.0079	0.1380	0.0025	6.6000

TABLE 5-10 (Cont' . MAXIMUM AND MEAN CONCENTRATIONS OF ORGANIC CONSTITUENTS DETECTED IN GROUND WATER SAMPLES, OCTOBER 1983 to NOVEMBER 1986 (mg/1)

1254.01

Parameter		8-D	9-S	9-D	10-S	11-S	12-S	13-S	14-S	15-S	16-S	17-S	18-S	19-S	20-S	FMC-33
PCB 1242	Count	1	2	1	2	2	1	0	1	1	1	1	1	1	1	5
	Maximum	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	NA	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010
	Mean	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	NA	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00009
PCB 1248	Count	1	2	1	2	2	1	0	1	1	1	1	1	1	1	5
	Maximum	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	NA	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010
	Mean	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	NA	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00009
PCB 1254	Count	1	2	1	2	2	1	0	1	1	1	1	1	1	1	5
	Maximum	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	NA	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010
	Mean	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	NA	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00009
PCB 1260	Count	1	2	1	2	2	1	0	1	1	1	1	1	1	1	5
	Maximum	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	NA	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010
	Mean	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	NA	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00009
Tetrachlorethene	Count	2	3	2	3	3	2	2	2	2	2	2	2	2	2	6
	Maximum	0.0025	0.2200	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0240
	Mean	0.0025	0.1833	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0074
TOC	Count	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
	Maximum	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	4.50
	Mean	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	4.05
Toluene	Count	2	3	2	3	3	2	2	2	2	2	2	2	2	2	6
	Maximum	0.0025	0.0025	0.0082	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0050
	Mean	0.0025	0.0025	0.0054	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0038
Trans 1,2-Dichloroethene	Count	2	3	2	3	3	2	2	2	2	2	2	2	2	2	6
	Maximum	0.0480	0.5100	0.0280	0.0360	0.0360	0.0025	0.0025	0.0025	0.0025	0.0025	0.0440	4.7000	0.0025	0.0025	0.2300
	Mean	0.0435	0.4500	0.0205	0.0210	0.0307	0.0025	0.0025	0.0025	0.0025	0.0025	0.0355	2.3150	0.0025	0.0025	0.1277
Trichloroethene	Count	2	3	2	3	3	2	2	2	2	2	2	2	2	2	6
	Maximum	10.7000	4.2000	0.6500	0.2100	0.0440	0.0025	0.0025	0.0025	0.0170	0.1700	0.1900	2.9000	0.0880	0.0025	37.0000
	Mean	8.2000	3.0667	0.4500	0.1647	0.0370	0.0025	0.0025	0.0025	0.0121	0.1330	0.1435	2.2150	0.0650	0.0025	7.9167

this compound is highly variable in space and time. In the April 1984 round, this compound was found at its highest concentrations in wells 3-S (0.14 mg/1) and 6-S (0.22 mg/1), both of which also exhibited high TCE levels. The samples collected from 14 wells in January 1985 had concentrations from < 0.00001 to 0.00007 mg/1. By June of 1985, 9 of these 14 wells yielded samples with concentrations of 0.00062 to 0.0049 mg/1. Bis (2 ethylhexyl) phthalate was not detected in the soil samples beneath the disposal pits (see Section 4.1). Bis (2 ethylhexyl) phthalate is widely used as a plasticizer in a variety of rubber and plastic compounds. As such, it has become a common contaminant in laboratory settings and sampling equipment. This may account for the sporadic occurrence of this compound in the NIROP data base. No MCL or MCLG has been set for bis (2 ethylhexyl) phthalate.

Benzene was analyzed in all eight sampling rounds. It was reported in 19 percent of the samples as detected but not quantifiable to 0.010 mg/1. Three samples had concentrations as high as 0.022, 0.021, and 0.023 mg/1. Almost all benzene detections (93%) were reported prior to June 1985. In November 1986, benzene was detected in only one well (17-S) at a concentration of 0.0065 mg/1. The MCL for benzene is 0.005 mg/1 and the MCLG is zero. Thirty-three of 34 samples did not exceed the MCL in November 1986. There are no apparent spatial or temporal trends related to past or current NIROP activities.

Chloroform was analyzed in all eight sampling rounds. It was reported at the detection limit of 0.010 mg/1 on several occasions, but never above the detection limit. The data show no consistent spatial or temporal pattern. Chloroform was not detected in any well during the

November 1986 sampling round. Chloroform was also not found in the soil samples collected beneath the pits (see Section 4.1). It is unlikely that a significant source exists based on these results. The MCL for chloroform is 0.10 mg/l.

1,1 Dichloroethane was analyzed for in all eight sampling rounds. It has been found in measurable concentrations only at 3-S, 8-S, and FMC-33 (in the pit/trench area) and, at well 9-S on the eastern boundary. It was not detected in wells in the vicinity of well 6-S until November 1986, when 1,1-dichloroethane was reported at 0.019 mg/l. No detectable concentrations of 1,1-dichloroethane were found in the background wells. No regulatory levels have been set for 1,1-dichloroethane.

1,1 Dichloroethylene was analyzed in all eight rounds. It was detected only in well 9-S at 0.0092 and 0.0056 mg/l in June 1985 and January 1986, respectively. It was not detected in the most recent (November 1986) sampling round. No detectable concentrations of this compound were found in background wells. The proposed MCL for 1,1 dichloroethylene is 0.007 mg/l.

1,2-Dichloroethylene was analyzed in samples from the April 1984 and October 1984 in only a few wells and again in November 1986 in all wells. The concentrations shown for cis 1,2-dichloroethylene are identical to the reported concentrations for trans 1,2-dichloroethylene. The value reported for both compounds is total 1,2 dichloroethylene, according to Richard Karn of the WES.

In April and October 1984, it was detected in shallow wells 3-S and 6-S, FMC-33 and the bedrock well 2-PC. In November 1986, cis 1,2-

dichloroethylene was reported in samples from 11 wells at concentrations ranging from 0.022 to 0.53 mg/l.

It is likely that 1,2 dichloroethylene originated from the microbial degradation of TCE. This process of degradation has been previously reported in both laboratory and field investigations. The MCLG of 0.07 mg/l was exceeded in samples from 6 wells. The wells which yield samples with 1,2 dichloroethylene also exhibited high concentrations of TCE.

Ethylbenzene was analyzed in samples from all eight sampling rounds. Ethylbenzene was not detected in any sample in November 1986. Previously, it has been detected in only two wells (3-S and FMC-33) immediately downgradient of the disposal pits. At FMC-33 the concentration decreased from 0.21 mg/l in October 1983 to < 0.005 mg/l in November 1986. At 3-S the concentration has decreased from 0.037 mg/l to below the detection limit during the last two rounds of sampling. The MCLG for ethylbenzene is 0.68 mg/l. Ethylbenzene was identified in both drums and soil samples collected below the disposal pits (see Section 4.1). The decrease observed in the monitoring well samples suggests that the pit excavations have removed the ethylbenzene source upgradient of wells 3-S and FMC-33.

Methylene chloride was analyzed in all eight sampling rounds. It was detected at least once in 16 of the 34 wells. Reported concentrations range from 0.0065 to 41.0 mg/l. The latest sampling round had methylene chloride occurring in only one sample (1-S at 0.013 mg/l). It was also detected in three of the field blanks taken prior to November 1986. The results are highly variable and difficult to interpret.

Methylene chloride is a common extraction solvent used for laboratory sample preparation, and its presence in field sample results may arguably be due to laboratory contamination. MCLs or MCLGs for methylene chloride have not been established.

PCB Aroclors 1016, 1221, 1232, 1242, 1248, 1254, and 1260 were analyzed in water samples from all monitoring wells. Aroclors 1016, 1221, 1232, and 1260 were not found in any sample. In the October 1984 sampling round, the only Aroclor reported was 1242, in 10 of 14 samples at concentrations ranging from 0.0002 to 0.0005 mg/l. Aroclor 1254 was reported only in January 1985 samples. Concentrations in 10 of 14 samples collected on that date ranged from 0.0002 to 0.0011 mg/l. Aroclor 1248 was detected in 2 of 5 rounds from well 3-PC in concentrations of 0.0004 and 0.0002 mg/l. The reported levels are at or near the detection limit of the method (0.0002 mg/l), and therefore identification and quantification are difficult. The proposed MCLG for PCBs is zero, which is below the detection limit. The lack of consistent spatial or temporal trends also makes the reliability of these low concentrations uncertain. PCBs were found in barrels and soils in the pit/trench area; however, the wells immediately downgradient of the disposal areas were never reported to contain any PCB Aroclors. The low confidence in the reported values (near detection limits) and the lack of spatial or temporal patterns suggests that PCBs are not of concern in the ground water.

Tetrachloroethylene (PCE) was analyzed in all eight sampling rounds. PCE has been found at much lower concentrations than TCE (0.0053 to 0.22 mg/l) in samples from 6 monitoring wells. These areas

include the pit/trench area wells FMC-33, 8-S, and 3-S (PCE not detected in 3-S since October 1984); well 9-S at the eastern boundary; and in well 6-S near the southwest corner of the main NIROP building. No detectable amounts were found in the background wells. The concentrations of PCE have decreased to at or below detection levels in the pit/trench area. However, the levels have remained somewhat constant at well 6-S (average of 0.028 mg/l) and were as high as 0.21 mg/l at well 9-S in the January 1986 sampling round and 0.20 mg/l in November 1986. The proposed MCLG for tetrachloroethylene is zero.

Toluene was analyzed in all eight sampling rounds. Toluene has been detected in 14 monitoring wells at near the detection limit (0.020 to < 0.005 mg/l) in 18 percent of the samples collected. Most of the samples (88%) with detectable concentrations were collected prior to June 1985. Toluene was not detected in any well sample in November 1986. The wells immediately downgradient of the disposal areas have not had significant toluene concentrations. The spatial distribution of toluene occurrences, therefore, does not appear to correlate with the pit locations, where it was reported in drums and soil samples below the pits. The MCLG for toluene is 2.0 mg/l.

Total Organic Carbon (TOC) concentrations are typically used as a general indicator of the presence of hazardous organic substances. TOC method detection limits are not compatible with compound-specific organic detection limits achieved using organic carbon techniques. In other words, fairly significant organic contaminant levels could go undetected because of the high detection limits of the TOC methods.

TOC was analyzed in the October 1983 and June 1984 sampling rounds. During the October 1983 sampling round, concentrations of TOC were reported to range from 649.0 to 2.3 mg/l. By June of 1984 these concentrations had decreased to 15.2 to 1.0 mg/l. The high TOC concentrations in October may be due to the following:

1) Poor well development. This was the first sampling round after installation, and organic drilling fluids (if used) may not have been completely removed.

2) Other nonvolatile organics (not routinely analyzed) may be present and contributing to the TOC values.

3) Laboratory measurement errors (e.g., 190 percent recovery was reported for FMC-33).

4) VOCs may have been lost in analyses; thus, TOC may be correct and VOCs low.

1,1,1 Trichloroethane (TCA) was analyzed in all eight sampling rounds. The highest concentrations of TCA have been measured in well 9-S, where concentrations have decreased from 0.39 to 0.12 mg/l between January 1985 and November 1986. Monitoring wells 6-S and 8-S have also consistently yielded samples with measurable TCA concentrations ranging from 0.018 to 0.13 mg/l. Traces of TCA (0.0086 to < 0.005 mg/l) have also been reported from wells 2-S, 7-S, and 9-D. No background wells contained measurable concentrations of 1,1,1 trichloroethane. The MCLG for this compound is 0.2 mg/l. Only the first two samples from well 9-S exceeded the MCLG. No concentrations detected in November 1986 exceeded the MCLG. This compound appears to be associated with the occurrence of TCE, and releases from the NIROP facility.

Trichloroethylene (TCE) has been analyzed in samples from all eight sampling rounds. TCE has been detected ($\geq$ 0.005 mg/l) in 22 of 34 monitoring wells at the NIROP, with concentrations ranging from 0.005 to

37.0 mg/l. TCE has been detected in two of the upgradient wells, in three monitoring wells on the east edge of the property, in 16 monitoring wells adjacent to or downgradient of disposal areas on the plant property and in one bedrock monitoring well. Seven wells have exhibited TCE concentrations an order of magnitude higher than other wells at the NIROP facility where TCE has been detected. The seven wells include the following:

Well	Maximum Concentration (mg/l)	Average Concentration (mg/l)
FMC-33	37.0	7.9
3-S	28.0	6.1
8-D	10.7	8.2
8-S	9.2	6.6
9-S	4.2	3.1
6-S	3.8	1.3
18-S	2.9	2.2

The proposed MCL for TCE is 0.005 mg/l; over one-half of the monitoring wells have exceeded the proposed MCL at least one time. The distribution and significance of TCE occurrence will be discussed fully in Section 5.3.4 of this report. In general, TCE occurrence appears to correspond to past waste disposal activities and be related to other past or on-going releases both on and off of the NIROP facility.

Table 5-11 has been prepared to aid in summarizing the occurrence of organic constituents in ground water. The primary organic compound found in wells on the NIROP site is trichloroethylene. Data suggest multiple source areas and changing concentrations with time (discussed in Section 5.4). The data also suggests that off-site (upgradient) sources of TCE may be present.

TABLE 5-11

SUMMARY OF ORGANIC CONSTITUENTS DETECTED AT LEAST ONE TIME IN GROUND WATER AT THE NIROP STUDY AREA

Constituent	Maximum Concentration Detected (mg/l)	Well	Comments
Benzene	0.023	2-PC	No consistent trend with concentrations usually near detection limit. Detected in only one well in November 1986.
Bis (2 ethylhexyl) phthalate	0.22	6-S	Highly variable concentrations in first seven rounds. All concentrations had decreased to < 0.0006 by June 1985.
Chloroform	0.010*	Several Wells	Barely present in several rounds. Not detected in November 1986.
Ethylbenzene	0.21	FMC-33	Only detected downgradient of pit areas. Concentrations have decreased since pit/trench excavation. Not detected in November 1986.
1,1 dichloroethane	0.066	9-S	Similar distribution as TCE.
1,1 dichloroethylene	0.0092	9-S	Only detected in 9-S.
1,1,1 trichloroethane	0.39	9-S	Similar distribution as TCE.
1,2-dichloroethylene	4.7	18-S	Similar distribution as TCE.
Methylene Chloride	41	2-S	Inconsistent concentration and locations. May be sampling or analytical contaminant.
PCBs	0.0011	2-S	Very low concentrations and inconsistent occurrence in any well.
Tetrachloroethylene	0.22	9-S	Similar distribution as TCE.
Toluene	0.02	2-PC	Detected in several on-site wells at low concentrations. Not detected in November 1986.
TOC	649	5-S	Poor indicator of site conditions. Analysis discontinued after June 1984.
Trichloroethylene	37.0	FMC-33	Widespread distribution suggests more than one source (both on- and off-site). Concentrations near pit area have declined since barrel removal.

* Indicates present, but not quantifiable, at concentrations below the detection limit.

Other organic compounds occur at much lower concentrations than TCE. 1,2-Dichloroethylene isomers (breakdown products of TCE) appear to be correlated with the occurrence of TCE. Tetrachloroethene, 1,1-dichloroethane, and 1,1,1-trichloroethane also generally occur in the same areas as TCE, but at much lower concentrations. They do not appear in the background wells. 1,1-Dichloroethylene exhibits a distinctive distribution pattern in that it is only reported from well 9-S. The balance of organic compounds detected in ground water were found infrequently, at very low concentrations, or demonstrated no obvious source areas.

5.3.5 Occurrence and Migration of Hazardous Substances in Ground Water

This section of the report relates the occurrence of hazardous substances in ground water (Section 5.3.3) to the site hydrogeology (Sections 5.3.1 and 5.3.2), industrial practices, and past disposal activities (Section 4.1). Section 5.3.3 described contaminant levels observed in ground water. Several organic contaminants and one inorganic contaminant (selenium) were shown to have been detected in ground water at concentrations above their respective MCLs and MCLGs. Section 5.3.3 showed that generally, wherever TCE was detected in ground water, several other contaminants were also detected. Additionally, Section 5.3.3 showed TCE was detected in the highest concentrations (37.0 mg/l at FMC-33) and in the most wells (21 of 34). TCE is the best indicator of ground water contamination at the NIROP site and has been used in this section to define contaminant plumes and migration.

The extent of the TCE contaminant plume in both shallow and deep zones of the aquifer in the unconsolidated sediments is shown in Figure 5-7. Mean TCE concentrations have been used in preparing Figure 5-7 because a single point-in-time presentation would not clearly represent the TCE occurrence. Mean TCE concentrations for the adjacent FMC study area (Conestoga Rovers, 1985) were checked against Figure 5-7 and showed good correlation to the NIROP contours. A figure has not been prepared for the bedrock aquifer since there is no indication of ongoing TCE contamination in the bedrock.

A single elongated TCE "plume" is near the base of the unconsolidated sediments (dashed line in Figure 5-7). The occurrence of TCE deep in the sediments is probably an extension of the "shallow plume" shown by solid contour lines in Figure 5-7. The TCE plume is not extended to the base of the aquifer northwest of the NIROP building because the existing deep wells in the area (1-D, 2-D, 4-D, 5-D, 6-D, and 7-D) yield samples with TCE concentrations less than or equal to 0.011 mg/l. The vertical extent of TCE in the aquifer beneath and immediately downgradient of the waste disposal pits is not known.

Two distinct TCE plumes are evident in the shallow portions of the in the unconsolidated sediments. The first forms part of possibly aquifer-thick plume extending from well 9-S to well 18-S. The second plume in the shallow portion of the aquifer extends from well 15-S, beyond the northern property of the NIROP, to well 6-S.

The distribution of TCE in the shallow aquifer suggests four potential hazardous constituent source areas which include the following:

- Pit/trench disposal area
- Off-site source(s) north and east of wells 16-S and 15-S
- An on-site source near well 9-S or, an upgradient (off-site) source northeast of well 9-S.
- Possible localized source(s) near the southwest corner of, or beneath, the main NIROP building.

These four potential source areas as well as NIROP activities which may have contributed to ground water contamination are discussed below.

Table 5-12 has been prepared to aid in the discussion of potential on-site source areas. The table includes those constituents which have been detected at the NIROP in drums, soils beneath disposal areas, and ground water. The table also lists raw or waste material constituents which are reported to have been used or disposed at the facility. Qualifiers showing whether constituents have been detected in significant or insignificant concentrations have been included in Table 5-12. The qualifiers were based on comparison to background levels and overall results.

The pit/trench area has been a source of ground water contamination at the NIROP site as reflected in the mean TCE concentrations observed at wells 3-S, FMC-33 and 8-S (Figure 5-7). The area impacted by TCE is bounded on the northeast by wells 1-D and 1-S which exhibit no detectable levels of TCE. On the north, TCE is reported at mean concentrations of 0.096 to 0.17 mg/l in wells 7-S and 16-S, but has not been detected in the base of the aquifer (well 5-D). Low TCE concentrations have been found below the northwest corner of the NIROP facility; well 2-S has averaged approximately 0.065 mg/l since April 1984, while well 2-D has shown increasing concentrations (< 0.005 to

TABLE 5-12 SUMMARY OF CONSTITUENTS DETECTED OR REPORTED ON THE NIROP FACILITY

ALL CONSTITUENTS DETECTED	KNOWN RAW MATERIALS OR WASTES	DETECTED IN DRUMS	DETECTED IN SOILS	DETECTED IN GROUND WATER
1,1,1,2 tetrachloroethane		*	ND	ND
1,1,1 trichloroethane	X	*	DS	DS
1,1,2,2 tetrachloroethane		*	ND	ND
1,1,2-trichloroethane		*	ND	ND
1,1 dichloroethane		*	DS	DS
1,1-dichloroethylenene		*	DS	DI
Benzenes		DS	ND	DI
Bis(2 ethylhexyl) phthalate		*	DS	DI
Chloroform		*	ND	DI
Cis 1,2-dichloroethylene		*	ND	DS
Cresols		DS	NA	NA
Cyanide	X	ND	ND	ND
Ethyl Benzene		DS	ND	DI
Ethylene Glycol	X	NA	NA	NA
Isocyanate	X	NA	NA	NA
Isoproponal		DS	NA	NA
Methyl Ethyl Ketone	X	DS	NA	ND
Methylene Chloride	X	*	DI	DI
Napnthalene	X	DS	NA	ND
PCBs	X	DS	DS	DI
Pesticides		ND	DI	ND
Phenols	X	NA	NA	ND
Tetrachloroethylene	X	*	DS	DS
Toluene	X	DS	DS	DI
Trans 1,2-dichloroethylene		*	DS	DS
Trichloroethylene	X	DS	DS	DS
Trichlorofluoromethane		NA	NA	DI
Triethylamine	X	NA	NA	NA
Xylenes	X	DS	NA	ND

* - Drum anlayses provided by Chemical Waste Management does not distinguish between VOCs which were not detected and those which were not analyzed.

X - Indicates raw materials known to have been used at the NIROP from file information.

NA - Constituent not analyzed.

ND - Constituent not detected.

DS - Constituent detected at a significant concentration.

DI - Constituent detected at an insignificant concentration.

TABLE 5-12 SUMMARY OF CONSTITUENTS DETECTED OR REPORTED ON THE NIROP FACILITY

ALL CONSTITUENTS DETECTED	KNOWN RAW MATERIALS OR WASTES	DETECTED IN DRUMS	DETECTED IN SOILS	DETECTED IN GROUND WATER
Arsenic		DI	DI	DI
Barium		DS	DS	DI
Cadmium	X	DS	DI	DI
Chromium	X	DS	DS	DI
Copper	X	DI	DS	DI
Lead	X	DS	DS	DI
Manganese	X	NA	DS	DI
Mercury		DI	DI	DI
Nickel	X	DI	DS	DI
Selenium		DI	DI	DS
Silver	X	DI	DI	DI
Zinc		DS	DS	DI
Acids	X			NA
Gasoline	X			
Hydrocarbons, Aliphatic	X			
Hydromatic, Aromatic	X			
Hydrocarbons		D		
Kerosene	X			
Mineral Spirits	X			
Oil and Grease	X			
Paint	X			
Paint Thinner	X			
Stoddard Solvent	X			

* - Drum anlayses provided by Chemical Waste Management does not distinguish between VOCs which were not detected and those which were not analyzed.

X - Indicates raw materials known to have been used at the NIROP from file information.

NA - Constituent not analyzed.

ND - Constituent not detected.

DS - Constituent detected at a significant concentration.

DI - Constituent detected at an insignificant concentration.

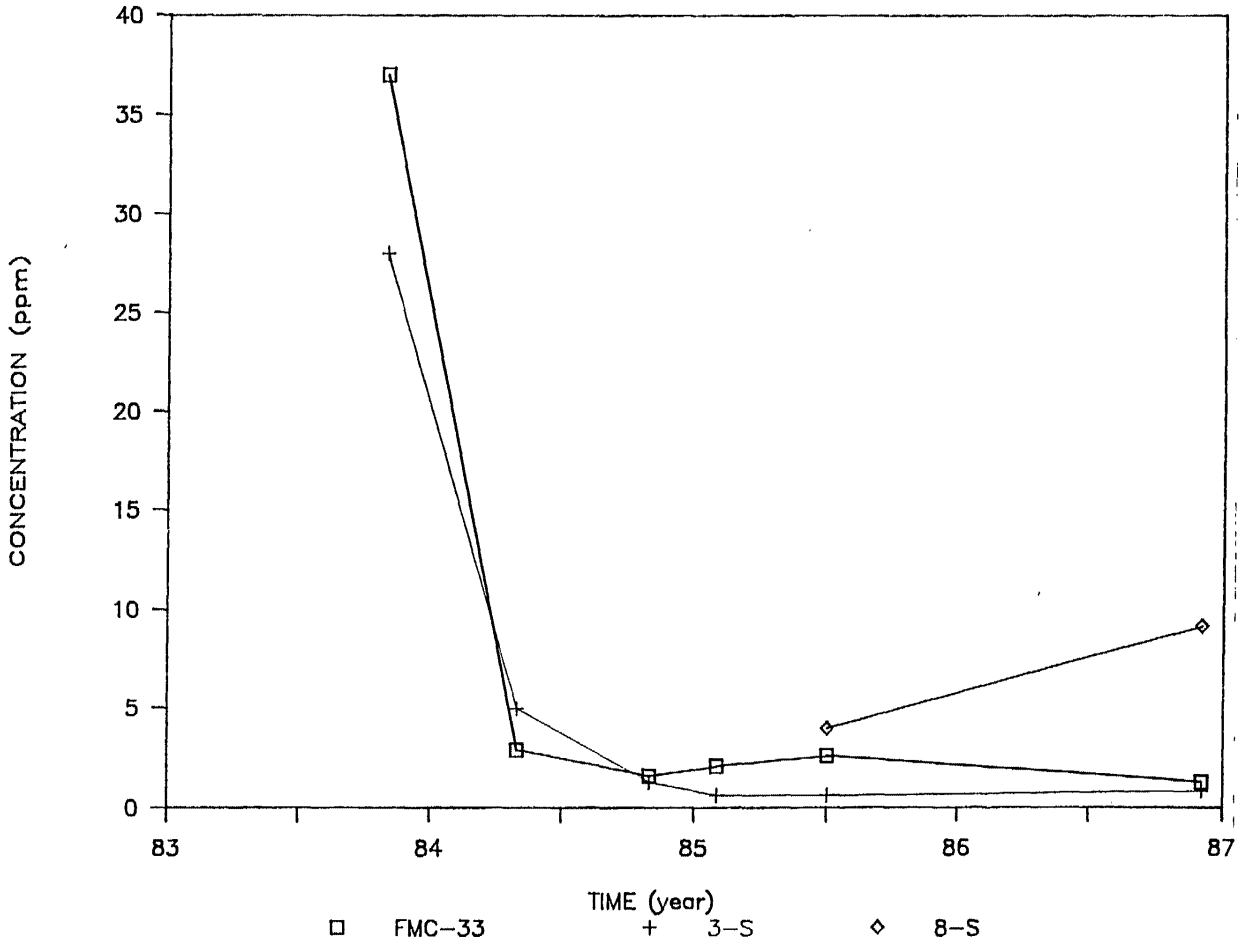
0.0092 mg/l) since April 1984. The intermittent pumping from Fridley municipal well 13 may be drawing TCE northwestward from the apparent source area(s) in the northcentral portions of the NIROP facility.

The high TCE concentrations observed immediately downgradient of the pit area decreased substantially between October 1983 and April 1984 (wells FMC-33 and 3-S, Figure 5-8). Since that time TCE concentrations have remained relatively stable between 0.5 and 3 mg/l. Samples from monitoring well 8-S, however, show the opposite trend; an increasing TCE concentration from 4.0 to 9.2 mg/l between June 1985 and November 1986. It is difficult to assess the significance of this apparent trend with only two data points.

The decreases in TCE concentrations observed in FMC-33 and 3-S may be linked to the pit/trench remedial action taken under COE direction in the fall of 1983 (described in Section 4.1 of this report). This action, however, consisted of the removal of 43 barrels, 41 of which came from one trench upgradient of well 8-S, where TCE concentrations do not appear to be decreasing. The data obtained to date therefore do not clearly indicate an improvement of ground water quality as a result of the barrel removal. At a minimum, the data suggest that there may be a continuing source of TCE in the pit/trench disposal area. If Pit 5, was not excavated as planned in earlier investigations, it may be contributing to the continuing TCE concentrations observed in wells 3-S, 8-S, and FMC-33.

Low concentrations of TCE have been reported in one of four monitoring wells in the bedrock aquifer (2-PC), since their installation in the fall of 1983. The low TCE concentrations from well 2-PC have

FIG 5-8 CHANGES IN TCE CONCENTRATIONS IMMEDIATELY DOWNGRADIENT OF THE PIT/TRENCH EXCAVATIONS



decreased by a factor of 12 (0.062 to 0.0053 mg/l) by November 1986. Three production wells are also completed in the Prairie du Chien/Jordan bedrock aquifer (Figure 2-2). The 3 wells on the NIROP and FMC property were found to contain from 0.035 mg/l (Navy 3) to 0.200 mg/l (FMC-1) of TCE in April 1981 (Hickok, 1981). Navy wells 2 and 3 were then shut down. FMC-1 was sampled until April 1982. The last two samples collected from this well contained 0.082 mg/l (Envirodyne, 1983). The mechanism by which TCE migrated into the bedrock aquifer is not known. Currently, vertical gradients are upward across the St. Peter Formation that separates the Prairie du Chien from the overlying unconfined aquifer. If TCE was released in volumes great enough to form a separate phase in the unconfined aquifer, it could have sunk through the unconfined aquifer and the St. Peter Formation. There is no evidence to suggest that this has happened near Navy wells 2 and 3 or beneath the NIROP facility. The TCE plume above production well FMC-1 may extend to the base of the unconfined aquifer. The Prairie du Chien aquifer is in contact with the unconfined aquifer (Figure 5-3), allowing for direct migration into the intake zone of this well. It is not known how pumping of these wells changed ground water flow patterns. It is likely that pumping reversed the vertical gradients near the wells and ground water flowed downward through the St. Peter. If TCE was present near the base of the unconfined aquifer, it would have been more likely that TCE could have crossed the St. Peter and entered the production wells. It is also possible that TCE migrated along the casing of Navy wells 2 and 3. These wells were installed in 1941 using cable tool methods. It is unlikely that the 16-inch drive casing that served as the well was

grouted or sealed into the St. Peter Formation. This unsealed contact between the sediments, rock, and casing could have allowed TCE to enter the wells. The potential for TCE migration by this route would be greatly enhanced by the reduction of heads caused by pumping.

Other contaminants detected in significant concentrations in ground water downgradient of the pit/trench source area include 1,1,1 trichloroethane (8-S), 1,1 dichloroethane (8-S, 3-S and FMC-33), 1,2-dichloroethylene (8-S, 3-S, and FMC-33), and tetrachloroethylene (8-S, 3-S, and FMC-33). These five constituents in ground water were detected in significant quantities in soils (Table 5-12).

Three of the five constituents detected at significant concentrations in soils were also used as raw materials at the NIROP (Table 5-12). Of the remaining two constituents detected in ground water, the 1,2-dichloroethylene isomers are breakdown products of TCE (see Section 5.3.3). 1,1 Dichloroethane is the only constituent detected in ground water and soils which cannot be linked directly to the NIROP. However, since 1,1 dichloroethane was detected in significant concentrations in soils from the pits/trenches, it is probable that it was used at the facility.

Several constituents which were either detected in drums found in the pits/trenches, or were known to have been used as raw materials, have not been detected in ground water samples or were detected in insignificant concentrations (Table 5-12). These constituents include cresol, methyl ethyl ketone, naphthalene, cyanide, phenols, and xylenes.

Several products used at the NIROP were not analyzed in any medium. These include acids, oil, grease, and gasoline. Although not

specifically tested for, most of these products contain constituents which would have been included in the analyses performed to date. For example, very low pH would have indicated the presence of acids and elevated benzene concentrations would have been detected from the presence of gasoline.

The extension of the TCE plume to the north and east of the NIROP facility (Figure 5-7) suggests a potential off-site contaminant source. TCE has been detected in wells 7-S, 15-S, and 16-S on both occasions that the wells have been sampled. TCE concentrations in samples from wells 7-S and 16-S have typically ranged from 0.097 to 0.19 mg/l while the two samples from well 15-S had concentrations of 0.017 and 0.0071 mg/l. The high concentrations at wells 7-S and 16-S suggest a source between these wells and wells 14-S and 15-S or a narrow TCE plume migrating southwestward between wells 14-S and 15-S.

Kurt Manufacturing is a CERCLA site to the northeast of the NIROP and could be a potential source of organic constituents. The likelihood of Kurt Manufacturing contributing to the observed concentrations has not been evaluated. Previous investigations (Braun Engineering, 1983), however, found that tetrachloroethylene was generally found in concentrations greater than or equal to TCE. Only TCE has been detected in the monitoring wells immediately upgradient of the NIROP.

The water table map (Figure 5-4) indicates that ground water flow in the shallow portions of the unconsolidated aquifer travels from the vicinity of wells 15-S and 16-S across the NIROP facility. Thus, TCE from an off-site source would contribute to the total TCE mass observed beneath the NIROP in the unconsolidated aquifer. No deep alluvial wells

have been completed in the vicinity of 15-S and 16-S. The contribution from any potential off-site source to the deep portions of the unconsolidated aquifer is unknown at this time.

The TCE concentration data on Figure 5-7 suggests a separate contaminant source either in the immediate vicinity of well 9-S or upgradient (offsite and to the northeast) of well 9-S. Well 9-S was first sampled in June 1985. Significant concentrations of 1,1,1 trichloroethane (0.39 mg/l), 1,1, dichloroethane (0.066 mg/l), tetrachloroethylene (0.22 mg/l), 1,2 dichloroethylene (0.50 mg/l) and TCE (3.2 mg/l) were detected at that time. Two subsequent sampling rounds in January 1986, and November 1986 yielded similar concentrations of the above constituents as well as dissolved selenium (0.049 mg/l), which was analyzed for the first time in November 1986. The mix of organic constituents detected in well 9-S are mostly the same as those detected in the pit/trench area. However, concentrations detected at 9-S are generally higher than those seen in the pit/trench area since drum excavation. In fact well 9-S has had the highest concentration detected at the NIROP for four VOCs including 1,2 dichloroethylene, tetrachloroethylene, 1,1,1 trichloroethane and 1,1 dichloroethylene (Table 5-11). Monitoring well 9-S was also the only well to yield samples with significant quantities of selenium.

Potential sources of the contamination detected at well 9-S on the NIROP facility include an above-ground TCE tank, underground fuel oil tanks, and underground Stoddard solvent tanks. The above-ground TCE tank was moved near well 9-S in 1983 as detailed in Section 4.1. If the above-ground TCE tank was the source of contamination at well 9-S then

one would not expect to see tetrachloroethylene, 1,1 dichloroethylene or selenium emanating from the tank area as well.

Similar arguments can be made for both the underground fuel tanks and the underground Stoddard solvent tanks located near 9-S. An underground fuel tank leak would have shown the presence of benzene, toluene and xylene and not the constituents detected above. Likewise, a leaking Stoddard solvent tank would also have shown benzene, ethylbenzene, toluene, and xylene and not TCE or selenium. Therefore, it appears that the source of contamination detected in well 9-S may be due to off-site activities to the northeast.

The vertical extent of hazardous substances into the deeper portions of the unconfined aquifer on the east side of the NIROP may be reflected by the chemistry of samples from well 3-D. TCE concentrations from this well have been low but consistent (0.023 to 0.012 mg/l). With the exception of the November 1986 sampling, the shallow well at that location (4-S) has been free of TCE, suggesting that the TCE in well 3-D could not have originated from downward migration. This still leaves open the possibility for lateral (off-site) migration through the gravelly sand layer in which well 3-D is completed.

The plume of hazardous constituents that originates near or migrates on to the eastern NIROP boundary apparently extends west of River Road to wells 8-D, 9-D, 18-S, and 19-S (Figure 5-7). TCE concentrations at well 8-D and 18-S are on the order of 8 mg/l and 2 mg/l, respectively, while concentrations from wells 9-D and 19-S are on the order of 3 mg/l and 0.07 mg/l. The highest concentrations are found at the base of the alluvial aquifer at both locations. Based on the ground

water flow paths in the base of the aquifer (Figure 5-5), it is likely that these high concentrations extend eastward toward well 9-S.

Other organic compounds found west of East River Road include 1,2-dichloroethylene (8-D, 9-D, and 18-S), tetrachloroethylene (8-D), and 1,1,1-trichloroethane (9-D). Only 1,2-dichloroethylene is found at significant concentrations (> 0.05 mg/l). This differs from the apparent upgradient mix of organic compounds found in samples from well 9-S; where 1,1-dichloroethylene, tetrachloroethylene, and 1,1,1-trichloroethane occur in concentrations from 0.008 to 0.4 mg/l. The mix of constituents is similar to that found at wells 7-S, 10-S, and 11-S (discussed below), but the concentrations at 18-S and 8-D are one to two orders of magnitude greater.

There is insufficient information at this time to assess the cause(s) or significance of the inconsistencies between the mix of hazardous constituents and their concentrations amoung the monitoring wells. It is apparent, however, that high concentrations of TCE (1 to 10 mg/l) are leaving the NIROP facility and moving toward the Mississippi River. It is also <u>not</u> clear as to whether some or all of the TCE observed on the east side of the NIROP originated on the site or has migrated onto the site from some unknown source to the east.

Separate sources of contamination may be located beneath or southwest of the main NIROP building, near wells 6-S, 10-S, 11-S, and 17-S. A narrow TCE plume extending from the pit/trench area through wells 10-S and 6-S is shown on Figure 5-7. Wells to the north and west of 6-S and 10-S (4-D, 5-S, and 4-PC) and to the south (11-S and 6-D) are outside of the plume indicated. Constituents detected in well 6-S

include TCE, 1,2 dichloroethylene, 1,1 dichloroethane, tetrachloroethylene, and 1,1,1 trichloroethane. However, well 10-S has shown only the presence of TCE and 1,2 dichloroethylene, suggesting separate sources for the constituents observed in these wells.

Well 10-S is located less than 100 feet from the pre-1983 location of the above-ground TCE tank (see Figure 2-2). The constituents detected in well 10-S (TCE and 1,2 dichloroethylene) suggest a pure TCE contaminant source near 10-S, the pre-1983 TCE tank. This may be the source of some of the constituents seen in 6-S; however, the tetrachloroethylene and 1,1 dichloroethane detected in 6-S would have to come from a source other than the former TCE tank.

Well 6-S is located very close to two storm sewers which exit the NIROP westward toward the Mississippi River (Figure 4-2). These lines drain most of the area within the NIROP building. Several spills of various materials into floor drains that are part of the sewer system were documented in Section 4.1. Corrective action taken in the instance of some spills was to seal storm sewer drains in the vicinity of the spill, thus implying that spilled materials have entered the storm sewer system. Sampling of the storm sewer outfall on one occasion also found several organic compounds, including TCE, to be in the effluent (Hickok, 1981). Leaks from the storm sewer system immediately west of the building might account for the hazardous substances seen at well 6-S. Monitoring well 6-S is also downgradient of the pit/trench disposal area (Figure 5-4 and 5-7). Some of the hazardous constituents observed in samples from well 6-S probably originated from the pit/trench area.

Monitoring wells 17-S and 7-D are downgradient of both wells 10-S and 6-S. Samples from well 17-S contain both TCE and 1,2-dichloroethylene while 7-D (the deep alluvial monitoring well) is free of organic constituents. The lack of organic constituents at the base of the alluvial aquifer supports the interpretation of a shallow plume on the west side of the NIROP facility. The data from the shallow well (17-S) show the plume continuing toward the Mississippi River, with a constituent mix similar to that found at well 10-S. It is not known why the other organic constituents seen at well 6-S are not found in 17-S.

Leaks from the sanitary sewer system (Figure 4-2) may also have contributed to the organic constituents detected in ground water. Spilled materials as well as treated wastes enter the sanitary system. For example, a 200-gallon TCE spill to the sanitary system was detailed in Section 4.1. Sampling of the effluent has found organic compounds, including TCE (Hickok, 1981). Thus, leaks from the sanitary system to the ground water may contribute to contamination in the vicinity of wells 6-S, 11-S, and 17-S. An attempt to evaluate potential leaks from the sanitary sewer by evaluation of major ion chemistry was made during the November 1986 sampling round. Sanitary sewage typically contains significant concentrations of chloride, nitrate, alkalinity, and sodium (Todd, 1980; Miller, 1980). The intent of the major ion analyses was to determine whether these constituents increased in concentration downgradient of the NIROP relative to upgradient or background concentrations. The data were evaluated using trilinear plots (Piper, 1944). The cation-anion balances for 88 percent of the samples were $\leq$ 10 percent, yielding a large set of acceptable data for the evaluation.

When the data were plotted, the samples generally fell within the Ca + Mg:HCO_3 + SO_4 field of the diagram. There was no evident change in chloride, alkalinity, or sodium concentrations downgradient of the NIROP sanitary sewers. Nitrate concentrations also did not show a spatial distribution related to the sanitary sewers. The highest nitrate values (17.0 to 3.29 mg/l) were found upgradient of the NIROP sewers. The 17.0 mg/l concentration measured in the sample from well 14-S exceeds the 10.0 mg/l MCL.

Summary. Four separate source areas of contamination have been related to the observed occurrence of hazardous constituents in ground water. These areas were identified on the basis of the constituents detected and ground water flow patterns. The four areas discussed included the pit/trench area near wells 8-S, 3-S, and FMC-33; an off-site source northeast of the NIROP; the area around well 9-S or an off-site source east of well 9-S; and the area southwest of the NIROP main building around wells 10-S and 6-S. Some of the constituents found southwest of the building may have originated with the TCE storage tank located near well 10-S from 1962 to 1983. The remaining constituents have probably migrated southwestward from the pit/trench area.

The distribution of hazardous constituents suggests two separate plumes are found beneath the NIROP facility. One plume begins north of the NIROP and moves beneath the pit/trench area where TCE concentrations increase by one order of magnitude. Migration continues to the southwest toward wells 6-S, 10-S, and 17-s, where TCE concentration increases suggest an additional source of TCE to the ground water. The plume also appears to be limited to the upper portions of the alluvial aquifer.

The second plume originates near well 9-S or somewhere east of the NIROP facility. The plume migrates southwestward toward wells 18-S and 8-D where the data suggest that the TCE plume may extend across the entire thickness of the alluvial aquifer.

The two plumes apparently merge in the vicinity of wells 17-S and 18-S, continuing to migrate westward until the ground water discharges to the Mississippi River. Concentrations of TCE in the ground water reaching the river are probably on the order of 1 to 10 mg/l.

6. SURFACE WATER INVESTIGATION

6.1 Surface Water Characteristics

The NIROP facility is situated on an alluvial terrace of the Mississippi River. Much of this very flat surface is covered by buildings and pavement. Runoff from these hard-surfaced areas, as well as from drains within the plant, is collected by a series of storm sewers, which discharge into the Mississippi River, located approximately 800 feet west of the plant boundary.

The flow of the Mississippi River is recorded by the United States Geological Survey (USGS) at a gaging station near Anoka, which is located about 6 river miles upstream from the NIROP site. Water elevation near the NIROP range from 800 to 810 feet MSL. The average discharge at this station is about 7,600 cubic feet per second (cfs) or 4,900 million gallons per day (Mgd). The average monthly flow at this station is seldom less than 1,000 cfs (650 Mgd) and is generally between 4,000 and 10,000 cfs (2,600 and 6,500 Mgd) (Norvitch and others, 1973). Low-flow conditions for the river are expressed generally in terms of a number of consecutive days during which the flow does not exceed a given value. Statistically, these conditions occur with a certain frequency called a recurrence interval. For the Mississippi River near Anoka, a flow of less than 1,000 cfs (650 Mgd) for a 7-day duration occurs about once every ten years. A low-flow of 2,400 cfs (1,500 Mgd) for a 7-day duration occurs about once every two years (Mann, 1971).

As part of a 1975 study, the U.S.G.S. determined flood plain datums at the I-694 bridge less than 1 mile north of the NIROP. The 100-year

flood plain elevation was found to be 818 feet (MSL) and the 500-year flood plain was found to be 821.5 feet (MSL) (U.S.G.S. 1987).

Ground elevations for the terrace on which the NIROP site is located are over 830 feet (MSL). Therefore, the facility is not within the boundaries of either the 100-year flood plain or the 500-year flood plain.

6.2 Ground Water/Surface Water Relationship

Papadopulos (1983) showed that hydraulic communication exists between both the alluvial and Prairie du Chien aquifers and the Mississippi River beneath the FMC study area, immediately south of the NIROP. Papadopulus determined that the control the Mississippi River exercises on ground water levels in the vicinity of the site is evidence that the river is the downstream head control for the ground water system and is the discharge area. Conditions at the adjacent NIROP study area are expected to be the same. Similar comparisons with NIROP well data and river stage are difficult at this time, since newer wells near the river were not installed until 1986.

6.3 Surface Water Use

The Mississippi River is a drinking water source for Minneapolis and St. Paul. Surface water is withdrawn from the Mississippi River at the St. Paul water intake (about 3 1/2 river miles upstream from the site) and at the Minneapolis water intake (about 1 mile downstream from the site). In 1970, St. Paul had a total water use of about 56 Mgd. Most of this water was derived from the intake on the Mississippi

River. In 1970, Minneapolis was withdrawing approximately 77 Mgd from the river (Norvitch and others, 1973). In 1979, St. Paul's total water use had declined to about 50 Mgd and Minneapolis' withdrawal was estimated to be about 55 Mgd (Papodopulos, 1983).

In addition to drinking water, the Mississippi River is used for recreation, transportation, and wastewater discharge. In the vicinity of the NIROP, the Anoka wastewater treatment facility is located about 13 river miles upstream from the disposal site and discharges effluent into the river. The discharge rate is about 2 Mgd (Larson and others, 1976).

6.4 Surface Water Contamination

On March 16, 1981, and April 23, 1981, Navy water supply wells and FMC well 1 (Figure 2-2) were tested and found to contain trichloroethylene (TCE) at concentrations ranging from 0.035 mg/l to 0.200 mg/l. Subsequent sampling in 1981 at the Minneapolis water supply intake, approximately 1 mile downstream in the Mississippi River (Figure 2-2), found detectable but unquantifiable TCE concentrations during 4 sampling rounds. On December 31, 1981, the first quantifiable concentration (0.0012 mg/l) of TCE was detected at the water supply intake. Table 6-1, adapted from the IAS report (Envirodyne 1983), summarizes the concentrations of TCE detected at the water intake for the period July 1981 to August 1982. The TCE concentrations detected at the water intake may have been related to activities at the NIROP (sewer discharge or ground water contamination) or from other upgradient sources.

TABLE 6-1

TRICHLOROETHYLENE CONCENTRATION AT MINNEAPOLIS SURFACE WATER INTAKE*
(mg/l)

Sample Date	Minneapolis Water Intake	Minneapolis Finished Water
07/22/81	**	
07/29/81	**	
08/14/81	**	
09/08/81	**	
12/31/81	0.0012	
01/27/82	0.0013	
02/03/82	0.0010	
02/10/82	0.0012	
02/17/82	0.0011	
03/03/82	0.0009	
03/17/82	0.0008	0.0006
04/01/82	< 0.0002	
04/07/82	< 0.0002	< 0.0004
04/16/82	< 0.0002	< 0.0002
04/19/82	< 0.0002	
04/21/82	< 0.0002	0.0004
04/23/82	< 0.0002	
06/16/82	0.0009	0.0004
06/30/82	0.0008	0.0002
07/14/82	0.0004	0.0010
07/28/82	0.0006	**
08/11/82	0.0006	0.0002

* (Envirodyne, 1983).

** Indicates that TCE was present, but the amount was too small to quantify.

7. ASSESSMENT OF POTENTIAL IMPACT OF EXISTING GROUND WATER CONTAMINATION TO PUBLIC HEALTH

7.1 Introduction

The factors evaluated to complete the assessment of the potential impact of the existing ground water contamination include the following:

- The contaminants present in the ground water
- The potential contaminant migration
- The distribution of ground water contamination on and off the site
- The potential for human exposure and the adverse effects of exposure

Existing conditions at the NIROP site were defined by available analytical data obtained through November 1986. The information was used to identify critical contaminants and the pathways by which they may impact public health. The risk assessment was evaluated for the potential receptor area of the Minneapolis municipal water supply intake situated downstream of the site on the Mississippi River.

7.2 Summary of Existing Conditions

The graphical representation of TCE contamination as shown in Figure 5-7 in the shallow alluvial wells reveals that there are probably at least 4 source areas. Two major potential sources are the "pits and trenches" area along the northern side of the plant and a second area to the east of the plant. Wells in these two locations exhibit the highest TCE concentrations. Soil samples taken after excavation of the pits and trenches also reveal residual levels of TCE, 1,2-dichloroethylene, 1,1-dichloroethylene, tetrachloroethane, toluene, and 1,1,1-trichloroethane.

The distribution of TCE in the unconsolidated aquifer is consistent with shallow ground water flow. For example, TCE levels generally

decrease at wells downgradient of the suspected source areas, and at wells that are transverse to flow lines through the source areas. Wells not subject to flow from the source areas typically exhibit TCE levels at the analytical detection level. It is also possible that there are additional off-site or on-site sources which have not yet been identified, and which may be influencing the observed distribution of TCE.

Ground water flow through the unconsolidated (as well as underlying bedrock) aquifer discharges to the Mississippi River west of the site. The unconsolidated aquifer pathway may result in contaminant loading to the river. Contaminants discharging to the river would be subject to dilution in proportion to the ratio of ground water flow to river flow. Based on available hydrogeological data and the annual average daily low flow for the river, this dilution factor was estimated to be approximately 555, assuming complete mixing (RMT, 1987). Since the receptor point of interest, the Minneapolis water supply intake, is located only 1 mile downstream of the NIROP facility, complete mixing may not be a valid assumption. If incomplete mixing is assumed which results in ground water mixing with only 10 percent of the river flow, the dilution factor would be 55.

The actual dilution factor is probably closer to 55 (10 percent mixing) as calculated with the following equation taken from the Draft Superfund Exposure Assessment Manual (Versar, 1986):

$$MZ = \frac{0.4\ w^2 u}{0.6d\ \sqrt{gds}}$$

where:

MZ = mixing zone length
w = width of water body
u = stream velocity
d = stream depth
s = slope of the stream channel
g = acceleration due to gravity

Values used in the above equation which were felt to be representative of the Mississippi River near the NIROP were as follows:

w = 720 feet; measured on site map
u = 2 feet/second (Case 1)
1 foot/second (Case 2); values for u were selected based on the equation

$$u = \frac{Q \text{ (discharge)}}{w \cdot d}$$

w = 720 feet (from above); d was assumed to be 10 feet (Case 1) and 20 feet (Case 2)
Q = Approximately 14,500 cubic feet/second was average discharge in water year 1985 reported by USGS

d = 10 feet (Case 1)
20 feet (Case 2); values assumed
s = 0.0003 feet/foot; measured on USGS topographic map
g = 32 feet/second^2

Solving the equation yields mixing zone values of 42 miles (Case 1) and 7.5 miles (Case 2). If mixing is assumed to be linear over the entire mixing zone and the distance to the water intake equals one mile, then that distance would equal 2.4 percent of the mixing zone (Case 1) and 13.3 percent of the mixing zone (Case 2). Thus, the use of a dilution factor of 55, asuming 10 percent mixing, is probably of the right order of magnitude. This level of precision is sufficient for the preliminary assessments made in this report.

7.3 Evaluation of the Impact of Existing Conditions to Public Health

7.3.1 Method of Evaluation

This evaluation is a preliminary assessment of the public health impacts based only on available ground water monitoring data and is not intended to be a comprehensive risk assessment. The method for evaluating the health risk for contaminants identified on-site has been adapted from the Superfund Public Health Evaluation Manual, draft edition, December 18, 1985, prepared for the USEPA by IFC, Inc. (RMT, 1987).

The risk level for TCE was calculated for the Minneapolis water supply intake by "diluting" the observed off-site concentrations by the dilution factors of 555 (100 percent mixing) and 55 (10 percent mixing) described in Section 7.2. The average mean value for all samples from the off-site wells was used in this calculation because the flux of ground water to the river is across a two-dimensional plane represented by all the wells, and not by any particular well. The water intake evaluation actually results in an incremental risk level since it does not include the potential presence of TCE in the river from other upstream sources. It is also conservative because it assumes that there is no removal in the river by volatilization or biodegradation.

7.3.2 Deviations and Assumptions

This evaluation is based on the assumption that the primary route of human exposure occurs only through ingestion of ground water or river water and that the effect of exposure through other media (e.g., air transport and inhalation, soil contact, etc.) are negligible. Hence, it

was not considered necessary to select other indicator chemicals through the ranking process outlined in the Superfund Public Health Evaluation Manual.

TCE contamination via ground water discharge to the Mississippi River has been evaluated in this section. Although Hickok (1981) reported several detected VOCs in storm water discharge to the river (see Section 4.1.3), the storm sewers have not been sampled since that time.

7.3.3 Computation of Results

The calculation of risk is based on the numerical technique described in the Superfund Public Health Evaluation Manual. The calculated values of TCE concentrations at the Minneapolis municipal water intake were found to be 0.003 mg/l if 100 percent dilution occurs and 0.033 mg/l if the dilution factor is 10 percent (RMT, 1987).

Since TCE is listed as a human carcinogen, the estimated daily intake was multiplied by the USEPA's carcinogenic potency factor to determine actual risk levels. In evaluating carcinogenic risks, the USEPA considers risks lower than 1×10^{-6} as the acceptable range. The Minnesota Health Department considers the risks of multiple carcinogens to be additive and uses risks lower than 1×10^{-5} as being in the acceptable range for the total of all carcinogens present.

Because the relationship between risk and observed concentration is linear, it can be plotted as a straight line on log-log paper. Figure 7-1 plots specific TCE data points at several locations. Figure 7-1 illustrates that there is a carcinogenic risk at on-site and off-site

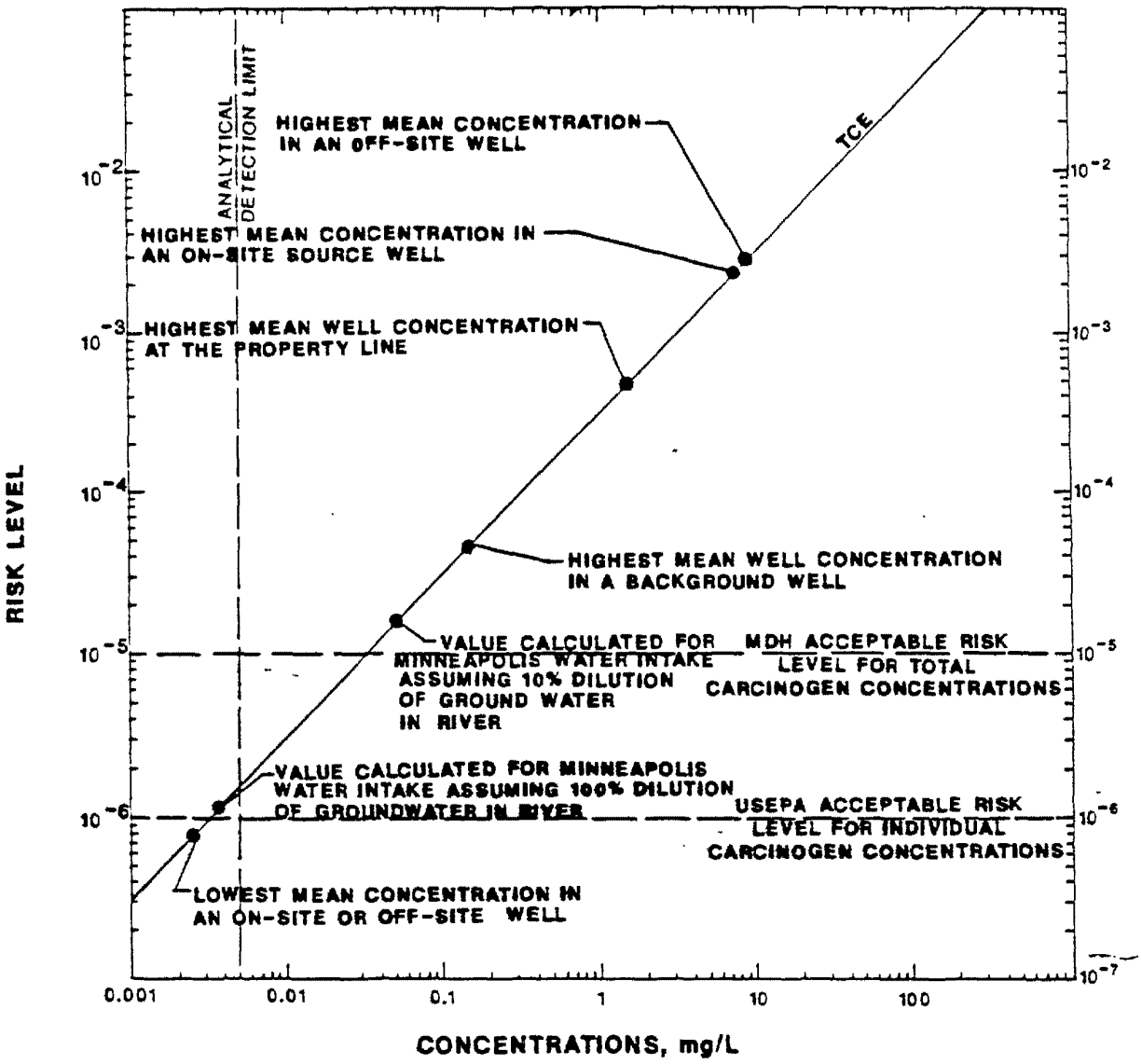


FIGURE 7-1

RISK LEVELS FOR VARIOUS OBSERVED TCE CONCENTRATIONS

RMT

Drawn by	MCS
Date	5/87
Proj #	1254.03

wells as well as in a background well (15-S), in excess of state and federal guidelines. The calculations for risk at the Minneapolis municipal water supply intake are generally in the range of acceptable levels, depending on the dilution assumption used.

7.4 Evaluation of Possible Future Effects

Based upon present knowledge regarding the extent of past waste disposal practices and the fact that TCE levels are declining in some wells, it appears that the risk evaluation for existing (observed) conditions provides a conservative estimate of future risks as well. The evaluation of risk for potential future conditions could be improved by better defining sources and by identifying any additional trends in ground water quality over time.

The future risk to public health may be summarized as follows:

- In the absence of remedial action, a large, unidentified continuous TCE source may yield downgradient concentrations which are higher than those presently observed. Public health risks would increase proportionally. The data to date, however, do not indicate worsening ground water quality in terms of TCE concentrations. This scenario is not realistic if all large sources are presently known.

- If there have been no new sources of TCE in the last 5-10 years, then the concentrations presently observed (and the corresponding risks) probably will not increase.

- Since the effects of small, isolated sources of relatively pure TCE (such as subsurface pools or pockets) are relatively local, not all of the risks may be presently known.

8. REFERENCES

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9. TERMINOLOGY GUIDE

The following guide is broken into the following two sections:

- Explanation of various federal environmental laws
- Other terminology

The laws are not in alphabetical order, the other terms are.

ENVIRONMENTAL LAWS:

RCRA

Resource Conservation and Recovery Act of 1976. What we commonly refer to as RCRA is an amendment to the first piece of Federal solid waste legislation called the Solid Waste Disposal Act of 1965. RCRA was amended in 1980 and most recently on November 8, 1984 by the Hazardous Solid Wastes Amendments of 1984 (HSWA).

The goals set by RCRA are the following:

- To protect human health and the environment.
- To reduce waste and conserve energy and natural resources.
- To reduce or eliminate the generation of hazardous waste as expeditiously as possible.

To achieve these goals, three distinct yet interrelated programs were developed under RCRA. The first program, outlined under Subtitle D of RCRA, encourages states to develop comprehensive plans for the management of solid wastes, primarily nonhazardous (e.g., household waste). The second program, outlined under Subtitle C of the Act, is the one most people think about when RCRA is mentioned. It establishes a system for controlling hazardous waste from the time it is generated until its ultimate disposal, in effect, from "cradle to grave." The last of the three programs established under RCRA is also the newest.

This program, outlined under Subtitle I of the Act, regulates certain underground storage tanks. It establishes performance standards for new tanks and requires leak detection, prevention and correction at underground tank sites.

It is important to note that although RCRA creates a framework for the proper management of hazardous and nonhazardous solid waste, it does not address the problems of hazardous waste encountered at inactive or abandoned sites or those resulting from spills that require emergency response. They are taken care of by a different act, the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), better known as Superfund.

The Subtitle C program developed under RCRA creates a Federal "cradle to grave" hazardous waste management system that sets forth statutory and regulatory requirements for the following:

- Identifying hazardous waste.
- Regulating generators of hazardous waste.
- Regulating transporters of hazardous waste.
- Regulating owners and operators of facilities that treat, store, or dispose of hazardous wastes.
- Issuing operating permits to owners or operators of treatment, storage, and disposal facilities.
- Enforcing the Subtitle C program.
- Transferring the responsibilities of the Subtitle C program from the federal government to the states.
- Requiring public participation in the Subtitle C program.

Subtitle I of the Act is a new program created by HSWA to regulate petroleum products and hazardous substances (as defined under CERCLA) stored in tanks underground. It is designed as a regulatory program

that may be delegated to states. Under this program, the EPA must establish regulations laying out performance standards for new tanks as well as standards covering leak detection, leak prevention, and corrective action for both new and existing underground storage tanks (UST). The objective of this subtitle is to prevent leakage from tanks that could pollute the environment, especially ground water.

Subtitle I regulates underground tanks storing petroleum products (including gasoline and crude oil) and any substance defined as hazardous under CERCLA. It is important to note that Subtitle I does not regulate tanks storing hazardous wastes as defined by RCRA. Such tanks are already regulated under Subtitle C.

Under certain circumstances, RCRA facilities may have to comply with the regulatory requirements of other federal environmental acts including the following:

- Clean Air Act
- Clean Water Act
- Safe Drinking Water Act
- Toxic Substances Control Act
- Comprehensive Environmental Response, Compensation, and Liability Act

HSWA

The Hazardous and Solid Waste Amendments of 1984 (Public Law 98-616) that significantly expanded both the scope and the coverage of RCRA, especially regarding Underground Storage Tanks.

CERCLA

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), passed in 1980 and commonly known as "Superfund." CERCLA gives the federal government the power to respond to releases (e.g., spills), or threatened releases, of any hazardous substance into the environment as well as to a release of a pollutant or contaminant that may present an imminent and substantial danger to public health or welfare. CERCLA established a Hazardous Substance Trust Fund (Superfund), available to finance responses taken by the Federal Government.

The Superfund program consists of the following three functions:

- Taking actions in response to releases or threatened releases of hazardous substances, pollutants, or contaminants.
- Requiring responsible parties (any individual(s) or corporation(s) responsible for, or contributing to a hazardous waste site—also referred to as RPs) to take the appropriate response action and overseeing their response.
- Recovering expenditures for response actions taken by the Federal Government.

EPA has authority to take action under CERCLA whenever any of the following occurs:

- A release or substantial threat of release of any hazardous substance.
- A release or a substantial threat of release of any pollutant or contaminant that may present an imminent and substantial danger to the public health or welfare.

Two types of response actions exist: removal and remedial.

- Removal actions generally are short-term cleanups that usually address problems only at the surface of a site. They are conducted in response to an emergency situation, e.g., to avert an explosion or to clean up a hazardous waste spill, or to stabilize a site until a permanent remedy can be found.

- Remedial actions are generally more expensive (an average of $6-$12 million) and of longer duration (an average of 3.5 years) than removal actions. Remedial actions are intended to provide permanent solutions to hazardous substance threats. The EPA can take remedial actions only at hazardous waste sites on the National Priorities List (NPL), which contain the nation's most dangerous sites. Sites are placed on the NPL after being evaluated through the Hazard Ranking System (HRS). The HRS is a model that determines the relative risk to public health and the environment posed by hazardous substances in ground water, surface water, air, and soil.

The EPA often tries to identify the parties that are responsible for the contamination before taking any response action. The following individuals can be considered responsible parties (RPs):

- Past and present owners or operators of the site.
- Generators of hazardous substances found at the site.
- Transporters of hazardous substances to the site.

Once the RPs are identified, the EPA determines whether they are able to undertake the response action. If they are, the EPA can either negotiate a legal agreement requiring the RPs to respond or unilaterally order them to take the response action. If the RPs are either unable to respond or refuse to comply with the Agency's order, the EPA can take the necessary response action itself.

Regardless of who carries out the response, the procedures for doing so are uniform. These procedures are outlined in the National Contingency Plan (NCP). Although CERCLA and RCRA are separate programs (CERCLA addressing problems at facilities no longer operating, RCRA regulating present and future waste management), they overlap in a number of areas. The areas of relationship encompass the following:

- Disposal of Superfund wastes.
- Corrective action.

- Imminent hazards.

Disposal

When wastes from a CERCLA site are taken off-site for treatment, storage, or disposal, the facility to which they are brought must have a RCRA permit to be operating under interim status. Superfund policy further requires that facilities used for treatment or disposal of Superfund waste be inspected by the EPA to ensure that they are in compliance with the appropriate RCRA regulations. In addition to sending waste to facilities that are in compliance with RCRA regulations, any individual moving waste from a Superfund site must adhere to RCRA's generator and transporter requirements.

Wherever applicable, on-site treatment, storage, or disposal of hazardous waste at Superfund sites must meet RCRA technical requirements for the design and operation or the closure of a facility.

Corrective Action

Prior to HSWA, the EPA's only explicit authority for requiring owners or operators of RCRA facilities to conduct extensive cleanups was under CERCLA. Now, RCRA authorizes EPA to require corrective action under an order or as part of a permit whenever there is or has been a release of hazardous waste or constituents into the environment. HSWA provides similar corrective action authority in response to releases at interim status facilities. HSWA further directs the EPA to require corrective action beyond the facility boundary, on a case-by-case basis, pending new regulations to that effect.

The EPA interprets the term "corrective action" to cover the full range of possible actions, from studies and quick-fix measures to full cleanups. Anyone who violates the corrective action order can be fined up to $25,000 per day of noncompliance and runs the risk of having their interim status suspended or revoked.

Imminent Hazard:

Both CERCLA and RCRA contain provisions that allow the EPA to require persons contributing to an imminent hazard to take the necessary actions to clean it up. Under CERCLA, the EPA is given authority, via the courts, to abate an imminent or substantial danger to public health or welfare or the environment that results from an actual or threatened release of a hazardous substance. The authority under RCRA is essentially the same, except that in RCRA's imminent hazard provision, nonhazardous as well as hazardous solid waste releases are addressed. The CERCLA and RCRA imminent hazard provisions may be used in tandem to strengthen the government's case.

SARA

Superfund Amendments and Reauthorization Act of 1986 (Public Law 99-499) which reauthorized and amended CERCLA (as well as certain other Acts), and established a new title pertaining to emergency planning and community "right-to-know."

Selected key factors include the following:

- Sets CERCLA cleanup standards with emphasis on permanent remedies -- particularly in favor of on-site treatment -- even when the remedy selected is untested or unproven in the field.

- Requires on-site remedial actions to meet all Federal and State "Applicable or Relevant and Appropriate Requirements (ARARs)" unless requirements are waived -- thereby closing the earlier gaps between CERCLA and other environmental acts.

- Allows for increased state participation in CERCLA cleanup decisions and in site evaluation/negotiation processes.

- Enables private citizens to file civil suits under CERCLA.

- Amends RCRA regarding underground storage tanks (UST) requiring, among other things, that EPA write financial responsibility requirements for UST owners.

- Applies CERCLA to federal facilities.

- Establishes an $8.5 billion fund to finance CERCLA cleanups and a $500 million UST trust fund to finance UST program activities.

OTHER TERMINOLOGY:

LD_{50} = Lethal dose 50 is the dose of a substance which is fatal to 50 percent of the test animals.

MCL = Maximum contaminant level which (per 40 CFR 141.2(c)) means the maximum permissible level of a contaminant in water which is delivered to the free flowing outlet of the ultimate user of a public water system, except in the case of turbidity where the maximum permissible level is measured at the point of entry to the distribution system. Contaminants added to the water under circumstances controlled by the user, except these resulting from corrosion of piping and plumbing caused by water quality, are excluded from this definition.

MCLG = Maximum contaminant level goal (formerly recommended maximum contaminant level or RMCL) which (per 40 CFR 141.2(u) means the maximum level of a contaminant in drinking water at which no known or anticipated adverse effect on the health of persons would occur, and which includes an adequate margin of safety. [Maximum contaminant level goals] are nonenforceable health goals.

Mineral Spirits = (per the Merch Index, 10th edition, item number 6067) Petroleum spirits. In the U.S.A. same as ligroin; in the U.K. a volatile hydrocarbon mixture having a flash point below 0°C. Mineral spirits are a petroleum distillate product. Petroleum distillates contain no chlorinated solvents.

MPCA = Minnesota Pollution Control Agency. The Minnesota Pollution Control Agency (MPCA) was established in 1967, replacing the Water Pollution Control Commission, established in 1945. The Agency was given all of the powers and duties of the commission, and was also

directed to establish air quality standards and make recommendations on solid waste disposal and land use. In 1969, the legislature increased the Agency's water pollution control authority, more fully described the Agency's air pollution standards and permit authority, and gave it the power to adopt standards and regulations for the collection, transportation, and disposal of solid waste. Over the years, additional responsibilities have been added, such as noise pollution and toxic and hazardous waste regulation.

PCBs (Aroclors) = Polychlorinated biphenyls (trade name under which they were marketed by Monsanto was Aroclor).

The term polychlorinated biphenyls (PCBs) refers to a family of organic chemicals which have been produced and marketed in this country for 45 years as a series of relatively complex mixtures under the trade name Aroclor. Each of these mixtures contains a number of chlorinated biphenyl isomers out of an overall range of chlorine content from one chlorine to ten chlorines per molecule. In general, higher chlorine content corresponds to greater resistance to chemical (and biochemical) degradation.

PCBs are among the stable organic compounds known, and, in addition, they exhibit other properties which render them extremely advantageous for use as dielectric and heat transfer fluids. These properties include low solubility in water, low vapor pressure, low flammability, high heat capacity, low electrical conductivity, favorable dielectric constant, and suitable viscosity-temperature relationships.

The commercial process by which the PCBs are made involves the chlorination of biphenyl with anhydrous chlorine in the presence of a catalyst which may be either iron filings or ferric chloride. The crude product is generally purified to remove color, traces of hydrogen chloride, and the catalysts by treatment with alkali and subsequent distillation. The resulting product is then a more or less complex mixture of the chlorobiphenyls, the precise composition depending on the conditions under which chlorination was carried out.

The products made by Monsanto under the tradename Aroclor are designated as to the starting material, with biphenyl represented by the 12 prefix, and with the approximate chlorine percentage by the second set of digits (i.e., Aroclor 1248 is a chlorinated biphenyl containing approximately 48 percent chlorine).

SMCL = Secondary Maximum Contaminant Level which (per 40 CFR 143.2(f)) means SMCLs which apply to public water systems and which, in the judgement of the [EPA] Administrator, are requisite to protect the public welfare. The SMCL means the maximum permissible level of a contaminant in water which is delivered to the free-flowing outlet of the ultimate user of public water system. Contaminants added to the water under circumstances controlled by

the user, except those resulting from corrosion of piping and plumbing caused by water quality, are excluded from this definition.

Stoddard Solvent = (per the Merch Index, 10th Edition, item number 8676) White spirits. A petroleum distillate. Liquid. Distillation range: Not less than 50 percent at 350°F, dry end point not above 410°F. Flash point 100-110°F. Insol in water. Miscible with abs alcohol, benzene, ether, chloroform, carbon tetrachloride, carbon disulfide, and oils except castor oil.

Use: In dry cleaning, as solvent.

Petroleum distillates contain no chlorinated solvents.

APPENDIX A

CHRONOLOGICAL SUMMARY OF CONSTITUENTS DETECTED IN AT LEAST ONE SAMPLE FROM NIROP WATER CHEMICAL ANALYSES

Chronological Summary of Constituents Detected in at Least One Sample From NIROP Ground Water Chemical Analyses (mg/l)

1254.01

Date	Parameter	1-S	1-D	1-PC	2-S	2-D	2-PC	3-S	3-D	3-PC	4-S	4-D	4-PC	5-S	5-D	6-S	4-D	7-S
Oct 83	1,1,1-Trichloroethane	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010		0.027		
Oct 83	1,1-Dichloroethane	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	0.017	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010		< 0.010		
Oct 83	1,1-Dichloroethene	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010		< 0.010		
Oct-83	Arsenic, Total																	
Oct-83	Benzene	P 0.010	0.022	0.021	P 0.010	P 0.010	< 0.010	P 0.010	P 0.010	0.014	< 0.010	P 0.010	P 0.010	< 0.010		P 0.010		
Oct 83	Bis(2ethylhexyl)Phthalate																	
Oct 83	Cadmium, Total	0.0085	0.0061	0.0024	0.0013	0.0031	0.0014	0.0076	0.0033	0.0013	0.0019	0.0029	0.0014	0.0068		0.0062		
Oct 83	Chloroform	< 0.010	< 0.010	< 0.010	P 0.010	< 0.010	P 0.010	< 0.010	< 0.010	P 0.010	P 0.010	< 0.010	< 0.010	< 0.010		< 0.010		
Oct-83	Chromium, Total	0.037	0.003	0.011	0.057	0.004	0.007	0.020	0.008	0.003	0.013	0.005	0.003	0.013		0.040		
Oct-83	Cis 1,2-Dichloroethene																	
Oct 83	Copper, Total	0.054	0.010	0.004	0.214	0.021	0.012	0.084	0.017	0.011	0.027	0.012	< 0.001	0.040		0.082		
Oct-83	Ethylbenzene	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	0.037	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010		< 0.010		
Oct-83	Lead, Total	0.035	0.035	< 0.001	0.334	0.025	0.003	0.083	0.025	0.001	0.021	0.013	0.002	0.018		0.142		
Oct-83	Manganese, Total	1.99	0.152	0.001	6.58	0.094	0.027	1.78	0.075	0.076	0.416	0.093	0.385	2.74		6.54		
Oct-83	Mercury, Total																	
Oct 83	Methylene Chloride	P 0.010	P 0.010	< 0.010	41.0	0.011	6.0	0.010	0.030	0.011	0.80	< 0.010	P 0.010	< 0.010		< 0.010		
Oct 83	Nickel, Total																	
Oct 83	PCB 1242	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001		< 0.0001		
Oct-83	PCB 1248	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001		< 0.0001		
Oct 83	PCB 1254	< 0.0015	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001		< 0.0001		
Oct 83	PCB 1260	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001		< 0.0001		
Oct-83	Silver, Total	< 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		
Oct-83	Tetrachloroethene	< 0.010	< 0.010	P 0.010	< 0.010	< 0.010	< 0.010	0.017	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010		P 0.010		
Oct-83	TOC	22.8	642.0	51.8	57.0	4.8	15.9	16.1	3.5	6.6	10.1	30.7	2.3	649.0		27.6		
Oct-83	Toluene	P 0.010	0.012	< 0.010	P 0.010	< 0.010	< 0.010	0.010	< 0.010	< 0.010	< 0.010	P 0.010	< 0.010	< 0.010		< 0.010		
Oct-83	Trans 1,2-Dichloroethene	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	0.075	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010		0.041		
Oct-83	Trichloroethene	< 0.010	< 0.010	< 0.010	0.13	< 0.010	0.062	28.0	P 0.010	0.081	P 0.010	< 0.010	< 0.010	< 0.010		1.8		
Oct-83	Zinc, Total	1.12	7.05	< 0.05	3.98	2.91	< 0.05	3.64	3.26	< 0.05	1.69	2.07	< 0.05	0.406		7.37		
Apr-84	1,1,1-Trichloroethane	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010		< 0.010		0.098		
Apr-84	1,1-Dichloroethane	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	0.026	< 0.010	< 0.010	< 0.010	< 0.010		< 0.010		< 0.010		
Apr-84	1,1-Dichloroethene	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010		< 0.010		< 0.010		
Apr-84	Arsenic, Total	0.008	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005		< 0.005		< 0.005		
Apr 84	Benzene	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	0.014	< 0.010	< 0.010		< 0.010		< 0.010		
Apr-84	Bis(2ethylhexyl)Phthalate	0.018	< 0.010	< 0.010	0.084	0.084	0.030	0.14	0.058	0.023	0.018	0.073		0.016		0.22		
Apr 84	Cadmium, Total	0.0016	0.0033	0.0017	0.0041	0.0014	0.0032	0.0010	0.0044	0.0092	0.0021	0.0015		0.0017		0.0017		
Apr-84	Chloroform	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010		< 0.010		< 0.010		
Apr-84	Chromium, Total	0.011	0.004	0.014	0.029	0.005	0.006	0.011	0.025	0.019	0.009	0.008		0.006		0.027		
Apr-84	Cis 1,2-Dichloroethene	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	0.076	< 0.010	< 0.010	< 0.010	< 0.010		< 0.010		0.15		
Apr 84	Copper, Total	0.019	0.056	0.041	0.060	0.029	0.019	0.026	0.053	0.034	0.041	0.056		0.018		0.023		
Apr 84	Ethylbenzene	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	0.029	< 0.010	< 0.010	< 0.010	< 0.010		< 0.010		< 0.010		
Apr-84	Lead, Total	0.014	0.019	0.170	0.018	0.007	0.015	0.010	0.077	0.046	0.019	0.044		0.008		0.022		
Apr-84	Manganese, Total																	
Apr 84	Mercury, Total	< 0.0004	< 0.0004	< 0.0004	< 0.0015	< 0.0004	0.0008	0.0013	< 0.0004	< 0.0004	0.0007	0.0004		< 0.0004		0.0008		
Apr-84	Methylene Chloride	< 0.010	< 0.010	0.022	< 0.010	0.010	0.021	0.064	< 0.010	0.11	< 0.010	0.013		< 0.010		< 0.010		
Apr-84	Nickel, Total	0.024	0.03	0.008	0.107	0.053	0.005	0.022	0.01	0.048	0.017	0.006		0.018		0.048		
Apr-84	PCB 1242	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002		< 0.0002		< 0.0002		
Apr-84	PCB 1248	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	0.0008	< 0.0002	< 0.0002		< 0.0002		< 0.0002		
Apr-84	PCB 1254	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002		< 0.0002		< 0.0002		
Apr-84	PCB 1260	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002		< 0.0002		< 0.0002		
Apr-84	Silver, Total	< 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		
Apr-84	Tetrachloroethene	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	0.013	< 0.010	< 0.010	< 0.010	< 0.010		< 0.010		0.042		
Apr-84	TOC	9.7	2.7	9.9	IS	7.4	3.0	15.2	1.7	3.2	9.1	1.0		13.5		13.2		
Apr-84	Toluene	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010		< 0.010		< 0.010		
Apr-84	Trans 1,2-Dichloroethene	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	0.076	< 0.010	< 0.010	< 0.010	< 0.010		< 0.010		0.15		

< means not detected using detection limit shown; P means present but below detection limit; IS means insufficient sample

21-Apr-87

Chronological Summary of Consitituents Detected in at Least One Sample From NIROP Ground Water Chemical Analyses (mg/l)

1254.01

Date	Parameter	1-S	1-D	1-PC	2-S	2-D	2-PC	3-S	3-D	3-PC	4-S	4-D	4-PC	5-S	5-D	6-S	6-D	7-S
Apr-84	Trichloroethene	< 0.010	< 0.010	< 0.010	0.060	< 0.010	0.014	5.0	0.023	0.081	< 0.010	< 0.010		< 0.010		0.94		
Apr-84	Zinc, Total	0.41	2.45	0.384	0.755	0.972	1.41	0.54	7.60	1.43	1.14	3.13		0.157		1.33		
Oct-84	1,1,1-Trichloroethane	< 0.010	< 0.010	< 0.010	P 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	P 0.010	< 0.010		< 0.010		0.069		
Oct-84	1,1-Dichloroethane	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010		< 0.010		P 0.010		
Oct 84	1,1-Dichloroethene	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010		< 0.010		< 0.010		
Oct 84	Arsenic, Total																	
Oct 84	Benzene	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010		< 0.010		< 0.010		
Oct-84	Bis(2ethylhexyl)Phthalate	0.002	< 0.002	< 0.012	< 0.002	0.003	0.005	0.008	0.004	0.008	0.003	0.004		0.011		0.005		
Oct-84	Cadmium, Total																	
Oct 84	Chloroform	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010		< 0.010		< 0.010		
Oct 84	Chromium, Total																	
Oct-84	Cis 1,2-Dichloroethene	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	0.024	0.084	< 0.010	P 0.010	< 0.010	< 0.010		< 0.010		0.017		
Oct-84	Copper, Total																	
Oct 84	Ethylbenzene	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	P 0.010	< 0.010	< 0.010	< 0.010	< 0.010		< 0.010		< 0.010		
Oct-84	Lead, Total	0.091	0.013	0.090	0.149	0.014	0.029	0.063	0.018	0.035	0.058	0.032		0.017		0.221		
Oct-84	Manganese, Total	3.68	0.095	0.775	1.89	0.368	0.283	2.12	0.100	0.109	0.430	0.231		2.31		2.37		
Oct-84	Mercury, Total																	
Oct-84	Methylene Chloride	< 0.010	0.062	< 0.010	0.029	P 0.010	0.20	0.13	P 0.010	0.012	0.014	0.44		0.029		0.070		
Oct-84	Nickel, Total																	
Oct-84	PCB 1242	0.0005	0.0002	0.0003	< 0.0002	< 0.0002	0.0005	< 0.0002	0.0002	0.0003	0.0002	< 0.0002		0.0004		0.0002		
Oct-84	PCB 1248	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	0.0002	< 0.0002	< 0.0002		< 0.0002		< 0.0002		
Oct-84	PCB 1254	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002		< 0.0002		< 0.0002		
Oct-84	PCB 1260	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0011		< 0.0002		< 0.0002		
Oct 84	Silver, Total																	
Oct-84	Tetrachloroethene	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	P 0.010	< 0.010	< 0.010	< 0.010	< 0.010		< 0.010		0.038		
Oct-84	TOC																	
Oct-84	Toluene	< 0.010	P 0.010	P 0.010	< 0.010	< 0.010	P 0.010	P 0.010	< 0.010	< 0.010	P 0.010	P 0.010		< 0.010		< 0.010		
Oct-84	Trans 1,2-Dichloroethene	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	0.084	< 0.010	< 0.010	< 0.010	< 0.010		< 0.010		0.17		
Oct-84	Trichloroethene	< 0.010	< 0.010	< 0.010	0.061	P 0.010	0.024	1.3	0.013	P 0.010	< 0.010	< 0.010		< 0.010		0.83		
Oct-84	Zinc, Total	1.69	4.75	1.31	3.14	0.469	0.743	3.39	0.959	0.425	6.20	0.995		0.781		26.6		
Jan-85	1,1,1-Trichloroethane	< 0.005	< 0.005	< 0.005	P 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005		< 0.005		< 0.005		
Jan-85	1,1-Dichloroethane	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005		< 0.005		< 0.005		
Jan 85	1,1-Dichloroethene	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005		< 0.005		< 0.005		
Jan-85	Arsenic, Total																	
Jan-85	Benzene	P 0.005	P 0.005	P 0.005	P 0.005	< 0.005	0.023	P 0.005	P 0.005	P 0.005	0.0061	P 0.005		0.0059		0.010		
Jan-85	Bis(2ethylhexyl)Phthalate	<0.00001	<0.00001	0.00007	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001		<0.00001		<0.00001		
Jan-85	Cadmium, Total																	
Jan-85	Chloroform	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005		< 0.005		< 0.005		
Jan-85	Chromium, Total																	
Jan-85	Cis 1,2-Dichloroethene																	
Jan-85	Copper, Total																	
Jan-85	Ethylbenzene	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005		< 0.005		< 0.005		
Jan-85	Lead, Total	0.037	0.043	0.058	0.083	0.030	0.011	0.035	0.024	0.015	0.020	0.018		0.022		0.023		
Jan-85	Manganese, Total	1.76	0.064	0.705	1.40	0.314	0.347	1.72	0.088	0.102	0.323	0.367		3.96		1.46		
Jan-85	Mercury, Total																	
Jan-85	Methylene Chloride	0.30	0.11	P 0.005	P 0.005	0.83	0.012	0.0067	< 0.0005	0.0065	0.065	P 0.0005		0.011		0.026		
Jan-85	Nickel, Total																	
Jan-85	PCB 1242	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002		< 0.0002		< 0.0002		
Jan-85	PCB 1248	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002		< 0.0002		< 0.0002		
Jan-85	PCB 1254	< 0.0002	0.0005	0.0003	0.0011	0.0002	0.0005	0.0007	0.0003	0.0003	0.0004	< 0.0002		0.0002		< 0.0002		
Jan-85	PCB 1260	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002		< 0.0002		< 0.0002		
Jan 85	Silver, Total																	
Jan-85	Tetrachloroethene	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005		< 0.005		< 0.005		
Jan-85	TOC																	

< means not detected using detection limit shown; P means present but below detection limit; IS means insufficient sample

21-Apr-87

Date	Parameter	1-S	1-D	1-PC	2-S	2-D	2-PC	3-S	3-D	3-PC	4-S	4-D	4-PC	5-S	5-D	6-S	6-D	7-S
Jan-85	Toluene	P 0.005	0.0099	0.011	P 0.005	P 0.005	0.020	P 0.005	0.0072	0.014	< 0.005	0.0061		< 0.005		< 0.005		
Jan-85	Trans 1,2-Dichloroethene	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.17	< 0.005	< 0.005	< 0.005	< 0.005		< 0.005		< 0.005		
Jan-85	Trichloroethene	< 0.005	< 0.005	< 0.005	0.060	P 0.005	0.011	0.63	0.017	P 0.005	< 0.005	< 0.005		< 0.005		< 0.005		
Jan-85	Zinc, Total	0.546	9.25	1.02	0.682	4.07	0.273	1.40	2.13	0.686	1.31	1.14		0.654		2.07		
Jun-85	1,1,1-Trichloroethane	< 0.005	< 0.005	< 0.005	0.0058	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.043	< 0.005	< 0.005
Jun-85	1,1-Dichloroethane	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Jun-85	1,1-Dichloroethene	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Jun-85	Arsenic, Total																	
Jun-85	Benzene	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Jun-85	Bis(2ethylhexyl)Phthalate	< 0.005	< 0.005	<0.00001	0.0038	0.0032	<0.00001	0.0036	0.0049	0.0013	0.0047	0.0030	0.0059	0.0026	0.0036	0.00062	0.0030	0.00091
Jun-85	Cadmium, Total																	
Jun-85	Chloroform	0.0014	0.0026	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Jun-85	Chromium, Total																	
Jun-85	Cis 1,2-Dichloroethene																	
Jun-85	Copper, Total																	
Jun-85	Ethylbenzene	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Jun-85	Lead, Total	0.010	0.054	0.018	0.293	0.023	0.039	0.026	0.045	0.011	0.084	0.029	0.026	0.022	0.166	0.294	0.016	0.009
Jun-85	Manganese, Total	1.15	0.065	0.844	6.90	0.516	0.439	3.16	0.081	0.139	1.81	0.093	0.424	4.09	0.312	4.28	0.361	27.50
Jun-85	Mercury, Total																	
Jun-85	Methylene Chloride	< 0.005	< 0.005	0.16	0.0057	< 0.005	< 0.005	0.025	< 0.005	< 0.005	< 0.005	< 0.005	0.019	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Jun-85	Nickel, Total																	
Jun-85	PCB 1242	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Jun-85	PCB 1248	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Jun-85	PCB 1254	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Jun-85	PCB 1260	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Jun-85	Silver, Total																	
Jun-85	Tetrachloroethene	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.045	< 0.005	< 0.005
Jun-85	TOC																	
Jun-85	Toluene	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.0065	< 0.005	< 0.005	0.014	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Jun-85	Trans 1,2-Dichloroethene	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.097	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.093	< 0.005	< 0.005
Jun-85	Trichloroethene	< 0.005	< 0.005	< 0.005	0.069	0.005	0.0087	0.62	0.014	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.62	0.006	0.15
Jun-85	Zinc, Total	0.256	2.54	0.234	3.57	1.17	0.143	1.37	4.58	0.136	3.73	0.462	1.34	0.419	6.02	3.43	2.30	1.16
Jan-86	1,1,1-Trichloroethane																	0.0065
Jan-86	1,1-Dichloroethane																	< 0.005
Jan-86	1,1-Dichloroethene																	< 0.005
Jan-86	Arsenic, Total																	
Jan-86	Benzene																	< 0.005
Jan-86	Bis(2ethylhexyl)Phthalate																	
Jan-86	Cadmium, Total																	
Jan-86	Chloroform																	< 0.005
Jan-86	Chromium, Total																	
Jan-86	Cis 1,2-Dichloroethene																	
Jan-86	Copper, Total																	
Jan-86	Ethylbenzene																	< 0.005
Jan-86	Lead, Total																	0.107
Jan-86	Manganese, Total																	9.30
Jan-86	Mercury, Total																	
Jan-86	Methylene Chloride																	< 0.005
Jan-86	Nickel, Total																	
Jan-86	PCB 1242																	< 0.0002
Jan-86	PCB 1248																	< 0.0002
Jan-86	PCB 1254																	< 0.0002
Jan-86	PCB 1260																	< 0.0002
Jan-86	Silver, Total																	

< means not detected using detection limit shown; P means present but below detection limit; IS means insufficient sample

Date	Parameter	1-S	1-D	1-PC	2-S	2-D	2-PC	3-S	3-D	3-PC	4-S	4-D	4-PC	5-S	5-D	6-S	6-D	7-S
Jan-86	Tetrachloroethene																	< 0.005
Jan-86	TOC																	
Jan-86	Toluene																	< 0.005
Jan-86	Trans 1,2-Dichloroethene																	< 0.005
Jan-86	Trichloroethene																	0.134
Jan-86	Zinc, Total																	3.25
Apr-86	1,1,1-Trichloroethane													< 0.005		< 0.005		
Apr-86	1,1 Dichloroethane													< 0.005		< 0.005		
Apr-86	1,1-Dichloroethene													< 0.005		< 0.005		
Apr-86	Arsenic, Total																	
Apr-86	Benzene													< 0.005		< 0.005		
Apr-86	Bis(2ethylhexyl)Phthalate																	
Apr-86	Cadmium, Total																	
Apr-86	Chloroform													< 0.005		< 0.005		
Apr-86	Chromium, Total																	
Apr-86	Cis 1,2-Dichloroethene																	
Apr-86	Copper, Total																	
Apr-86	Ethylbenzene													< 0.005		< 0.005		
Apr-86	Lead, Total													0.061		0.133		
Apr-86	Manganese, Total													0.138		0.503		
Apr-86	Mercury, Total																	
Apr-86	Methylene Chloride													< 0.005		< 0.005		
Apr-86	Nickel, Total																	
Apr-86	PCB 1242													< 0.0002		< 0.0002		
Apr-86	PCB 1248													< 0.0002		< 0.0002		
Apr-86	PCB 1254													< 0.0002		< 0.0002		
Apr-86	PCB 1260													< 0.0002		< 0.0002		
Apr-86	Silver, Total																	
Apr-86	Tetrachloroethene													< 0.005		< 0.005		
Apr-86	TOC																	
Apr-86	Toluene													< 0.005		< 0.005		
Apr-86	Trans 1,2-Dichloroethene													< 0.005		< 0.005		
Apr-86	Trichloroethene													< 0.005		0.0067		
Apr-86	Zinc, Total													4.02		5.57		
Nov-86	1,1,1-Trichloroethane	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.13	< 0.005	0.0051	
Nov-86	1,1-Dichloroethane	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.019	< 0.005	< 0.005	
Nov-86	1,1-Dichloroethene	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	
Nov-86	2-Butanone	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	
Nov-86	Alkalinity	333	231	234	369	268	8.5	481	302	239	242	258	233	497	383	456	260	533
Nov-86	Arsenic, Diss.	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	
Nov-86	Arsenic, Total							< 0.005										
Nov-86	Barium, Diss	0.080	0.040	0.119	0.105	0.075	0.051	0.165	0.074	0.034	0.058	0.099	0.093	0.061	0.080	0.077	0.092	0.060
Nov-86	Barium, Total							0.088										
Nov-86	Benzene	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Nov-86	Bis(2ethylhexyl)Phthalate																	
Nov-86	Cadmium, Diss.	< 0.0001	0.0004	0.0008	0.0006	< 0.0001	0.0005	0.0003	0.0004	0.0005	0.0006	0.0002	0.0005	0.0009	< 0.0001	0.0004	< 0.0001	0.0008
Nov-86	Cadmium, Total							0.0014										
Nov-86	Calcium, Diss.	101	86.0	81.5	169	110	21.1	157	115	110	64.9	99.3	90.4	186	117	145	102	216
Nov-86	Calcium, Total							169										
Nov-86	Chloride	19.5	30.9	58.4	4.5	41.7	59.7	4.8	22.6	31.7	4.2	72.6	75.6	50.0	3.2	32.7	72.5	18.7
Nov-86	Chloroform	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Nov-86	Chromium, Diss.	0.005	0.002	0.002	0.003	0.001	0.002	0.003	0.001	0.002	0.002	0.001	< 0.001	0.002	0.002	< 0.001	< 0.001	0.002
Nov-86	Chromium, Total							0.009										
Nov-86	Cis 1,2-Dichloroethene	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.29	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.58	< 0.005	< 0.005

< means not detected using detection limit shown; P means present but below detection limit; IS means insufficient sample

Date	Parameter	1-S	1-D	1-PC	2-S	2-D	2-PC	3-S	3-D	3-PC	4-S	4-D	4-PC	5-S	5-D	6-S	6-D	7-S
Nov-86	Copper, Diss.	0.004	< 0.001	0.005	0.008	< 0.001	0.003	0.003	0.006	0.003	0.009	< 0.001	0.002	0.004	< 0.001	< 0.001	0.009	0.003
Nov-86	Copper, Total							0.024										
Nov-86	Ethylbenzene	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Nov-86	Lead, Diss.	< 0.001	< 0.001	0.002	0.001	< 0.001	0.003	0.002	< 0.001	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.002	0.003	0.002
Nov-86	Lead, Total							0.171										
Nov-86	Magnesium, Diss.	20.2	38.8	45.0	39.6	51.6	10.7	30.1	43.5	54.9	21.5	48.4	45.9	43.5	61.4	39.4	47.6	27.3
Nov-86	Manganese, Diss.	1.07	0.090	0.046	0.198	0.392	0.002	1.04	0.076	0.052	0.005	0.362	0.210	0.593	0.100	0.564	0.330	1.01
Nov-86	Manganese, Total							1.56										
Nov-86	Mercury, Diss.	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004
Nov 86	Mercury, Total							< 0.0004										
Nov-86	Methylene Chloride	0.013	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Nov-86	Nickel, Diss.	0.009	0.003	< 0.001	0.005	0.002	0.007	< 0.001	0.004	< 0.001	0.009	< 0.001	0.014	0.012	< 0.001	0.025	0.043	0.072
Nov 86	Nickel, Total							0.018										
Nov-86	Nitrate-Nitrogen			0.209	1.37		0.160	1.17		0.060	6.56		0.106	2.66			0.036	3.29
Nov-86	PCB 1242																	
Nov-86	PCB 1248																	
Nov-86	PCB 1254																	
Nov-86	PCB 1260																	
Nov-86	Potassium, Diss.	3.92	2.20	3.28	3.69	2.67	36.8	3.85	2.20	7.62	2.79	2.43	3.52	4.67	2.74	4.00	2.34	2.83
Nov-86	Selenium, Diss.	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Nov-86	Selenium, Total							< 0.005										
Nov-86	Silver, Diss.	0.005	0.003	0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.003	< 0.001	< 0.001	< 0.001
Nov-86	Silver, Total							0.001										
Nov-86	Sodium, Diss.	14.3	5.85	12.9	5.99	6.06	34.0	7.83	4.81	5.68	11.5	13.5	10.2	18.0	3.57	26.0	15.0	6.77
Nov-86	Sulfates	77.5	129	96.0	56.3	184	130	97.0	203	304	45.2	148	85.9	192	184	172	176	148
Nov-86	Tetrachlorethene	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.20	< 0.005	< 0.005
Nov-86	TOC																	
Nov-86	Toluene	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Nov-86	Trans 1,2-Dichloroethene	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.29	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.58	< 0.005	< 0.005
Nov-86	Trichloroethene	< 0.005	< 0.005	< 0.005	0.065	0.0092	0.0053	0.88	0.012	< 0.005	0.019	< 0.005	< 0.005	< 0.005	< 0.005	3.8	0.011	0.13
Nov-86	Trichlorofluoromethane	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.0077	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Nov-86	Zinc, Diss.	0.133	1.25	0.068	0.851	0.660	< 0.030	0.131	0.842	0.357	0.634	0.492	0.086	0.601	0.687	0.909	0.823	1.05
Nov-86	Zinc, Total							1.52										

Date	Parameter	7-D	8-S	8-D	9-S	9-D	10-S	11-S	12-S	13-S	14-S	15-S	16-S	17-S	18-S	19-S	20-S	FMC-33
Oct-83	1,1,1-Trichloroethane																	< 0.010
Oct 83	1,1-Dichloroethane																	0.027
Oct-83	1,1-Dichloroethene																	< 0.010
Oct 83	Arsenic, Total																	
Oct 83	Benzene																	0.010
Oct-83	Bis(2ethylhexyl)Phthalate																	
Oct-83	Cadmium, Total																	0.0013
Oct-83	Chloroform																	< 0.010
Oct 83	Chromium, Total																	0.003
Oct-83	Cis 1,2-Dichloroethene																	
Oct-83	Copper, Total																	0.008
Oct-83	Ethylbenzene																	0.21
Oct-83	Lead, Total																	0.014
Oct-83	Manganese, Total																	0.957
Oct 83	Mercury, Total																	
Oct-83	Methylene Chloride																	< 0.010
Oct-83	Nickel, Total																	
Oct-83	PCB 1242																	< 0.0001
Oct 83	PCB 1248																	< 0.0001
Oct-83	PCB 1254																	< 0.0001
Oct-83	PCB 1260																	< 0.0001
Oct 83	Silver, Total																	< 0.050
Oct 83	Tetrachloroethene																	0.024
Oct 83	TOC																	3.6
Oct-83	Toluene																	< 0.010
Oct-83	Trans 1,2-Dichloroethene																	0.12
Oct-83	Trichloroethene																	37.0
Oct-83	Zinc, Total																	4.09
Apr-84	1,1,1-Trichloroethane																	< 0.010
Apr-84	1,1-Dichloroethane																	0.011
Apr 84	1,1-Dichloroethene																	< 0.010
Apr 84	Arsenic, Total																	< 0.005
Apr-84	Benzene																	< 0.010
Apr-84	Bis(2ethylhexyl)Phthalate																	0.079
Apr-84	Cadmium, Total																	0.0051
Apr 84	Chloroform																	< 0.010
Apr-84	Chromium, Total																	0.004
Apr-84	Cis 1,2-Dichloroethene																	0.096
Apr-84	Copper, Total																	0.032
Apr 84	Ethylbenzene																	0.063
Apr-84	Lead, Total																	0.057
Apr-84	Manganese, Total																	
Apr 84	Mercury, Total																	0.0012
Apr-84	Methylene Chloride																	< 0.010
Apr-84	Nickel, Total																	0.003
Apr 84	PCB 1242																	< 0.0002
Apr-84	PCB 1248																	< 0.0002
Apr-84	PCB 1254																	< 0.0002
Apr-84	PCB 1260																	< 0.0002
Apr-84	Silver, Total																	< 0.001
Apr-84	Tetrachloroethene																	< 0.010
Apr-84	TOC																	4.5
Apr 84	Toluene																	< 0.010
Apr-84	Trans 1,2-Dichloroethene																	0.096

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Date	Parameter	7-D	8-S	8-D	9-S	9-D	10-S	11-S	12-S	13-S	14-S	15-S	16-S	17-S	18-S	19-S	20-S	FMC-33
Apr-84	Trichloroethene																	2.9
Apr-84	Zinc, Total																	2.95
Oct-84	1,1,1-Trichloroethane																	< 0.010
Oct-84	1,1-Dichloroethane																	P 0.010
Oct-84	1,1-Dichloroethene																	< 0.010
Oct-84	Arsenic, Total																	
Oct-84	Benzene																	< 0.010
Oct-84	Bis(2ethylhexyl)Phthalate																	0.013
Oct-84	Cadmium, Total																	
Oct-84	Chloroform																	< 0.010
Oct-84	Chromium, Total																	
Oct-84	Cis 1,2-Dichloroethene																	0.23
Oct-84	Copper, Total																	
Oct 84	Ethylbenzene																	0.099
Oct-84	Lead, Total																	0.030
Oct 84	Manganese, Total																	0.414
Oct-84	Mercury, Total																	
Oct-84	Methylene Chloride																	0.12
Oct-84	Nickel, Total																	
Oct-84	PCB 1242																	< 0.0002
Oct-84	PCB 1248																	< 0.0002
Oct-84	PCB 1254																	< 0.0002
Oct 84	PCB 1260																	< 0.0002
Oct 84	Silver, Total																	
Oct 84	Tetrachloroethene																	< 0.010
Oct-84	TOC																	
Oct-84	Toluene																	P 0.010
Oct-84	Trans 1,2-Dichloroethene																	0.23
Oct-84	Trichloroethene																	1.6
Oct-84	Zinc, Total																	1.56
Jan-85	1,1,1-Trichloroethane																	< 0.005
Jan-85	1,1-Dichloroethane																	0.011
Jan-85	1,1-Dichloroethene																	< 0.005
Jan-85	Arsenic, Total																	
Jan-85	Benzene																	0.0069
Jan-85	Bis(2ethylhexyl)Phthalate																	<0.00001
Jan-85	Cadmium, Total																	
Jan-85	Chloroform																	< 0.005
Jan-85	Chromium, Total																	
Jan-85	Cis 1,2-Dichloroethene																	
Jan-85	Copper, Total																	
Jan-85	Ethylbenzene																	< 0.005
Jan-85	Lead, Total																	0.021
Jan 85	Manganese, Total																	0.539
Jan-85	Mercury, Total																	
Jan-85	Methylene Chloride																	0.038
Jan-85	Nickel, Total																	
Jan 85	PCB 1242																	< 0.0002
Jan 85	PCB 1248																	< 0.0002
Jan 85	PCB 1254																	< 0.0002
Jan 85	PCB 1260																	< 0.0002
Jan 85	Silver, Total																	
Jan-85	Tetrachloroethene																	P 0.005
Jan-85	TOC																	

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Date	Parameter	7-D	8-S	8-D	9-S	9-D	10-S	11-S	12-S	13-S	14-S	15-S	16-S	17-S	18-S	19-S	20-S	FMC-33
Jan 85	Toluene																	< 0.005
Jan-85	Trans 1,2-Dichloroethene																	0.10
Jan-85	Trichloroethene																	2.1
Jan 85	Zinc, Total																	0.919
Jan 85	1,1,1-Trichloroethane		0.039		0.39		< 0.005	< 0.005										< 0.005
Jun-85	1,1-Dichloroethane		< 0.005		0.066		< 0.005	< 0.005										0.0063
Jun-85	1,1-Dichloroethene		< 0.005		0.0092		< 0.005	< 0.005										< 0.005
Jun-85	Arsenic, Total																	
Jun-85	Benzene		< 0.005		< 0.005		< 0.005	< 0.005										< 0.005
Jun-85	Bis(2ethylhexyl)Phthalate		<0.00001		<0.00001		0.00033	0.00080										<0.00001
Jun-85	Cadmium, Total																	
Jun 85	Chloroform		< 0.005		< 0.005		< 0.005	< 0.005										< 0.005
Jun-85	Chromium, Total																	
Jun-85	Cis 1,2-Dichloroethene																	
Jun-85	Copper, Total																	
Jun-85	Ethylbenzene		< 0.005		< 0.005		< 0.005	< 0.005										0.016
Jun 85	Lead, Total		0.154		0.054		0.109	0.063										0.010
Jun-85	Manganese, Total		11.8		2.07		8.74	5.00										0.84
Jun-85	Mercury, Total																	
Jun-85	Methylene Chloride		< 0.005		< 0.005		< 0.005	< 0.005										0.016
Jun 85	Nickel, Total																	
Jun-85	PCB 1242		< 0.0002		< 0.0002		< 0.0002	< 0.0002										< 0.0002
Jun-85	PCB 1248		< 0.0002		< 0.0002		< 0.0002	< 0.0002										< 0.0002
Jun-85	PCB 1254		< 0.0002		< 0.0002		< 0.0002	< 0.0002										< 0.0002
Jun 85	PCB 1260		< 0.0002		< 0.0002		< 0.0002	< 0.0002										< 0.0002
Jun-85	Silver, Total																	
Jun-85	Tetrachloroethene		0.046		0.22		< 0.005	< 0.005										0.0053
Jun-85	TOC																	
Jun-85	Toluene		< 0.005		< 0.005		< 0.005	< 0.005										< 0.005
Jun-85	Trans 1,2-Dichloroethene		0.19		0.50		0.015	0.036										0.11
Jun-85	Trichloroethene		4.0		3.2		0.15	0.035										2.6
Jun-85	Zinc, Total		1.81		1.10		1.38	1.47										0.730
Jan-86	1,1,1-Trichloroethane				0.29		< 0.005	< 0.005										
Jan-86	1,1-Dichloroethane				0.061		< 0.005	< 0.005										
Jan-86	1,1-Dichloroethene				0.0056		< 0.005	< 0.005										
Jan-86	Arsenic, Total																	
Jan-86	Benzene				< 0.005		< 0.005	< 0.005										
Jan-86	Bis(2ethylhexyl)Phthalate																	
Jan-86	Cadmium, Total																	
Jan-86	Chloroform				< 0.005		< 0.005	< 0.005										
Jan-86	Chromium, Total																	
Jan 86	Cis 1,2-Dichloroethene																	
Jan 86	Copper, Total																	
Jan-86	Ethylbenzene				< 0.005		< 0.005	< 0.005										
Jan-86	Lead, Total				0.035		0.040	0.030										
Jan-86	Manganese, Total				1.30		9.59	2.23										
Jan-86	Mercury, Total																	
Jan-86	Methylene Chloride				< 0.005		< 0.005	< 0.005										
Jan 86	Nickel, Total																	
Jan-86	PCB 1242				< 0.0002		< 0.0002	< 0.0002										
Jan-86	PCB 1248				< 0.0002		< 0.0002	< 0.0002										
Jan-86	PCB 1254				< 0.0002		< 0.0002	< 0.0002										
Jan-86	PCB 1260				< 0.0002		< 0.0002	< 0.0002										
Jan-86	Silver, Total																	

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Date	Parameter	7-D	8-S	8-D	9-S	9-D	10-S	11-S	12-S	13-S	14-S	15-S	16-S	17-S	18-S	19-S	20-S	FMC-33
Jan-86	Tetrachloroethene				0.21		< 0.005	< 0.005										
Jan-86	TOC																	
Jan-86	Toluene				< 0.005		< 0.005	< 0.005										
Jan-86	Trans 1,2-Dichloroethene				0.51		0.012	0.034										
Jan-86	Trichloroethene				4.2		0.134	0.044										
Jan-86	Zinc, Total				1.05		29.8	1.01										
Apr-86	1,1,1-Trichloroethane	< 0.005		< 0.005		< 0.005			< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	
Apr-86	1,1-Dichloroethane	< 0.005		< 0.005		< 0.005			< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	
Apr-86	1,1 Dichloroethene	< 0.005		< 0.005		< 0.005			< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	
Apr-86	Arsenic, Total																	
Apr-86	Benzene	< 0.005		0.0052		0.005			< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	
Apr-86	Bis(2ethylhexyl)Phthalate																	
Apr-86	Cadmium, Total																	
Apr-86	Chloroform	< 0.005		< 0.005		< 0.005			< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	
Apr-86	Chromium, Total																	
Apr-86	Cis 1,2-Dichloroethene																	
Apr-86	Copper, Total																	
Apr-86	Ethylbenzene	< 0.005		< 0.005		< 0.005			< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	
Apr-86	Lead, Total	0.034		0.112		0.061			0.366	0.033	0.101	0.054	0.073	0.060	0.120	0.097	0.152	
Apr-86	Manganese, Total	0.695		0.883		0.523			10.7	1.89	0.532	2.12	1.64	1.46	1.38	0.622	1.71	
Apr-86	Mercury, Total																	
Apr-86	Methylene Chloride	< 0.005		< 0.005		< 0.005			< 0.005	< 0.005	< 0.005	0.0056	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	
Apr-86	Nickel, Total																	
Apr-86	PCB 1242	< 0.0002		< 0.0002		< 0.0002			< 0.0002	Broken	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	
Apr-86	PCB 1248	< 0.0002		< 0.0002		< 0.0002			< 0.0002	Broken	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	
Apr-86	PCB 1254	< 0.0002		< 0.0002		< 0.0002			< 0.0002	Broken	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	
Apr-86	PCB 1260	< 0.0002		< 0.0002		< 0.0002			< 0.0002	Broken	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	
Apr-86	Silver, Total																	
Apr-86	Tetrachloroethene	< 0.005		< 0.005		< 0.005			< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	
Apr-86	TOC																	
Apr-86	Toluene	< 0.005		< 0.005		0.0082			< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	
Apr-86	Trans 1,2-Dichloroethene	< 0.005		0.039		0.013			< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.044	4.7	< 0.005	< 0.005	
Apr-86	Trichloroethene	< 0.005		5.7		0.25			< 0.005	< 0.005	< 0.005	0.017	0.096	0.19	2.9	0.042	< 0.005	
Apr-86	Zinc, Total	10.4		14.90		4.43			6.11	6.13	17.6	17.5	6.11	4.56	9.08	3.21	4.25	
Nov-86	1,1,1-Trichloroethane	< 0.005	0.018	< 0.005	0.12	0.0086	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Nov-86	1,1-Dichloroethane	< 0.005	0.0073	< 0.005	0.035	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.0073
Nov-86	1,1-Dichloroethene	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Nov-86	2-Butanone	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Nov-86	Alkalinity	303	469	267	436	362	493	426	417	374	383	477	395	458	302	264	190	504
Nov-86	Arsenic, Diss.	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.014	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Nov-86	Arsenic, Total				0.023							0.045						
Nov-86	Barium, Diss	0.111	0.072	0.090	0.109	0.061	0.079	0.106	0.064	0.093	0.093	0.136	0.068	0.050	0.095	0.032	0.055	0.128
Nov-86	Barium, Total				0.986							0.172						
Nov-86	Benzene	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.0065	< 0.005	< 0.005	< 0.005	< 0.005
Nov-86	Bis(2ethylhexyl)Phthalate																	
Nov-86	Cadmium, Diss.	0.0002	0.0009	0.0003	0.0006	0.0007	0.0006	< 0.0001	0.0010	0.0011	0.0021	0.0008	0.0010	0.0006	0.0005	0.0024	0.0009	0.0004
Nov-86	Cadmium, Total				0.0034							0.0194						
Nov-86	Calcium, Diss.	113	134	113	133	122	143	158	126	154	190	159	108	170	157	66.0	66.0	208
Nov-86	Calcium, Total				154							207						
Nov-86	Chloride	36.0	5.9	47.7	15.2	42.9	36.6	23.2	45.7	13.7	58.8	15.0	4.6	25.6	26.6	54.6	15.3	12.9
Nov-86	Chloroform	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Nov-86	Chromium, Diss.	0.002	0.002	0.002	0.003	0.002	0.003	0.001	< 0.001	< 0.001	< 0.001	0.002	0.001	0.003	0.002	0.002	0.001	0.001
Nov-86	Chromium, Total				0.267							0.011						
Nov-86	Cis 1,2-Dichloroethene	< 0.005	0.24	0.048	0.34	0.028	0.036	0.022	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.027	0.33	< 0.005	< 0.005	0.11

< means not detected using detection limit shown; P means present but below detection limit; IS means insufficient sample

Date	Parameter	7-D	8-S	8-D	9-S	9-D	10-S	11-S	12-S	13-S	14-S	15-S	16-S	17-S	18-S	19-S	20-S	FMC-33
Nov 86	Copper, Diss.	0.004	0.003	0.002	0.005	0.002	0.005	0.002	0.002	0.006	0.002	0.002	0.004	0.003	0.003	0.004	0.004	0.002
Nov 86	Copper, Total				0.377							0.089						
Nov 86	Ethylbenzene	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Nov 86	Lead, Diss.	0.002	< 0.001	0.002	0.003	0.011	0.005	0.001	0.001	0.005	0.004	0.003	0.003	0.005	0.004	0.009	0.004	0.003
Nov 86	Lead, Total				0.174							0.174						
Nov 86	Magnesium, Diss.	52.4	33.0	54.9	33.0	49.2	50.8	58.1	33.8	36.9	33.8	53.4	29.0	54.9	54.1	18.0	17.2	53.4
Nov 86	Manganese, Diss.	0.403	1.94	0.700	0.026	0.142	1.58	0.003	1.20	1.50	0.876	1.96	1.04	0.388	0.920	0.034	0.088	1.00
Nov 86	Manganese, Total				2.54							2.46						
Nov 86	Mercury, Diss.	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004
Nov 86	Mercury, Total				< 0.0004							< 0.0004						
Nov 86	Methylene Chloride	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Nov 86	Nickel, Diss.	< 0.001	0.054	< 0.001	< 0.001	0.001	0.032	0.004	0.006	0.013	0.037	< 0.001	0.005	0.003	< 0.001	< 0.001	0.004	< 0.001
Nov 86	Nickel, Total				0.332							0.039						
Nov 86	Nitrate-Nitrogen	0.031	1.69	0.022	3.92	0.221	0.205	0.803	6.05	2.09	17.0	0.028	0.110	2.02	0.016	2.74	0.434	0.020
Nov 86	PCB 1242																	
Nov 86	PCB 1248																	
Nov 86	PCB 1254																	
Nov 86	PCB 1260																	
Nov 86	Potassium, Diss.	4.75	3.74	4.51	5.49	3.52	3.67	3.97	3.67	3.06	1.92	4.92	3.28	3.85	2.87	2.22	2.22	3.36
Nov 86	Selenium, Diss.	< 0.005	< 0.005	< 0.005	0.049	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.008	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Nov 86	Selenium, Total				0.076							< 0.005						
Nov 86	Silver, Diss.	< 0.001	0.002	< 0.001	< 0.001	0.002	< 0.001	< 0.001	0.001	< 0.001	< 0.001	< 0.001	0.003	< 0.001	0.002	0.002	< 0.001	< 0.001
Nov 86	Silver, Total				0.001							< 0.001						
Nov 86	Sodium, Diss.	9.36	6.89	11.0	28.2	19.5	16.5	7.44	17.1	6.50	5.77	10.6	4.14	16.8	8.18	41.1	9.45	7.19
Nov 86	Sulfates	251	183	272	91.7	189	224	363	56.4	218	164	318	59.5	333	422	26.8	72.4	321
Nov 86	Tetrachloroethene	< 0.005	0.046	< 0.005	0.12	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Nov 86	TOC																	
Nov 86	Toluene	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Nov 86	Trans 1,2-Dichloroethene	< 0.005	0.24	0.048	0.34	0.028	0.036	0.022	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.027	0.33	< 0.005	0.005	0.11
Nov 86	Trichloroethene	< 0.005	9.2	10.7	1.8	0.65	0.21	0.032	< 0.005	< 0.005	< 0.005	0.0071	0.17	0.097	1.53	0.088	< 0.005	1.3
Nov 86	Trichlorofluoromethane	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Nov 86	Zinc, Diss.	1.23	4.42	1.03	0.184	1.07	0.735	0.246	3.81	3.03	3.25	1.84	2.87	2.21	4.71	3.78	3.10	0.526
Nov 86	Zinc, Total				3.15							25.4						

< means not detected using detection limit shown; P means present but below detection limit; IS means insufficient sample

Date	Parameter	Blank	RinBlk1	RinBlk2	TrpBlk1	Trp Blk2	TrpBlk3	TrpBlk4	Dupl 1	Dupl 2	Dupl 3
Oct 83	1,1,1-Trichloroethane										
Oct-83	1,1 Dichloroethane										
Oct-83	1,1-Dichloroethene										
Oct-83	Arsenic, Total										
Oct-83	Benzene										
Oct-83	Bis(2ethylhexyl)Phthalate										
Oct-83	Cadmium, Total										
Oct-83	Chloroform										
Oct-83	Chromium, Total										
Oct-83	Cis 1,2-Dichloroethene										
Oct 83	Copper, Total										
Oct-83	Ethylbenzene										
Oct-83	Lead, Total										
Oct-83	Manganese, Total										
Oct 83	Mercury, Total										
Oct 83	Methylene Chloride										
Oct-83	Nickel, Total										
Oct-83	PCB 1242										
Oct 83	PCB 1248										
Oct-83	PCB 1254										
Oct-83	PCB 1260										
Oct-83	Silver, Total										
Oct-83	Tetrachlorethene										
Oct-83	TOC										
Oct-83	Toluene										
Oct-83	Trans 1,2-Dichloroethene										
Oct-83	Trichloroethene										
Oct 83	Zinc, Total										
Apr 84	1,1,1-Trichloroethane										
Apr-84	1,1-Dichloroethane										
Apr-84	1,1-Dichloroethene										
Apr 84	Arsenic, Total										
Apr-84	Benzene										
Apr-84	Bis(2ethylhexyl)Phthalate										
Apr-84	Cadmium, Total										
Apr-84	Chloroform										
Apr-84	Chromium, Total										
Apr-84	Cis 1,2-Dichloroethene										
Apr-84	Copper, Total										
Apr 84	Ethylbenzene										
Apr-84	Lead, Total										
Apr-84	Manganese, Total										
Apr-84	Mercury, Total										
Apr-84	Methylene Chloride										
Apr-84	Nickel, Total										
Apr-84	PCB 1242										
Apr-84	PCB 1248										
Apr 84	PCB 1254										
Apr-84	PCB 1260										
Apr-84	Silver, Total										
Apr-84	Tetrachlorethene										
Apr-84	TOC										
Apr-84	Toluene										
Apr-84	Trans 1,2-Dichloroethene										

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Date	Parameter	Blank	RinBlk1	RinBlk2	TrpBlk1	Trp Blk2	TrpBlk3	TrpBlk4	Dupl 1	Dupl 2	Dupl 3
Apr-84	Trichloroethene										
Apr 84	Zinc, Total										
Oct-84	1,1,1 Trichloroethane	< 0.010									
Oct 84	1,1-Dichloroethane	< 0.010									
Oct-84	1,1-Dichloroethene	< 0.010									
Oct-84	Arsenic, Total										
Oct-84	Benzene	< 0.010									
Oct-84	Bis(2ethylhexyl)Phthalate										
Oct 84	Cadmium, Total										
Oct 84	Chloroform	< 0.010									
Oct-84	Chromium, Total										
Oct-84	Cis 1,2-Dichloroethene	< 0.010									
Oct 84	Copper, Total										
Oct 84	Ethylbenzene	< 0.010									
Oct-84	Lead, Total										
Oct-84	Manganese, Total										
Oct-84	Mercury, Total										
Oct-84	Methylene Chloride	P 0.010									
Oct 84	Nickel, Total										
Oct-84	PCB 1242										
Oct-84	PCB 1248										
Oct 84	PCB 1254										
Oct-84	PCB 1260										
Oct 84	Silver, Total										
Oct-84	Tetrachloroethene	< 0.010									
Oct-84	TOC										
Oct-84	Toluene	< 0.010									
Oct-84	Trans 1,2-Dichloroethene	< 0.010									
Oct-84	Trichloroethene	< 0.010									
Oct 84	Zinc, Total										
Jan-85	1,1,1-Trichloroethane	< 0.005									
Jan-85	1,1-Dichloroethane	< 0.005									
Jan-85	1,1-Dichloroethene	< 0.005									
Jan-85	Arsenic, Total										
Jan-85	Benzene	< 0.005									
Jan-85	Bis(2ethylhexyl)Phthalate										
Jan-85	Cadmium, Total										
Jan 85	Chloroform	< 0.005									
Jan-85	Chromium, Total										
Jan-85	Cis 1,2-Dichloroethene										
Jan-85	Copper, Total										
Jan 85	Ethylbenzene	< 0.005									
Jan-85	Lead, Total										
Jan-85	Manganese, Total										
Jan-85	Mercury, Total										
Jan-85	Methylene Chloride	P 0.005									
Jan-85	Nickel, Total										
Jan-85	PCB 1242										
Jan 85	PCB 1248										
Jan 85	PCB 1254										
Jan-85	PCB 1260										
Jan-85	Silver, Total										
Jan-85	Tetrachloroethene	< 0.005									
Jan-85	TOC										

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Date	Parameter	Blank	RinBlk1	RinBlk2	TrpBlk1	Trp Blk21	TrpBlk3	TrpBlk4	Dupl 1	Dupl 2	Dupl 3
Jan-85	Toluene	< 0.005									
Jan 85	Trans 1,2-Dichloroethene	< 0.005									
Jan-85	Trichloroethene	< 0.005									
Jan-85	Zinc, Total										
Jun-85	1,1,1-Trichloroethane										
Jun-85	1,1-Dichloroethane										
Jun-85	1,1-Dichloroethene										
Jun-85	Arsenic, Total										
Jun 85	Benzene										
Jun-85	Bis(2ethylhexyl)Phthalate										
Jun-85	Cadmium, Total										
Jun 85	Chloroform										
Jun-85	Chromium, Total										
Jun-85	Cis 1,2-Dichloroethene										
Jun-85	Copper, Total										
Jun-85	Ethylbenzene										
Jun-85	Lead, Total										
Jun-85	Manganese, Total										
Jun-85	Mercury, Total										
Jun-85	Methylene Chloride										
Jun-85	Nickel, Total										
Jun-85	PCB 1242										
Jun-85	PCB 1248										
Jun 85	PCB 1254										
Jun-85	PCB 1260										
Jun-85	Silver, Total										
Jun 85	Tetrachloroethene										
Jun-85	TOC										
Jun-85	Toluene										
Jun-85	Trans 1,2-Dichloroethene										
Jun-85	Trichloroethene										
Jun-85	Zinc, Total										
Jan 86	1,1,1-Trichloroethane										
Jan 86	1,1-Dichloroethane										
Jan-86	1,1-Dichloroethene										
Jan-86	Arsenic, Total										
Jan-86	Benzene										
Jan-86	Bis(2ethylhexyl)Phthalate										
Jan-86	Cadmium, Total										
Jan 86	Chloroform										
Jan-86	Chromium, Total										
Jan-86	Cis 1,2-Dichloroethene										
Jan-86	Copper, Total										
Jan-86	Ethylbenzene										
Jan-86	Lead, Total										
Jan 86	Manganese, Total										
Jan-86	Mercury, Total										
Jan-86	Methylene Chloride										
Jan-86	Nickel, Total										
Jan 86	PCB 1242										
Jan-86	PCB 1248										
Jan-86	PCB 1254										
Jan-86	PCB 1260										
Jan-86	Silver, Total										

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Date	Parameter	Blank	RinBlk1	RinBlk2	TrpBlk1	Trp Blk2	TrpBlk3	TrpBlk4	Dupl 1	Dupl 2	Dupl 3
Jan-86	Tetrachloroethene										
Jan-86	TOC										
Jan-86	Toluene										
Jan-86	Trans 1,2-Dichloroethene										
Jan-86	Trichloroethene										
Jan-86	Zinc, Total										
Apr-86	1,1,1-Trichloroethane	< 0.005									
Apr-86	1,1-Dichloroethane	< 0.005									
Apr-86	1,1-Dichloroethene	< 0.005									
Apr-86	Arsenic, Total										
Apr-86	Benzene	< 0.005									
Apr-86	Bis(2ethylhexyl)Phthalate										
Apr-86	Cadmium, Total										
Apr-86	Chloroform	< 0.005									
Apr-86	Chromium, Total										
Apr-86	Cis 1,2-Dichloroethene										
Apr-86	Copper, Total										
Apr-86	Ethylbenzene	< 0.005									
Apr-86	Lead, Total	IS									
Apr-86	Manganese, Total	IS									
Apr-86	Mercury, Total										
Apr-86	Methylene Chloride	0.013									
Apr-86	Nickel, Total										
Apr-86	PCB 1242	IS									
Apr-86	PCB 1248	IS									
Apr 86	PCB 1254	IS									
Apr-86	PCB 1260	IS									
Apr-86	Silver, Total										
Apr-86	Tetrachloroethene	< 0.005									
Apr-86	TOC										
Apr-86	Toluene	< 0.005									
Apr-86	Trans 1,2-Dichloroethene	< 0.005									
Apr-86	Trichloroethene	< 0.005									
Apr-86	Zinc, Total	IS									
Nov-86	1,1,1-Trichloroethane		< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.093	< 0.005
Nov-86	1,1-Dichloroethane		< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.025	< 0.005
Nov-86	1,1-Dichloroethene		< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Nov-86	2-Butanone		< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Nov-86	Alkalinity		< 5.0	< 5.0	< 5.0				484	437	476
Nov-86	Arsenic, Diss.		< 0.005	< 0.005	< 0.005				< 0.005	< 0.005	0.013
Nov-86	Arsenic, Total		< 0.005	< 0.0050	< 0.005				< 0.005	0.006	0.043
Nov-86	Barium, Diss		< 0.010	< 0.010	< 0.010				0.152	0.115	0.147
Nov-86	Barium, Total		< 0.010	< 0.010	< 0.010				0.194	0.514	0.160
Nov-86	Benzene		< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Nov-86	Bis(2ethylhexyl)Phthalate										
Nov-86	Cadmium, Diss.		0.0004	< 0.0001	0.0002				0.0003	0.0004	0.0008
Nov-86	Cadmium, Total		0.0002	0.0003	0.0005				0.0010	0.0019	0.0159
Nov-86	Calcium, Diss.		< 0.100	< 0.100	< 0.100				157	128	157
Nov-86	Calcium, Total		< 0.1		< 0.1				173	86.5	380
Nov-86	Chloride		< 1.0	< 1.0	< 1.0				4.6	15.3	15.1
Nov-86	Chloroform		< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Nov-86	Chromium, Diss.		0.001	0.002	0.002				0.002	0.002	0.002
Nov-86	Chromium, Total		0.004	0.007	0.002				0.009	0.123	0.009
Nov-86	Cis 1,2-Dichloroethene		< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.19	0.34	< 0.005

Chronological Summary of Consititueents Detected in at Least One Sample From NIROP Ground Water Chemical Analyses (mg/l)

Date	Parameter	Blank	RinBlk1	RinBlk2	TrpBlk1	Trp Blk2	TrpBlk3	TrpBlk4	Dupl 1	Dupl 2	Dupl 3
Nov-86	Copper, Diss.		0.003	0.009	0.002				0.002	0.004	0.002
Nov-86	Copper, Total		0.005	0.004	0.007				0.019	0.181	0.046
Nov-86	Ethylbenzene		< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Nov-86	Lead, Diss.		0.002	< 0.001	0.002				0.003	0.003	0.003
Nov-86	Lead, Total		0.009	< 0.001	0.007				0.033	0.049	0.048
Nov-86	Magnesium, Diss.		< 0.010	< 0.100	< 0.100				29.5	32.8	52.4
Nov-86	Manganese, Diss.		< 0.030	< 0.030	< 0.030				1.02	0.027	1.98
Nov-86	Manganese, Total		< 0.030	< 0.030	< 0.030				1.55	1.13	2.49
Nov-86	Mercury, Diss.		< 0.0004	< 0.0004	< 0.0004				< 0.0004	< 0.0004	< 0.0004
Nov-86	Mercury, Total		< 0.0004	< 0.0004	< 0.0004				< 0.0004	< 0.0004	< 0.0004
Nov-86	Methylene Chloride		< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Nov 86	Nickel, Diss.		< 0.001	0.001	< 0.001				< 0.001	< 0.001	< 0.001
Nov-86	Nickel, Total		0.017	0.003	0.010				0.035	0.155	0.033
Nov-86	Nitrate-Nitrogen		0.021		0.023				1.16	3.83	0.028
Nov-86	PCB 1242										
Nov-86	PCB 1248										
Nov-86	PCB 1254										
Nov-86	PCB 1260										
Nov 86	Potassium, Diss.		< 0.100	< 0.100	< 0.100				3.85	5.49	4.92
Nov-86	Selenium, Diss.		< 0.005	< 0.005	< 0.005				< 0.005	0.051	< 0.005
Nov-86	Selenium, Total		< 0.005	< 0.0050	< 0.005				< 0.005	0.035	< 0.005
Nov-86	Silver, Diss.		< 0.001	< 0.001	< 0.001				< 0.001	< 0.001	< 0.001
Nov 86	Silver, Total		< 0.001	< 0.001	< 0.001				0.003	< 0.001	< 0.001
Nov-86	Sodium, Diss.		< 0.100	0.100	< 0.100				6.27	25.1	10.6
Nov-86	Sulfates		< 10.0	8.0	< 10.0				96.5	43.0	319
Nov-86	Tetrachloroethene		< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.14	< 0.005
Nov-86	TOC										
Nov-86	Toluene		< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Nov-86	Trans 1,2-Dichloroethene		< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.19	0.34	< 0.005
Nov-86	Trichloroethene		< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.60	1.5	0.009
Nov-86	Trichlorofluoromethane		< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Nov-86	Zinc, Diss.		< 0.030	< 0.030	< 0.030				0.129	0.172	1.86
Nov-86	Zinc, Total		< 0.030	< 0.03	< 0.030				1.43	1.19	20.7

< means not detected using detection limit shown; P means present but below detection limit; IS means insufficient sample

APPENDIX B

ALPHABETICAL SUMMARY OF CONSTITUENTS DETECTED IN AT LEAST ONE SAMPLE FROM NIROP GROUND WATER ANALYSES

Date	Parameter	1-S	1-D	1-PC	2-S	2-D	2-PC	3-S	3-D	3-PC	4-S	4-D	4-PC	5-S	5-D	6-S	6-D	7-S
Oct-83	1,1,1-Trichloroethane	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010		0.027		
Apr 84	1,1,1-Trichloroethane	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010		< 0.010		0.098		
Oct-84	1,1,1-Trichloroethane	< 0.010	< 0.010	< 0.010	P 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	P 0.010	< 0.010		< 0.010		0.069		
Jan-85	1,1,1-Trichloroethane	< 0.005	< 0.005	< 0.005	P 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005		< 0.005		< 0.005		
Jun-85	1,1,1-Trichloroethane	< 0.005	< 0.005	< 0.005	0.0058	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.043	< 0.005	< 0.005
Jan-86	1,1,1-Trichloroethane																	0.0065
Apr 86	1,1,1-Trichloroethane														< 0.005		< 0.005	
Nov 86	1,1,1-Trichloroethane	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.13	< 0.005	0.0051
Oct-83	1,1-Dichloroethane	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	0.017	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010		< 0.010		
Apr-84	1,1-Dichloroethane	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	0.026	< 0.010	< 0.010	< 0.010	< 0.010		< 0.010		< 0.010		
Oct-84	1,1-Dichloroethane	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010		< 0.010		P 0.010		
Jan 85	1,1-Dichloroethane	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005		< 0.005		< 0.005		
Jun-85	1,1-Dichloroethane	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Jan-86	1,1-Dichloroethane																	< 0.005
Apr 86	1,1-Dichloroethane														< 0.005		< 0.005	
Nov-86	1,1-Dichloroethane	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.019	< 0.005	< 0.005
Oct-83	1,1-Dichloroethene	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010		< 0.010		
Apr-84	1,1-Dichloroethene	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010		< 0.010		< 0.010		
Oct-84	1,1-Dichloroethene	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010		< 0.010		< 0.010		
Jan-85	1,1-Dichloroethene	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005		< 0.005		< 0.005		
Jun-85	1,1-Dichloroethene	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Jan 86	1,1-Dichloroethene																	< 0.005
Apr-86	1,1-Dichloroethene														< 0.005		< 0.005	
Nov 86	1,1-Dichloroethene	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Nov-86	2-Butanone	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Nov-86	Alkalinity	333	231	234	569	268	8.5	481	302	239	242	258	233	497	383	456	260	533
Nov-86	Arsenic, Diss.	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Oct-83	Arsenic, Total																	
Apr-84	Arsenic, Total	0.008	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005		< 0.005		< 0.005		
Oct-84	Arsenic, Total																	
Jan-85	Arsenic, Total																	
Jun-85	Arsenic, Total																	
Jan 86	Arsenic, Total																	
Apr-86	Arsenic, Total																	
Nov-86	Arsenic, Total							< 0.005										
Nov-86	Barium, Diss	0.080	0.040	0.119	0.105	0.075	0.051	0.165	0.074	0.034	0.058	0.099	0.093	0.061	0.080	0.077	0.092	0.060
Nov-86	Barium, Total							0.088										
Oct-83	Benzene	P 0.010	0.022	0.021	P 0.010	P 0.010	< 0.010	P 0.010	P 0.010	0.014	< 0.010	P 0.010	P 0.010	< 0.010		P 0.010		
Apr-84	Benzene	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	0.014	< 0.010	< 0.010		< 0.010		< 0.010		
Oct-84	Benzene	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010		< 0.010		< 0.010		
Jan-85	Benzene	P 0.005	P 0.005	P 0.005	P 0.005	< 0.005	0.023	P 0.005	P 0.005	P 0.005	0.0061	P 0.005		0.0059		0.010		
Jun-85	Benzene	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Jan-86	Benzene																	< 0.005
Apr-86	Benzene														< 0.005		< 0.005	
Nov 86	Benzene	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Oct 83	Bis(2ethylhexyl)Phthalate																	
Apr-84	Bis(2ethylhexyl)Phthalate	0.018	< 0.010	< 0.010	0.084	0.084	0.030	0.14	0.058	0.023	0.018	0.073		0.016		0.22		
Oct-84	Bis(2ethylhexyl)Phthalate	0.002	< 0.002	< 0.012	< 0.002	0.003	0.005	0.008	0.004	0.008	0.003	0.004		0.011		0.005		
Jan-85	Bis(2ethylhexyl)Phthalate	<0.00001	<0.00001	0.00007	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001		<0.00001		<0.00001		
Jun-85	Bis(2ethylhexyl)Phthalate	< 0.005	< 0.005	<0.00001	0.0038	0.0032	<0.00001	0.0036	0.0049	0.0013	0.0047	0.0030	0.0059	0.0026	0.0036	0.00062	0.0030	0.00091
Jan 86	Bis(2ethylhexyl)Phthalate																	
Apr-86	Bis(2ethylhexyl)Phthalate																	
Nov-86	Bis(2ethylhexyl)Phthalate																	
Nov-86	Cadmium, Diss.	< 0.0001	0.0004	0.0008	0.0006	< 0.0001	0.0005	0.0003	0.0004	0.0005	0.0006	0.0002	0.0005	0.0009	< 0.0001	0.0004	< 0.0001	0.0008

< means not detected using detection limit shown; P means present but below detection limit; IS means insufficient sample

Date	Parameter	1-S	1-D	1-PC	2-S	2-D	2-PC	3-S	3-D	3-PC	4-S	4-D	4-PC	5-S	5-D	6-S	6-D	7-S
Oct-83	Cadmium, Total	0.0085	0.0061	0.0024	0.0013	0.0031	0.0014	0.0076	0.0033	0.0013	0.0019	0.0029	0.0014	0.0068		0.0062		
Apr-84	Cadmium, Total	0.0016	0.0033	0.0017	0.0041	0.0014	0.0032	0.0010	0.0044	0.0092	0.0021	0.0015		0.0017		0.0017		
Oct-84	Cadmium, Total																	
Jan 85	Cadmium, Total																	
Jun-85	Cadmium, Total																	
Jan-86	Cadmium, Total																	
Apr-86	Cadmium, Total																	
Nov 86	Cadmium, Total							0.0014										
Nov-86	Calcium, Diss.	101	86.0	81.5	169	110	21.1	157	115	110	64.9	99.3	90.4	186	117	145	102	216
Nov-86	Calcium, Total							169										
Nov-86	Chloride	19.5	30.9	58.4	4.5	41.7	59.7	4.8	22.6	31.7	4.2	72.6	75.6	50.0	3.2	32.7	72.5	18.7
Oct 83	Chloroform	< 0.010	< 0.010	< 0.010	P 0.010	< 0.010	P 0.010	< 0.010	< 0.010	P 0.010	P 0.010	< 0.010	< 0.010	< 0.010		< 0.010		
Apr-84	Chloroform	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010		< 0.010		< 0.010		
Oct-84	Chloroform	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010		< 0.010		< 0.010		
Jan-85	Chloroform	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005		< 0.005		< 0.005		
Jun-85	Chloroform	0.0014	0.0026	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Jan-86	Chloroform																	< 0.005
Apr-86	Chloroform														< 0.005		< 0.005	
Nov-86	Chloroform	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Nov 86	Chromium, Diss.	0.005	0.002	0.002	0.003	0.001	0.002	0.003	0.001	0.002	0.002	0.001	< 0.001	0.002	0.002	< 0.001	< 0.001	0.002
Oct-83	Chromium, Total	0.037	0.003	0.011	0.057	0.004	0.007	0.020	0.008	0.003	0.013	0.005	0.003	0.013		0.040		
Apr 84	Chromium, Total	0.011	0.004	0.014	0.029	0.005	0.006	0.011	0.025	0.019	0.009	0.008		0.006		0.027		
Oct-84	Chromium, Total																	
Jan-85	Chromium, Total																	
Jun-85	Chromium, Total																	
Jan 86	Chromium, Total																	
Apr-86	Chromium, Total																	
Nov-86	Chromium, Total							0.009										
Oct-83	Cis 1,2-Dichloroethene																	
Apr-84	Cis 1,2-Dichloroethene	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	0.076	< 0.010	< 0.010	< 0.010	< 0.010		< 0.010		0.15		
Oct-84	Cis 1,2-Dichloroethene	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	0.024	0.084	< 0.010	P 0.010	< 0.010	< 0.010		< 0.010		0.017		
Jan-85	Cis 1,2-Dichloroethene																	
Jun-85	Cis 1,2-Dichloroethene																	
Jan-86	Cis 1,2-Dichloroethene																	
Apr-86	Cis 1,2-Dichloroethene																	
Nov-86	Cis 1,2-Dichloroethene	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.29	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.58	< 0.005	< 0.005
Nov-86	Copper, Diss.	0.004	< 0.001	0.005	0.008	< 0.001	0.003	0.003	0.006	0.003	0.009	< 0.001	0.002	0.004	< 0.001	< 0.001	0.009	0.003
Oct-83	Copper, Total	0.054	0.010	0.004	0.214	0.021	0.012	0.084	0.017	0.011	0.027	0.012	< 0.001	0.040		0.082		
Apr-84	Copper, Total	0.019	0.056	0.041	0.060	0.029	0.019	0.026	0.053	0.034	0.041	0.056		0.018		0.023		
Oct-84	Copper, Total																	
Jan-85	Copper, Total																	
Jun-85	Copper, Total																	
Jan-86	Copper, Total																	
Apr-86	Copper, Total																	
Nov-86	Copper, Total							0.024										
Oct-83	Ethylbenzene	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	0.037	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010		< 0.010		
Apr-84	Ethylbenzene	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	0.029	< 0.010	< 0.010	< 0.010	< 0.010		< 0.010		< 0.010		
Oct-84	Ethylbenzene	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	P 0.010	< 0.010	< 0.010	< 0.010	< 0.010		< 0.010		< 0.010		
Jan-85	Ethylbenzene	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005		< 0.005		< 0.005		
Jun 85	Ethylbenzene	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Jan 86	Ethylbenzene																	< 0.005
Apr-86	Ethylbenzene														< 0.005		< 0.005	
Nov-86	Ethylbenzene	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Nov-86	Lead, Diss.	< 0.001	< 0.001	0.002	0.001	< 0.001	0.003	0.002	< 0.001	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.002	0.003	0.002

< means not detected using detection limit shown; P means present but below detection limit; IS means insufficient sample

Date	Parameter	1-S	1-D	1-PC	2-S	2-D	2-PC	3-S	3-D	3-PC	4-S	4-D	4-PC	5-S	5-D	6-S	6-D	7-S
Oct-83	Lead, Total	0.035	0.035	< 0.001	0.334	0.025	0.003	0.083	0.025	0.001	0.021	0.013	0.002	0.018		0.142		
Apr 84	Lead, Total	0.014	0.019	0.170	0.018	0.007	0.015	0.010	0.077	0.046	0.019	0.044		0.008		0.022		
Oct 84	Lead, Total	0.091	0.013	0.090	0.149	0.014	0.029	0.063	0.018	0.035	0.058	0.032		0.017		0.221		
Jan 85	Lead, Total	0.037	0.043	0.058	0.083	0.030	0.011	0.035	0.024	0.015	0.020	0.018		0.022		0.023		
Jun 85	Lead, Total	0.010	0.054	0.018	0.293	0.023	0.039	0.026	0.045	0.011	0.084	0.029	0.026	0.022	0.166	0.294	0.016	0.009
Jan 86	Lead, Total																	0.107
Apr 86	Lead, Total														0.061		0.133	
Nov-86	Lead, Total							0.171										
Nov 86	Magnesium, Diss.	20.2	38.8	45.0	38.6	51.6	10.7	30.1	45.5	54.9	21.3	48.4	45.9	43.5	61.4	39.4	47.6	27.3
Nov 86	Manganese, Diss.	1.07	0.090	0.046	0.198	0.392	0.002	1.04	0.076	0.052	0.005	0.362	0.210	0.593	0.100	0.564	0.330	1.01
Oct-83	Manganese, Total	1.99	0.152	0.001	6.58	0.094	0.027	1.78	0.075	0.076	0.416	0.093	0.385	2.74		6.54		
Apr-84	Manganese, Total																	
Oct-84	Manganese, Total	3.68	0.095	0.775	1.89	0.368	0.283	2.12	0.100	0.109	0.430	0.231		2.31		2.37		
Jan-85	Manganese, Total	1.76	0.064	0.705	1.40	0.314	0.347	1.72	0.088	0.102	0.323	0.362		3.86		1.46		
Jun-85	Manganese, Total	1.15	0.065	0.844	6.90	0.516	0.439	3.16	0.081	0.139	1.81	0.093	0.424	4.09	0.312	4.28	0.361	27.50
Jan-86	Manganese, Total																	9.30
Apr-86	Manganese, Total														0.138		0.503	
Nov-86	Manganese, Total							1.56										
Nov-86	Mercury, Diss.	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004
Oct-83	Mercury, Total																	
Apr-84	Mercury, Total	< 0.0004	< 0.0004	< 0.0004	< 0.0015	< 0.0004	0.0008	0.0013	< 0.0004	< 0.0004	0.0007	0.0004		< 0.0004		0.0008		
Oct-84	Mercury, Total																	
Jan-85	Mercury, Total																	
Jun-85	Mercury, Total																	
Jan-86	Mercury, Total																	
Apr-86	Mercury, Total																	
Nov-86	Mercury, Total							< 0.0004										
Oct-83	Methylene Chloride	P 0.010	P 0.010	< 0.010	41.0	0.011	6.0	0.010	0.030	0.011	0.80	< 0.010	P 0.010	< 0.010		< 0.010		
Apr-84	Methylene Chloride	< 0.010	< 0.010	0.022	< 0.010	0.010	0.021	0.064	< 0.010	0.11	< 0.010	0.013		< 0.010		< 0.010		
Oct-84	Methylene Chloride	< 0.010	0.062	< 0.010	0.029	P 0.010	0.20	0.13	P 0.010	0.012	0.014	0.44		0.029		0.070		
Jan-85	Methylene Chloride	0.30	0.11	P 0.005	P 0.005	0.83	0.012	0.0067	< 0.0005	0.0065	0.065	P 0.0005		0.011		0.026		
Jun 85	Methylene Chloride	< 0.005	< 0.005	0.16	0.0057	< 0.005	< 0.005	0.025	< 0.005	< 0.005	< 0.005	< 0.005	0.019	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Jan-86	Methylene Chloride																	< 0.005
Apr-86	Methylene Chloride														< 0.005		< 0.005	
Nov-86	Methylene Chloride	0.013	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Nov-86	Nickel, Diss.	0.009	0.003	< 0.001	0.005	0.002	0.007	< 0.001	0.004	< 0.001	0.009	< 0.001	0.014	0.012	< 0.001	0.025	0.043	0.072
Oct-83	Nickel, Total																	
Apr 84	Nickel, Total	0.024	0.03	0.008	0.107	0.053	0.005	0.022	0.01	0.048	0.017	0.006		0.018		0.048		
Oct-84	Nickel, Total																	
Jan-85	Nickel, Total																	
Jun-85	Nickel, Total																	
Jan-86	Nickel, Total																	
Apr-86	Nickel, Total																	
Nov-86	Nickel, Total							0.018										
Nov-86	Nitrate-Nitrogen			0.209	1.37		0.160	1.17		0.060	6.56		0.106	2.66			0.036	3.29
Oct 83	PCB 1242	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001		< 0.0001		
Apr 84	PCB 1242	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002		< 0.0002		< 0.0002		
Oct-84	PCB 1242	0.0005	0.0002	0.0003	< 0.0002	< 0.0002	0.0005	< 0.0002	0.0002	0.0003	0.0002	< 0.0002		0.0004		0.0002		
Jan-85	PCB 1242	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002		< 0.0002		< 0.0002		
Jun-85	PCB 1242	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Jan-86	PCB 1242																	< 0.0002
Apr 86	PCB 1242														< 0.0002		< 0.0002	
Nov-86	PCB 1242																	
Oct-83	PCB 1248	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001		< 0.0001		

< means not detected using detection limit shown; P means present but below detection limit; IS means insufficient sample

Date	Parameter	1-S	1-D	1-PC	2-S	2-D	2-PC	3-S	3-D	3-PC	4-S	4-D	4-PC	5-S	5-D	6-S	6-D	7-S
Apr 84	PCB 1248	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	0.0004	< 0.0002	< 0.0002		< 0.0002		< 0.0002		
Oct-84	PCB 1248	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	0.0002	< 0.0002	< 0.0002		< 0.0002		< 0.0002		
Jan 85	PCB 1248	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002		< 0.0002		< 0.0002		
Jun-85	PCB 1248	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Jan-86	PCB 1248																	< 0.0002
Apr-86	PCB 1248														< 0.0002		< 0.0002	
Nov 86	PCB 1248																	
Oct-83	PCB 1254	< 0.0015	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001		< 0.0001		
Apr 84	PCB 1254	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002		< 0.0002		< 0.0002		
Oct-84	PCB 1254	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002		< 0.0002		< 0.0002		
Jan-85	PCB 1254	< 0.0002	0.0005	0.0003	0.0011	0.0002	0.0005	0.0007	0.0003	0.0003	0.0004	< 0.0002		0.0002		< 0.0002		
Jun-85	PCB 1254	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Jan-86	PCB 1254																	< 0.0002
Apr 86	PCB 1254														< 0.0002		< 0.0002	
Nov-86	PCB 1254																	
Oct-83	PCB 1260	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001		< 0.0001		
Apr-84	PCB 1260	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002		< 0.0002		< 0.0002		
Oct 84	PCB 1260	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0011		< 0.0002		< 0.0002		
Jan-85	PCB 1260	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002		< 0.0002		< 0.0002		
Jun-85	PCB 1260	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Jan-86	PCB 1260																	< 0.0002
Apr-86	PCB 1260														< 0.0002		< 0.0002	
Nov-86	PCB 1260																	
Nov-86	Potassium, Diss.	3.92	2.20	3.28	3.69	2.67	36.8	3.85	2.20	2.62	2.79	2.43	3.52	4.67	2.74	4.00	2.34	2.83
Nov-86	Selenium, Diss.	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Nov-86	Selenium, Total							< 0.005										
Nov 86	Silver, Diss.	0.005	0.003	0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.003	< 0.001	< 0.001	< 0.001
Oct 83	Silver, Total	< 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		
Apr-84	Silver, Total	< 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		
Oct-84	Silver, Total																	
Jan-85	Silver, Total																	
Jun-85	Silver, Total																	
Jan-86	Silver, Total																	
Apr-86	Silver, Total																	
Nov-86	Silver, Total							0.001										
Nov-86	Sodium, Diss.	14.3	5.85	12.9	5.99	6.06	34.0	7.83	4.81	5.68	11.5	13.5	10.2	18.0	3.57	26.0	15.0	6.77
Nov-86	Sulfates	77.5	129	96.0	56.3	184	130	97.0	203	304	45.2	148	85.9	192	184	172	176	148
Oct 83	Tetrachlorethene	< 0.010	< 0.010	P 0.010	< 0.010	< 0.010	< 0.010	0.017	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010		P 0.010		
Apr-84	Tetrachlorethene	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	0.013	< 0.010	< 0.010	< 0.010	< 0.010		< 0.010		0.042		
Oct 84	Tetrachlorethene	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	P 0.010	< 0.010	< 0.010	< 0.010	< 0.010		< 0.010		0.038		
Jan-85	Tetrachlorethene	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005		< 0.005		< 0.005		
Jun-85	Tetrachlorethene	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.045	< 0.005	< 0.005
Jan-86	Tetrachlorethene																	< 0.005
Apr 86	Tetrachlorethene														< 0.005		< 0.005	
Nov-86	Tetrachlorethene	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.20	< 0.005	< 0.005
Oct-83	TOC	22.8	642.0	51.8	57.0	4.8	15.9	16.1	3.5	6.6	10.1	30.7	2.3	649.0		27.6		
Apr 84	TOC	9.7	2.7	9.9	IS	7.4	3.0	15.2	1.7	3.2	9.1	1.0		13.5		13.2		
Oct-84	TOC																	
Jan 85	TOC																	
Jun-85	TOC																	
Jan 86	TOC																	
Apr-86	TOC																	
Nov-86	TOC																	
Oct-83	Toluene	P 0.010	0.012	< 0.010	P 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	P 0.010	< 0.010	< 0.010		< 0.010		

< means not detected using detection limit shown; P means present but below detection limit; IS means insufficient sample

Date	Parameter	1-S	1-D	1-PC	2-S	2-D	2-PC	3-S	3-D	3-PC	4-S	4-D	4-PC	5-S	5-D	6-S	6-D	7-S
Apr-84	Toluene	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010		< 0.010		< 0.010		
Oct-84	Toluene	< 0.010	P 0.010	P 0.010	< 0.010	< 0.010	P 0.010	P 0.010	< 0.010	< 0.010	P 0.010	P 0.010		< 0.010		< 0.010		
Jan-85	Toluene	P 0.005	0.0099	0.011	P 0.005	P 0.005	0.020	P 0.005	0.0072	0.014	< 0.005	0.0061		< 0.005		< 0.005		
Jun-85	Toluene	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.0065	< 0.005	< 0.005	0.014	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Jan-86	Toluene																	< 0.005
Apr-86	Toluene														< 0.005		< 0.005	
Nov-86	Toluene	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Oct 83	Trans 1,2-Dichloroethene	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	0.075	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010		0.041		
Apr-84	Trans 1,2-Dichloroethene	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	0.076	< 0.010	< 0.010	< 0.010	< 0.010		< 0.010		0.15		
Oct-84	Trans 1,2-Dichloroethene	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	0.084	< 0.010	< 0.010	< 0.010	< 0.010		< 0.010		0.17		
Jan-85	Trans 1,2-Dichloroethene	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.17	< 0.005	< 0.005	< 0.005	< 0.005		< 0.005		< 0.005		
Jun-85	Trans 1,2-Dichloroethene	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.097	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.093	< 0.005	< 0.005
Jan-86	Trans 1,2-Dichloroethene																	< 0.005
Apr-86	Trans 1,2 Dichloroethene														< 0.005		< 0.005	
Nov-86	Trans 1,2-Dichloroethene	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.29	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.58	< 0.005	< 0.005
Oct-83	Trichloroethene	< 0.010	< 0.010	< 0.010	0.13	< 0.010	0.062	28.0	P 0.010	0.081	P 0.010	< 0.010	< 0.010	< 0.010		1.8		
Apr 84	Trichloroethene	< 0.010	< 0.010	< 0.010	0.068	< 0.010	0.014	5.0	0.023	0.081	< 0.010	< 0.010		< 0.010		0.94		
Oct-84	Trichloroethene	< 0.010	< 0.010	< 0.010	0.061	P 0.010	0.024	1.3	0.013	P 0.010	< 0.010	< 0.010		< 0.010		0.83		
Jan-85	Trichloroethene	< 0.005	< 0.005	< 0.005	0.060	P 0.005	0.011	0.63	0.017	P 0.005	< 0.005	< 0.005		< 0.005		< 0.005		
Jun 85	Trichloroethene	< 0.005	< 0.005	< 0.005	0.069	0.005	0.0087	0.62	0.014	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.62	0.006	0.15
Jan-86	Trichloroethene																	0.134
Apr-86	Trichloroethene														< 0.005		0.0067	
Nov-86	Trichloroethene	< 0.005	< 0.005	< 0.005	0.065	0.0092	0.0053	0.88	0.012	< 0.005	0.019	< 0.005	< 0.005	< 0.005	< 0.005	3.8	0.011	0.13
Nov-86	Trichlorofluoromethane	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.0077	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Nov-86	Zinc, Diss.	0.133	1.25	0.068	0.851	0.660	< 0.030	0.131	0.842	0.357	0.634	0.492	0.086	0.601	0.687	0.909	0.823	1.05
Oct-83	Zinc, Total	1.12	7.05	< 0.05	3.98	2.91	< 0.05	3.64	3.26	< 0.05	1.69	2.07	< 0.05	0.406		7.37		
Apr-84	Zinc, Total	0.41	2.45	0.384	0.755	0.972	1.41	0.54	7.68	1.43	1.14	3.13		0.157		1.33		
Oct-84	Zinc, Total	1.68	4.75	1.31	3.14	0.469	0.743	3.39	0.959	0.425	6.20	0.995		0.781		26.6		
Jan-85	Zinc, Total	0.546	9.25	1.02	0.682	4.07	0.273	1.40	2.13	0.686	1.31	1.14		0.654		2.07		
Jun 85	Zinc, Total	0.256	2.54	0.234	3.57	1.17	0.143	1.37	4.58	0.136	3.73	0.462	1.34	0.419	6.02	3.43	2.30	1.16
Jan-86	Zinc, Total																	3.25
Apr-86	Zinc, Total														4.02		5.57	
Nov-86	Zinc, Total							1.52										

Blank means not detected; < means detection limit shown; P means present but below detection limit; IS means insufficient sample

Date	Parameter	7-D	8-S	8-D	9-S	9-D	10-S	11-S	12-S	13-S	14-S	15-S	16-S	17-S	18-S	19-S	20-S	FMC-33
Oct-83	1,1,1-Trichloroethane																	< 0.010
Apr 84	1,1,1-Trichloroethane																	< 0.010
Oct-84	1,1,1-Trichloroethane																	< 0.010
Jan-85	1,1,1-Trichloroethane																	< 0.005
Jun 85	1,1,1-Trichloroethane		0.039		0.39		< 0.005	< 0.005										< 0.005
Jan 86	1,1,1-Trichloroethane				0.29		< 0.005	< 0.005										
Apr 86	1,1,1-Trichloroethane	< 0.005		< 0.005		< 0.005			< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	
Nov 86	1,1,1-Trichloroethane	< 0.005	0.018	< 0.005	0.12	0.0086	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Oct-83	1,1-Dichloroethane																	0.027
Apr-84	1,1-Dichloroethane																	0.011
Oct-84	1,1 Dichloroethane																	P 0.010
Jan 85	1,1 Dichloroethane																	0.011
Jun-85	1,1-Dichloroethane		< 0.005		0.066		< 0.005	< 0.005										0.0063
Jan-86	1,1-Dichloroethane				0.061		< 0.005	< 0.005										
Apr-86	1,1-Dichloroethane	< 0.005		< 0.005		< 0.005			< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	
Nov-86	1,1-Dichloroethane	< 0.005	0.0073	< 0.005	0.035	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.0073
Oct-83	1,1-Dichloroethene																	< 0.010
Apr-84	1,1-Dichloroethene																	< 0.010
Oct 84	1,1-Dichloroethene																	< 0.010
Jan 85	1,1-Dichloroethene																	< 0.005
Jun-85	1,1-Dichloroethene		< 0.005		0.0092		< 0.005	< 0.005										< 0.005
Jan 86	1,1-Dichloroethene				0.0056		< 0.005	< 0.005										
Apr 86	1,1-Dichloroethene	< 0.005		< 0.005		< 0.005			< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	
Nov 86	1,1 Dichloroethene	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Nov 86	2-Butanone	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Nov-86	Alkalinity	303	469	267	436	362	493	426	417	374	383	477	395	458	302	264	190	504
Nov-86	Arsenic, Diss.	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.014	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Oct-83	Arsenic, Total																	
Apr 84	Arsenic, Total																	< 0.005
Oct-84	Arsenic, Total																	
Jan 85	Arsenic, Total																	
Jun 85	Arsenic, Total																	
Jan-86	Arsenic, Total																	
Apr-86	Arsenic, Total																	
Nov-86	Arsenic, Total				0.023							0.045						
Nov-86	Barium, Diss	0.111	0.072	0.090	0.109	0.061	0.079	0.106	0.064	0.093	0.093	0.136	0.068	0.050	0.095	0.032	0.055	0.128
Nov-86	Barium, Total				0.986							0.172						
Oct-83	Benzene																	0.010
Apr-84	Benzene																	< 0.010
Oct-84	Benzene																	< 0.010
Jan 85	Benzene																	0.0069
Jun 85	Benzene		< 0.005		< 0.005		< 0.005	< 0.005										< 0.005
Jan-86	Benzene				< 0.005		< 0.005	< 0.005										
Apr-86	Benzene	< 0.005		0.0052		0.005			< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	
Nov-86	Benzene	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.0065	< 0.005	< 0.005	< 0.005	< 0.005
Oct-83	Bis(2ethylhexyl)Phthalate																	
Apr-84	Bis(2ethylhexyl)Phthalate																	0.079
Oct-84	Bis(2ethylhexyl)Phthalate																	0.013
Jan-85	Bis(2ethylhexyl)Phthalate																	<0.00001
Jun 85	Bis(2ethylhexyl)Phthalate		<0.00001		<0.00001		0.00033	0.00080										<0.00001
Jan-86	Bis(2ethylhexyl)Phthalate																	
Apr-86	Bis(2ethylhexyl)Phthalate																	
Nov-86	Bis(2ethylhexyl)Phthalate																	
Nov-86	Cadmium, Diss.	0.0002	0.0009	0.0003	0.0006	0.0007	0.0006	< 0.0001	0.0010	0.0011	0.0021	0.0008	0.0010	0.0006	0.0005	0.0024	0.0009	0.0004

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Date	Parameter	7-D	8-S	8-D	9-S	9-D	10-S	11-S	12-S	13-S	14-S	15-S	16-S	17-S	18-S	19-S	20-S	FMC-33
Oct-83	Cadmium, Total																	0.0013
Apr-84	Cadmium, Total																	0.0051
Oct-84	Cadmium, Total																	
Jan-85	Cadmium, Total																	
Jun-85	Cadmium, Total																	
Jan-86	Cadmium, Total																	
Apr-86	Cadmium, Total																	
Nov-86	Cadmium, Total				0.0034							0.0194						
Nov-86	Calcium, Diss.	113	134	113	133	122	145	158	126	154	190	159	108	170	157	66.0	66.0	208
Nov-86	Calcium, Total				154							207						
Nov-86	Chloride	36.0	5.9	47.7	15.2	42.9	36.6	23.2	45.7	13.7	58.8	15.0	4.6	25.6	26.6	54.6	15.3	12.9
Oct-83	Chloroform																	< 0.010
Apr-84	Chloroform																	< 0.010
Oct-84	Chloroform																	< 0.010
Jan-85	Chloroform																	< 0.005
Jun-85	Chloroform		< 0.005		< 0.005		< 0.005	< 0.005										< 0.005
Jan-86	Chloroform				< 0.005		< 0.005	< 0.005										
Apr-86	Chloroform	< 0.005		< 0.005		< 0.005			< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	
Nov-86	Chloroform	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Nov-86	Chromium, Diss.	0.002	0.002	0.002	0.003	0.002	0.003	0.001	< 0.001	< 0.001	< 0.001	0.002	0.001	0.003	0.002	0.002	0.001	0.001
Oct-83	Chromium, Total																	0.003
Apr-84	Chromium, Total																	0.004
Oct-84	Chromium, Total																	
Jan-85	Chromium, Total																	
Jun-85	Chromium, Total																	
Jan-86	Chromium, Total																	
Apr-86	Chromium, Total																	
Nov-86	Chromium, Total				0.267							0.011						
Oct 83	Cis 1,2-Dichloroethene																	
Apr-84	Cis 1,2-Dichloroethene																	0.096
Oct-84	Cis 1,2-Dichloroethene																	0.23
Jan-85	Cis 1,2-Dichloroethene																	
Jun-85	Cis 1,2-Dichloroethene																	
Jan 86	Cis 1,2-Dichloroethene																	
Apr-86	Cis 1,2-Dichloroethene																	
Nov-86	Cis 1,2-Dichloroethene	< 0.005	0.24	0.048	0.34	0.028	0.036	0.022	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.027	0.33	< 0.005	< 0.005	0.11
Nov 86	Copper, Diss.	0.004	0.003	0.002	0.005	0.002	0.005	0.002	0.002	0.006	0.002	0.002	0.004	0.003	0.003	0.004	0.004	0.002
Oct-83	Copper, Total																	0.008
Apr-84	Copper, Total																	0.032
Oct 84	Copper, Total																	
Jan-85	Copper, Total																	
Jun-85	Copper, Total																	
Jan-86	Copper, Total																	
Apr-86	Copper, Total																	
Nov-86	Copper, Total				0.377							0.089						
Oct-83	Ethylbenzene																	0.21
Apr-84	Ethylbenzene																	0.063
Oct 84	Ethylbenzene																	0.099
Jan-85	Ethylbenzene																	< 0.005
Jun-85	Ethylbenzene		< 0.005		< 0.005		< 0.005	< 0.005										0.016
Jan-86	Ethylbenzene				< 0.005		< 0.005	< 0.005										
Apr-86	Ethylbenzene	< 0.005		< 0.005		< 0.005			< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	
Nov-86	Ethylbenzene	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Nov 86	Lead, Diss.	0.002	< 0.001	0.002	0.003	0.011	0.005	< 0.001	0.001	0.005	0.004	0.003	0.003	0.003	0.004	0.009	0.004	0.003

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Oct-83	Lead, Total																	0.014
Apr-84	Lead, Total																	0.057
Oct 84	Lead, Total																	0.030
Jan-85	Lead, Total																	0.021
Jun-85	Lead, Total		0.154		0.054		0.109	0.063										0.010
Jan-86	Lead, Total				0.035		0.040	0.030										
Apr-86	Lead, Total	0.034		0.112		0.061			0.366	0.033	0.101	0.054	0.073	0.060	0.120	0.097	0.152	
Nov-86	Lead, Total				0.174							0.174						
Nov-86	Magnesium, Diss.	52.4	33.0	54.9	33.0	49.2	50.8	58.1	33.8	36.9	33.8	33.4	29.0	54.9	54.1	18.0	17.2	53.4
Nov-86	Manganese, Diss.	0.403	1.94	0.700	0.026	0.142	1.58	0.003	1.20	1.50	0.876	1.96	1.04	0.388	0.920	0.034	0.088	1.00
Oct-83	Manganese, Total																	0.957
Apr-84	Manganese, Total																	
Oct-84	Manganese, Total																	0.414
Jan-85	Manganese, Total																	0.539
Jun-85	Manganese, Total		11.8		2.07		8.74	5.00										0.84
Jan-86	Manganese, Total				1.30		9.59	2.23										
Apr-86	Manganese, Total	0.695		0.883		0.523			10.7	1.89	0.532	2.12	1.64	1.46	1.38	0.622	1.71	
Nov-86	Manganese, Total				2.54							2.46						
Nov-86	Mercury, Diss.	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004
Oct-83	Mercury, Total																	
Apr-84	Mercury, Total																	0.0012
Oct-84	Mercury, Total																	
Jan-85	Mercury, Total																	
Jun-85	Mercury, Total																	
Jan-86	Mercury, Total																	
Apr-86	Mercury, Total																	
Nov-86	Mercury, Total				< 0.0004							< 0.0004						
Oct-83	Methylene Chloride																	< 0.010
Apr-84	Methylene Chloride																	< 0.010
Oct-84	Methylene Chloride																	0.12
Jan-85	Methylene Chloride																	0.038
Jun-85	Methylene Chloride		< 0.005		< 0.005		< 0.005	< 0.005										0.016
Jan-86	Methylene Chloride				< 0.005		< 0.005	< 0.005										
Apr-86	Methylene Chloride	< 0.005		< 0.005		< 0.005			< 0.005	< 0.005	< 0.005	0.0056	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	
Nov-86	Methylene Chloride	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Nov-86	Nickel, Diss.	< 0.001	0.054	< 0.001	< 0.001	0.001	0.032	0.004	0.006	0.013	0.037	< 0.001	0.005	0.003	< 0.001	< 0.001	0.004	< 0.001
Oct 83	Nickel, Total																	
Apr-84	Nickel, Total																	0.003
Oct-84	Nickel, Total																	
Jan-85	Nickel, Total																	
Jun-85	Nickel, Total																	
Jan-86	Nickel, Total																	
Apr-86	Nickel, Total																	
Nov-86	Nickel, Total				0.332							0.039						
Nov-86	Nitrate-Nitrogen	0.031	1.69	0.022	3.92	0.221	0.205	0.803	6.05	2.09	17.0	0.028	0.110	2.02	0.016	2.74	0.434	0.020
Oct-83	PCB 1242																	< 0.0001
Apr-84	PCB 1242																	< 0.0002
Oct 84	PCB 1242																	< 0.0002
Jan-85	PCB 1242																	< 0.0002
Jun 85	PCB 1242		< 0.0002		< 0.0002		< 0.0002	< 0.0002										< 0.0002
Jan 86	PCB 1242				< 0.0002		< 0.0002	< 0.0002										
Apr-86	PCB 1242	< 0.0002		< 0.0002		< 0.0002			< 0.0002	Broken	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	
Nov-86	PCB 1242																	
Oct-83	PCB 1248																	< 0.0001

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Apr-84	PCB 1248																	< 0.0002
Oct-84	PCB 1248																	< 0.0002
Jan 85	PCB 1248																	< 0.0002
Jun-85	PCB 1248		< 0.0002		< 0.0002		< 0.0002	< 0.0002										< 0.0002
Jan-86	PCB 1248				< 0.0002		< 0.0002	< 0.0002										
Apr-86	PCB 1248	< 0.0002		< 0.0002		< 0.0002			< 0.0002	Broken	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	
Nov-86	PCB 1248																	
Oct-83	PCB 1254																	< 0.0001
Apr-84	PCB 1254																	< 0.0002
Oct-84	PCB 1254																	< 0.0002
Jan-85	PCB 1254																	< 0.0002
Jun-85	PCB 1254		< 0.0002		< 0.0002		< 0.0002	< 0.0002										< 0.0002
Jan 86	PCB 1254				< 0.0002		< 0.0002	< 0.0002										
Apr 86	PCB 1254	< 0.0002		< 0.0002		< 0.0002			< 0.0002	Broken	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	
Nov-86	PCB 1254																	
Oct-83	PCB 1260																	< 0.0001
Apr-84	PCB 1260																	< 0.0002
Oct-84	PCB 1260																	< 0.0002
Jan-85	PCB 1260																	< 0.0002
Jun-85	PCB 1260		< 0.0002		< 0.0002		< 0.0002	< 0.0002										< 0.0002
Jan-86	PCB 1260				< 0.0002		< 0.0002	< 0.0002										
Apr-86	PCB 1260	< 0.0002		< 0.0002		< 0.0002			< 0.0002	Broken	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	
Nov-86	PCB 1260																	
Nov-86	Potassium, Diss.	4.75	3.74	4.51	5.49	3.52	3.67	3.97	3.67	3.06	1.92	4.92	3.28	3.85	2.87	2.22	2.22	3.36
Nov-86	Selenium, Diss.	< 0.005	< 0.005	< 0.005	0.049	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.008	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Nov-86	Selenium, Total				0.076							< 0.005						
Nov-86	Silver, Diss.	< 0.001	0.002	< 0.001	< 0.001	0.002	< 0.001	< 0.001	0.001	< 0.001	< 0.001	< 0.001	0.003	< 0.001	0.002	0.002	< 0.001	< 0.001
Oct-83	Silver, Total																	< 0.050
Apr-84	Silver, Total																	< 0.001
Oct-84	Silver, Total																	
Jan-85	Silver, Total																	
Jun-85	Silver, Total																	
Jan-86	Silver, Total																	
Apr-86	Silver, Total																	
Nov-86	Silver, Total				0.001							< 0.001						
Nov-86	Sodium, Diss.	9.36	6.89	11.0	28.2	19.5	16.5	7.44	17.1	6.50	5.77	10.6	4.14	16.8	8.18	41.1	9.45	7.19
Nov-86	Sulfates	251	183	272	91.7	189	224	363	56.4	218	164	318	59.5	333	422	26.8	72.4	321
Oct-83	Tetrachlorethene																	0.024
Apr-84	Tetrachlorethene																	< 0.010
Oct-84	Tetrachlorethene																	< 0.010
Jan-85	Tetrachlorethene																	P 0.005
Jun-85	Tetrachlorethene		0.046		0.22		< 0.005	< 0.005										0.0053
Jan-86	Tetrachlorethene				0.21		< 0.005	< 0.005										
Apr-86	Tetrachlorethene	< 0.005		< 0.005		< 0.005			< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	
Nov-86	Tetrachlorethene	< 0.005	0.046	< 0.005	0.12	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Oct-83	TOC																	3.6
Apr-84	TOC																	4.5
Oct 84	TOC																	
Jan-85	TOC																	
Jun 85	TOC																	
Jan-86	TOC																	
Apr-86	TOC																	
Nov 86	TOC																	
Oct-83	Toluene																	< 0.010

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Date	Parameter	7-D	8-S	8-D	9-S	9-D	10-S	11-S	12-S	13-S	14-S	15-S	16-S	17-S	18-S	19-S	20-S	FMC-33
Apr-84	Toluene																	< 0.010
Oct-84	Toluene																	P 0.010
Jan-85	Toluene																	< 0.005
Jun-85	Toluene		< 0.005		< 0.005		< 0.005	< 0.005										< 0.005
Jan-86	Toluene				< 0.005		< 0.005	< 0.005										
Apr-86	Toluene	< 0.005		< 0.005		0.0082			< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	
Nov-86	Toluene	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Oct-83	Trans 1,2-Dichloroethene																	0.12
Apr-84	Trans 1,2-Dichloroethene																	0.096
Oct-84	Trans 1,2-Dichloroethene																	0.23
Jan-85	Trans 1,2-Dichloroethene																	0.10
Jun-85	Trans 1,2-Dichloroethene		0.49		0.50		0.015	0.036										0.11
Jan-86	Trans 1,2-Dichloroethene				0.51		0.012	0.034										
Apr-86	Trans 1,2-Dichloroethene	< 0.005		0.039		0.013			< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.044	4.7	< 0.005	< 0.005	
Nov-86	Trans 1,2-Dichloroethene	< 0.005	0.24	0.048	0.34	0.028	0.036	0.022	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.027	0.33	< 0.005	< 0.005	0.11
Oct-83	Trichloroethene																	37.0
Apr-84	Trichloroethene																	2.9
Oct-84	Trichloroethene																	1.6
Jan-85	Trichloroethene																	2.1
Jun-85	Trichloroethene		4.0		3.2		0.15	0.035										2.6
Jan-86	Trichloroethene				4.2		0.134	0.044										
Apr-86	Trichloroethene	< 0.005		5.7		0.25			< 0.005	< 0.005	< 0.005	0.017	0.096	0.19	2.9	0.042	< 0.005	
Nov-86	Trichloroethene	< 0.005	9.2	10.7	1.8	0.65	0.21	0.032	< 0.005	< 0.005	< 0.005	0.0071	0.17	0.097	1.53	0.088	< 0.005	1.3
Nov-86	Trichlorofluoromethane	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Nov-86	Zinc, Diss.	1.23	4.42	1.03	0.184	1.07	0.735	0.246	3.81	3.03	3.25	1.84	2.87	2.21	4.71	3.78	3.10	0.526
Oct-83	Zinc, Total																	4.09
Apr-84	Zinc, Total																	2.95
Oct 84	Zinc, Total																	1.56
Jan-85	Zinc, Total																	0.919
Jun-85	Zinc, Total		1.81		1.10		1.38	1.47										0.730
Jan-86	Zinc, Total				1.05		29.8	1.01										
Apr-86	Zinc, Total	10.4		14.90		4.43			6.11	6.13	17.6	17.5	6.11	4.36	9.08	3.21	4.25	
Nov-86	Zinc, Total				3.15							25.4						

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Date	Parameter	Blank	RinBlk1	RinBlk2	TrpBlk1	Trp Blk2	TrpBlk3	TrpBlk4	Dupl 1	Dupl 2	Dupl 3
Oct-83	1,1,1-Trichloroethane										
Apr-84	1,1,1-Trichloroethane										
Oct-84	1,1,1-Trichloroethane	< 0.010									
Jan-85	1,1,1 Trichloroethane	< 0.005									
Jun-85	1,1,1-Trichloroethane										
Jan-86	1,1,1-Trichloroethane										
Apr 86	1,1,1-Trichloroethane	< 0.005									
Nov-86	1,1,1-Trichloroethane		< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.093	< 0.005
Oct 83	1,1-Dichloroethane										
Apr 84	1,1-Dichloroethane										
Oct-84	1,1-Dichloroethane	< 0.010									
Jan-85	1,1-Dichloroethane	< 0.005									
Jun-85	1,1-Dichloroethane										
Jan-86	1,1-Dichloroethane										
Apr-86	1,1-Dichloroethane	< 0.005									
Nov-86	1,1-Dichloroethane		< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.025	< 0.005
Oct-83	1,1-Dichloroethene										
Apr-84	1,1-Dichloroethene										
Oct-84	1,1-Dichloroethene	< 0.010									
Jan-85	1,1-Dichloroethene	< 0.005									
Jun-85	1,1-Dichloroethene										
Jan 86	1,1-Dichloroethene										
Apr-86	1,1-Dichloroethene	< 0.005									
Nov-86	1,1-Dichloroethene		< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Nov-86	2-Butanone		< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Nov-86	Alkalinity		< 5.0	< 5.0	< 5.0				484	437	476
Nov-86	Arsenic, Diss.		< 0.005	< 0.005	< 0.005				< 0.005	< 0.005	0.013
Oct-83	Arsenic, Total										
Apr-84	Arsenic, Total										
Oct-84	Arsenic, Total										
Jan-85	Arsenic, Total										
Jun-85	Arsenic, Total										
Jan-86	Arsenic, Total										
Apr-86	Arsenic, Total										
Nov-86	Arsenic, Total		< 0.005	< 0.0050	< 0.005				< 0.005	0.006	0.043
Nov-86	Barium, Diss		< 0.010	< 0.010	< 0.010				0.152	0.115	0.147
Nov-86	Barium, Total		< 0.010	< 0.010	< 0.010				0.194	0.514	0.160
Oct-83	Benzene										
Apr-84	Benzene										
Oct-84	Benzene	< 0.010									
Jan-85	Benzene	< 0.005									
Jun-85	Benzene										
Jan-86	Benzene										
Apr 86	Benzene	< 0.005									
Nov-86	Benzene		< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Oct-83	Bis(2ethylhexyl)Phthalate										
Apr-84	Bis(2ethylhexyl)Phthalate										
Oct-84	Bis(2ethylhexyl)Phthalate										
Jan-85	Bis(2ethylhexyl)Phthalate										
Jun-85	Bis(2ethylhexyl)Phthalate										
Jan 86	Bis(2ethylhexyl)Phthalate										
Apr 86	Bis(2ethylhexyl)Phthalate										
Nov-86	Bis(2ethylhexyl)Phthalate										
Nov-86	Cadmium, Diss.		0.0004	< 0.0001	0.0002				0.0003	0.0004	0.0008

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Alphabetical Summary of Consititueats Detected in at Least One Sample From NIROP Ground Water Chemical Analyses (mg/l) 1254.01

Date	Parameter	Blank	RinBlk1	RinBlk2	TrpBlk1	Trp Blk2	TrpBlk3	TrpBlk4	Dupl 1	Dupl 2	Dupl 3
Oct-83	Cadmium, Total										
Apr-84	Cadmium, Total										
Oct-84	Cadmium, Total										
Jan-85	Cadmium, Total										
Jun-85	Cadmium, Total										
Jan-86	Cadmium, Total										
Apr-86	Cadmium, Total										
Nov 86	Cadmium, Total		0.0002	0.0003	0.0005				0.0010	0.0019	0.0159
Nov-86	Calcium, Diss.		< 0.100	< 0.100	< 0.100				157	128	157
Nov-86	Calcium, Total		< 0.1		< 0.1				173	86.5	380
Nov-86	Chloride		< 1.0	< 1.0	< 1.0				4.6	15.3	15.1
Oct-83	Chloroform										
Apr-84	Chloroform										
Oct-84	Chloroform	< 0.010									
Jan-85	Chloroform	< 0.005									
Jun-85	Chloroform										
Jan-86	Chloroform										
Apr-86	Chloroform	< 0.005									
Nov-86	Chloroform		< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Nov-86	Chromium, Diss.		0.001	0.002	0.002				0.002	0.002	0.002
Oct-83	Chromium, Total										
Apr-84	Chromium, Total										
Oct-84	Chromium, Total										
Jan-85	Chromium, Total										
Jun-85	Chromium, Total										
Jan-86	Chromium, Total										
Apr-86	Chromium, Total										
Nov-86	Chromium, Total		0.004	0.007	0.002				0.009	0.123	0.009
Oct-83	Cis 1,2-Dichloroethene										
Apr-84	Cis 1,2-Dichloroethene										
Oct-84	Cis 1,2-Dichloroethene	< 0.010									
Jan-85	Cis 1,2-Dichloroethene										
Jun-85	Cis 1,2-Dichloroethene										
Jan-86	Cis 1,2-Dichloroethene										
Apr-86	Cis 1,2-Dichloroethene										
Nov-86	Cis 1,2-Dichloroethene		< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.19	0.34	< 0.005
Nov-86	Copper, Diss.		0.003	0.009	0.002				0.002	0.004	0.002
Oct-83	Copper, Total										
Apr 84	Copper, Total										
Oct-84	Copper, Total										
Jan-85	Copper, Total										
Jun-85	Copper, Total										
Jan-86	Copper, Total										
Apr 86	Copper, Total										
Nov-86	Copper, Total		0.005	0.004	0.007				0.019	0.181	0.046
Oct-83	Ethylbenzene										
Apr-84	Ethylbenzene										
Oct-84	Ethylbenzene	< 0.010									
Jan-85	Ethylbenzene	< 0.005									
Jun-85	Ethylbenzene										
Jan-86	Ethylbenzene										
Apr-86	Ethylbenzene	< 0.005									
Nov-86	Ethylbenzene		< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Nov-86	Lead, Diss.		0.002	< 0.001	0.002				0.003	0.003	0.003

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Date	Parameter	Blank	RinBlk1	RinBlk2	TrpBlk1	Trp Blk2	TrpBlk3	TrpBlk4	Dupl 1	Dupl 2	Dupl 3
Oct-83	Lead, Total										
Apr-84	Lead, Total										
Oct-84	Lead, Total										
Jan-85	Lead, Total										
Jun-85	Lead, Total										
Jan-86	Lead, Total										
Apr-86	Lead, Total	IS									
Nov-86	Lead, Total		0.009	< 0.001	0.007				0.033	0.049	0.048
Nov-86	Magnesium, Diss.		< 0.010	< 0.100	< 0.100				29.5	32.8	52.4
Nov-86	Manganese, Diss.		< 0.030	< 0.030	< 0.030				1.02	0.027	1.98
Oct-83	Manganese, Total										
Apr-84	Manganese, Total										
Oct-84	Manganese, Total										
Jan-85	Manganese, Total										
Jun-85	Manganese, Total										
Jan-86	Manganese, Total										
Apr-86	Manganese, Total	IS									
Nov-86	Manganese, Total		< 0.030	< 0.030	< 0.030				1.55	1.13	2.49
Nov-86	Mercury, Diss.		< 0.0004	< 0.0004	< 0.0004				< 0.0004	< 0.0004	< 0.0004
Oct-83	Mercury, Total										
Apr-84	Mercury, Total										
Oct-84	Mercury, Total										
Jan-85	Mercury, Total										
Jun-85	Mercury, Total										
Jan-86	Mercury, Total										
Apr-86	Mercury, Total										
Nov-86	Mercury, Total		< 0.0004	< 0.0004	< 0.0004				< 0.0004	< 0.0004	< 0.0004
Oct-83	Methylene Chloride										
Apr 84	Methylene Chloride										
Oct-84	Methylene Chloride	P 0.010									
Jan-85	Methylene Chloride	P 0.005									
Jun 85	Methylene Chloride										
Jan-86	Methylene Chloride										
Apr-86	Methylene Chloride	0.013									
Nov-86	Methylene Chloride		< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Nov-86	Nickel, Diss.		< 0.001	0.001	< 0.001				< 0.001	< 0.001	< 0.001
Oct-83	Nickel, Total										
Apr-84	Nickel, Total										
Oct-84	Nickel, Total										
Jan-85	Nickel, Total										
Jun-85	Nickel, Total										
Jan-86	Nickel, Total										
Apr-86	Nickel, Total										
Nov-86	Nickel, Total		0.017	0.003	0.010				0.033	0.155	0.033
Nov-86	Nitrate-Nitrogen		0.021		0.023				1.16	3.83	0.028
Oct-83	PCB 1242										
Apr-84	PCB 1242										
Oct 84	PCB 1242										
Jan-85	PCB 1242										
Jun-85	PCB 1242										
Jan-86	PCB 1242										
Apr-86	PCB 1242	IS									
Nov-86	PCB 1242										
Oct-83	PCB 1248										

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Date	Parameter	Blank	RinBlk1	RinBlk2	TrpBlk1	Trp Blk2	TrpBlk3	TrpBlk4	Dupl 1	Dupl 2	Dupl 3
Apr-84	PCB 1248										
Oct-84	PCB 1248										
Jan-85	PCB 1248										
Jun 85	PCB 1248										
Jan-86	PCB 1248										
Apr-86	PCB 1248	IS									
Nov-86	PCB 1248										
Oct-83	PCB 1254										
Apr-84	PCB 1254										
Oct-84	PCB 1254										
Jan-85	PCB 1254										
Jun-85	PCB 1254										
Jan-86	PCB 1254										
Apr-86	PCB 1254	IS									
Nov-86	PCB 1254										
Oct-83	PCB 1260										
Apr-84	PCB 1260										
Oct-84	PCB 1260										
Jan-85	PCB 1260										
Jun-85	PCB 1260										
Jan-86	PCB 1260										
Apr-86	PCB 1260	IS									
Nov-86	PCB 1260										
Nov-86	Potassium, Diss.		< 0.100	< 0.100	< 0.100				3.85	5.49	4.92
Nov 86	Selenium, Diss.		< 0.005	< 0.005	< 0.005				< 0.005	0.051	< 0.005
Nov-86	Selenium, Total		< 0.005	< 0.0050	< 0.005				< 0.005	0.035	< 0.005
Nov-86	Silver, Diss.		< 0.001	< 0.001	< 0.001				< 0.001	< 0.001	< 0.001
Oct-83	Silver, Total										
Apr-84	Silver, Total										
Oct-84	Silver, Total										
Jan-85	Silver, Total										
Jun 85	Silver, Total										
Jan-86	Silver, Total										
Apr-86	Silver, Total										
Nov-86	Silver, Total		< 0.001	< 0.001	< 0.001				0.003	< 0.001	< 0.001
Nov 86	Sodium, Diss.		< 0.100	< 0.100	< 0.100				6.27	25.1	10.6
Nov 86	Sulfates		< 10.0	< 8.0	< 10.0				96.5	43.0	319
Oct 83	Tetrachlorethene										
Apr-84	Tetrachlorethene										
Oct 84	Tetrachlorethene	< 0.010									
Jan-85	Tetrachlorethene	< 0.005									
Jun-85	Tetrachlorethene										
Jan 86	Tetrachlorethene										
Apr-86	Tetrachlorethene	< 0.005									
Nov-86	Tetrachlorethene		< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.14	< 0.005
Oct-83	TOC										
Apr-84	TOC										
Oct-84	TOC										
Jan-85	TOC										
Jun-85	TOC										
Jan-86	TOC										
Apr-86	TOC										
Nov-86	TOC										
Oct-83	Toluene										

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Date	Parameter	Blank	RinBlk1	RinBlk2	TrpBlk1	Trp Blk2	TrpBlk3	TrpBlk4	Dupl 1	Dupl 2	Dupl 3
Apr-84	Toluene										
Oct-84	Toluene	< 0.010									
Jan-85	Toluene	< 0.005									
Jun-85	Toluene										
Jan-86	Toluene										
Apr-86	Toluene	< 0.005									
Nov-86	Toluene		< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Oct-83	Trans 1,2-Dichloroethene										
Apr-84	Trans 1,2-Dichloroethene										
Oct-84	Trans 1,2-Dichloroethene	< 0.010									
Jan-85	Trans 1,2-Dichloroethene	< 0.005									
Jun-85	Trans 1,2-Dichloroethene										
Jan-86	Trans 1,2 Dichloroethene										
Apr-86	Trans 1,2-Dichloroethene	< 0.005									
Nov-86	Trans 1,2-Dichloroethene		< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.19	0.34	< 0.005
Oct-83	Trichloroethene										
Apr-84	Trichloroethene										
Oct-84	Trichloroethene	< 0.010									
Jan-85	Trichloroethene	< 0.005									
Jun-85	Trichloroethene										
Jan-86	Trichloroethene										
Apr-86	Trichloroethene	< 0.005									
Nov-86	Trichloroethene		< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.60	1.5	0.009
Nov-86	Trichlorofluoroethane		< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Nov-86	Zinc, Diss.		< 0.030	< 0.030	< 0.030				0.129	0.172	1.86
Oct-83	Zinc, Total										
Apr-84	Zinc, Total										
Oct-84	Zinc, Total										
Jan-85	Zinc, Total										
Jun-85	Zinc, Total										
Jan 86	Zinc, Total										
Apr-86	Zinc, Total	IS									
Nov-86	Zinc, Total		< 0.030	< 0.03	< 0.030				1.43	1.19	20.7

APPENDIX C

MAXIMUM AND MEAN CONCENTRATIONS DETECTED IN NIROP GROUND WATER ANALYSES

Parameter		1-S	1-D	1-PC	2-S	2-D	2-PC	3-S	3-D	3-PC	4-S	4-D	4-PC	5-S	5-D	6-S	6-D	7-S	7-D	8-S
	Count	1	1	1	1	1	1	2	1	1	1	1	0	1	0	1	0	0	0	0
Arsenic, Total	Maximum	0.0080	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	NA	0.0025	NA	0.0025	NA	NA	NA	NA
	Mean	0.0080	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	NA	0.0025	NA	0.0025	NA	NA	NA	NA
	Count	2	2	2	2	2	2	3	2	2	2	2	1	2	0	2	0	0	0	0
Cadmium, Total	Maximum	0.0085	0.0061	0.0024	0.0041	0.0031	0.0032	0.0076	0.0044	0.0092	0.0021	0.0029	0.0014	0.0068	NA	0.0062	NA	NA	NA	NA
	Mean	0.0051	0.0047	0.0021	0.0027	0.0023	0.0023	0.0033	0.0039	0.0053	0.0020	0.0022	0.0014	0.0043	NA	0.0040	NA	NA	NA	NA
	Count	2	2	2	2	2	2	3	2	2	2	2	1	2	0	2	0	0	0	0
Chromium, Total	Maximum	0.0370	0.0040	0.0140	0.0570	0.0050	0.0070	0.0200	0.0250	0.0190	0.0130	0.0080	0.0030	0.0130	NA	0.0400	NA	NA	NA	NA
	Mean	0.0240	0.0035	0.0125	0.0430	0.0045	0.0065	0.0133	0.0165	0.0110	0.0110	0.0065	0.0030	0.0095	NA	0.0335	NA	NA	NA	NA
	Count	2	2	2	2	2	2	3	2	2	2	2	1	2	0	2	0	0	0	0
Copper, Total	Maximum	0.0540	0.0560	0.0410	0.2140	0.0290	0.0190	0.0840	0.0530	0.0340	0.0410	0.0560	0.0005	0.0400	NA	0.0820	NA	NA	NA	NA
	Mean	0.0365	0.0330	0.0225	0.1370	0.0250	0.0155	0.0447	0.0350	0.0225	0.0340	0.0340	0.0005	0.0290	NA	0.0525	NA	NA	NA	NA
	Count	5	5	5	5	5	5	6	5	5	5	5	2	5	2	5	2	2	1	1
Lead, Total	Maximum	0.0910	0.0540	0.1700	0.3340	0.0300	0.0390	0.1710	0.0770	0.0460	0.0840	0.0440	0.0260	0.0220	0.1660	0.2940	0.1330	0.1070	0.0340	0.1540
	Mean	0.0374	0.0328	0.0673	0.1754	0.0198	0.0194	0.0647	0.0378	0.0216	0.0404	0.0272	0.0140	0.0174	0.1135	0.1404	0.0745	0.0580	0.0340	0.1540
	Count	4	4	4	4	4	4	5	4	4	4	4	2	4	2	4	2	2	1	1
Manganese, Total	Maximum	3.6800	0.1520	0.8440	6.9000	0.5160	0.4390	3.3600	0.1000	0.1390	1.8100	0.3620	0.4240	4.0900	0.3120	6.5400	0.5030	27.5000	0.6950	11.8000
	Mean	2.1450	0.0940	0.5813	4.1925	0.3230	0.2740	2.0680	0.0860	0.1065	0.7448	0.1948	0.4045	3.2500	0.2250	3.6625	0.4320	18.4000	0.6950	11.8000
	Count	1	1	1	1	1	1	2	1	1	1	1	0	1	0	1	0	0	0	0
Mercury, Total	Maximum	0.0002	0.0002	0.0002	0.0008	0.0002	0.0008	0.0013	0.0002	0.0002	0.0007	0.0004	NA	0.0002	NA	0.0008	NA	NA	NA	NA
	Mean	0.0002	0.0002	0.0002	0.0008	0.0002	0.0008	0.0008	0.0002	0.0002	0.0007	0.0004	NA	0.0002	NA	0.0008	NA	NA	NA	NA

Half the detection limit was used for constituents which were not detected.

Parameter		1-S	1-D	1-PC	2-S	2-D	2-PC	3-S	3-D	3-PC	4-S	4-D	4-PC	5-S	5-D	6-S	6-D	7-S	7-D	8-S
	Count	1	1	1	1	1	1	2	1	1	1	1	0	1	0	1	0	0	0	0
Nickel, Total	Maximum	0.0240	0.0300	0.0080	0.1070	0.0530	0.0050	0.0220	0.0100	0.0480	0.0170	0.0060	NA	0.0180	NA	0.0480	NA	NA	NA	NA
	Mean	0.0240	0.0300	0.0080	0.1070	0.0530	0.0050	0.0200	0.0100	0.0480	0.0170	0.0060	NA	0.0180	NA	0.0480	NA	NA	NA	NA
	Count	2	2	2	2	2	2	3	2	2	2	2	1	2	0	2	0	0	0	0
Silver, Total	Maximum	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0010	0.0005	0.0005	0.0010	0.0005	0.0005	0.0005	NA	0.0005	NA	NA	NA	NA
	Mean	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0007	0.0005	0.0005	0.0008	0.0005	0.0005	0.0005	NA	0.0005	NA	NA	NA	NA
	Count	5	5	5	5	5	5	6	5	5	5	5	2	5	2	5	2	2	1	1
Zinc, Total	Maximum	1.6800	9.2500	1.3100	3.9800	4.0700	1.4100	3.6400	7.6800	1.4300	6.2000	3.1300	1.3400	0.7810	6.0200	26.6000	5.5700	3.2500	10.4000	1.8100
	Mean	0.8026	5.2080	0.5946	2.4254	1.9182	0.5188	1.9770	3.7218	0.5404	2.8140	1.5594	0.6825	0.4834	5.0200	8.1600	3.9350	2.2050	10.4000	1.8100

Maximum and Mean Concentrations of Constituents Detected in NIROP Ground Water Analyses (mg/l)

Parameter		8-D	9-S	9-D	10-S	11-S	12-S	13-S	14-S	15-S	16-S	17-S	18-S	19-S	20-S	FMC-33
Arsenic, Total	Count	0	1	0	0	0	0	0	0	1	0	0	0	0	0	1
	Maximum	NA	0.0230	NA	NA	NA	NA	NA	NA	0.0450	NA	NA	NA	NA	NA	0.0025
	Mean	NA	0.0230	NA	NA	NA	NA	NA	NA	0.0450	NA	NA	NA	NA	NA	0.0025
Cadmium, Total	Count	0	1	0	0	0	0	0	0	1	0	0	0	0	0	2
	Maximum	NA	0.0034	NA	NA	NA	NA	NA	NA	0.0194	NA	NA	NA	NA	NA	0.0051
	Mean	NA	0.0034	NA	NA	NA	NA	NA	NA	0.0194	NA	NA	NA	NA	NA	0.0032
Chromium, Total	Count	0	1	0	0	0	0	0	0	1	0	0	0	0	0	2
	Maximum	NA	0.2670	NA	NA	NA	NA	NA	NA	0.0110	NA	NA	NA	NA	NA	0.0040
	Mean	NA	0.2670	NA	NA	NA	NA	NA	NA	0.0110	NA	NA	NA	NA	NA	0.0035
Copper, Total	Count	0	1	0	0	0	0	0	0	1	0	0	0	0	0	2
	Maximum	NA	0.3770	NA	NA	NA	NA	NA	NA	0.0890	NA	NA	NA	NA	NA	0.0320
	Mean	NA	0.3770	NA	NA	NA	NA	NA	NA	0.0890	NA	NA	NA	NA	NA	0.0200
Lead, Total	Count	1	3	1	2	2	1	1	1	2	1	1	1	1	1	5
	Maximum	0.1120	0.1740	0.0610	0.1090	0.0630	0.3660	0.0330	0.1010	0.1740	0.0730	0.0600	0.1200	0.0970	0.1520	0.0570
	Mean	0.1120	0.0877	0.0610	0.0745	0.0465	0.3660	0.0330	0.1010	0.1140	0.0730	0.0600	0.1200	0.0970	0.1520	0.0264
Manganese, Total	Count	1	3	1	2	2	1	1	1	2	1	1	1	1	1	4
	Maximum	0.8830	2.5400	0.5230	9.5900	5.0000	10.7000	1.8900	0.5320	2.4600	1.6400	1.4600	1.3800	0.6220	1.7100	0.9570
	Mean	0.8830	1.9700	0.5230	9.1650	3.6150	10.7000	1.8900	0.5320	2.2900	1.6400	1.4600	1.3800	0.6220	1.7100	0.6875
Mercury, Total	Count	0	1	0	0	0	0	0	0	1	0	0	0	0	0	1
	Maximum	NA	0.0002	NA	NA	NA	NA	NA	NA	0.0002	NA	NA	NA	NA	NA	0.0012
	Mean	NA	0.0002	NA	NA	NA	NA	NA	NA	0.0002	NA	NA	NA	NA	NA	0.0012

Half the detection limit was used for constituents which were not detected.

Parameter		8-D	9 S	9-D	10-S	11-S	12-S	13-S	14-S	15-S	16-S	17-S	18-S	19-S	20-S	FMC-33
	Count	0	1	0	0	0	0	0	0	1	0	0	0	0	0	1
Nickel, Total	Maximum	NA	0.3320	NA	NA	NA	NA	NA	NA	0.0390	NA	NA	NA	NA	NA	0.0030
	Mean	NA	0.3320	NA	NA	NA	NA	NA	NA	0.0390	NA	NA	NA	NA	NA	0.0030
	Count	0	1	0	0	0	0	0	0	1	0	0	0	0	0	2
Silver, Total	Maximum	NA	0.0010	NA	NA	NA	NA	NA	NA	0.0005	NA	NA	NA	NA	NA	0.0250
	Mean	NA	0.0010	NA	NA	NA	NA	NA	NA	0.0005	NA	NA	NA	NA	NA	0.0128
	Count	1	3	1	2	2	1	1	1	2	1	1	1	1	1	5
Zinc, Total	Maximum	14.9000	3.1500	4.4300	29.8000	1.4700	6.1100	6.1300	17.6000	25.4000	6.1100	4.5600	9.0800	3.2100	4.2500	4.0900
	Mean	14.9000	1.7667	4.4300	15.5900	1.2400	6.1100	6.1300	17.6000	21.4500	6.1100	4.5600	9.0800	3.2100	4.2500	2.0498

Half the detection limit was used for constituents which were not detected.

Maximum and Mean Concentrations of Constituents Detected in NIROP Ground Water (mg/l)

1254.01

Parameter		1-S	1-D	1-PC	2-S	2-D	2-PC	3-S	3-D	3-PC	4-S	4-D	4-PC	5-S	5-D	6-S	6-D	7-S	7-D
	Count	6	6	6	6	6	6	6	6	6	6	6	3	6	3	6	3	3	2
1,1,1-Trichloroethane	Maximum	0.0050	0.0050	0.0050	0.0058	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0025	0.1300	0.0025	0.0065	0.0025
	Mean	0.0038	0.0038	0.0038	0.0043	0.0038	0.0038	0.0038	0.0038	0.0038	0.0038	0.0038	0.0033	0.0038	0.0025	0.0616	0.0025	0.0047	0.0025
	Count	6	6	6	6	6	6	6	6	6	6	6	3	6	3	6	3	3	2
1,1-Dichloroethane	Maximum	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0260	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0025	0.0190	0.0025	0.0025	0.0025
	Mean	0.0038	0.0038	0.0038	0.0038	0.0038	0.0038	0.0093	0.0038	0.0038	0.0038	0.0038	0.0033	0.0038	0.0025	0.0065	0.0025	0.0025	0.0025
	Count	6	6	6	6	6	6	6	6	6	6	6	3	6	3	6	3	3	2
1,1-Dichloroethene	Maximum	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0025	0.0050	0.0025	0.0025	0.0025
	Mean	0.0038	0.0038	0.0038	0.0038	0.0038	0.0038	0.0038	0.0038	0.0038	0.0038	0.0038	0.0033	0.0038	0.0025	0.0038	0.0025	0.0025	0.0025
	Count	6	6	6	6	6	6	6	6	6	6	6	3	6	3	6	3	3	2
Benzene	Maximum	0.0050	0.0220	0.0210	0.0050	0.0050	0.0230	0.0050	0.0050	0.0140	0.0061	0.0050	0.0050	0.0059	0.0025	0.0100	0.0025	0.0025	0.0025
	Mean	0.0038	0.0066	0.0064	0.0038	0.0038	0.0072	0.0038	0.0038	0.0068	0.0044	0.0038	0.0033	0.0043	0.0025	0.0050	0.0025	0.0025	0.0025
	Count	4	4	4	4	4	4	4	4	4	4	4	1	4	1	4	1	1	0
Bis(2ethylhexyl)Phthalate	Maximum	0.0180	0.0050	0.0060	0.0840	0.0840	0.0300	0.1400	0.0580	0.0230	0.0180	0.0730	0.0059	0.0160	0.0036	0.2200	0.0030	0.0009	NA
	Mean	0.0056	0.0021	0.0028	0.0222	0.0226	0.0088	0.0379	0.0167	0.0081	0.0064	0.0200	0.0059	0.0074	0.0036	0.0564	0.0030	0.0009	NA
	Count	6	6	6	6	6	6	6	6	6	6	6	3	6	3	6	3	3	2
Chloroform	Maximum	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0025	0.0050	0.0025	0.0025	0.0025
	Mean	0.0038	0.0038	0.0038	0.0038	0.0038	0.0038	0.0038	0.0038	0.0038	0.0038	0.0038	0.0033	0.0038	0.0025	0.0038	0.0025	0.0025	0.0025
	Count	3	3	3	3	3	3	3	3	3	3	3	1	3	1	3	1	1	1
Cis 1,2-Dichloroethene	Maximum	0.0050	0.0050	0.0050	0.0050	0.0050	0.0240	0.2900	0.0050	0.0050	0.0050	0.0050	0.0025	0.0050	0.0025	0.5800	0.0025	0.0025	0.0025
	Mean	0.0042	0.0042	0.0042	0.0042	0.0042	0.0105	0.1500	0.0042	0.0042	0.0042	0.0042	0.0025	0.0042	0.0025	0.2490	0.0025	0.0025	0.0025

Half the detection limit was used for constituents which were not detected.

21-Apr-87

Parameter		1-S	1-D	1-PC	2-S	2-D	2-PC	3-S	3-D	3-PC	4-S	4-D	4-PC	5-S	5-D	6-S	6-D	7-S	7-D
	Count	6	6	6	6	6	6	6	6	6	6	6	3	6	3	6	3	3	2
Ethylbenzene	Maximum	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0370	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0025	0.0050	0.0025	0.0025	0.0025
	Mean	0.0038	0.0038	0.0038	0.0038	0.0038	0.0038	0.0131	0.0038	0.0038	0.0038	0.0038	0.0033	0.0038	0.0025	0.0038	0.0025	0.0025	0.0025
	Count	6	6	6	6	6	6	6	6	6	6	6	3	6	3	6	3	3	2
Methylene Chloride	Maximum	0.3000	0.1100	0.1600	41.0000	0.8300	6.0000	0.1300	0.0300	0.1100	0.8000	0.4400	0.0190	0.0290	0.0025	0.0700	0.0025	0.0025	0.0025
	Mean	0.0551	0.0312	0.0328	6.8408	0.1435	1.0397	0.0397	0.0075	0.0241	0.1482	0.0772	0.0088	0.0092	0.0025	0.0185	0.0025	0.0025	0.0025

Maximum and Mean Concentrations of Constituents Detected in NIROP Ground Water (mg/l)

1254.01

Parameter		8-S	8-D	9-S	9-D	10-S	11-S	12-S	13-S	14-S	15-S	16-S	17-S	18-S	19-S	20-S	FMC-33
	Count	2	2	3	2	3	3	2	2	2	2	2	2	2	2	2	6
1,1,1-Trichloroethane	Maximum	0.0390	0.0025	0.3900	0.0086	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0050
	Mean	0.0285	0.0025	0.2667	0.0056	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0038
	Count	2	2	3	2	3	3	2	2	2	2	2	2	2	2	2	6
1,1-Dichloroethane	Maximum	0.0073	0.0025	0.0660	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0270
	Mean	0.0049	0.0025	0.0540	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0113
	Count	2	2	3	2	3	3	2	2	2	2	2	2	2	2	2	6
1,1-Dichloroethene	Maximum	0.0025	0.0025	0.0092	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0050
	Mean	0.0025	0.0025	0.0058	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0038
	Count	2	2	3	2	3	3	2	2	2	2	2	2	2	2	2	6
Benzene	Maximum	0.0025	0.0052	0.0025	0.0050	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0065	0.0025	0.0025	0.0025	0.0100
	Mean	0.0025	0.0039	0.0025	0.0038	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0045	0.0025	0.0025	0.0025	0.0053
	Count	1	0	1	0	1	1	0	0	0	0	0	0	0	0	0	4
Bis(2ethylhexyl)Phthalate	Maximum	0.0000	NA	0.0000	NA	0.0003	0.0008	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.0790
	Mean	0.0000	NA	0.0000	NA	0.0003	0.0008	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.0230
	Count	2	2	3	2	3	3	2	2	2	2	2	2	2	2	2	6
Chloroform	Maximum	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0050
	Mean	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0038
	Count	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	3
Cis 1,2-Dichloroethene	Maximum	0.2400	0.0480	0.3400	0.0280	0.0360	0.0220	0.0025	0.0025	0.0025	0.0025	0.0025	0.0270	0.3300	0.0025	0.0025	0.2300
	Mean	0.2400	0.0480	0.3400	0.0280	0.0360	0.0220	0.0025	0.0025	0.0025	0.0025	0.0025	0.0270	0.3300	0.0025	0.0025	0.1453

Half the detection limit was used for constituents which were not detected.

21-Apr-87

Parameter		8-S	8-D	9-S	9-D	10-S	11-S	12-S	13-S	14-S	15-S	16-S	17 S	18-S	19-S	20-S	FMC-33
	Count	2	2	3	2	3	3	2	2	2	2	2	2	2	2	2	6
Ethylbenzene	Maximum	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.2100
	Mean	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0655
	Count	2	2	3	2	3	3	2	2	2	2	2	2	2	2	2	6
Methylene Chloride	Maximum	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0056	0.0025	0.0025	0 0025	0.0025	0.0025	0.1200
	Mean	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0041	0.0025	0.0025	0.0025	0.0025	0.0025	0.0311

Maximum and Mean Concentrations of Constituents Detected in NIROP Ground Water Analysis (mg/l) 1254.01

Parameter		1-S	1-D	1-PC	2-S	2-D	2-PC	3-S	3-D	3-PC	4-S	4-D	4-PC	5-S	5-D	6-S	6-D	7-S	7-D	8-S
	Count	5	5	5	5	5	5	5	5	5	5	5	2	5	2	5	2	2	1	1
PCB 1242	Maximum	0.00050	0.00020	0.00030	0.00010	0.00010	0.00050	0.00010	0.00020	0.00030	0.00020	0.00010	0.00010	0.00040	0.00010	0.00020	0.00010	0.00010	0.00010	0.00010
	Mean	0.00017	0.00011	0.00013	0.00009	0.00009	0.00017	0.00009	0.00011	0.00013	0.00011	0.00009	0.00008	0.00015	0.00010	0.00011	0.00010	0.00010	0.00010	0.00010
	Count	5	5	5	5	5	5	5	5	5	5	5	2	5	2	5	2	2	1	1
PCB 1248	Maximum	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00040	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010
	Mean	0.00009	0.00009	0.00009	0.00009	0.00009	0.00009	0.00009	0.00009	0.00017	0.00009	0.00009	0.00008	0.00009	0.00010	0.00009	0.00010	0.00010	0.00010	0.00010
	Count	5	5	5	5	5	5	5	5	5	5	5	2	5	2	5	2	2	1	1
PCB 1254	Maximum	0.00075	0.00050	0.00030	0.00110	0.00020	0.00050	0.00070	0.00030	0.00030	0.00040	0.00010	0.00010	0.00020	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010
	Mean	0.00023	0.00017	0.00013	0.00029	0.00011	0.00017	0.00021	0.00013	0.00013	0.00015	0.00009	0.00008	0.00011	0.00010	0.00009	0.00010	0.00010	0.00010	0.00010
	Count	5	5	5	5	5	5	5	5	5	5	5	2	5	2	5	2	2	1	1
PCB 1260	Maximum	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00055	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010
	Mean	0.00009	0.00009	0.00009	0.00009	0.00009	0.00009	0.00009	0.00009	0.00009	0.00009	0.00018	0.00008	0.00009	0.00010	0.00009	0.00010	0.00010	0.00010	0.00010

Half the detection limit was used for constituents which were not detected.

21-Apr-87

Parameter		8-D	9-S	9-D	10-S	11-S	12-S	13-S	14-S	15-S	16-S	17-S	18-S	19-S	20-S	FMC-33
	Count	1	2	1	2	2	1	0	1	1	1	1	1	1	1	5
PCB 1242	Maximum	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	NA	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010
	Mean	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	NA	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00009
	Count	1	2	1	2	2	1	0	1	1	1	1	1	1	1	5
PCB 1248	Maximum	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	NA	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010
	Mean	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	NA	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00009
	Count	1	2	1	2	2	1	0	1	1	1	1	1	1	1	5
PCB 1254	Maximum	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	NA	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010
	Mean	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	NA	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00009
	Count	1	2	1	2	2	1	0	1	1	1	1	1	1	1	5
PCB 1260	Maximum	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	NA	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010
	Mean	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	NA	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00009

Parameter		1-S	1-D	1-PC	2-S	2-D	2-PC	3-S	3-D	3-PC	4-S	4-D	4-PC	5-S	5-D	6-S	6-D	7-S	7-D	8-S
	Count	6	6	6	6	6	6	6	6	6	6	6	3	6	3	6	3	3	2	2
Tetrachloroethene	Maximum	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0170	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0025	0.2000	0.0025	0.0025	0.0025	0.0460
	Mean	0.0038	0.0038	0.0038	0.0038	0.0038	0.0038	0.0071	0.0038	0.0038	0.0038	0.0038	0.0033	0.0038	0.0025	0.0554	0.0025	0.0025	0.0025	0.0460
	Count	2	2	2	1	2	2	2	2	2	2	2	1	2	0	2	0	0	0	0
TOC	Maximum	22.80	642.00	51.80	57.00	7.40	15.90	16.10	3.50	6.60	10.10	30.70	2.30	649.00	NA	27.60	NA	NA	NA	NA
	Mean	16.25	322.35	30.85	57.00	6.10	9.45	15.65	2.60	4.90	9.60	15.85	2.30	331.25	NA	20.40	NA	NA	NA	NA
	Count	6	6	6	6	6	6	6	6	6	6	6	3	6	3	6	3	3	2	2
Toluene	Maximum	0.0050	0.0120	0.0110	0.0050	0.0050	0.0200	0.0050	0.0072	0.0140	0.0050	0.0061	0.0140	0.0050	0.0025	0.0050	0.0025	0.0025	0.0025	0.0025
	Mean	0.0038	0.0062	0.0052	0.0038	0.0038	0.0067	0.0038	0.0045	0.0063	0.0038	0.0044	0.0072	0.0038	0.0025	0.0038	0.0025	0.0025	0.0025	0.0025
	Count	6	6	6	6	6	6	6	6	6	6	6	3	6	3	6	3	3	2	2
Trans 1,2-Dichloroethene	Maximum	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.2900	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0025	0.5800	0.0025	0.0025	0.0025	0.2400
	Mean	0.0038	0.0038	0.0038	0.0038	0.0038	0.0038	0.1320	0.0038	0.0038	0.0038	0.0038	0.0033	0.0038	0.0025	0.1728	0.0025	0.0025	0.0025	0.2150
	Count	6	6	6	6	6	6	6	6	6	6	6	3	6	3	6	3	3	2	2
Trichloroethene	Maximum	0.0050	0.0050	0.0050	0.1300	0.0092	0.0620	28.0000	0.0230	0.0810	0.0190	0.0050	0.0050	0.0050	0.0025	3.8000	0.0110	0.1500	0.0025	9.2000
	Mean	0.0038	0.0038	0.0038	0.0755	0.0053	0.0208	6.0717	0.0140	0.0291	0.0065	0.0038	0.0033	0.0038	0.0025	1.3321	0.0079	0.1380	0.0025	6.6000

Half the detection limit was used for constituents which were not detected.

Maximum and Mean Concentrations of Constituents Detected in NIROP Ground Water (mg/l)

Parameter		8-D	9-S	9-D	10-S	11-S	12-S	13-S	14-S	15-S	16-S	17-S	18 S	19-S	20 S	FMC-33
	Count	2	3	2	3	3	2	2	2	2	2	2	2	2	2	6
Tetrachlorethene	Maximum	0.0025	0.2200	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0240
	Mean	0.0025	0.1833	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0074
	Count	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
TOC	Maximum	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	4.50
	Mean	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	4.05
	Count	2	3	2	3	3	2	2	2	2	2	2	2	2	2	6
Toluene	Maximum	0.0025	0.0025	0.0082	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0050
	Mean	0.0025	0.0025	0.0054	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0038
	Count	2	3	2	3	3	2	2	2	2	2	2	2	2	2	6
Trans 1,2-Dichloroethene	Maximum	0.0480	0.5100	0.0280	0.0360	0.0360	0.0025	0.0025	0.0025	0.0025	0.0025	0.0440	4.7000	0.0025	0.0025	0.2300
	Mean	0.0435	0.4500	0.0205	0.0210	0.0307	0.0025	0.0025	0.0025	0.0025	0.0025	0.0355	2.5150	0.0025	0.0025	0.1277
	Count	2	3	2	3	3	2	2	2	2	2	2	2	2	2	6
Trichloroethene	Maximum	10.7000	4.2000	0.6500	0.2100	0.0440	0.0025	0.0025	0.0025	0.0170	0.1700	0.1900	2.9000	0.0880	0.0025	37.0000
	Mean	8.2000	3.0667	0.4500	0.1647	0.0370	0.0025	0.0025	0.0025	0.0121	0.1330	0.1435	2.2150	0.0650	0.0025	7.9167

Half the detection limit was used for constituents which were not detected.

APPENDIX D

CONSTITUENTS ADDED NOVEMBER 1986

Constituents Added Nov-86

Maximum and Mean Concentrations of Constituents Detected in NIROP Ground Water Analysis (mg/l)

Date	Parameter	1-S	1-D	1-PC	2-S	2-D	2-PC	3-S	3-D	3-PC	4-S	4-D	4-PC	5-S	5-D	6-S	6-D	7-S
Nov-86	2-Butanone	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Nov-86	Alkalinity	333	231	234	569	268	8.5	481	302	239	242	258	233	497	383	456	260	533
Nov-86	Arsenic, Diss.	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Nov-86	Barium, Diss	0.080	0.040	0.119	0.105	0.075	0.051	0.165	0.074	0.034	0.058	0.099	0.093	0.061	0.080	0.077	0.092	0.060
Nov-86	Barium, Total							0.088										
Nov-86	Cadmium, Diss.	< 0.0001	0.0004	0.0008	0.0006	< 0.0001	0.0005	0.0003	0.0004	0.0005	0.0006	0.0002	0.0005	0.0009	< 0.0001	0.0004	< 0.0001	0.0008
Nov-86	Calcium, Diss.	101	86.0	81.5	169	110	21.1	157	115	110	64.9	99.3	90.4	186	117	145	102	216
Nov-86	Calcium, Total							169										
Nov-86	Chloride	19.5	30.9	58.4	4.5	41.7	59.7	4.8	22.6	31.7	4.2	72.6	75.6	50.0	3.2	32.7	72.5	18.7
Nov-86	Chromium, Diss.	0.005	0.002	0.002	0.003	0.001	0.002	0.003	0.001	0.002	0.002	0.001	< 0.001	0.002	0.002	< 0.001	< 0.001	0.002
Nov-86	Copper, Diss.	0.004	< 0.001	0.005	0.008	< 0.001	0.003	0.003	0.006	0.003	0.009	< 0.001	0.002	0.004	< 0.001	< 0.001	0.009	0.003
Nov-86	Lead, Diss.	< 0.001	< 0.001	0.002	0.001	< 0.001	0.003	0.002	< 0.001	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.002	0.003	0.002
Nov-86	Magnesium, Diss.	20.2	38.8	45.0	38.6	51.6	10.7	30.1	43.5	54.9	21.5	48.4	45.9	43.5	61.4	39.4	47.6	27.3
Nov-86	Manganese, Diss.	1.07	0.090	0.046	0.198	0.392	0.002	1.04	0.076	0.052	0.005	0.362	0.210	0.593	0.100	0.564	0.330	1.01
Nov-86	Mercury, Diss.	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004
Nov-86	Nickel, Diss.	0.009	0.003	< 0.001	0.005	0.002	0.007	< 0.001	0.004	< 0.001	0.009	< 0.001	0.014	0.012	< 0.001	0.025	0.043	0.072
Nov-86	Nitrate-Nitrogen			0.209	1.37		0.160	1.17		0.060	6.56		0.106	2.66			0.036	3.29
Nov-86	Potassium, Diss.	3.92	2.20	3.28	3.69	2.67	36.8	3.85	2.20	2.62	2.79	2.43	3.52	4.67	2.74	4.00	2.34	2.83
Nov-86	Selenium, Diss.	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Nov-86	Selenium, Total							< 0.005										
Nov-86	Silver, Diss.	0.005	0.003	0.002	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.003	< 0.001	< 0.001	< 0.001
Nov-86	Sodium, Diss.	14.3	5.85	12.9	5.99	6.06	34.0	7.83	4.81	5.68	11.5	13.5	10.2	18.0	3.57	26.0	15.0	6.77
Nov-86	Sulfates	77.5	129	96.0	56.3	184	130	97.0	203	304	45.2	148	85.9	192	184	172	176	148
Nov-86	Trichlorofluoromethane	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.0077	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Nov-86	Zinc, Diss.	0.133	1.25	0.068	0.851	0.660	< 0.030	0.131	0.842	0.357	0.634	0.492	0.086	0.601	0.687	0.909	0.823	1.05

Maximum and Mean Concentrations of Constituents Detected in NIRBP Ground Water Analysis (mg/l)

Date	Parameter	7-D	8-S	8-D	9-S	9-D	10-S	11-S	12-S	13-S	14-S	15-S	16-S	17-S	18-S	19-S	20-S	FMC-33
Nov-86	2-Butanone	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Nov-86	Alkalinity	303	469	267	436	362	493	426	417	374	383	477	395	458	302	264	190	504
Nov-86	Arsenic, Diss.	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.014	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Nov-86	Barium, Diss	0.111	0.072	0.090	0.109	0.061	0.079	0.106	0.064	0.093	0.093	0.136	0.068	0.050	0.095	0.032	0.055	0.128
Nov-86	Barium, Total				0.986							0.172						
Nov-86	Cadmium, Diss.	0.0002	0.0009	0.0003	0.0006	0.0007	0.0006	< 0.0001	0.0010	0.0011	0.0021	0.0008	0.0010	0.0006	0.0005	0.0024	0.0009	0.0004
Nov-86	Calcium, Diss.	113	134	113	133	122	143	158	126	154	190	159	108	170	157	86.0	66.0	208
Nov-86	Calcium, Total				154							207						
Nov-86	Chloride	36.0	5.9	47.7	15.2	42.9	36.6	23.2	45.7	13.7	58.8	15.0	4.6	25.6	26.6	54.6	15.3	12.9
Nov-86	Chromium, Diss.	0.002	0.002	0.002	0.003	0.002	0.003	0.001	< 0.001	< 0.001	< 0.001	0.002	0.001	0.003	0.002	0.002	0.001	0.001
Nov-86	Copper, Diss.	0.004	0.003	0.002	0.005	0.002	0.005	0.002	0.002	0.006	0.002	0.002	0.004	0.003	0.003	0.004	0.004	0.002
Nov-86	Lead, Diss.	0.002	< 0.001	0.002	0.003	0.011	0.005	< 0.001	0.001	0.005	0.004	0.003	0.003	0.005	0.004	0.009	0.004	0.003
Nov-86	Magnesium, Diss.	52.4	33.0	54.9	33.0	49.2	50.8	58.1	33.8	36.9	33.8	53.4	29.0	54.9	54.1	18.0	17.2	53.4
Nov-86	Manganese, Diss.	0.403	1.94	0.700	0.026	0.142	1.58	0.003	1.20	1.50	0.076	1.96	1.04	0.388	0.920	0.034	0.088	1.00
Nov-86	Mercury, Diss.	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004	< 0.0004
Nov-86	Nickel, Diss.	< 0.001	0.054	< 0.001	< 0.001	0.001	0.032	0.004	0.006	0.013	0.037	< 0.001	0.005	0.003	< 0.001	< 0.001	0.004	< 0.001
Nov-86	Nitrate-Nitrogen	0.031	1.69	0.022	3.92	0.221	0.205	0.803	6.05	2.09	17.0	0.028	0.110	2.02	0.016	2.74	0.434	0.020
Nov-86	Potassium, Diss.	4.75	3.74	4.31	5.49	3.52	3.67	3.97	3.67	3.06	1.92	4.92	3.28	3.85	2.87	2.22	2.22	3.36
Nov-86	Selenium, Diss.	< 0.005	< 0.005	< 0.005	0.049	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.008	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Nov-86	Selenium, Total				0.074							< 0.005						
Nov-86	Silver, Diss.	< 0.001	0.002	< 0.001	< 0.001	0.002	< 0.001	< 0.001	0.001	< 0.001	< 0.001	0.001	0.003	< 0.001	0.002	0.002	< 0.001	< 0.001
Nov-86	Sodium, Diss.	9.36	6.89	11.0	28.2	19.5	16.5	7.44	17.1	6.50	5.77	10.6	4.14	16.8	8.18	41.1	9.15	7.19
Nov-86	Sulfates	251	183	272	91.7	189	224	363	56.4	218	164	318	59.5	333	422	26.8	72.4	321
Nov-86	Trichlorofluoromethane	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Nov-86	Zinc, Diss.	1.23	4.42	1.03	0.184	1.07	0.735	0.246	3.81	3.03	3.25	1.84	2.87	2.21	4.71	3.78	3.10	0.526

Constituents Added Nov-86

Maximum and Mean Concentrations of Constituents Detected in NIRDP Ground Water Analysis (mg/l)

Date	Parameter	Blank	RinBlk1	RinBlk2	TrpBlk1	Trp Blk2	TrpBlk3	TrpBlk4	Dupl 1	Dupl 2	Dupl 3
Nov-86	2-Butanone		< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Nov-86	Alkalinity		< 5.0	< 5.0	< 5.0				484	437	476
Nov-86	Arsenic, Diss.		< 0.005	< 0.005	< 0.005				< 0.005	< 0.005	0.013
Nov-86	Barium, Diss		< 0.010	< 0.010	< 0.010				0.152	0.115	0.147
Nov-86	Barium, Total		< 0.010	< 0.010	< 0.010				0.194	0.514	0.160
Nov-86	Cadmium, Diss.		0.0004	< 0.0001	0.0002				0.0003	0.0004	0.0008
Nov-86	Calcium, Diss.		< 0.100	< 0.100	< 0.100				157	128	157
Nov-86	Calcium, Total		< 0.1		< 0.1				173	86.5	380
Nov-86	Chloride		< 1.0	< 1.0	< 1.0				4.6	15.3	15.1
Nov-86	Chromium, Diss.		0.001	0.002	0.002				0.002	0.002	0.002
Nov-86	Copper, Diss.		0.003	0.009	0.002				0.002	0.004	0.002
Nov-86	Lead, Diss.		0.002	< 0.001	0.002				0.003	0.003	0.003
Nov-86	Magnesium, Diss.		< 0.010	< 0.100	< 0.100				29.5	32.8	52.4
Nov-86	Manganese, Diss.		< 0.030	< 0.030	< 0.030				1.02	0.027	1.98
Nov-86	Mercury, Diss.		< 0.0004	< 0.0004	< 0.0004				< 0.0004	< 0.0004	< 0.0004
Nov-86	Nickel, Diss.		< 0.001	0.001	< 0.001				< 0.001	< 0.001	< 0.001
Nov-86	Nitrate-Nitrogen		0.021		0.023				1.16	3.83	0.028
Nov-86	Potassium, Diss.		< 0.100	< 0.100	< 0.100				3.85	5.49	4.92
Nov-86	Selenium, Diss.		< 0.005	< 0.005	< 0.005				< 0.005	0.051	< 0.005
Nov-86	Selenium, Total		< 0.005	< 0.0050	< 0.005				< 0.005	0.035	< 0.005
Nov-86	Silver, Diss.		< 0.001	< 0.001	< 0.001				< 0.001	< 0.001	< 0.001
Nov-86	Sodium, Diss.		< 0.100	< 0.100	< 0.100				6.27	25.1	10.6
Nov-86	Sulfates		< 10.0	< 8.0	< 10.0				96.5	43.0	319
Nov-86	Trichlorofluoromethane		< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Nov-86	Zinc, Diss.		< 0.030	< 0.030	< 0.030				0.129	0.172	1.86

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PRELIMINARY SUBMITTAL OF
FEASIBILITY STUDY TASK #10

FOR
NAVAL INDUSTRIAL RESERVE ORDNANCE PLANT
FRIDLEY, MINNESOTA

JULY 1987
CONTRACT NO. DACA 45-86-C-0015
MODIFICATION NO. P00002

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1254.04 106:RTA:frid0623

TABLE OF CONTENTS

Title	Page
1. INTRODUCTION	1
2. PURPOSE	2
3. CONSTITUENTS OF CONCERN	3
3.1 Metals	3
3.2 PCBs	4
3.3 Organics	4
4. CONTAMINATED MEDIA	7
5. RESPONSE OBJECTIVES	8
6. REMEDIAL ALTERNATIVES	13
7. REFERENCES	22

List of Figures

Figure 1 - Potential Remedial Technologies/Alternatives for the NIROP 14

1. INTRODUCTION

RMT recently completed two reports for the COE concerning the Naval Industrial Reserve Ordnance Plant (NIROP) at Fridley, Minnesota:

- Remedial Investigation Report for Remedial Investigation/ Feasibility Study at Naval Industrial Reserve Ordnance Plant, Fridley, Minnesota. June 1987.

- Interim Report for RI/FS at NIROP, Fridley, Minnesota. May 1987.

These reports summarized existing information related to the NIROP site and surrounding areas which was developed by other consultants, the Corps of Engineers, and RMT. The information and data were then used to describe the site conditions, to identify potential chemical constituents of concern, and to prepare a proposed workplan for additional investigations on and around the NIROP site.

2. PURPOSE

The purpose of this preliminary submittal of Feasibility Study (FS) Task #10 is to develop a preliminary listing and description of site-specific remedial alternatives for review by the Minnesota Pollution Control Agency (MPCA) prior to further development and screening of the alternatives. Comments on FS Task #10 received from the MPCA will be addressed during preparation of FS Task #11 - Initial Screening of Remedial Alternatives. FS Task #11 will also be submitted to the MPCA for review and comments prior to preparation of the complete FS Report.

3. CONSTITUENTS OF CONCERN

Based on information presented in the two reports identified above, the potential constituents of concern may be grouped into three categories: metals, PCBs, and organics. Specific compounds or elements within each category have been detected in soil and/or ground water at the NIROP site. Major findings of the RI Report and the Interim Report related to these constituents are summarized as follows:

3.1 Metals

1. Relatively high concentrations of several metals were detected in the residuals removed from drums which were excavated from the pit/trench area in 1983.

   However, residual concentrations in the unexcavated soils sampled at the bottom of the pit/trench areas are generally consistent with "typical" soil concentrations. Therefore, metals were not considered when developing and screening treatment technologies for soil.

2. Ground water samples collected during most investigations at the NIROP were not filtered in the field prior to analysis; only the November 1986 round of samples was filtered in the field. Prior to November 1986, only total concentrations (unfiltered samples) were reported and the data suggested that significant concentrations of hazardous inorganic constituents could be found in the ground water. The samples collected in November 1986 had total concentrations fairly consistent with previous results. However, dissolved concentrations were considerably lower, indicative of the fact that much of the inorganic concentrations were associated with sediment in the samples. Sediment is not transported by ground water and is not generally consumed. In fact, only three constituents exceeded federal standards when dissolved concentrations were considered: manganese, sulfate, and selenium. Of these constituents, manganese and sulfate both exhibited concentrations in excess of Secondary Maximum Contaminant Levels (SMCLs) in background wells as well as downgradient wells.

   Selenium in a sample from well 9-S (0.049 mg/l) is the only dissolved inorganic constituent detected in ground water above a Maximum Contaminant Level (MCL). The MCL and Maximum Contaminant Level Goal (MCLG) for selenium are 0.010 and 0.045 mg/l, respectively. Well 9-S is located along the eastern (upgradient) edge of the NIROP facility. Thus, it is possible that the selenium

detected in well 9-S may be related to an off-site source. Selenium (total or dissolved) has only been analyzed in one sampling round (November 1986). Additional sampling would be required to increase the certainty in any interpretation of selenium occurrence.

3.2 PCBs

1. PCBs have been detected in drums excavated from the pit/trench area. Residual concentrations in the unexcavated soils were less than 1 mg/kg (1 ppm).

2. PCBs have been reported in ground water samples during 1984, 1985, and 1986. However, the reported levels are generally less than 1 ug/l (1 ppb), at or near the analytical detection limit, and show inconsistent identification of the Aroclors detected. Based on the above results, the occurrence of PCBs was not considered significant when developing and screening treatment technologies.

3.3 Organics

Several organics have been detected in excavated drums, soil, and ground water at the NIROP site.

1. Organics detected in drums excavated from the pit/trench area include benzene, alkylated benzenes, cresols, isopropanol, methyl ethyl ketone (MEK), naphthalene, toluene, trichloroethylene (TCE), and xylenes.

2. Based on the results of unsaturated zone soil samples from one foot below the pit/trench bottoms, residual VOC concentrations beneath the excavated pit/trench areas were reported as generally less than 1 mg/kg total VOC. However, trenches 3, 6, and 7 contained higher concentrations. Subsequent analyses of trenches 3 and 6 indicated that, although 34 samples had total VOCs of less than 1 ppm, samples from two soil borings in trench 3 had total VOCs greater than 100 mg/kg. TCE was the predominant organic, with PCE, toluene, and 1,1,1-trichloroethane also present.

3. Organic constituents have been analyzed in samples from all eight ground water monitoring rounds. However, the same constituents have not been analyzed in all the rounds. The four constituents that appear to be of concern include the following:

- Benzene was analyzed in all eight sampling rounds and detected in 19 percent of the samples (although it was not always quantifiable). Reported values exceed the MCL of 0.005 mg/l in 10 of the 34 monitoring wells.

- 1,2-Dichloroethylene was analyzed in three sampling rounds. In the November 1986 round, it was reported in samples from 11 wells, ranging from 0.022 to 0.53 mg/l. The proposed MCLG of 0.07 mg/l was exceeded in samples from six wells.

- Tetrachloroethylene (PCE) was analyzed in all eight sampling rounds. The concentrations have generally decreased since completion of the remedial actions in the pit/trench areas. However, levels have remained relatively constant and high in samples from wells 6-S and 9-S (located near the southwest corner of the main NIROP building and near the eastern boundary of the property, respectively). The proposed MCLG for PCE is zero.

- Trichloroethylene (TCE) was analyzed in samples from all eight sampling rounds. Over one-half (22 of 34 wells) of the monitoring wells have had samples which exceeded the MCL of 0.005 mg/l at least one time. The highest concentrations have been associated with the following wells:

  - FMC-33 (Pit/Trench Area)
  - 3-S (Pit/Trench Area)
  - 6-S (Southwestern Edge of Property)
  - 8-D (Downgradient and Off-Site)
  - 8-S (Pit/Trench Area)
  - 9-S (Eastern Edge of Property)
  - 18-S (Downgradient and Off-Site)

There are 34 ground water monitoring wells at the facility at this time. After eight rounds of sampling, the results indicate the following for TCE:

- It was reported in more samples than any other organic compound.

- The reported values exceeded the MCL in more samples than any other organic compound.

- It was reported at a concentration greater than that reported for any other organic compound.

- 22 of the 34 monitoring wells have had samples which reportedly exceed the MCL.

- There are only 3 wells where the TCE MCL was not exceeded but another organic compound MCL or MCLG was exceeded.

Based on the findings described above, TCE was chosen as the primary chemical constituent of concern for several reasons. First, it was the most frequently detected chemical. Second, it has been reported at relatively high concentrations. Third, it was normally reported whenever another organic was reported. Fourth, the physical, chemical, and thermal properties of the other organics that have been detected are similar to those of TCE. Therefore, the remediation technologies that were developed and screened (as described in the Interim Report, May 1987) addressed the containment, removal, treatment, and disposal of the organic compounds observed at the facility as well as TCE.

4. CONTAMINATED MEDIA

Based on information from the two reports described in the previous section, two types of media and several areas of contamination will be considered when developing the remedial alternatives. The types of media and areas of contamination include ground water beneath the entire NIROP facility and VOC-contaminated soil beneath trench 3.

At the present time, the existing information is not sufficient to define the potential presence and extent of residual or continuing contamination of soil and ground water by organics in several additional areas at the NIROP. These areas include the following:

- The pit/trench area north of the NIROP plant.
- Two underground tanks near monitoring well 9-S.
- Plant storm sewers discharging to the Mississippi River on the west side of the NIROP building.
- A potential TCE source near the southwestern corner of the NIROP building.
- Sources of ground water contamination off the NIROP property.

The "Conceptual Workplan for Additional Field Investigations at NIROP" (RMT, June 1987) which was recently submitted to the Corps of Engineers and the U.S. Navy, addresses proposed site investigation activities for the areas listed above. Therefore, these areas have not been specifically addressed when developing the preliminary list of site-specific remedial alternatives.

5. RESPONSE OBJECTIVES

Under the Superfund Amendments and Reauthorization Act (SARA) of 1986, the basic framework of the CERCLA RI/FS process remains intact. However, greater emphasis has been placed on risk reduction through destruction or detoxification remedial alternatives by utilizing technologies that permanently reduce toxicity, mobility, or volume. In addition, SARA Compliance Policy requires that remedial actions attain the applicable or relevant and appropriate requirements (ARARs) of federal and state public health and environmental laws. This has been codified in the National Contingency Plan - 40 CFR Part 300.68(i).

Remedial technologies developed during the FS prescreening stage are assembled into remedial alternatives. The alternatives should be developed to cover a variety of response objectives. They should range from an alternative that would reduce toxicity, mobility, or volume to an alternative that would eliminate the need for long-term management (including monitoring). In addition, an alternative using containment with little or no treatment and a no-action alternative should be developed. Therefore, alternatives will be developed based on the following five categories:

- Alternatives for off-site treatment or disposal, as appropriate.
- Alternatives which <u>attain</u> applicable and/or relevant federal public health or environmental standards.
- Alternatives which <u>exceed</u> applicable and/or relevant public health or environmental standards.
- Alternatives which do not attain applicable and/or relevant public health or environmental standards but will reduce the likelihood of present or future threat from the hazardous

substances. This must include an alternative which closely approaches the level of protection provided by the applicable or relevant standards.

- No action.

It is possible for a particular alternative to be put into more than one of these five categories. This is possible because treatment technologies can be implemented with several degrees of effectiveness, depending on the type of equipment involved, contaminant concentration, rate of treatment, etc.

Some of the public health and environmental standards and criteria which should be considered when developing remedial alternatives are presented in the following list. The list is not intended to include all possible ARARs.

	Benzene	1,2-Dichloroethylene	PCE	TCE
MCL	5 ppb	—	—	5 ppb
MCLG	0	70 ppb*	0*	0
Ambient Water Quality Criteria for Human Health	0.66 ppb	—	0.80 ppb	2.7 ppb
ACGIH (8-Hour TLV-Time Weighted Average)	10 ppm	200 ppm	50 ppm	50 ppm

ACGIH = American Conference of Governmental Industrial Hygienists
* Indicates a proposed value.

Information obtained from selected reports found in the literature dealing with other hazardous waste/CERCLA sites, including Records of Decisions (RODs), which involve soil and/or ground water remediation activities of TCE and/or VOCs, are summarized below as examples of the types of alternatives which may be applicable to remedial action at the NIROP:

- Approximately 30,000 cubic yards of paint sludge and associated contaminated soils were excavated from an unnamed facility. Site hydrogeology was complex with 5 major units, the uppermost being an unconfined glacial outwash aquifer, hydraulically connected with a river. It was determined that all contamination was confined to the upper aquifer and that TCE was the dominant contaminant at the site. The Feasibility Study solution was to collect ground water via pumping, treat ground water via air stripping (selection based on lower capital, operation and maintenance costs versus carbon adsorption), with recharge of the treated water into the area of contamination to act as a flushing mechanism. Twelve air stripping units were needed with a total pumping rate of 600 gallons per minute in order to attain a treatment level of less than or equal to 15 micrograms per liter (15 ppb) of TCE at a ground water temperature of 55°F (Reference 1, page 220).

- In Situ air stripping (vacuum extraction) was used during a 14-week field program at a site comprised of sandy glacial soils where open burning of waste solvents had been performed periodically during a 30-year period. TCE had been found in the ground water at the site at concentrations 2 to 3 orders of magnitude greater than the recommended drinking water quality criteria at that time of 2.7 micrograms per liter, while soil concentrations had been found as high as 5,000 mg/kg. The extraction wells were spaced 50 feet apart, using variable air flows of 50 to 225 cubic feet per minute. Exhaust air TCE concentrations ranged from 250 to 350 ppm. Although only an estimated 10 to 20 percent of the TCE was removed from the soil during the 14-week program, this amounted to nearly 1,600 pounds of TCE. Cost of the full-scale remediation utilizing this technology was estimated at $15 to $20 per cubic yard of soil treated (Reference 1, page 322).

- At the Verona Well Field site (suppliers of potable water to most of the City of Battle Creek, Michigan) the ground water was found to be contaminated with 7 VOCs (1,1-dichloroethane, 1,2-dichloroethane, 1,1,1-trichloroethane, cis-1,2-dichloroethylene, 1,1-dichloroethylene, trichloroethylene, and perchloroethylene).

  VOC concentrations as high as 1,000 ppm were found in both ground water and soils. Soils on the property contained a total of approximately 1,700 pounds of VOCs and the ground water in the immediate vicinity contained a total of almost 4,000 pounds of VOCs. The USEPA selected the enhanced volatilization of VOCs using a soil vapor extraction system to augment ground water treatment. Nearly complete removal of the contaminant mass from the unsaturated zone was expected to occur within one year. Vacuum pump rates were in the range of 100 to 150 cubic feet per minute of air from each well with a

combined rate of approximately 1,000 to 2,000 cubic feet per minute. Cost of construction and operation of the vapor extraction system alone for the first year was estimated to be $410,000 (Reference 1, page 361).

- Approximately 2,200 gallons of TCE and TCA (1,1,1-trichloroethane) had been released into the soil and had entered the ground water system at site A. The hydrogeologic system consisted of an alluvial aquifer separated from the lower aquifer by an aquitard. After reviewing several remedial action technologies, ground water pumping in conjunction with air stripping was selected as the most applicable technology (Reference 1, page 430).

- At the Wurtsmith Air Force Base in Oscoda, Michigan, over 6,000 micrograms per liter of TCE was discovered in drinking water. Removal of the contaminated plume by pumping was chosen as a containment technology. The estimated cost for a granular activated carbon system to treat the ground water was determined to be unacceptable. After much full-scale experience with air stripping, the overall treatment cost was approximately $0.03 per 1,000 liters, almost tenfold less than the estimated cost of activated carbon. The investigators determined that (assuming complete removal of 500 micrograms per liter of TCE from the 6.6 million liters per day ground water stream) the TCE concentration leaving the stripping towers would be approximately 25 micrograms per cubic meter, far below the 270 micrograms per cubic meter time weighted exposure limit recommended by the American Conference of Governmental Hygienists (Reference 3, page 119).

- An abandoned hazardous waste landfill in a gravel mine resulted in TCE, TCA, and other VOCs in the range of 500 to 1,000 ppm being found in shallow ground water. Remedial action used on the medium to coarse sand and gravel aquifer of 17 to 35 foot thickness included excavation, aeration and treatment of contaminated soils, and pumping of the contaminated ground water along with activated carbon treatment (Reference 2, Case Study #12).

- At the Fisher & Porter Site in Pennsylvania, ground water was contaminated with 87,000 ppb TCE and 26,000 ppb PCE. A packed column aeration tower was used to treat 75 gallons per minute of removed ground water down to a level of 4.5 ppb TCE and 3.5 ppb PCE. The treated effluent was then discharged to surface waters according to state stream discharge requirements (ROD/R03-84/004).

- At the LeHillier/Mankato Site in Minnesota, the shallow sand and gravel aquifer was contaminated with volatile halogenated

hydrocarbons, primarily TCE. Ten extraction wells with treatment by air stripping were used to lower TCE concentrations to acceptable levels (ROD/R05-85/024).

- The Main Street, Elkhart, Indiana site consisted of a coarse sand and gravel aquifer 175 feet thick which was contaminated with over 3,000 ppb TCE. Air stripping of ground water with discharge to the existing water treatment plant was chosen as the preferred remedial alternative (ROD/R05-85/017).

- At the San Gabriel/Area 1 site in California, ground water was contaminated with 1,800 ppb of TCE. The selected remedial alternative was the installation of 3 packed tower air-stripping treatment systems (ROD/R09-84-004).

The information presented in this Response Objectives section will be used as a framework to develop remedial alternatives which fit into the five previously described categories.

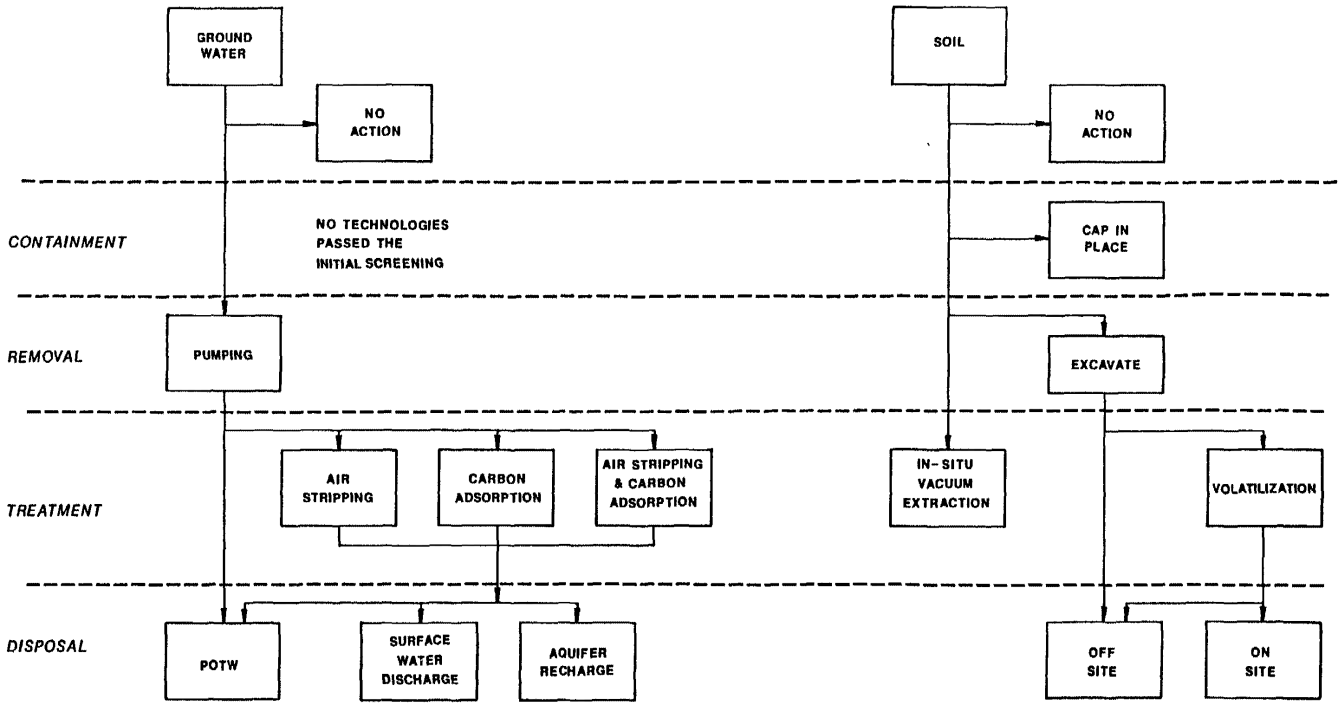
6. REMEDIAL ALTERNATIVES

As described in Section 5 and in the Interim Report (May, 1987), trichloroethylene (TCE) and the associated organic compounds were identified as the constituents of concern. TCE is considered the primary constituent of concern. The technologies that contain, remove, treat, or dispose of TCE-contaminated ground water and subsurface source areas in soil were identified and screened in order to eliminate those remedial technologies which were not appropriate for the NIROP site. The potentially viable remedial technologies which passed the screening (FS Task #9) are shown in Figure 1 and are listed below.

Grouping	Technology
Containment	• Capping soil with concrete or asphalt pavement.
Removal	• Excavation of soil. • Removal of ground water with pumping wells.
Treatment	• Treatment of soil with in-situ vacuum extraction, or with windrow volatilization. • Treatment of ground water with air stripping, carbon adsorption, or both.
Disposal	• Disposal of soil either on-site or off-site. • Disposal of treated ground water using aquifer recharge or discharge to near-by surface waters, or discharge of untreated ground water to a POTW.

Six remedial alternatives have been developed from these technologies. Four of the six are intended to be source control measures for contaminated soil, and two are migration management measures for contaminated ground water. In addition, two alternatives have been developed to protect potential ground water receptors by addressing the proposed Ranney Well Field. The final remedial alternatives to be applied to the specific operable units as ultimately

FIGURE 1
POTENTIAL REMEDIAL TECHNOLOGIES/ALTERNATIVES
FOR THE NIROP
FRIDLEY, MINNESOTA



defined at the NIROP site may include various combinations of the 8 alternatives listed below.

Alternative	Description
A -	Capping Contaminated Portions of Site
B -	Excavation and Disposal of Contaminated Soils
C -	Excavation, Treatment and Disposal of Soils
D -	Soils Treatment Using In-situ Vacuum Extraction
E -	Pumping and Disposal of Ground Water
F -	Pumping, Treatment, and Disposal of Ground Water
G -	Ground Water Treatment at the Proposed Ranney Well Field to Protect Receptors
H -	Movement of the Proposed Ranney Well Field to Protect Receptors

The following is a brief discussion of each alternative and its advantages, disadvantages, and/or limitations.

Alternative A - Capping Contaminated Portions of Site

This alternative would consist of capping the contaminated area with concrete or asphalt pavement. Only those pit/trench areas which contain contaminated soil and which are not presently covered by the NIROP building or employee parking lot would be capped. This relatively economical alternative would reduce precipitation onto and infiltration through the contaminated soils, thereby reducing the amount of residual organics leached into the ground water. This alternative would reduce the mobility of residual organic compounds by reducing the quantity of leaching liquid, but would not reduce the toxicity, volume, or persistence of the contaminants. It does not remove actual or potential contaminant sources from the site such as contaminated soils, leaking tanks, or associated piping. Therefore, long-term monitoring would be required. While this alternative does not deal with already contaminated ground water, it does allow full use of the site in the

future. This alternative can be accomplished using conventional equipment and techniques, and does provide protection from direct exposure to contaminants.

Alternative B - Excavation and Disposal of Contaminated Soils

Areas which are identified as having VOC contamination above the specified cleanup level (an ARAR or other criteria) would be subject to this remedial alternative. Only those source areas accessible to excavation (i.e., the areas not below the plant building) may be practically dealt with by this option. Vacuum extraction (Alternative D) may be feasible for those inaccessible source areas. Diffuse source areas or sources in deep saturated soils may limit the feasibility of this alternative by increasing the excavation cost and by generating prohibitively large soil volumes for subsequent disposal. This alternative will not deal with existing contaminated ground water and/or residual liquids from the dewatering of previously saturated alluvium. For liquid wastes, ground water treatment technologies may be feasible. There are recent USEPA regulations restricting and/or banning the land disposal of certain solvent-contaminated wastes and soils. At this time, it appears that the soils at the NIROP facility may be land disposed at a RCRA Subtitle C hazardous waste disposal facility because they appear to contain less than 1 percent by weight of the "listed" solvents, and are therefore eligible for a variance from the land disposal restrictions. However, the de-emphasis on land disposal with SARA may limit the acceptability of this remedial alternative. Under this alternative, excavated soil would be disposed at an off-site facility.

Alternative C - Excavation, Treatment and Disposal of Soils

This alternative would consist of excavation of soils which are contaminated by VOCs above the specified cleanup level (an ARAR or other criteria), followed by treatment using "natural" air stripping (i.e., volatilization) of the VOCs. The nature and extent of soil contamination would need to be identified prior to implementing this remedial alternative. In addition, the areas being excavated would need to be accessible to excavation equipment. Vacuum extraction (Alternative D) may be feasible for inaccessible areas. This alternative would not deal with the already contaminated ground water or the liquids resulting from dewatering of the saturated materials. Therefore, the toxicity, volume or mobility of the contaminated ground water would not be affected. Soil treatment could consist of placing windrows of soil on an impervious surface (concrete or asphalt paved parking lot) and "turning" them on a regular basis until the VOC concentration was reduced to a predetermined level. The "reclaimed" soil could then be returned to the excavation areas at the NIROP facility. Field studies or volatilization modeling would need to be done to estimate the rate of volatilization and the daily quantity of VOCs released by this remediation method. A comparison would then be made between the quantity of VOCs and applicable state or federal air quality standards.

Alternative D - Soils Treatment Using In-Situ Vacuum Extraction

This remedial alternative has been designated by USEPA as an "innovative" technology and involves removal of volatile organic

contaminants from unsaturated soils using an air (vacuum) extraction well system. Areas with contaminated, unsaturated soils would first need to be identified, and the soil types would need to be classified. Specific well construction requirements, air extraction rates, and the estimated time to complete remediation would need to be determined under field conditions using pilot-scale tests because the treatment effectiveness is a function of several site-specific variables. Vacuum extraction technologies are being used at hazardous waste cleanup sites with various degrees of success. In certain instances, the off-gases need to be treated prior to discharge to the atmosphere. Vacuum extraction could reduce the volume and toxicity of the VOC-contaminated unsaturated soil, but would have little or no effect on the previously contaminated ground water. This alternative may also require some form of ground water remediation for the previously contaminated ground water. Ground water pumping wells used to lower the water level (thus allowing optimum effectiveness of the in-situ vacuum extraction) may also be beneficial, and would need to be evaluated using pumping tests.

Alternative E - Pumping and Disposal of Ground Water

Removal of ground water by pumping wells followed by disposal to a Publicly Owned Treatment Works (POTW) may be technically and economically feasible. Ground water would most likely be removed through use of large-diameter pumping wells placed in areas of known TCE (and other organics) migration. For instance, possible locations include the pit/trench area, the southwest corner of the NIROP facility, and the southeast corner of the NIROP. The series of extraction wells would

then pump to a central collection line with subsequent disposal of the contaminated ground water to a POTW through the existing sanitary sewers. The optimum location of the extraction wells can only be determined after in-field pumping tests have more fully characterized the hydraulic properties of the aquifer.

The technology of ground water removal by pumping provides for recovery of the contaminated water, as well as gradient control to limit migration of contaminated ground water. Removal of contaminated ground water also has the advantage of "decontaminating" site soils located beneath the water table (e.g., desorbing contaminants from the soil particles), thereby potentially avoiding soil remediation measures for the saturation-zone soils. TCE and the associated organics would be removed from the soil's unsaturated zone by the natural leaching action of infiltration by precipitation. However, the amount of leaching required and the rate of desorption have not been evaluated for the soils at the NIROP site, and therefore the length of time needed for desorption has not been estimated. Large quantities of dilute organic compounds or small quantities of concentrated organic compounds may require an extended time period for complete leaching. Potentially, the rate of leaching could be enhanced by augmented infiltration of water through the unsaturated soil. Potable water or a portion of the pumped ground water that is treated could be used to increase the VOC flushing.

Alternative F - Pumping, Treatment, and Disposal of Ground Water

This remedial alternative addresses only the ground water aspects of the NIROP site. Ground water pumping wells would be placed at

strategic locations on the NIROP property and/or in areas of known ground water contamination immediately adjacent to the property. Under this alternative, there are no provisions for containing, removing, treating, or disposing of VOC-contaminated soil. However, a separate remedial alternative could be developed for the soil (e.g., Alternatives A, B, C, or D). This alternative for pumping, treating, and disposing ground water would reduce the volume and toxicity of contaminated ground water. Ground water treatment would consist of air stripping, carbon adsorption, or both. The treated ground water could be disposed by reinjection into the aquifer, discharge to nearby surface waters, or discharge to the POTW (depending on the final effluent concentration).

Alternative G - Ground Water Treatment at the Proposed Ranney Well Field to Protect Receptors

This alternative would make use of air stripping, carbon adsorption, or air stripping followed by carbon adsorption to treat ground water pumped by the City of Minneapolis' proposed Ranney well system. This proposed auxiliary water supply system consists of a series of large diameter extraction wells finished in the alluvial deposits with horizontal feeder arms attached to the end of the extraction well. The proposed location of the wells is such that they would capture ground water flow from the NIROP site prior to discharge into the Mississippi River. The water collected by the Ranney wells would then be air stripped and polished using carbon adsorption prior to distribution to Minneapolis area water users. This alternative has the advantage of treating only the water actually intended for distribution. Prior to development of the Ranney well field, pumping tests

would need to be done to more fully define pump capture areas and ground water quantities to be treated. Ground water samples would also need to be analyzed to determine their quality and the potential variation of the TCE contamination over time.

Alternative H - Movement of the Proposed Ranney Well Field to Protect Receptors

This alternative would consist of moving the proposed Ranney well field to an area of uncontaminated ground water. Preliminary data, developed by firms other than RMT, indicate that such an area may be available further north on the shoreline of the Mississippi River near Fridley well No. 13, or further east of the NIROP facility, upgradient of the site. This alternative would not deal with the existing ground water flowing into the river, which is then drawn upon by the waterworks. This alternative would also require in-depth analysis of aquifer conditions in the alternate area proposed for the location of the Ranney well field, including quantities of uncontaminated ground water available for removal.

7. REFERENCES

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