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5/1/00

8615 W. Bryn Mawr Avenue
Chicago, Illinois 60631
(773) 380-9933 Office (773) 380-6421 Fax

May 30, 2000

Reference No. 5369-76

Mr. Vince Epps
Indiana Department of Environmental Management
Federal Programs Section
Office of Land Quality
100 North Senate Avenue
P.O. Box 6015
Indianapolis, Indiana 46206

Dear Mr. Epps:

Re: Revised Operable Unit 1 Long-Term Groundwater Monitoring Plan
Four County Landfill State Cleanup Site
Delong, Fulton County, Indiana

Enclosed are four copies of the document entitled *"Operable Unit 1 Long-Term Groundwater Monitoring Program, Four County Landfill Site, Fulton County, Indiana"* (LTGMP) submitted on behalf of the Four County Landfill Group (Group). The LTGMP has been revised pursuant to the comments received from the Indiana Department of Environmental Management (IDEM) dated December 27, 1999, our responses to IDEM's comments dated February 8, 2000, and the discussions during the March 1, 2000 meeting between representatives of IDEM and the Group. Additionally, revisions were made to the Quality Assurance Project Plan (QAPP) consistent with the responses to IDEM's comments dated March 3, 2000 provided as Attachment A herewith.

Consistent with previous practice, one copy of this document was also forwarded to Mr. Jon Peterson of the U.S. Environmental Protection Agency. We trust that this submittal addresses the issues discussed and that the LTGMP may proceed in the near future. Please contact the undersigned should you have any questions concerning this matter.

Yours truly,

CONESTOGA-ROVERS & ASSOCIATES

Steven J. Warner

Steven J. Warner

SJW/ko/396
Encl.

c.c.: J. Peterson - U.S. EPA
J. Leed - Leed Environmental, Inc.

ATTACHMENT A

RESPONSES TO COMMENTS
LTGMP QUALITY ASSURANCE PROJECT PLAN

GENERAL COMMENTS

1. *The QAPP was submitted as Attachment I to the Long-Term Groundwater Monitoring Program (LTGMP) plan. The QAPP refers to Sections 1.0, 2.3, 6.0, 6.1, and 6.2 of the LTGMP plan for more detail on (1) the site location and history, (2) sampling procedures, (3) the project schedule, and (4) the sampling network and rationale. Because the QAPP must be a stand-alone document, this information should be included in appropriate sections of the QAPP. Also, various sections of the QAPP state that field standard operating procedures (SOP) are included in Attachment A of the QAPP. Attachment A contains laboratory SOPs only. The QAPP should be revised to include appropriate field SOPs.*

   Response

   To our knowledge, there is no requirement in the U.S. EPA Region 5 Superfund Model Quality Assurance Project Plan (Model QAPP) that a QAPP be a "stand-alone" document. In fact, the use of specific references to other portions of the overall work plan is encouraged by U.S. EPA Region 5 to avoid the need to revise historical or background information that is provided in the supporting documents (e.g., field sampling plan, health and safety plan). This format has been used for numerous projects in Region 5, including the long-term groundwater monitoring program at the Fisher-Calo Site in Kingsbury, Indiana as well as previous project documents such as the RI/FS Work Plan. Per our recent discussion, we understand that IDEM does not object to combining the QAPP and the LTGMP.

   Field standard operating procedures have been included in Attachment A in the revised QAPP.

2. *The text of the QAPP refers to figures and tables that appear at the end of the text by citing a "C" before each Figure or table number. For example, Figure 2.1 is identified as "Figure C.2.1" and Table 1.1 is identified as "Table C.1.1." The text of the QAPP should be checked, and the letter "C" should be deleted from all figure and table numbers in the text.*

   Response

   As requested, the references to "C" have been removed in the revised QAPP.

SPECIFIC COMMENTS

1. *Table of Contents:* ***The table of contents does not include a distribution list of all recipients who will receive a copy of the QAPP. The table of contents should be revised to include this distribution list.***

   Response

   As requested, the distribution list has been included in the revised QAPP.

2. *Title and Signature Page:* ***The title and signature page does not include signatures and dates for appropriate CRA and SIMALABS International (SIMALABS) project personnel that must review and approve the QAPP. Because their signatures are missing, it is unknown whether the CRA and SIMALABS project personnel reviewed and approved the QAPP. The QAPP should be revised and resubmitted to IDEM with the appropriate signatures and dates.***

   Response

   The signature page was not completed as the QAPP has not received approval from IDEM. When IDEM has submitted an approval letter for the QAPP, or has returned the signature page with the appropriate IDEM signatures, the signature page will be circulated to the project team for execution. This procedure ensures that only final, approved copies of the QAPP are maintained by the project team. Consequently, this revision of QAPP does not have an executed signature page.

3. *Section 1.5, Page 2, Paragraph 2:* ***The Paragraph states that the QAPP is to be used for years one to five and will be reviewed and may be revised after this time period. This could be interpreted to mean that the QAPP could be changed without the prior approval of IDEM. The Paragraph must reflect that the QAPP cannot be changed without the approval of IDEM.***

   Response

   The text has been revised to state that IDEM approval will be required before any changes are made to the QAPP.

4. *Section 1.3, Page 1, Paragraph 6:* ***The text states that the purpose of the LTGMP is to monitor groundwater at the site to determine whether any future remediation of groundwater is required. The text should be revised to state the problem in more detail by discussing the parameters of concern and their concentrations, frequency of detection, action levels, and other information that will indicate the need for future groundwater remediation.***

Response

A reference to the section of the Long-Term Groundwater Monitoring Program (LTGMP) that provides the project objectives and scope has been included in the revised text.

5. *Section 1.6, Page 2, Paragraph 3: The text provides boiler-plate language from the Model QAPP that discusses the data quality objective (DQO) process in general terms. The text refers to the seven-step process presented in EPA's "Guidance for the Data Quality Objectives Process" (QA/G-4) dated September 1994. However, the text does not discuss project-specific DQOs. In order to meet the intent of the Model QAPP and QA/R-5, project-specific DQOs should be developed and described in the QAPP according to the seven-step process presented in EPA's "Guidance for the Data Quality Objectives Process" (QA-IG-4) dated September 1994 and "Data Quality Objectives Process for Hazardous Waste Site Investigations" (QA/G-4HW) dated June 1999. Project-specific DQOs should include the following:*

- *Description of the type of data to be collected (including any statistical sampling designs).*
- *Detailed decision statements that describe actions to be taken when sample analytical results exceed specific action levels.*
- *Acceptable limits on decision errors.*

Response

The boilerplate language provided is indeed from the Model QAPP and, by definition, is pre-approved language for Region 5's Superfund program. Project-specific data quality objectives (DQOs), including type and number of sample data to be obtained, have been determined through negotiation with IDEM. No action levels exist for the sample data. As discussed in the LTGMP, the data will be assessed throughout the monitoring program and after the first five-year period. After the first five-year monitoring period, decisions on the data as they relate to the effectiveness of the remedy will occur.

Therefore, the data quality objectives were determined during the scoping process that occurred with IDEM. The quality assurance and quality control (QA/QC) procedures detailed in the QAPP provide the precision, accuracy, representativeness, completeness, and comparability information that are necessary to ensure the DQOs will be met.

6. *Section 2.0, Page 1, Paragraph 1: The text discusses project organization and responsibilities for various key CRA and SIMALABS project personnel. However, the text does not discuss any special training or certification requirements for CRA,*

SIMALABS, or other key project personnel as required by the Model QAPP. The text should be revised to discuss special training and certification requirements for CRA, SIMALABS, and key project personnel.

Response

To our knowledge, there are no special training or certification requirements necessary for this project. The text has been revised to reflect this fact.

7. *Section 2.0, Page 1, Paragraph 2: The text states that CRA will maintain a file copy of all laboratory deliverables. The text does not state (1) whether the files will be in hard copy or electronic format or both, (2) where CRA will maintain the files, and (3) how long the files will be maintained. The text should be revised to include this information.*

Response

It should be noted that document control procedures are provided in Section 5.0, which has been revised to address the comment. The revised text in Section 2.0 provides a reference to this section.

8. *Section 2.0, Page 3, Paragraph 1: The text describes the responsibilities for the SIMALABS sample custodian and EPA Region 5. However, the SIMALABS sample custodian and EPA Region 5 are not included in the project organization chart in Figure 2.1. Figure 2.1 should be revised to include all key project personnel discussed in Section 2.0.*

Response

U.S. EPA has been added to the organization chart. The sample custodian is part of SimaLabs staff and has not been separated out on the chart.

9. *Section 3.0, Page 1, Paragraph 1: The text states that the overall quality assurance (QA) objective for the LTGMP plan is to develop and implement procedures for field sampling, chain-of-custody, laboratory analysis, and reporting that will provide results that would be legally defensible in a court of law. This section cites boilerplate language from the Model QAPP. Results generated may be legally defensible in a court of law but may not be adequate to determine whether future groundwater remediation is required (see Specific Comments No. 3 and 4). After establishing project-specific DQOs, the QA objective should be revised to incorporate project-specific DQOs.*

Response

The boilerplate language provided is indeed from the Model QAPP and, by definition, is pre-approved language for Region 5's Superfund program. The text has been revised to state that project-specific data quality objectives (DQOs) have been determined through negotiation with IDEM.

10. Section 3.6, Page 5, Paragraph 2: *The text states that the Field Blank, Trip Blank, Method Blank, Field Duplicate, Matrix Spike Matrix Spike Duplicate (MS/MSD), and Laboratory Duplicate will be used to assess the quality of the laboratory data resulting from field sampling and analysis program. A Laboratory Control Sample (LCS) should be added to this list. SW846-Chapter One Section 4.4.3 states that an acceptable Laboratory Control Sample (LCS) demonstrates that the laboratory analytical process was is in control during each data collecting activity. A LCS should be analyzed for each analytical batch of twenty or fewer samples, to verify the precision and bias for each analytical method* used.

Response

The text has been revised to include laboratory control samples as required laboratory QC samples.

11. Section 4.0, Page 1, Paragraph 1: *The text refers to the field sampling plan (FSP), which is included as Appendix B of the LTGMP plan. Neither the QAPP nor the FSP discusses the sampling network design and rationale (see General Comment No. 1). Also, the FSP contains the deficiencies summarized below.*

- *Decontamination procedures for all sampling equipment are not consistent with those cited in Title 329 of the Indiana Administrative Code (329 IAC), Part 10-21-2-(9) and are not sufficient for the proposed purging and sampling methods. The FSP should be revised to specify all the equipment and materials that will be used and how each will be decontaminated. If a deviation from the procedures specified in 329 IAC 10-2 1-2-(9) is proposed, technical justification and supporting documentation should be provided.*

- *The proposed procedures for purging of groundwater samples are not consistent with 329 IAC 10-21-2-(5) and are not sufficient to collect representative groundwater samples. If a deviation from the procedures specified in 329 IAC 10-21-2-(5) is proposed, technical justification and supporting documentation should be provided. In addition, field meters must be consistent with specifications in 329 IAC 10-2 1-2-(11). Further, the procedures state that groundwater will be purged onto the ground. The FSP should be revised to*

indicate that all purge water will be placed into containers and transferred to the on-site leachate tank.

- *The FSP states that sample containers, sample preservation methods, maximum holding times, and filling instructions are listed in Tables 6.5 and 6.6 in the main body of the LTGMP plan. This information is not contained in Table 6.5, and Table 6.6 is not provided in the main body of the LTGMP plan. The LTGMP plan should be revised to include the required information and provide correct references to the location of the information where appropriate.*

Response

The comments on the Field Sampling Plan (FSP) have been noted, but will not be addressed in the QAPP. Consistent with the intent of the Model QAPP, a reference to the FSP was included in the QAPP to avoid unnecessary duplication of FSP information in the QAPP.

12. *Section 5.0, Page 1, Paragraph 1: The text states that files and reports are maintained under document control in a secure area. The text does not state the location of the secure area or the name of the company that controls the secure area. The text should be revised to include this information.*

Response

The text has been revised to include the physical location of the secure area for document control. It should be noted that the name of the company and individual responsible for the final evidence file maintenance is provided in Section 5.4.

13. *Section 5.1, Page 3, Paragraph 2, Item 3: The text discusses sample labels but does not provide an example of a sample label. The QAPP should be revised to include an example of a sample label.*

Response

Examples of a typical sample label and custody seal have been added to the end of Section 5.0.

14. *Section 5.1, Page 3, Paragraph 2, Item 5: The text discusses custody tape (custody seals) used to seal sample coolers but does not provide an example of a custody seal. The QAPP should be revised to include an example of a custody seal.*

Response

Examples of a typical sample label and custody seal document have been added to the end of Section 5.0.

15. *Section 6.2, Page 1, Paragraph 5:* ***The text briefly discusses calibration of laboratory instruments and refers to SOPs in Attachment A. However, specific laboratory instruments to be used are not listed in the text of Section 6.2. The text should be revised to list and discuss the calibration of each laboratory instrument to be used for the project. This information would best be presented in a table that includes the type, frequency, acceptance criterion, and corrective action for each analytical method to be performed.***

Response

As noted in this section, calibration procedures are provided in the field and laboratory SOPs. This is consistent with the suggested language in the Model QAPP and the need to reiterate or summarize calibration procedures is not justified.

The text has been revised to indicate that the laboratory instruments to be used during the LTGMP are identified in the laboratory SOPs.

16. *Section 7.0, Page 1, Paragraph 1:* ***The text does not discuss field analytical procedures or laboratory analytical procedures but refers instead to Table 7.1 and SOPs in Attachment A. The text should be revised to discuss the field and laboratory analytical procedures as required by the Model QAPP. Also, the text states that field measurements will be obtained using the methods specified in Table 7.1 and detailed in the SOPs in Attachment A. Table 7.1 does not provide field measurement methods, and field SOPs are not provided in Attachment A. Table 7.1 should be revised to include field measurement methods, and appropriate field SOPs should be included in Attachment A of the QAPP.***

Response

A brief discussion of the methods to be used for field and laboratory analyses has been included in the revised text. Table 7.1 has been revised to include the field analytical methods. Field SOPs have been included in Attachment A.

17. *Section 8.2.4, Page 2, Paragraph 3:* ***The text states that the surrogate spike percent recoveries are required to be within control limits specified in the method and for samples not requiring dilution. Additional text should be added such that as long as the surrogates are within measurable concentrations, then those surrogates will need to be within acceptable recovering limits. Also, if the laboratory is aware that the samples***

contain high concentrations of contaminants, then higher concentrations of surrogates should be added to the environmental sample.

Response

The text currently states that dilutions "may dilute the surrogates below the quantitation range" and that data quality would be evaluated differently in these situations. The text does not state that any dilution will preclude surrogate data from being evaluated.

The primary constituents of concern for the Site are VOCs. Surrogate compounds are added to samples for VOC analysis prior to purging. If the sample requires dilution, "new" surrogate and internal standards are added to the diluted sample prior to reanalysis. Therefore, the comment has no bearing on the VOC data. Although surrogate compounds are added to samples for SVOC analysis prior to extraction and may be diluted below the quantitation range, SVOCs have not been detected historically at elevated concentrations. Therefore, adjusting the concentration of SVOC surrogate compounds for this project will be unnecessary.

18. *Section 8.2.5, Page 2, Paragraph 4: The text states that the acceptance criteria and corrective action requirements are specified in the appropriate Standard Operating Procedure (SOP) in Attachment A. However, the SOPs could not be found in that attachment. The acceptance criteria and corrective action requirements for all types of blanks need to be provided.*

Response

A new SOP for corrective action in included in Attachment A.

19. *Section 11.0, Page 1, Paragraph 1: The text discusses routine preventive maintenance for laboratory and field instruments. However, the text does not discuss inspection and acceptance criteria for supplies and consumables (such as sample bottles, calibration gases, reagents, hoses, materials for decontamination activities, deionized water, and potable water) used that may directly or indirectly affect data quality. The text should be revised to discuss inspection and acceptance criteria for these supplies and consumables.*

Response

Preventive maintenance procedures have been provided as specified by the Model QAPP. There is no requirement for discussion of supplies and consumables in the Model QAPP.

20. *Section 12.0, Page 1, Paragraph 1:* ***The text discusses the procedures and formulae used to assess data accuracy, precision, and completeness. However, the text does not discuss how the results of this assessment will be reconciled with project-specific DQOs by the data user or decision maker for the project as required by QA/R-5. The data assessment should determine whether the data are of the right type, quantity, and quality to support their intended uses. The text should be revised to (1) describe how project results will be reconciled with DQOs, (2) outline the proposed methods to be used for analyzing data and determining possible anomalies or departures from assumptions established during the planning phase of data collection, and (3) describe how issues will be resolved and limitations on data use will be reported to decision makers.***

Response

The specific routine procedures to assess data precision, accuracy, and completeness have been provided as specified by the Model QAPP. Reconciliation of DQOs is not a routine assessment procedure.

21. *Section 13.3, Page 2, Paragraph 4:* ***The text states that the need for corrective action may occur during either data validation or data assessment. However, the text does not discuss how the results of these assessments will trigger corrective action. Corrective actions may be required because of analytical and field equipment problems or noncompliance problems during implementation of the FSP and QAPP. The text should be revised to include the following information:***

- ***The mechanism for triggering the initiation of each corrective action***
- ***The proper procedures to be used for initiating, developing, approving, and implementing corrective actions***
- ***Identification of project personnel responsible for initiating, developing, approving, and implementing corrective actions***
- ***Alternate corrective actions to be taken***
- ***The documentation process for corrective actions***

Response

The text has been revised to include corrective action trigger mechanisms and documentation of corrective actions that are applicable to corrective actions during data validation or assessment. The remaining items in the comment were provided in the original text or are not relevant to this section.

22. *Section 14.0, Page 1, Paragraph 1:* ***The text briefly discusses QA reports to management. However, the text does not discuss potential follow-up actions that will be taken by management as a result of the findings and recommendations presented in the QA***

reports. Also, the text does not include a distribution list of management personnel who will receive copies of the QA reports. The text should be revised to discuss potential follow-up actions that will be taken by management as a result of the findings and recommendations presented in the QA reports and include a distribution list of management personnel that will receive copies of the QA reports.

Response

The text has been revised to indicate that CRA's Project Manager will be the primary recipient of QA reports and will responsible for including these reports in the LTGMP Annual Reports. Additionally, the text has been revised to indicate that the distribution of QA reports will be the recipients of the Annual Reports.

23. *Figure 2.1: Figure 2.1 does not include the names of the key CRA, IDEM, and SIMALABS personnel responsible for the project. Also, the figure does not include all key project personnel discussed in Section 2.0 (see Specific Comment No. 7). Figure 2.1 should be revised to include the names of all key CRA, IDEM, and SIMALABS personnel responsible for the project.*

Response

The figure as drafted fulfills the requirements of the Model QAPP. The names of all the key project personnel are provided in the text in Section 3.0.

24. *Attachment A: Attachment A provides SIMALABS SOPs. Attachment A should also include field SOPs that will be used by CRA field personnel. Also, Attachment A should provide a list of all laboratory and field SOPs included.*

SOP for VOCs, Page 8, Calibration Procedures: The text lists the concentrations of the Initial Calibration Standards. These concentrations are set at 10 ppb, 20 ppb, 50 ppb, 100 ppb, and 200 ppb. The lower quantification limit should be set at 1 ppb because the MCLs for all the major contaminants of concern are set below these concentrations.

SOP for VOCs, Page 8, Calibration Procedures: The text states that if the Calibration Relative Standard Deviation exceeds 15% then a calibration curve using first or higher order regression curve will be constructed for calculations. SW846-8000, Section 7.5 and pages 19 to 23, December, 1996 list alternate calibration procedures, one of which is linear regression. Therefore, the use of linear regression can be acceptable. However, in Section 7.5.3, Page 22 the note states that it is not EPA's intent to allow nonlinear calibration to be used to compensate for detector saturation at higher concentrations or to avoid proper instrument maintenance. Therefore, nonlinear calibration should not be used for methods or instruments previously shown to exhibit linear calibration for the

analytes of interest. Therefore, the QAPP SOP should state clearly when a nonlinear calibration method is used and when a new calibration standard is required.

Response

Field SOPs have been provided in the revised QAPP. A new VOC SOP has been provided to address the comments on calibration procedures.

OPERABLE UNIT 1
LONG-TERM GROUNDWATER MONITORING PROGRAM

FOUR COUNTY LANDFILL SITE
FULTON COUNTY, INDIANA

Prepared By:

Conestoga-Rovers & Associates
8615 W. Bryn Mawr Avenue
Chicago, Illinois 60631
(773) 380-9933 Office (773) 380-6421 Fax

MAY 2000
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ATTACHMENT I	QUALITY ASSURANCE PROJECT PLAN

1.0 INTRODUCTION

1.1 SITE LOCATION

The Four County Landfill (Site) is located in Aubbeenaubbee Township, in north-central Indiana, in the southern half of the southwest quarter of Section 16, Range 1 East, Township 31 North (Figure 1.1). The Site is located approximately 3.5 miles southeast of the common corner of Fulton, Marshall, Starke, and Pulaski counties, near the intersection of State Highway 17 and County Highway 525 North. The nearest towns are Delong, located approximately 1 mile to the northeast, and Leiters Ford, located approximately 2 miles to the east-southeast. The Site is approximately 6 miles south of Culver and 15 miles northwest of Rochester.

The Site occupies approximately 61.5 acres, including the County and State highway rights-of-way. State Highway 17 divides the property into an eastern and western parcel. Land disposal activities were formerly conducted on approximately 30 acres of the western parcel, which has been the focus of investigative activities conducted at the Site. The western parcel (i.e., the Four County Landfill Site) is bounded on the east by State Highway 17, on the north by County Highway 525 North, on the west by a county road right-of-way and on the south by wooded land. A Site Plan is provided in Figure 1.2.

1.2 PURPOSE

This document presents the Long-Term Groundwater Monitoring Program (LTGMP) for the Four County Landfill Site. This LTGMP has been developed in accordance with Section VII.A of the Indiana Department of Environmental Management's (IDEM's) Declaration for the Record of Decision (ROD) for Operable Unit One (OU1) dated July 16, 1998.

Significant components of the selected remedy for OU1 include:

- construction of RCRA Subtitle C cap with a geocomposite layer;
- collection of leachate from the lined cells with disposal at a Treatment Storage and Disposal Facility;
- implementation of stormwater controls;
- abandonment of on-Site groundwater monitoring wells;
- consolidation of soil/sediment and disposal within Cell C;
- implement deed and groundwater-use restrictions and access control;

- construction of passive landfill gas collection system and monitoring of landfill gases;
- grading and revegetation of the Site; and
- performance of groundwater monitoring.

The OU1 remedial components related to construction of the cap were substantially completed in the last quarter of 1999. The final inspection for the OU1 remedial activities was held at the Site on May 25, 2000. The monitoring program detailed herein will be implemented as part of the OU1 Remedial Action and upon approval by IDEM.

1.3 BASIS OF THE LONG-TERM GROUNDWATER MONITORING PLAN

Pursuant to the ROD, monitoring of the groundwater quality proximal to the Site is required. Specifically, the OU1 ROD requires the following with respect to groundwater monitoring.

> "*Groundwater Monitoring*
>
> *Groundwater monitoring will be conducted in order to determine changes in groundwater quality with time.*
>
> *Upgradient monitoring wells will be installed in a "clean" area so that they may provide representative background groundwater quality in the aquifer of concern.*
>
> *Downgradient monitoring wells will be installed near the landfill boundary and in the saturated zone so that any changes in the water quality downgradient due to changes in the upgradient groundwater quality can be determined.*
>
> *The initial monitoring system will be defined during the design phase in consultation with and subject to approval of IDEM. It will be used to monitor all levels of the aquifer that might be impacted by leakage of leachate from the landfill and would monitor the waters for the substances specified by IDEM. The sampling and analysis plan for this monitoring would be subject to the prior approval of IDEM.*
>
> *The purpose of the groundwater monitoring system being installed without any groundwater remediation components having been implemented is to determine whether any future remediation of the groundwater would be required. At a minimum, the groundwater monitoring system would have to meet the Indiana requirements for solid waste land disposal facilities (329 IAC 10)."*

1.4 SCOPE OF THE LTGMP

Key components in scoping the LTGMP included determining the list of analytical parameters, the frequency of monitoring, the number of monitored locations, and the duration of monitoring. Generally, the monitoring frequency, number of monitoring wells and analytes were selected consistent with 329 Indiana Administrative Code (IAC) regulations. However, a considerable groundwater analytical database has already been compiled for the Site including data from numerous groundwater monitoring wells installed in the source area. Therefore, it is reasonable and technically appropriate to consider the existing analytical database in order to prepare a work scope for a subsequent long-term groundwater monitoring program.

This LTGMP includes a fixed scope during its initial five years to confirm the analytical database generated during the OU1/OU2 Remedial Investigations and to compile a sufficient database to evaluate potential seasonal trends in groundwater quality. However, beyond the first five years of the LTGMP, it is difficult to establish a fixed scope for a groundwater monitoring program since the scope beyond the first few years will be largely based on the results from the initial five years of monitoring.

As such, it is the intent of this document to set forth:

- a work scope for a five-year monitoring/evaluation period designed to confirm existing groundwater analytical data and obtain additional data to establish background groundwater quality conditions;
- a decision-making process for the continuation of groundwater monitoring activities beyond the initial five year period of the LTGMP; and
- the decision-making criteria for termination of the LTGMP.

Summaries of the operational history, geologic and hydrogeologic conditions and the existing groundwater analytical database for the Site are provided hereinafter for reference. The rationale for the work scope for the initial five years of monitoring during the LTGMP is also discussed followed by the decision-making criteria for scoping groundwater monitoring activities beyond the initial five years of the LTGMP.

2.0 SITE HISTORY

The Four County Landfill commenced operation in August 1972 and continued operating until 1989 when the U. S. District Court ordered operations to cease. On August 13, 1993, an Agreed Order for a Remedial Investigation/Feasibility Study (Agreed Order) between a group of Potentially Responsible Parties (PRPs) and IDEM became effective upon execution by the Commissioner of IDEM. The PRPs identified by IDEM comprised both de minimis and non-de minimis respondents who allegedly contributed waste materials to the Site and/or participated in the operation of the landfill. The majority of non-de minimis respondents identified by IDEM formed the Four County Landfill Group (Group).

A "Site Background Summary and Detailed Scope of Work" (SOW) prepared by Environmental Resources Management - North Central, Inc. (ERM) was submitted to IDEM by the Group, in support of a Good Faith Offer to IDEM put forth on April 27, 1992. The SOW was incorporated into the Agreed Order by reference and presents a summary of existing data previously collected at the Four County Landfill Site, including a compilation and evaluation of available information regarding Site history, Site physical characteristics, waste characteristics, and the nature and extent of contamination. In addition, a scope of work was included for performing Site stabilization activities. Moreover, the SOW, in accordance with the Agreed Order, set out the basis for the work to be undertaken during a Remedial Investigation/Feasibility Study (RI/FS).

An RI/FS Work Plan (hereinafter "Work Plan") was prepared by CRA in accordance with Paragraphs 38 and 39 of the Agreed Order, the SOW (Exhibit II of the Agreed Order), Section 121 of CERCLA, and U. S. Environmental Protection Agency (USEPA) guidance documents. Much of the Site background and ancillary historical operational information contained in the SOW was incorporated into the Work Plan. On May 3, 1994, IDEM approved the Work Plan. Initiation of investigative activities detailed in the approved Work Plan commenced shortly thereafter on May 23, 1994.

Following the successful implementation of the Work Plan, a Groundwater Technical Memorandum that summarized Site groundwater data acquired during the RI as well as historical data, was submitted to IDEM. IDEM subsequently approved the Groundwater Technical Memorandum by letter dated May 22, 1995. The Groundwater Technical Memorandum provided a comprehensive database of available groundwater information. The purpose of the Groundwater Technical Memorandum was to evaluate and discuss the comprehensive database and assess whether supplemental data were necessary to evaluate remedial alternatives for this Site.

A significant finding of the Groundwater Technical Memorandum was that supplemental investigative activities were necessary to adequately define the nature and extent of groundwater contamination at the Site. Addendum 1 to the approved Work Plan (hereinafter, "Addendum 1") was prepared to outline the additional work that was necessary. Addendum 1 set forth the rationale for these tasks and detailed data collection and analytical protocols that had not been previously established by the Sampling and Analytical Plan (SAP) provided as Appendix H of the approved Work Plan. IDEM approved Addendum 1 by letter dated September 27, 1995.

Early in 1995, the Four County Landfill Technical Committee proposed to divide the Site into two operable units. The first proposed operable unit (OU1) was the landfill cap and the second proposed operable unit (OU2) was groundwater. Dividing the Site into operable units allowed the flexibility to close and stabilize the landfill on an earlier and shorter timetable from the groundwater investigation that could require several phases to complete. The "operable units approach" was first proposed in a memorandum to IDEM dated February 10, 1995. In response, IDEM approved the "operable units approach" and clarified the components of each of the operable units. On this basis, operable unit OU1 consists of the landfill cap, leachate collection and treatment from both lined and unlined cells, landfill gas collection and treatment, institutional controls to supplement engineering controls, and "source-area groundwater" control and treatment.[1]

The OU1 RI Report was submitted to IDEM on June 27, 1997. The OU1 RI Report provided a detailed discussion of the data acquired during the RI and extensive investigative activities performed prior to the RI. The OU1 RI Report was prepared specifically to address OU1. The OU1 RI Report concluded that sufficient data were available to evaluate and select remedial alternatives necessary to close the landfill. Remedial action objectives for the OU1 were established for surface soil and the landfill contents, air and dust, landfill gas, surface water, sediment leachate and source-area groundwater. The established remedial action objectives consist of medium- or operable unit-specific goals for protecting human health and the environment.

The FS Report for OU1 is dated February 24, 1998. Applicable or Relevant and Appropriate Requirements (ARARs) for the Site were identified including chemical, action, and location-specific ARARs. The ARARs were used to evaluate each remedial alternative for compliance with regulatory requirements. The Group received IDEM's approval of the OU1 Remedial Investigation Report on December 15, 1997 and IDEM's approval of the OU1 Feasibility Study on March 19, 1998.

[1] Source-area groundwater refers to all groundwater beneath the Site. Definition of operable units per IDEM letter dated August 16, 1995, Re: Four County Landfill Site, Fulton County, Indiana.

Prior to IDEM's issuance of the OU1 Proposed Remedial Action Plan on April 15, 1998, the Group voluntarily initiated OU1 remedial design activities. IDEM approved the OU1 remedial design and issued a ROD for OU1 in July 1998. Construction of the OU1 remedy commenced at the Site in May 1999 and was substantially completed in the fourth quarter of 1999. Additional OU1 remedial action tasks were performed at the Site in April and May 2000, and a final inspection was held at the Site with IDEM on May 25, 2000.

Investigative activities associated with off-Site groundwater (OU2) were intiated in February 1995 and completed by June of 1999. An OU2 RI Report summarizing the extensive groundwater database was submitted to IDEM in January 2000. This report concluded that the nature and extent of off-Site groundwater impacts had been successfully delineated during the OU2 RI and that sufficient data existed to proceed with the Feasibility Study (FS) for OU2. In a letter dated July 28, 1999, IDEM concurred with the conclusion stating that the leading edge of the groundwater plume, as well as the nature and extent of off-Site groundwater impacts were defined. Moreover, IDEM's letter stated that no further work was required to provide additional data relative to the nature and extent of off-Site groundwater impacts. Development of the OU2 FS document was initiated shortly thereafter. The completed OU2 FS Report was submitted to IDEM on May 5, 2000 and approval of this document is expected in the near future. Although this monitoring program is designed to be comprehensive, modifications to this LTGMP may be appropriate at the conclusion of the OU2 RI/FS process.

A more detailed summary of the Site's operational history may be found in the Work Plan and the OU1 Remedial Investigation Report (CRA, June 11, 1997).

3.0 SITE CHARACTERISTICS

3.1 SITE GEOLOGY

Unconsolidated sediments at the Site consist of four major lithostratigraphic units (Units A, B, C, and D) that overlie carbonate bedrock. The four relatively distinct stratigraphic units and the bedrock encountered at the Site are described in the following subsections. A general geologic cross-section is provided in Figure 3.1.

3.1.1 UNIT A

Stratigraphic Unit A consists of a sequence of four, distinct subunits of loam and silt loam glacial till. Groundwater in the Unit A till sequence occurs in discontinuous perched zones within thin, stratified, intertill sand and gravel deposits. Off-Site borings advanced during the OU2 RI confirmed the presence of the shallow Unit A deposits and sporadic lenses of perched groundwater in all directions from the Site.

3.1.2 UNIT B

Stratigraphic Unit B, a glacio-lacustrine sequence, underlies Unit A and is comprised of well-stratified, fine to medium-grained sand with interbedded silt. Unit B has a relatively uniform thickness on Site of 28 to 42 feet and appears to contain three significant silt beds; one near the top, a second in the middle portion, and a third marking the base. The top of the water table generally lies within Unit B.

The interbedded silt and sand layers associated with Unit B deposits were encountered at off-Site borings and well installations advanced during the OU2 investigation. In addition, a peat layer appears to extend into the top of the Unit B formation immediately north of the Site.

3.1.3 UNIT C

Stratigraphic Unit C consists of glaciofluvial sediments comprised of an upper (upward fining) sequence overlying a lower (upward coarsening) sequence that cuts unconformably and irregularly into an underlying glacial till unit (Unit D). The top of the upper sequence is gradational with the overlying Unit B. In the northwest quadrant of the Site, over 100 feet of sand and gravel overlie Devonian carbonate bedrock. At the

southern margin of the southwest quadrant of the Site, the lower sequence of Unit C is approximately five feet thick and overlies glacial till (Unit D).

3.1.4 UNIT D

Stratigraphic Unit D consists of unconsolidated loam or finer-textured silty glacial till that is absent in certain areas, presumably as a result of erosion. Where present, the till unconformably overlies the carbonate bedrock of Devonian Age. The maximum thickness of Unit D is 47 feet in the southwest quadrant of the Site. The unit thins abruptly to the north and is cut out by sand and gravel in the lower part of Unit C. However, investigative activities conducted north of the Site during the OU2 investigation indicate that the erosional feature resulting in the thinning of the Unit D till deposits on Site is likely a localized phenomenon. A boring advanced adjacent to MW114 revealed that the Unit D till is less than 5 feet thick at that location. However, during the installation of MW124, located approximately 600 feet to the northeast of MW114, a significant thickness of Unit D till is once again present.

3.1.5 BEDROCK

Bedrock beneath the facility is comprised of carbonate (limestone and dolomite) bedrock of middle Devonian Age, probably of the Detroit River Formation. Approximately 4 feet of light gray to dark brown, fine to coarsely crystalline limestone and dolomite were penetrated at four separate locations during previous investigations. Carbonate bedrock was confirmed at a depth of approximately 204 feet below ground surface adjacent to MW114 during the OU2 investigation. This depth is consistent with the information generated prior to the RI investigation.

3.2 SITE HYDROGEOLOGY

Groundwater flow data were compiled during investigations completed by the Site owners prior to the RI. These investigations demonstrated that the general direction of groundwater flow in the unconsolidated overburden deposits was toward the northeast. A considerably larger groundwater flow database was generated during 1989 from a greater number of monitoring wells and piezometers screened at various depths in Site stratigraphic units. This information was reported in the 1989 Annual Ground Water Report (Regional Services Corporation (RSC), March 1989). A total of ten rounds of water level data were compiled during the period of June through December 1989.

These data also indicated that groundwater flow beneath the Site is primarily north to northeast.

During the OU1 RI, two rounds of hydraulic head data were collected from each of the 71 on-Site groundwater monitoring wells and piezometers originally identified in the on-Site sampling network. Associating wells screened at similar elevations within Unit C minimized uncertainty in the data, which may have resulted from significant variations in the screened interval and the potential presence of vertical gradients. During the OU1 RI, four different elevation intervals within Unit C were selected for evaluation. These elevation intervals included 690 - 710 feet for the upper portion of Unit C, 665 - 685 feet and 635 - 655 feet for the middle portion of Unit C, and 580 - 625 feet for the lower portion of Unit C. Monitoring wells from each interval were used to generate groundwater contours that were representative of groundwater flow at each of these intervals within Unit C. Groundwater flow in each of these elevation intervals within Unit C was consistently observed to be towards the north to northeast.

Hydraulic monitoring continued under the auspices of the OU2 RI confirmed that the northeasterly groundwater flow direction continued in off-Site deposits. Seven rounds of hydraulic monitoring data were collected from the off-Site monitoring wells during the OU2 RI. The final two rounds of depth-to-groundwater measurements were collected from the entire network of 31 off-Site monitoring wells.

Groundwater contours in the shallow (Unit B) and deep (Unit C) off-Site units prepared from depth-to-water level measurements recorded during June 1999 are presented in Figures 3.2 and 3.3, respectively. Groundwater flow in Unit B (see Figure 3.2) near the water table interface is generally towards the northeast but is more complex due to the presence of the wetlands north of the Site. Groundwater flow in Unit C (see Figure 3.3) is uniformly towards the northeast.

4.0 GROUNDWATER DATA SUMMARY

The list of compounds investigated during the OU1 RI was developed in concert with IDEM following a thorough review of waste disposal records and analytical data generated by the previous Site owners. The work scope developed with IDEM was detailed in the SOW and incorporated into the Agreed Order for the RI/FS (Cause No. OER-92). The investigation required by the Agreed Order was completed and a thorough understanding of the hydrogeology and groundwater quality proximal to the Site was obtained.

Additional groundwater investigative activities continued off-Site under the auspices of the OU2 RI. This work included the installation of 31 off-Site groundwater monitoring wells and several rounds of groundwater sampling. Results from the off-Site groundwater monitoring program were reported in the OU2 RI report.

4.1 ON-SITE GROUNDWATER

On the basis of the data generated during the OU1 RI, volatile organic compounds (VOCs) were determined to be the Site-related groundwater concern. The more significant VOC detections in the saturated units (Unit B and Unit C) beneath the Site are primarily localized to a relatively narrow zone near the western Site boundary. Other analytes detected in groundwater samples from on-Site groundwater monitoring wells included several semivolatile organic compounds (SVOCs), metals, and total cyanide. The concentrations of SVOCs and total cyanide were above maximum contaminant levels (MCLs) only in a few Unit A wells and piezometers. Metals concentrations above MCLs were primarily related to suspended sediment present in the sample due to poor construction of the on-Site wells installed by the previous Site owner. Summaries of on-Site groundwater analytical data are provided in the figures presented in Appendix A.

In accordance with the ROD, the on-Site monitoring wells were abandoned during field activities performed from April through August of 1998. Monitoring wells were abandoned in accordance with protocols contained in the CRA document entitled, "*Well Abandonment Technical Memorandum, Four County Landfill, Fulton County, Indiana*" dated February 1996 and re-printed on May 28, 1996. IDEM approved this document in correspondence dated April 24, 1998.

4.2 OFF-SITE GROUNDWATER

The OU2 groundwater investigation consisted of three major sampling events conducted in September 1996, November 1997 and April/May of 1999. Several supplemental sampling events were also completed during this time frame to address specific OU2 RI objectives. Groundwater samples were collected from all 31 off-Site monitoring wells during the final round of sampling.

Groundwater samples collected from the off-Site monitoring well network also indicated that Site-related analytes of concern are the VOCs. This is consistent with the data generated during the OU1 RI. In general, VOCs are the most soluble and mobile of the Site-related compounds in groundwater and are most likely to migrate with groundwater from the Site. Moreover, these VOCs were confined to a limited number of monitoring wells. Specifically, significant downgradient detections above the MCLs for benzene, carbon tetrachloride, 1,2-dichloroethane (1,2-DCA), and vinyl chloride were confined primarily to the MW113/114 and the MW123/124 monitoring well clusters.

SVOCs and total cyanide were not detected in groundwater samples collected from off-Site groundwater monitoring wells. The analytical data from the off-Site wells demonstrate that the concentrations of metals observed in Unit B and C groundwater samples are not the result of past waste disposal activities as these concentrations are similar in upgradient and downgradient monitoring wells. Where concentrations of metals in groundwater above the MCLs or SMCLs occur, these detections are likely related to natural groundwater chemistry and/or the presence of suspended solids in groundwater samples, which were dissolved into the water sample by the acid preservative in the laboratory containers.

The analytical data collected during the remedial investigation completed over a period of six years has shown that the only analytes consistently detected above the primary MCLs in off-Site groundwater were several VOCs. Thus, VOCs are identified as the primary compounds of concern (COCs) in off-Site groundwater. Off-Site groundwater data are summarized in the figures provided in Appendix B.

5.0 LONG-TERM GROUNDWATER MONITORING PROGRAM

5.1 OVERVIEW

This LTGMP includes a fixed scope during its initial five years to confirm the analytical database generated during the OU1/OU2 Remedial Investigations and to compile a sufficient database to evaluate potential seasonal trends in groundwater quality. However, beyond the first five years of the LTGMP, it is difficult to establish a fixed scope for a groundwater monitoring program since the scope beyond the first few years will be largely based on the results of monitoring over time.

As such, it is the intent of this document to set forth:

- a work scope for a five-year monitoring/evaluation period designed to confirm existing groundwater analytical data and obtain additional data to establish background groundwater quality conditions;
- a decision-making process for the continuation of groundwater monitoring activities beyond the initial five year period of the LTGMP; and
- the decision-making criteria for termination of the LTGMP.

Pursuant to the ROD, the LTGMP is intended to monitor changes in groundwater quality over time. In accordance with this intent, this section provides details concerning:

- existing off-Site monitoring well network;
- hydraulic monitoring program;
- work scope and rationale for the initial five years of the LTGMP; and a
- summary of the scope for the LTGMP for Year 6 and beyond.

Details of the field sampling program are summarized in the Field Sampling Plan (FSP) that is provided as Appendix C. The Quality Assurance Project Plan (QAPP) for the LTGMP is contained in Attachment I.

5.2 GROUNDWATER MONITORING NETWORK

The existing off-Site groundwater monitoring well network will be utilized to monitor groundwater quality. This monitoring network consists of 31 groundwater monitoring wells installed as part of the OU2 investigation (Table 5.1). Monitoring wells are

constructed to monitor groundwater in Unit B and Unit C. The off-Site monitoring network is depicted in Figure 5.1. A summary of monitoring well construction details is provided in Table 5.2. Upon completion of the OU2 RI, the off-Site monitoring-well network was determined to be sufficient to monitor the nature and extent of groundwater-quality impacts. However, modification of the existing network will be determined in consultation with IDEM, should LTGMP monitoring determine additional monitoring wells are necessary to effectively monitor groundwater quality trends.

There are 6 groundwater monitoring wells (3 completed in Unit B and 3 completed in Unit C) installed in clean areas where background groundwater quality may be monitored. These upgradient monitoring wells include the MW100/101, MW115/116, and MW117/118. This is a sufficient number of monitoring wells, pursuant to 329 of IAC 10-15-5(7), to monitor background groundwater quality at the Site. There are 13 monitoring wells in six well clusters located near the downgradient (north) property boundary screened in the saturated zones (Units B and C). Monitoring of selected wells from these clusters is sufficient to meet the requirements of the ROD and the regulations contained at 329 IAC 10-15-5(7).

In addition to the upgradient and perimeter monitoring well sets discussed in the previous paragraph, sentry wells are positioned to monitor groundwater quality at a greater distance downgradient from the landfill. The downgradient sentry well network is comprised of 12 monitoring locations consisting of five well clusters and two single monitoring wells (MW129 and MW130). These sentry wells will also serve to evaluate the fate and transport mechanisms, and groundwater quality downgradient of the Site.

The locations selected for monitoring groundwater quality near the landfill are summarized in Table 5.3. Stratigraphic and instrumentation logs for each of the off-Site groundwater monitoring wells are provided in Appendix D.

5.3 HYDRAULIC MONITORING

Groundwater levels at each of the 31 off-Site groundwater monitoring wells will be collected during each groundwater sampling event throughout the LTGMP. The more frequent hydraulic monitoring specified during the first two years will assess water-level trends following completion of the landfill cap to determine whether there are any capping related impacts on groundwater flow and to assess potential seasonal trends in water level data. The data obtained during each hydraulic monitoring event will be used to construct groundwater contour maps for the monitored units from which, groundwater flow will be interpreted.

In addition, the monitoring wells will be inspected to insure they are in good repair and that the locks are functioning properly. Repairs to the monitoring wells will be completed on an as needed basis.

5.4 LTGMP- INITIAL 5 YEARS

The LTGMP consists of a fixed scope of work (SOW) for the first five years of monitoring. This will allow a groundwater analytical database to be developed which is representative of Site conditions following completion of the OU1 remedial action. The initial five years of the LTGMP monitoring, in conjunction with the historical groundwater database, will determine background concentrations in groundwater proximal to the Site and also provide a basis for statistical comparisons of long-term data trends. This initial 5-year program satisfies regulatory requirements cited in Sections 7 and 10, respectively, of 329 IAC 10-21.

The groundwater monitoring program during the initial five years of the LTGMP is summarized in Tables 5.3 and 5.4. The initial five years of the LTGMP includes frequent monitoring for a broad list of analytes including select IDEM Table 2 constituents, Target Compound List (TCL) volatile organic compounds (VOCs), TCL semivolatile organic compounds (SVOCs), Target Analyte List (TAL) metals, landfill indicator parameters and fate and transport analytes.

A discussion of the scope and rationale for the initial five years of the LTGMP is provided below.

5.4.1 MODIFIED CONSTITUENTS OF TABLE 2

During the first LTGMP event, groundwater samples from three monitoring wells (MW113, MW114 and MW101) will be collected and analyzed for selected constituents contained in Table 2 of the regulations cited at 329 IAC 10-21-16. Consistent with 329 IAC 10-21-10(c)(4), dioxins/furans, pesticides/herbicides and polychlorinated biphenyls will be excluded from the Table 2 parameter list.

Monitoring wells MW113 and MW114 have been selected as representative of groundwater conditions in Units B and C, respectively, downgradient of the landfill. Monitoring well MW101 will serve as an upgradient control well. It should also be noted that the most recent groundwater sampling event included collection and analysis of a groundwater sample from MW124 for Appendix IX analytes. This parameter list is

equivalent to Indiana's Table 2 constituent list. Other than the expected VOCs and metals analytes, which occurred at expected background concentrations, no other Appendix IX analytes were detected in this downgradient groundwater sample.

5.4.2 VOLATILE ORGANIC COMPOUNDS

As stated previously herein, several VOCs were identified as the primary COCs at the Site. Therefore, groundwater samples will be collected most frequently and from the greatest number of monitoring wells, for VOC analysis. Groundwater samples will be collected for VOC analysis from the upgradient, perimeter, and sentry monitoring well sets on a quarterly basis for the first 2-years and on a semiannual basis in Years 3 through 5. Monitoring for VOCs at the frequency cited herein during the first five years of the LTGMP is sufficient to determine whether there are any seasonal data trends and is consistent with the regulations at 329 IAC 10-21-10(c)(4).

5.4.3 SEMIVOLATILE ORGANIC COMPOUNDS AND TAL METALS

A limited number of SVOC detections were noted in groundwater samples collected from on-Site monitoring wells and SVOCs were not detected in groundwater samples collected from off-Site groundwater monitoring wells. Therefore, groundwater samples will be collected for SVOC analysis annually in Years 1 through 5 of the LTGMP. The sampling events will be timed such that groundwater samples for SVOC analysis during the first three years will be collected during different seasons in successive years. However, if SVOCs are not detected above applicable groundwater quality during the first three years of the LTGMP, these SVOCs will be permanently dropped from the LTGMP. Otherwise continued monitoring for SVOCs would be conducted in accordance with Section 6.0 of this document.

Groundwater samples for SVOC analysis will be collected from the perimeter and upgradient groundwater monitoring wells. The more limited well set and reduction in monitoring frequency is warranted due to the lack of significant SVOC detections in both the on-Site of off-Site groundwater monitoring wells. Moreover, any release of SVOCs from the landfill will first be detected at the monitoring wells located at the downgradient perimeter of the landfill, since SVOCs are not very soluble or mobile in groundwater. Therefore, unless a release is confirmed at the landfill perimeter, there is no need to collect and analyze groundwater samples from monitoring wells located further downgradient of the landfill. In the event SVOCs are detected above applicable groundwater quality criteria in groundwater samples collected from the downgradient

perimeter monitoring wells during the initial five years of the LTGMP, continued monitoring would be conducted in accordance with Section 6.0 of this document.

5.4.4 TARGET ANALYTE LIST METALS

TAL metals will be sampled at the same frequency as the SVOCs discussed in the previous section. The sampling events will be timed such that groundwater samples will be collected during different seasons in successive years. However, if TAL metals are not detected above applicable groundwater quality standards during the first three years of the LTGMP, these analytes will be permanently dropped from the LTGMP. Both unfiltered and filtered TAL metal samples will be collected from the perimeter and upgradient monitoring well locations. Unfiltered samples will be analyzed first and the filtered samples will be archived by the project laboratory. If the analyzed unfiltered groundwater sample displays exceedence of an applicable groundwater standard, then the filtered sample will be analyzed for that analyte that exhibited a concentration above an applicable groundwater quality criteria.

In the event TAL metals are detected above an applicable groundwater quality criteria in groundwater samples collected from the downgradient perimeter monitoring wells during the initial five years of the LTGMP, continued monitoring for the TAL metals analytes present above the applicable criteria would be conducted in accordance with Section 6.0 of this document.

5.4.5 LANDFILL INDICATORS\FATE AND TRANSPORT ANALYTES

Landfill indicator parameters will be analyzed from the perimeter and upgradient monitoring wells on an annual basis in Years 1 through 3 and once again in Year 5. Evaluation of fate and transport analytes, initiated during the OU1/OU2 RI, will continue during the LTGMP to monitor the efficiency of natural attenuation mechanisms at degrading VOCs in groundwater. Samples will be collected for fate and transport parameters during Years 1, 2, and 5. The fate and transport evaluation parameters to be monitored during the LTGMP and their analytical methods are listed in Table 5.5.

5.5 LTGMP- YEAR 6 AND BEYOND

Beginning with Year 6, the LTGMP is designed to allow modification to the work scope to accommodate spatial and chemical changes in groundwater quality over time and to focus the monitoring where chemical constituents exceed applicable groundwater

quality criteria. The analytical data generated during the first five years of the LTGMP will be evaluated in accordance with the criteria set forth in Section 6.0 to select monitoring locations and analytes of concern for the Year 6. Groundwater monitoring events beginning with Year 6 of the LTGMP will be conducted on an annual basis. This frequency is consistent with the requirements of 329 IAC 10-21-10(c)(4).

Beginning in Year 6 and through the termination of the LTGMP, groundwater analytical data from the previous sampling events will be evaluated in accordance with the criteria set forth in Section 6.0 to determine monitoring locations and analytes of concern for the subsequent monitoring event. The proposed work scope for the subsequent monitoring events will be detailed in the annual reports submitted to IDEM. In this manner, groundwater sampling events will be focused on those monitoring wells in areas where groundwater is impacted by Site-related compounds, and chemical analyses will be limited to those compounds of concern.

Analyses of fate and transport parameters will continue through the LTGMP to monitor the continued efficiency of natural attenuation mechanisms. Evaluation of fate and transport mechanisms will occur at least twice beyond Year 6 of the LTGMP. Monitoring locations will remain unchanged from the fate and transport sampling conducted during the initial five years of the program.

A comprehensive discussion concerning the data evaluation procedures is provided in Section 6.0 of this document.

6.0 LTGMP DATA EVALUATION AND SCOPING

6.1 OVERVIEW

Consistent with regulations cited at 329 IAC 10-21, groundwater analytical data will be evaluated following each LTGMP monitoring event to ensure changes in groundwater quality are documented and the integrity of the monitoring network is maintained. Groundwater analytical data will be inserted into a database and tabulated and sorted based upon the relationship of the groundwater monitoring point to the Site (i.e., background data point or a downgradient data point).

The following sections provide details on the data evaluation protocols for the LTGMP. The LTGMP consists of a fixed scope of work during the initial five years followed by a flexile scope that is determined based upon the analytical data developed during the LTGMP.

6.2 YEARS 1 THROUGH 5 - FIXED SCOPE OF WORK

The initial five years of the LTGMP is designed to determine if there are any seasonal concentration trends in the groundwater analytical data and to build a groundwater quality database over regularly spaced monitoring events. These data will be used to supplement the existing historical groundwater database. Upon completion of this initial program, background concentrations will be determined and the basis for statistical comparisons for groundwater proximal to the Site will be developed. As such, the scope of the LTGMP is largely fixed during Years 1 through 5. The only modification that may be made to the fixed scope during the first five years of the LTGMP would be to terminate monitoring for SVOCs and TAL metals. Monitoring for SVOCs and/or TAL metals may be terminated if analyte concentrations do not exceed applicable groundwater quality criteria in groundwater samples collected during Years 1 through 3.

6.3 SCOPING OF THE LTGMP - YEAR 6 AND BEYOND

Groundwater monitoring events beginning with Year 6 of the LTGMP will be conducted on an annual basis. This frequency is consistent with the requirements of 329 IAC 10-21-10(c)(4). Beginning in Year 6 through the termination of the LTGMP, groundwater analytical data from the previous sampling events will be evaluated in accordance with the criteria set forth in Section 6.0 to determine monitoring locations and analytes of concern for the subsequent monitoring event. This section establishes criteria by which

the analytical data developed on an ongoing basis through the LTGMP will be evaluated and a groundwater monitoring scope developed based upon the results of the data evaluation. The objective of this approach is to focus the groundwater monitoring on the area(s) and analytes of concern while still being protective of human health and the environment.

In general, beginning with Year 6, scoping of the LTGMP events is a three-step process as summarized below:

1. identification/elimination of compounds of concern (COCs);
2. identification of monitoring location to be sampled; and
3. scoping of the subsequent LTGMP monitoring event.

Further information concerning each of the above is provided in the following paragraphs.

6.3.1 IDENTIFICATION AND ELIMINATION OF COCs

6.3.1.1 IDENTIFICATION OF CHEMICALS OF CONCERN

At the end of Year 5, groundwater analytical data collected during the previous five years of the LTGMP will be evaluated to determine the monitoring scope for Year 6. Similarly, beyond Year 6, analytical data from each of the previous LTGMP monitoring events will be evaluated and the work scope for the annual monitoring programs determined based upon the analytical database compiled and the criteria presented in this section. Specifically, this evaluation will include the following:

- a comparison of all groundwater analytical data relative to applicable groundwater quality criteria,
- an evaluation of concentration trends at individual monitoring locations using appropriate statistical procedures, and
- an evaluation of the concentrations of analytes at downgradient wells relative to the concentrations at the upgradient monitoring wells using appropriate statistical procedures.

An analyte will be identified as a COC if the following criteria are met:

1. analyte concentrations are above applicable groundwater quality criteria; and

2. analyte concentrations in groundwater are above background (by statistical evaluation).

At this time specific statistical methods cannot be positively identified without an understanding of the distribution of the dataset (i.e., normal, lognormal, etc.). Therefore, appropriate statistical evaluation methods will be determined following the initial five-year monitoring program. Consistent with the regulations cited at 329 IAC 10-21-6 and 329 IAC 10-29-5, the selected statistical methods will be scientifically valid and provide a 95 percent upper confidence level when determining if a change in the concentration of an analyte has occurred or if groundwater quality standards have been exceeded.

In accordance with 329 IAC 10-21-6(a), statistical evaluations will not be performed on the constituents cited in Table 1B including but not limited to calcium, carbonate, iron, magnesium, manganese and potassium. Furthermore, inorganic analytes that are commonly present in groundwater and may be present at concentrations above applicable groundwater quality criteria will not be considered COCs unless the observed concentrations are above background concentrations as determined by appropriate statistical procedures.

If VOCs are identified as COCs consistent with the criteria summarized in this section, the entire suite of TCL VOCs will be considered COCs to account for the presence of potential daughter products that may be present due to biodegradation. Otherwise, individual analytes will be identified as COCs based on the evaluation procedure documented herein.

6.3.1.2 ELIMINATION OF CHEMICALS OF CONCERN

Analytes or suites of analytes will be eliminated as COCs if three consecutive groundwater monitoring events demonstrate the following:

1. analyte concentrations are below applicable groundwater quality criteria in the downgradient monitoring wells, or
2. analyte concentrations in groundwater samples from the downgradient monitoring wells are below background concentrations as determined by appropriate statistical procedures.

Analytes eliminated as COCs will be permanently dropped from the LTGMP.

6.3.2 SELECTION OF MONITORING LOCATIONS

Beginning with Year 6 of the LTGMP, groundwater samples will be collected from groundwater monitoring wells where analytes exceed both applicable groundwater quality standards and statistical background levels consistent with the regulations at 329 IAC 10-21-10(c)(4). Additionally, groundwater samples will be collected from monitoring wells located adjacent to monitoring wells where analytes exceed both applicable groundwater quality standards and analyte concentrations above statistical background levels. The objective of selecting monitoring well locations for the collection of groundwater samples is to maintain definition of the areal and vertical extent of groundwater quality impacts and to determine groundwater quality trends over time. The monitoring locations would be selected to accomplish this objective. Upon completion of the OU2 RI, the off-Site monitoring-well network was sufficient to determine the nature and extent of groundwater-quality impacts. However, in the event that groundwater monitoring proposed in the LTGMP identifies the need to install additional groundwater monitoring wells to effectively monitor groundwater quality trends, modification of the existing network will be determined in consultation with IDEM.

6.3.3 SCOPING OF SUBSEQUENT LTGMP EVENTS

Once the COCs and monitoring locations are identified, a work scope for the annual LTGMP events subsequent to Year 5 will be prepared and discussed in the annual report to IDEM. The annual reports will provide a description of groundwater sampling activity for the most recent event, the laboratory results, and a comparison to applicable standards and previous analytical results. The reports will also contain figures showing summaries of groundwater flow and analytical results.

The reports will also summarize any statistical evaluation of the groundwater data, provide the rationale for selection of the statistical test used to evaluate the data and discuss the results of concentration-trend analyses. The annual report will also discuss the rationale for the selection of COCs and monitoring locations for the subsequent LTGMP event based upon the selection criteria established herein.

Under certain circumstances, analytical data obtained during the LTGMP may warrant follow-up sampling prior to the next scheduled event. Such circumstances include, but are not necessarily limited to accidental breakage or loss of samples during shipment or during handling at the project laboratory and unexpected analytical results. With

respect to the latter circumstance, the need to resample prior to the next scheduled event will be made in consultation with IDEM.

6.4 DURATION OF THE LTGMP

Unless otherwise approved by IDEM, the LTGMP will continue for a period of 30 years or until three consecutive monitoring events demonstrate the following:

1. COC concentrations are below applicable groundwater quality criteria; or
2. COC concentrations of analytes in groundwater are comparable to background (by statistical evaluation).

Additionally, the Group may request termination of the LTGMP if monitoring demonstrates that COCs present in groundwater exceed only aesthetic-based standards rather than health-based standards or analyte concentrations in groundwater fall within acceptable human health-based risk levels.

7.0 REPORTING

LTGMP data summaries will be submitted to IDEM within 60 business days following the receipt and validation of the analytical data from the sampling event. Quarterly and semiannual reports will include tabulated summaries of the groundwater analytical data, groundwater elevation data, and the data validation report from the last event. A figure depicting groundwater flow will also be provided in each quarterly or semiannual report. Quarterly reports will be submitted following the first three sampling rounds during years that quarterly monitoring is performed. A semiannual report will be submitted to IDEM following the first semiannual monitoring event during years that semiannual monitoring is performed. Quarterly and semiannual reports will not be submitted to IDEM following the last quarterly or semiannual event during the year since the annual report discussed in the following paragraph will be submitted following the final monitoring event in any given year.

An annual report will also be generated each year summarizing LTGMP data and activities for the entire calendar year. The annual report will be submitted to IDEM within 90-days following the receipt and validation of the analytical data for the last sampling round in that calendar year. This annual report will discuss the groundwater data generated for the LTGMP during that calendar year and discuss whether data quality objectives were met. The annual report will also contain figures showing summaries of groundwater flow and analytical results.

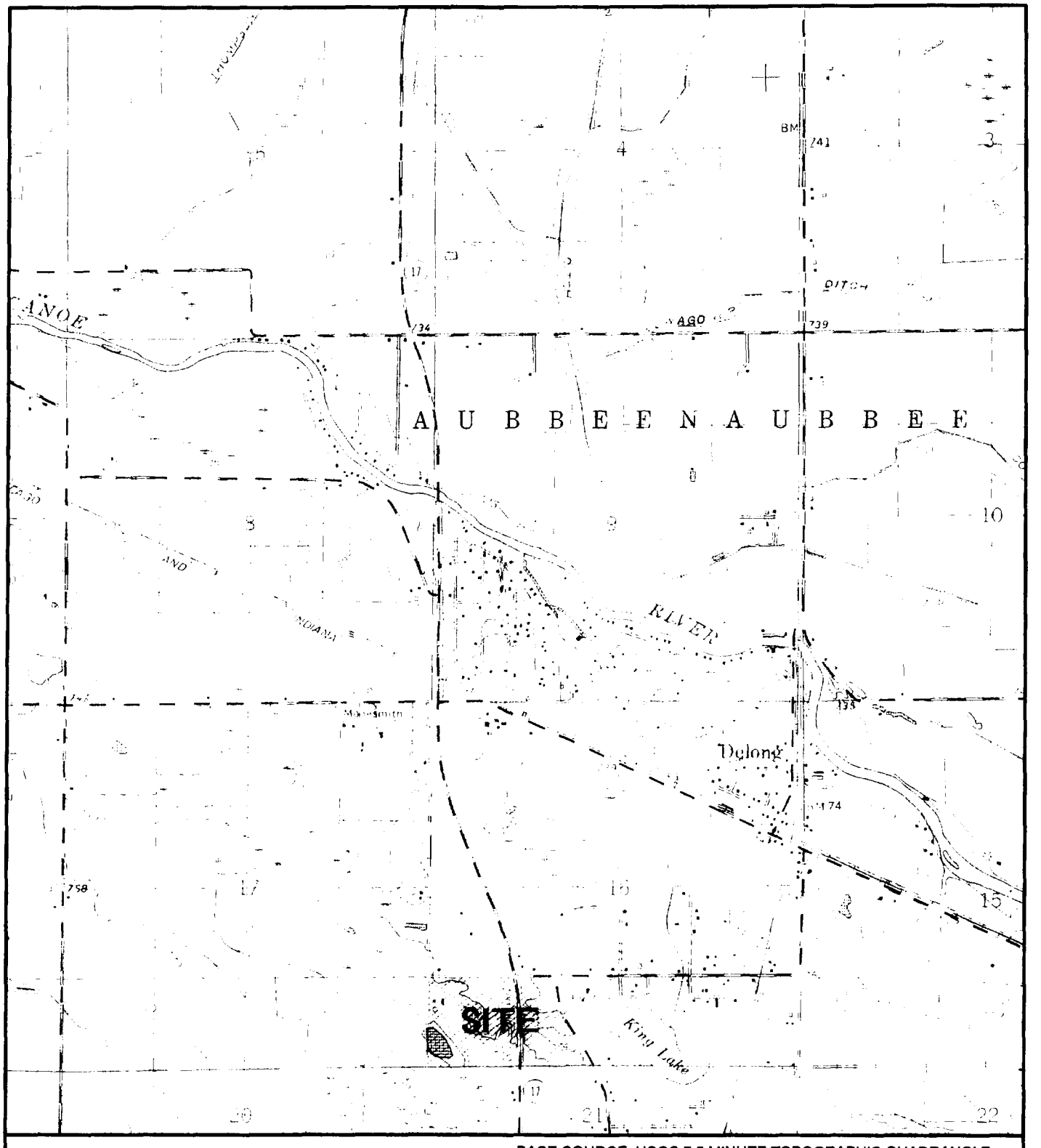
Beginning with the annual report for Year 5 of the LTGMP, annual reports will also summarize statistical evaluation of the groundwater analytical data and provide the rationale for selection of the statistical test used to evaluate the data. The annual report will also discuss the rationale for the selection of COCs and monitoring locations for the subsequent annual LTGMP event based upon the selection criteria established herein.

8.0 HEALTH AND SAFETY PLAN

Health and safety protocols detailed in Appendix E will be adhered to while performing LTGMP-related field activities.

9.0 REVIEW OF THE LTGMP

Following the Year 5 of the LTGMP and every 5 years thereafter, the LTGMP will be evaluated to ensure that it is meeting the objectives stated in the ROD. The LTGMP monitoring program summarized in Table 5.4 may be modified based upon the results of monitoring conducted during Years 1 through 5. Suggested revisions to the LTGMP will be made to IDEM's designated project manager in the summary report transmitting the data for Year 5. IDEM will review the proposed modifications and, in consultation with the Group, decide upon the appropriate monitoring program for the next 5-year period.



BASE SOURCE: USGS 7.5 MINUTE TOPOGRAPHIC QUADRANGLE; CULVER, INDIANA 1965

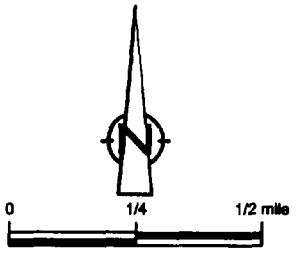


figure 1.1

SITE LOCATION
FOUR COUNTY LANDFILL SITE
Fulton County, Indiana

CRA

05369-76(024)GN-CO001 MAY 30/2000

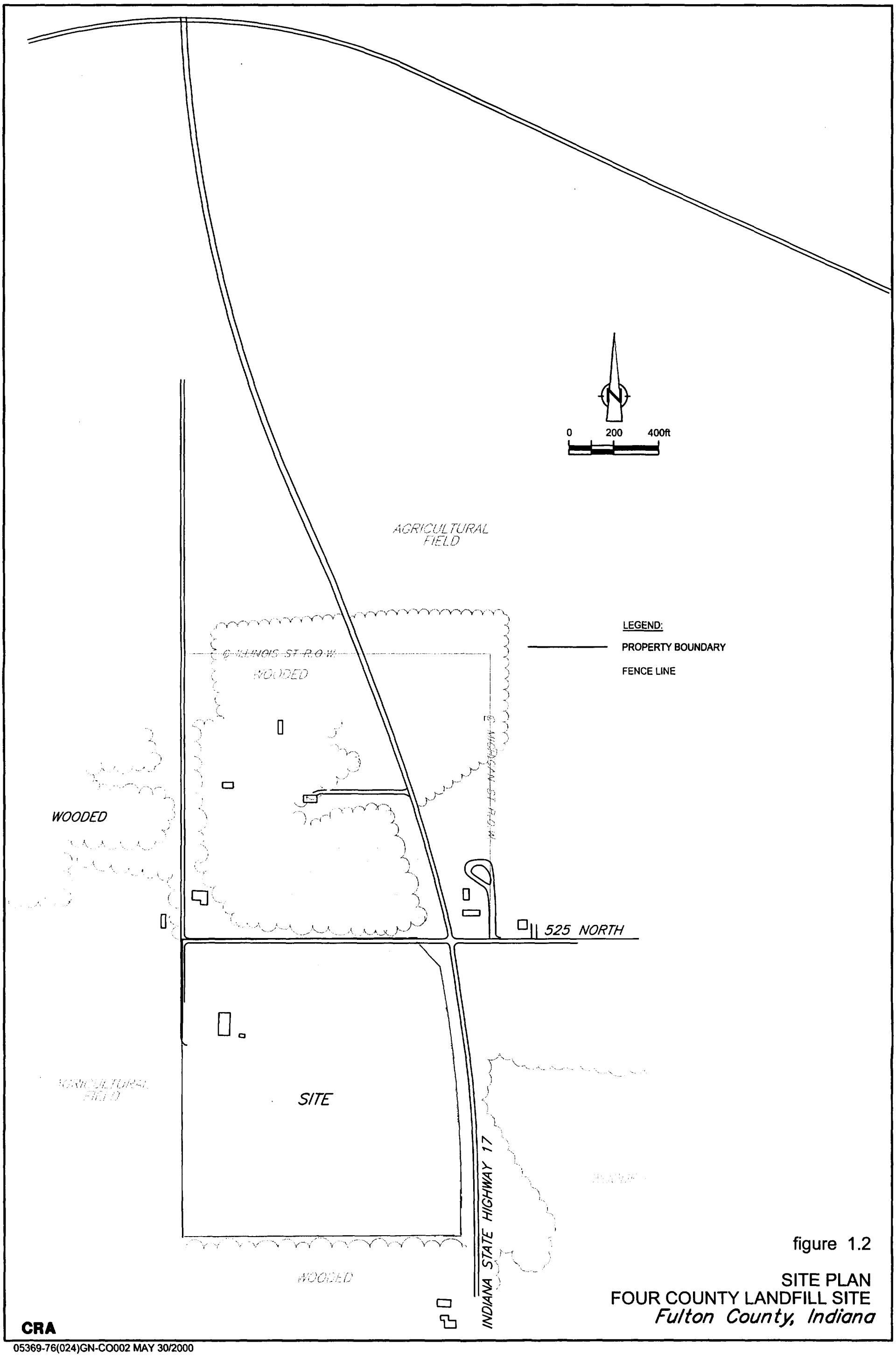


figure 1.2

SITE PLAN
FOUR COUNTY LANDFILL SITE
Fulton County, Indiana

CRA

05369-76(024)GN-CO002 MAY 30/2000

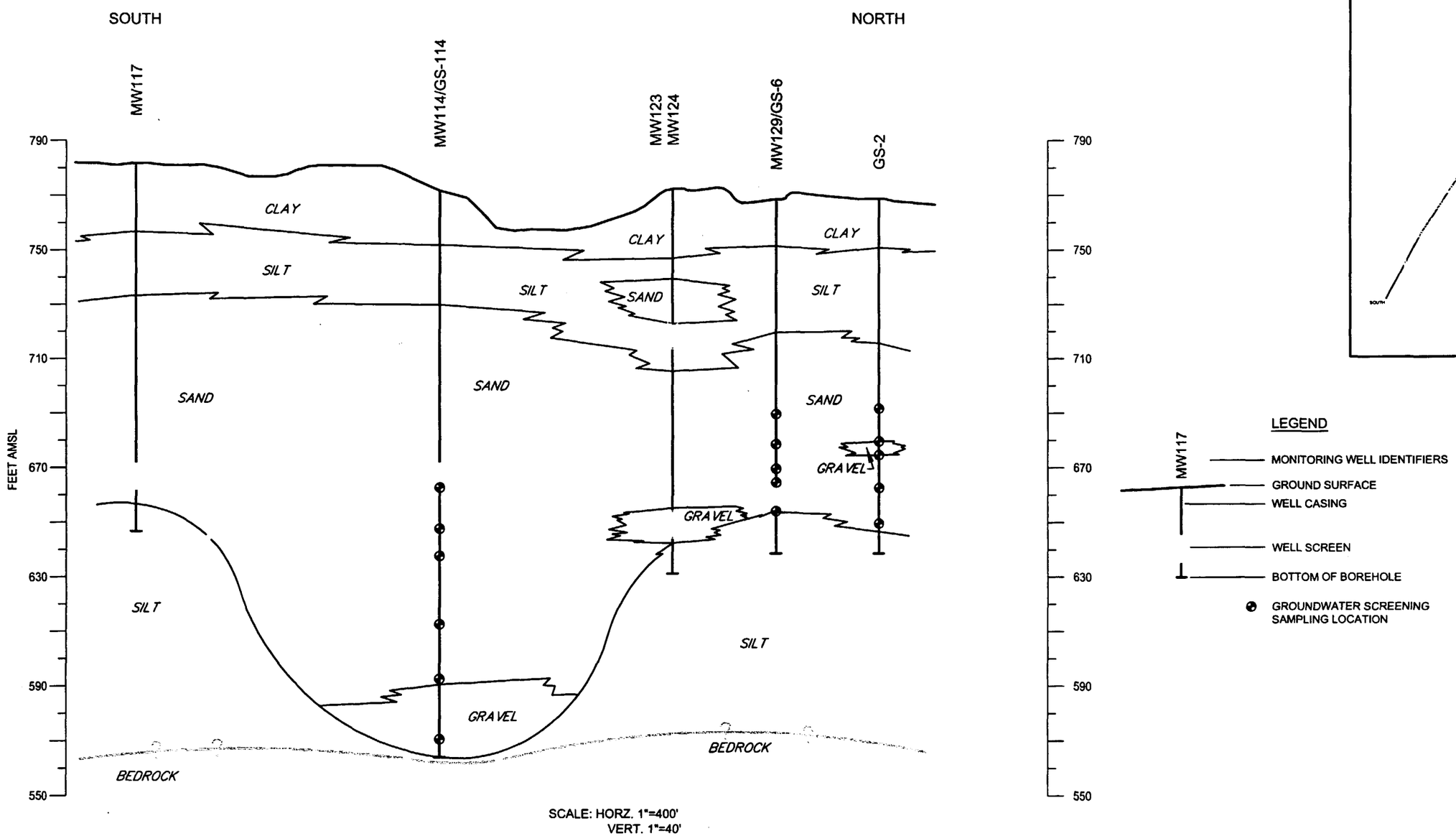
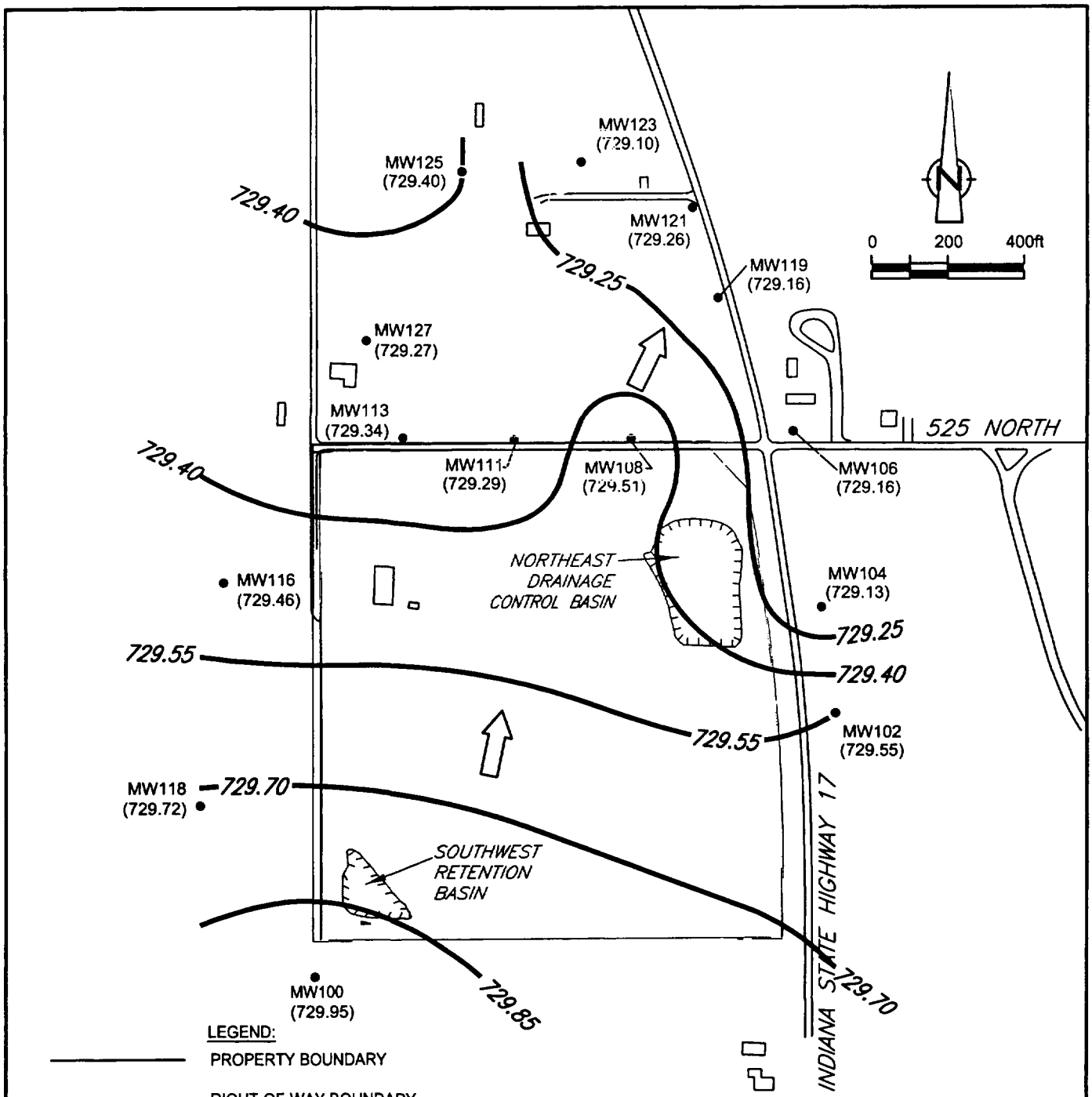


figure 3.1

GENERALIZED GEOLOGIC CROSS SECTION
WITH GROUNDWATER SCREENING LOCATIONS
FOUR COUNTY LANDFILL SITE
Fulton County, Indiana

CRA

05369-76(024)GN-CO005 MAY 30/2000



LEGEND:

PROPERTY BOUNDARY

RIGHT-OF-WAY BOUNDARY

FENCE LINE

MW100 ● MONITORING WELL LOCATION AND IDENTIFIER

(729.10) GROUNDWATER ELEVATION (FT. AMSL)

729.25 GROUNDWATER CONTOUR, INTERVAL=0.15 ft.

GROUNDWATER FLOW DIRECTION

NOTE:

THE GROUNDWATER ELEVATION AT MW110 WAS NOT USED IN THE GENERATION OF GROUNDWATER CONTOURS

figure 3.2

GROUNDWATER CONTOURS-JUNE 1999
SHALLOW OFF-SITE MONITORING WELL LOCATIONS
FOUR COUNTY LANDFILL SITE
Fulton County, Indiana

CRA

05369-76(024)GN-CO003 MAY 30/2000

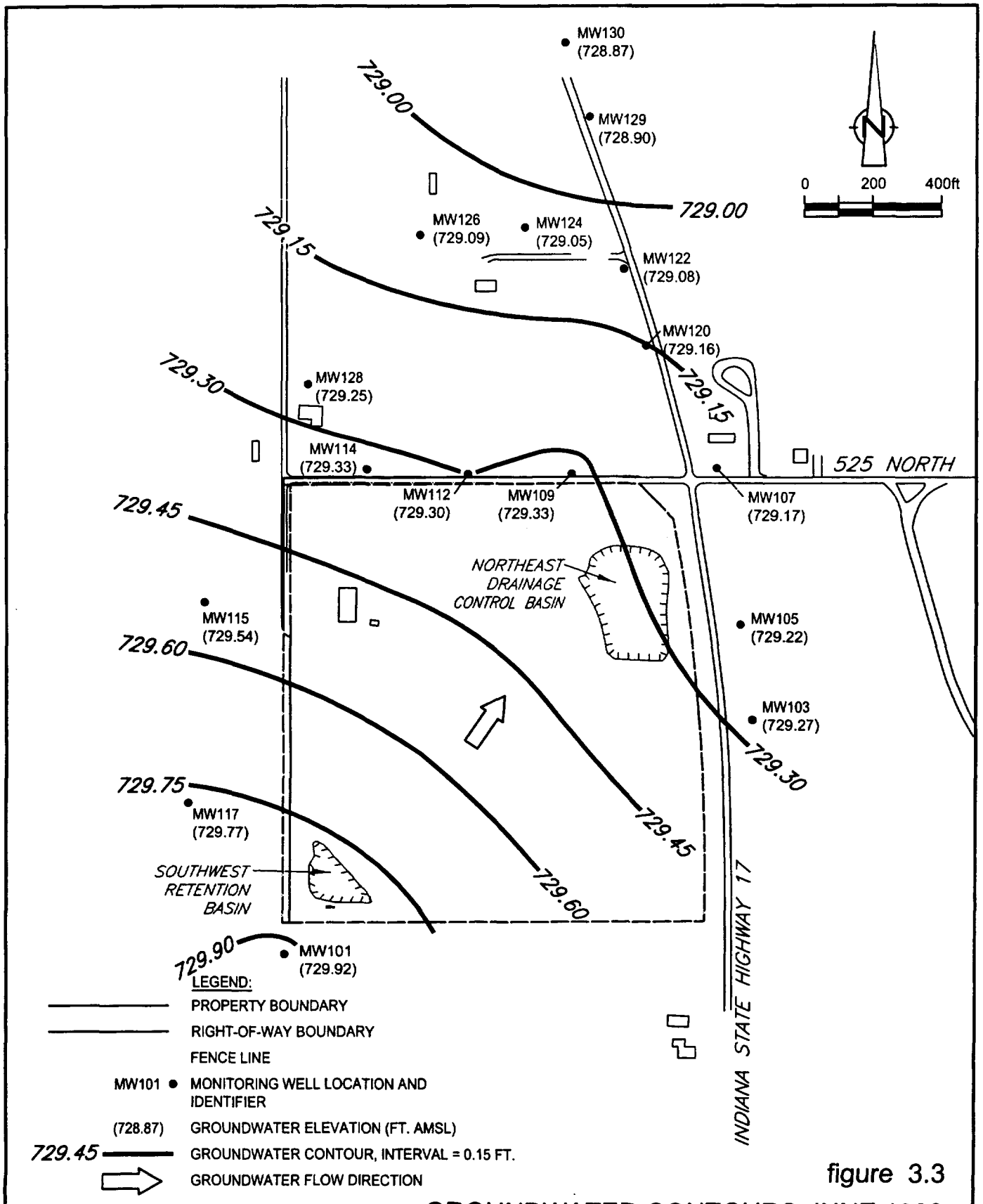


figure 3.3

GROUNDWATER CONTOURS-JUNE 1999
DEEP OFF-SITE MONITORING WELL LOCATIONS
FOUR COUNTY LANDFILL SITE
Fulton County, Indiana

CRA

05369-76(024)GN-CO004 MAY 30/2000

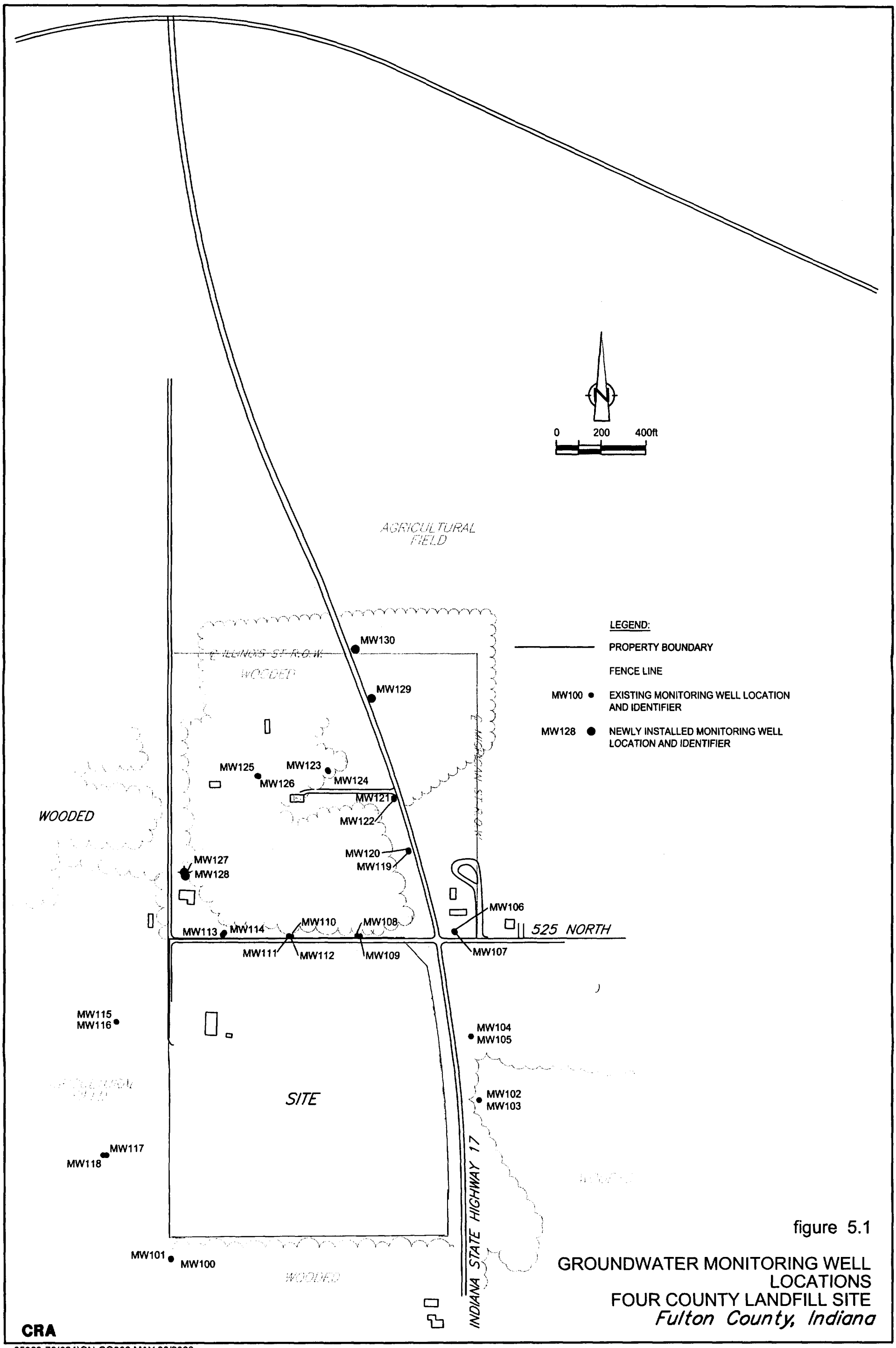


figure 5.1

GROUNDWATER MONITORING WELL LOCATIONS
FOUR COUNTY LANDFILL SITE
Fulton County, Indiana

05369-76(024)GN-CO006 MAY 30/2000

TABLE 5.1

GROUNDWATER MONITORING WELLS
LONG-TERM GROUNDWATER MONITORING PROGRAM
FOUR COUNTY LANDFILL SITE
FULTON COUNTY, INDIANA

Shallow Monitoring Wells	*Deep Monitoring Wells*
MW100	MW101
MW102	MW103
MW104	MW105
MW106	MW107
MW108	MW109
MW110	MW112
MW111	MW114
MW113	MW115
MW116	MW117
MW118	MW120
MW119	MW122
MW121	MW124
MW123	MW126
MW125	MW128
MW127	MW129
	MW130

SUMMARY OF MONITORING WELL CONSTRUCTION DETAILS
FOUR COUNTY LANDFILL SITE
FULTON COUNTY, INDIANA

Location	Ground Surface (ft NGVD)[1]	Top of Casing (ft NGVD)	Screened Interval Top (ft bgs)[2]	Screened Interval Bottom (ft bgs)	Screened Interval Top (ft NGVD)	Screened Interval Bottom (ft NGVD)	Screen Length (feet)	Top of Sand Pack (ft bgs)	Top of Sand Pack (ft NGVD)	Construction
MW-100	783.0	785.06	60	70	723.0	713.0	10	57	726.0	2" PVC
MW-101	783.2	785.31	100	110	683.2	673.2	10	97	686.2	2" PVC
MW-102	755.9	758.11	35	45	720.9	710.9	10	32	723.9	2" PVC
MW-103	756.0	758.10	75	85	681.0	671.0	10	72	684.0	2" PVC
MW-104	771.2	773.00	50	60	721.2	711.2	10	47	724.2	2" PVC, double cased to 25 ft.
MW-105	771.8	773.74	85	95	686.8	676.8	10	81	690.8	2" PVC, double cased to 25 ft.
MW-106	766.1	768.12	75	85	691.1	681.1	10	72	694.1	2" PVC
MW-107	766.3	768.43	115	125	651.3	641.3	10	112	654.3	2" PVC
MW-108	755.0	756.87	65	75	690.0	680.0	10	62	693.0	2" PVC
MW-109	754.7	756.89	115	125	639.7	629.7	10	112	642.7	2" PVC
MW-110	760.5	762.72	40	50	720.5	710.5	10	37	723.5	2" PVC
MW-111	760.3	762.49	75	85	685.3	675.3	10	72	688.3	2" PVC
MW-112	759.6	761.70	115	125	644.6	634.6	10	112	647.6	2" PVC
MW-113	771.8	774.12	60	70	711.8	701.8	10	57	714.8	2" PVC
MW-114	772.3	774.57	100	110	672.3	662.3	10	97	675.3	2" PVC
MW-115	782.7	784.98	105	115	677.7	667.7	10	102	680.7	2" PVC, double cased to 60 ft.
MW-116	782.5	784.82	55	65	727.5	717.5	10	52	730.5	2" PVC, double cased to 50 ft.
MW-117	781.7	784.84	110	120	671.7	661.7	10	107	674.7	2" PVC, double cased to 50 ft.
MW-118	782.9	784.96	55	65	727.9	717.9	10	52	730.9	2" PVC, double cased to 40 ft.
MW-119	763.3	765.71	40	50	723.3	713.3	10	37	726.3	2" PVC
MW-120	763.0	765.30	85	95	678.0	668.0	10	79	684.0	2" PVC
MW-121	766.5	768.92	43	53	723.5	713.5	10	40	726.5	2" PVC
MW-122	766.1	768.48	97	107	669.1	659.1	10	92	674.1	2" PVC
MW-123	772.1	773.88	49	59	723.1	713.1	10	47	725.1	2" PVC
MW-124	772.3	774.03	118	128	654.3	644.3	10	116	656.3	2" PVC
MW-125	756.9	759.34	34	44	722.9	712.9	10	31	725.9	2" PVC
MW-126	757.0	759.07	103	113	654.0	644.0	10	99	658.0	2" PVC
MW-127	780.8	783.03	58	68	722.8	712.8	10	53	727.8	2" PVC, double cased to 21 ft.
MW-128	780.9	782.87	118	128	662.9	652.9	10	115	665.9	2" PVC, double cased to 21 ft.
MW-129	768.6	770.98	105	115	663.6	653.6	10	101	667.6	2" PVC
MW-130	768.5	772.14	112	122	656.5	646.5	10	108	660.5	2" PVC

[1]ft NGVD - feet as referenced to National Geodetic Vertical Datum

[2]ft bgs - feet below ground surface

TABLE 5.3

MONITORING WELL SETS
LONG-TERM GROUNDWATER MONITORING PROGRAM
FOUR COUNTY LANDFILL SITE
FULTON COUNTY, INDIANA

Monitoring Well Set	*Monitoring Well Identifier*	
	Shallow Well	*Deep Well*
Upgradient Monitoring Well Set (6 wells)	MW100	MW101
	MW116	MW115
	MW118	MW117
Perimeter Monitoring Well Set (12 wells)	MW102	MW103
	MW104	MW105
	MW106	MW107
	MW108	MW109
	MW110	MW112
	MW113	MW114
Sentry Monitoring Well Set (12 wells)	MW119	MW120
	MW121	MW122
	MW123	MW124
	MW125	MW126
	MW127	MW128
		MW129
		MW130
Fate & Transport Well Set (15 wells)	MW110	MW112
	MW113	MW114
	MW116	MW115
	MW118	MW117
	MW121	MW122
	MW123	MW124
	MW125	MW126
		MW129

TABLE 5.4

SUMMARY OF THE INITIAL FIVE YEARS OF THE LONG-TERM GROUNDWATER MONITORING PROGRAM
FOUR COUNTY LANDFILL SITE
FULTON COUNTY, INDIANA

Analytes	*Monitoring Frequency*	*Monitoring Locations*[1]
Modified Constituents of Table 2[2]	Once in Year 1	Selected Monitoring Wells[3]
TCL VOC	Quarterly in Years 1 and 2 Semiannually in Years 3 through 5	All Monitoring Well Sets in Table 5.3
TCL SVOC	Annually in Years 1 through 5[4]	Perimeter and Upgradient Monitoring Well Sets
TAL Metals (Filtered/Unfiltered)[5]	Annually in Years 1 through 5[4]	Perimeter and Upgradient Monitoring Well Sets
Landfill Indicator Parameters[6]	Annually in Years 1 through 3, and 5[4]	Perimeter and Upgradient Monitoring Well Sets
Fate & Transport Parameters	Annually in Years 1 through 3, and 5[4]	Fate & Transport Well Set[7]
Hydraulic Monitoring	During Each Monitoring Event	All Monitoring Wells

Abbreviations

TCL VOCs - Target Compound List Volatile Organic Compounds
TCL SVOCs - Target Compound List Semivolatile Organic Compounds excluding pesticides and polychlorinated biphenyls
TAL - Target Analyte List

Footnotes

1) See Table 5.3 for the identity of monitoring well sets identified in this column.

2) Table 2, Section 16 of IAC Code 329 10-21 constituents excluding dioxins/furans, pesticides/herbicides, and polychlorinated biphenyls. Where overlap between Table 2 analytes occurs with other analyte lists during the first event, groundwater samples will be analyzed for the Table 2 parameters.

3) Selected locations consisting of MW101, MW113, & MW114.

4) Sampling to be performed in different quarters during successive events.

5) Both filtered and unfiltered samples will be collected. Only the unfiltered samples will be analyzed. The filtered samples will be archived and analyzed as necessary based upon the results of the filtered samples.

6) Landfill indicator parameters include chloride, sulfate, nitrate, total dissolved solids, total suspended solids, and total cyanide.

7) Samples for fate & transport evaluation will be collected from selected wells located within, proximal to, and upgradient of the area of groundwater impact.

TABLE 5.5

SUMMARY OF ANALYTICAL METHODS
LONG-TERM GROUNDWATER MONITORING PROGRAM
FOUR COUNTY LANDFILL SITE
FULTON COUNTY, INDIANA

Parameter[1]	*Preparation Method Reference*[2]	*Analysis Method Reference*[2]
TCL VOCs	SW-846 5030B	SW-846 8260B
TCL SVOCs	SW-846 3510C	SW-846 8270C
Aluminum	SW-846 3005A	SW-846 6010B
Antimony	SW-846 3005A/3020A	SW-846 7041
Arsenic	SW-846 3005A/3020A	SW-846 7060A
Barium	SW-846 3005A	SW-846 6010B
Beryllium	SW-846 3005A	SW-846 6010B
Cadmium	SW-846 3005A	SW-846 6010B
Calcium	SW-846 3005A	SW-846 6010B
Chromium	SW-846 3005A	SW-846 6010B
Cobalt	SW-846 3005A	SW-846 6010B
Copper	SW-846 3005A	SW-846 6010B
Iron	SW-846 3005A	SW-846 6010B
Lead	SW-846 3005A/3020A	SW-846 7421
Magnesium	SW-846 3005A	SW-846 6010B
Manganese	SW-846 3005A	SW-846 6010B
Mercury	SW-846 7470A	SW-846 7470A
Nickel	SW-846 3005A	SW-846 6010B
Potassium	SW-846 3005A	SW-846 6010B
Selenium	SW-846 3005A/3020A	SW-846 7740
Silver	SW-846 3005A	SW-846 6010B
Sodium	SW-846 3005A	SW-846 6010B
Thallium	SW-846 3005A/3020A	SW-846 7841
Vanadium	SW-846 3005A	SW-846 6010B
Zinc	SW-846 3005A	SW-846 6010B
Alkalinity (Carbonate, Bicarbonate)	EPA 310.1	EPA 310.1
Chloride	EPA 325.3	EPA 325.3
Nitrogen-Ammonia	EPA 350.3	EPA 350.3
Nitrogen-Nitrate	EPA 353.3	EPA 353.3
Nitrogen-Nitrite	EPA 353.3	EPA 353.3

TABLE 5.5

SUMMARY OF ANALYTICAL METHODS
LONG-TERM GROUNDWATER MONITORING PROGRAM
FOUR COUNTY LANDFILL SITE
FULTON COUNTY, INDIANA

Parameter[1]	*Preparation Method Reference*[2]	*Analysis Method Reference*[2]
Sulfate	EPA 375.4	EPA 375.4
Sulfide	SW-846 9030B	SW-846 9030B
Total Organic Carbon	SW-846 9060	SW-846 9060
Dissolved Organic Carbon	SW-846 9060	SW-846 9060
Total Suspended Solids	EPA 160.2	EPA 160.2
Total Dissolved Solids	EPA 160.1	EPA 160.1
Dissolved Gases[3]	SW-846 3810	SW-846 3810
Field pH/Temperature	NA	EPA 150.1
Field Conductivity	NA	EPA 120.1
Field Dissolved Oxygen	NA	EPA 360.1
Field Turbidity	NA	EPA 180.1
Field Oxidation-Reduction Potential	NA	SM 2580B

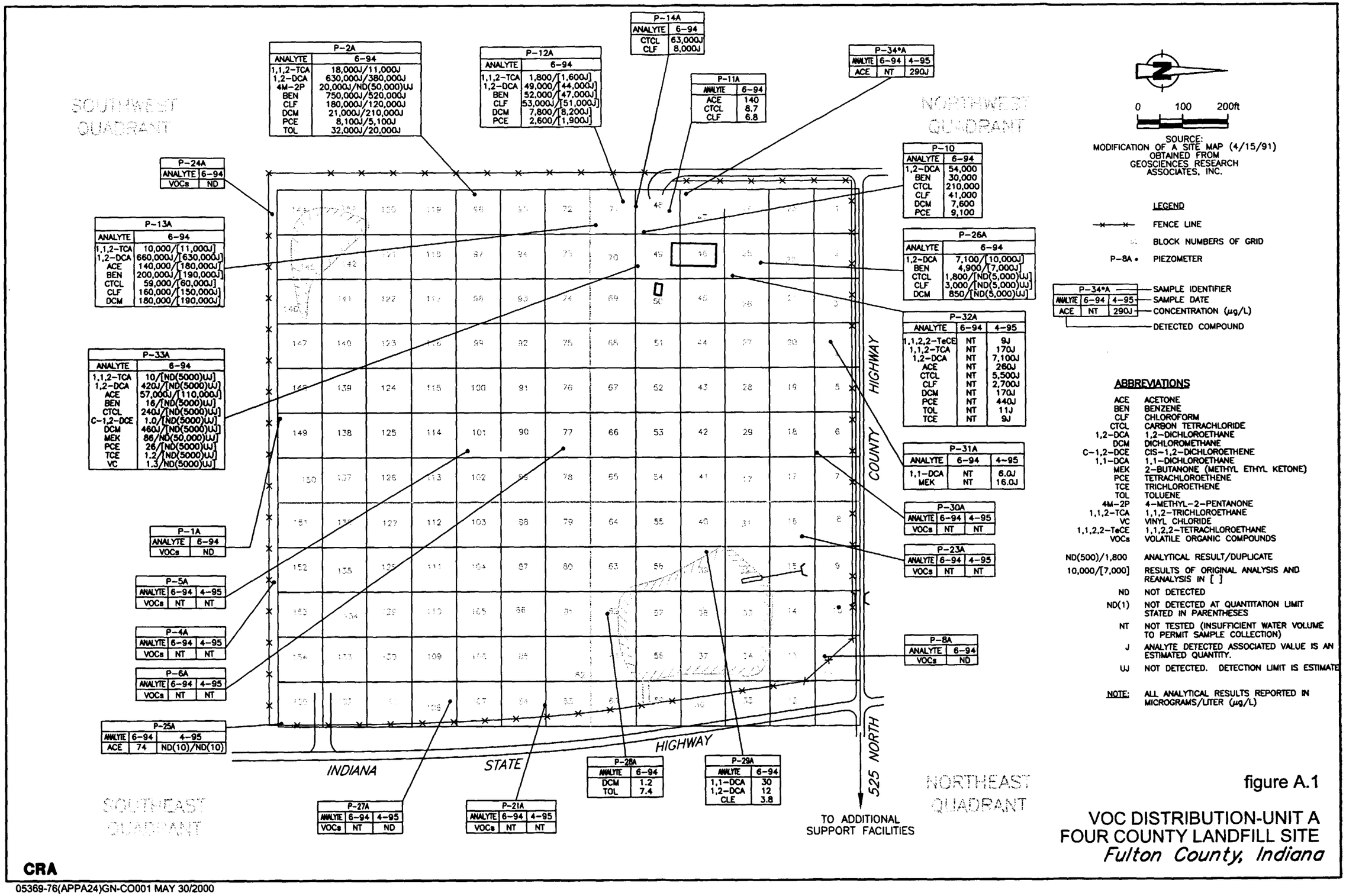
[1] TCL VOCs - Target Compound List Volatile Organic Compounds
SVOCs - Semivolatile Organic Compounds

[2] SW-846 - "Test Methods for Evaluating Solid Wastes, Physical/Chemical Methods", EPA SW-846, 3rd Edition with promulgated updates, November 1986.
EPA - "Methods for Chemical Analysis of Water and Wastes", EPA-600/4-79-020, March 1983.
SM - "Standard Methods for the Examination of Water and Wastewater", APHA, 19 Edition, 1995.
Dissolved metals will be prepared using SW-846 method 3005A prior to graphite furnace atomic absorption spectroscopy analysis.

[3] Dissolved gases include ethane, ethene, and methane.

APPENDIX A

ON-SITE GROUNDWATER DATA SUMMARY FIGURES



P-2A	
ANALYTE	6-94
1,1,2-TCA	18,000J/11,000J
1,2-DCA	630,000J/380,000J
4M-2P	20,000J/ND(50,000)UJ
BEN	750,000J/520,000J
CLF	180,000J/120,000J
DCM	21,000J/210,000J
PCE	8,100J/5,100J
TOL	32,000J/20,000J

P-12A	
ANALYTE	6-94
1,1,2-TCA	1,800/[1,600J]
1,2-DCA	49,000/[44,000J]
BEN	52,000/[47,000J]
CLF	53,000J/[51,000J]
DCM	7,800/[8,200J]
PCE	2,600/[1,900J]

P-14A	
ANALYTE	6-94
CTCL	63,000J
CLF	8,000J

P-11A	
ANALYTE	6-94
ACE	140
CTCL	8.7
CLF	6.8

P-34*A		
ANALYTE	6-94	4-95
ACE	NT	290J

P-10	
ANALYTE	6-94
1,2-DCA	54,000
BEN	30,000
CTCL	210,000
CLF	41,000
DCM	7,600
PCE	9,100

P-24A	
ANALYTE	6-94
VOCs	ND

P-13A	
ANALYTE	6-94
1,1,2-TCA	10,000/[11,000J]
1,2-DCA	660,000J/[630,000J]
ACE	140,000/[180,000J]
BEN	200,000J/[190,000J]
CTCL	59,000/[60,000J]
CLF	160,000/[150,000J]
DCM	180,000/[190,000J]

P-26A	
ANALYTE	6-94
1,2-DCA	7,100/[10,000J]
BEN	4,900/[7,000J]
CTCL	1,800/[ND(5,000)UJ]
CLF	3,000/[ND(5,000)UJ]
DCM	850/[ND(5,000)UJ]

P-32A		
ANALYTE	6-94	4-95
1,1,2,2-TeCE	NT	9J
1,1,2-TCA	NT	170J
1,2-DCA	NT	7,100J
ACE	NT	260J
CTCL	NT	5,500J
CLF	NT	2,700J
DCM	NT	170J
PCE	NT	440J
TOL	NT	11J
TCE	NT	9J

P-33A	
ANALYTE	6-94
1,1,2-TCA	10/[ND(5000)UJ]
1,2-DCA	420J/[ND(5000)UJ]
ACE	57,000J/[110,000J]
BEN	16/[ND(5000)UJ]
CTCL	240J/[ND(5000)UJ]
C-1,2-DCE	1.0/[ND(5000)UJ]
DCM	460J/[ND(5000)UJ]
MEK	86/ND(50,000)UJ
PCE	26/[ND(5000)UJ]
TCE	1.2/[ND(5000)UJ]
VC	1.3/ND(5000)UJ]

P-31A		
ANALYTE	6-94	4-95
1,1-DCA	NT	6.0J
MEK	NT	16.0J

P-30A		
ANALYTE	6-94	4-95
VOCs	NT	NT

P-23A		
ANALYTE	6-94	4-95
VOCs	NT	NT

P-1A	
ANALYTE	6-94
VOCs	ND

P-5A		
ANALYTE	6-94	4-95
VOCs	NT	NT

P-4A		
ANALYTE	6-94	4-95
VOCs	NT	NT

P-6A		
ANALYTE	6-94	4-95
VOCs	NT	NT

P-8A	
ANALYTE	6-94
VOCs	ND

P-25A		
ANALYTE	6-94	4-95
ACE	74	ND(10)/ND(10)

P-28A	
ANALYTE	6-94
DCM	1.2
TOL	7.4

P-29A	
ANALYTE	6-94
1,1-DCA	30
1,2-DCA	12
CLE	3.8

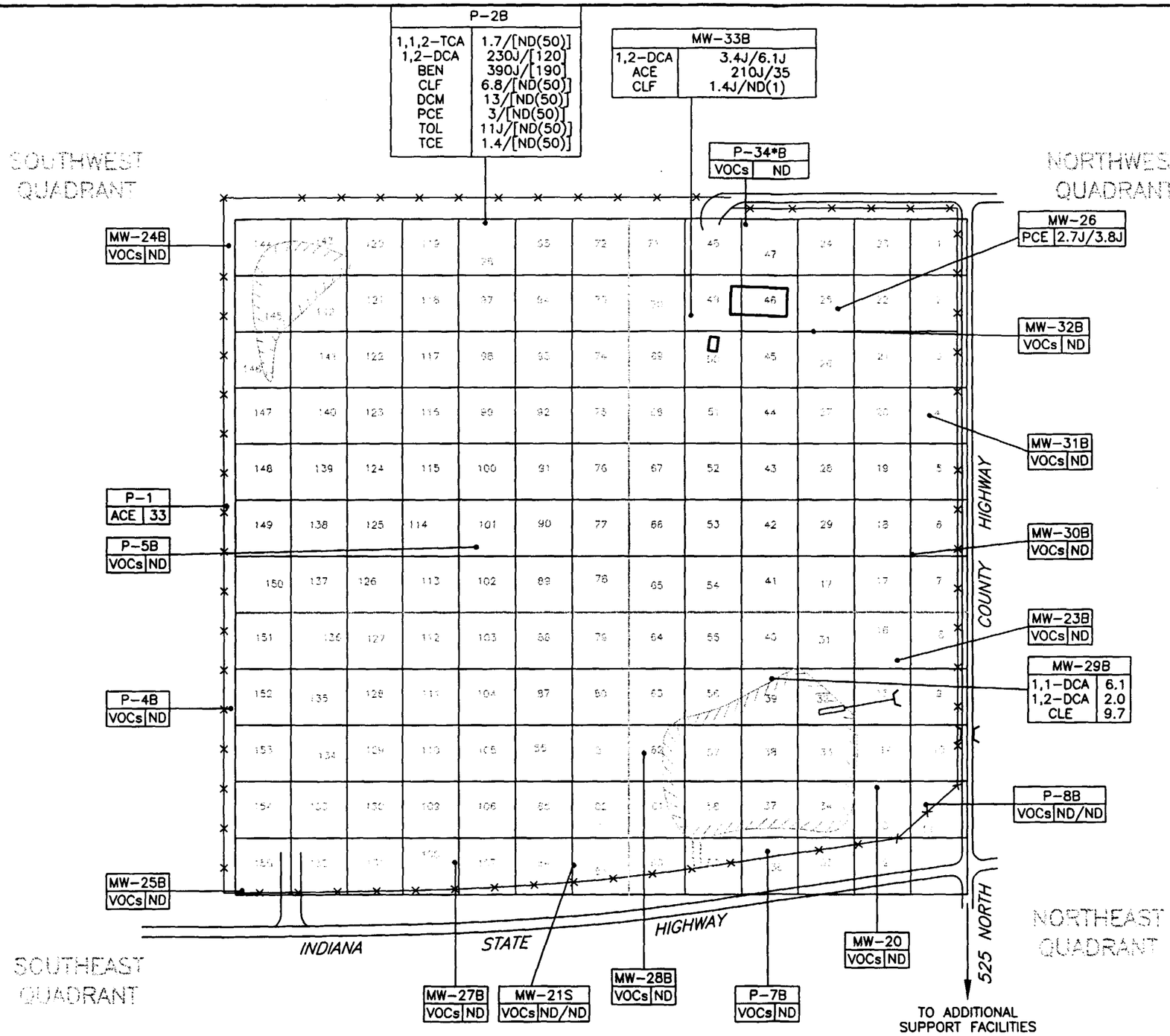
P-27A		
ANALYTE	6-94	4-95
VOCs	NT	ND

P-21A		
ANALYTE	6-94	4-95
VOCs	NT	NT

figure A.1

VOC DISTRIBUTION-UNIT A
FOUR COUNTY LANDFILL SITE
Fulton County, Indiana

05369-76(APPA24)GN-CO001 MAY 30/2000



0 100 200ft

SOURCE:
MODIFICATION OF A SITE MAP (4/15/91) OBTAINED FROM GEOSCIENCES RESEARCH ASSOCIATES, INC.

LEGEND

—×—×—	FENCE LINE
150	BLOCK NUMBERS OF GRID
P-8B •	PIEZOMETER
MW-26 •	MONITORING WELL

ABBREVIATIONS

1,2-DCA	1,2-DICHLOROETHANE
ACE	ACETONE
BEN	BENZENE
CLF	CHLOROFORM
CLE	CHLOROETHANE
DCM	DICHLOROMETHANE
PCE	TETRACHLOROETHENE
TOL	TOLUENE
TCE	TRICHLOROETHENE
1,1,2-TCA	1,1,2-TRICHLOROETHANE
1,1-DCA	1,1-DICHLOROETHANE
VOCs	VOLATILE ORGANIC COMPOUNDS
ND(1)/ND(1)	ANALYTICAL RESULT/DUPLICATE
1.7/[ND(50)]	RESULTS OF ORIGINAL ANALYSIS AND REANALYSIS IN [ ]
ND	NOT DETECTED
ND(1)	NOT DETECTED AT QUANTITATION LIMIT STATED IN PARENTHESES
J	ANALYTE DETECTED ASSOCIATED VALUE IS AN ESTIMATED QUANTITY.
UJ	NOT DETECTED. DETECTION LIMIT IS ESTIMATED.

NOTE: ALL ANALYTICAL RESULTS REPORTED IN MICROGRAMS/LITER (μg/L)

figure A.2

VOC DISTRIBUTION-UNIT B
JUNE 1994
FOUR COUNTY LANDFILL SITE
Fulton County, Indiana

CRA

05369-76(APPA24)GN-CO002 MAY 30/2000

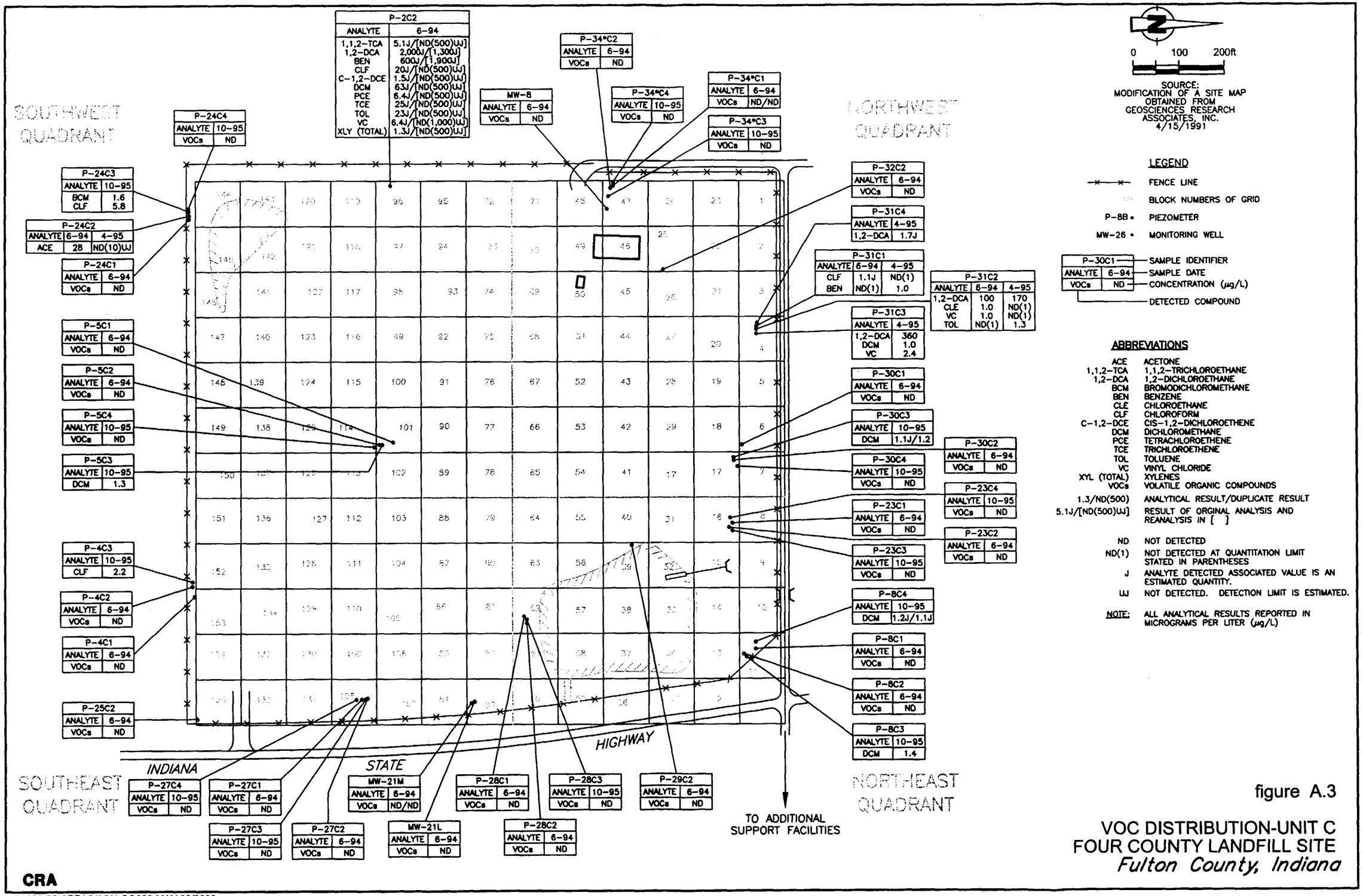


figure A.3

VOC DISTRIBUTION-UNIT C
FOUR COUNTY LANDFILL SITE
Fulton County, Indiana

CRA

05369-76(APPA24)GN-CO003 MAY 30/2000

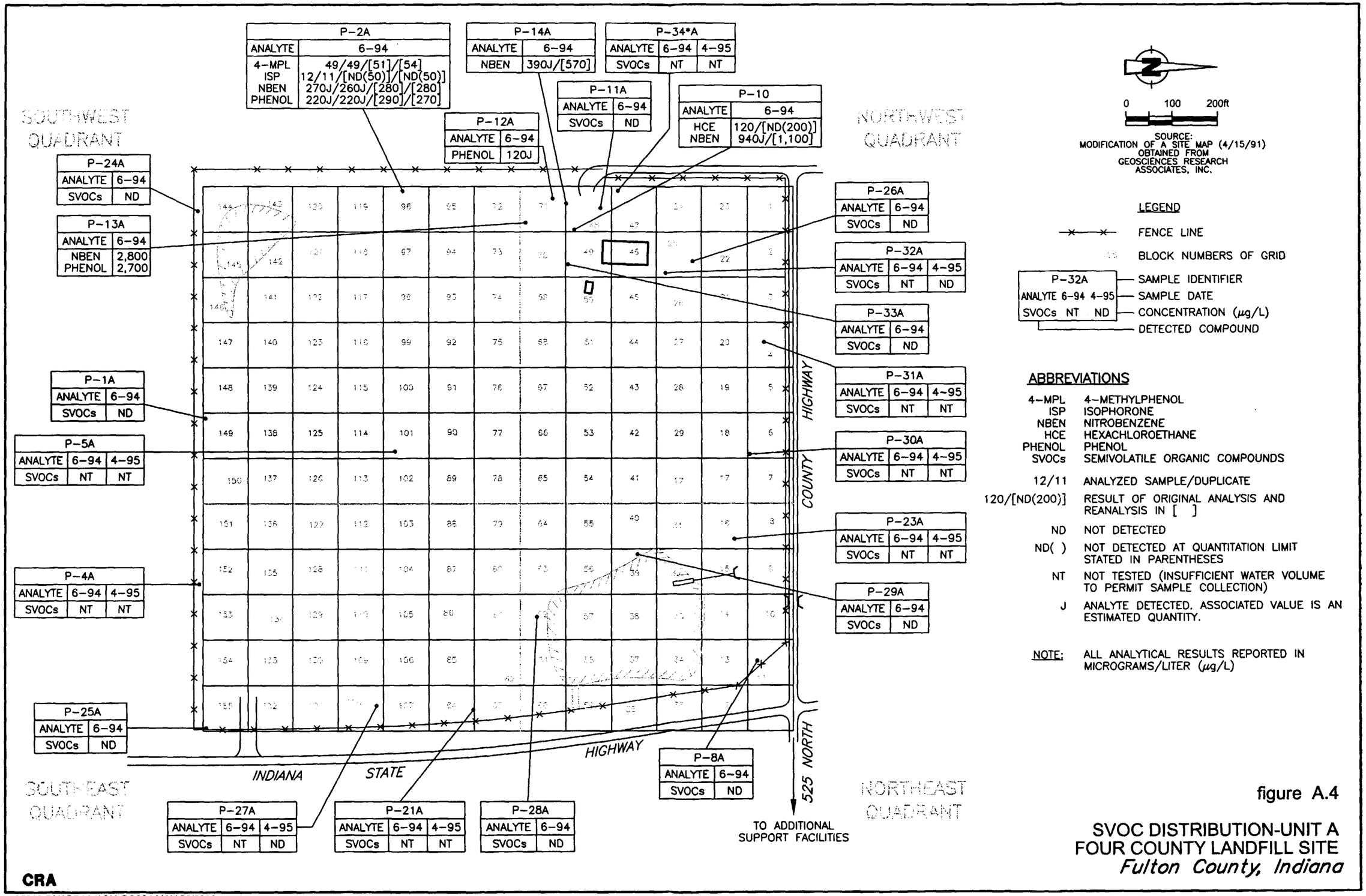


figure A.4

SVOC DISTRIBUTION-UNIT A
FOUR COUNTY LANDFILL SITE
Fulton County, Indiana

05369-76(APPA24)GN-CO004 MAY 30/2000

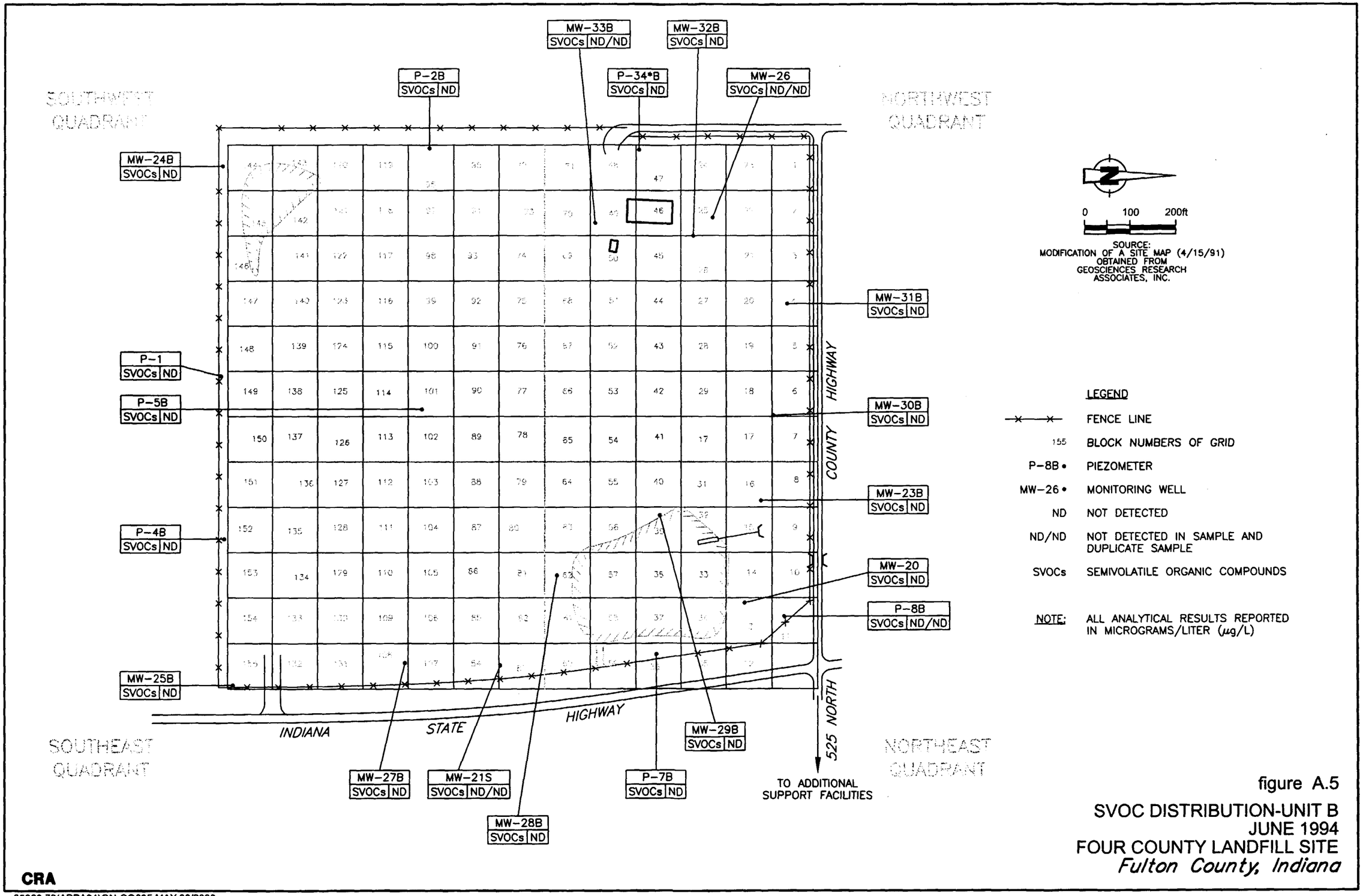


figure A.5

SVOC DISTRIBUTION-UNIT B
JUNE 1994
FOUR COUNTY LANDFILL SITE
Fulton County, Indiana

CRA

05369-76(APPA24)GN-CO005 MAY 30/2000

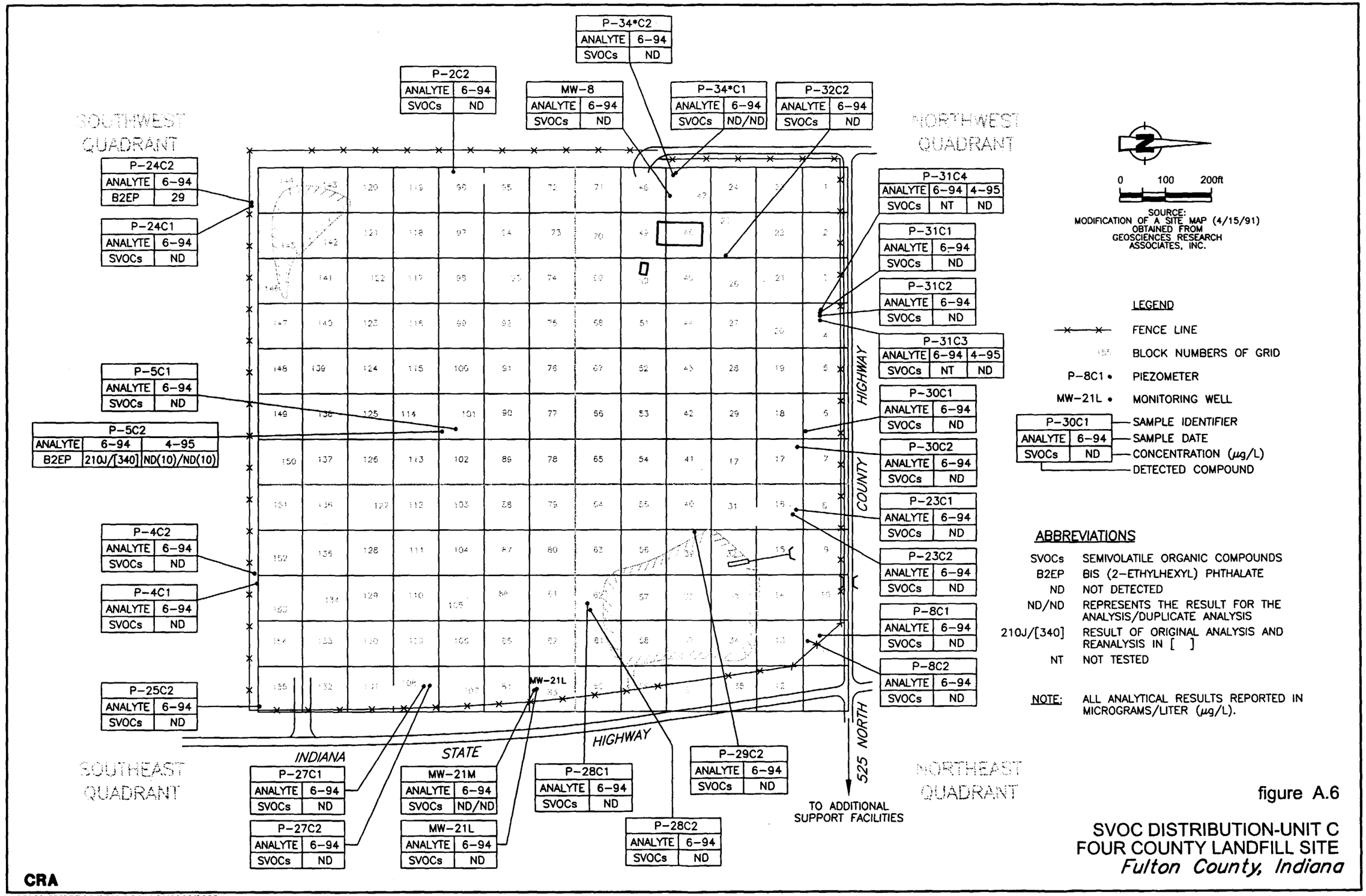
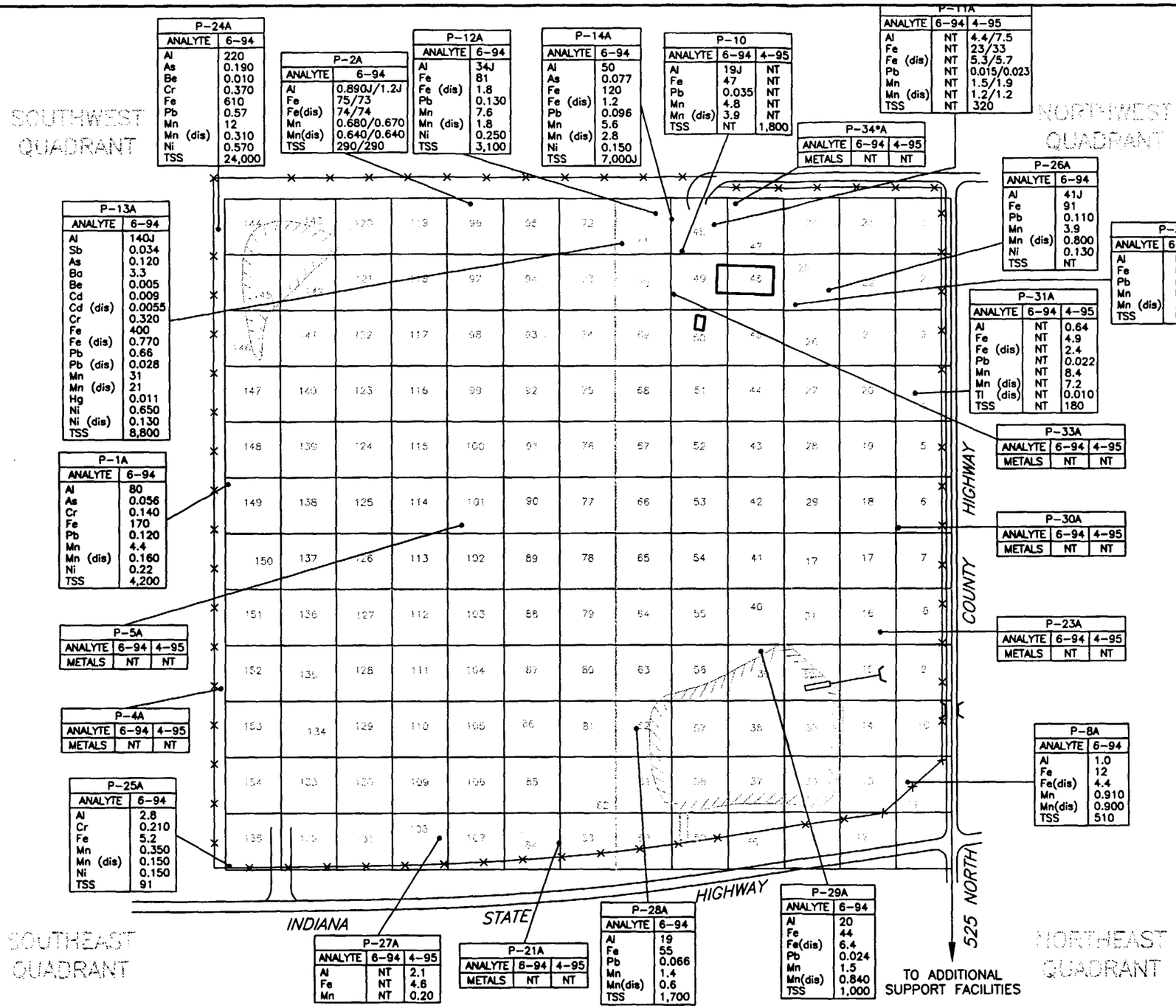


figure A.6

SVOC DISTRIBUTION-UNIT C
FOUR COUNTY LANDFILL SITE
Fulton County, Indiana

05369-76(APPA24)GN-CO006 MAY 30/2000



P-24A	
ANALYTE	6-94
Al	220
As	0.190
Be	0.010
Cr	0.370
Fe	610
Pb	0.57
Mn	12
Mn (dis)	0.310
Ni	0.570
TSS	24,000

P-2A	
ANALYTE	6-94
Al	0.890J/1.2J
Fe	75/73
Fe(dis)	74/74
Mn	0.680/0.670
Mn(dis)	0.640/0.640
TSS	290/290

P-12A	
ANALYTE	6-94
Al	34J
Fe	81
Fe (dis)	1.8
Pb	0.130
Mn	7.6
Mn (dis)	1.8
Ni	0.250
TSS	3,100

P-14A	
ANALYTE	6-94
Al	50
As	0.077
Fe	120
Fe (dis)	1.2
Pb	0.096
Mn	5.6
Mn (dis)	2.8
Ni	0.150
TSS	7,000J

P-10		
ANALYTE	6-94	4-95
Al	19J	NT
Fe	47	NT
Pb	0.035	NT
Mn	4.8	NT
Mn (dis)	3.9	NT
TSS	NT	1,800

P-11A		
ANALYTE	6-94	4-95
Al	NT	4.4/7.5
Fe	NT	23/33
Fe (dis)	NT	5.3/5.7
Pb	NT	0.015/0.023
Mn	NT	1.5/1.9
Mn (dis)	NT	1.2/1.2
TSS	NT	320

P-34*A		
ANALYTE	6-94	4-95
METALS	NT	NT

P-26A	
ANALYTE	6-94
Al	41J
Fe	91
Pb	0.110
Mn	3.9
Mn (dis)	0.800
Ni	0.130
TSS	NT

P-32A		
ANALYTE	6-94	4-95
Al	NT	14
Fe	NT	35
Pb	NT	0.064
Mn	NT	2
Mn (dis)	NT	1.2
TSS	NT	1,800

P-13A	
ANALYTE	6-94
Al	140J
Sb	0.034
As	0.120
Ba	3.3
Be	0.005
Cd	0.009
Cd (dis)	0.0055
Cr	0.320
Fe	400
Fe (dis)	0.770
Pb	0.66
Pb (dis)	0.028
Mn	31
Mn (dis)	21
Hg	0.011
Ni	0.650
Ni (dis)	0.130
TSS	8,800

P-31A		
ANALYTE	6-94	4-95
Al	NT	0.64
Fe	NT	4.9
Fe (dis)	NT	2.4
Pb	NT	0.022
Mn	NT	8.4
Mn (dis)	NT	7.2
Tl (dis)	NT	0.010
TSS	NT	180

P-33A		
ANALYTE	6-94	4-95
METALS	NT	NT

P-1A	
ANALYTE	6-94
Al	80
As	0.056
Cr	0.140
Fe	170
Pb	0.120
Mn	4.4
Mn (dis)	0.160
Ni	0.22
TSS	4,200

P-30A		
ANALYTE	6-94	4-95
METALS	NT	NT

P-5A		
ANALYTE	6-94	4-95
METALS	NT	NT

P-23A		
ANALYTE	6-94	4-95
METALS	NT	NT

P-4A		
ANALYTE	6-94	4-95
METALS	NT	NT

P-8A	
ANALYTE	6-94
Al	1.0
Fe	12
Fe(dis)	4.4
Mn	0.910
Mn(dis)	0.900
TSS	510

P-25A	
ANALYTE	6-94
Al	2.8
Cr	0.210
Fe	5.2
Mn	0.350
Mn (dis)	0.150
Ni	0.150
TSS	91

P-27A		
ANALYTE	6-94	4-95
Al	NT	2.1
Fe	NT	4.6
Mn	NT	0.20

P-21A		
ANALYTE	6-94	4-95
METALS	NT	NT

P-28A	
ANALYTE	6-94
Al	19
Fe	55
Pb	0.066
Mn	1.4
Mn(dis)	0.6
TSS	1,700

P-29A	
ANALYTE	6-94
Al	20
Fe	44
Fe(dis)	6.4
Pb	0.024
Mn	1.5
Mn(dis)	0.840
TSS	1,000

LEGEND

FENCE LINE

BLOCK NUMBERS OF GRID

P-26A • PIEZOMETER

P-33A		
ANALYTE	6-94	4-95
METALS	NT	NT

— SAMPLE IDENTIFIER
— SAMPLE DATE
— CONCENTRATION
— DETECTED PARAMETER

ABBREVIATIONS

Al	ALUMINUM
Sb	ANTIMONY
As	ARSENIC
Ba	BARIUM
Be	BERYLLIUM
Cd	CADMIUM
Cr	CHROMIUM
Fe	IRON
Hg	MERCURY
Pb	LEAD
Mn	MANGANESE
Ni	NICKEL
Tl	THALLIUM
TSS	TOTAL SUSPENDED SOLIDS
Fe(dis)	REPRESENTS A METALLIC SPECIES IN DISSOLVED PHASE (FILTERED SAMPLE)
2.5/2.5	REPRESENTS THE RESULT FOR THE ANALYSIS/DUPLICATE ANALYSIS
NT	NOT TESTED DUE TO INSUFFICIENT WATER VOLUME TO PERMIT SAMPLE COLLECTION
J	ANALYTE DETECTED ASSOCIATED VALUE IS AN ESTIMATED QUANTITY.

NOTES:
1. ALL CONCENTRATIONS REPORTED IN MILLIGRAMS PER LITER (mg/L).
2. ALL VALUES REPRESENT CONCENTRATIONS FOR UNFILTERED SAMPLES UNLESS INDICATED BY (dis).

figure A.7

COMPARISON OF METALS DATA WITH MCLs-UNIT A
FOUR COUNTY LANDFILL SITE
Fulton County, Indiana

CRA

05369-76(APPA24)GN-CO007 MAY 30/2000

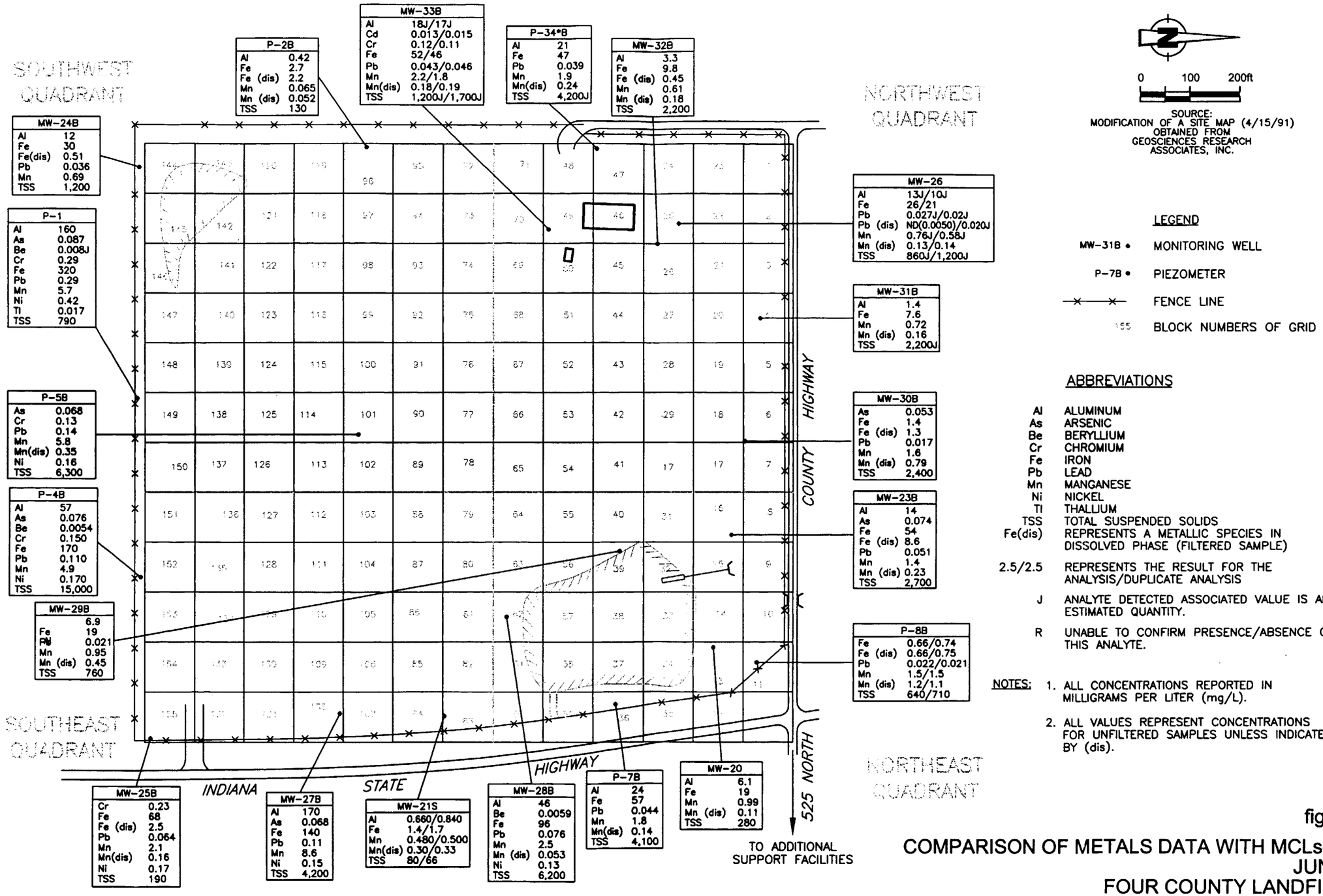


figure A.8

COMPARISON OF METALS DATA WITH MCLs-UNIT B
JUNE 1994
FOUR COUNTY LANDFILL SITE
Fulton County, Indiana

CRA

05369-76(APPA24)GN-CO008 MAY 30/2000

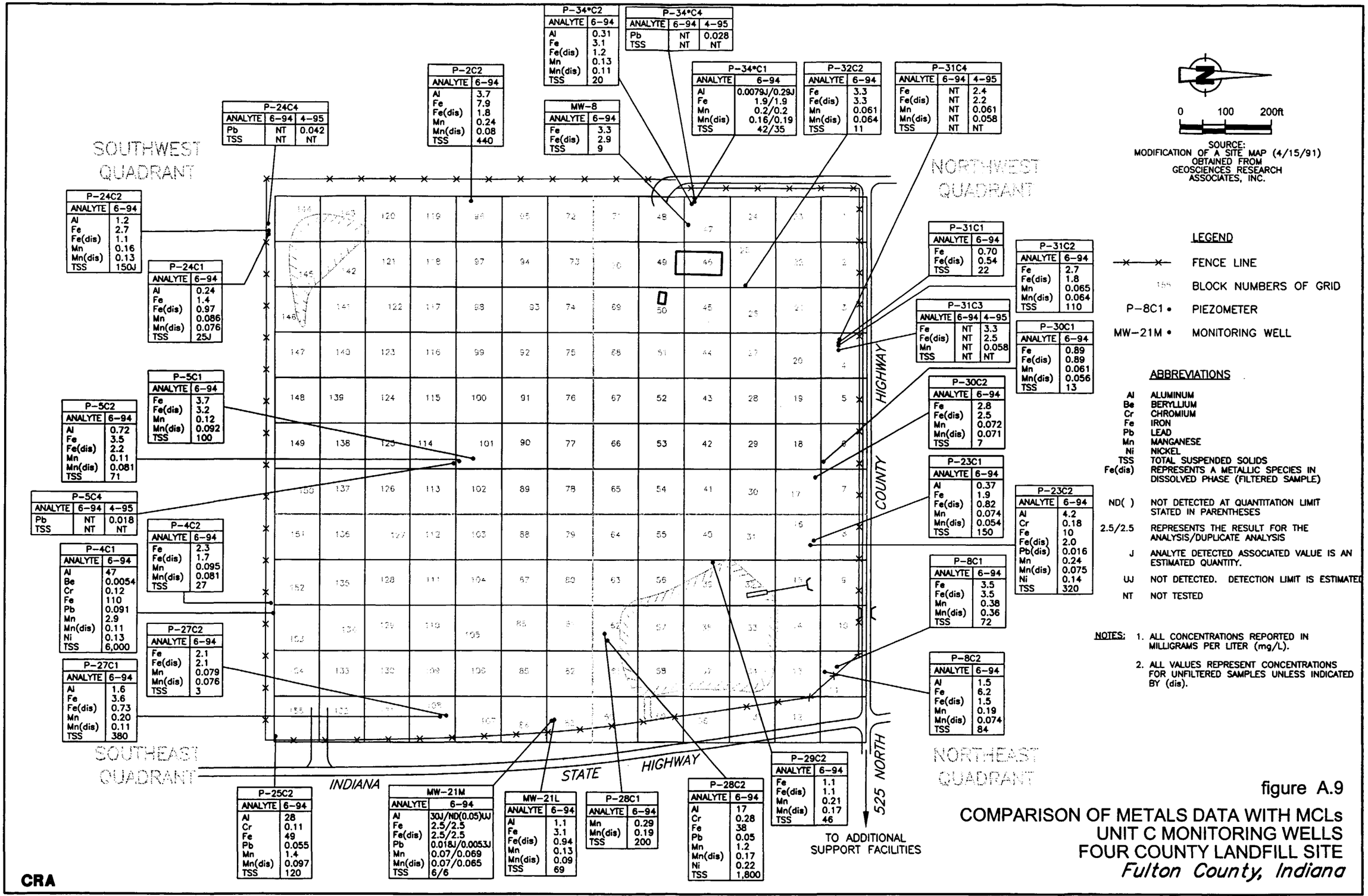
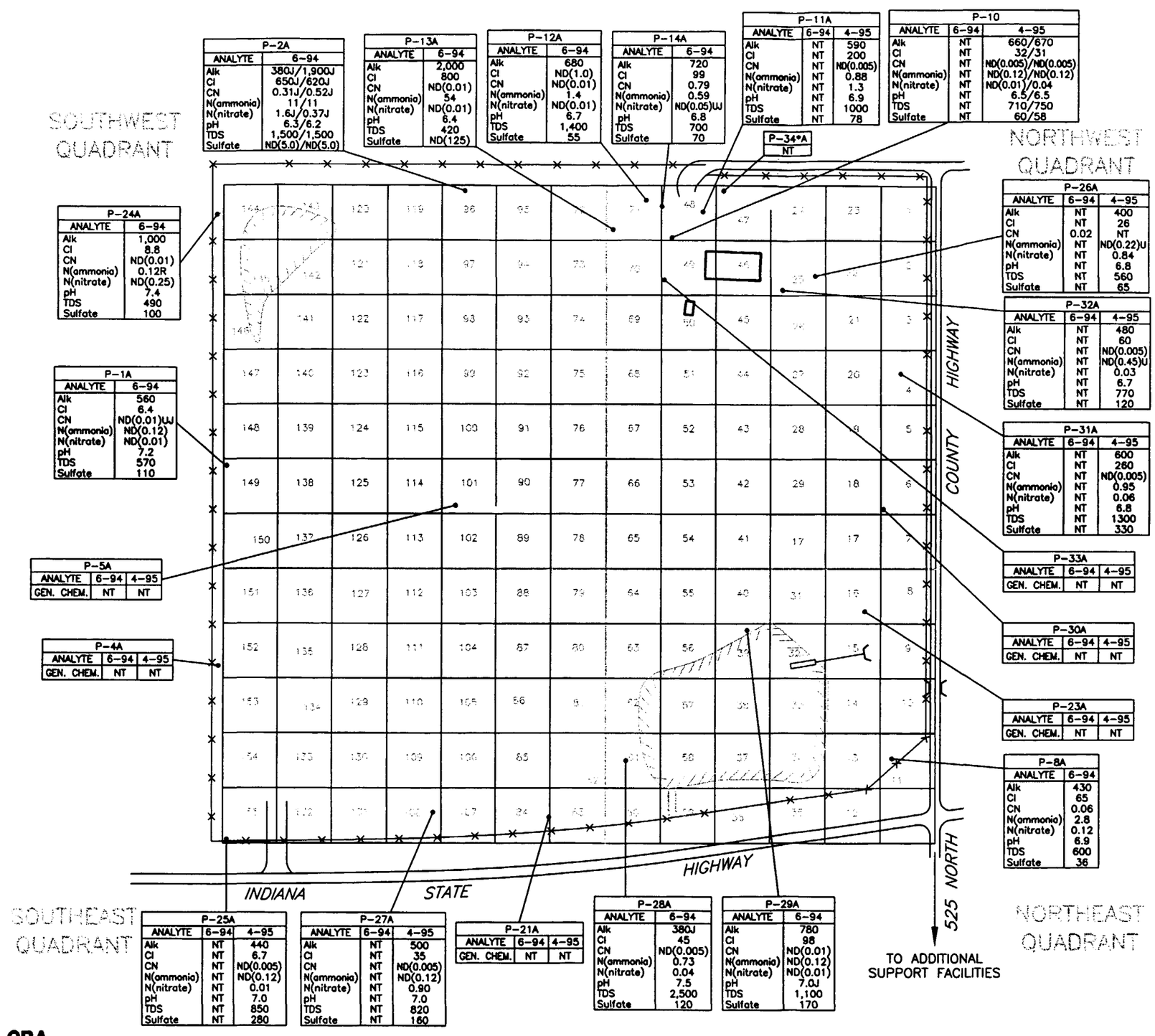


figure A.9

COMPARISON OF METALS DATA WITH MCLs
UNIT C MONITORING WELLS
FOUR COUNTY LANDFILL SITE
Fulton County, Indiana

CRA

05369-76(APPA24)GN-CO009 MAY 30/2000



P-2A	
ANALYTE	6-94
Alk	380J/1,900J
Cl	650J/620J
CN	0.31J/0.52J
N(ammonia)	11/11
N(nitrate)	1.6J/0.37J
pH	6.3/6.2
TDS	1,500/1,500
Sulfate	ND(5.0)/ND(5.0)

P-13A	
ANALYTE	6-94
Alk	2,000
Cl	800
CN	ND(0.01)
N(ammonia)	54
N(nitrate)	ND(0.01)
pH	6.4
TDS	420
Sulfate	ND(125)

P-12A	
ANALYTE	6-94
Alk	680
Cl	ND(1.0)
CN	ND(0.01)
N(ammonia)	1.4
N(nitrate)	ND(0.01)
pH	6.7
TDS	1,400
Sulfate	55

P-14A	
ANALYTE	6-94
Alk	720
Cl	99
CN	0.79
N(ammonia)	0.59
N(nitrate)	ND(0.05)UJ
pH	6.8
TDS	700
Sulfate	70

P-11A		
ANALYTE	6-94	4-95
Alk	NT	590
Cl	NT	200
CN	NT	ND(0.005)
N(ammonia)	NT	0.88
N(nitrate)	NT	1.3
pH	NT	6.9
TDS	NT	1000
Sulfate	NT	78

P-10		
ANALYTE	6-94	4-95
Alk	NT	660/670
Cl	NT	32/31
CN	NT	ND(0.005)/ND(0.005)
N(ammonia)	NT	ND(0.12)/ND(0.12)
N(nitrate)	NT	ND(0.01)/0.04
pH	NT	6.5/6.5
TDS	NT	710/750
Sulfate	NT	60/58

P-34*A
NT

P-24A	
ANALYTE	6-94
Alk	1,000
Cl	8.8
CN	ND(0.01)
N(ammonia)	0.12R
N(nitrate)	ND(0.25)
pH	7.4
TDS	490
Sulfate	100

P-1A	
ANALYTE	6-94
Alk	560
Cl	6.4
CN	ND(0.01)UJ
N(ammonia)	ND(0.12)
N(nitrate)	ND(0.01)
pH	7.2
TDS	570
Sulfate	110

P-5A		
ANALYTE	6-94	4-95
GEN. CHEM.	NT	NT

P-4A		
ANALYTE	6-94	4-95
GEN. CHEM.	NT	NT

P-26A		
ANALYTE	6-94	4-95
Alk	NT	400
Cl	NT	26
CN	0.02	NT
N(ammonia)	NT	ND(0.22)U
N(nitrate)	NT	0.84
pH	NT	6.8
TDS	NT	560
Sulfate	NT	65

P-32A		
ANALYTE	6-94	4-95
Alk	NT	480
Cl	NT	60
CN	NT	ND(0.005)
N(ammonia)	NT	ND(0.45)U
N(nitrate)	NT	0.03
pH	NT	6.7
TDS	NT	770
Sulfate	NT	120

P-31A		
ANALYTE	6-94	4-95
Alk	NT	600
Cl	NT	260
CN	NT	ND(0.005)
N(ammonia)	NT	0.95
N(nitrate)	NT	0.06
pH	NT	6.8
TDS	NT	1300
Sulfate	NT	330

P-33A		
ANALYTE	6-94	4-95
GEN. CHEM.	NT	NT

P-30A		
ANALYTE	6-94	4-95
GEN. CHEM.	NT	NT

P-23A		
ANALYTE	6-94	4-95
GEN. CHEM.	NT	NT

P-8A	
ANALYTE	6-94
Alk	430
Cl	65
CN	0.06
N(ammonia)	2.8
N(nitrate)	0.12
pH	6.9
TDS	600
Sulfate	36

P-25A		
ANALYTE	6-94	4-95
Alk	NT	440
Cl	NT	6.7
CN	NT	ND(0.005)
N(ammonia)	NT	ND(0.12)
N(nitrate)	NT	0.01
pH	NT	7.0
TDS	NT	850
Sulfate	NT	280

P-27A		
ANALYTE	6-94	4-95
Alk	NT	500
Cl	NT	35
CN	NT	ND(0.005)
N(ammonia)	NT	ND(0.12)
N(nitrate)	NT	0.90
pH	NT	7.0
TDS	NT	820
Sulfate	NT	160

P-21A		
ANALYTE	6-94	4-95
GEN. CHEM.	NT	NT

P-28A	
ANALYTE	6-94
Alk	380J
Cl	45
CN	ND(0.005)
N(ammonia)	0.73
N(nitrate)	0.04
pH	7.5
TDS	2,500
Sulfate	120

P-29A	
ANALYTE	6-94
Alk	780
Cl	98
CN	ND(0.01)
N(ammonia)	ND(0.12)
N(nitrate)	ND(0.01)
pH	7.0J
TDS	1,100
Sulfate	170

0 100 200ft

SOURCE:
MODIFICATION OF A SITE MAP (4/15/91)
OBTAINED FROM
GEOSCIENCES RESEARCH
ASSOCIATES, INC.

LEGEND

- FENCE LINE
- BLOCK NUMBERS OF GRID
- P-26A • PIEZOMETER
- P-21A — SAMPLE IDENTIFIER
- ANALYTE 6-94 — SAMPLE DATE
- GEN. CHEM. NT — CONCENTRATION
- DETECTED PARAMETERS

ABBREVIATIONS

GEN. CHEM.	GENERAL CHEMISTRY PARAMETERS
Alk	ALKALINITY
Cl	CHLORIDE
CN	CYANIDE (TOTAL)
N	NITROGEN
TDS	TOTAL DISSOLVED SOLIDS
TSS	TOTAL SUSPENDED SOLIDS
NT	NOT TESTED (INSUFFICIENT WATER VOLUME TO PERMIT SAMPLE COLLECTION)
U	ANALYTE WAS NOT DETECTED ABOVE THE QUANTITATION LIMIT STATED IN PARENTHESES
0.31/0.52	SAMPLE/DUPLICATE SAMPLE
J	ANALYTE DETECTED. ASSOCIATED VALUE IS AN ESTIMATED QUANTITY.
UJ	NOT DETECTED. DETECTION LIMIT IS ESTIMATED.
R	UNABLE TO CONFIRM PRESENCE/ABSENCE OF THIS ANALYTE.

NOTES:
1. SITE GRID = 100 FEET
2. ALL RESULTS REPORTED IN mg/L EXCEPT pH WHICH IS REPORTED IN STANDARD UNITS.

figure A.10

GENERAL CHEMISTRY DATA
UNIT A
FOUR COUNTY LANDFILL SITE
Fulton County, Indiana

CRA

05369-76(APPA24)GN-CO010 MAY 30/2000

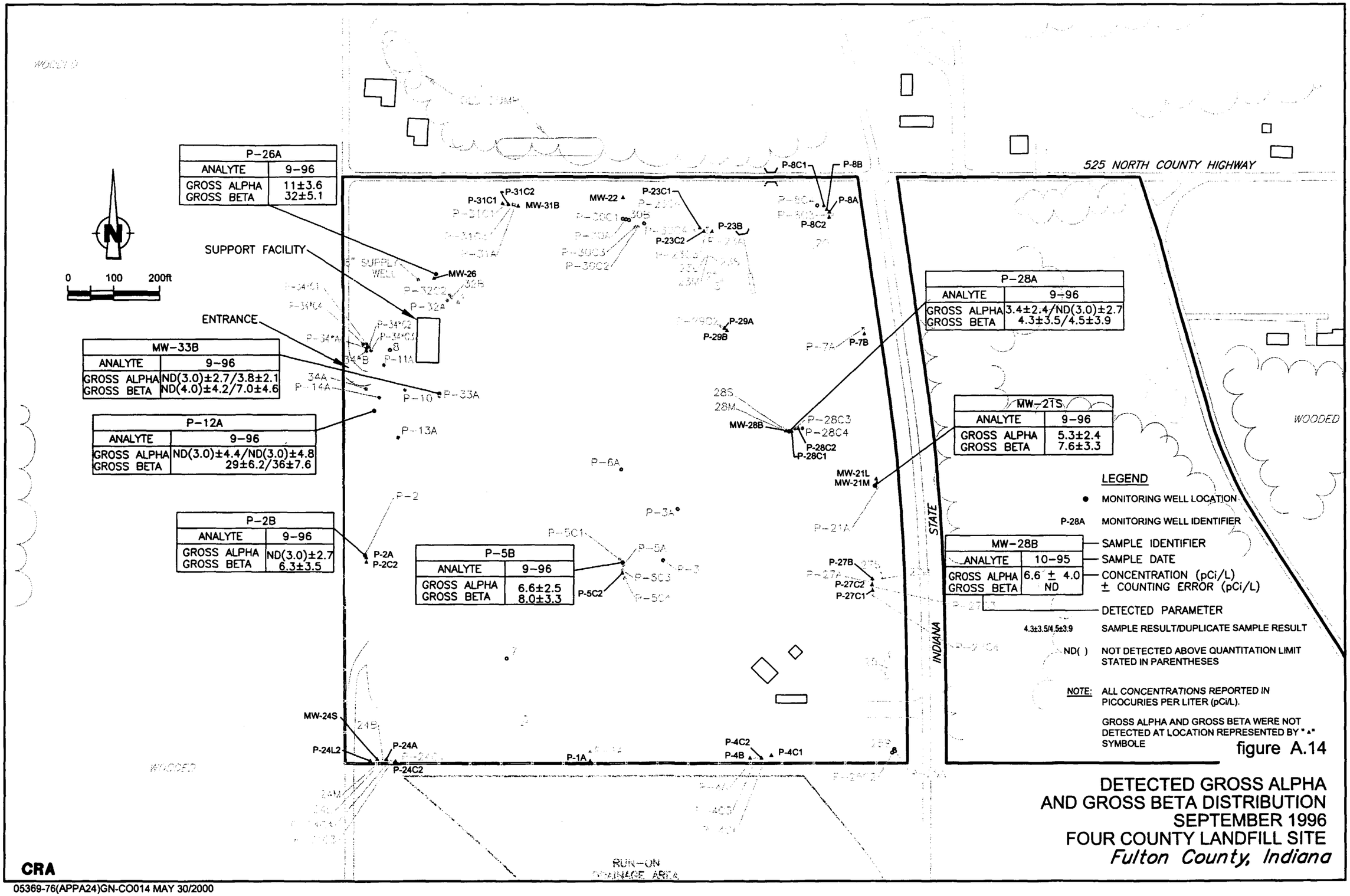


figure A.14

DETECTED GROSS ALPHA AND GROSS BETA DISTRIBUTION
SEPTEMBER 1996
FOUR COUNTY LANDFILL SITE
Fulton County, Indiana

05369-76(APPA24)GN-CO014 MAY 30/2000

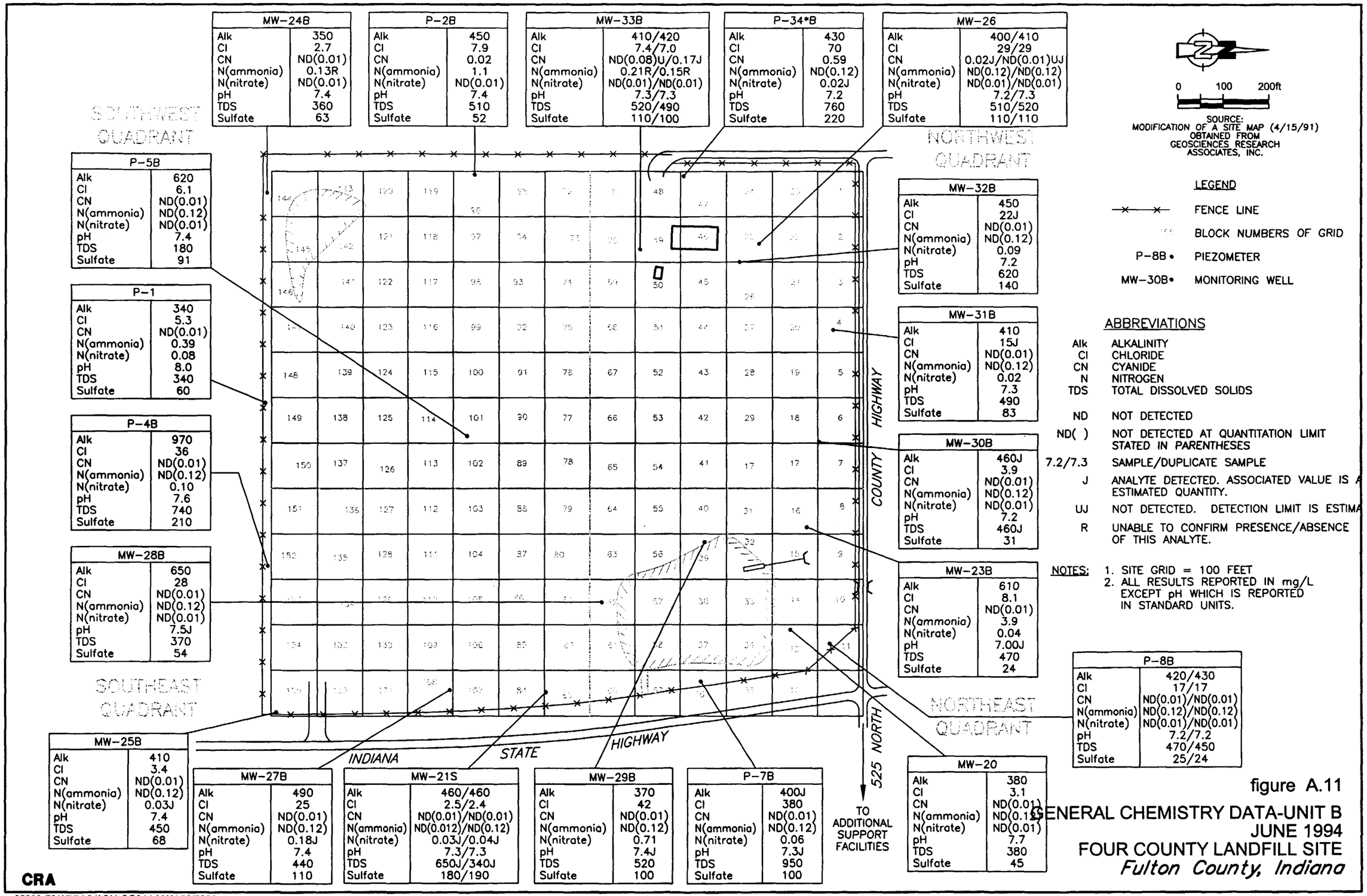


figure A.11

GENERAL CHEMISTRY DATA-UNIT B
JUNE 1994
FOUR COUNTY LANDFILL SITE
Fulton County, Indiana

CRA

05369-76(APPA24)GN-CO011 MAY 30/2000

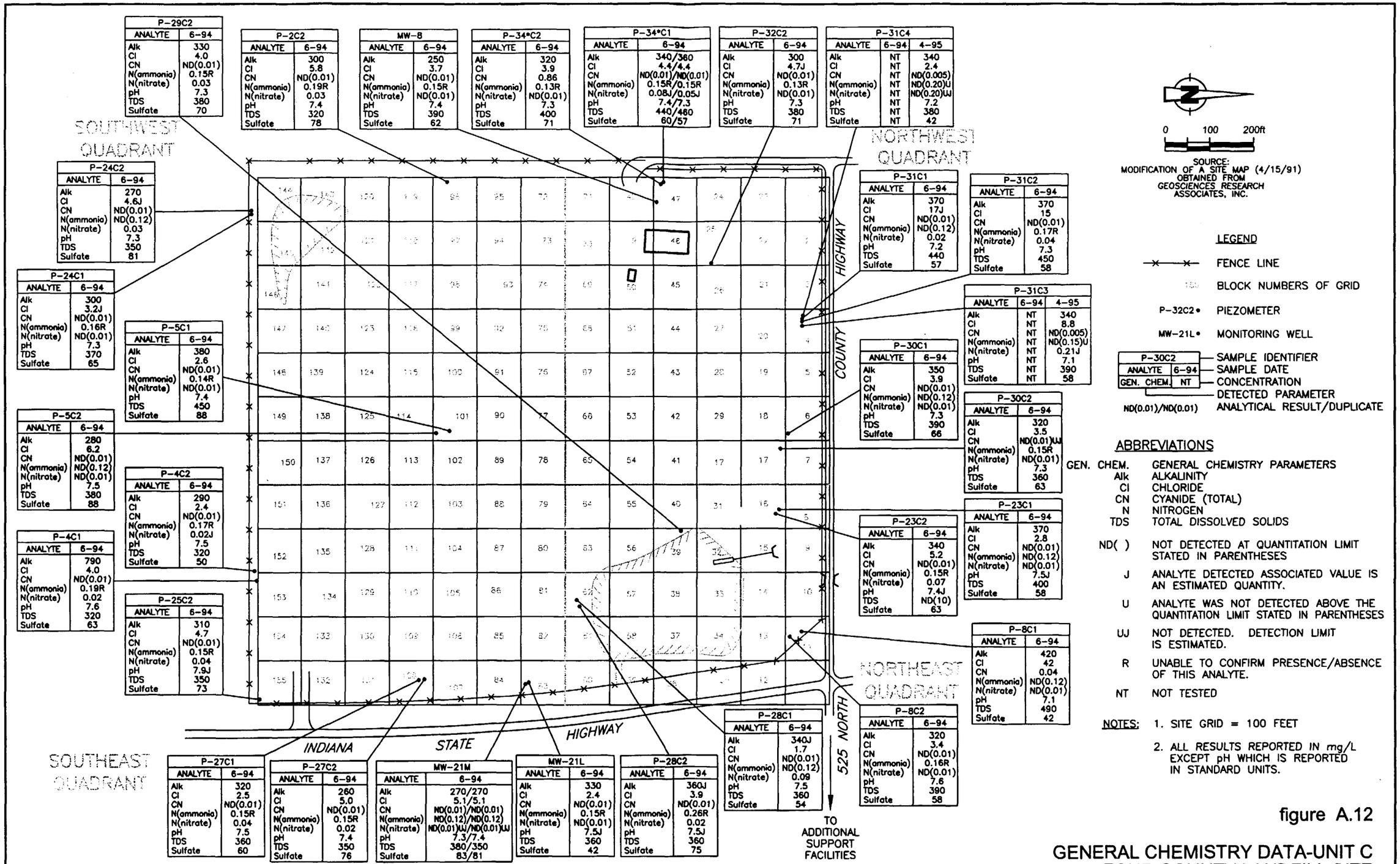


figure A.12

GENERAL CHEMISTRY DATA-UNIT C
FOUR COUNTY LANDFILL SITE
Fulton County, Indiana

CRA

05369-76(APPA24)GN-CO012 MAY 30/2000

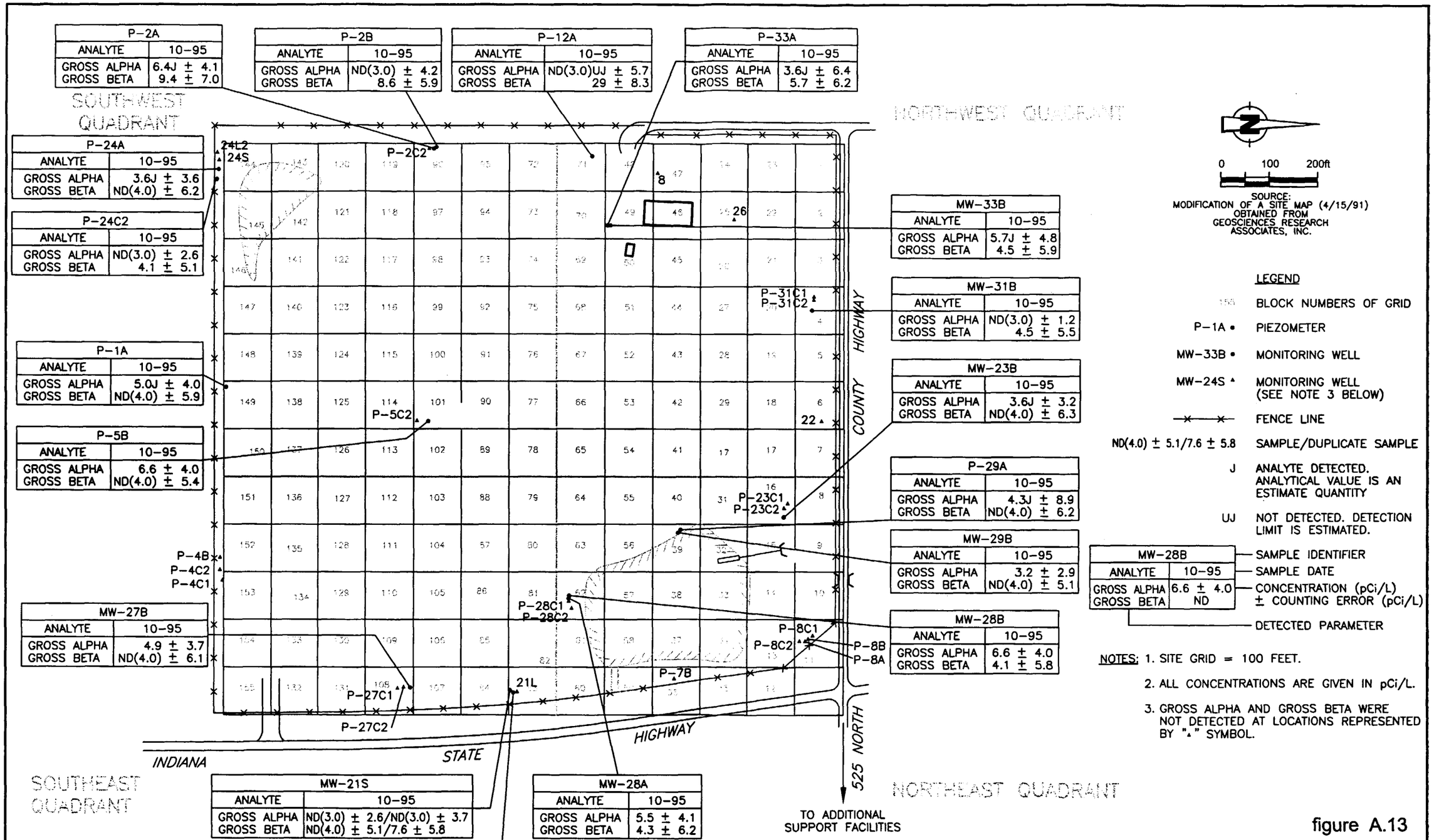


figure A.13

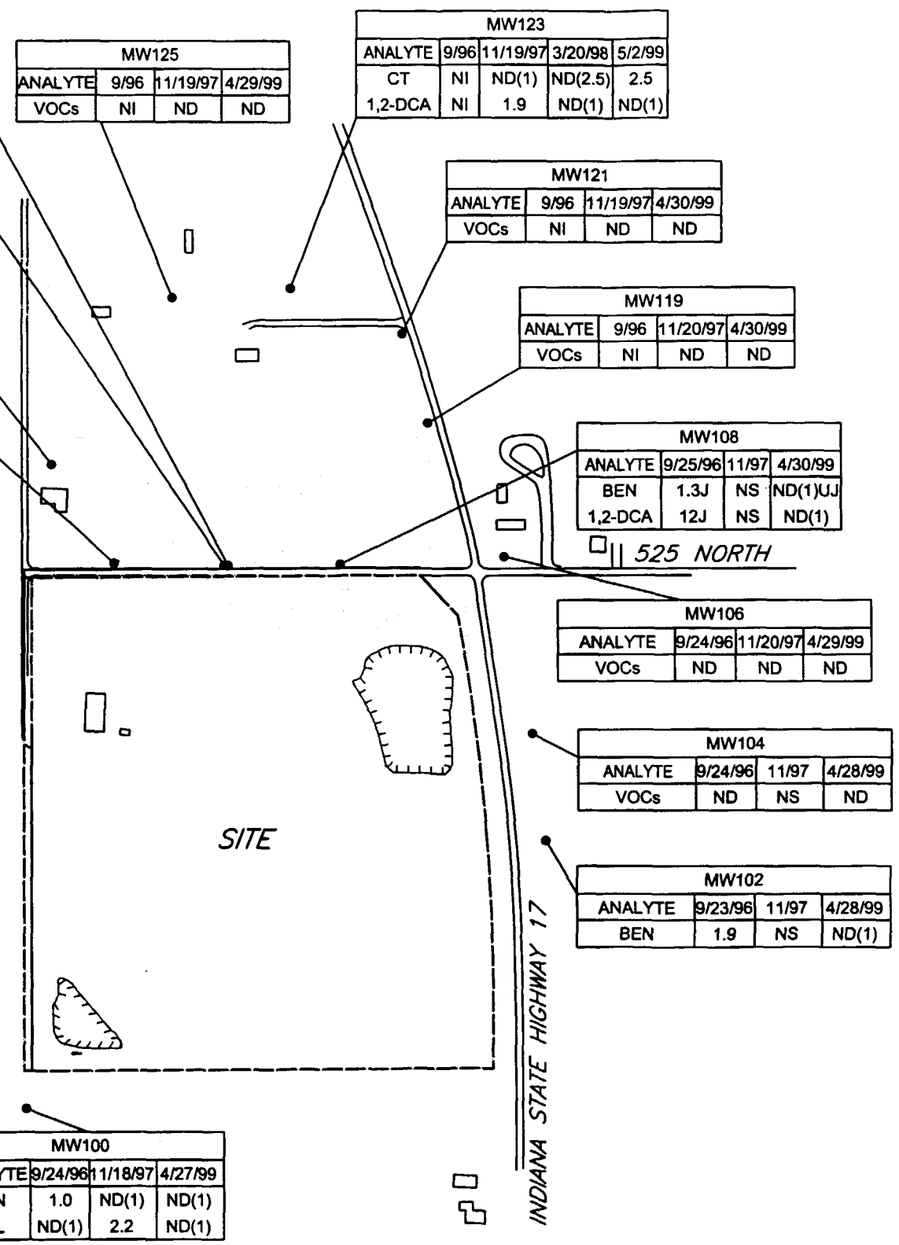
DETECTED GROSS ALPHA AND GROSS BETA DISTRIBUTION
OCTOBER 1995
FOUR COUNTY LANDFILL SITE
Fulton County, Indiana

CRA

05369-76(APPA24)GN-CO013 MAY 30/2000

APPENDIX B

OFF-SITE GROUNDWATER DATA SUMMARY FIGURES



MW110			
ANALYTE	9/25/96	11/21/97	5/1/99
VOCs	ND/ND	ND	ND

MW111				
ANALYTE	9/25/96	11/21/97	3/20/98	5/1/99
1,2-DCA	1.3	ND(1)	ND(1.4)U	ND(1)
DCM	ND(1)	ND(1)	1.1J	ND(1)U

MW125			
ANALYTE	9/96	11/19/97	4/29/99
VOCs	NI	ND	ND

MW123				
ANALYTE	9/96	11/19/97	3/20/98	5/2/99
CT	NI	ND(1)	ND(2.5)	2.5
1,2-DCA	NI	1.9	ND(1)	ND(1)

MW121			
ANALYTE	9/96	11/19/97	4/30/99
VOCs	NI	ND	ND

MW127				
ANALYTE	9/96	11/97	3/98	5/1/99
TOL	NI	NI	NI	1.1J

MW119			
ANALYTE	9/96	11/20/97	4/30/99
VOCs	NI	ND	ND

MW113				
ANALYTE	9/25/96	11/21/97	3/20/98	5/2/99
ACE	58J	ND(10)	ND(5)UJ	ND(10)/ND(10)
BEN	3.4J	ND(1)	ND(1)UJ	1.3/1.2
CDS	2.8J	14	19J	ND(1)/ND(1)
CLF	57J	64	66J	83/79
CT	45J	140	96J	340J/340J
1,2-DCA	4.4J	ND(1.1)U	ND(1)UJ	ND(1.3)U/ND(1.1)U
DCM	2.0J	1.1	ND(1)UJ	ND(1)/ND(1)

MW108			
ANALYTE	9/25/96	11/97	4/30/99
BEN	1.3J	NS	ND(1)UJ
1,2-DCA	12J	NS	ND(1)

MW106			
ANALYTE	9/24/96	11/20/97	4/29/99
VOCs	ND	ND	ND

MW116			
ANALYTE	9/24/96	11/97	4/29/99
VOCs	ND	NS	ND

MW104			
ANALYTE	9/24/96	11/97	4/28/99
VOCs	ND	NS	ND

MW118			
ANALYTE	9/23/96	11/18/97	4/27/99
VOCs	ND	ND	ND

MW102			
ANALYTE	9/23/96	11/97	4/28/99
BEN	1.9	NS	ND(1)

MW100			
ANALYTE	9/24/96	11/18/97	4/27/99
BEN	1.0	ND(1)	ND(1)
TOL	ND(1)	2.2	ND(1)

0 200 400ft

LEGEND:

PROPERTY BOUNDARY

RIGHT-OF-WAY BOUNDARY

FENCE LINE

MW100 ● SHALLOW MONITORING WELL LOCATION

MW100		
ANALYTE	9/96	11/97
BEN	1.0	ND(1)

MONITORING WELL IDENTIFIER
SAMPLE DATE
CONCENTRATION (µg/L)
COMPOUND

ABBREVIATIONS

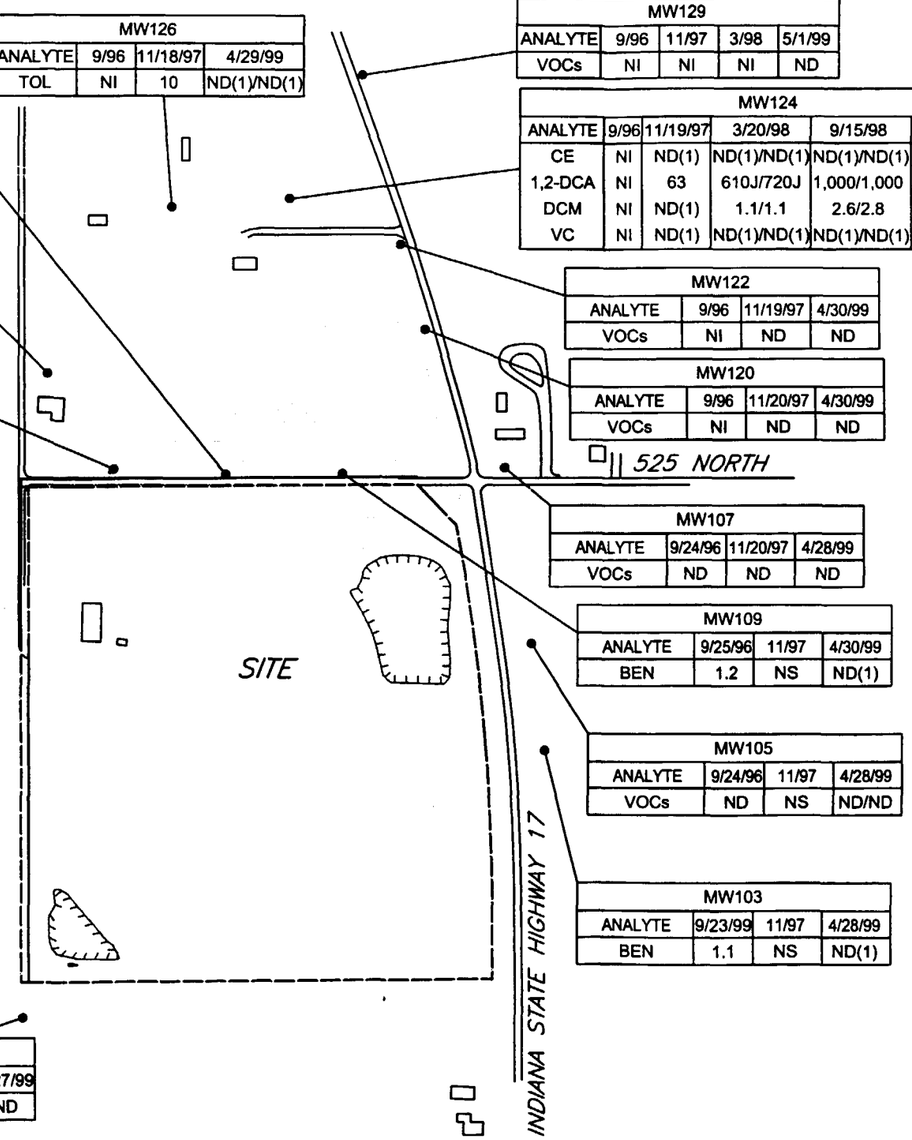
VOCs	VOLATILE ORGANIC COMPOUNDS
ACE	ACETONE
BEN	BENZENE
CDS	CARBON DISULFIDE
CLF	CHLOROFORM
CT	CARBON TETRACHLORIDE
1,2-DCA	1,2-DICHLOROETHANE
DCM	DICHLOROMETHANE
TOL	TOLUENE
83/85	SAMPLE RESULT/DUPLICATE SAMPLE RESULT
J	ESTIMATED CONCENTRATION
ND	VOCs NOT DETECTED
ND()	NOT DETECTED ABOVE QUANTITATION LIMIT STATED IN PARENTHESES
NI	NOT INSTALLED
NS	NOT SAMPLED
U	QUALIFIED NON-DETECT DUE TO METHOD BLANK CONTAMINATION

figure B.1

SUMMARY OF DETECTED VOCs IN GROUNDWATER
SHALLOW OFF-SITE WELL LOCATIONS
FOUR COUNTY LANDFILL SITE
Fulton County, Indiana

CRA

05369-76(APPB24)GN-CO001 MAY 30/2000



MW112				
ANALYTE	9/25/96	11/21/97	3/20/98	5/1/99
1,2-DCA	83/85	ND(58)U/ND(54)U	45	44/38
VC	ND(1)	ND(1)/ND(1)	ND(1)	0.65J/0.65J

MW130				
ANALYTE	9/96	11/97	3/98	5/1/99
VOCs	NI	NI	NI	ND

MW126			
ANALYTE	9/96	11/18/97	4/29/99
TOL	NI	10	ND(1)/ND(1)

MW129				
ANALYTE	9/96	11/97	3/98	5/1/99
VOCs	NI	NI	NI	ND

MW128				
ANALYTE	9/96	11/97	3/98	5/1/99
VOCs	NI	NI	NI	ND

MW124						
ANALYTE	9/96	11/19/97	3/20/98	9/15/98	5/2/99	5/2/99*
CE	NI	ND(1)	ND(1)/ND(1)	ND(1)/ND(1)	1.8	ND(1)
1,2-DCA	NI	63	610J/720J	1,000/1,000	380J	1,400
DCM	NI	ND(1)	1.1/1.1	2.6/2.8	ND(1)	ND(1)
VC	NI	ND(1)	ND(1)/ND(1)	ND(1)/ND(1)	8	8.7

MW122			
ANALYTE	9/96	11/19/97	4/30/99
VOCs	NI	ND	ND

MW114				
ANALYTE	9/25/96	11/21/97	3/20/98	5/2/99
ACE	ND(1)	ND(10)/10	ND(10)	ND(10)
BEN	330	460/350	240	240J
1,2-DCA	2,000	1,000/1,200	880	780
MEK	ND(10)	ND(10)/19	ND(100)	ND(10)
VC	3.9	5.2J/4.9	ND(10)	4

MW120			
ANALYTE	9/96	11/20/97	4/30/99
VOCs	NI	ND	ND

MW103		
ANALYTE	9/96	11/97
BEN	1.1	NS

MW107			
ANALYTE	9/24/96	11/20/97	4/28/99
VOCs	ND	ND	ND

MW109			
ANALYTE	9/25/96	11/97	4/30/99
BEN	1.2	NS	ND(1)

MW115			
ANALYTE	9/24/96	11/21/97	4/29/99
VOCs	ND	NS	ND

MW105			
ANALYTE	9/24/96	11/97	4/28/99
VOCs	ND	NS	ND/ND

MW117			
ANALYTE	9/23/96	11/18/97	4/27/99
TOL	ND(1)	1.0	ND(1)

MW103			
ANALYTE	9/23/99	11/97	4/28/99
BEN	1.1	NS	ND(1)

MW101			
ANALYTE	9/24/96	11/18/97	4/27/99
VOCs	ND	ND	ND

N

0 200 400ft

LEGEND:

PROPERTY BOUNDARY

RIGHT-OF-WAY BOUNDARY

FENCE LINE

MW101 ● DEEP MONITORING WELL LOCATION

MONITORING WELL IDENTIFIER

SAMPLE DATE

CONCENTRATION (μg/L)

COMPOUND

ABBREVIATIONS

VOCs	VOLATILE ORGANIC COMPOUNDS
ACE	ACETONE
BEN	BENZENE
CE	CHLOROETHANE
1,2-DCA	1,2-DICHLOROETHANE
DCM	DICHLOROMETHANE
MEK	2-BUTANONE (METHYL ETHYL KETONE)
TOL	TOLUENE
VC	VINYL CHLORIDE
83/85	SAMPLE RESULT/DUPLICATE SAMPLE RESULT
J	ESTIMATED CONCENTRATION
ND	VOCs NOT DETECTED
ND()	NOT DETECTED ABOVE QUANTITATION LIMIT STATED IN PARENTHESES
NI	NOT INSTALLED
NS	NOT SAMPLED
U	QUALIFIED AS NON-DETECT DUE TO METHOD BLANK CONTAMINATION

NOTE:

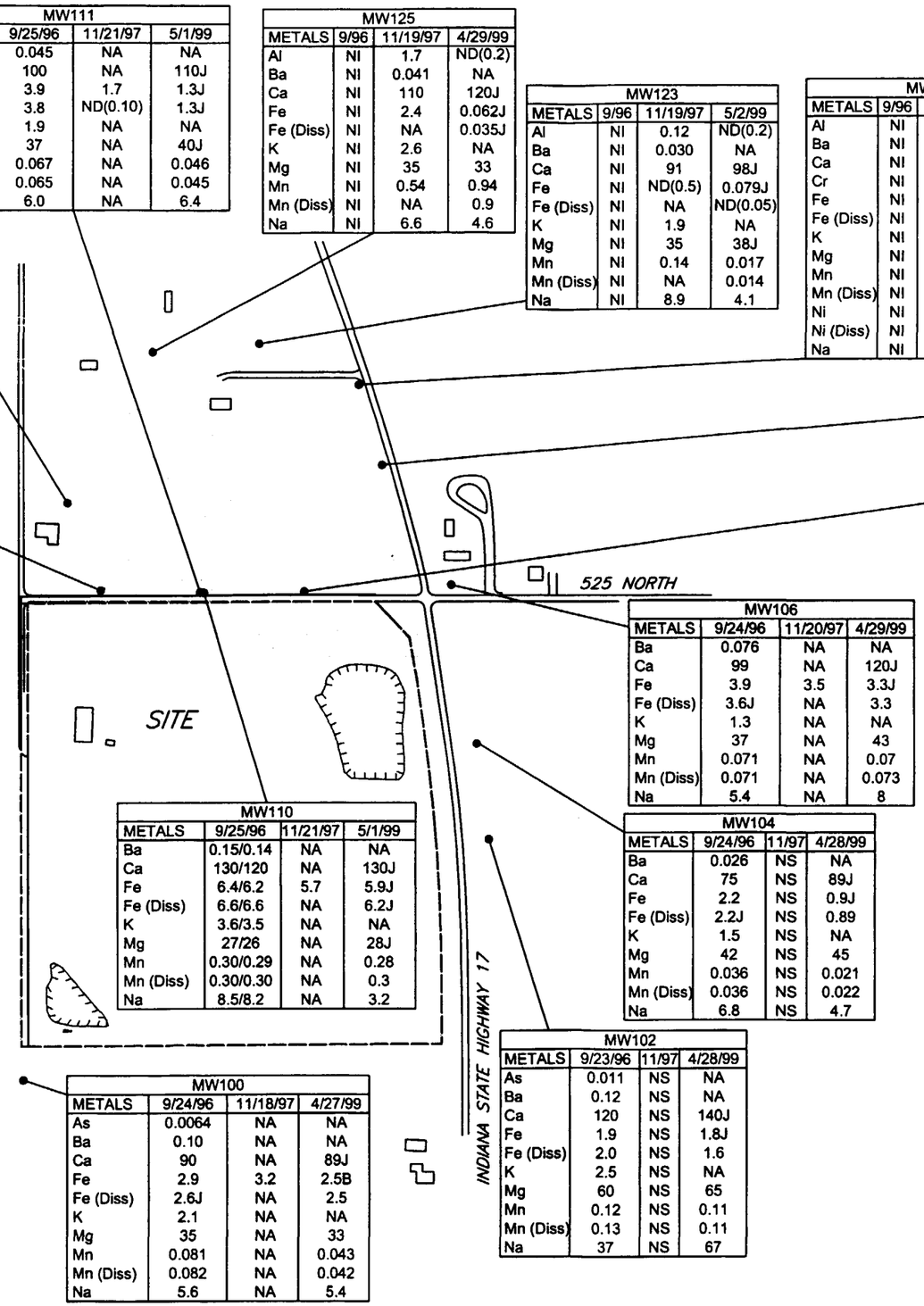
* ADDITIONAL SAMPLE VOLUME WAS COLLECTED FROM MW124 ON 5/2/99 FOR APPENDIX IX ANALYSES

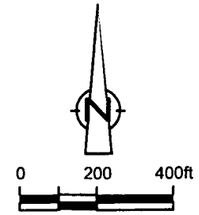
figure B.2

SUMMARY OF DETECTED VOCs IN GROUNDWATER
DEEP OFF-SITE WELL LOCATIONS
FOUR COUNTY LANDFILL SITE
Fulton County, Indiana

CRA

05369-76(APPB24)GN-CO002 MAY 30/2000





MW127			
METALS	9/96	11/97	5/1/99
Ca	NI	NI	89J
Fe	NI	NI	1.1J
Fe (Diss)	NI	NI	1J
Mg	NI	NI	34J
Mn	NI	NI	0.24
Mn (Diss)	NI	NI	0.22
Na	NI	NI	17

MW111			
METALS	9/25/96	11/21/97	5/1/99
Ba	0.045	NA	NA
Ca	100	NA	110J
Fe	3.9	1.7	1.3J
Fe (Diss)	3.8	ND(0.10)	1.3J
K	1.9	NA	NA
Mg	37	NA	40J
Mn	0.067	NA	0.046
Mn (Diss)	0.065	NA	0.045
Na	6.0	NA	6.4

MW125			
METALS	9/96	11/19/97	4/29/99
Al	NI	1.7	ND(0.2)
Ba	NI	0.041	NA
Ca	NI	110	120J
Fe	NI	2.4	0.062J
Fe (Diss)	NI	NA	0.035J
K	NI	2.6	NA
Mg	NI	35	33
Mn	NI	0.54	0.94
Mn (Diss)	NI	NA	0.9
Na	NI	6.6	4.6

MW123			
METALS	9/96	11/19/97	5/2/99
Al	NI	0.12	ND(0.2)
Ba	NI	0.030	NA
Ca	NI	91	98J
Fe	NI	ND(0.5)	0.079J
Fe (Diss)	NI	NA	ND(0.05)
K	NI	1.9	NA
Mg	NI	35	38J
Mn	NI	0.14	0.017
Mn (Diss)	NI	NA	0.014
Na	NI	8.9	4.1

MW121			
METALS	9/96	11/19/97	4/30/99
Al	NI	1.3	0.09J
Ba	NI	0.015	NA
Ca	NI	120	78J
Cr	NI	0.026	NA
Fe	NI	2.9	1.4J
Fe (Diss)	NI	NA	0.019J
K	NI	2.7	NA
Mg	NI	46	27
Mn	NI	0.18	0.067
Mn (Diss)	NI	NA	ND(0.01)U
Ni	NI	0.017	NA
Ni (Diss)	NI	NA	NA
Na	NI	15	18

MW119			
METALS	9/96	11/20/97	4/30/99
Al	NI	1.1	ND(0.2)
Ba	NI	0.039	NA
Ca	NI	150	86J
Fe	NI	1.4	0.13J
Fe (Diss)	NI	ND(0.025)	ND(0.05)
K	NI	4.7	NA
Mg	NI	50	27
Mn	NI	0.44	0.0051J
Mn (Diss)	NI	0.12	ND(0.01)
Na	NI	85	21
Pb	NI	0.011	NA

MW108			
METALS	9/25/96	11/97	4/30/99
As	0.0062	NS	NA
Ba	0.069	NS	NA
Ca	93	NS	78J
Fe	25	NS	22J
Fe (Diss)	26	NS	21
K	1.8	NS	NA
Mg	21	NS	18
Mn	0.43	NS	0.38
Mn (Diss)	0.43	NS	0.38
Na	4.7	NS	1.5J

MW113			
METALS	9/25/96	11/21/97	5/2/99
Ba	0.061	NA	NA/NA
Ca	110	NA	130J/140J
Fe	2.8	2.5	1.3J/1.3J
Fe (Diss)	3.0	NA	1.2J/1.3J
K	5.4	NA	NA/NA
Mg	46	NA	45J/46J
Mn	0.38	NA	0.16/0.16
Mn (Diss)	0.40	NA	0.17/0.16
Na	46	NA	37/37

MW116			
METALS	9/24/96	11/97	4/29/99
Al	0.18	NS	ND(0.2)
Ba	0.10	NS	NA
Ca	100	NS	120J
Fe	1.5	NS	0.59J
Fe (Diss)	1.4J	NS	0.63
Mg	42	NS	47
Mn	0.25	NS	0.081
Mn (Diss)	0.24	NS	0.081
K	2.5	NS	NA
Na	22	NS	9.4
Sb	0.042	NS	NA
Sb (Diss)	ND(0.03)	NS	NA

MW118			
METALS	9/23/96	11/18/97	4/27/99
As	ND(0.005)	NA	NA
Ba	0.15	NA	NA
Ca	87	NA	91J
Fe	4.3	2.9	3.1B
Fe (Diss)	4.4	NA	3.2
K	3.5	NA	NA
Mg	40	NA	30
Mn	0.14	NA	0.046
Mn (Diss)	0.14	NA	0.047
Na	4.6	NA	4.7

MW106			
METALS	9/24/96	11/20/97	4/29/99
Ba	0.076	NA	NA
Ca	99	NA	120J
Fe	3.9	3.5	3.3J
Fe (Diss)	3.6J	NA	3.3
K	1.3	NA	NA
Mg	37	NA	43
Mn	0.071	NA	0.07
Mn (Diss)	0.071	NA	0.073
Na	5.4	NA	8

MW110			
METALS	9/25/96	11/21/97	5/1/99
Ba	0.15/0.14	NA	NA
Ca	130/120	NA	130J
Fe	6.4/6.2	5.7	5.9J
Fe (Diss)	6.6/6.6	NA	6.2J
K	3.6/3.5	NA	NA
Mg	27/26	NA	28J
Mn	0.30/0.29	NA	0.28
Mn (Diss)	0.30/0.30	NA	0.3
Na	8.5/8.2	NA	3.2

MW104			
METALS	9/24/96	11/97	4/28/99
Ba	0.026	NS	NA
Ca	75	NS	89J
Fe	2.2	NS	0.9J
Fe (Diss)	2.2J	NS	0.89
K	1.5	NS	NA
Mg	42	NS	45
Mn	0.036	NS	0.021
Mn (Diss)	0.036	NS	0.022
Na	6.8	NS	4.7

MW100			
METALS	9/24/96	11/18/97	4/27/99
As	0.0064	NA	NA
Ba	0.10	NA	NA
Ca	90	NA	89J
Fe	2.9	3.2	2.5B
Fe (Diss)	2.6J	NA	2.5
K	2.1	NA	NA
Mg	35	NA	33
Mn	0.081	NA	0.043
Mn (Diss)	0.082	NA	0.042
Na	5.6	NA	5.4

MW102			
METALS	9/23/96	11/97	4/28/99
As	0.011	NS	NA
Ba	0.12	NS	NA
Ca	120	NS	140J
Fe	1.9	NS	1.8J
Fe (Diss)	2.0	NS	1.6
K	2.5	NS	NA
Mg	60	NS	65
Mn	0.12	NS	0.11
Mn (Diss)	0.13	NS	0.11
Na	37	NS	67

LEGEND:

PROPERTY BOUNDARY
RIGHT-OF-WAY BOUNDARY
FENCE LINE
MW100 ● SHALLOW MONITORING WELL LOCATION

Al	ALUMINUM
As	ARSENIC
Ba	BARIUM
Ca	CALCIUM
Fe	IRON
Fe (Diss)	IRON (DISSOLVED)
K	POTASSIUM
Mg	MAGNESIUM
Mn	MANGANESE
Mn (Diss)	MANGANESE (DISSOLVED)
Na	SODIUM
Ni	NICKEL
Pb	LEAD
Sb	ANTIMONY
J	ESTIMATED CONCENTRATION
U	QUALIFIED AS NON-DETECT DUE TO METHOD BLANK CONTAMINATION
6.6/6.6	SAMPLE RESULT/DUPLICATE SAMPLE RESULT
ND()	NOT DETECTED ABOVE QUANTITATION LIMIT STATED IN PARENTHESES
NI	NOT INSTALLED
NS	NOT SAMPLED
NA	NOT ANALYZED
B	ASSOCIATED VALUE IS ESTIMATED
NOTE:	ALL CONCENTRATIONS REPORTED IN MILLIGRAMS PER LITER (mg/L)

figure B.3

SUMMARY OF METALS IN GROUNDWATER
SHALLOW OFF-SITE WELL LOCATIONS
FOUR COUNTY LANDFILL SITE
Fulton County, Indiana

CRA

05369-76(APPB24)GN-CO003 MAY 30/2000

MW128			
METALS	9/96	11/97	5/1/99
Ca	NI	NI	90
Fe	NI	NI	2.5J
Fe (Diss)	NI	NI	2.6J
Mg	NI	NI	30J
Mn	NI	NI	0.066J
Mn (Diss)	NI	NI	0.071J
Na	NI	NI	7.9J

MW126			
METALS	9/96	11/18/97	4/29/99
As	NI	0.010	NA/NA
Ba	NI	0.15	NA/NA
Ca	NI	95	100J/100J
Fe	NI	3.3	2.6J/2.6J
Fe (Diss)	NI	NA	2.5/2.7
K	NI	1.5	NA/NA
Mg	NI	34	33/35
Mn	NI	0.084	0.035/0.036
Mn (Diss)	NI	NA	0.038/0.038
Na	NI	7.6	5.1/5.1

MW130			
METALS	9/96	11/97	5/1/99
Ca	NI	NI	97J
Fe	NI	NI	4.4J
Fe (Diss)	NI	NI	4.6J
Mg	NI	NI	35J
Mn	NI	NI	0.061
Mn (Diss)	NI	NI	0.06
Na	NI	NI	5.4

MW129			
METALS	9/96	11/97	5/1/99
Ca	NI	NI	90J
Fe	NI	NI	4.8J
Fe (Diss)	NI	NI	4.8J
Mg	NI	NI	36J
Mn	NI	NI	0.051
Mn (Diss)	NI	NI	0.05
Na	NI	NI	14

MW122			
METALS	9/96	11/19/97	4/30/99
Ba	NI	0.068	NA
Ca	NI	90	93J
Fe	NI	3.6	3.7J
Fe (Diss)	NI	NA	3.7
K	NI	1.6	NA
Mg	NI	32	30
Mn	NI	0.13	0.06
Mn (Diss)	NI	NA	0.063
Na	NI	12	4.4

MW120			
METALS	9/96	11/20/97	4/30/99
Ba	NI	0.13	NA
Ca	NI	86	98J
Fe	NI	2.9	3.2J
Fe (Diss)	NI	2.5	3
K	NI	1.6	NA
Mg	NI	30	30
Mn	NI	0.067	0.041
Mn (Diss)	NI	0.064	0.038
Na	NI	10	5

MW109			
METALS	9/25/96	11/97	4/30/99
As (Diss)	0.0051	NA	NA
Ba	0.046	NA	NA
Ca	92	NA	87J
Fe	4.4	NA	3J
Fe (Diss)	4.2	NA	3.1
K	0.94	NA	NA
Mg	36	NA	34
Mn	0.075	NA	0.054
Mn (Diss)	0.070	NA	0.054
Na	3.8	NA	2.9
Sb	0.035	NA	NA
Sb(Diss)	ND(0.03)	NA	NA

MW114			
METALS	9/25/96	11/21/97	5/2/99
Ba	0.047	NA	NA
Ca	97	NA	100J
Fe	2.7	2.5	2.7J
Fe (Diss)	2.9	NA	2.6J
K	1.0	NA	NA
Mg	34	NA	39J
Mn	0.043	NA	0.042
Mn (Diss)	0.045	NA	0.041
Na	4.2	NA	3.8

MW115			
METALS	9/24/96	11/21/97	5/2/99
Ba	0.12	NS	NA
Ca	95	NS	110J
Fe	4.3	NS	3.4J
Fe (Diss)	4.4J	NS	3.4
K	1.1	NS	NA
Mg	32	NS	34
Mn	0.057	NS	0.04
Mn (Diss)	0.057	NS	0.041
Na	5.3	NS	5.2

MW112			
METALS	9/25/96	11/21/97	5/1/99
As	0.008/0.0074	NA/NA	NA/NA
As (Diss)	0.011/0.0084	NA/NA	NA/NA
Ba	0.12/0.12	NA/NA	NA/NA
Ca	98/96	NA/NA	100J/100J
Fe	3.3/3.2	3.2/3.3	3.5J/3.4J
Fe (Diss)	3.5/3.1	NA/NA	3.6J/3.5J
K	0.99/0.95	NA/NA	NA/NA
Mg	31/31	NA/NA	36J/35J
Mn	0.039/0.038	NA/NA	0.039/0.038
Mn (Diss)	0.040/0.034	NA/NA	0.041/0.041
Na	6.1/5.9	NA/NA	5.8/5.5

MW117			
METALS	9/23/96	11/18/97	4/27/99
Ba	0.11	NA	NA
Ca	88	NA	99J
Fe	4.0	3.0	2.3B
Fe (Diss)	4.1	NA	2.3
K	1.1	NA	NA
Mg	30	NA	41
Mn	0.064	NA	0.025
Mn (Diss)	0.065	NA	0.027
Na	5.2	NA	7

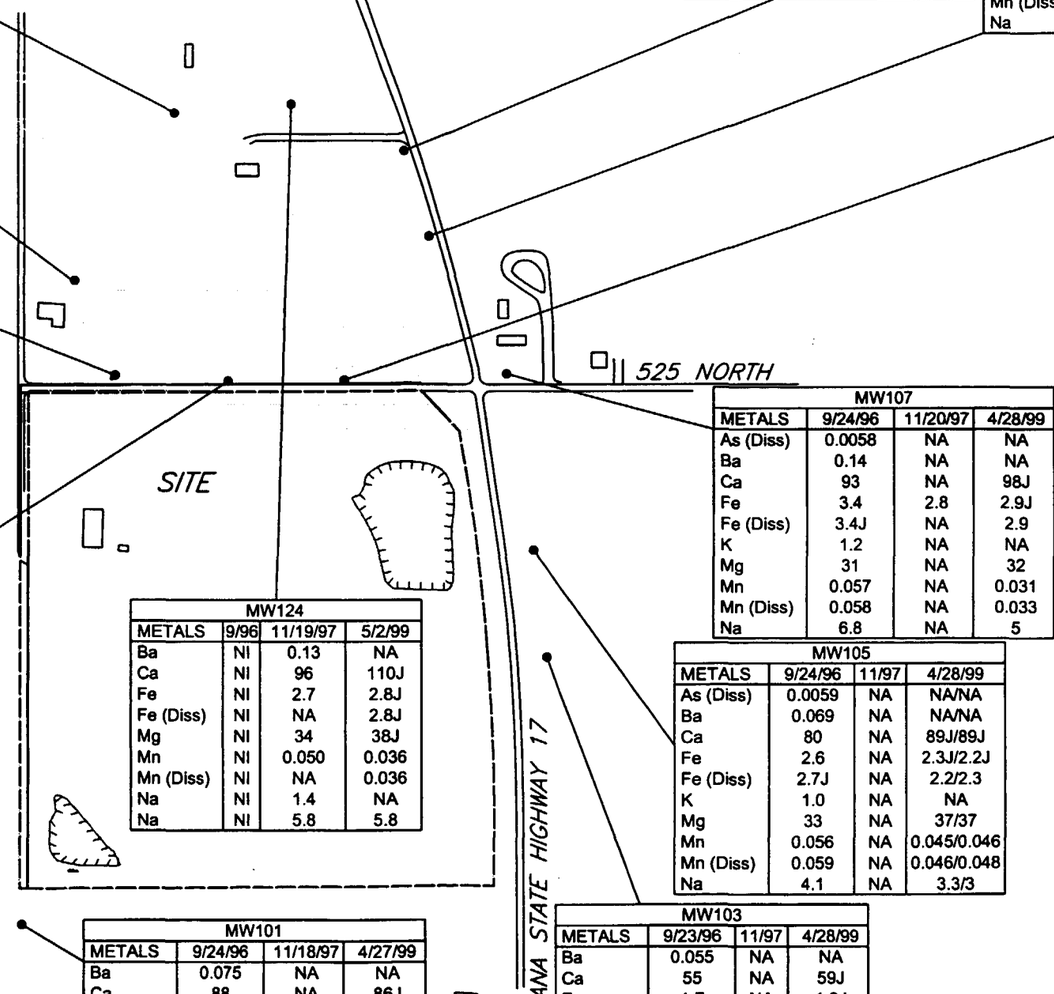
MW101			
METALS	9/24/96	11/18/97	4/27/99
Ba	0.075	NA	NA
Ca	88	NA	86J
Fe	3.0	5.3	2.6B
Fe (Diss)	3.0J	NA	2.7
K	1.1	NA	NA
Mg	30	NA	28
Mn	0.075	NA	0.066
Mn (Diss)	0.075	NA	0.07
Na	3.6	NA	3

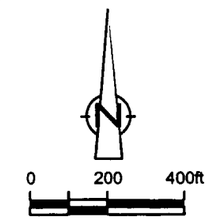
MW124			
METALS	9/96	11/19/97	5/2/99
Ba	NI	0.13	NA
Ca	NI	96	110J
Fe	NI	2.7	2.8J
Fe (Diss)	NI	NA	2.8J
Mg	NI	34	38J
Mn	NI	0.050	0.036
Mn (Diss)	NI	NA	0.036
Na	NI	1.4	NA
Na	NI	5.8	5.8

MW107			
METALS	9/24/96	11/20/97	4/28/99
As (Diss)	0.0058	NA	NA
Ba	0.14	NA	NA
Ca	93	NA	98J
Fe	3.4	2.8	2.9J
Fe (Diss)	3.4J	NA	2.9
K	1.2	NA	NA
Mg	31	NA	32
Mn	0.057	NA	0.031
Mn (Diss)	0.058	NA	0.033
Na	6.8	NA	5

MW105			
METALS	9/24/96	11/97	4/28/99
As (Diss)	0.0059	NA	NA/NA
Ba	0.069	NA	NA/NA
Ca	80	NA	89J/89J
Fe	2.6	NA	2.3J/2.2J
Fe (Diss)	2.7J	NA	2.2/2.3
K	1.0	NA	NA
Mg	33	NA	37/37
Mn	0.056	NA	0.045/0.046
Mn (Diss)	0.059	NA	0.046/0.048
Na	4.1	NA	3.3/3

MW103			
METALS	9/23/96	11/97	4/28/99
Ba	0.055	NA	NA
Ca	55	NA	59J
Fe	1.7	NA	1.9J
Fe (Diss)	1.7	NA	1.8
K	3.6	NA	NA
Mg	48	NA	52
Mn	0.033	NA	0.029
Mn (Diss)	0.033	NA	0.029
Na	7.0	NA	6





LEGEND:

PROPERTY BOUNDARY

RIGHT-OF-WAY BOUNDARY

FENCE LINE

MW101 ● DEEP MONITORING WELL LOCATION

ABBREVIATIONS:

As	ARSENIC
As (Diss)	ARSENIC (DISSOLVED)
Ba	BARIUM
Ca	CALCIUM
Fe	IRON
Fe (Diss)	IRON (DISSOLVED)
K	POTASSIUM
Mg	MAGNESIUM
Mn	MANGANESE
Mn (Diss)	MANGANESE (DISSOLVED)
Na	SODIUM
Sb	ANTIMONY
J	ESTIMATED CONCENTRATION
330/320	SAMPLE RESULT/DUPLICATE SAMPLE RESULT
ND()	NOT DETECTED ABOVE QUANTITATION LIMIT STATED IN PARENTHESES
NI	NOT INSTALLED
NA	NOT ANALYZED

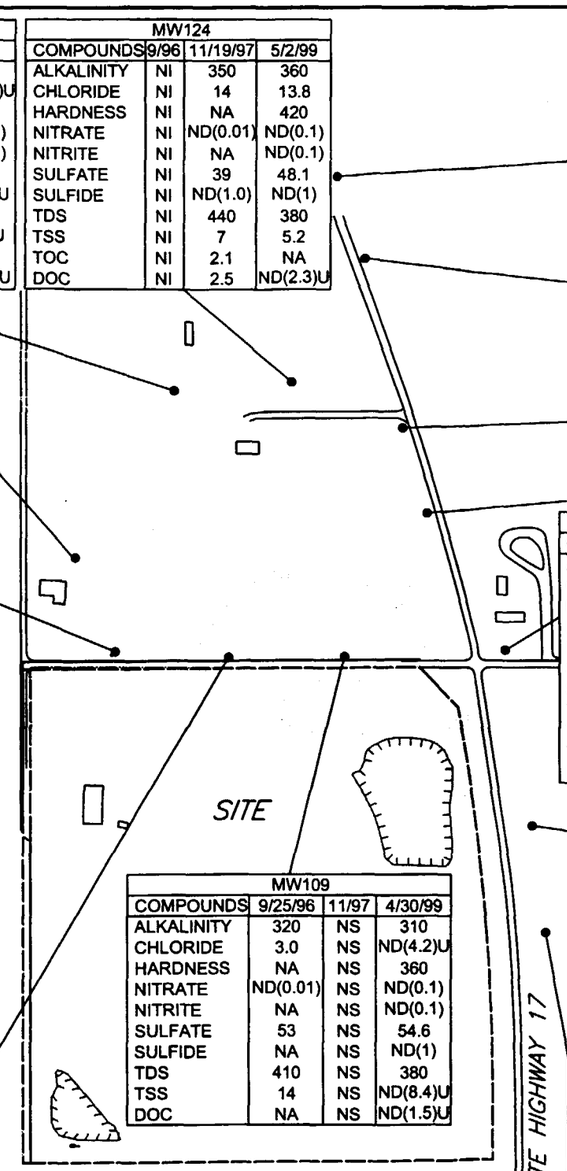
NOTE: ALL CONCENTRATIONS REPORTED IN MILLIGRAMS PER LITER (mg/L)

figure B.4

SUMMARY OF METALS IN GROUNDWATER
DEEP-OFF SITE WELL LOCATIONS
FOUR COUNTY LANDFILL SITE
Fulton County, Indiana

CRA

05369-76(APPB24)GN-CO004 MAY 30/2000



MW126			
COMPOUNDS	9/96	11/18/97	4/29/99
ALKALINITY	NI	360	340/340
CHLORIDE	NI	4.0	ND(3.2)U/ND(2.5)U
HARDNESS	NI	NA	390/400
NITRATE	NI	ND(0.01)	ND(0.1)/ND(0.1)
NITRITE	NI	NA	ND(0.1)/ND(0.1)
SULFATE	NI	36	35.6/36
SULFIDE	NI	ND(1.0)	ND(11)/ND(2.5)U
TDS	NI	380	410/390
TSS	NI	11	ND(5)/ND(5.2)U
TOC	NI	1.8	NA/NA
DOC	NI	2.1	ND(1.8)U/ND(2)U

MW124			
COMPOUNDS	9/96	11/19/97	5/2/99
ALKALINITY	NI	350	360
CHLORIDE	NI	14	13.8
HARDNESS	NI	NA	420
NITRATE	NI	ND(0.01)	ND(0.1)
NITRITE	NI	NA	ND(0.1)
SULFATE	NI	39	48.1
SULFIDE	NI	ND(1.0)	ND(1)
TDS	NI	440	380
TSS	NI	7	5.2
TOC	NI	2.1	NA
DOC	NI	2.5	ND(2.3)U

MW130			
COMPOUNDS	9/96	11/97	5/1/99
ALKALINITY	NI	NI	350J
CHLORIDE	NI	NI	3.8
HARDNESS	NI	NI	390
NITRATE	NI	NI	ND(0.1)
NITRITE	NI	NI	ND(0.1)
SULFATE	NI	NI	42.3
SULFIDE	NI	NI	ND(1)
TDS	NI	NI	400
TSS	NI	NI	8
DOC	NI	NI	ND(1.8)U

MW128			
COMPOUNDS	9/96	11/97	5/1/99
ALKALINITY	NI	NI	300J
CHLORIDE	NI	NI	3.5
HARDNESS	NI	NI	350
NITRATE	NI	NI	ND(0.1)
NITRITE	NI	NI	ND(0.1)
SULFATE	NI	NI	48
SULFIDE	NI	NI	ND(1)
TDS	NI	NI	380
TSS	NI	NI	6
DOC	NI	NI	ND(2.2)U

MW129			
COMPOUNDS	9/96	11/97	5/1/99
ALKALINITY	NI	NI	340J
CHLORIDE	NI	NI	12
HARDNESS	NI	NI	370
NITRATE	NI	NI	ND(0.1)
NITRITE	NI	NI	ND(0.1)
SULFATE	NI	NI	42.9
SULFIDE	NI	NI	ND(1)
TDS	NI	NI	400
TSS	NI	NI	7.2
DOC	NI	NI	ND(2.7)U

0 200 400ft

MW122			
COMPOUNDS	9/96	11/19/97	4/30/99
ALKALINITY	NI	320	280
CHLORIDE	NI	6.6	ND(5.5)U
HARDNESS	NI	NA	350
NITRATE	NI	ND(0.01)	ND(0.1)
NITRITE	NI	NA	ND(0.1)
SULFATE	NI	47	44.2
SULFIDE	NI	ND(1.0)	ND(2.2)U
TDS	NI	400	380
TSS	NI	6	ND(30)U
TOC	NI	2.3	NA
DOC	NI	2.4	ND(2.9)U

MW114			
COMPOUNDS	9/25/96	11/21/97	5/2/99
ALKALINITY	340	350/350	340
CHLORIDE	12	12/12	12
HARDNESS	NA	NA/NA	420
NITRATE	ND(0.01)	ND(0.01)UJ/ND(0.01)UJ	ND(0.1)
NITRITE	NA	NA/NA	ND(0.1)
SULFATE	48	40/41	54.2
SULFIDE	NA	ND(1.0)/ND(1.0)	ND(1)
TDS	430	430/430	420
TSS	5	15/8	ND(5)
DOC	NA	ND(1.0)/ND(1.0)	ND(1.4)U

MW120			
COMPOUNDS	9/96	11/20/97	4/30/99
ALKALINITY	NI	340	330
CHLORIDE	NI	3.9	ND(3.5)U
HARDNESS	NI	NA	370
NITRATE	NI	ND(0.01)UJ	ND(0.1)
NITRITE	NI	NA	ND(0.1)
SULFATE	NI	40	31.9
SULFIDE	NI	ND(1.0)	ND(1)
TDS	NI	360	320
TSS	NI	7	ND(6)U
TOC	NI	2.7	NA
DOC	NI	2.8	ND(2.1)U

MW107			
COMPOUNDS	9/24/96	11/20/97	4/28/99
ALKALINITY	330	330	270
CHLORIDE	3.1	3.1	3.8
HARDNESS	NA	NA	380
NITRATE	ND(0.01)	ND(0.01)	ND(0.1)
NITRITE	NA	NA	ND(0.1)
SULFATE	40	44	43.9
SULFIDE	NA	ND(1)	ND(1)
TDS	390	400	400
TSS	9	7	ND(5)
TOC	NA	1.6	NA
DOC	NA	2.0	ND(2)U

MW115			
COMPOUNDS	9/24/96	11/97	4/29/99
ALKALINITY	320	NS	300
CHLORIDE	2.8	NS	ND(3.8)U
HARDNESS	NA	NS	400
NITRATE	ND(0.01)	NS	ND(0.1)
NITRITE	NA	NS	ND(0.1)
SULFATE	58	NS	49.5
SULFIDE	NA	NS	ND(1)
TDS	420	NS	420
TSS	13	NS	ND(8.4)U
DOC	NA	NS	ND(2)U

MW109			
COMPOUNDS	9/25/96	11/97	4/30/99
ALKALINITY	320	NS	310
CHLORIDE	3.0	NS	ND(4.2)U
HARDNESS	NA	NS	360
NITRATE	ND(0.01)	NS	ND(0.1)
NITRITE	NA	NS	ND(0.1)
SULFATE	53	NS	54.6
SULFIDE	NA	NS	ND(1)
TDS	410	NS	380
TSS	14	NS	ND(8.4)U
DOC	NA	NS	ND(1.5)U

MW105			
COMPOUNDS	9/24/96	11/97	4/28/99
ALKALINITY	290	NS	270/260
CHLORIDE	3.8	NS	3.8/4.5
HARDNESS	NA	NS	370/370
NITRATE	ND(0.01)	NS	ND(0.1)/ND(0.1)
NITRITE	NA	NS	ND(0.1)/ND(0.1)
SULFATE	60	NS	55.5/55.6
SULFIDE	NA	NS	ND(1)/1.6
TDS	340	NS	380/370
TSS	7	NS	ND(5)/ND(5)
DOC	NA	NS	ND(1.7)U/ND(2.2)U

MW117			
COMPOUNDS	9/23/96	11/18/97	4/27/99
ALKALINITY	280	300	410
CHLORIDE	4.7	4.5	1.5
HARDNESS	NA	NA	410
NITRATE	ND(0.01)	ND(0.01)	ND(0.1)
NITRITE	NA	NA	ND(0.1)
SULFATE	54	46	30.1
SULFIDE	NA	ND(1.0)	1.4
TDS	410	360	460
TSS	19	12	ND(5)
DOC	NA	1.4	ND(1.4)U

MW103			
COMPOUNDS	9/23/96	11/97	4/28/99
ALKALINITY	300	NS	290
CHLORIDE	14	NS	13
HARDNESS	NA	NS	360
NITRATE	ND(0.01)	NS	ND(0.1)
NITRITE	NA	NS	ND(0.1)
SULFATE	41	NS	37.1
SULFIDE	NA	NS	2
TDS	380	NS	440
TSS	7	NS	ND(5)
DOC	NA	NS	ND(1.3)U

MW112			
COMPOUNDS	9/25/96	11/21/97	5/1/99
ALKALINITY	330/330	330/320	330J/330J
CHLORIDE	5.6/5.3	5.5/5.4	8.5/8.8
HARDNESS	NA	NA	410/400
NITRATE	ND(0.01)/ND(0.01)	ND(0.01)UJ/ND(0.01)UJ	ND(0.01)/ND(0.01)
NITRITE	NA	NA	ND(0.01)/ND(0.01)
SULFATE	53/56	45/45	52.4/52.7
SULFIDE	NA	ND(1.0)/ND(1.0)	ND(1)/ND(1)
TDS	440/420	390/410	400/390
TSS	11/6	8/6	ND(5)/8.8
TOC	NA	ND(2.3)U/ND(2.4)U	ND(1.9)U/ND(1.9)U
DOC	NA	ND(2.3)U/NA	ND(1.9)U/ND(1.9)U

MW101			
COMPOUNDS	9/24/96	11/18/97	4/27/99
ALKALINITY	270	270	260
CHLORIDE	7.1	7.3	6
HARDNESS	NA	NA	330
NITRATE	ND(0.01)	ND(0.01)	ND(0.1)
NITRITE	NA	NA	ND(0.1)
SULFATE	82	74	71.8
SULFIDE	NA	ND(0.01)	ND(1)
TDS	420	350	400
TSS	7	10	ND(5)
TOC	NA	2.8	NA
DOC	NA	2.0	ND(2.1)U

LEGEND:

PROPERTY BOUNDARY
RIGHT-OF-WAY BOUNDARY
FENCE LINE
MW101 ● DEEP MONITORING WELL LOCATION AND IDENTIFIER

ABBREVIATIONS:

TDS TOTAL DISSOLVED SOLIDS
TSS TOTAL SUSPENDED SOLIDS
TOC TOTAL ORGANIC CARBON
DOC DISSOLVED ORGANIC CARBON
NA NOT ANALYZED
NI NOT INSTALLED
NS NOT SAMPLED
ND COMPOUND NOT DETECTED AT THE QUANTITATION LIMIT SHOWN IN PARENTHESES
8.5/8.8 SAMPLE RESULT/DUPLICATE SAMPLE RESULT
U QUALIFIED AS NON-DETECT DUE TO METHOD BLANK CONTAMINATION
J ESTIMATED CONCENTRATION

NOTE: ALL CONCENTRATIONS REPORTED IN MILLIGRAMS PER LITER (mg/L)

CRA

figure B.6

SUMMARY OF GENERAL CHEMISTRY PARAMETERS IN GROUNDWATER
DEEP-OFF SITE WELL LOCATIONS
FOUR COUNTY LANDFILL SITE
Fulton County, Indiana

05369-76(APPB24)GN-CO006 MAY 30/2000

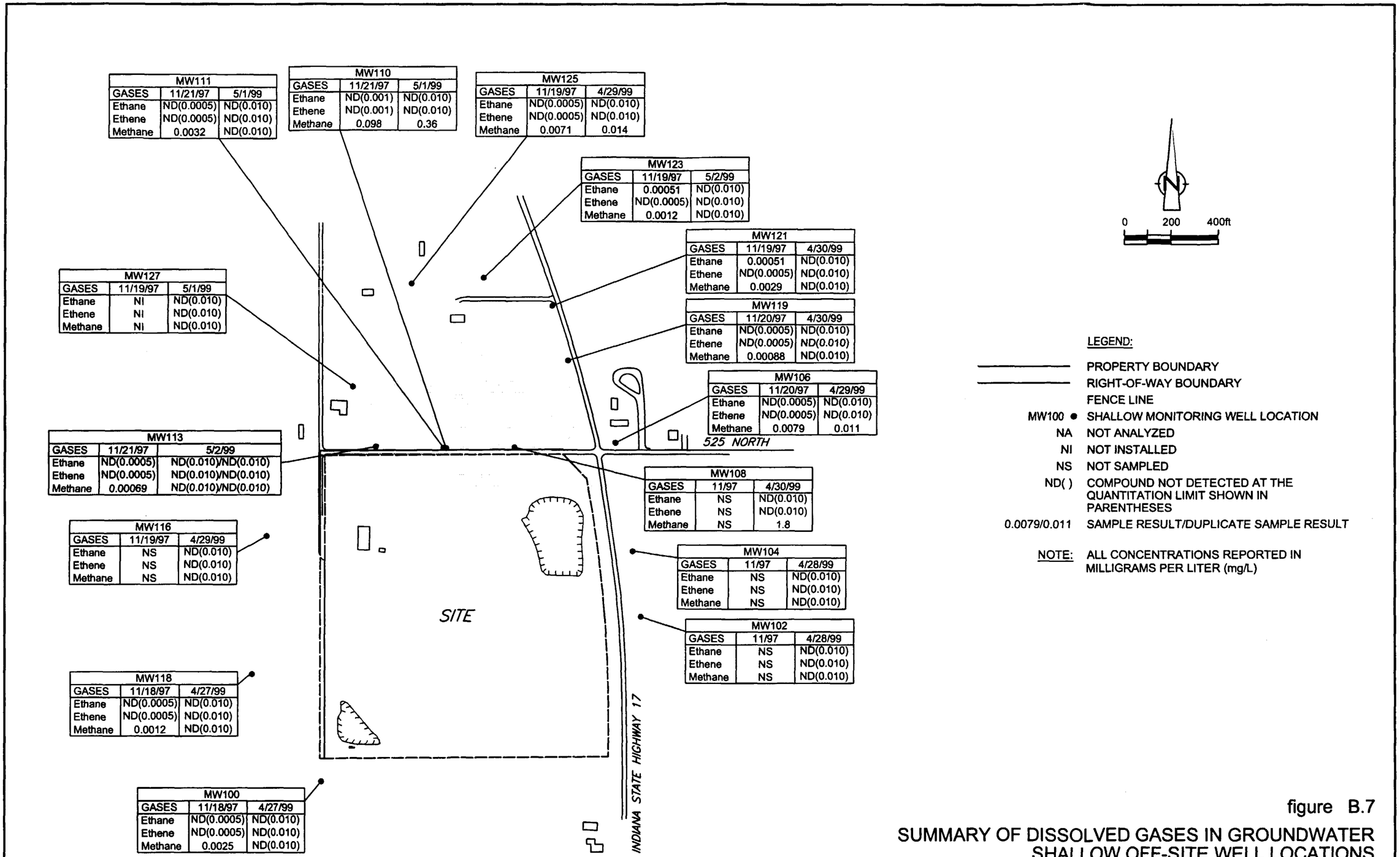
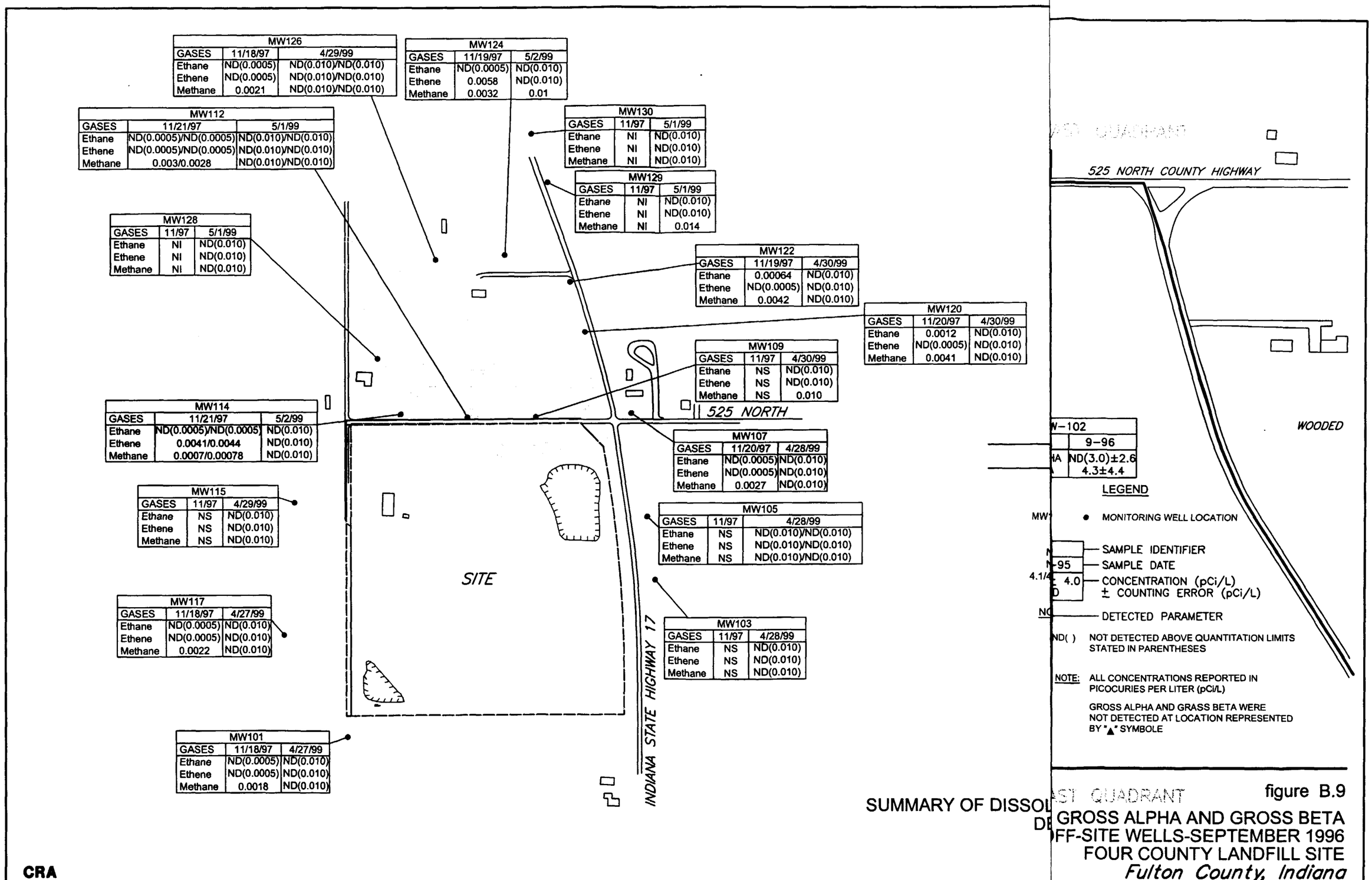


figure B.7

SUMMARY OF DISSOLVED GASES IN GROUNDWATER
SHALLOW OFF-SITE WELL LOCATIONS
FOUR COUNTY LANDFILL SITE
Fulton County, Indiana

CRA

05369-76(APPB24)GN-CO007 MAY 30/2000



MW126		
GASES	11/18/97	4/29/99
Ethane	ND(0.0005)	ND(0.010)/ND(0.010)
Ethene	ND(0.0005)	ND(0.010)/ND(0.010)
Methane	0.0021	ND(0.010)/ND(0.010)

MW124		
GASES	11/19/97	5/2/99
Ethane	ND(0.0005)	ND(0.010)
Ethene	0.0058	ND(0.010)
Methane	0.0032	0.01

MW112		
GASES	11/21/97	5/1/99
Ethane	ND(0.0005)/ND(0.0005)	ND(0.010)/ND(0.010)
Ethene	ND(0.0005)/ND(0.0005)	ND(0.010)/ND(0.010)
Methane	0.003/0.0028	ND(0.010)/ND(0.010)

MW130		
GASES	11/97	5/1/99
Ethane	NI	ND(0.010)
Ethene	NI	ND(0.010)
Methane	NI	ND(0.010)

MW129		
GASES	11/97	5/1/99
Ethane	NI	ND(0.010)
Ethene	NI	ND(0.010)
Methane	NI	0.014

MW128		
GASES	11/97	5/1/99
Ethane	NI	ND(0.010)
Ethene	NI	ND(0.010)
Methane	NI	ND(0.010)

MW122		
GASES	11/19/97	4/30/99
Ethane	0.00064	ND(0.010)
Ethene	ND(0.0005)	ND(0.010)
Methane	0.0042	ND(0.010)

MW120		
GASES	11/20/97	4/30/99
Ethane	0.0012	ND(0.010)
Ethene	ND(0.0005)	ND(0.010)
Methane	0.0041	ND(0.010)

MW109		
GASES	11/97	4/30/99
Ethane	NS	ND(0.010)
Ethene	NS	ND(0.010)
Methane	NS	0.010

MW114		
GASES	11/21/97	5/2/99
Ethane	ND(0.0005)/ND(0.0005)	ND(0.010)
Ethene	0.0041/0.0044	ND(0.010)
Methane	0.0007/0.00078	ND(0.010)

MW107		
GASES	11/20/97	4/28/99
Ethane	ND(0.0005)	ND(0.010)
Ethene	ND(0.0005)	ND(0.010)
Methane	0.0027	ND(0.010)

MW115		
GASES	11/97	4/29/99
Ethane	NS	ND(0.010)
Ethene	NS	ND(0.010)
Methane	NS	ND(0.010)

MW105		
GASES	11/97	4/28/99
Ethane	NS	ND(0.010)/ND(0.010)
Ethene	NS	ND(0.010)/ND(0.010)
Methane	NS	ND(0.010)/ND(0.010)

MW117		
GASES	11/18/97	4/27/99
Ethane	ND(0.0005)	ND(0.010)
Ethene	ND(0.0005)	ND(0.010)
Methane	0.0022	ND(0.010)

MW103		
GASES	11/97	4/28/99
Ethane	NS	ND(0.010)
Ethene	NS	ND(0.010)
Methane	NS	ND(0.010)

MW101		
GASES	11/18/97	4/27/99
Ethane	ND(0.0005)	ND(0.010)
Ethene	ND(0.0005)	ND(0.010)
Methane	0.0018	ND(0.010)

W-102	
	9-96
HA	ND(3.0)±2.6
	4.3±4.4

SUMMARY OF DISSOL
DE

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figure B.9

GROSS ALPHA AND GROSS BETA
FF-SITE WELLS-SEPTEMBER 1996
FOUR COUNTY LANDFILL SITE
Fulton County, Indiana

MW127			
COMPOUNDS	9/96	11/97	5/1/99
ALKALINITY	NI	NI	340J
CHLORIDE	NI	NI	3.8
HARDNESS	NI	NI	360
NITRATE	NI	NI	ND(0.1)
NITRITE	NI	NI	ND(0.1)
SULFATE	NI	NI	29.4
SULFIDE	NI	NI	ND(1)
TDS	NI	NI	350
TSS	NI	NI	ND(5)
DOC	NI	NI	ND(1)

MW111			
COMPOUNDS	9/25/96	11/21/97	5/1/99
ALKALINITY	340	350	330
CHLORIDE	12	14	20
HARDNESS	NA	NA	430
NITRATE	ND(0.01)	ND(0.01)U	ND(0.1)
NITRITE	NA	NA	ND(0.1)
SULFATE	82	59	59.6
SULFIDE	NA	ND(1)	ND(1)
TDS	460	450	1,200
TSS	10	8	11
TOC	NA	ND(2.1)U	NA
DOC	NA	ND(1.2)U	ND(1.3)U

MW125			
COMPOUNDS	9/96	11/19/97	4/29/99
ALKALINITY	NI	400	350
CHLORIDE	NI	8.7	9.5
HARDNESS	NI	NA	430
NITRATE	NI	0.38	0.0401J
NITRITE	NI	NA	ND(0.1)
SULFATE	NI	29	18.5
SULFIDE	NI	ND(1.0)	ND(1)
TDS	NI	400	410
TSS	NI	7	ND(5)
TOC	NI	4.2	NA
DOC	NI	4.8	ND(5.5)U

MW123			
COMPOUNDS	9/96	11/19/97	5/2/99
ALKALINITY	NI	340	360
CHLORIDE	NI	4.1	4.75
HARDNESS	NI	NA	400
NITRATE	NI	0.24	0.0324J
NITRITE	NI	NA	ND(0.1)
SULFATE	NI	38	33.3
SULFIDE	NI	ND(1.0)	ND(1)
TDS	NI	390	370
TSS	NI	6	ND(5)
TOC	NI	ND(1.0)	NA
DOC	NI	ND(1.0)	ND(1.3)U

MW121			
COMPOUNDS	9/96	11/19/97	4/30/99
ALKALINITY	NI	300	230
CHLORIDE	NI	45	26
HARDNESS	NI	NA	310
NITRATE	NI	1.2	0.395
NITRITE	NI	NA	0.0378J
SULFATE	NI	41	23.6
SULFIDE	NI	ND(1.0)	ND(1.5)U
TDS	NI	420	320
TSS	NI	270	ND(8.8)U
TOC	NI	1.8	NA
DOC	NI	1.7	ND(2.7)U

MW113			
COMPOUNDS	9/25/96	11/21/97	5/2/99
ALKALINITY	380	420	420/430
CHLORIDE	94	87	68.5/67.5
HARDNESS	NA	NA	520/530
NITRATE	0.02	0.03J	0.0959J/0.0955J
NITRITE	NA	NA	ND(0.1)/ND(0.1)
SULFATE	83	81	88.9/88
SULFIDE	NA	ND(1.0)	ND(1)/ND(1)
TDS	670	650	620/640
TSS	8	10	ND(5)/ND(5)
TOC	NA	ND(1.8)U	NA/NA
DOC	NA	ND(1.6)U	ND(1.6)U/ND(1.6)U

MW119			
COMPOUNDS	9/96	11/20/97	4/30/99
ALKALINITY	NI	380	290
CHLORIDE	NI	200	49
HARDNESS	NI	NA	320
NITRATE	NI	ND(0.01)UJ	ND(0.1)
NITRITE	NI	NA	ND(0.1)
SULFATE	NI	29	20.1
SULFIDE	NI	ND(1.0)	ND(1)
TDS	NI	680	360
TSS	NI	690	ND(5)
TOC	NI	ND(1.0)	NA
DOC	NI	ND(1.0)	ND(1.7)U

MW106			
COMPOUNDS	9/24/96	11/20/97	4/29/99
ALKALINITY	330	340	340
CHLORIDE	16	52	47
HARDNESS	NA	NA	470
NITRATE	ND(0.01)	ND(0.01)UJ	ND(0.1)
NITRITE	NA	NA	ND(0.1)
SULFATE	62	54	51.8
SULFIDE	NA	ND(1.0)	ND(1)
TDS	440	470	510
TSS	10	8	ND(8)U
TOC	NA	ND(1.0)	NA
DOC	NA	1.6	ND(1.8)U

MW116			
COMPOUNDS	9/24/96	11/97	4/29/99
ALKALINITY	410	NS	410
CHLORIDE	5.9	NS	ND(2.5)U
HARDNESS	NA	NS	480
NITRATE	ND(0.01)	NS	ND(0.1)
NITRITE	NA	NS	ND(0.1)
SULFATE	45	NS	43.7
SULFIDE	NA	NS	ND(1)
TDS	470	NS	460
TSS	29	NS	ND(5)
DOC	NA	NS	ND(1.1)U

MW118			
COMPOUNDS	9/23/96	11/18/97	4/27/99
ALKALINITY	360	400	300
CHLORIDE	6.0	5.1	3.8
HARDNESS	NA	NA	350
NITRATE	ND(0.01)	ND(0.01)	ND(0.1)
NITRITE	NA	NA	ND(0.1)
SULFATE	40	31	59.1
SULFIDE	NA	ND(1.0)	1.3
TDS	440	400	410
TSS	34	16	ND(5)
DOC	NA	1.2	ND(1.9)U

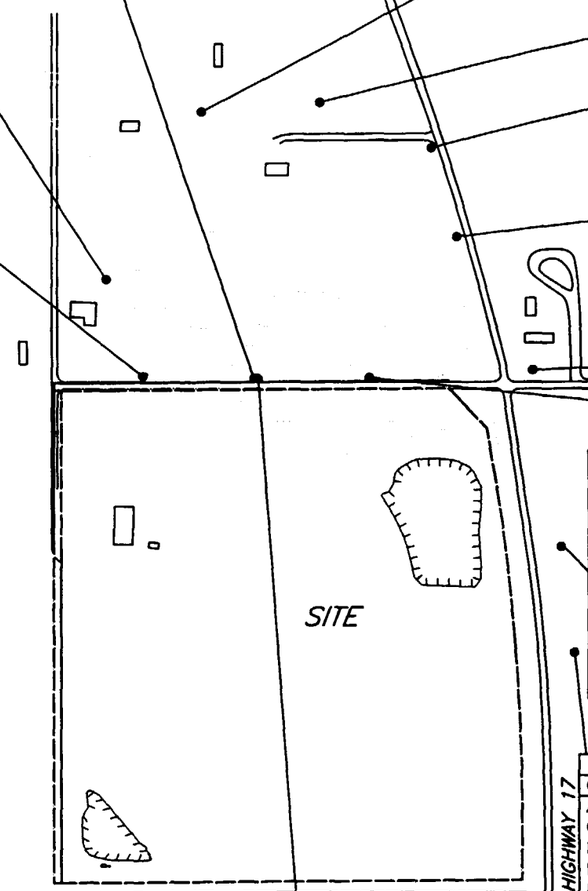
MW100			
COMPOUNDS	9/24/96	11/18/97	4/27/99
ALKALINITY	330	340	330
CHLORIDE	3.6	4.6	3.5
HARDNESS	NA	NA	360
NITRATE	ND(0.16)U	ND(0.10)	ND(0.1)
NITRITE	NA	NA	ND(0.1)
SULFATE	56	48	46.6
SULFIDE	NA	ND(0.01)	1.6
TDS	400	370	420
TSS	13	62	ND(5)
TOC	NA	1.7	NA
DOC	NA	1.2	ND(1.6)U

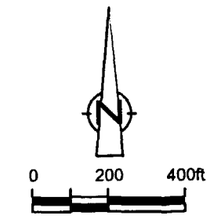
MW110			
COMPOUNDS	9/25/96	11/21/97	5/1/99
ALKALINITY	430/420	420	430J
CHLORIDE	8.5/8.6	9.8	6.5
HARDNESS	NA	NA	430
NITRATE	ND(0.01)/ND(0.01)	ND(0.01)UJ	ND(0.1)
NITRITE	NA	NA	ND(0.1)
SULFATE	21/21	14	18.2
SULFIDE	NA	ND(1.0)	ND(1)
TDS	490/490	500	470
TSS	16/17	20	15
TOC	NA	15	NA
DOC	NA	15	14

MW104			
COMPOUNDS	9/24/96	11/97	4/28/99
ALKALINITY	350	NS	300
CHLORIDE	2.9	NS	5.2
HARDNESS	NA	NS	410
NITRATE	ND(0.01)	NS	ND(0.1)
NITRITE	NA	NS	ND(0.1)
SULFATE	35	NS	42.5
SULFIDE	NA	NS	ND(1)
TDS	380	NS	410
TSS	6	NS	ND(5)
DOC	NA	NS	ND(1.2)U

MW108			
COMPOUNDS	9/25/96	11/97	4/30/99
ALKALINITY	300	NS	230
CHLORIDE	19	NS	29
HARDNESS	NA	NS	270
NITRATE	ND(0.01)	NS	ND(0.1)
NITRITE	NA	NS	0.0579J
SULFATE	ND(5.0)	NS	16.7
SULFIDE	NA	NS	ND(1)
TDS	360	NS	310
TSS	59	NS	ND(52)U
DOC	NA	NS	13

MW102			
COMPOUNDS	9/23/96	11/97	4/28/99
ALKALINITY	430	NS	390
CHLORIDE	150	NS	180
HARDNESS	NA	NS	610
NITRATE	ND(0.01)	NS	ND(0.1)
NITRITE	NA	NS	ND(0.1)
SULFATE	35	NS	25.7
SULFIDE	NA	NS	1.2
TDS	690	NS	730
TSS	20	NS	ND(5)
DOC	NA	NS	ND(3.1)U





LEGEND:

PROPERTY BOUNDARY

RIGHT-OF-WAY BOUNDARY

FENCE LINE

MW100 ● SHALLOW MONITORING WELL LOCATION AND IDENTIFIER

ABBREVIATIONS:

- TDS TOTAL DISSOLVED SOLIDS
- TSS TOTAL SUSPENDED SOLIDS
- TOC TOTAL ORGANIC CARBON
- DOC DISSOLVED ORGANIC CARBON
- NA NOT ANALYZED
- NI NOT INSTALLED
- NS NOT SAMPLED
- ND COMPOUND NOT DETECTED AT THE QUANTITATION LIMIT SHOWN IN PARENTHESES
- 430/420 SAMPLE RESULT/DUPLICATE SAMPLE RESULT
- J ESTIMATED CONCENTRATION
- U QUALIFIED NON-DETECT DUE TO METHOD BLANK CONTAMINATION

NOTE: ALL CONCENTRATIONS REPORTED IN MILLIGRAMS PER LITER (mg/L)

figure B.5

SUMMARY OF GENERAL CHEMISTRY PARAMETERS IN GROUNDWATER
SHALLOW OFF-SITE WELL LOCATIONS
FOUR COUNTY LANDFILL SITE
Fulton County, Indiana

CRA

05369-76(APPB24)GN-CO005 MAY 30/2000

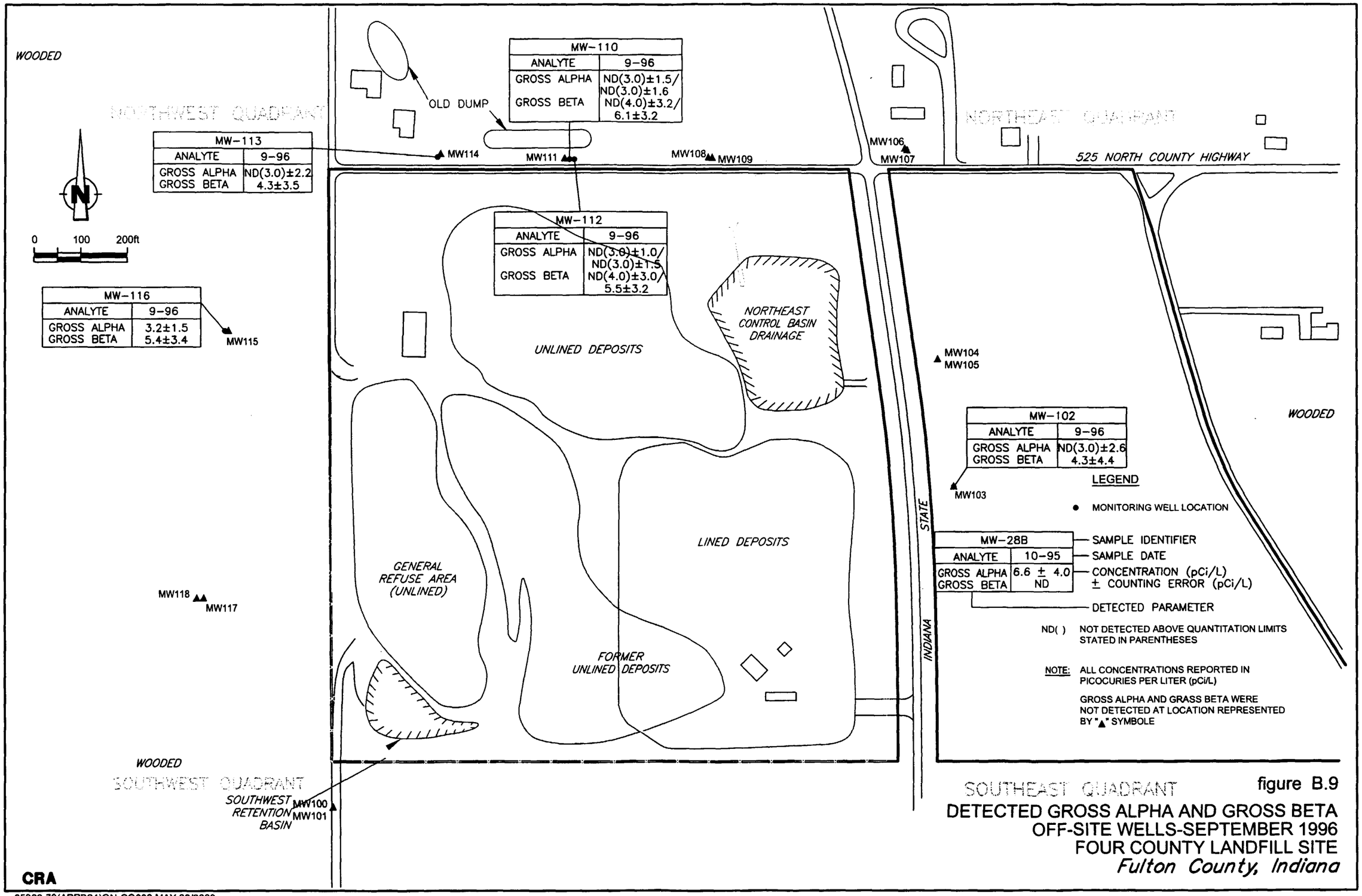


figure B.9

DETECTED GROSS ALPHA AND GROSS BETA
OFF-SITE WELLS-SEPTEMBER 1996
FOUR COUNTY LANDFILL SITE
Fulton County, Indiana

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APPENDIX C

FIELD SAMPLING PLAN

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1.0 INTRODUCTION

These field procedures have been prepared by Conestoga-Rovers and Associates (CRA) on behalf of the Four County Landfill Group (Group). This document provides field procedures and sampling protocols for the Long-Term Groundwater Monitoring Program (LTGMP) at the Four County Landfill, located in Fulton County, Indiana (Site). Procedures to be adhered to and sample analyses to be performed during the LTGMP will be completed consistent with the protocols identified herein.

2.0 FIELD TASKS AND PROCEDURES

The field procedures presented in this document detail the investigative sampling protocols which will be utilized during the LTGMP at the Site.

2.1 EQUIPMENT DECONTAMINATION PROCEDURES

2.1.1 SAMPLING EQUIPMENT

All sampling equipment will be decontaminated prior to field use and after each sample is collected to minimize the potential for cross-contamination between sample locations. Duplicate samples will be collected concurrently with original samples; therefore, sampling equipment will not be decontaminated before collection of the duplicate samples. Groundwater samples will be collected using a stainless steel, variable-speed pump or equivalent. Consistent with the regulations cited at 329 Indiana Administrative Code (IAC) 10-21-2, paragraph (9)(B), decontamination of this equipment will be performed as follows:

i) place pump and its associated wiring and tubing inside a container holding several gallons of either a distilled or potable water and nonphosphate detergent solution;

ii) brush, if necessary, to remove all visible foreign matter;

iii) activate pump and allow water/detergent solution to circulate through pump and tubing for several minutes;

iv) remove pump from container and place in 2 to 4-ich diameter polyvinyl chloride (PVC) tube;

v) fill tube with a minimum of three gallons of distilled water;

vi) activate pump and allow distilled water to exit system through tubing; and

vii) transport pump to next sampling location inside PVC tubing.

Following the final rinse, equipment will be visually inspected to verify that it is free of soil particles and other solid material which could contribute to possible sample cross-contamination. Equipment decontamination will not be performed if dedicated sampling equipment is utilized.

2.2 MONITORING WELL DEVELOPMENT

It may be necessary to once again develop selected monitoring wells due to the accumulation of fine sediment in the well. In the event that monitoring well development is required it will be conducted in accordance with the procedures outlined below:

i) surge the screened interval of the monitoring well using a clean surge block or weighted bailer for a period of at least ten minutes;

ii) purge the monitoring well using a precleaned electronic or pneumatic submersible pump, or a hand operated pump;

iii) collect the pH, temperature, and conductivity of the purge water at regular intervals using field instruments. Calibrate instruments according to the manufacturer's specifications. Observe and record the color, odor, and turbidity of the purged water;

iv) continue development until the turbidity and silt content of the monitoring well is significantly reduced and three consistent readings of pH, temperature, and conductivity are recorded, or a minimum of ten well volumes are purged as calculated below for two-inch diameter wells:

$$V_p = 10(0.16H)$$

where:

V_p = purge volume (gallons)
H = height of the water column in the well (feet)
$0.16H$ = one well volume (gallons)

Three consistent readings for pH, temperature, and conductivity are defined as three consecutive readings within 10-percent of each other for purposes of monitoring well development.

2.3 GROUNDWATER SAMPLING PROTOCOLS

Groundwater sampling will proceed such that groundwater samples will be collected from background and unimpacted monitoring wells first, then proceed to the impacted monitoring wells. Groundwater samples will be collected according to the protocols specified below:

i) A new pair of disposable nitrile gloves will be used for each sample.

ii) The depth to water in each well will be measured to the nearest 0.01 foot using an electronic water level meter. The measuring device will be decontaminated prior to use.

iii) Prior to sampling, each well will be purged using a pre-cleaned stainless-steel-cased electric submersible pump (Grundfos® or similar), or a stainless-steel-cased pneumatic bladder pump. The pump will be positioned within the well screen. The pump will be lowered slowly into position to minimize mixing of the stagnant well casing water and to minimize the agitation of any solids into suspension, which could increase purging times.

iv) Purging of the monitoring well will be conducted in a manner to minimize sediment agitation and drawdown.

v) Field measurements of temperature, pH, conductivity, oxidation/reduction potential (ORP), and turbidity of the purged water will be recorded at regular intervals throughout purging. During sampling events for fate and transport parameters, field measurements for dissolved oxygen (DO) will also be measured and recorded. The field parameters will be measured and recorded every few minutes after purging one well volume (or as appropriate). Three consecutive readings for each parameter, within the following limits, will indicate stabilization:

pH	-	±10 percent of the average value three readings;
temperature	-	±10 percent of the average value three readings;
conductivity	-	±10 percent of the average value three readings;
ORP	-	±10 percent of the average value three readings;

Should stabilization not be achieved for all field parameters, purging will continue until a maximum of 5 well volumes are purged from the monitoring well. Measurement of the field parameters may be obtained using individual meters or a multiple meter unit. The meters will be calibrated in accordance with the manufacturer's instructions.

vi) In the event that a well is purged dry prior to achieving well stabilization, groundwater will be allowed to recover to a level sufficient for sample collection. The time that the well was pumped dry will be recorded in the field book. Upon recovery, the sample will be collected.

vii) Groundwater samples will be collected directly from the purging apparatus. Pumping volumes will be reduced to minimize analyte volatilization during the

collection of the sample aliquot for VOC analysis. Containers will be filled using techniques that minimize sample agitation. Groundwater samples will be collected in order of decreasing analyte volatility.

viii) Groundwater samples collected for dissolved analyses will be field filtered prior to sample preservation. At the time of collection, the sample will be field filtered using a dedicated 0.45 micron filter attached to the end of the sampling hose. If a peristaltic pump is used, the sample will initially be placed in an unpreserved laboratory-supplied sample container. The sample will then be drawn through the filter apparatus into a preserved laboratory-supplied sample container.

2.4 QUALITY ASSURANCE/QUALITY CONTROL SAMPLES

Quality Assurance/Quality Control (QA/QC) samples will be collected during groundwater sampling according to the following schedule:

- Duplicate groundwater samples will be collected at a frequency of one per ten investigative samples collected or at a minimum of one per sampling event.
- Samples will be collected for matrix spike/matrix spike duplicate (MS/MSD) analysis at a frequency of one per 20 investigative samples. The sample for MS/MSD analysis will be collected from a well representative of the condition of the majority of the monitoring wells. The chain-of-custody forms sent to the project laboratory will identify those samples collected for MS/MSD analysis.
- Field equipment blank (rinsate) samples will be collected at a frequency of one per ten investigative samples collected or at a minimum of one per sampling event. These samples consist of distilled or deionized water poured/pumped into and then sampled out of the pump. This provides a quality assurance check on the decontamination procedures employed for the pumps and sample containers. The equipment blank samples will be analyzed for the same analytical parameters as investigative samples.

The laboratory will provide a trip blank for each sample cooler containing multiple aqueous samples for VOC analysis. Trip blanks will be analyzed for VOCs.

The level of QC effort provided for groundwater will be equivalent to the level of QC effort specified in "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods", SW-846 3rd edition, November 1986, with revisions (SW-846).

The Quality Assurance Project Plan (QAPP) prepared for this project provides specific details regarding protocols and checks associated with laboratory analyses and sampling procedures (see Attachment I).

2.5 WASTE HANDLING PROTOCOL

Purged groundwater will be discharged onto the ground near the majority of the monitoring well locations. However, groundwater purged from monitoring wells that contain concentrations of contaminants above applicable standards will be containerized and transferred to the on Site leachate storage tank. Analytical data from previous sampling rounds will be reviewed regularly to determine which monitoring wells should be containerized. Sampling order of the monitoring wells ensures that wells containing impacted groundwater are sampled last, if practicable. Therefore, water used in cleaning the pumps will also be discharged to the ground surface until sampling of the impacted wells is initiated. At that time, decontamination water will also be transported to the Site for storage and treatment.

3.0 SAMPLE HANDLING PROTOCOLS

3.1 FIELD LOG DOCUMENTATION

The field log book will consist of a bound document with consecutively numbered pages. The entries for each day will commence on a new page, which will be dated. All entries will be made only in indelible ink. Corrections will be made by marking through the error with a single line, so as to remain legible, and initialing this action followed by writing the correction. The person making the entries in the log book will sign or initial each page of entries as they are completed. Upon completion of the field work or during periods when field work is not scheduled, the field log books will be maintained in CRA's office.

The following information will be recorded in the field log book for each sample collected:

i) Site location identification;

ii) unique sample identification number;

iii) date and time (in 2400-hour time format) of sample collection;

iv) weather conditions;

v) designation as to the type of sample (groundwater, soil, etc.);

vi) designation as to the means of collection (grab, bailer, etc.);

vii) name of sampler;

viii) analyses to be performed on sample;

ix) any other relevant comments such as odor, staining, texture, filtering, preservation, etc.; and

x) sample location.

3.2 SAMPLE LABELING

Each sample will be labeled with a unique sample number that will facilitate tracking and cross-referencing of sample information. The sample numbering system to be used is described as follows:

Example: - GW-MMDDYY-XX-01

Where:

GW	-	designates the type of sample (GW = groundwater)
MMDDYY	-	designates the date of collection presented as month/day/year
XX	-	designates the sampler's initials
01	-	designates a sequential number starting with 01 at the start of the project

To prevent laboratory bias of field QC samples, rinsate blank and field duplicate samples also will be numbered with a unique sample number consistent with the numbering system described above.

3.3 CHAIN-OF-CUSTODY FORMS

Chain-of-custody records will be used to track all samples from time of sampling to the arrival of samples at the laboratory. Each shipping container being sent to the laboratory will contain a chain-of-custody form. The chain-of-custody form consists of four copies which are distributed to the sampler, to the shipper, to the contract laboratory, and to the office file of the engineer. The sampler and shipper will maintain their copies while the other two copies are enclosed in a waterproof enclosure within the sample container. The laboratory, upon receiving the samples, will complete the remaining copies. The laboratory will maintain one copy for its records. The executed original will be returned to the engineer with the data deliverables package.

3.4 SAMPLE CONTAINERS AND HANDLING

Required sample containers, sample preservation methods, maximum holding times, and filling instructions are contained in the QAPP, which is provided as Attachment I. All samples will be placed in appropriate sample containers, labeled, and properly sealed. Sample labels will include sample number, place of collection, date of collection, and analyses to be performed. Samples will be cushioned within the shipping coolers by the use of bubble pack. Samples will be kept cool by the use of plastic bags of ice, as required. A trip blank will accompany each shipment of groundwater samples submitted for VOC analyses.

Samples will be shipped by commercial courier, hand delivered, or picked up by the laboratory on a daily basis to the project laboratory. The exception to this will be samples which are collected on a Saturday, Sunday, or holiday. For samples collected

on a Saturday, Sunday, or holiday, additional ice will be placed in the coolers, as required, and the coolers will be sealed and kept under surveillance. Immediately prior to shipment on the next business day, the samples will be checked to ensure that the samples have been stored appropriately and have not been tampered with.

Two seals comprised of the sampler's chain-of-custody tape will be placed over the lid on the front and back of each shipping cooler prior to shipment to secure the lid and provide evidence that the samples have not been tampered with en route to the laboratory. Clear tape will be placed over the seals to ensure that they are not accidentally broken during shipment. The on-Site representative conducting the sampling will be responsible for packaging the samples and sealing and delivering the cooler to an overnight courier.

Upon receipt of the cooler at the laboratory, the designated sample custodian will inspect the cooler. The sample custodian will note the condition of the cooler and seal on the chain-of-custody form. The sample custodian will document the date and time of receipt of the cooler and sign the chain-of-custody forms.

The sample custodian then will check the contents of the cooler with those samples listed on the chain-of-custody form. If damage or discrepancies are noticed, they will be recorded in the remarks column of the chain-of-custody form, dated and signed. They will be reported to the laboratory supervisor who will inform the laboratory manager and QA officer.

Sample disposal will be the responsibility of the laboratory.

3.5 ANALYTICAL LABORATORY

Samples collected for laboratory analysis will be analyzed by SIMILABS of Merrillville, Indiana. The shipping address of SIMILABS is as follows:

SIMILABS
250 West 84th Drive
Merrillville, Indiana 46410
Phone: (219) 769-8378

The QAPP is provided under separate cover as Attachment I to this document.

2.0 HEAT STRESS

2.1 OVERVIEW

Heat induced occupational illnesses, injuries and reduced productivity occur in situations in which the total heat load (environmental plus metabolic) exceeds the body's capacities to maintain normal body functions without excessive strain. Heat stress is the sum of the heat generated in the body plus the heat gained from the environment minus the heat lost from the body to the environment. The body's response to heat stress is called heat strain. The level of heat stress at which excessive heat strain will result depends on the heat tolerance of the individual. Certain predisposing factors may reduce an individual's ability to tolerate heat stress.

Using PPE may put a hazardous waste worker at an increased risk of developing heat stress. Health effects may range from heat rash or heat fatigue to serious illness or death. Heat stress is caused by a number of interacting factors, including environmental conditions such as temperature and relative humidity, protective clothing which limits natural heat loss through perspiration, workload and the individual characteristics of the worker.

It is the responsibility of the project team members to inform the HSO or industrial hygienist if any of the predisposing factors listed below apply to them. This enables the HSO to monitor the individual if necessary, or use other means of preventing/reducing the individual's likelihood of experiencing a heat related illness or disorder.

2.2 PREDISPOSING FACTORS

Predisposing factors that will increase the individual's susceptibility to heat stress are listed below:

- Lack of Physical Fitness: Such individuals experience more physiological strain including a higher heart rate, a higher body temperature, less efficient sweating and slightly higher oxygen consumption as compared to fit individuals.
- Obesity: Overweight individuals produce more heat per unit surface area than thin individuals and have a lowered ability to dissipate heat.

- Age: Older individuals may have a decreased ability to cope with heat stress.
- Dehydration: Dehydrated individuals will have a decreased ability to cool the body by sweating. Diarrhea can cause dehydration.
- Alcohol, Medications and Drug Use: Alcohol consumption may dehydrate individuals and certain medications/drugs may act as diuretics. Hence, the individual may have a decreased ability to lose heat by sweating.
- Infection, Sunburn, Illness and Certain Chronic Diseases: These factors may interfere with the body's normal mechanisms to lose heat.
- Heart Conditions or Circulatory Problems: Heat stress may place an additional strain on the heart and circulatory system that could harm the individual as well as decrease the individual's physiologic response.
- Low Salt Diet: Could affect the individual's electrolyte balance.
- Pregnancy
- Previous History of Heat Stroke or Heat Exhaustion: May increase the individual's susceptibility to heat stress.
- Heavy Work Load: Will generate metabolic heat thereby increasing the heat stress placed on the individual
- The Use of PPE Over Light Summer Clothing: This will decrease the ability of an individual to lose heat by sweating as evaporative cooling can no longer occur.
- Lack of Acclimatization: Acclimatization is the gradual introduction of workers into a hot environment to allow their bodies to physiologically adjust to hot working conditions. Acclimatized individuals generally have lower heart rates and lower body temperatures. In addition, they sweat sooner and more profusely and even have more dilute sweat (thereby losing less electrolytes) than non-acclimatized individuals.

2.3 PREVENTION OF HEAT STRESS

There are a variety of measures that can be implemented to prevent or reduce the likelihood of employees developing heat stress related disorders. These include fluid and electrolyte replenishment, the provision of shelter from the sun and heat, work schedule adjustment, the use of cooling devices, acclimatization, heat stress monitoring and employee education, as discussed below:

- Fluid and Electrolyte Replenishment: Personnel should drink about 16 ounces of water before starting work and drink water at every break. To encourage water consumption, cool water and disposable cups should be made available. The normal thirst mechanism is not sensitive enough to ensure that enough water will be drunk to replace lost sweat. When heavy sweating occurs, personnel should be encouraged to drink more. Replacing body fluids with Gatorade is an option. It is advisable to have Gatorade on-site if the air temperature is 70°F (21°C) or more and the workers are performing tasks with a moderate to heavy work load in chemical resistant clothing.
- Shelter From the Sun and Heat: Air-conditioned (if possible) or shaded areas should be made available for rest periods. Sitting in an air-conditioned truck is an acceptable option.
- Work Schedule Adjustment: Scheduling work for early mornings and/or late afternoons will avoid the hottest parts of the day and reduce the heat stress placed on personnel. Rotation of personnel will help reduce overexertion of workers and adjusting the work-rest schedule will help personnel recover from the effects of heat stress periodically.
- Use of Cooling Devices: The use of cooling devices like field showers, hose-down areas or cooling vests should be considered for project tasks that involve heavy work loads in chemical resistant clothing.
- Acclimatization: Acclimatization is the gradual introduction of workers into a hot environment to allow their body to physiologically adjust to hot working conditions. Acclimatized individuals generally have lower heart rates and lower body temperatures. In addition, they sweat sooner and more profusely and even have more dilute sweat (thereby losing less electrolytes) than non-acclimatized individuals.
- Heat Stress Monitoring: Monitoring hot environments for potential heat stress should be initiated when the ambient air temperature is in excess of 70°F. There are several ways to monitor heat stress: measuring heart rate, oral temperature, loss of body weight and the Wet Bulb Globe Temperature using a Reuter-Stokes or Quest Electronics heat stress monitor.
- Employee Education: Workers have already been trained to recognize and treat the effects of heat stress during the 40-hour training course. Signs, symptoms and treatment of heat stress should be discussed in site safety meetings. The buddy system will help in preventing heat stress once the employees are trained to recognize the signs and symptoms of heat stress.

2.3.1 PREVENTION PRACTICES

It may not be practically feasible to implement all of the above prevention measures. The following has been developed as a field guide for use in actual field situations.

Ambient air temperature is 70°F (21°C) or more:

- Replenish fluids and electrolytes. Drink cool (50°F to 60°F/10°C to 15°C) fluids hourly. The fluids should be caffeine-free and non-alcoholic. Do not wait until you are thirsty. Your normal thirst mechanism is not sufficient to overcome the effects of dehydration. If you feel thirsty, you are already becoming dehydrated.
- Provide shelter from the sun and heat.

Ambient air temperature is 70°F (21°C) or more and chemical-resistant clothing is being used:

- Same as above;
- Adjust work schedules if feasible; and
- Initiate heat stress monitoring and/or the use of cooling devices.

2.3.2 HEAT STRESS MONITORING

Heat stress monitoring may be performed by monitoring the heart rate. Heart rate should be measured at the beginning of the work shift, at regular intervals and at the start of each rest period.

1) If the heart rate is <110 beats per minute (bpm), personnel may continue the current work/rest schedule.
2) If the heart rate is >110 bpm, take a 10 minute break. Monitor heart rate at the end of the rest period. If not <110 bpm, rest until the heart rate is <110 bpm. Reduce the current work time between breaks by approximately one hour. If the next scheduled monitoring session shows a heart rate of >110 bpm once again, reduce the work time between breaks by one hour.

2.4 HEAT STRESS FIRST AID

2.4.1 HEAT CRAMPS

Cause: Excessive water loss/electrolyte imbalance.

Symptoms	First-Aid Guidelines
Muscular pain in arms, legs, abdomen Faintness, dizziness, exhaustion Normal temp, cool moist skin	Administer sips of Gatorade (1/2 glass every 15 minutes) Do not massage cramping muscles Relax person

2.4.2 HEAT EXHAUSTION

Cause: Large amount of water loss; blood circulation diminishes.

Symptoms	First-Aid Guidelines
Moist, clammy, skin, usually pale Dilated pupils Weak, dizzy, nauseous, headache Normal or low body temperature	Move to a cool place Apply cold, wet compresses to skin Raise feet 8 to 12 inches Administer sips of Gatorade (1/2 glass every 15 minutes) Get medical attention

2.4.3 HEAT STROKE

Cause: Body overheats; temperature rises; no sweating occurs

Symptoms	First-Aid Guidelines
No sweating occurs	Get emergency medical assistance ASAP
Dry, hot skin, usually red	Remove from sunlight
Constricted pupils	Wet down body with cool water or rubbing alcohol
Hot body temperature (105°F to 110°F/40.5°C to 43.5°C)	Elevate head/shoulders
Strong, rapid pulse	Wrap in wet, cold wrapping
Unconsciousness may occur	Once cooled to 102°F (38.9°C), stop cooling measures
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ATTACHMENT 1

QUALITY ASSURANCE PROJECT PLAN

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QAPP DISTRIBUTION LIST

Vince Epps - IDEM	4 copies
Jeff Leed - Leed Environmental	1 copy
Steve Wanner - CRA	1 copy
Sean Cordier - CRA	1 copy
Steve Day - CRA	1 copy
Carla Svetich - Simalabs	1 copy

1.0 PROJECT DESCRIPTION

The United States Environmental Protection Agency (U.S. EPA) and the Indiana Department of Environmental Management (IDEM) require that all environmental monitoring and measurement efforts mandated or supported by the U.S. EPA and IDEM participate in a centrally managed quality assurance (QA) program.

Any party generating data under this program has the responsibility to implement minimum procedures to assure that the precision, accuracy, completeness, and representativeness of its data are known and documented. To ensure this responsibility is met uniformly, each party must prepare a written Quality Assurance Project Plan (QAPP) covering each project it is to perform.

This QAPP has been developed for, and is part of, the Long-Term Groundwater Monitoring Program (LTGMP) for the Four County Landfill Site (Site). The LTGMP defines the functional organization, activities, and evaluations to be implemented in support of the Long-Term Monitoring phase of the groundwater monitoring program at the Site.

1.1 SITE LOCATION AND HISTORY

The Site location and history are provided in Sections 1.0 and 2.0 of the LTGMP.

1.2 SAMPLING NETWORK AND RATIONALE

The sampling network and rationale is summarized in Sections 5.0 and 6.0 of the LTMGP.

1.3 PROJECT OBJECTIVES AND SCOPE

The objectives and scope of the LTGMP is presented in Sections 1.3 and 1.4 of the LTGMP.

1.4 PARAMETERS TO BE TESTED AND FREQUENCY

The sampling program, sample matrices, analytical parameters, and frequencies of sample collection for years one through five of the LTGMP activities are presented in Table 1.1.

1.5 PROJECT SCHEDULE

The first LTGMP event will be completed within three months following completion of the landfill cap and approval of the LTGMP. This QAPP has been prepared for years one through five of the LTGMP monitoring. After the fifth year, the monitoring program and this QAPP will be reviewed and revised if deemed necessary. Any revisions to this QAPP will be submitted for IDEM approval prior to implementation. The sampling schedule is discussed in Section 5.0 of the LTGMP.

1.6 DATA QUALITY OBJECTIVES

The Data Quality Objective (DQO) Process is a series of planning steps based on the Scientific Method that is designed to ensure that the type, quality, and quantity of environmental data used in decision making are appropriate for their intended application.

DQOs are qualitative and quantitative statements derived from outputs of each step of the DQO Process that:

- clarify the study objective;
- define the most appropriate type of data to collect; and
- determine the most appropriate conditions from which to collect the data.

The DQOs were used to develop a scientific and resource-effective sampling design. The DQO process allows decision makers to define their data requirements and acceptable levels of decision during planning before any data are collected. DQOs are

based on the seven step process described in "Guidance for the Data Quality Objectives Process", EPA QA/G-4, September 1994.

In general, all groundwater samples will require off-Site analysis using laboratory standard operating procedures (SOPs) based on the methods referenced in Section 7.0.

Field measurements associated with groundwater monitoring will be conducted according to SOPs based on methods referenced in "Methods for Chemical Analysis of Water and Wastes", EPA 600/4-79-020, March 1983.

The SOPs and analytical methods are summarized in Section 7.0. The quality assurance (QA) and quality control (QC) procedures to ensure the DQOs are achieved are presented in Section 3.0.

2.0 PROJECT ORGANIZATION AND RESPONSIBILITY

Conestoga-Rovers & Associates (CRA), as consultant to the Four County Landfill Group (Group), has overall responsibility for all phases of the LTGMP activities at the Site.

SIMALABS International of Merrillville, Indiana (SIMALABS) will analyze all groundwater samples collected during the LTGMP activities. SIMALABS will provide project management as appropriate to their responsibilities. CRA will provide administrative oversight and QA/QC for all deliverables. CRA will maintain a file copy of all laboratory deliverables. All final project deliverables will be issued by CRA. Section 5.4 provides details regarding storage and archiving of LTGMP-related data and project files.

A project organization chart showing the relationship and lines of communication among all project participants with QA/QC responsibilities is presented as Figure 2.1. The QA/QC responsibilities of key project personnel are summarized below.

Steven J. Wanner - Project Manager - CRA

- general overview of the project to ensure that the Group's objectives are met;
- liaison with IDEM;
- data assessment;
- preparation and review of reports; and
- provide technical representation of project activities.

Steven Day - QA/QC Officer - CRA

- perform laboratory system audits;
- overview and review field QA/QC;
- review laboratory QA/QC;
- oversee data validation and assessment;
- advise on data corrective action procedures;
- preparation and review of reports; and
- provide QA/QC representation of project activities.

Sean Cordier - Project Coordinator/Field QA Officer - CRA

- management of field activities and field QA/QC;
- data assessment;
- technical representation of field activities;
- preparation of SOPs for field activities;
- preparation of reports;
- evidence file custodian; and
- advise on field corrective action procedures.

Carla Svetich - Project Manager - SIMALABS

- ensures all resources of the laboratory are available on an as-required basis;
- overview of final analytical reports; and
- approve final analytical reports prior to submission to CRA.

Carla Svetich - Operations Manager - SIMALABS

- coordinate laboratory analyses;
- supervise in-house chain-of-custody procedures;
- schedule sample analyses;
- oversee data review; and
- oversee preparation of analytical reports.

Dennis Jachim - Laboratory QA Officer - SIMALABS

- overview laboratory quality assurance;
- overview QA/QC documentation;
- conduct detailed data review;
- decide laboratory corrective actions, if required;
- provide technical representation of laboratory QA procedures; and
- coordinate preparation of laboratory SOPs.

Nicole Taylor - Sample Custodian - SIMALABS

- receive and inspect the incoming sample containers;
- record the condition of the incoming sample containers;
- sign appropriate documents;
- verify chain-of-custody and its correctness;
- notify laboratory manager and laboratory supervisor of sample receipt and inspection;
- with the help of the operations manager, initiate transfer of the samples to appropriate lab sections; and
- control and monitor access/storage of samples and extracts.

Primary responsibility for project quality rests with CRA's QA/QC Officer and Field QA Officer. Ultimate responsibility for project quality rests with CRA's Project Manager. Independent quality assurance will be provided by SIMALABS' Project Manager and QA Officer prior to release of all data to CRA.

IDEM RESPONSIBILITIES

The IDEM Project Manager (PM) will be responsible for the overview of this project. The PM will also be responsible for providing approval of the QAPP. Vince Epps is the PM for the LTGMP activities.

U.S. EPA RESPONSIBILITIES

U.S. EPA Region 5 will provide technical support and review to IDEM.

SPECIAL TRAINING OR CERTIFICATION REQUIREMENTS

There are no special training or certification requirements associated with the LTGMP. However, CRA has been providing engineering and environmental consulting services to entities involved in remedial investigations/remedial actions, including long-term monitoring programs, for approximately 25 years. SIMALABS is a support laboratory for IDEM and U.S. EPA Region 5, and has been providing environmental laboratory services for over 9 years.

3.0 QUALITY ASSURANCE OBJECTIVES FOR MEASUREMENT DATA

The overall QA objective for the LTGMP is to develop and implement procedures for field sampling, chain-of-custody, laboratory analysis, and reporting that will provide results that are legally defensible in a court of law. Data quality objectives for the LTGMP sampling and analysis program have been developed through negotiation with IDEM to ensure that the objectives specified in Sections 1.3 and 1.4 of the LTGMP are achieved. Specific procedures for sampling, chain-of-custody, laboratory instrument calibration, laboratory analysis, reporting of data, internal quality control, audits, preventive maintenance of field equipment, and corrective action are described in subsequent sections of this QAPP.

3.1 PRECISION

3.1.1 DEFINITION

Precision is a measure of the degree to which two or more measurements are in agreement.

3.1.2 FIELD PRECISION OBJECTIVES

Precision of the field sampling procedures will be assessed by the data from field duplicate samples. Precision of field measurements associated with groundwater monitoring will be assessed through the collection and measurement of duplicate samples or calibration check solutions. The precision control limits for field measurements obtained during the LTGMP activities are summarized in the SOPs in Attachment A.

3.1.3 LABORATORY PRECISION OBJECTIVES

Precision in the laboratory will be assessed through the calculation of relative percent differences (RPDs) for replicate/duplicate samples. The equation to be used for

calculating precision for this project can be found in Section 12.2 of this QAPP. Precision control limits for laboratory parameters are provided in Table 3.1.

3.2 ACCURACY

3.2.1 DEFINITION

Accuracy is the degree of agreement between an observed value and an accepted reference value.

3.2.2 FIELD ACCURACY OBJECTIVES

Accuracy in the field is assessed through the use of field and trip blank samples and is ensured by observing all sample handling procedures, preservation requirements, and holding time periods. Accuracy of field measurements associated with groundwater monitoring will be assessed by analyzing calibration check solutions. Accuracy control limits for the field measurements obtained during the LTGMP activities are presented in the field SOPs in Attachment A.

3.2.3 LABORATORY ACCURACY OBJECTIVES

Laboratory accuracy will be assessed by determining percent recoveries from the analysis of matrix spikes (MS), laboratory control samples (LCS), or standard reference materials (SRMs). The equation to be used for calculating accuracy for this project can be found in Section 12.1 of this QAPP. Accuracy control limits for laboratory parameters are provided in Table 3.2.

Analytical sensitivity is also a measure of laboratory accuracy. The sensitivities required for the analyses will be the targeted quantitation limits presented in Table 3.3.

3.3 COMPLETENESS

3.3.1 DEFINITION

Completeness is a measure of the amount of valid data obtained from a measurement system compared to the amount that was expected to be obtained under normal conditions.

3.3.2 FIELD COMPLETENESS OBJECTIVES

Field completeness is a measure of the amount of valid field measurements obtained from all the measurements taken during the project. The equation for completeness is presented in Section 12.3 of this QAPP. The field completeness objective for this project will be greater than 90 percent.

3.3.3 LABORATORY COMPLETENESS OBJECTIVES

Laboratory completeness is a measure of the amount of valid laboratory measurements obtained from all the measurements taken during the project. The equation for completeness is presented in Section 12.3 of this QAPP. The laboratory completeness objective for this project will be greater than 90 percent.

3.4 REPRESENTATIVENESS

3.4.1 DEFINITION

Representativeness expresses the degree to which data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, a process condition, or an environmental condition.

3.4.2 MEASURES TO ENSURE REPRESENTATIVENESS OF FIELD DATA

Representativeness is dependent upon the proper design of the sampling program. Representativeness will be ensured by following the proper sampling protocols and using proper sampling techniques.

3.4.3 MEASURES TO ENSURE REPRESENTATIVENESS OF LABORATORY DATA

Representativeness in the laboratory is ensured by using the proper analytical procedures, meeting sample holding times, and analyzing and assessing field duplicate samples. The sampling network is designed to provide data representative of Site conditions. During development of this network, consideration has been given to historical operations, existing analytical data, and physical setting and processes.

3.5 COMPARABILITY

3.5.1 DEFINITION

Comparability is an expression of the confidence with which one data set can be compared with another. Comparability is also dependent on similar QA objectives.

3.5.2 MEASURES TO ENSURE COMPARABILITY OF FIELD DATA

Comparability is dependent upon the proper design of the sampling program and will be ensured by using proper sampling techniques.

3.5.3 MEASURES TO ENSURE COMPARABILITY OF LABORATORY DATA

The laboratory data to be gathered during the LTGMP activities will be comparable to previous data when similar sampling and analytical methods are used. Comparability is also dependent on similar QA objectives.

3.6 LEVEL OF QUALITY CONTROL EFFORT

Field blank, trip blank, method blank, field duplicate, matrix spike, laboratory control samples, and laboratory duplicate samples will be analyzed to assess the quality of the laboratory's data resulting from the field sampling and analysis program.

Field and trip blank samples will be submitted to the laboratory to provide the means to assess the quality of the data resulting from the field sampling program. Field blank samples are analyzed to check for contamination that may be introduced into the samples during the sampling procedures. Field blank samples will be submitted with groundwater samples collected during the LTGMP activities. Field blank samples consist of distilled water that has been used to rinse sampling equipment that has undergone the decontamination procedures specified in Section 2.1 of the LTGMP Field Procedures.

Trip blank samples are used to assess the potential for contamination of samples resulting from contaminant migration during sample shipment and storage. Trip blank samples pertain only to aqueous VOC samples. Trip blank samples that consist of ultra pure water are prepared in sample containers at the laboratory prior to the sampling event and are kept with the investigative samples throughout the sampling event. Trip blank samples will be packaged for shipment with other groundwater samples and submitted to the laboratory for analysis. One trip blank sample will be included in each cooler used to ship groundwater samples to the laboratory for VOC analysis. Trip blank sample containers will not be opened prior to analysis at the laboratory.

Method blank samples are generated within the laboratory and are used to assess contamination resulting from laboratory procedures.

Field duplicate samples are analyzed to assess the overall sampling and analytical reproducibility. Field duplicate samples are collected by alternately filling the sample containers for each parameter to be analyzed from the same sampling device.

Matrix spikes provide information about the effect of the sample matrix on the preparation and measurement methodology. Matrix spike samples are generally analyzed in duplicate and are referred to as matrix spike/matrix spike duplicate

(MS/MSD) samples. MS/MSD samples are investigative samples which have been fortified (spiked) by the laboratory with a known amount of the analyte(s) of interest. Aqueous MS/MSD samples must be collected at triple the usual volume for VOCs, and double the usual volume for extractable organics (e.g., semivolatile organic compounds).

Laboratory control sample (LCS) analyses will be analyzed by the laboratory assess the accuracy of the preparation and analysis methods. LCSs consist of standard reference materials that are from a different source than calibration standards. As such, LCSs serve to document that the analytical process was in control during each data collecting activity. An LCS will be analyzed with each batch of twenty or fewer samples for each analysis.

The level of the QC effort for groundwater matrices will be one field duplicate sample and one field blank sample for every ten or fewer samples. One VOC trip blank sample consisting of laboratory-prepared ultra pure water will be included along with each shipment of groundwater VOC samples. One MS/MSD sample will be submitted with every 20 or fewer groundwater samples designated for organic, inorganic or general chemistry (where applicable) analyses. Alternately, laboratory control sample/laboratory duplicate (LCS/DUP) samples may be designated for some general chemistry analyses. The SOPs in Attachment A detail whether MS/MSD or LCS/DUP samples are analyzed for a particular method.

The level of QC effort for the field measurement of pH consists of daily calibration and periodic calibration verification using two standard reference solutions as appropriate to the sample pH. The level of QC effort for field conductivity, oxidation-reduction potential (ORP), dissolved oxygen (DO), and turbidity measurements will include periodic calibration verification of the instrument using standard solutions of known conductivity, ORP, DO, and turbidity. Temperature measurements are obtained with pH and/or conductivity and field calibration is neither possible nor practical.

The number of QC samples to be collected for each monitoring program associated with the LTGMP activities is provided in Table 1.1.

4.0 SAMPLING PROCEDURES

The groundwater sampling procedures at the Site are provided in Section 2.3 of LTGMP Appendix C, which provides the LTGMP Field Procedures. Table 4.1 details the sample preservation, sample container, sample holding time, sample packaging, and sample shipping requirements for the analyses to be performed on the samples collected during the LTGMP activities. All samples will be shipped to:

SIMALABS INTERNATIONAL
250 West 84th Drive
Merrillville, Indiana 46410
Attn.: Sample Receiving
Phone: 219-769-8378
Fax: 219-769-1664

Sample containers will be precleaned by SIMALABS, or purchased precleaned, as described in the U.S. EPA guidance document entitled "Specifications and Guidance for Contaminant-Free Sample Containers", EPA 540/R-93/051.

5.0 SAMPLE CUSTODY AND DOCUMENT CONTROL

Custody is one of several factors which is necessary for the admissibility of environmental data as evidence in a court of law. Custody procedures help to satisfy the two major requirements for evidence admissibility: relevance and authenticity. Sample custody is addressed in three parts: field sample collection, laboratory analysis, and final evidence files. Final evidence files, including all original laboratory reports, will be maintained by CRA under document control in a secure area in its Chicago, Illinois office.

A sample or evidence file is in a person's custody if:

- the item is in actual possession of a person; or
- the item is in the view of the person after being in actual possession of the person; or
- the item was in actual physical possession but is locked up to prevent tampering; or
- the item is in a designated and identified secure area.

5.1 FIELD CHAIN-OF-CUSTODY PROTOCOLS

Field logbooks will provide the means of recording the data collecting activities performed. As such, logbook entries will be described in as much detail as possible so that persons going to the Site could reconstruct a particular situation solely from the logbook entries.

Field logbooks will be bound field survey books or notebooks. Logbooks will be assigned to field personnel and will be stored at CRA's Chicago, Illinois office when not in use. Each logbook will be identified by the project-specific document number.

The title page of each logbook will contain the following:

- person to whom the logbook is assigned;
- logbook number;
- project name;
- project start date; and
- end date.

Entries into the logbook will contain a variety of information. At the beginning of each day's logbook entry, the date, start time, weather, names of all sampling team members present, and the signature of the person making the entry will be entered. The names of individuals visiting the Site or field sampling team and the purpose of their visit will also be recorded in the field logbook.

All field measurements obtained and samples collected will be recorded. All logbook entries will be made in ink, signed, and dated with no erasures. If an incorrect logbook entry is made, the incorrect information will be crossed out with a single strike mark, which is initialed and dated by the person making the erroneous entry. The correct information will be entered into the logbook adjacent to the original entry.

Whenever a sample is collected or a measurement is made, a detailed description of the location will be recorded in the logbook. Photographs taken at a location, if any, will also be noted in the logbook. All equipment used to obtain field measurements will be recorded in the field logbook. In addition, the calibration data for all field measurement equipment will be recorded in the field logbook or on field instrument calibration summary forms that will be maintained with the final evidence files.

Samples will be collected following the sampling procedures documented in the LTGMP Field Procedures. The equipment used to collect samples, time of sample collection, sample description, and volume and number of containers will be recorded in the field logbook.

Site-specific sample identification numbers will be assigned to each sample when it is collected. An example of the Site-specific sample numbering system is provided in the following:

GW-MMDDYY-XX-01

where:

GW	-	designates sample type (e.g., GW - groundwater)
MMDDYY	-	date of collection (month-day-year)
XX	-	sampler initials
01	-	sequential number starting with 01

Field blank and field duplicate samples will be submitted blindly to the laboratory using this numbering system. Trip blank samples and samples selected for MS/MSD or LCS/DUP analysis will not be submitted blindly to the laboratory.

The sample packaging and shipping procedures summarized below will ensure that the samples arrive at the laboratory with the chain-of-custody intact:

1) The field sampler is personally responsible for the care and custody of the samples until they are transferred to another person or the laboratory. As few people as possible will handle the samples.
2) All sample containers will be identified by using sample labels that include the date of collection and analyses to be performed.
3) Sample labels will be completed for each sample using waterproof ink unless prohibited by weather conditions. For example, a logbook entry would explain that a pencil was used to fill out the sample label because the ballpoint pen would not function in freezing weather. An example sample label is provided at the end of this section.
4) Samples will be accompanied by a properly completed chain-of-custody form (see Figure 5.1). The sample identification numbers will be listed on the chain-of-custody form. When transferring the possession of samples, the individuals relinquishing and receiving the samples will sign and record the date and time on the form. The chain-of-custody form documents sample custody transfers from the sampler to another person, to the laboratory, or to/from a secure storage area.
5) Samples will be properly packaged for shipment (see Table 4.1) and dispatched to SIMALABS for analysis with a separate signed chain-of-custody form enclosed in and secured to the inside top of each sample cooler. Shipping coolers will be secured with custody tape for shipment to the laboratory. The custody tape is then covered with clear plastic tape to prevent accidental damage to the custody tape. An example of CRA's custody tape is provided at the end of this section.
6) Whenever samples are collocated with a government agency, a separate chain-of-custody form will be prepared for those samples and marked to indicate with whom the samples are being collocated. The person relinquishing the samples to the agency should request the representative's signature

acknowledging sample receipt. If the representative is unavailable or refuses to sign, this is noted in the "Received By" space on the chain-of-custody form.

7) All sample shipments will be accompanied by the chain-of-custody form identifying its contents. The chain-of-custody form is a four part carbonless-copy form. The form is completed by the sampling team that, after signing and relinquishing custody to the shipper, retains the bottom (goldenrod) copy. The shipper, if different than the sampling team members, retains the pink copy after relinquishing custody to the laboratory. The yellow copy is retained by the laboratory and the fully executed white copy is returned as part of the data deliverables package.

8) If the samples are sent by common carrier, a bill of lading will be used and copies will be retained as permanent documentation. Commercial carriers are not required to sign the chain-of-custody form as long as the form is sealed inside the sample cooler and the custody tape remains intact.

9) Samples will usually be transported or shipped to the laboratory the same day the samples are collected in the field.

5.2 LABORATORY CHAIN-OF-CUSTODY PROCEDURES

Laboratory custody and document control procedures will be carried out as specified in the appropriate SOPs in Attachment A.

5.3 STORAGE OF SAMPLES

Following laboratory sample receipt and log-in, all samples will be stored in the appropriate locations. All samples will be stored within an access-controlled location and will be maintained properly preserved until completion of all analytical work or, as a minimum, for 30 days after receipt of the final report by CRA.

5.4 FINAL EVIDENCE FILES CUSTODY PROCEDURES

Evidentiary files for the entire project will be maintained by CRA's Field QA Officer and will consist of the following:

- project plan;
- project log books;
- field data records;
- sample identification documents;
- chain-of-custody records;
- correspondence;
- references and literature;
- laboratory data deliverables in hardcopy format;
- data validation reports;
- interim project/progress reports;
- QA reports;
- miscellaneous (photos, maps, drawings, etc.); and
- final report.

The evidentiary file materials will be the responsibility of the evidentiary file custodian with respect to file maintenance and document removal.

The laboratory will be responsible for maintaining analytical logbooks and data. Raw laboratory data files will be maintained by the laboratory for a period of five years, at which time CRA will advise the laboratory regarding the need for additional storage.

CONESTOGA-ROVERS & ASSOCIATES
JOB NAME: Four County Landfill LTGMP
JOB NO: 5369
PRESERVED? YES ☐ (Circle) NO ☐

HNO_3 HCl NaOH H_2SO_4 NaOH/ZnOAc

Other

MONTH/DAY/YEAR: EXAMPLE TIME: _____

SAMPLE ID: EXAMPLE

SAMPLER'S SIGNATURE: EXAMPLE

LAB SAMPLE ID: EXAMPLE

EXAMPLE SAMPLE LABEL

EXAMPLE CUSTODY SEAL

6.0 CALIBRATION PROCEDURES AND FREQUENCY

The procedures for maintaining the accuracy for all the instruments and measuring equipment that will be used for conducting field tests and laboratory analyses are described below. The instruments and equipment used for sample analysis and field measurements will be calibrated prior to each use or on a scheduled, periodic basis.

6.1 FIELD INSTRUMENTS/EQUIPMENT

Instruments and equipment used to gather, generate, or measure environmental data will be calibrated with sufficient frequency and in such a manner that accuracy and reproducibility of the data are consistent with the manufacturer's specification and the SOPs in Attachment A. Routine equipment used for field measurement may include a pH/temperature meter, turbidity meter, DO meter, ORP meter, and conductivity meter. The meters to be used are specified in the field SOPs or will be equipment with equivalent capability.

Equipment to be used during field sampling will be examined to verify that it is in operating condition. This includes checking the manufacturer's operating manual for each instrument to ensure that all maintenance requirements are being observed. Field notes from previous sampling trips will be reviewed to ensure that any prior equipment problems are not overlooked and all necessary repairs to equipment have been completed.

6.1.1 FIELD INSTRUMENT CALIBRATION

Field equipment will be calibrated, operated, and maintained in a manner consistent with the manufacturer's guidelines.

6.2 LABORATORY INSTRUMENTS

Calibration of laboratory equipment will be based on approved written procedures. The laboratory instruments to be used for analyzing samples collected during the LTGMP

are indentified in the SOPs in Attachment A. Records of calibration, repairs, or replacement will be filed and maintained by the designated laboratory personnel performing QA activities. These records will be filed at the location where the work is performed and will be subject to QA audit. The laboratories will maintain a properly trained repair staff with in-house spare parts for all instruments, or will maintain instrument service contracts.

The records of calibration will be kept as follows:

- Each instrument's calibration history will be maintained in logbooks kept with each instrument;
- Records for each instrument, which includes manufacturer, model numbers, date of last calibration and by whom calibrated (signature), due date of next calibration, and compensation or correction figures, are maintained by the laboratory QA Officer;
- A written stepwise calibration procedure will be available for each instrument; and
- Any instrument that is not calibrated within the manufacturer's original specification will display an appropriate warning tag or otherwise will be removed from service.

Specific calibration procedures are detailed in the appropriate SOPs presented in Attachment A.

7.0 ANALYTICAL PROCEDURES

The samples collected during the LTGMP will be analyzed for the parameters presented in Table 1.1 of this QAPP. These parameters consist of volatile organic compounds, semivolatile organic compounds, metals, and general water quality analytes. The samples will be analyzed for these parameters using gas chromatographic, gas chromatography/mass spectrometric, inductively coupled plasma spectroscopic, atomic absorption spectroscopic, infrared spectroscopic, titrametric, spectrophotometric, and gravimetric methods. The analytical methods are listed in Table 7.1. The laboratory's detailed procedures are presented in the SOPs included in Attachment A.

Field measurements of pH, conductivity, ORP, DO, and turbidity will be obtained using electrometric and turbidimetric methods. The analytical methods are listed in Table 7.1. The detailed procedure for each field measurement is presented in the SOPs in Attachment A.

8.0 INTERNAL QUALITY CONTROL AND FREQUENCY

This section presents the internal quality control checks that will be employed for field and laboratory measurements and the frequencies at which they will be performed.

8.1 FIELD QC

Quality control procedures for field measurements will be limited to checking the reproducibility of the measurement in the field by obtaining multiple readings and by calibrating the instruments (where appropriate).

Quality control of field sampling will involve collecting field duplicate, field blank, and trip blank samples in accordance with the applicable procedures and frequencies described in Section 3.0, and the level of QC effort indicated in Table 1.1.

8.2 LABORATORY QC

Specific procedures related to internal laboratory QC samples are detailed in the following subsections. The internal QC checks will be consistent with the requirements of the methods specified in Table 7.1. The evaluation criteria outlined in the SOPs presented in Attachment A will be used by laboratory personnel to assess the QC data.

8.2.1 INSTRUMENT CALIBRATION

The compliance requirements for satisfactory instrument calibration are established to ensure that the instrument is capable of producing acceptable quantitative data. The initial calibration demonstrates that the instrument is capable of acceptable performance prior to sample analysis. Continuing calibration checks document that the initial calibration is still valid, and that satisfactory maintenance and adjustment of the instrument is achieved on a day-to-day basis. The specific control criteria and corrective action requirements for initial and continuing calibrations will be as specified in the appropriate SOPs presented in Attachment A.

8.2.2 INSTRUMENT PERFORMANCE CHECKS

Performance checks ensure proper mass resolution, identification, and sensitivity of the gas chromatography/mass spectrometry (GC/MS) instruments. Prior to calibration, each instrument must be successfully "tuned" using the performance check standards specified in the methods. The acceptance criteria are detailed in the appropriate SOPs in Attachment A.

8.2.3 INTERNAL STANDARDS PERFORMANCE

Internal standards percent recovery and retention time evaluations ensure that GC/MS sensitivity and response is stable during every analysis. Acceptance criteria are specified in the appropriate SOPs presented in Attachment A.

8.2.4 SURROGATE COMPOUNDS

Surrogate compounds are used to monitor overall method performance for the organic analyses. Every blank, standard and sample (including MS/MSD samples) will be fortified with surrogate compounds prior to sample preparation. Surrogates will be spiked into samples as specified in the SOPs in Attachment A. Surrogate spike percent recoveries are required to be within the control limits specified in the method for samples not requiring dilutions. Dilution of samples to bring the detected analyte concentrations into the instrument's calibration range may dilute the surrogates below the quantitation range. Assessment of data quality in these cases will be based on the quality control data from the QC check, matrix spike, and matrix spike duplicate samples. The surrogate spike percent recovery acceptance criteria are specified in Table 8.1.

8.2.5 BLANK SAMPLES

Blank samples, including preparation or method blanks and instrument blanks, will be analyzed at the required frequencies specified in the SOPs. Preparation or method blank samples, consisting of an aliquot of analyte-free water, will be carried through the

entire analytical procedure to determine the existence and magnitude of contamination resulting from laboratory activities. Instrument blanks consist of analyte-free water or solvent used to determine whether or not the instrument is free of contaminants and ready to calibrate and analyze samples. The specific acceptance criteria and corrective action requirements are specified in the appropriate SOPs presented in Attachment A.

8.2.6 MS/MSD AND LCS/DUP SAMPLES

A MS/MSD sample set will be analyzed by the laboratories at a minimum frequency of 1 per 20 samples for organic, inorganic and general chemistry (where appropriate) parameters. Percent spike recoveries will be used to evaluate analytical accuracy relative to the sample matrices. The RPD of the MS/MSD data will be used to assess analytical precision relative to the sample matrices. The acceptance criteria are detailed in Tables 3.1 and 3.2

The MS data for metals analysis is used to provide information about the effect of each sample matrix on the sample preparation procedures and measurement methodology. The spike may be added before digestion (pre-digestion spike) or after completion of digestion procedures (post-digestion spike). The acceptance criteria for pre-digestion spikes are detailed in Tables 3.1 and 3.2.

A LCS/DUP sample set will be analyzed for those parameters not amenable to matrix spiking (e.g., TDS, alkalinity). LCSs consist of standard reference materials added to purified water and are analyzed to check the accuracy of the analytical methods independent of sample matrix interferences. Laboratory duplicate sample data will be used to assess the precision of the analytical methods.

8.2.7 INTERFERENCE CHECK SAMPLES

Interference check samples (ICS) are used to verify that proper inter-element correction factors have been established for analyses performed using inductively coupled plasma (ICP) spectroscopy methods. The ICP ICS is analyzed before and after each batch of samples. The acceptance criteria are detailed in the appropriate SOPs in Attachment A.

8.2.8 ICP SERIAL DILUTION SAMPLES

ICP serial dilution samples are analyzed to determine whether significant chemical or physical interferences exist due to the sample matrix. The acceptance criteria are detailed in the appropriate SOP in Attachment A.

9.0 DATA REDUCTION, VALIDATION, AND REPORTING

The laboratory will perform analytical data reduction, review, and reporting under the direction of the laboratory QA Officer who will be responsible for assessing data quality and advising of any data that were rated "preliminary" or "unacceptable" or other qualifications based on the established QC acceptance criteria. Data reduction, review, and reporting typically will be conducted as detailed in the following:

1) Raw data produced and checked by the responsible analyst are turned over for independent review by another analyst.
2) The area supervisor or his designee reviews the data for attainment of QC acceptance criteria established by this QAPP.
3) The area supervisor or his designee will decide whether any sample re-analysis is required.
4) Upon completion of all reviews and acceptance of the raw data by the supervisor, a report will be generated and sent to the laboratory Project Manager.
5) The laboratory Project Manager will complete a thorough inspection of all reports.
6) Upon acceptance of the preliminary reports by the laboratory Project Manager, final reports will be generated and signed by the laboratory Project Manager.
7) Routine audits of selected data packages are performed by the laboratory Quality Assurance Officer or his/her designee.

Laboratory data reduction will be performed using the equations in the appropriate SOPs provided in Attachment A. Field measurement data from direct-reading instruments will not require reduction.

Validation of the laboratory data will be performed by CRA's QA/QC Officer or his designee based on the relevant and applicable evaluation criteria outlined in "National Functional Guidelines for Organic Data Review", EPA-540/R-94/012, February 1994 and "National Functional Guidelines for Inorganic Data Review", EPA-540/R-94-013, February 1994. The assessment of laboratory data will include checks for adherence to the laboratory QA procedures and the accuracy and precision acceptance criteria presented in this QAPP, the presence of transcription errors, and anomalously high or

low parameter values. The results of the data validation procedure will be summarized in a memorandum and reported to CRA's Project Manager. The data validation memoranda will detail any violations of QC acceptance criteria and their effects upon the usability of the data.

Field data and sample collection activities that are presented in project reports will be appropriately identified and appended to the report. Where data have been reduced or summarized, the method of reduction will be documented in the report. In addition, field data will be audited for anomalously high or low values that may appear to be inconsistent with other Site data.

Data packages for the laboratory analyses will consist of the following deliverables:

- a case narrative that includes a summary of analytical methods used and a description of any unusual action or conditions;
- dates of sample receipt, extraction/digestion, and analysis;
- laboratory and field sample identification numbers;
- samples results in tabular format;
- method blank sample data summaries;
- surrogate compound recovery data and control limits;
- MS/MSD, LCS/DUP percent recovery, RPD data, and control limits;
- QC check sample data and control limits; and
- executed chain-of-custody forms.

The data packages will be stored with the evidentiary files as described in Section 5.4.

10.0 PERFORMANCE AND SYSTEM AUDITS

Performance and system audits of both field and laboratory activities will be conducted to verify that sampling and analysis are performed in accordance with the procedures established in this QAPP. The audits of field and laboratory activities include two separate, independent parts: internal and external audits.

10.1 FIELD PERFORMANCE AND SYSTEM AUDITS

10.1.1 INTERNAL FIELD AUDITS

10.1.1.1 INTERNAL FIELD AUDIT RESPONSIBILITIES

An internal audit of field activities (sampling and measurements) will be conducted by CRA's Field QA Officer or his designee.

10.1.1.2 INTERNAL FIELD AUDIT FREQUENCY

Field audits will verify that the procedures established by this QAPP and the LTGMP Field Procedures are being followed. These audits will be conducted at project start-up to identify deficiencies in the field sampling and documentation procedures. Any deficiencies identified will be documented and corrective actions will be taken to rectify the deficiencies. Follow-up audits will be performed as necessary to verify that deficiencies have been corrected, and that QA procedures are maintained throughout the project.

10.1.1.3 INTERNAL FIELD AUDIT PROCEDURES

Internal field audits will include examination of field sampling records, chain-of-custody documentation, field instrument operating records, and field instrument calibration records. In addition, sample collection, handling, and packaging procedures will be reviewed during field audits.

10.1.2 EXTERNAL FIELD AUDITS

10.1.2.1 EXTERNAL FIELD AUDIT RESPONSIBILITIES

External field audits may be conducted by IDEM.

10.1.2.2 EXTERNAL FIELD AUDIT FREQUENCY

External field audits may be conducted any time during the field operations. These audits may or may not be announced and are at the discretion of the IDEM.

10.1.2.3 OVERVIEW OF THE EXTERNAL FIELD AUDIT PROCESS

External field audits may be conducted according to the field activity information presented in the QAPP.

10.2 LABORATORY SYSTEMS AND PERFORMANCE AUDITS

10.2.1 INTERNAL LABORATORY AUDITS

10.2.1.1 INTERNAL LABORATORY AUDIT RESPONSIBILITIES

Internal laboratory audits will be conducted by the laboratory QA Officer.

10.2.1.2 INTERNAL LABORATORY AUDIT FREQUENCY

Internal system audits of the laboratory will be conducted on an annual basis and internal performance audits will be conducted on a quarterly basis.

10.2.1.3 INTERNAL LABORATORY AUDIT PROCEDURES

Systems audits will include examining laboratory documentation of sample receipt and log-in, sample storage, chain-of-custody procedures, sample preparation and analysis procedures, and instrument operating and QC records.

Performance audits will consist of the laboratory's QA Officer preparing and submitting blind QC samples to the laboratory for analysis. The laboratory's QA Officers will evaluate the analytical results of these blind performance samples to ensure the laboratory maintains acceptable QA performance.

10.2.2 EXTERNAL LABORATORY AUDITS

10.2.2.1 EXTERNAL LABORATORY AUDIT RESPONSIBILITIES

An external audit may be conducted by IDEM.

10.2.2.2 EXTERNAL LABORATORY AUDIT FREQUENCY

An external laboratory audit may be conducted at least once prior to the initiation of the sampling and analysis activities. These audits may or may not be announced and are at the discretion of the IDEM.

10.2.2.3 OVERVIEW OF THE EXTERNAL LABORATORY AUDIT PROCESS

External laboratory audits will include, but not be limited to, review of laboratory analytical procedures, laboratory on-site audits, and/or submitting performance evaluation samples to the laboratory for analysis.

11.0 PREVENTIVE MAINTENANCE

All analytical instruments to be used for this project will be serviced by the laboratory personnel at regularly scheduled intervals in accordance with the manufacturer's recommendations. Instruments may also be serviced at other times due to failure. Requisite servicing beyond the abilities of the laboratory personnel will be performed by the equipment manufacturer or its designated representative.

Daily checks of each instrument will be conducted by the analyst who has been assigned responsibility for that instrument. These checks will include changing GC inlet liners, tuning GC/MS instruments, checking operation of data systems, and checking for leaks. Manufacturer's recommended procedures will be followed in every case.

Table 11.1 presents routine preventive maintenance for laboratory and field instruments. Additional routine preventive maintenance information is contained in the SOPs in Attachment A.

12.0 SPECIFIC ROUTINE PROCEDURES USED TO ASSESS DATA PRECISION, ACCURACY AND COMPLETENESS

The following sections include the procedures and formulae utilized to assess the levels of precision, accuracy, and completeness achieved during the associated sample analyses.

12.1 ACCURACY ASSESSMENT

In order to ensure the accuracy of the analytical procedures, an environmental sample will be designated by the sampler, or a sample will be randomly selected by the laboratory, and spiked with a known amount of the analyte or analytes to be evaluated. In general, a sample spike will be included in and analyzed with every batch of 20 samples analyzed on each instrument. The analyte concentration in the spiked sample compared to the analyte concentration in the unspiked sample will be used to determine percent recovery. The percent recovery (%R) for a spiked sample is calculated according to the following formula:

$$\%R = \frac{\text{Amount in Spiked Sample} - \text{Amount in Sample}}{\text{Known Amount Added}} \times 100$$

Percent recovery control charts for each spiked analyte will be maintained on a matrix-specific basis.

12.2 PRECISION ASSESSMENT

MS/MSD samples are prepared by choosing a designated sample or a sample at random from each sample shipment received at the laboratory, dividing the sample into equal aliquots, and spiking each of the aliquots with a known amount of analyte. The duplicate spiked sample is then included in the analytical sample batch. The analysis of MS/MSD samples provides information regarding the precision of the preparation and analytical techniques. The RPD of the MS and MSD will be calculated and plotted on control charts. The RPD is calculated using the following formula:

$$RPD = \frac{|\text{Amount in Spike 1} - \text{Amount in Spike 2}|}{\frac{(\text{Amount in Spike 1} + \text{Amount in Spike 2})}{2}} \times 100$$

The RPDs for laboratory duplicates are determined similarly, but the samples are not spiked prior to analysis.

12.3 COMPLETENESS ASSESSMENT

Completeness is the number of valid sample results compared to the total number of sample results of a specific matrix analyzed using a specific method. Following completion of the analytical testing, the percent completeness will be calculated using the following equation:

$$\text{Completeness} = \frac{(\text{Number of Valid Measurements})}{(\text{Number of Measurements Planned})} \times 100$$

13.0 CORRECTIVE ACTION

Corrective action is the process of identifying, recommending, approving, and implementing measures to rectify unacceptable procedures or out-of-control QC performance that can affect data quality. Corrective action can occur during field activities, laboratory analyses, data validation, and data assessment. All corrective actions proposed and implemented will be documented.

13.1 FIELD CORRECTIVE ACTION

Corrective action in the field may be necessary when the sample network is changed (i.e., more/less samples, sampling locations other than those specified in the QAPP) and when sampling procedures and/or field analytical procedures require modification due to unexpected conditions. IDEM will be notified of any field changes. In general, the field sampling team may identify the need for corrective action. The field sampling team, in consultation with the Field QA Officer, will recommend a corrective action. The Field QA Officer will approve the corrective action, which will be implemented by the field team. It will be the responsibility of the Field QA Officer to ensure the corrective action has been implemented.

Corrective action resulting from internal field audits will be implemented immediately if data may be adversely affected due to the use of unapproved methods or improper use of approved methods. The Field QA Officer will identify deficiencies and recommend corrective action to CRA's Project Manager. Implementation of corrective actions will be performed by the Field QA Officer. Corrective action will be documented in quality assurance reports to management.

13.2 LABORATORY CORRECTIVE ACTION

Corrective action in the laboratory may occur prior to, during, or after the initial sample analyses. A number of conditions such as broken sample containers, multiple phases, low/high pH readings, or potentially high concentration samples may be identified during sample log-in or prior to analysis. Following consultation with analysts and area supervisors, it may be necessary for the laboratory QA Officer to approve the

implementation of corrective action. The submitted SOPs specify some conditions during or after analysis that may automatically trigger corrective action or optional procedures. These conditions may include dilution of samples, additional sample extract cleanup or automatic re-injection/re-analysis when certain QC criteria are not met. A corrective action SOP that details laboratory corrective action procedures is provided in Attachment A.

The analyst will identify the need for corrective action. The Operations Manager or area supervisors, in consultation with the laboratory staff, will approve the required corrective action to be implemented by the laboratory staff. The laboratory QA Officer will ensure implementation and documentation of the corrective action.

All laboratory corrective actions will be completed prior to release of the data from the laboratory. The corrective action will be documented in both the laboratory's corrective action report and the case narrative report sent with the laboratory report.

The need for corrective action may also be identified during systems or performance audits. In these cases, the need for corrective action will be identified by the auditor and the corrective action taken to resolve the problem will be documented by the laboratory QA Officer. The corrective action taken will depend upon the QA/QC criteria which was violated. All problems requiring corrective action and the corrective action taken will be reported to the laboratory Project Manager.

13.3 CORRECTIVE ACTION DURING DATA VALIDATION AND DATA ASSESSMENT

CRA's QA/QC Officer may identify the need for corrective action during either data validation or data assessment. The primary mechanism that will trigger corrective action will be the field and laboratory completeness determined for each LTGMP event. CRA's QA/QC Officer will be responsible for identifying and initiating corrective action if he determines that the quantity or quality of data obtained does not meet the objectives for an LTGMP event. The corrective action will be developed by CRA's field QA Officer if the problem that requires corrective action is related to the field sampling program. The corrective action will developed by the laboratory's QA Officer if the problem requiring corrective action is related to laboratory analysis.

Approval and implementation of the corrective action developed for data quantity problems that necessitate a resampling effort will be the responsibility of CRA's Project Manager. Approval and implementation of the corrective action developed for laboratory data quality problems will be the responsibility of SIMALABS' Project Manager. All corrective actions will be documented by CRA's QA/QC Officer.

The corrective actions that will be implemented are dependent upon the ability to mobilize the field team and whether the affected data is necessary to meet the required quality assurance objectives. It may be determined that recollecting the samples will not correct the problem (e.g., the problem is confirmed to be related to the sample matrix). In these cases samples will not be recollected and the data will be appropriately qualified. Additionally, alternate corrective actions may be required for specific situations if recollecting or reanalyzing samples does not correct the problem. Although alternate corrective actions cannot be predicted prior to the occurrence of a problem, they will be developed, approved, implemented, and documented as detailed above.

14.0 QUALITY ASSURANCE REPORTS TO MANAGEMENT

Management (including IDEM) will receive reports on the performance of the measurement system and data quality following the completion of each sampling event. These reports will be included in LTGMP Annual Reports submitted to IDEM.

Minimally, these reports will include:

- assessment of measurement data quality indicators (i.e., data accuracy, precision, and completeness);
- any changes in the QA/QC program;
- results of external system audits (if conducted by IDEM and the results provided to CRA); and
- QA problems, corrective actions taken, and resolutions.

CRA's QA/QC Officer will be responsible within the organizational structure for preparing these reports. CRA's Project Manager will be responsible for including these reports in LTGMP Annual Reports and distributing the Annual Reports. The final report for the project will also include a separate QA section which will summarize data quality information contained in the periodic QA/QC reports to management and detail an overall data assessment and validation in accordance with the data quality objectives outlined in this QAPP.

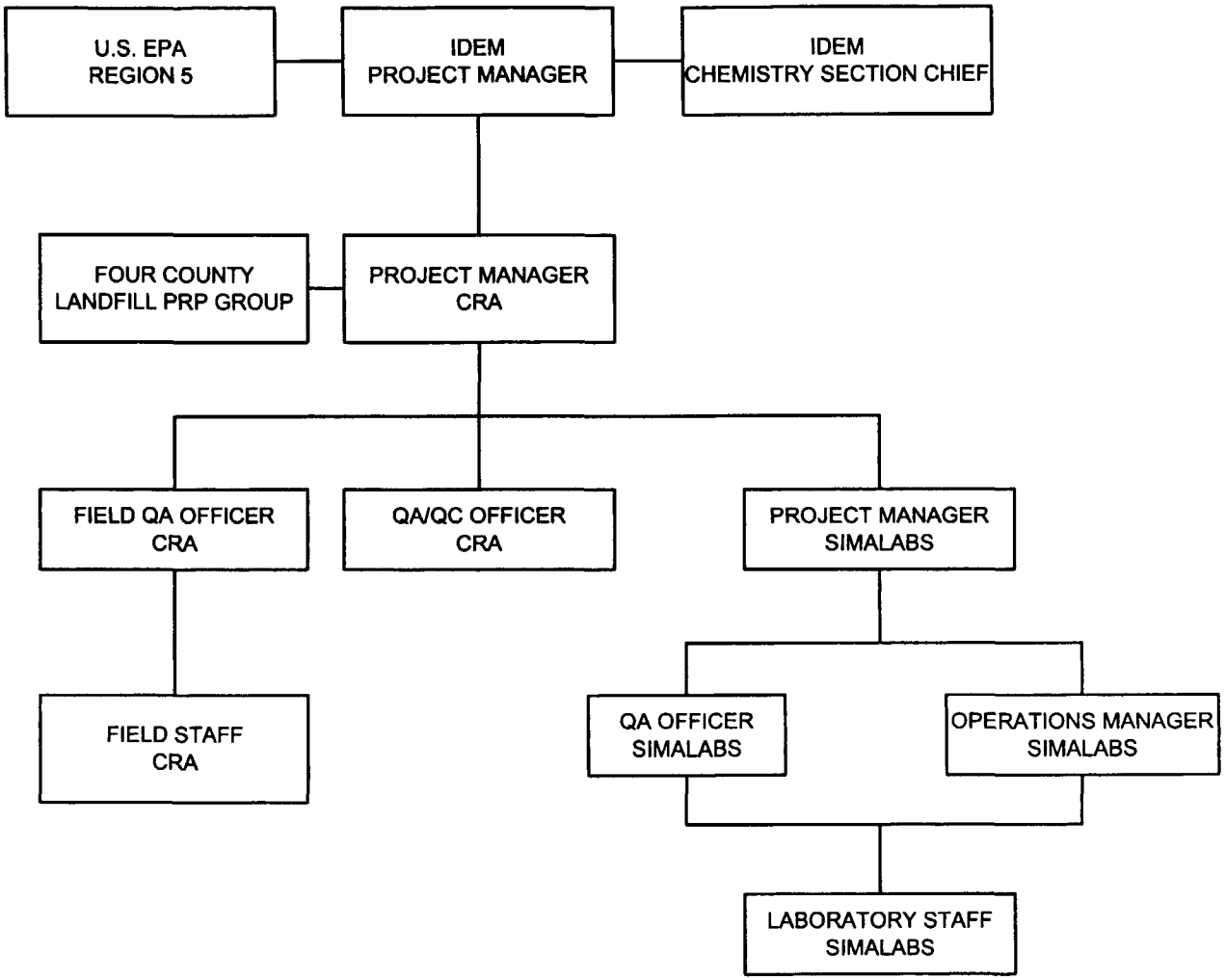

figure 2.1

PROJECT ORGANIZATION CHART
FOUR COUNTY LANDFILL SITE
Fulton County, Indiana

CRA

05369-76(024)GN-CO007 MAY 30/2000

CRA
CONESTOGA-ROVERS & ASSOCIATES
8615 West Bryn Mawr Avenue
Chicago, IL 60631 (773)380-9933

CHAIN OF CUSTODY RECORD

SHIPPED TO (Laboratory Name):

REFERENCE NUMBER:

PROJECT NAME:

SAMPLER'S SIGNATURE: _____ PRINTED NAME: _____

SEQ. No.	DATE	TIME	SAMPLE No.	SAMPLE MATRIX	No. OF CONTAINERS	PARAMETERS										REMARKS
			TOTAL NUMBER OF CONTAINERS													

SAMPLE

RELINQUISHED BY: ① _____	DATE: TIME:	RECEIVED BY: ② _____	DATE: TIME:
RELINQUISHED BY: ② _____	DATE: TIME:	RECEIVED BY: ③ _____	DATE: TIME:
RELINQUISHED BY: ③ _____	DATE: TIME:	RECEIVED BY: ④ _____	DATE: TIME:

METHOD OF SHIPMENT: AIR BILL No.

White -Fully Executed Copy
Yellow -Receiving Laboratory Copy
Pink -Shipper Copy
Goldenrod -Sampler Copy

SAMPLE TEAM: _____ _____

RECEIVED FOR LABORATORY BY: _____

DATE: _____ TIME: _____

figure 5.1

TYPICAL CHAIN-OF-CUSTODY RECORD
FOUR COUNTY LANDFILL SITE
Fullton County, Indiana

CRA

05369-76(024)GN-C0008 MAY 30/2000

TABLE 1.1

SUMMARY OF SAMPLING AND ANALYSIS PROGRAM
LONG-TERM GROUNDWATER MONITORING PLAN - INITIAL 5 YEARS
FOUR COUNTY LANDFILL SITE
FULTON COUNTY, INDIANA

Monitoring Locations[2]	*Monitoring Frequency*	*Laboratory Parameters*[3]	*Investigative Samples*	*QC Samples*[1] *Field Blank*	*Field Duplicate*	*MS/MSD*[4]	*Total Per Event*	*Number of Events*[5]
MW101, MW113, MW114	One Time Only (1st event)	Modified Table 2 Constituents[6]	3	1	1	1	6	1
All Monitoring Well Sets	Quarterly in Years 1 and 2 Semiannually in Years 3 through 5	TCL VOC	30	3	3	2	38	14
Perimeter and Upgradient Monitoring Well Sets	Annually in Years 1 through 5	TCL SVOC[7]	18	2	2	1	23	5
	Annually in Years 1 through 5	TAL Metals[7](Filtered/Unfiltered)[8]	18	2	2	1	23	5
	Annually in Years 1, 2, 3 & 5	Landfill Indicator Parameters[9]	18	2	2	1	23	4
Fate & Transport Well Set	Annually in Years 1, 2, 3 & 5	Fate & Transport Parameters[10]	15	2	2	1	20	4

[1] One trip blank sample will be shipped with each cooler containing multiple investigative groundwater samples submitted for VOC analysis.

[2] See Table 5.3 of the LTGMP report for the identity of monitoring wells in each set identified in this column.

[3] TCL VOC - Target Compound List Volatile Organic Compounds
TCL SVOC - Target Compound List Semivolatile Organic Compounds (excluding pesticides and polychlorinated biphenyls)
TAL - Target Analyte List

[4] Matrix spike/matrix spike duplicate (MS/MSD) samples will be collected at a frequency of one per group of twenty (20) or fewer investigative samples. MS/MSD samples for water matrices require triple the normal volume be collected for TCL VOCs and double the normal volume for extractable organics.

[5] Number of events for the first 5 years only.

[6] Selected constituents of Table 2, Section 16 of IAC 329-10-21 exluding dioxins/furans, pesticides/herbicides, and polychlorinated biphenyls.

[7] In the absence of any significant detections, these analytes may be dropped from regular monitoring events after the first 3 sampling events.

[8] Both filtered and unfiltered samples will be collected. Only the unfiltered samples will be analyzed. The filtered samples will be archived and analyzed as necessary based upon th results of the filtered samples.

[9] Landfill indicator parameters include chloride, sulfate, nitrate, total dissolved solids, total suspended solids, and carbonate and bicarbonate alkalinity.

[10] Fate and Transport parameters include nitrate, nitrite, manganese, chloride, sulfate, dissolved organic carbon, total organic carbon, bicarbonate alkalinity, carbonate alkalinity, total suspended solids, total dissolved solids, total sulfide, total iron, and dissolved methane, ethane, and ethene.

TABLE 3.1

LABORATORY PRECISION CONTROL LIMITS
LONG-TERM GROUNDWATER MONITORING PROGRAM
FOUR COUNTY LANDFILL SITE
FULTON COUNTY, INDIANA

	RPD Control Limits (%) [1]
Volatile Organic Compounds:	
1,1-Dichloroethene	14
Trichloroethene	14
Benzene	11
Toluene	13
Chlorobenzene	13
Semivolatile Organic Compounds:	
1,2,4-Trichlorobenzene	28
Acenaphthene	31
2,4-Dinitrotoluene	38
Pyrene	31
N-Nitroso-di-n-propylamine	38
1,4-Dichlorobenzene	28
Phenol	42
2-Chlorophenol	40
4-Chloro-3-methylphenol (p-Chloro-m-cresol)	42
4-Nitrophenol	50
Pentachlorophenol	50
Metals:	
Aluminum	20
Antimony	20
Arsenic	20
Barium	20
Beryllium	20
Cadmium	20
Calcium	20
Chromium	20
Cobalt	20
Copper	20
Iron	20
Lead	20
Magnesium	20
Manganese	20
Mercury	20
Nickel	20
Potassium	20
Selenium	20
Silver	20
Sodium	20

TABLE 3.1

LABORATORY PRECISION CONTROL LIMITS
LONG-TERM GROUNDWATER MONITORING PROGRAM
FOUR COUNTY LANDFILL SITE
FULTON COUNTY, INDIANA

	RPD Control Limits (%)
Metals:	
Thallium	20
Vanadium	20
Zinc	20
General Chemistry Parameters:	
Alkalinity - Carbonate	20
Alkalinity - Bicarbonate	20
Chloride	20
Iron	20
Nitrogen - Ammonia	20
Nitrogen - Nitrate	20
Nitrogen - Nitrite	20
Manganese	20
Sulfate	20
Sulfide	20
Total Organic Carbon	20
Dissolved Organic Carbon	20
Total Suspended Solids	20
Total Dissolved Solids	20
Dissolved Gases:	
Ethane	20
Ethene	20
Methane	20

[1] Values are the maximum RPD values allowed for MS/MSD sample analyses except alkalinity and TDS, for which duplicate analyses are performed. Laboratory control limits are updated on a periodic basis and the control limits in effect when the samples are analyzed will be used for validating the data.

TABLE 3.2

LABORATORY ACCURACY CONTROL LIMITS
LONG-TERM GROUNDWATER MONITORING PLAN
FOUR COUNTY LANDFILL SITE
FULTON COUNTY, INDIANA

	% Recovery Control Limits [1]
Volatile Organic Compounds:	
1,1-Dichloroethene	61-145
Trichloroethene	71-120
Benzene	76-127
Toluene	76-125
Chlorobenzene	75-130
Semivolatile Organic Compounds:	
1,2,4-Trichlorobenzene	39-98
Acenaphthene	46-118
2,4-Dinitrotoluene	24-96
Pyrene	26-127
N-Nitroso-di-n-Propylamine	41-116
1,4-Dichlorobenzene	36-97
Phenol	12-89
2-Chlorophenol	27-123
4-Chloro-3-methylphenol (p-Chloro-m-cresol)	23-97
4-Nitrophenol	10-80
Pentachlorophenol	9-103
Metals:	
Aluminum	80-120
Antimony	80-120
Arsenic	80-120
Barium	80-120
Beryllium	80-120
Cadmium	80-120
Calcium	80-120
Chromium	80-120
Cobalt	80-120
Copper	80-120
Iron	80-120
Lead	80-120
Magnesium	80-120
Manganese	80-120
Mercury	80-120
Nickel	80-120
Potassium	80-120
Selenium	80-120
Silver	80-120
Sodium	80-120
Thallium	80-120
Vanadium	80-120
Zinc	80-120

TABLE 3.2

LABORATORY ACCURACY CONTROL LIMITS
LONG-TERM GROUNDWATER MONITORING PLAN
FOUR COUNTY LANDFILL SITE
FULTON COUNTY, INDIANA

General Chemistry Parameters:	*% Recovery Control Limits* [1]
Alkalinity - Carbonate	80-120
Alkalinity - Bicarbonate	80-120
Chloride	80-120
Iron	80-120
Nitrogen - Ammonia	80-120
Nitrogen - Nitrate	80-120
Nitrogen - Nitrite	80-120
Manganese	80-120
Sulfate	80-120
Sulfide	60-130
Total Organic Carbon	80-120
Dissolved Organic Carbon	80-120
Total Suspended Solids	80-120
Total Dissolved Solids	80-120
Dissolved Gases:	
Ethane	80-120
Ethene	80-120
Methane	80-120

[1] Values are the range of percent recoveries allowed for MS/MSD sample analyses except for alkalinity and TDS, for which LCS analyses will be performed. Laboratory control limits are updated on a periodic basis and the control limits in effect when the samples are analyzed will be used for validating the data.

TABLE 3.3

TARGETED QUANTITATION LIMITS
LONG-TERM GROUNDWATER MONITORING PLAN
FOUR COUNTY LANDFILL SITE
FULTON COUNTY, INDIANA

Volatile Organic Compounds (µg/L)	*Targeted Quantitation Limits*[1]
Acetone	10
Benzene	1
Bromodichloromethane	1
Bromoform	1
Bromomethane	1
2-Butanone	10
Carbon tetrachloride	1
Carbon disulfide	1
Chlorobenzene	1
Chloroethane	1
Chloroform	1
Chloromethane	1
Dibromochloromethane	1
1,1-Dichloroethane	1
1,2-Dichloroethane	1
1,1-Dichloroethene	1
cis-1,2-Dichloroethene	1
trans-1,2-Dichloroethene	1
1,2-Dichloropropane	1
cis-1,3-Dichloropropene	1
trans-1,3-Dichloropropene	1
Ethylbenzene	1
2-Hexanone	10
Methylene chloride	1
4-Methyl-2-pentanone	10
Styrene	1
1,1,2,2-Tetrachloroethane	1
Tetrachloroethene	1
Toluene	1
1,1,1-Trichloroethane	1
1,1,2-Trichloroethane	1
Trichloroethene	1
Vinyl chloride	1
Total Xylenes	1

TABLE 3.3

TARGETED QUANTITATION LIMITS
LONG-TERM GROUNDWATER MONITORING PLAN
FOUR COUNTY LANDFILL SITE
FULTON COUNTY, INDIANA

Semivolatile Organic Compounds (µg/L)	*Targeted Quantitation Limits*
Phenol	10
bis-(2-Chloroethyl)ether	10
2-Chlorophenol	10
1,3-Dichlorobenzene	10
1,4-Dichlorobenzene	10
1,2-Dichlorobenzene	10
2-Methylphenol	10
2,2'-oxybis(1-Chloropropane)	10
4-Methylphenol	10
N-Nitroso-di-n-propylamine	10
Hexachloroethane	10
Nitrobenzene	10
Isophorone	10
2-Nitrophenol	10
2,4-Dimethylphenol	10
bis(2-Chloroethoxy)methane	10
2,4-Dichlorophenol	10
1,2,4-Trichlorobenzene	10
Naphthalene	10
4-Chloroaniline	10
Hexachlorobutadiene	10
4-Chloro-3-methylphenol	20
2-Methylnaphthalene	10
Hexachlorocyclopentadiene	10
2,4,6-Trichlorophenol	10
2,4,5-Trichlorophenol	10
2-Chloronaphthalene	10
2-Nitroaniline	10
Dimethylphthalate	10
Acenaphthylene	10
2,6-Dinitrotoluene	10
3-Nitroaniline	10
Acenaphthene	10
2.4-Dinitrophenol	50
4-Nitrophenol	10

TABLE 3.3

TARGETED QUANTITATION LIMITS
LONG-TERM GROUNDWATER MONITORING PLAN
FOUR COUNTY LANDFILL SITE
FULTON COUNTY, INDIANA

Semivolatile Organic Compounds (µg/L)	*Targeted Quantitation Limits*
Dibenzofuran	10
2,4-Dinitrotoluene	10
Diethylphthalate	10
4-Chlorophenyl-phenyl ether	10
Fluorene	10
4-Nitroaniline	10
4,6-Dinitro-2-methylphenol	10
N-Nitroso-diphenylamine	10
4-Bromophenyl-phenylether	10
Hexachlorobenzene	10
Pentachlorophenol	50
Phenanthrene	10
Anthracene	10
Carbazole	10
Di-n-butylphthalate	10
Fluoranthene	10
Pyrene	10
Butylbenzylphthalate	10
3,3'-Dichlorobenzidine	10
Benzo(a)anthracene	10
Chyrsene	10
bis(2-Ethylhexyl)phthalate	10
Di-n-octylphthalate	10
Benzo(b)fluroanthene	10
Benzo(k)fluroanthene	10
Benzo(a)pyrene	10
Indeno(1,2,3-cd)pyrene	10
Dibenzo(a,h)anthracene	10
Benzo(g,h,i)perylene	10

TABLE 3.3

TARGETED QUANTITATION LIMITS
LONG-TERM GROUNDWATER MONITORING PLAN
FOUR COUNTY LANDFILL SITE
FULTON COUNTY, INDIANA

TAL Metals (mg/L)	*Targeted Quantitation Limits*
Aluminum	0.2
Antimony	0.3
Arsenic	0.01
Barium	0.01
Beryllium	0.005
Cadmium	0.01
Calcium	1
Chromium	0.02
Cobalt	0.05
Copper	0.02
Iron	0.05
Lead	0.005
Magnesium	0.2
Manganese	0.01
Mercury	0.0002
Nickel	0.04
Potassium	2
Selenium	0.005
Silver	0.01
Sodium	2
Thallium	0.005
Vanadium	0.05
Zinc	0.05
General Chemistry Parameters (mg/L)	
Alkalinity - Carbonate	10
Alkalinity - Bicarbonate	10
Chloride	1
Iron	0.05
Nitrogen - Ammonia	0.1
Nitrogen - Nitrate	0.1
Nitrogen - Nitrite	0.1
Manganese	0.01
Sulfate	10
Sulfide	1
Total Organic Carbon	1
Dissolved Organic Carbon	1.0
Total Suspended Solids	5.0
Total Dissolved Solids	10

TABLE 3.3

TARGETED QUANTITATION LIMITS
LONG-TERM GROUNDWATER MONITORING PLAN
FOUR COUNTY LANDFILL SITE
FULTON COUNTY, INDIANA

Dissolved Gases (µg/mL)	*Targeted Quantitation Limits*
Methane	0.0005
Ethane	0.0005
Ethene	0.0005

[1] Targeted quantitations limits are presented for guidance only and may not be achievable for all samples.

TABLE 4.1

CONTAINER, PRESERVATION, SHIPPING AND PACKAGING REQUIREMENTS
LONG-TERM GROUNDWATER MONTORING PROGRAM
FOUR COUNTY LANDFILL SITE
FULTON COUNTY, OHIO

Matrix	*Parameter*[1]	*Containers*[2]	*Preservatives*[3]	*Maximum Holding Time From Sample Collection*[4]	*Volume of Sample*	*Shipping*	*Packaging*
Groundwater	VOCs	Three 40-mL glass septum vials	HCl of pH<2 iced	14 days for analysis	Fill completely	Overnight Courier	Bubble Wrap
	SVOCs, Pesticides	One 2-liter glass bottles (each)	iced	7 days for extraction, 40 days for analysis	Fill to neck of bottle	Overnight Courier	Bubble Wrap
	Metals (total and dissolved)[5]	One 1-L polyethylene bottle	HNO_3 to pH<2 iced	6 months for analysis (28 days for mercury)	Fill to neck of bottle	Overnight Courier	Bubble Wrap
	Methane, Ethane, Ethene	Four 40-ml glass septum vials	iced	14 days for analysis	Fill completely	Overnight Courier	Bubble Wrap
	Alkalinity, Chloride, TDS Nitrate, Nitrite, Sulfate	Two 1-L polyethylene bottles	iced	14 days for Alkalinity; 7 days for TDS 28 days for Sulfate, Chloride 48 hours for Nitrate, Nitrite	Fill to neck of bottle	Overnight Courier	Bubble Wrap
	Ammonia, TOC, DOC	One 1-L polyethylene bottle	H_2SO_4 to pH<2 iced	28 days for analysis	Fill to neck of bottle	Overnight Courier	Bubble Wrap
	Sulfide	One 500-mL polyethylene bottle	NaOH, ZnOAc to pH>9, iced	7 days for analysis	Fill to neck of bottle	Overnight Courier	Bubble Wrap

[1] VOCs - Volatile Organic Compounds
SVOCs - Semivolatile Organic Compounds
TDS - Total Dissolved Solids
DOC - Dissolved Organic Carbon (field filtered)
TOC - Total Organic Carbon

[2] To the extent possible, parameters will be combined into as few sample containers as possible with respect to sample preservation requirements.

[3] Samples requiring refrigeration will be shipped with bagged, cubed ice and will be stored by the laboratory at 4°C ± 2°C following sample receipt and log-in.

[4] Sample holding time will be calculated from the time of sample collection to sample analysis.

[5] Samples for dissolved metals will be field-filtered using a 0.45 μm filter membrane prior to preservation and analysis.

TABLE 7.1

SUMMARY OF ANALYTICAL METHODS
LONG-TERM GROUNDWATER MONITORING PROGRAM
FOUR COUNTY LANDFILL SITE
FULTON COUNTY, INDIANA

Parameter[1]	*Preparation Method Reference*[2]	*Analysis Method Reference*[2]
TCL VOCs	SW-846 5030B	SW-846 8260B
TCL SVOCs	SW-846 3510C	SW-846 8270C
Aluminum	SW-846 3005A	SW-846 6010B
Antimony	SW-846 3005A/3020A	SW-846 7041
Arsenic	SW-846 3005A/3020A	SW-846 7060A
Barium	SW-846 3005A	SW-846 6010B
Beryllium	SW-846 3005A	SW-846 6010B
Cadmium	SW-846 3005A	SW-846 6010B
Calcium	SW-846 3005A	SW-846 6010B
Chromium	SW-846 3005A	SW-846 6010B
Cobalt	SW-846 3005A	SW-846 6010B
Copper	SW-846 3005A	SW-846 6010B
Iron	SW-846 3005A	SW-846 6010B
Lead	SW-846 3005A/3020A	SW-846 7421
Magnesium	SW-846 3005A	SW-846 6010B
Manganese	SW-846 3005A	SW-846 6010B
Mercury	SW-846 7470A	SW-846 7470A
Nickel	SW-846 3005A	SW-846 6010B
Potassium	SW-846 3005A	SW-846 6010B
Selenium	SW-846 3005A/3020A	SW-846 7740
Silver	SW-846 3005A	SW-846 6010B
Sodium	SW-846 3005A	SW-846 6010B
Thallium	SW-846 3005A/3020A	SW-846 7841
Vanadium	SW-846 3005A	SW-846 6010B
Zinc	SW-846 3005A	SW-846 6010B
Alkalinity (Carbonate, Bicarbonate)	EPA 310.1	EPA 310.1
Chloride	EPA 325.3	EPA 325.3
Nitrogen-Ammonia	EPA 350.3	EPA 350.3
Nitrogen-Nitrate	EPA 353.3	EPA 353.3
Nitrogen-Nitrite	EPA 353.3	EPA 353.3

TABLE 7.1

SUMMARY OF ANALYTICAL METHODS
LONG-TERM GROUNDWATER MONITORING PROGRAM
FOUR COUNTY LANDFILL SITE
FULTON COUNTY, INDIANA

Parameter[1]	*Preparation Method Reference*[2]	*Analysis Method Reference*[2]
Sulfate	EPA 375.4	EPA 375.4
Sulfide	SW-846 9030B	SW-846 9030B
Total Organic Carbon	SW-846 9060	SW-846 9060
Dissolved Organic Carbon	SW-846 9060	SW-846 9060
Total Suspended Solids	EPA 160.2	EPA 160.2
Total Dissolved Solids	EPA 160.1	EPA 160.1
Dissolved Gases[3]	SW-846 3810	SW-846 3810
Field pH/Temperature	NA	EPA 150.1
Field Conductivity	NA	EPA 120.1
Field Dissolved Oxygen	NA	EPA 360.1
Field Turbidity	NA	EPA 180.1
Field Oxidation-Reduction Potential	NA	SM 2580B

[1] TCL VOCs - Target Compound List Volatile Organic Compounds
SVOCs - Semivolatile Organic Compounds

[2] SW-846 - "Test Methods for Evaluating Solid Wastes, Physical/Chemical Methods", EPA SW-846, 3rd Edition with promulgated updates, November 1986.
EPA - "Methods for Chemical Analysis of Water and Wastes", EPA-600/4-79-020, March 1983.
SM - "Standard Methods for the Examination of Water and Wastewater", APHA, 19 Edition, 1995.
Dissolved metals will be prepared using SW-846 method 3005A prior to graphite furnace atomic absorption spectroscopy analysis.

[3] Dissolved gases include ethane, ethene, and methane.

TABLE 8.1

SURROGATE COMPOUNDS PERCENT RECOVERY CONTROL LIMITS
LONG-TERM GROUNDWATER MONITORING PROGRAM
FOUR COUNTY LANDFILL SITE
FULTON COUNTY, INDIANA

Analysis	*Matrix*	*Surrogate Compound*	*% Recovery Control Limits* [1]
Volatile Organic Compounds	Water	4-Bromofluorobenzene	86-115
		1,2-Dichloroethane-d_4	80-120
		Toluene-d_8	88-110
		Dibromofluoromethane	86-118
Semivolatile Organic Compounds	Water	Nitrobenzene-d_5	35-114
		2-Fluorobiphenyl	43-116
		Terphenyl-d_{14}	33-141
		Phenol-d_5	10-110
		2-Fluorophenol	21-100
		2,4,6-Tribromophenol	10-123
		2-Chlorophenol-d_4	20-120
		1,2-Dichlorobenzene-d_4	20-120

[1] Laboratory control limits are updated on a periodic basis and the control limits in effect when the samples are analyzed will be used for data validation purposes.

TABLE 11.1

ROUTINE PREVENTIVE MAINTENANCE PROCEDURES AND SCHEDULES LONG-TERM GROUNDWATER MONITORING PROGRAM FOUR COUNTY LANDFILL SITE FULTON COUNY, INDIANA

Instrument	*Maintenance Procedures/Schedule*	*Spare Parts in Stock*
Gas Chromatograph/Mass Spectrometer (GC/MS)	1. Replace pump oil as needed. 2. Change septa weekly or as often as needed. 3. Change gas line dryers as needed. 4. Replace electron multiplier as often as needed. 5. Replace gas jet splitter as needed. 6. Replace GC injector glass liner weekly or as often as needed. 7. Replace GC column as needed. 8. Check to ensure that gas supply is sufficient for the day's activity, and the delivery pressures are set as described in the SOP. 9. Check to ensure the pressure on the primary regulator never runs below 100 psi.	1. Syringes 2. Septa 3. Various electronic components 4. Glass jet splitter 5. GC column 6. Glass liners
Gas Chromatograph	1. Change septa weekly or as often as needed. 2. Change gas line dryers as needed. 3. Replace GC injector glass liner weekly or as often as needed. 4. Replace GC column as needed. 5. Clean/replace GC detector as needed. 6. Check to ensure that gas supply is sufficient for the day's activity, and the delivery pressures are set as described in the SOP. 7. Check to ensure the pressure on the primary regulator never run below 100 psi.	1. Syringes 2. Septa 3. Detectors 4. Glass liners 5. GC column

TABLE 11.1

ROUTINE PREVENTIVE MAINTENANCE PROCEDURES AND SCHEDULES LONG-TERM GROUNDWATER MONITORING PROGRAM FOUR COUNTY LANDFILL SITE FULTON COUNY, INDIANA

Instrument	*Maintenance Procedures/Schedule*	*Spare Parts in Stock*
Purge and Trap Sample Concentrator	1. Replace trap as needed. 2. Decontaminate the system after running high concentration samples or as required by blank analysis. 3. Leak check system daily and as often as needed 4. Check to ensure the gas supply is sufficient for the day's activity, and the delivery pressures are set as described in the SOP. 5. Check to ensure the pressure on the primary regulator never run below 100 psi.	1. Spare traps 2. Spare sparger 3. Various electronic components/ circuits 4. Plumbing supplies - tubing, fittings
Mercury Analyzer	1. Clean tubing and quartz cell weekly or as often as needed. 2. Clean aspirator as necessary. 3. Check to ensure the gas supply is sufficient pressures are set as described in the SOP.	1. Quartz cells 2. Aspirator
Inductively Coupled Plasma Spectrometer (ICP)	1. Clean torch assembly and mixing chamber when discolored or after eight hours of running high dissolved solid samples. 2. Clean nebulizer as needed. 3. Check to ensure the gas supply is sufficient for the day's activity pressures are set as described in the SOP.	1. Spare torch mixing chambers 2. Spare nebulizer

TABLE 11.1

ROUTINE PREVENTIVE MAINTENANCE PROCEDURES AND SCHEDULES LONG-TERM GROUNDWATER MONITORING PROGRAM FOUR COUNTY LANDFILL SITE FULTON COUNY, INDIANA

Instrument	*Maintenance Procedures/Schedule*	*Spare Parts in Stock*
Spectrophotometer/ Autoanalyzer	1. Clean cuvettes and tubing after each use or as often as needed. 2. Inspect and clean peristaltic pump and necessary. 3. Check lamp daily and clean as necessary	1. Cuvettes 2. Pump tubing 3. Spare lamps
Specific Ion Meter	1. Check meter function daily using shorting cables. 2. Check electrolyte levels in reference and analytical probes prior to use. 3. Clean probes after each use.	1. Standard solutions 2. Electrolyte filling solution 3. Spare electrodes
Flow-through Conductivity, pH, Temperature, Redox Meter	1. Check battery prior to use and replace as necessary. 2. Rinse flow-through between samples and clean probes with detergent and rinse thoroughly with deionized water .	1. Standard solutions 2. Spare electrodes 3. Spare batteries
Dissolved Oxygen Meter	1. Check battery and replace if needed. 2. Check membrane and filling solution prior to each use. 3. Rreplace membrane if torn or wrinkled 4. Polish gold electode if it becomes tarnished.	1. Standard solutions 2. Spare membranes 3. Spare batteries

TABLE 11.1

ROUTINE PREVENTIVE MAINTENANCE
PROCEDURES AND SCHEDULES
LONG-TERM GROUNDWATER MONITORING PROGRAM
FOUR COUNTY LANDFILL SITE
FULTON COUNY, INDIANA

Instrument	*Maintenance Procedures/Schedule*	*Spare Parts in Stock*
Electric Water Level Meter	1. Check battery and replace if needed. 2. Check connection between probe and tape periodically. Repair with electrical tape if required. 3. After use, wash the probe and reel in soap and rinse thoroughly with distilled water.	1. Probes, tapes, cable reels, batteries
Turbidity Meter	1. Replace turbidity standards after nine months of use. Store between 10° and 40°C. 2. Do not open the standards in a dusty environment. Do not put unused standard or possible contaminant into opened standard bottle. 3. After each use, rinse turbidity tubes with detergent and distilled water. Replace tubes as required. 4. Replace Nickel-Cadmium batteries as required. Charge batteries after every use.	1. Cuvettes, batteries

ATTACHMENT A

FIELD AND LABORATORY STANDARD OPERATING PROCEDURES

Title	*SOP Number*
Field pH/Temperature	PHT-5369
Field Conductivity	SC-5369
Field Turbidity	NTU-5369
Field DO	DO-5369
Field Redox	ORP-5369
Sample Management	SOP-ADM-SAMPLE-1
Data Reduction and Validation	SOP-ADM-DATARED-1
Corrective Action	SOP-ADM-CORACT-1
VOC Analysis	SOP-ORG-8260B25mlW
SVOC Extraction	SOP-ORG-3510-1
SVOC Analysis	SOP-ORG-8270C-1
Metals Digestion for ICP	SOP-MET-3005-1
Metals Digestion for GFAA	SOP-MET-3020-1
Metals Analysis by ICP	SOP-MET-6010A-1
Mercury Preparation and Analysis	SOP-MET-7470-1
Lead Analysis	SOP-MET-7421-1
Antimony Analysis	SOP-MET-7041-1
Arsenic Analysis	SOP-MET-7060-1
Thallium Analysis	SOP-MET-7841-1
Selenium Analysis	SOP-MET-7740-1
Ammonia Analysis	SOP-WET-3502-1
Sulfate Analysis	SOP-WET-3754-1
Chloride Analysis	SOP-WET-3253-1
TDS Analysis	SOP-WET-1601-1
TSS Analysis	SOP-WET-1602-1
Sulfide Analysis	SOP-WET-9030
Nitrate, Nitrite Analysis	SOP-WET-353.3
TOC Analysis	SOP-ORG-9060-1
Alkalinity Analysis	SOP-WET-310.1
Dissolved Gases	SOP-58

pH/TEMPERATURE

Scope and Application: This method is applicable to surface water, wastewater and groundwater.

Method: Potentiometric

Reference: "Methods for Chemical Analysis of Water and Wastes:", EPA-600/4-79-020, revised March 1983, Method 150.1

Sensitivity: 0.01 pH unit; 0.1 °C

Optimum Range: pH 1.00 to 12.00; temperature -5 to 50 °C

Sample Handling: Determined on site

Reagents and Apparatus:

1. Temperature compensated pH meter, YSI Model 3560 Water Quality Monitoring System;
2. Combination pH electrode YSI Model 3530;
3. Thermilinear thermister YSI Model 3510 temperature probe;
4. pH buffer solutions, pH 4.00, 7.00, and 10.00 (certified buffer solutions);
5. Distilled or deionized water in wash bottle.

Calibration:

1. Switch On/Off key to On. Before connecting the pH electrode, zero the electronics with the shorting cap attached to the meter. Turn on the meter and set the pH function switch to pH. Connect the shorting cap to the pH input jack and set the manual temperature compensation knob to 25°C. Adjust the CAL control to indicate 7.00 ±0.01 on the pH-mV display. Disconnect the shorting cap from the pH input and connect it to the mV input jack. The monitor is now zeroed.
2. Test the 3530 pH electrode for noise and offset as follows: Rinse the 3530 and the YSI 3510 Temperature Probe with pH 7.00 buffer to remove any contaminants. Connect the 3530 to the pH input jack and the 3510 to the TEMP input jack. Pour pH 7.00 buffer into a 50 mL sample cup then immerse both of the sensors into the buffer at 25.0 ±0.1°C (use the °C display to confirm the temperature). Allow the sensors to equilibrate. A display value other than 7.00 shows electrode background noise and offset. The 3530 background noise and offset at pH 7.00 should not exceed ±0.2 pH units at 25°C. Replace pH probe if background noise exceeds this tolerance.

analysis. If the results are still outside of the control limits, check calibration and recalibrate if necessary (see item 2, below). If drift is suspected to be the cause of the problem, clean the electrode and recalibrate. If drift is still apparent, replace electrode.

2. Calibration check results must be ±0.10 pH unit of the true value. If the result is outside of ±0.10 pH unit, rinse electrodes and check solution again. If still outside the control limit, recalibrate the meter and reanalyze all samples analyzed since the last in-control calibration.

3. All glassware is to be soap and water washed, tap water rinsed and distilled or deionized water rinsed prior to analyses.

Interferences:

Interferences in pH measurements occur with presence of weak organic and inorganic salts and oil and grease. If oil and grease are visible, note in logbook. Clean electrode with soap and water, followed by 10% HCl and deionized water rinse. Recalibrate meter before analysis of next sample.

CONDUCTIVITY

Scope and Application: This method is applicable to surface water, wastewater and groundwater.

Method: Specific Conductance

Reference: "Methods for Chemical Analysis of Water and Wastes" EPA-600/4-79-020, revised March 1983, Method 120.1

Sensitivity: 0.1 mmhos/cm

Optimum Range: 0 - 100.0 mmhos/cm

Sample Handling; Determine on site

Reagents and Apparatus:

1. Conductivity meter - YSI Model 3560 Water Quality Monitoring System;
2. Conductivity Cell - YSI Model 3520 Flow-Through Conductivity Cell (K=5/cm);
3. Thermilinear Thermister - YSI Model 3510 Temperature Probe;
4. Deionized water;
5. Conductivity standard, 1.0mmho/cm @25°C - YSI Model 3167.

Notes:

The conductivity meter is factory calibrated. The calibration is checked using a solution of known conductance.

Calibration Check

Connect the 3520 cell and a 3510 Temperature Probe to the 3500, and remove them from the sample chamber. Set the conductivity function switch to 2 ATC. Rinse the inside and outside of the cell and the probe with about 1/3 the content of the 3167 bottle. Place both of the sensors into the remainder of the solution in the bottle and allow them to come to temperature equilibrium. Make sure that the 3250 body is immersed so that the liquid level is half way up the knurled portion of the cell. Read the displayed value and determine if the cell/instrument is within specified accuracy. The displayed value is corrected to 25°C automatically and should be 1.000 ±070 mmho/cm. If the value is not within specification replace 3250 cell.

Procedure:

1. Check calibration of meter.

2. Set up meter as outlined in the operating manual.

TURBIDITY

Scope and Application: This method is applicable to surface water, wastewater and groundwater.

Method: Nephalometric

Reference: "Methods for Chemical Analysis of Water and Wastes:", EPA-600/4-79-020, revised March 1983, Method 180.1

Sensitivity: 0.01 Nephalometric Turbidity Unit (NTU)

Optimum Range: 0 - 20; 0 - 200 NTU

Sample Handling: Determined on site

Reagents and Apparatus:

1. Direct reading turbidity meter, HF Scientific Model DRT-15C;
2. Cuvettes with screw tops;
3. Battery charger;
4. 0.02 NTU (nominal) reference standard;
5. Distilled or deionized water in wash bottle.

Calibration Check and Operation

The turbidimeter has been calibrated by the manufacturer and electronic calibration using freshly prepared formazin standards should only be performed if the electronic printed circuit board, the photodetectors or the light source has been replaced. The calibration procedure is presented in pages 5 and 6 of the operating manual (attached).

The procedures for calibration checks and the operation of the meter follows:

1. For accurate measurements in the low range rotate the cuvettes in the well to obtain the minimum reading. Mark the cuvette with one of the adhesive dots provided with the instrument so that orientation of the cuvette will be identical each time it is placed in the instrument.

2. To operate the turbidimeter, switch to the "20" range and place the Reference Standard (0.02 NTU) in the optical well.

DISSOLVED OXYGEN

Scope and Application: This method is applicable to surface water, wastewater and groundwater.

Method: Potentiometric

Reference: "Methods for Chemical Analysis of Water and Wastes:", EPA-600/4-79-020, revised March 1983, Method 360.1

Sensitivity: 0.1 mg/L as O_2

Optimum Range: 0.1 mg/L to 20 mg/L O_2

Sample Handling: Determined on site

Reagents and Apparatus:

1. Temperature compensated dissolved oxygen (DO) meter, Corning Check Mate System;
2. Zero oxygen standard;
3. DO sensor filling solution;
4. DO membrane replacement kit;
5. Distilled or deionized water in wash bottle.

Setting Up DO Sensor:

The sensor is shipped dry and must be filled before use.

1. Unscrew the membrane cap from sensor and fill using DO electrolyte.
2. Tap membrane cap gently to remove air bubbles. Gently screw cap onto probe body allowing surplus electrolyte to run out. (Caution: Do not overtighten)
3. Fit sensor to meter module.
4. Allow 30 minutes for polarization of electrode.

analysis. If the results are still outside of the control limits, check calibration and recalibrate if necessary (see item 2, below). If unable to recalibrate, replace sensor membrane.

2. Calibration check results must be within 10% of the true value. If the result is outside of 10%, rinse electrodes and check solution again. If still outside the control limit, recalibrate the meter and reanalyze all samples analyzed since the last in control calibration.

3. All glassware is to be soap and water washed, tap rinsed and distilled or deionized water rinsed prior to analyses unless pre-cleaned sample jars are used.

Interferences:

Interferences in DO measurements generally occur due to membrane coating. Clean probe as specified in the sensor manual.

The presence of other gases such as chlorine, nitrous and nitric oxide, hydrogen sulfide and sulfur dioxide interfere with DO measurements. The sulfur based compounds will tarnish the electrodes resulting in sluggish or erratic measurements. Polishing the electrodes as specified in the operating manual will restore the performance of the meter. Recalibrate meter before analysis of next sample.

OXIDATION-REDUCTION POTENTIAL (ORP)

Scope and Application: This method is applicable to surface water, wastewater and groundwater.

Method: Potentiometric

Reference: "Standard Methods for the Examination of Water and Wastewater", APHA, 18th edition, 1992, Method 2580B.

Sensitivity: 1 mV

Optimum Range: -1,500 to 1,500 mV

Sample Handling: Determined on site

Reagents and Apparatus:

1. ORP meter, YSI Model 3560 Water Quality Monitor;
2. ORP electrode assembly, YSI Model 3540;
3. Thermilinear thermistor temperature probe, YSI Model 3510;
4. ZoBell Solution, YSI Model 3682;
5. Distilled or deionized water in wash bottle.

Calibration:

1. Turn on the YSI 3500 Water Quality Monitor and set the pH function switch to mV.
2. Connect the shorting cap attached to the 3500 to the mV input jack. The display should read 000 ±2 mV. This indicates that the 3500 electronics are zeroed.
3. Detach the shorting cap and connect the 3540 to the mV input jack. If a pH electrode is not attached to the pH input jack, connect the shorting cap to it.
4. Attach the 3510 to the TEMP input jack.
5. Rinse the 3540 and 3510 with distilled or deionized water, followed by a rinse with a small amount of reconstituted YSI 3682 ZoBell Solution.

2. Calibration check results must be 231±10 mV. If the result is outside of this range, rinse electrodes and check solution again. If still outside the this range, recalibrate the meter and reanalyze all samples analyzed since the last in-control calibration.

Interferences:

Interferences in ORP measurements occur when the platinum electrode surface becomes coated. Clean the ORP electrode as follows:

1. Soft coatings should be removed by use of a wash bottle of water or by gently wiping with a soft cloth. Remove the bulb guard if necessary. Be careful not to scratch the platinum.

2. Hard coatings or organic chemicals should be removed by an appropriate chemical solvent, by gently scrubbing with a very fine cleansing powder such as "Softscrub", or by gently polishing with 600 grade wet silicon carbide paper. Wet a piece of the paper with water and gently polish the electrode with a circular twisting motion.

Note:
After cleaning the platinum surface, soak the electrode for a 8 to 24 hours in 4.0 pH buffer, then recheck it with YSI 3682 ZoBell Solution before further use.

Standard Operating Procedure For Sample Management

Prepared For SIMALABS International.
All Laboratory Sections

Revision # 2.0
Issued: March 5, 1999

Immediate Supervisor	3-8-99 Date
Sample Custodian	3-8-99 Date
QA/QC Officer	3-8-99 Date

Effective: October 16, 1997

CAUTION

Disclaimer: This Standard Operating Procedure has been prepared for the sole use of American Analytical, Inc. and may not be specifically applicable to the activities of other organizations.

STANDARD OPERATING PROCEDURE
FOR SAMPLE MANAGEMENT

PURPOSE:

This SOP is intended to detail all aspects of sample management, including all shipping, receiving, handling, storage, container, and holding time requirements.

APPLICABILITY:

This SOP is to be followed while handling all samples, and sample related issues. All laboratory personnel should be trained in the details of this SOP, as sample management issues affect all job functions.

DEFINITIONS:

Sample Custodian (SC): The individual responsible for all sample management issues, including shipping, receiving, handling, and container requirements.

Chain-of-Custody (COC): Documentation and handling process used to insure the sample integrity from collection through the entire analytical process.

REFERENCES:

Simalabs International Program Plan (QAPP), March 1998

DISCUSSION:

Sample management practices are developed to insure the integrity of the sample from time of collection until disposal. As representative samples are required to generate representative results, these processes must be followed with

of problems exist, the SC is to notify a Manager before proceeding with unpacking.

2) The cooler seals are broken, and the COC is removed. A thermometer is placed in the cooler for 5 minutes, and the receipt temperature is recorded on the COC. While the cooler temperature is being measured, the COC is reviewed and signed by the SC.

3) The entire contents of the cooler are removed and all samples are placed on the log-in counter in COC order. All bottles are inspected for problems such as breakage. VOA vials are inspected for head-space, and any problems are noted on the COC. **Special care is to be taken while removing and inspecting containers, as breakage during shipment can present a hazard. The SC is to notify a manager immediately if shipment problems are identified.**

4) The COC is checked against the bottles received, and tests requested. Any discrepancies or inadequate sample volumes are indicated to the manager immediately. **Discrepancies are noted in the comment section of the COC.**

Sample Handling:

1) The sample custodian will log-in the samples on to the LIMS system, and assign a unique identification number. This number will be placed on a label generated by the LIMS system and affixed to each jar received for a given sample.

2) The SC will give the COC to the project manager. The project manager will review the information on the COC and compare it against the information entered into the LIMS system for that COC. Once all information has been verified a workorder sheet is generated. A copy of the workorder is filed in the workorder binder and another copy is filed with the COC with the project manager until the analyses is complete.

3) The sample is initially signed in by the sample custodian, and the samples are placed in the cooler (@ 4 °C). VOA samples are placed in a segregated refrigerator (@ 4 °C).

QA/QC:

Sample Shipment:

Bottle requests are reviewed by a PM prior to shipment to the client. This review will consist of verification of the bottles provided, coolers and shipping materials, method of shipment, and client address.

Sample Handling:

The PM will review all COC, workorder information entered into Lims system for accuracy prior to distribution to the laboratory staff. The PM will add any additional information deemed pertinent to the project. A laboratory staff meeting will be initiated for those projects warranting special attention.

Sample Storage:

After designated storage time has been reached, the SC will verify with the PM that the samples are cleared for disposal. Additionally, the SC will verify that the samples are designated for the proper type of disposal relative to hazard level.

RECORDS:

External COC:

An original COC will be received with all samples, any samples collected by Simalabs will have a COC initiated at time of collection. The nature of COCs vary greatly by client. Any samples received without a COC will require notification to the client, and initiation of COC at the point of receipt. This new COC will be faxed to the client to provide proper signatures of transfer. An example of the external COC is provided in the Appendix.

Delivery of the final report to the client includes a copy of the COC, and the original is filed with the file copy of the report.

Attachment A

Appendix

Standard Operating Procedure For Data Reduction and Validation

Prepared For SIMALABS International
All Laboratory Sections

Revision # 1.0
Issued: March 5, 1999

Immediate Supervisor	3/8/99 Date
Second Supervisor	3/8/99 Date
QA/QC Officer	3/3/99 Date

Effective: March 5, 1999

CAUTION

Disclaimer: This Standard Operating Procedure has been prepared for the sole use of SIMALABS International and may not be specifically applicable to the activities of other organizations.

STANDARD OPERATING PROCEDURE
FOR DATA REDUCTION and VALIDATION

PURPOSE:

This SOP is intended to detail all aspects of data reduction and validation for all laboratory sections. Details will be provided for result calculation, transcription, and all validation processes.

APPLICABILITY:

The contents of this SOP are to be followed by analytical staff involved in generating sample results. All laboratory personnel should be trained in the details of this SOP, as calculation and validation issues affect all job functions and are crucial to generating an accurate product.

DEFINITIONS:

Validation: The internal laboratory process of checks instituted to verify the accuracy of analytical results.

Data Reduction: The process by which raw analysis values are turned into final reportable results.

REFERENCES:

American Analytical, Inc. Quality Assurance Program Plan (QAPP), Feb. 1995.

DISCUSSION:

C_1 = concentration
M = slope of curve
X = absorbance
B = y intercept

$C_1 \times DF = C_F$

where,

DF = dilution factor
C_F = concentration final

These calculations are achieved on a statistical calculator with linear regression capabilities.

Data reduction for non-spectrometric analyses involves basic weight and volume calculations and is specified in each analyses SOP.

Metals:

Graphite Furnace and Cold-vapor AA:

Data reduction for Graphite Furnace and Cold-vapor AA analyses involves plotting curves of the absorbance verses concentration from the initial calibration curves. All concentrations reported from continuing calibrations and samples are derived from the 1st order linear regression applied to the curve where:

$C_1 = MX + B$

where,

C_1 = concentration
M = slope of curve
X = absorbance
B = y intercept

$C_1 \times DF = C_F$

where,

I_S = Amount of internal standard injection (ng)

A_{IS} = Area of characteristic ion for applicable internal standard

RF = Response factor (see below)

V_O = Volume of sample used (ml) or weight used in soil samples (g)

DF =Dilution factor

V_F =Volume of final extract (ul)

V_I = Volume injected (ul)

$RF = (A_X C_{IS} / A_{IS} C_X)$

where,

A_X = Area of characteristic ion for compound measured in standard

A_{IS} = Area of characteristic ion from the specific internal standard

C_{IS} = Concentration of the specific internal standard

C_X = Concentration of the compound added to the standard

Data reduction for GC analyses is achieved by comparison of the average peak area of the calibration curve to the peak area generated from the 12-hour continuing calibration. If the continuing calibration passes all criteria, analysis is initiated. All subsequent results are calculated by comparison of the compounds peak area generated in the sample to the area generated in the continuing calibration. The peak areas are generated on an integrator, and concentrations are determined using an external standard method as follows:

tion of data entry, the final report is reviewed by the Laboratory Manager and signed.

QA/QC:

In addition to review of all QC results, the QC personnel will be responsible for reviewing a minimum of 10% of the raw data and reproducing all applicable calculations.

The QC personnel will be responsible for maintaining control charts for each test in the laboratory. These charts will be utilized to identify trends in the analysis and to establish operational control limits in the laboratory. Additionally, the QC personnel will insure monthly that all data is filed properly and in complete form.

The validation procedure has built-in QA/QC processes through which the reduction process is adequately reviewed. The QC Officer and Laboratory Manager will review this process through internal audits, and periodic spot checks.

RECORDS:

Data Reduction:

All pertinent calculation results are indicated on the analysis sheets. All method specific data reduction calculations are detailed in the individual analysis SOPs. All records of these calculation are part of the raw data information stored for each analysis.

Data Validation:

The data validation process generates summary forms as shown in the Appendix. The QC officer maintains these forms, filed chronologically by analysis. These forms contain the verification initials of validation completeness. These records additionally include all pertinent quality control results for each test.

The QC officer is responsible for generating a "Quarterly Quality Control Report to Management." This report includes all control charted data for the quarter, and an analysis of any data trends. The QC officer maintains the original of this document.

APPENDIX

STANDARD OPERATING PROCEDURE FOR CORRECTIVE ACTION

PURPOSE:

This SOP is intended to detail aspects of corrective action for quality control results that measure outside their limits, including blanks, standards, spikes, and duplicates. This is not intended to address certain QC requirements dealing with instrumental analysis (eg. Calibration Curves, Continuing Calibration Verifications, Continuing Calibration Blanks, etc.) since these requirements should be met for analysis to continue.

APPLICABILITY:

This SOP is to be followed when identifying and employing corrective action. All laboratory personnel should be trained in the details of this SOP, as identification of and corrective action procedures affect the validity of all data produced.

DEFINITIONS:

Peer Analyst: The individual responsible for reproducing all calculations and verifications of the data and quality control adherences to the QAPP.

QC: Quality Control. A set of measures within a sample analysis methodology to ensure that the process is in control.

CAPs: Corrective action procedures. Steps taken to determine, correct, and eliminate the causes for unacceptable QC data.

Blank (Method Blank): A sample, usually DI water, that is free of all analytes being tested. The blank goes through the same preparation and analysis procedures as the entire batch of samples for a particular analyte. The final result for the blank should be less than the detection limit for that particular analyte.

Duplicate: A sample that is tested more than once for a particular analyte, during the same analysis set, in the same manner. The sample and its duplicate should have similar results.

Laboratory Control Standard (LCS): A known concentration of an analyte added to DI water. The standard goes through the same preparation and analysis procedures as the entire batch of samples for a particular analyte. When analyzed, the final result obtained should be similar to the concentration initially added.

Matrix Spike/Matrix Spike Duplicate: (MS/MSD). A sample or a sample and its duplicate that has had a known concentration of a particular analyte added to it. The MS/MSD goes through the same preparation and analysis procedures as the entire batch of samples for a particular analyte. The concentration difference between the MS/MSD analytical results and the original sample results should be very similar to the concentration initially added.

Batch: A set of samples with a similar matrix that are prepared and analyzed at the same time.

REFERENCES:

SIMALABS International , Inc. Quality Assurance Program Plan (QAPP), Feb. 1998.

Standard Methods for the Examination of Water & Wastewater, 17th Edition, 1989.

DISCUSSION:

Corrective action practices are developed to correct for and to help eliminate contamination contributing to QC results measuring outside their respective control limits. QC processes must always be followed with diligence. The validity of the QC data helps ensure the validity of the sample analytical results.

RESPONSIBILITIES:

The contents of this SOP are the direct responsibility of every individual generating analytical results in the laboratory. It is the responsibility of the analyst and the Department Manager to develop and implement CAPs. The Laboratory Manager should approve all CAPs.

PROCEDURE:

Blanks:

All analytical methods utilized in the laboratory incorporate blanks to check for contamination. When a blank demonstrates contamination higher than the quantitation limit for any reported analyte, a re-analysis of the blank will be performed. The samples within the batch may also be re-prepared and re-analyzed.

Duplicates:

Duplicate analysis results must fall within the % difference limits established for a particular analyte. If duplicates do not fall within these limits, re-analysis or other measures are employed to determine if the cause is matrix interference. If matrix interference is determined, analysis may proceed. If no evidence of matrix problems exists, then the samples should be re-prepared and re-analyzed.

Laboratory Control Standard:

LCS analysis results must fall within the % limits established for a particular analyte. If the standard results do not fall within this range, a re-analysis of the LCS will be performed. If after re-analysis the results still do not fall within the set limits, other measures such as, re-preparing and re-analyzing the LCS, or re-standardizing the instrument and then re-analyzing the LCS may be employed.

Matrix Spikes/Matrix Spike Duplicates

Matrix spike recoveries should fall within the limits established for a particular analyte. If matrix spike recoveries are not within these limits, re-analysis or other measures are employed to determine if the cause is matrix interference. If matrix interference is determined, analysis may proceed.

EXCEPTIONS/DOCUMENTATION:

All corrective actions will be documented on a corrective action report form. Any exceptions to the above procedures due to matrix or amount of sample will be specified on this form. Procedures different than those stated above will be used only with the approval of quality assurance personnel.

Situation-Out-Of-Control:

When the QC data measures outside of its limits for a particular analyte, a corrective action report form is filled out by the analyst. A copy of this form is submitted as ATTACHMENT 1.

The analyst must document the problem that has occurred, for which test, and which samples. Together, the analyst and the Department Manager determine the resolution to the problem at hand and any preventive action, if possible, to prevent the problem from reoccurring in the future. The resolution and preventive action are documented.

SIMALABS International
CORRECTIVE ACTION REPORT
Attachment 1

Date: _____ Analyte: _____

SIMALABS Sample ID#: _____

Problem: _____

Corrective Action Taken: _____

Preventative Action: _____

Analyst Signature: _____ Date: _____

Supervisor Signature: _____ Date: _____

QC CRITERIA / CORRECTIVE ACTION PROCEDURES ORGANIC ANALYSES

INITIAL LINEARITY

GC/MS : VOLATILES and SEMI-VOLATILES

SPCCs :Average relative response factors must meet minimum Method criteria
CCCs:%RSD must be less than 30%

GC

%RSD must be less than 20% for all analytes

For All: Compounds that have a RSD of 15%(20% GC) or less are considered to be linear and the average RF is used for further calculations.

If criteria is not met:
Given the large number of analytes analyzed by the methods, it is likely that some analytes may exceed the acceptance limit. In this case, a number of options are recommended in Method 8000B- Section 7.5.1. One option is to construct a calibration curve using first or higher order linear regression for the particular analyte. This non-linear calibration is not intended to compensate for detector saturation at higher concentrations or to avoid proper instrument maintenance. It should not be used for instruments previously shown to exhibit linear calibration for particular analytes. Alternately, the initial calibration may still be acceptable if the mean of the RSD values for all analytes in the calibration is less than or equal to 15%(20% GC). This mean RSD criteria applies to all analytes in the calibration standard, regardless of whether or not they are of interest for a particular project. The analyst and data user must be aware that this approach will lead to greater uncertainty for those analytes for which the %RSD is greater than the acceptance limit.

TUNE(GC/MS):

Prior to analysis, the tune standard must be analyzed and the resulting spectra must meet the Method criteria. If criteria is not met, the tune should be re-analyzed. If a good tune cannot be obtained, corrective action should be taken (clean source, re-autotune, change liner, etc.) before a new tune is attempted, and analysis can begin.

CONTINUING CALIBRATION

A continuing calibration check (CCV) must be run to show the system is operating correctly and the initial calibration is still valid.

GC/MS: This standard must meet SPCC criteria . The %RPD for each individual Calibration Check Compound (CCC) must be equal or less than 20%. If a CCC is high, analysis may proceed, but positive results for any outlying (high) analytes should not be reported without qualification that results may be biased high.

If necessary, (SPCCs low, CCCs low), the system should be inspected and any necessary corrective action should be taken before a new initial calibration is generated.

GC: The %RPD for each individual compound must be equal or less than 15%. If a compound is high, analysis may proceed, but positive results for any outlying (high) analytes should not be reported without qualification that results may be biased high. If necessary,(target analyte(s) low), the system should be inspected and any necessary corrective action should be taken before a new initial calibration is generated. Note:For GC analyses, a CCV that meets criteria must be run to end the analysis sequence. Samples must be bracketed by standards that meet Method criteria.

ANALYSIS SEQUENCE

GC/MS: 12 Hour Analysis sequence: Tune
CCV Standard
MB,LCS,Samples, QC Samples

GC: 12 Hour Analysis sequence: CCV Standard
MB,LCS,Samples, QC Samples
CCV Standard

SURROGATES

GC/MS VOA: Spiked with four surrogates. All must meet laboratory acceptance limits.

If any surrogate fails, the sample must be reanalyzed. If the re-analysis has all surrogates in, only the re-analysis is reported. If surrogate(s) are still out, both the original and the re-analysis (RA) are reported, and a CAR is written.

SEMI-VOLATILES: Spiked with eight surrogates(4 Acid, 4 Base). One Acid and one Base surrogate may be out of laboratory acceptance limits.

If more than one Acid and one Base surrogate is out, the sample should be re-analyzed. If still out, the sample should be re-extracted, assuming there is sufficient sample and that the sample is still within holding time. If re-extraction is not possible, the validity of the data must be assessed and qualified when necessary. A CAR also must be written.

If the re-analysis/ re-extraction has all surrogates in, only the re-analysis/re-extraction is reported. If surrogate(s) are still out, both the original and the re-analysis/re-extraction (RA) are reported, and a CAR is written.

GC: PCBs/Pesticides: Spiked with two surrogates. One surrogate may be out of laboratory acceptance limits.

If both surrogates are out, the sample should be re-analyzed. If still out, the sample should be re-extracted, assuming there is sufficient sample and that the sample is still within holding time. If re-extraction is not possible, the validity of the data must be assessed and qualified when necessary. A CAR also must be written. If the re-analysis/re-extraction meets surrogate criteria, only the re-analysis/re-extraction is reported. If surrogate(s) are still out, both the original and the re-analysis/re-extraction (RA) are reported, and a CAR is written.

GC(General): Generally spiked with a single surrogate, which must meet laboratory criteria for the particular method. If the surrogate is out, the sample should be re-analyzed. If still out, the sample should be re-extracted, assuming there is sufficient sample and that the sample is still within holding time. If re-extraction is not possible, the validity of the data must be assessed and qualified when necessary. A CAR also must be written. If the re-analysis/re-extraction meets surrogate criteria, only the re-analysis/re-extraction is reported. If the surrogate is still out, both the original and the re-analysis/re-extraction (RA) are reported, and a CAR is written.

For All: Dilution of the sample may lessen interferences, so that quantitation of surrogates is more feasible(in particular for VOA-purge and trap analyses). For extractables, this may dilute out the surrogate. This may be necessary in some cases (even when the dilution is for interfering non-target analytes). The surrogate recovery in this case is flagged with a "D" qualifier.

Because of the number of targets in an analysis, it is often necessary to run a sample at more than one dilution. Rather than report a sample at only the highest dilution, it is preferable to report whatever is possible from the most concentrated analysis. Due to the presence of target or non-target interfering peaks in the more concentrated analysis, there may be interferences with surrogate recovery. If the surrogate(s) in question is within range for the diluted sample, QC criteria is met, and the more concentrated sample does not need to be re-run.

Sample Batch

Definition
Volatiles: The samples of the same matrix that are analyzed in the same daily analytical sequence, per instrument (not to exceed 20 samples).
Extractables: The samples of the same matrix that are processed (extracted) as a unit (not to exceed 20 samples).

Method Blanks

Method blanks must be free of target analytes at the PQL.
1.An exception is in the Volatiles analysis for common laboratory artifacts,e.g. MeCl2 and acetone. As a general rule, analysis can continue if the quantitation of these analytes in the blank is <5 x the PQL.
2.For all organic analyses, if a target is detected in the blank, but is a non-target for a particular sample, analysis may also continue.
3. If the MB contains a target analyte, but the samples do not, the analysis is acceptable.
4. If the MB contains a target analyte, and samples contain the same analyte, the batch should be re-extracted and re-analyzed. If acceptable to the client, these results may be reported, with a "B" qualifier.

LCS (Laboratory Control Spike)

The LCS is spiked with the same analytes at the same concentration as the MS/MSD. Each extraction batch of samples should have at least one LCS. Volatiles analysis should have one LCS daily, per instrument.

1. Spike recoveries are evaluated against CLP published limits, when available. If there are no CLP limits for a particular analysis, laboratory limits are used.
2. If any recoveries are low, the LCS should be re-extracted and/or reanalyzed. If still low, measures must be taken to determine the problem. The problem should be resolved before analysis/reporting of the samples in the batch.
3. If any recoveries are high, analysis can continue and the results can be reported, providing there are no hits detected for the outlying analyte in the samples associated with

the LCS. Per client request, results can also be reported if there are hits for the particular analyte, provided the client is aware that the results may be biased high.
4. There is often insufficient water sample provided in order to do a MS/MSD. When this is the case, a second LCS is extracted/analyzed with the batch.

MS/MSD (MATRIX SPIKE/MATRIX SPIKE DUPLICATE)

One MS/MSD is extracted/analyzed per sample batch.

1. Spike recoveries are evaluated against CLP published limits, when available. If there are no CLP limits for a particular analysis, laboratory limits are used.
2. If any recoveries are out of acceptance limits,the chromatograms/reports are examined for matrix effects. If recoveries for the MS and MSD are out, but consistent with each other, a matrix effect may be present. The surrogate recoveries should also be used to evaluate the
data. If matrix effects are indeed present, neither the MS or MSD need to be re-analyzed and/or re-extracted as long as the associated LCS is within QC limits for the outlying spiked analyte(s). Alternately, it may be that the sample itself needs to be re-extracted and/or re-analyzed.
3. If the MS does not match the MSD, then either one or both may be re-analyzed and/or re-extracted. It should be noted that it is often difficult to get a representative sample with soils/sludges. If acceptable recoveries are not obtained from re-extraction and/or re-analysis,
no more action is warranted, and a CAR is written.
4. There is often insufficient sample provided in order to do a MS/MSD. When this is the case, a second LCS is extracted/analyzed with the batch.
5. In Volatiles analyses, whenever possible, the MS and MSD should be prepared and analyzed concurrently with the samples. In the case of samples that involve an extraction procedure, the MS and MSD should be extracted with the batch of samples, but may be analyzed at any time.
6. In Volatiles analyses, when an MS/MSD is being done on a sample that was analyzed at more than one dilution due to the presence of target analytes, it is preferable to run the MS/MSD at the most concentrated level that the sample was run.
7. For extractables, the presence of target or non-target interfering peaks in the sample may necessitate a dilution of the MS/MSD. The MS/MSD should be run at the same dilution as the sample. This will likely dilute out the spike. When this is the case, the spike recoveries should be flagged with a "D". As long as the associated LCS for the batch has acceptable spike recovery(ies) the QC for the batch is satisfied, and no further action is required.

Note: Volatile LCSs, MS and MSDs are all spiked with a "full list spike", rather than the short CLP target spike list. Only the five CLP targets are controlled.

DILUTIONS

The initial linearity for the instrument defines the working range of the instrument. A sample with a target analyte having a response over that of the highest standard in the linearity must be diluted, so that the target comes within range. The presence of non-target peaks may also necessitate a dilution.

1. For extractables, the dilution will likely also dilute out the surrogate and/or spike. When this is the case, the recovery is flagged with a "D". A CAR is not required, but this may be noted in the sample's case narrative.
2. Because of the number of targets in an analysis, it is often necessary to run a sample at more than one dilution. Rather than report a sample at only the highest dilution, it is preferable to report whatever is possible from the most concentrated analysis.
3. Due to the presence of target or non-target interfering peaks in the more concentrated analysis, there may be interferences with surrogate recovery. If the surrogate(s) in question is within range for the diluted sample, QC criteria is met, and the more concentrated sample does not need to be re-run.

MATRIX INTERFERENCES

If there are obvious matrix interferences present in the sample, the course of action will depend on the particular sample/analysis. Possible cases are:

1. Non-target peaks that interfere with the quantitation of targets. Action: Dilution, so that the non-targets are no longer interfering. This will produce an elevated PQL, and may also dilute out the surrogate(s)/spike(s).
2. Non-target peaks eluting at the same time as the surrogate. Action: Re-analysis is suggested, but if there is an obvious pattern of peaks (particularly for samples containing fuel-type contamination) that is causing the surrogate quantitation to be elevated, the surroate recovery should be flagged with an "I" (for interferences), and a CAR should be written.

CARs (CORRECTIVE ACTION REPORTS)

Outlying QC for a sample and/or batch needs to be addressed in a CAR. The CAR is preferably completed by the analyst at the end of the analytical /batch sequence. The problem and any corrective action taken should be stated. Specific topics/explanations may also be discussed here. The CAR is then reviewed and signed by the unit leader, who then forwards a copy to the QC department.

Standard Operating Procedure For Volatile Organics Compounds (VOC)-Aqueous Samples 25 ml Purge-Utilizing the Tekmar Precept II Autosampler

Author: Nancy Tavitas
Prepared For SIMALABS International
Organics, Organics Laboratory & Main Laboratory

SW-846, 3rd Edition, Method 8260B
SW-846,3rd Edition, Method 5030

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Second Supervisor	5/10/00 Date
QA/QC Officer	5/10/00 Date
Analyst	5-10-00 Date

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CAUTION

<u>Disclaimer:</u> This Standard Operating Procedure has been prepared for the sole use of SIMALABS International and may not be specifically applicable to the activities of other organizations.

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STANDARD OPERATING PROCEDURE
VOLATILE ORGANIC COMPOUNDS (VOC)-AQUEOUS SAMPLES
25 ml Purge-UTILIZING THE TEKMAR PRECEPT II AUTOSAMPLER

I. LOCATION

Organics, Organics Laboratory

II. REFERENCES:

SW-846, 3rd Edition, Method 8260B
SW-846, 3rd Edition, Method 5030

III. MATRICES:

Waters, TCLP Leachates

IV. DETECTION LIMITS:

Detection limits are five times lower than the Method PQLs, since a five times greater volume of sample is purged- 25 ml.

V. RANGE:

Aqueous: 1 ug/L to 40 ug/L, without dilution

VI. PRINCIPLE, SCOPE AND APPLICATION:

Volatile organic compounds are extracted from a water or TCLP leachate matrix using the purge and trap method and analyzed on a computer controlled GC/MS system following the criteria established in SW-846 Method 8260B.

VII. INTERFERENCES AND CORRECTIVE ACTION:

Since SW-846 Method 8260B uses extracted ion counts and internal standards, interferences are kept to a minimum.

VIII. SAFETY PRECAUTIONS:

Lab coats and safety glasses are to be worn while working with samples. Standards are stored in crimp-top vials and/or mini-inert vessels in a freezer.

IX. SAMPLE SIZE, COLLECTION, PRESERVATION AND HANDLING:

Aqueous samples should be collected in 40 ml vials with Teflon lined lids and pre-preserved with HCI. Care should be taken to eliminate all head-space from the vials. Holding times are 7 days for unpreserved waters and 14 days for preserved waters.

X. APPARATUS:

Tekmar Precept II Autosampler.

Tekmar LSC 3000 configured as follows:

Standby - 35°
Purge - 11 minutes
Dry Purge - 3 minute
Desorb - 2 minutes at 250 °C
Bake - 7 minutes at 270 °C

HP 5890 Series II Gas Chromatograph temperature-programmed as follows:

Initial temp. - 35 °C	Initial time - 2 minutes	
Rate A - 8 °C/min	Final temp. A- 180 °C	Final time A - 0 minutes
Rate B- 15 °C/min	Final temp B - 230 °C	Final time B - 0 minutes

HP 5971A Mass selective Detector configured as follows:

Scan Mode
Mass range 35 to 350
Sampling 2
Threshold - 500

HP Vectra 386/25 computer with MS Chemstation software, monitor and LaserJet II

Vocarb 3000 Trap

10 uL, 500 uL and 5.0 mL gas-tight syringes

2 mL vials with crimp tops or screw caps

1 ml mininert vessels

XI. ROUTINE MAINTENANCE:

A daily check of the carrier gas is done and the tank is changed when the pressure reaches 500 psi. Pump leaks are checked for quarterly. The following are done as needed: changing septa, changing gas filters, changing trap on Tekmar, changing GC column, cleaning MS source, checking septa for leaks, checking gas flow, cutting capillary column, and replacing liner.

XII. REAGENTS AND STANDARDS

1. CALIBRATION STANDARDS

   A. M-502A-R2-10X, Accustandard (or equivalent):2000 ug/ml each non-gas component in methanol:

Benzene	
Bromobenzene	2,2-Dichloropropane
cis-1,3-Dichloropropene	1,1-Dichloropropene
Bromodichloromethane	trans-1,3-Dichloropropene
Bromoform	Ethylbenzene
n-Butylbenzene	Hexachlorobutadiene
sec-Butylbenzene	Isopropylbenzene
tert-Butylbenzene	p-Isopropyltoluene
Carbon tetrachloride	Methylene chloride
Chlorobenzene	Naphthalene
Chloroform	n-Propylbenzene
2-chlorotoluene	Styrene
4-chlorotoluene	1,1,1,2-Tetrachloroethane
Dibromochloromethane	1,1,2,2-Tetrachloroethane
1,2-Dibromoethane	Tetrachloroethene
Dibromomethane	Toluene
1,2-Dibromo-3-chloropropane	1,1,1-Trichloroethane
1,2-Dichlorobenzene	1,1,2-Trichloroethane
1,3-Dichlorbenzene	Trichloroethene
1,4-Dichlorobenzene	1,2,3-Trichlorobenzene
1,1-Dichloroethane	1,2,4-Trichlorobenzene
1,2-Dichloroethane	1,2,3-Trichloropropane
1,1-Dichloroethene	1,2,4-Trimethylbenzene
cis-1,2-Dichloroethene	1,3,5-Trimethylbenzene
trans-1,2-Dichloroethene	m-Xylene
1,2-Dichloropropane	p-Xylene
1,3-Dichloropropane	o-Xylene

B. Method 8260 Additions - Accustandard-M-8260-ADD-10X
2000 ug/ml each gas component in methanol:

Acetone	Iodomethane
2-Butanone	4-Methyl-2-pentanone
Carbon disulfide	Vinyl acetate
2-chloroethylvinyl ether	4-Methyl-2-pentanone
2-Hexanone	

C. M-601-B 10X Gases, Accustandard (or equivalent)
2000 ug/ml each gas component in MeOH:

Bromomethane	Dichlorodifluoromethane
Chloroethane	Trichlorofluoromethane
Chloromethane	Vinyl chloride

D. Acrolein/Acrylonitrile- M-603-10X-Accustandard (or equivalent)
10,000 ug/ml each component in MeOH

E. Acetonitrile - APP-9-005-10X-Accustandard-(or equivalent)
10,000 ug/ml in MeOH

F. MTBE (Methyl-t-butyl ether)- S-078-10X- Accustandard (or equivalent)
2000 ug/ml in MeOH

2. INTERNAL STANDARDS: M-8260A/B-IS-10X, Purgeable internal standard, Accustandard (or equivalent)- 2000 ug/ml each component in methanol:

chlorobenzene-d5
1,4-dichlorobenzene-d5
fluorobenzene

3. SURROGATES: M-8260A/B-SS-10X, Purgeable surrogate standard, Accustandard (or equivalent)- 2000 ug/ml each component in methanol:

4-bromofluorobenzene
dibromofluoromethane
1,2-dichloroethane-d5
toluene-d8

4. MATRIX SPIKE/LCS SPIKE SOLUTION

A. Non-Gases: 502/524 Volatile Organics Calibration Mix - Supelco Cat.#502111 - 2000 ug/ml each component in methanol:

Benzene	2,2-Dichloropropane
Bromobenzene	1,1-Dichloropropene
Bromochloromethane	cis-1,3-Dichloropropene
Bromodichloromethane	trans-1,3-Dichloropropene
Bromoform	Ethylbenzene
n-Butylbenzene	Hexachlorobutadiene
sec-Butylbenzene	Isopropylbenzene
tert-Butylbenzene	p-Isopropyltoluene
Carbon tetrachloride	Methylene chloride
Chlorobenzene	Naphthalene
Chloroform	n-Propylbenzene
2-chlorotoluene	Styrene
4-chlorotoluene	1,1,1,2-Tetrachloroethane
Dibromochloromethane	1,1,2,2-Tetrachloroethane
1,2-Dibromoethane	Tetrachloroethene
Dibromomethane	Toluene
1,2-Dibromo-3-chloropropane	1,1,1-Trichloroethane
1,2-Dichlorobenzene	1,1,2-Trichloroethane
1,3-Dichlorbenzene	Trichloroethene
1,4-Dichlorobenzene	1,2,3-Trichlorobenzene
1,1-Dichloroethane	1,2,4-Trichlorobenzene
1,2-Dichloroethane	1,2,3-Trichloropropane
1,1-Dichloroethene	1,2,4-Trimethylbenzene
cis-1,2-Dichloroethene	1,3,5-Trimethylbenzene
trans-1,2-Dichloroethene	m-Xylene
1,2-Dichloropropane	p-Xylene
1,3-Dichloropropane	o-Xylene

B. Gases: 502/524 Volatile Organics Calibration Mix - Supelco Cat.#502111 -2000 ug/ml each component in methanol:

Bromomethane	Dichlorodifluoromethane
Chloroethane	Trichlorofluoromethane
Chloromethane	Vinyl chloride

C. TCLP Spike-TCLP-VOC-Accustandard (or equivalent): 5000 ug/ml each component in methanol:

Benzene	1,2-Dichloroethane
2-Butanone (10,000 ug/ml)	1,1-Dichloroethene
Carbon tetrachloride	Trichloroethane
Chlorobenzene	Tetrachloroetnene
Chloroform	Vinyl Chloride
1,4-Dichlorobenzene	

5. Methanol, purge & trap grade

6. Organic- free water (DI water that is constantly purged with N2 in the VOA laboratory)

XIII. STANDARD PREPARATION

1. STOCK STANDARDS

A. VOA Cal Standard: 50 ug/ml each component
To a 1.0 ml volumetric flask partially filled with MEOH, add 25 ul each standards 1A and 1B above. Fill to the mark with MEOH. Transfer to a mininert vessel, and label. Store in the freezer. Std expiration: 6 months.

B. VOA Gas Standard: 50 ug/ml each component
To a 1.0 ml volumetric flask partially filled with MEOH, add 25 ul standard 1C above. Fill to the mark with MEOH. Transfer to a mininert vessel, and label. Store in the freezer. Std expiration: 1 week.

C. Acrolein/Acrylonitrile: 500 ug/ml each component
To a 1.0 ml volumetric flask partially filled with MEOH, add 50 ul standard 1D above. Fill to the mark with MEOH. Transfer to a mininert vessel, and label. Store in the freezer. Std expiration: 6 months.

D. Acetonitrile: 500 ug/ml
To a 1.0 ml volumetric flask partially filled with MEOH, add 50 ul standard 1E above. Fill to the mark with MEOH. Transfer to a mininert vessel, and label. Store in the freezer. Std expiration: 6 months.

E. MTBE (Methyl-t-butyl ether): 50 ug/ml
To a 1.0 ml volumetric flask partially filled with MEOH, add 25 ul standard 1F above. Fill to the mark with MEOH. Transfer to a mininert vessel, and label. Store in the freezer. Std expiration: 6 months.

F. VOC internal standard/surrogate solution working solution: 250 ug/ml each component in methanol.
Partially fill a10 ml volumetric with MEOH. Add 200 ul each of standards 2 and 3 above. Fill to the mark with methanol. Load into Standard Vessel #1 on the Tekmar Precept autosampler. Std expiration: 6 months.

G. Matrix Spike/LCS (non-gases)-50 ug/ml each component in MeOH
To a 1.0 ml volumetric flask partially filled with MEOH, add 25 ul standard 4A above. Fill to the mark with MEOH. Transfer to a mininert vessel, and label. Store in the freezer. Std expiration: 6 months.

H. Matrix Spike/LCS (gases)-50 ug/ml each component in MeOH
To a 1.0 ml volumetric flask partially filled with MEOH, add 25 ul standard 4B above. Fill to the mark with MEOH. Transfer to a mininert vessel, and label. Store in the freezer. Std expiration: 1 week.

I. Matrix Spike/TCLP-50 ug/ml each component in MeOH (2-butanone:100 ug/ml)
To a 10.0 ml volumetric flask partially filled with MEOH, add 100 ul standard 4C above. Fill to the mark with MEOH. Transfer to a mininert vessel, and label. Store in the freezer. Std expiration: 6 months.

J. VOC internal standard/surrogate tuning solution: 50 ug/ml each component in methanol.
Partially fill a10 ml volumetric with MEOH. Add 40 ul each of standards 2 and 3 above. Fill to the mark with methanol. Std expiration: 6 months.

2. DAILY CALIBRATION STANDARD- Concentration 10 ug/L (ppb)*

Preparation procedure: Fill 50 ml volumetric nearly to the mark with reagent water. Add 10 ul of each calibration standard (mix A,B,C,D, and E above). Fill volumetric to the mark with reagent water. Fill a VOA vial to overflowing with the standard. Cap tightly, and analyze immediately.
* The concentration of of acetonitrile, acrolein and acrylonitrile is 100 ppb.

3. DAILY LCS STANDARD- Concentration 10 ug/L (ppb)

Preparation procedure: Fill 50 ml volumetric nearly to the mark with reagent water. Add 10 ul of each LCS-MS/MSD standard (mix 4A and 4B above). Fill volumetric to the mark with reagent water. Fill a VOA vial to overflowing with the standard. Cap tightly, and analyze immediately.

XIV. BFB (BROMOFLUOROBENZENE) TUNE:

Prior to analysis, 50 ng of BFB must be analyzed and the resulting spectra must meet the following criteria:

Mass	Ion Abundance Criteria
50	8 to 40% of mass 95
75	30 to 66% of mass 95
95	base peak, 100% relative abundance
96	5 to 9% of mass 95
173	less than 2% of mass 174
174	greater than 50% but less than 120% of mass 95
175	5 to 9% of mass 174
176	greater than 93% but less than 101% of mass 174
177	5 to 9% of mass 176

This is done by injecting 1.0 uL of Volatiles Internal Standard/Surrogate Mix (std 1J above) into the injection port on the GC while pressing the start button to initiate the run using the BFB method built into the software. The above criteria must be demonstrated for each 12-hour shift.

(1) Set up analysis sequence in Sample Table Log in *sequence* in main menu.

(2) Enter sample name as BFB tune and type in BFB in the Method column.

(3) Press start on the the GC.

(4) Inject 1ul of tune standard into the injection portion of the GC.

(5) Allow method to run and generate a report. The report will indicate whether or not the BFB spectrum has passed. If it does not pass, the operator must enter manual tuning, adjust various mass spectrometer parameters (lenses) within the tune file, and perform the tuning process again. If a good tune cannot be obtained, corrective action should be taken (clean source, re-autotune, etc.) Before a new tune is attempted, and analysis can begin. The tune must meet criteria before any samples are analyzed.

(6) After tune is complete, the analysis of standards, MB, LCS and samples can begin.

XV. CALIBRATION PROCEDURE:

An initial 5 pt. Calibration is constructed with concentrations of 1, 4, 10, 20 and 40 ppb VOC. They are prepared by adding 1 ul,4 ul,10 ul,20ul and 40 ul of the calibration standards listed

above to 50 ml of reagent water. The standards are transferred to VOA vials, tightly capped, and analyzed.

Purging and transfer to the LSC3000 is initiated through the Tekmar Precept autosampler . The GC/MS is enabled by using the Method - Run pull down menus on the instrument top window on the computer. The internal standards and surrogates are automatically added to each 25 ml aliquot of standard.

Response factors and RSD's are calculated for each compound and must meet the criteria in Table 1 for SPCCs and CCCs. Compounds that have a RSD of 15% or less are considered to be linear and the average RF is used for further calculations. Given the large number of analytes analyzed by the method, it is likely that some analytes may exceed the 15% acceptance limit. In this case, a number of options are recommended in Method 8000B- Section 7.5.1. One option is to construct a calibration curve using first or higher order linear regression for the particular analyte. This non-linear calibration is not intended to compensate for detector saturation at higher concentrations or to avoid proper instrument maintenance. It should not be used for instruments previously shown to exhibit linear calibration for particular analytes. Alternately, the initial calibration may still be acceptable if the mean of the RSD values for all analytes in the calibration is less than or equal to 15%. This mean RSD criteria applies to all analytes in the calibration standard, regardless of whether or not they are of interest for a particular project. The analyst and data user must be aware that this approach will lead to greater uncertainty for those analytes for which the %RSD is greater than 15%.

In addition to a BFB check every 12 hours, a continuing calibration check must also be run to show the system is operating correctly and the initial calibration is still valid. This is done by preparing and analyzing a 10 ppb daily calibration standard. This standard must meet SPCC and CCC criteria. See Table 1 attached.

After the SPCC and CCC criteria have been verified ,the analyst must analyze a blank sample of 25 mL reagent water to show there is not contamination in the operating system.

XVI. SAMPLE PREPARATION:

VOA vials containing the samples are loaded into the Precept autosampler. A 25 ml aliquot is taken, 1 ul of the internal standard/surrogate solution is automatically added, and the sample is purged, trapped, and analyzed by the GC/MS. Dilutions up to 1/10 can be programmed and prepared by the autosampler. If higher dilutions are necessary, they are prepared in volumetric flasks, and transferred to VOA vials for analysis.

XVII. ANALYSIS PROCEDURE:

From the LSC 3000 the volatile compounds are injected directly onto the column. At this time, the computer begins to generate a chromatogram of the total amount of ions that pass through the detector. At the end of the run the computer extracts the necessary target ions from the

total chromatogram and using the internal standards and RF values from the initial calibration, a report is generated that quantifies the sample.

Analysis sequence/ Daily Calibration:

(1) Set up analysis sequence in Sample Table Log in *sequence* in main menu.

(2) Enter the sequence as it is to be run, including the applicable analysis method.

(3) Following the tune, the daily calibration standard CCV must be run.

(3) Click on *position and run.*

(4) Start the Precept schedule.

(5) Allow to run, retrieve report, check to see that all compounds have been detected.

(6) The software will calculate RF values and % drift values for all analytes. All performance check compounds and calibration check compounds must meet criteria according to method 8260 in the SW-846 manual.

(7) Once it has been determined that the tune and CCV meet Method criteria, the analysis of samples can begin. The sequence starts with a Method Blank, followed by an LCS, samples and QC samples.

XVIII. QUALITY CONTROL:

A matrix spike and a matrix spike duplicate are required to be purged and analyzed for every batch (batch not to exceed 20 samples). In addition, a LCS, containing all the spike analytes, is analyzed. All samples are spiked with surrogates.

Surrogates
Volatile samples analyzed with a 25 ml purge are spiked with four surrogates, each at a level of 10 ppb. The control limits for surrogate recoveries are listed on Table 2 attached. All must meet laboratory acceptance limits.

If any surrogate fails, the sample must be reanalyzed. If the re-analysis has all surrogates in, only the re-analysis is reported. If surrogate(s) are still out, both the original and the re-analysis (RA) are reported, and a CAR is written.

Dilution of the sample may lessen interferences, so that quantitation of surrogates is more feasible. This may be necessary in some cases (even when the dilution is for interfering non-target analytes). This will increase the sample's PQL.

Because of the number of targets in an analysis, it is often necessary to run a sample at more than one dilution. Rather than report a sample at only the highest dilution, it is preferable to report whatever is possible from the most concentrated analysis. Due to the presence of target or non-target interfering peaks in the more concentrated analysis, there may be interferences with surrogate recovery. If the surrogate(s) in question is within range for the diluted sample, QC criteria is met, and the more concentrated sample does not need to be re-run.

Sample Batch

Definition
The samples of the same matrix_that are analyzed in the same daily analytical sequence, per instrument (not to exceed 20 samples).

Method Blanks

Method blanks must be free of target analytes at the PQL.
1.An exception is for volatiles analysis for common laboratory artifacts,e.g. MeCl2 and acetone. As a general rule, analysis can continue if the quantitation of these analytes in the blank is <5 x the PQL.
2. If a target is detected in the blank, but is a non-target for a particular sample, analysis may also continue.
3. If the MB contains a target analyte, but the samples do not, the analysis is acceptable.
4. If the MB contains a target analyte, and samples contain the same analyte, the batch should re-analyzed. If acceptable to the client, these results may be reported, with a "B" qualifier.

LCS (Laboratory Control Spike)

The LCS is spiked with the same analytes at the same concentration as the MS/MSD.

Volatiles analysis should have one LCS daily, per instrument.

1. Spike recoveries are evaluated against CLP published limits.
2. If any recoveries are low, the LCS should be reanalyzed. If still low, measures must be taken to determine the problem. The problem should be resolved before analysis/reporting of the samples in the batch.
3. If any recoveries are high, analysis can continue and the results can be reported, providing there are no hits detected for the outlying analyte in the samples associated with the LCS. Per client request, results can also be reported if there are hits for the particular analyte, provided the client is aware that the results may be biased high.

MS/MSD (Matrix spike/Matrix spike duplicate)

One MS/MSD is analyzed per sample batch.

1. Spike recoveries are evaluated against CLP published limits.

2. If any recoveries are out of acceptance limits,the chromatograms/reports are examined for matrix effects. If recoveries for the MS and MSD are out, but consistent with each other, a matrix effect may be present. The surrogate recoveries should also be used to evaluate the data. If matrix effects are indeed present, neither the MS or MSD need to be re-analyzed as long as the associated LCS is within QC limits for the outlying spiked analyte(s) . Alternately, it may be that the sample itself needs to be re-analyzed.
3. If the MS does not match the MSD, then either one or both may be re-analyzed. It should be noted that it is often difficult to get a representative sample with soils/sludges. If acceptable recoveries are not obtained from re-analysis, no more action is warranted, and a CAR is written.
4. Whenever possible, the MS and MSD should be analyzed concurrently with the samples.
5. When an MS/MSD is being done on a sample that was analyzed at more than one dilution due to the presence of target analytes, it is preferable to run the MS/MSD at the most concentrated level that the sample was run.

Note: Volatile LCSs, MS and MSDs are all spiked with a "full list spike", rather than the short CLP target spike list. Only the five CLP targets are controlled.

Dilutions

The initial linearity for the instrument defines the working range of the instrument. A sample with a target analyte having a response over that of the highest standard in the linearity must be diluted, so that the target comes within range. The presence of non-target peaks may also necessitate a dilution.

1. Because of the number of targets in an analysis, it is often necessary to run a sample at more than one dilution. Rather than report a sample at only the highest dilution, it is preferable to report whatever is possible from the most concentrated analysis.
2. Due to the presence of target or non-target interfering peaks in the more concentrated analysis, there may be interferences with surrogate recovery. If the surrogate(s) in question is within range for the diluted sample, QC criteria is met, and the more concentrated sample does not need to be re-run.

Matrix Interferences

If there are obvious matrix interferences present in the sample, the course of action will depend on the particular sample/analysis. Possible cases are:

1. Non-target peaks that interfere with the quantitation of targets. Action: Dilution, so that the non-targets are no longer interfering. This will produce an elevated PQL.
2. Non-target peaks eluting at the same time as the surrogate. Action: Re-analysis is suggested, but if there is an obvious pattern of peaks (particularly for samples containing fuel-type contamination) that is causing the surrogate quantitation to be elevated, the surroate recovery should be flagged with an "I" (for interferences), and a CAR should be written.

CARs (Corrective Action Reports)

Outlying QC for a sample and/or batch needs to be addressed in a CAR. The CAR is preferably completed by the analyst at the end of the analytical /batch sequence. The problem and any corrective action taken should be stated. Specific topics/explanations may also be discussed here. The CAR is then reviewed and signed by the unit leader, who then forwards a copy to the QC department.

XIX. DATA TREATMENT:

The computer report will show the ng/ml (ug/L) of VOCs found in the sample.

$$RF = (A_x C_{is}) / (A_{is} C_x)$$

where,

A_x = Area of the characteristic ion of the compound being measured

A_{is} = Area of the characteristic ion for the specific internal standard

C_{is} = Concentration of the specific internal standard

C_x = Concentration of the compound being measured

$$\% \text{ drift} = \frac{C_I - C_c}{C_I} \times 100$$

where,

C_I = Calibration check compound standard concentration

C_c = Measured concentration

$$\text{Concentration (ug/L)} = \frac{(A_x)(I_s)}{(A_{is})(RF)(V_o)} \times DF$$

where,

A_x = Area of the characteristic ion for compound being measured

I_s = Amount of internal standard injected (ng)

A_{is} = Area of characteristic ion for the internal standard

RF = Initial average response factor for compound being measured

V_o = Volume of water purged (mL)

DF = Dilution factor

* $\frac{(A_x)(I_s)}{(A_{is})(RF)}$ is calculated by HP computer software

$$\%RSD = \frac{SD}{RF} \times 100$$

where,

RSD = relative standard deviation.
RF = mean of 5 initial RFs for a compound.
SD = standard deviation of average RFs for a compound.

XX. IDENTIFICATION OF TARGET ANALYTES

The qualitative identification of each target compound is based on retention time and on comparison of the sample mass spectrum with characteristic ions in a reference mass spectrum. The reference mass spectra are generated by the instrument and are updated each time an initial linearity is run. The reference spectra are updated with the 10 ppb standard in the initial linearity.

XXI. DATA DELIVERABLES:

Depending on particular client requirements, reports to the client may include:

- Date of receipt
- Date of preparation
- Date of analysis
- Analyst
- Matrix
- Laboratory I.D. #
- Client I.D. #
- Analytical method and #
- Blank data
- Concentrations determined and resulting limits
- Surrogate summary form
- Matrix spike summary form
- Blank summary form
- Tune check summary form
- Initial calibration summary form
- Continuing calibration summary form
- IS area/retention time summary form

- All raw data
- Target spectra for all positive hits with corresponding reference spectra
- TIC spectra
- Preparation records

Table 1

CALIBRATION CHECK COMPOUNDS (CCCs)

1,1-Dichloroethene
Chloroform
1,2-Dichloropropane
Toluene
Ethylbenzene
Vinyl chloride

The %RSD for each individual Calibration Check Compound must be less than 30%.

The CCCs listed are also used to check the validity of the initial calibration. If the % drift for each CCC is less than 20%, the initial calibration is assumed to be valid.

SYSTEM PERFORMANCE CHECK COMPOUNDS (SPCCs)

The minimum relative response factor for SPCCs are as follows:

Chloromethane	0.10
1,1-Dichloroethane	0.10
Bromoform	>0.10
Chlorobenzene	0.30
1,1,2,2-Tetrachloroethane	0.30

Table 2

Quality Control Criteria for Matrix Spike/Matrix Spike Duplicates/LCSs

VOC Analyte	MS/MSD/LCS Aqueous % Recovery	MS/MSD/LCS Soil/Sludge % Recovery
1,1-Dichloroethene	61-145	59-172
Benzene	75-127	66-142
Trichloroethene	71-120	62-137
Toluene	76-125	59-139
Chlorobenzene	75-130	60-133

Quality Control Criteria for Surrogates

Surrogate	Aqueous %Recovery	Soil/Sludge %Recovery
Dibromofluoromethane	86-118	80-120
1,2-Dichloroethane-d4	80-120	80-120
Toluene-d8	88-110	81-117
4-Bromofluorobenzene	86-115	74-121

Standard Operating Procedure For ORGANICS SEPARATORY FUNNEL LIQUID-LIQUID EXTRACTION FOR BNA'S

Prepared For SIMALABS International
Organics, Organics Laboratory & Main Laboratory

EPA Method 3510/625

Revision # 4.1
Issued: March 5, 1999

Nancy L Farias	3/8/99
Immediate Supervisor	Date
	3/8/99
Second Supervisor	Date
	3/8/99
QA/QC Officer	Date
Nina Campio	3-8-99
Analyst	Date

Effective: March 5, 1999

CAUTION

<u>Disclaimer:</u> This Standard Operating Procedure has been prepared for the sole use of SIMALABS International and may not be specifically applicable to the activities of other organizations.

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STANDARD OPERATING PROCEDURE

ORGANICS SEPARATORY FUNNEL LIQUID-LIQUID EXTRACTION FOR BNAs

LOCATION:

Organics, Main Laboratory and Organics Laboratory

REFERENCE:

SW-846, 3rd Edition, Methods 3510 and 3500

MATRIX:

Aqueous, Leachate

DETECTION LIMIT:

N/A

RANGE:

N/A

PRINCIPLE, SCOPE, AND APPLICATION:

This procedure is for isolating organic compounds from aqueous samples. This process involves isolation and concentration of water-insoluble and slightly water-soluble organics in preparation for a variety of chromatographic procedures. A measured volume of sample, usually 1 L, at a specific pH (5-9 for PCB's and pesticides, >11 for base/neutral fraction of SVOC and < 2 for acid fraction of SVOC), is serially extracted with methylene chloride using a separatory funnel. The extract is dried, concentrated, and, as necessary, exchanged into a solvent compatible with analytical method used.

INTERFERENCES AND CORRECTIVE ACTION:

Samples requiring analysis for volatile organic compounds, can be contaminated by diffusion of volatile organics (particularly chlorofluoro-carbons and methylene chloride) through the sample container septum during shipment and storage. A field blank prepared from organic-free reagent water and carried through sampling and subsequent storage and handling can serve as check on such contamination. Solvents, reagents, glassware, and other processing hardware may yield artifacts and/or interferences to sample analysis. All these materials must be demonstrated to be free from interferences under the conditions of the analysis by analyzing method blanks. Specific selection of reagents and purification of solvents by distillation in all glass systems may be required. Interferences coextracted from samples will vary considerably from source to source. If analysis of an extracted sample is prevented due to interferences, further clean up may be required. Phthalate esters contaminate many types of products commonly found in the laboratory. Plastics, in particular, must be avoided because phthalates are commonly used as plasticizers and are easily extracted from plastic materials. Serious phthalate contamination may result at any time if consistent quality control is not practiced. Glassware contamination resulting in analyte degradation: Soap residue on glassware may cause degradation of certain analytes. Specifically, aldrin, heptachlor, and most organophosphorus pesticides will degrade in this situation. This problem is especially pronounced with glassware that may be difficult to rinse. These items should be hand-rinsed very carefully to avoid this problem.

SAFETY PRECAUTIONS:

Wear lab coat, gloves, and safety glasses. Work in exhaust hood. Keep separatory funnels well vented to avoid high pressure._Refer to MSDS for inquiries about chemicals used in this method. The MSDS is located in the Main Laboratory.

SAMPLE SIZE, COLLECTION, PRESERVATION, AND HANDLING:

Samples should be collected in 2 1 L glass amber jars. Holding times for aqueous samples are 7 days.

APPARATUS:

1) Turbo Vap II (water bath temperature = 37 °C)

2) Turbo Vap II concentrator tube

3) 2 L separatory funnel

4) 100 mL and 1 L glass graduated cylinder

5) Glass funnels

6) Glass wool

7) 1 mL syringe

8) 1 mL and 10 mL disposable pipettes

9) IEC Centra-HN centrifuge

ROUTINE MAINTENANCE:

Check water level in Turbo Vap II and add deionized water if needed.

REAGENTS AND CALIBRATION STANDARDS:

1) Methylene chloride

2) Acetone

3) Sodium sulfate

4) Sulfuric acid (concentrated)

5) 10N Sodium hydroxide (400 g NaOH into 1 L deionized water)

CALIBRATION PROCEDURES:

N/A

CLEANING GLASSWARE:

(1) All glassware should be cleaned with detergent and hot water.

(2) Rinse glassware three times with deionized water to remove metallic deposits from the tap water.

(3) Rinse all glassware with acetone.

(4) Triple rinse the glassware with methylene chloride.

SAMPLE PREPARATION:

1) Prepare funnel filter with glass wool and sodium sulfate.

2) Rinse filter and sodium sulfate with about 20 mL of methylene chloride and discard rinse methylene chloride. Place concentrator tube under the filter.

3) Transfer sample into separatory funnel.

4) Adjust pH of the sample using concentrated sulfuric acid. Check the pH of the sample with pH paper. If the sample does not have a pH less than or equal to 2, adjust the pH by adding more sulfuric acid.

5) Add 1 mL of BNA surrogate to the sample (and 1 mL BNA spike to the matrix spike sample and the matrix spike duplicate sample) and record type and amount added in the organic extraction log book.

6) Add 60 mL methylene chloride to separatory funnel.

7) Shake separatory funnel for 2 minutes, venting frequently.

8) Allow the layers of the separatory funnel to separate. (If the contents in the separatory funnel do not separate, the samples will need to be centrifuged to complete the separation.)

9) Drain extract from separatory funnel through the sodium sulfate filter and into the concentrator tube.

10) Repeat steps (6), (7), (8) and (9) two more times.

11) Rinse the sodium sulfate filter with methylene chloride to remove any organics still in filter.

12) Place concentrator tube into Turbo Vap II until the sample is concentrated to approximately 10 mL. Then place the concentrator tube back under the sodium sulfate filter.

13) Adjust pH of the sample using 10N NaOH. Check the pH of the sample with pH paper. If the sample does not have a pH greater than or equal to 12, adjust the pH by adding more 10N NaOH.

14) Repeat steps (6), (7), (8), and (9) three times.

15) Rinse sodium sulfate filter with methylene chloride to remove any organics still in filter.

16) Place the concentrator tube into Turbo Vap II.

17) When the volume of the extract is below 1 mL, remove the concentrator tube from Turbo Vap II. **CAUTION: DO NOT LET EXTRACT GO DRY!**

18) Using the 1 mL syringe, measure and remove extract from concentrator tube. Rinse concentrator tube walls with 2-3 mL of methylene chloride. Bring the extract up to a final volume of 1mL with the methylene chloride rinse from the concentrator tube.

19) Place the extract into a labeled 1 mL vial with the sample I.D., volume, parameter, date of extraction and extraction personnel initials.

20) Cap container of extract.

21) Measure volume of sample in separatory funnel using 1 L graduated cylinder and record in the organics extraction log book.

ANALYSIS PROCEDURE:

N/A

QUALITY CONTROL REQUIREMENTS:

A blank, matrix spike, and matrix spike duplicate are required to be extracted and analyzed for every batch (batch not to exceed 20 samples). In addition a surrogate mix is spiked into the blank, matrix spike, matrix spike duplicate, and all the samples.

CALCULATIONS:

N/A

DATA DELIVERABLES:

All preparation records will be submitted with data submitted.

APPENDIX D

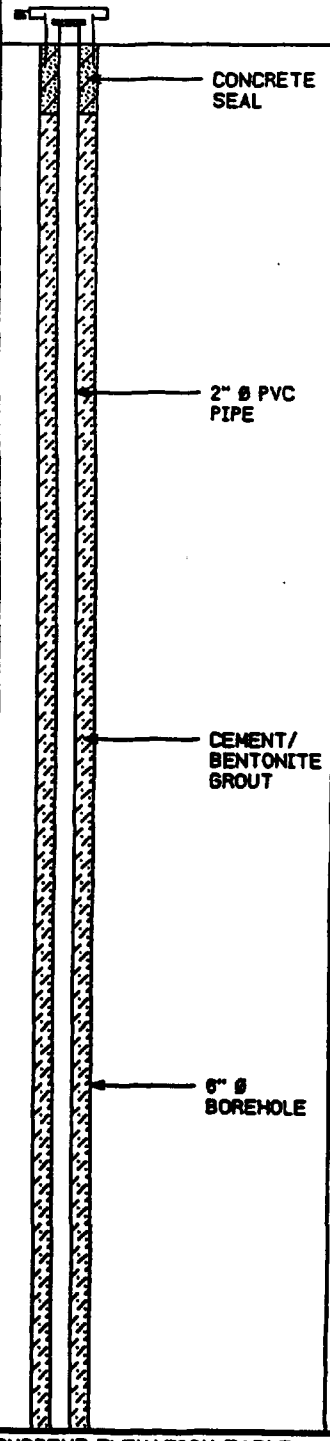
STRATIGRAPHIC AND INSTRUMENTATION LOGS - OFF SITE GROUNDWATER MONITORING WELLS

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: FOUR COUNTY LANDFILL
PROJECT NUMBER: 5369-51
CLIENT:
LOCATION:

HOLE DESIGNATION: MW100
DATE COMPLETED: MARCH 19, 1996
DRILLING METHOD: 6" Ø ROTOSONIC
CRA SUPERVISOR: V. FITZGERALD

DEPTH ft. BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft. AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE STATE	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
	REFERENCE POINT (Top of Riser) GROUND SURFACE	*785.06* *783.0*					
	For stratigraphic details, please refer to MW-101.						
2.5							
5.0							
7.5							
10.0							
12.5							
15.0							
17.5							
20.0							
22.5							
25.0							
27.5							
30.0							
32.5							
35.0							
37.5							



NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE
WATER FOUND ▼ STATIC WATER LEVEL ▼

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: FOUR COUNTY LANDFILL
PROJECT NUMBER: 5369-51
CLIENT:
LOCATION:

HOLE DESIGNATION: MW100
DATE COMPLETED: MARCH 19, 1996
DRILLING METHOD: 6" Ø ROTOSONIC
CRA SUPERVISOR: V. FITZGERALD

DEPTH ft. BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft. AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE STATE	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
42.5			CEMENT/ BENTONITE GROUT				
45.0							
47.5							
50.0			2" Ø PVC PIPE				
52.5							
55.0			BENTONITE PELLETS				
57.5							
60.0			SAND PACK				
62.5							
65.0			WELL SCREEN				
67.5							
70.0	END OF HOLE @ 70ft BGS	713.0	6" Ø BOREHOLE				
72.5							
75.0							
77.5							

SCREEN DETAILS
Screened Interval:
60 to 70ft BGS
Length: 10.0ft
Diameter: 2"
Slot Size: #10
Material: PVC
Sand Pack:
57 to 70ft BGS
Material: #00N Sand

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE
WATER FOUND ▼ STATIC WATER LEVEL ▼

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: FOUR COUNTY LANDFILL
PROJECT NUMBER: 5369-51
CLIENT:
LOCATION:

HOLE DESIGNATION: MW101
DATE COMPLETED: MARCH 18, 1996
DRILLING METHOD: 6" Ø ROTOSONIC
CRA SUPERVISOR: V. FITZGERALD

DEPTH ft. BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft. AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE STATE	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
	REFERENCE POINT (Top of Riser) GROUND SURFACE	785.31 783.2					
	CL-CLAY, trace gravel, brown, dry		CONCRETE SEAL				
2.5				1CS			0
5.0	- orange mottling						
7.5				2CS			0
10.0			2" Ø PVC PIPE				
12.5	- gray			3CS			0
15.0							
17.5				4CS			0
20.0			CEMENT/ BENTONITE GROUT				
22.5				5CS			0
	SW-SAND, some clay, fine to medium grained, gray, dry	759.2					
25.0	CL-CLAY, trace gravel, gray, moist	758.2					
27.5				6CS			0
	SW-SAND, some clay, fine to medium grained, gray, very moist	754.2					
30.0			6" Ø BOREHOLE				
32.5	ML-SILT, some clay, trace gravel and sand, gray, dry to moist	751.2		7CS			0
	SP-SAND, trace gravel, medium grained, brownish gray, dry	749.2					
35.0	CL-CLAY, trace gravel, gray with reddish tint, damp	748.2					
37.5				8CS			0

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE
WATER FOUND ▼ STATIC WATER LEVEL ▼

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: FOUR COUNTY LANDFILL
PROJECT NUMBER: 5369-51
CLIENT:
LOCATION:

HOLE DESIGNATION: MW101
DATE COMPLETED: MARCH 18, 1996
DRILLING METHOD: 6" Ø ROTOSONIC
CRA SUPERVISOR: V. FITZGERALD

DEPTH ft. BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft. AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE STATE	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
	~~little silt, no red tint, dry~~						
42.5			CEMENT/ BENTONITE GROUT	9CS			0
45.0							
47.5				10CS			0
50.0	- no silt, damp		2" Ø PVC PIPE				
52.5				11CS			0
55.0	SW-SAND, little gravel, fine to coarse grained, gray, wet	728.2					
57.5				12CS			0
60.0	- no gravel, very moist						
62.5		720.2		13CS			0
	SP-SAND, fine grained, gray, very moist	719.2					
65.0	SW-SAND, some gravel, fine to coarse grained, gray, very moist - gray to brown, wet						
67.5	SP-SAND, fine grained, brownish gray, very moist	715.7		14CS			0
70.0	- tan		6" Ø BOREHOLE				
72.5				15CS			0
75.0							
77.5				16CS			0

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE
WATER FOUND ▼ STATIC WATER LEVEL ▼

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: FOUR COUNTY LANDFILL
PROJECT NUMBER: 5369-51
CLIENT:
LOCATION:

HOLE DESIGNATION: MW101
DATE COMPLETED: MARCH 18, 1996
DRILLING METHOD: 6" Ø ROTOSONIC
CRA SUPERVISOR: V. FITZGERALD

DEPTH ft. BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft. AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE STATE	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
82.5			CEMENT/ BENTONITE GROUT	17CS			0
	SW-SAND, little gravel, fine to coarse grained, tan, very moist	699.2					
85.0			2" Ø PVC PIPE				
87.5				18CS			0
			6" Ø BOREHOLE				
90.0	SP-SAND, trace gravel, fine grained, tan, wet	693.2					
92.5				19CS			0
95.0	- no gravel						
			BENTONITE PELLETS				
97.5				20CS			0
100.0	SW-SAND, little gravel, fine to coarse grained, tan, wet	683.2	SAND PACK				
102.5			WELL SCREEN	21CS			0
105.0							
107.5			SAND PACK	22CS			0
110.0	END OF HOLE @ 110ft BGS	673.2					
112.5							
115.0							
117.5							

SCREEN DETAILS
Screened Interval:
100 to 110ft BGS
Length: 10.0ft
Diameter: 2"
Slot Size: #10
Material: PVC
Sand Pack:
97 to 110ft BGS
Material: #00N Sand

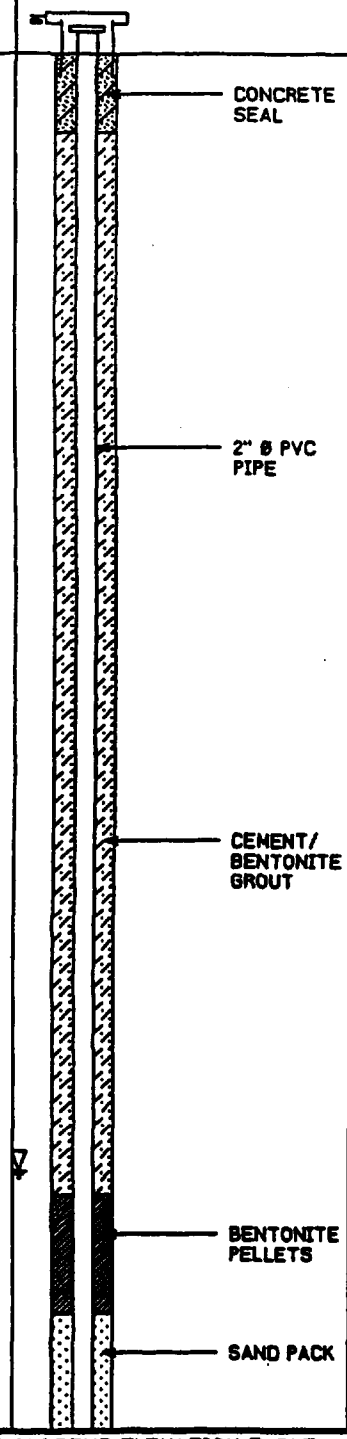
NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE
WATER FOUND ▼ STATIC WATER LEVEL ▼

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: FOUR COUNTY LANDFILL
PROJECT NUMBER: 5369-51
CLIENT:
LOCATION:

HOLE DESIGNATION: MW102
DATE COMPLETED: MARCH 20, 1996
DRILLING METHOD: 6" Ø ROTOSONIC
CRA SUPERVISOR: V. FITZGERALD

DEPTH ft. BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft. AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE STATE	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
	REFERENCE POINT (Top of Riser) GROUND SURFACE	*758.11* *755.9*					
	For stratigraphic details, please refer to MW-103.						
2.5							
5.0							
7.5							
10.0							
12.5							
15.0							
17.5							
20.0							
22.5							
25.0							
27.5							
30.0							
32.5							



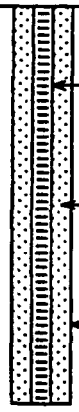
NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE
WATER FOUND ▼ STATIC WATER LEVEL ▼

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: FOUR COUNTY LANDFILL
PROJECT NUMBER: 5369-51
CLIENT:
LOCATION:

HOLE DESIGNATION: MW102
DATE COMPLETED: MARCH 20, 1996
DRILLING METHOD: 6" Ø ROTOSONIC
CRA SUPERVISOR: V. FITZGERALD

DEPTH ft. BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft. AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE STATE	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
37.5			WELL SCREEN				
40.0			SAND PACK				
42.5			6" Ø BOREHOLE				
45.0	END OF HOLE @ 45ft BGS	710.9					
47.5							
50.0							
52.5							
55.0							
57.5							
60.0							
62.5							
65.0							
67.5							



SCREEN DETAILS
Screened Interval:
35 to 45ft BGS
Length: 10.0ft
Diameter: 2"
Slot Size: #10
Material: PVC
Sand Pack:
32 to 45ft BGS
Material: #00N Sand

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE
WATER FOUND ▼ STATIC WATER LEVEL ▼

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: FOUR COUNTY LANDFILL
PROJECT NUMBER: 5369-51
CLIENT:
LOCATION:

HOLE DESIGNATION: MW103
DATE COMPLETED: MARCH 19, 1996
DRILLING METHOD: 6" Ø ROTOSONIC
CRA SUPERVISOR: V. FITZGERALD

DEPTH ft. BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft. AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE STATE	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
	REFERENCE POINT (Top of Riser)	758.10					
	GROUND SURFACE	756.0					
	CL-CLAY, brown, wet		CONCRETE SEAL				
	- little sand						
2.5				1CS			0
	- no sand, black, little orgaincs						
5.0	- No recovery						
7.5				2CS			--
10.0			2" Ø PVC PIPE				
12.5				3CS			0
	- little silt, trace gravel, brown with orange and gray mottling, damp						
15.0	- some silt, gray						
17.5				4CS			0
20.0			CEMENT/ BENTONITE GROUT				
22.5	ML-SILT, little clay, trace gravel, gray, dry	733.5		5CS			0
25.0							
27.5				6CS			0
30.0			6" Ø BOREHOLE				
	SP-SAND, some silt, little gravel, fine grained, gray, moist	725.0					
32.5				7CS			0

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE
WATER FOUND ▼ STATIC WATER LEVEL ▼

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: FOUR COUNTY LANDFILL
PROJECT NUMBER: 5369-51
CLIENT:
LOCATION:

HOLE DESIGNATION: MW103
DATE COMPLETED: MARCH 19, 1996
DRILLING METHOD: 6" Ø ROTOSONIC
CRA SUPERVISOR: V. FITZGERALD

DEPTH ft. BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft. AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE STATE	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
		720.0					
37.5	SW-SAND, little gravel, fine to coarse grained, brown, moist			8CS			0
		717.0					
40.0	ML-SILT, gray, moist		CEMENT/ BENTONITE GROUT				
		715.0					
42.5	SW-SAND, little gravel, fine to coarse grained, brown, moist			9CS			0
		712.0					
45.0	ML-SILT, gray, moist - wet - 5" SW-SAND seam, fine to coarse grained, gray, wet						
47.5				10CS			0
50.0			2" Ø PVC PIPE				
52.5				11CS			0
		702.5					
55.0	SW-SAND, fine to coarse grained, gray, vey moist						
		700.5					
57.5	ML-SILT, some fine grained sand, gray, wet - no sand			12CS			0
60.0			6" Ø BOREHOLE				
62.5				13CS			0
		691.5					
65.0	SP-SAND, little silt, fine grained, gray, very moist	691.0					
	SW-SAND, fine to medium grained, tan, wet						
67.5				14CS			0

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE
WATER FOUND ▼ STATIC WATER LEVEL ▼

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: FOUR COUNTY LANDFILL
PROJECT NUMBER: 5369-51
CLIENT:
LOCATION:

HOLE DESIGNATION: MW103
DATE COMPLETED: MARCH 19, 1996
DRILLING METHOD: 6" Ø ROTOSONIC
CRA SUPERVISOR: V. FITZGERALD

DEPTH ft. BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft. AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE STATE	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
72.5	- f ML-SILT seam, gray, moist		BENTONITE PELLETS	15CS			0
75.0	SW-SAND, trace gravel, fine to coarse grained, tan, very moist	681.0	SAND PACK				
77.5				16CS			0
80.0	- fine to medium grained		WELL SCREEN				
82.5				17CS			0
85.0			6" Ø BOREHOLE				
87.5				18CS			0
90.0	END OF HOLE @ 90ft BGS	666.0					
92.5							
95.0							
97.5							
100.0							
102.5							

SCREEN DETAILS
Screened interval:
75 to 85ft BGS
Length: 10.0ft
Diameter: 2"
Slot Size: #10
Material: PVC
Sand Pack:
72 to 90ft BGS
Material: #00N Sand

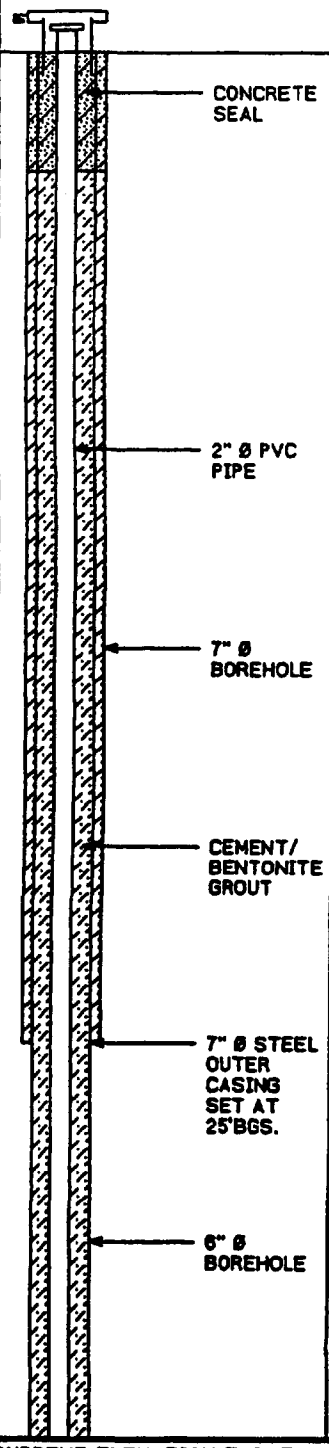
NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE
WATER FOUND ▼ STATIC WATER LEVEL ▼

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: FOUR COUNTY LANDFILL
PROJECT NUMBER: 5369-51
CLIENT:
LOCATION:

HOLE DESIGNATION: MW104
DATE COMPLETED: MARCH 22, 1996
DRILLING METHOD: 6" Ø ROTOSONIC
CRA SUPERVISOR: K. DUWAL

DEPTH ft. BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft. AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE STATE	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
	REFERENCE POINT (Top of Riser) GROUND SURFACE	*773.00* *771.2*					
	For stratigraphic details, please see MW-105.						
2.5							
5.0							
7.5							
10.0							
12.5							
15.0							
17.5							
20.0							
22.5							
25.0	Set 7" diameter outer steel casing at 25 bgs.	*746.2*					
27.5							
30.0							
32.5							



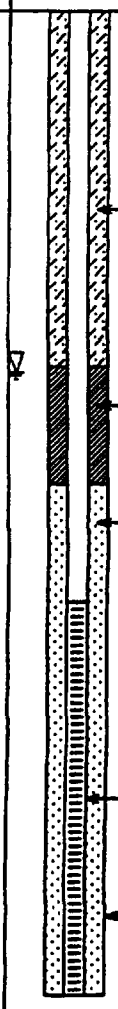
NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE
WATER FOUND ⚳ STATIC WATER LEVEL ⚳

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: FOUR COUNTY LANDFILL
PROJECT NUMBER: 5369-51
CLIENT:
LOCATION:

HOLE DESIGNATION: MW104
DATE COMPLETED: MARCH 22, 1996
DRILLING METHOD: 6" Ø ROTOSONIC
CRA SUPERVISOR: K. DUWAL

DEPTH ft. BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft. AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE STATE	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
37.5							
40.0			CEMENT/ BENTONITE GROUT				
42.5							
45.0			BENTONITE PELLETS				
47.5			SAND PACK				
50.0							
52.5							
55.0			WELL SCREEN				
57.5			6" Ø BOREHOLE				
60.0	END OF HOLE @ 60ft BGS	711.2					
62.5							
65.0							
67.5							



SCREEN DETAILS
Screened Interval:
50 to 60ft BGS
Length: 10.01t
Diameter: 2"
Slot Size: #10
Material: PVC
Sand Pack:
47 to 60ft BGS
Material: #00N Sand

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE
WATER FOUND ▼ STATIC WATER LEVEL ▼

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: FOUR COUNTY LANDFILL
PROJECT NUMBER: 5369-51
CLIENT:
LOCATION:

HOLE DESIGNATION: MW105
DATE COMPLETED: MARCH 21, 1996
DRILLING METHOD: 6" Ø ROTOSONIC
CRA SUPERVISOR: K. DUWAL

DEPTH ft. BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft. AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE STATE	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
	REFERENCE POINT (Top of Riser) GROUND SURFACE	*773.74* *771.8*					
	CL-CLAY, some silt, firm, low plasticity, brown/gray, moist		CONCRETE SEAL				
2.5				1CS			0
	- 3" silt seam						
5.0	- trace gravel and pebbles						
	- little gravel and pebbles up to 1" in diamter, silty						
7.5				2CS			0.2
	- trace root fragments						
10.0			2" Ø PVC PIPE				
	- clay color grades to gray						
12.5				3CS			1.0
15.0	- gray clay, some silt, trace sand and gravel, moist		7" Ø BOREHOLE				
	1" seam of brown sand and gravel						
17.5				4CS			0.8
20.0			CEMENT/ BENTONITE GROUT				
	- softer clay, little sand more brown color						
22.5	SP-SAND, little to some silt, trace gravel, fine to medium grained, moist, brown	*749.8*		5CS			2.1
	6" seam of brown silt with clay, wet to saturated						
25.0	- whitish colored sand	*748.3*	7" Ø STEEL OUTER CASING SET AT 25'BGS.				
	ML-SILT, some very fine sand, whitish-brown						
27.5				6CS			0.8
	- 6" seam pf very fine sand						
30.0	- trace to little clay, trace gravel		6" Ø BOREHOLE				
32.5				7CS			0.6

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE
WATER FOUND ▼ STATIC WATER LEVEL ▼

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: FOUR COUNTY LANDFILL
PROJECT NUMBER: 5369-51
CLIENT:
LOCATION:

HOLE DESIGNATION: MW105
DATE COMPLETED: MARCH 21, 1996
DRILLING METHOD: 6" Ø ROTOSONIC
CRA SUPERVISOR: K. DUWAL

DEPTH ft. BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft. AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE STATE	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
	- 1' layer of fine sand						
37.5				8CS			0.7
40.0	- 2' layer of silty-clay, brown, saturated						
			CEMENT/ BENTONITE GROUT				
42.5				9CS			0.2
45.0							
47.5	- grading to sand, more gray color, saturated			10CS			0.4
	SP-SAND little silt, fine grained, gray, saturated	722.8					
50.0			2" Ø PVC PIPE				
52.5	- less silt, slightly coarser grained			11CS			0
55.0							
57.5				12CS			0
60.0			6" Ø BOREHOLE				
62.5				13CS			0
	- coarser grained						
65.0							
	- fine to medium grained sand, saturated						
67.5				14CS			0

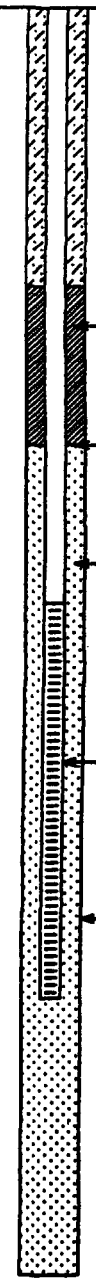
NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE
WATER FOUND ▼ STATIC WATER LEVEL ▼

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: FOUR COUNTY LANDFILL
PROJECT NUMBER: 5369-51
CLIENT:
LOCATION:

HOLE DESIGNATION: MW105
DATE COMPLETED: MARCH 21, 1996
DRILLING METHOD: 6" Ø ROTOSONIC
CRA SUPERVISOR: K. DUWAL

DEPTH ft. BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft. AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE STATE	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
72.5	- medium grained, gray, saturated			15CS			0
75.0	- coarse sand and gravel						
77.5	GW-GRAVEL, some sand, saturated, up to 1" diameter pebbles	694.8	BENTONITE PELLETS	16CS			0.2
80.0			BENTONITE PELLETS				
82.5			SAND PACK	16CS			0.2
85.0	- large pebbles up to 3" in diameter						
87.5							
90.0			WELL SCREEN	17CS			0.1
92.5	SP-SAND fine to medium grained, gray, saturated	679.8	6" Ø BOREHOLE				
95.0							
97.5							
100.0							
102.5	END OF HOLE @ 102ft BGS	669.8					



SCREEN DETAILS
Screened interval:
85 to 95ft BGS
Length: 10.0ft
Diameter: 2"
Slot Size: .010
Material: PVC
Sand Pack:
81 to 102ft BGS
Material: #00N Sand

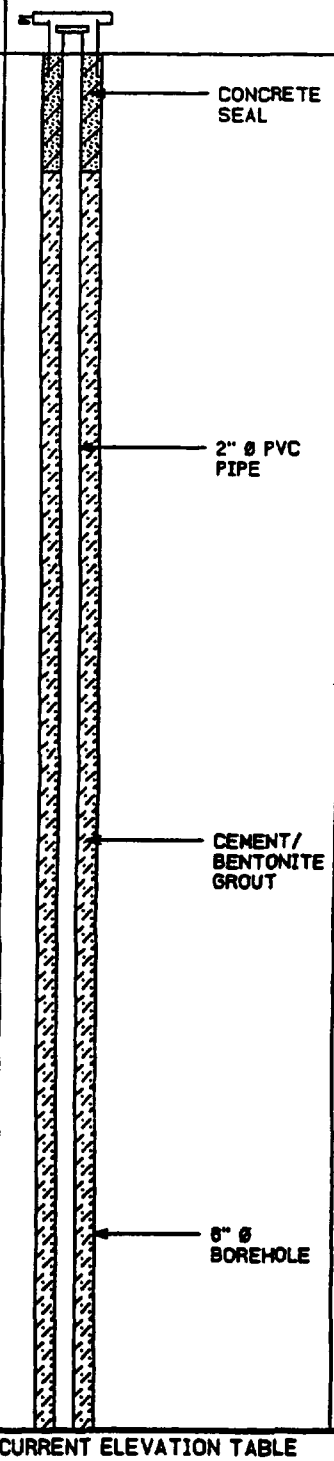
NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE
WATER FOUND ▼ STATIC WATER LEVEL ▼

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: FOUR COUNTY LANDFILL
PROJECT NUMBER: 5369-51
CLIENT:
LOCATION:

HOLE DESIGNATION: MW106
DATE COMPLETED: MARCH 26, 1996
DRILLING METHOD: 6" Ø ROTOSONIC
CRA SUPERVISOR: V. FITZGERALD

DEPTH ft. BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft. AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE STATE	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
	REFERENCE POINT (Top of Riser) GROUND SURFACE	*768.12* *766.1*					
	For stratigrphic details, please refer to MW-107.						
2.5							
5.0							
7.5							
10.0							
12.5							
15.0							
17.5							
20.0							
22.5							
25.0							
27.5							
30.0							
32.5							



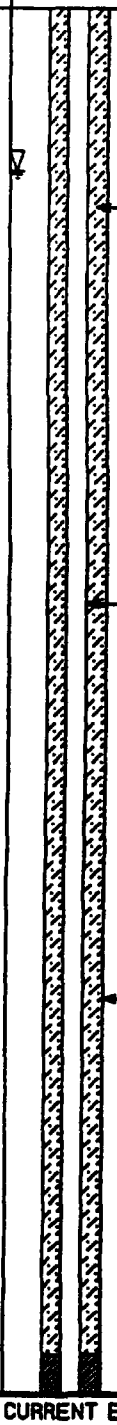
NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE
WATER FOUND ▼ STATIC WATER LEVEL ▼

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: FOUR COUNTY LANDFILL
PROJECT NUMBER: 5369-51
CLIENT:
LOCATION:

HOLE DESIGNATION: MW106
DATE COMPLETED: MARCH 26, 1996
DRILLING METHOD: 6" Ø ROTOSONIC
CRA SUPERVISOR: V. FITZGERALD

DEPTH ft. BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft. AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE STATE	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
37.5							
40.0			CEMENT/ BENTONITE GROUT				
42.5							
45.0							
47.5							
50.0			2" Ø PVC PIPE				
52.5							
55.0							
57.5							
60.0			6" Ø BOREHOLE				
62.5							
65.0							
67.5							

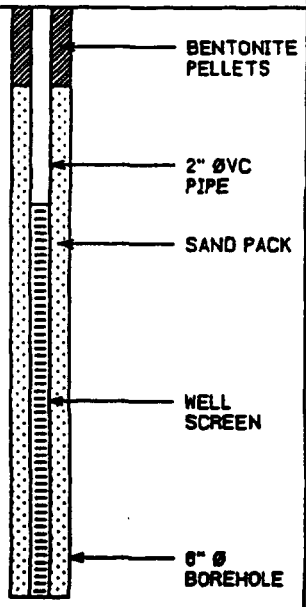


NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE
WATER FOUND ▼ STATIC WATER LEVEL ▼

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: FOUR COUNTY LANDFILL -
PROJECT NUMBER: 5369-51
CLIENT:
LOCATION:

HOLE DESIGNATION: MW106
DATE COMPLETED: MARCH 26, 1996
DRILLING METHOD: 6" Ø ROTOSONIC
CRA SUPERVISOR: V. FITZGERALD

DEPTH ft. BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft. AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE STATE	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
72.5							
75.0							
77.5							
80.0							
82.5							
85.0	END OF HOLE @ 85ft BGS	681					
87.5							
90.0							
92.5							
95.0							
97.5							
100.0							
102.5							

SCREEN DETAILS
Screened Interval:
75 to 85ft BGS
Length: 10.0ft
Diameter: 2"
Slot Size: #10
Material: PVC
Sand Pack:
72 to 85ft BGS
Material: #00N Sand

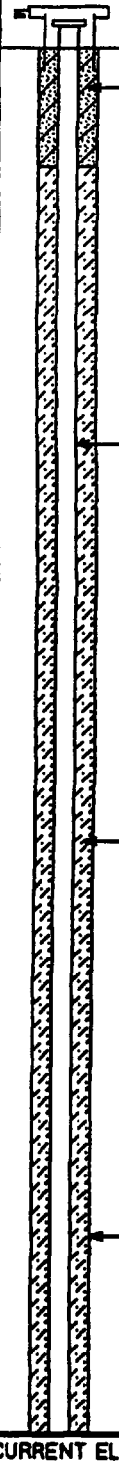
NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE
WATER FOUND ▼ STATIC WATER LEVEL ▼

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: FOUR COUNTY LANDFILL
PROJECT NUMBER: 5369-51
CLIENT:
LOCATION:

HOLE DESIGNATION: MW107
DATE COMPLETED: MARCH 25, 1996
DRILLING METHOD: 6" Ø ROTOSONIC
CRA SUPERVISOR: V. FITZGERALD

DEPTH ft. BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft. AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE STATE	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
	REFERENCE POINT (Top of Riser) GROUND SURFACE	*768.43* *766.3*					
	CL-CLAY, trace gravel, brown, wet		CONCRETE SEAL				
2.5		*763.3*		1CS			0
	ML-SILT, brown, moist to dry						
5.0							
7.5		*757.8*		2CS			0
	SW-SAND, fine to coarse grained, brown, dry						
10.0	- trace gravel, moist		2" Ø PVC PIPE				
12.5				3CS			0.2
15.0	- no gravel, fine to medium grained, dry						
17.5				4CS			0.2
20.0			CEMENT/ BENTONITE GROUT				
	SP-SAND, fine grained, brown, dry	*745.3*					
22.5		*743.3*		5CS			0.3
	ML-SILT, brown, dry						
25.0	- damp						
27.5				6CS			0
30.0			6" Ø BOREHOLE				
	SW-SAND, trace gravel, fine to coarse grained, brown, dry	*735.3*					
32.5				7CS			0



NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE
WATER FOUND ▼ STATIC WATER LEVEL ▼

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: FOUR COUNTY LANDFILL
PROJECT NUMBER: 5369-51
CLIENT:
LOCATION:

HOLE DESIGNATION: MW107
DATE COMPLETED: MARCH 25, 1996
DRILLING METHOD: 6" Ø ROTOSONIC
CRA SUPERVISOR: V. FITZGERALD

DEPTH ft. BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft. AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE STATE	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
	ML-SILT, brown, moist	731.3					
37.5				8CS			0
40.0	SP-SAND, fine grained, brown, wet	726.3	CEMENT/ BENTONITE GROUT				
42.5	ML-SILT, brown, moist	724.3		9CS			0
	- gray						
45.0	SP-SAND, fine grained, gray, wet	721.3					
47.5				10CS			0
	ML-SILT, gray, dry	717.3					
50.0	SW-SAND, fine to medium grained, gray, moist	716.8	2" Ø PVC PIPE				
52.5				11CS			0
55.0	- very moist						
57.5				12CS			0
60.0			6" Ø BOREHOLE				
62.5				13CS			0
65.0	- fine to coarse grained						
67.5				14CS			0

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE: REFER TO CURRENT ELEVATION TABLE
WATER FOUND ▼ STATIC WATER LEVEL ▼

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: FOUR COUNTY LANDFILL
PROJECT NUMBER: 5369-51
CLIENT:
LOCATION:

HOLE DESIGNATION: MW107
DATE COMPLETED: MARCH 25, 1996
DRILLING METHOD: 6" Ø ROTOSONIC
CRA SUPERVISOR: V. FITZGERALD

DEPTH ft. BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft. AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE STATE	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
	~~fine to medium grained, brown~~						
72.5				15CS			0
75.0	- wet						
77.5	- fine to coarse grained			16CS			0
80.0	- little gravel		CEMENT/ BENTONITE GROUT				
82.5				17CS			0
85.0							
87.5				18CS			0
90.0			2" Ø PVC PIPE				
92.5				19CS			0
95.0	- some gravel						
97.5				20CS			0
100.0	- No recovery		6" Ø BOREHOLE				
102.5				21CS			—

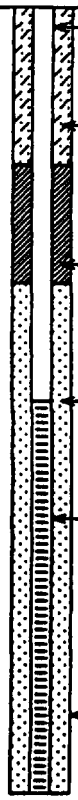
NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE
WATER FOUND ▼ STATIC WATER LEVEL ▼

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: FOUR COUNTY LANDFILL
PROJECT NUMBER: 5369-51
CLIENT:
LOCATION:

HOLE DESIGNATION: MW107
DATE COMPLETED: MARCH 25, 1996
DRILLING METHOD: 6" Ø ROTOSONIC
CRA SUPERVISOR: V. FITZGERALD

DEPTH ft. BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft. AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE STATE	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
	~~trace gravel~~						
107.5			2" Ø PVC PIPE; CEMENT/ BENOTONITE GROUT	22CS			0
110.0							
112.5			BENTONITE PELLETS	23CS			0
115.0			SAND PACK				
117.5			WELL SCREEN	24CS			0
120.0							
122.5			6" Ø BOREHOLE	25CS			0
125.0	END OF HOLE @ 125ft BGS	841.3					
127.5							
130.0							
132.5							
135.0							
137.5							



SCREEN DETAILS
Screened Interval:
115 to 125ft BGS
Length: 10.0ft
Diameter: 2"
Slot Size: #10
Material: PVC
Sand Pack:
112 to 125ft BGS
Material: #00N Sand

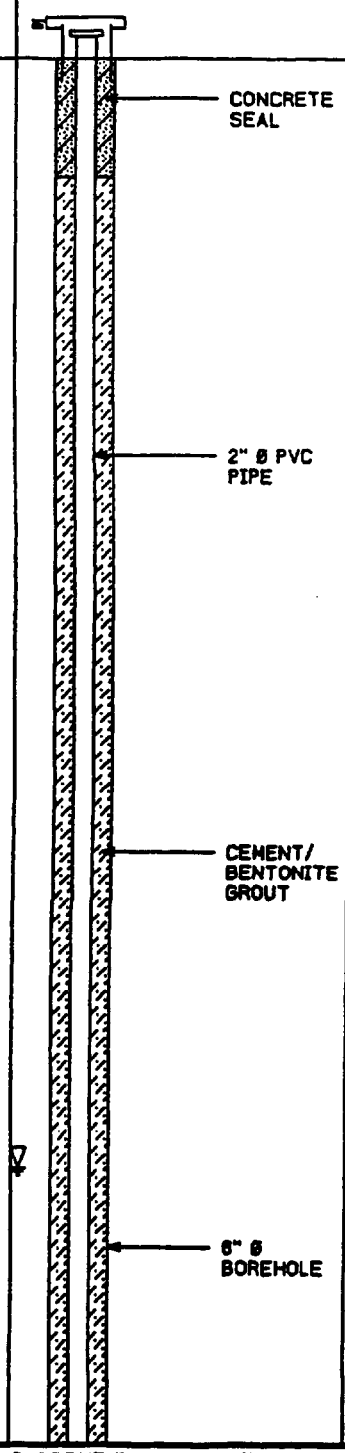
NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE
WATER FOUND ▼ STATIC WATER LEVEL ▼

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: FOUR COUNTY LANDFILL
PROJECT NUMBER: 5369-51
CLIENT:
LOCATION:

HOLE DESIGNATION: MW108
DATE COMPLETED: APRIL 1, 1996
DRILLING METHOD: 6" Ø ROTOSONIC
CRA SUPERVISOR: V. FITZGERALD

DEPTH ft. BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft. AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE STATE	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
	REFERENCE POINT (Top of Riser) GROUND SURFACE	*756.87* *755.0*					
	For stratigraphic details, please refer to MW-109.						
-2.5							
-5.0							
-7.5							
-10.0							
-12.5							
-15.0							
-17.5							
-20.0							
-22.5							
-25.0							
-27.5							
-30.0							
-32.5							



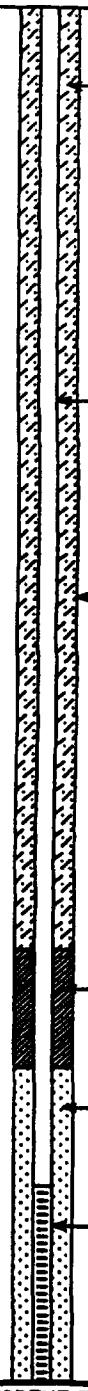
NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE
WATER FOUND ▼ STATIC WATER LEVEL ▼

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: FOUR COUNTY LANDFILL
PROJECT NUMBER: 5369-51
CLIENT:
LOCATION:

HOLE DESIGNATION: MW108
DATE COMPLETED: APRIL 1, 1996
DRILLING METHOD: 6" Ø ROTOSONIC
CRA SUPERVISOR: V. FITZGERALD

DEPTH ft. BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft. AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE STATE	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
37.5			CEMENT/ BENTONITE GROUT				
40.0							
42.5							
45.0			2" Ø PVC PIPE				
47.5							
50.0			6" Ø BOREHOLE				
52.5							
55.0							
57.5							
60.0			BENTONITE PELLETS				
62.5			SAND PACK				
65.0			WELL SCREEN				
67.5							

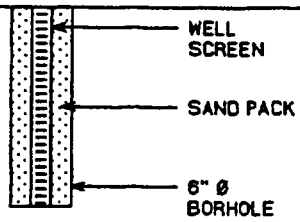


NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE
WATER FOUND ⊽ STATIC WATER LEVEL ⊽

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: FOUR COUNTY LANDFILL
PROJECT NUMBER: 5369-51
CLIENT:
LOCATION:

HOLE DESIGNATION: MW108
DATE COMPLETED: APRIL 1, 1996
DRILLING METHOD: 6" Ø ROTOSONIC
CRA SUPERVISOR: V. FITZGERALD

DEPTH ft. BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft. AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE STATE	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
72.5							
75.0	END OF HOLE @ 75ft BGS	680.0	SCREEN DETAILS Screened interval: 65 to 75ft BGS Length: 10.0ft Diameter: 2" Slot Size: #10 Material: PVC Sand Pack: 62 to 75ft BGS Material: #00N Sand				
77.5							
80.0							
82.5							
85.0							
87.5							
90.0							
92.5							
95.0							
97.5							
100.0							
102.5							

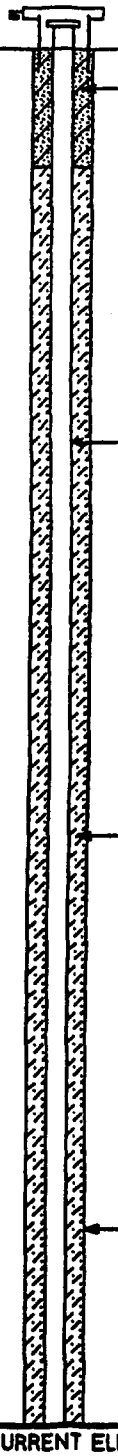
NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE
WATER FOUND ▼ STATIC WATER LEVEL ▼

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: FOUR COUNTY LANDFILL
PROJECT NUMBER: 5369-51
CLIENT:
LOCATION:

HOLE DESIGNATION: MW109
DATE COMPLETED: MARCH 27, 1996
DRILLING METHOD: 6" Ø ROTOSONIC
CRA SUPERVISOR: V. FITZGERALD

DEPTH ft. BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft. AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE STATE	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
	REFERENCE POINT (Top of Riser) GROUND SURFACE	756.89 754.7					
	CL-CLAY, brown, moist, trace organics		CONCRETE SEAL				
2.5				1CS			0
5.0							
7.5	SW-SAND, fine to medium grained, gray brown, wet	747.7 747.2		2CS			0
	CL-CLAY, black, wet, some peat						
10.0	PT-PEAT, black and brown, moist	744.7	2" Ø PVC PIPE				
12.5				3CS			0
15.0	- brown						
17.5				4CS			0
20.0			CEMENT/ BENTONITE GROUT				
22.5	CL-CLAY, black, very moist	732.2		5CS			0
25.0	- gray						
27.5				6CS			0
30.0			6" Ø BOREHOLE				
32.5				7CS			0



NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE
WATER FOUND ⊻ STATIC WATER LEVEL ⊻

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: FOUR COUNTY LANDFILL
PROJECT NUMBER: 5369-51
CLIENT:
LOCATION:

HOLE DESIGNATION: MW109
DATE COMPLETED: MARCH 27, 1996
DRILLING METHOD: 6" Ø ROTOSONIC
CRA SUPERVISOR: V. FITZGERALD

DEPTH ft. BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft. AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE STATE	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
	ML-SILT, some clay, trace gravel, gray, moist	719.7					
37.5				8CS			0
40.0			CEMENT/ BENTONITE GROUT				
42.5				9CS			0
45.0							
47.5				10CS			0
50.0			2" Ø PVC PIPE				
52.5				11CS			0
55.0							
57.5				12CS			0
60.0	SW-SAND, trace gravel, fine to coarse grained, gray, wet	695.7	6" Ø BOREHOLE				
62.5				13CS			0
65.0							
67.5				14CS			0

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE
WATER FOUND ▼ STATIC WATER LEVEL ▼

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: FOUR COUNTY LANDFILL
PROJECT NUMBER: 5369-51
CLIENT:
LOCATION:

HOLE DESIGNATION: MW109
DATE COMPLETED: MARCH 27, 1996
DRILLING METHOD: 6" Ø ROTOSONIC
CRA SUPERVISOR: V. FITZGERALD

DEPTH ft. BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft. AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE STATE	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
	~~fine to medium grained, tan~~						
72.5				15CS			0
	ML-SILT, tan, moist	681.7					
	SP-SAND, fine grained, tan, wet	680.7					
75.0	ML-SILT, gray, moist	679.7					
77.5				16CS			0
80.0	SW-SAND, fine to coarse grained, gray, wet	674.7	CEMENT/ BENTONITE GROUT				
82.5	- fine to medium grained, tan			17CS			0
85.0	SP-SAND, fine grained, gray, wet	669.7					
87.5				18CS			0
90.0	ML-SILT, gray, moist	664.7	2" Ø PVC PIPE				
92.5				19CS			0
95.0	SP-SAND, fine grained, gray, wet	659.7					
97.5				20CS			0
100.0	ML-SILT, gray, moist	654.7	6" Ø BOREHOLE				
102.5	SW-SAND, fine to medium grained, gray, wet	651.7		21CS			0

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE: REFER TO CURRENT ELEVATION TABLE
WATER FOUND ▼ STATIC WATER LEVEL ▼

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: FOUR COUNTY LANDFILL
PROJECT NUMBER: 5369-51
CLIENT:
LOCATION:

HOLE DESIGNATION: MW109
DATE COMPLETED: MARCH 27, 1996
DRILLING METHOD: 6" Ø ROTOSONIC
CRA SUPERVISOR: V. FITZGERALD

DEPTH ft. BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft. AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE STATE	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
	ML-SILT, gray, damp	~~649.7~~					
	SP-SAND, fine grained, gray, moist	648.7	CEMENT/ BENTONITE GROUT				
107.5				22CS			0
110.0			BENTONITE PELLETS				
112.5			SAND PACK	23CS			0
115.0	- wet to saturated						
117.5			WELL SCREEN	24CS			0
120.0	- No recovery						
			6" Ø BOREHOLE				
122.5				25CS			—
125.0	END OF HOLE @ 125ft BGS	629.7					
127.5							
130.0							
132.5							
135.0							
137.5							

SCREEN DETAILS
Screened Interval:
115 to 125ft BGS
Length: 10.0ft
Diameter: 2"
Slot Size: #10
Material: PVC
Sand Pack:
112 to 125ft BGS
Material: #00N Sand

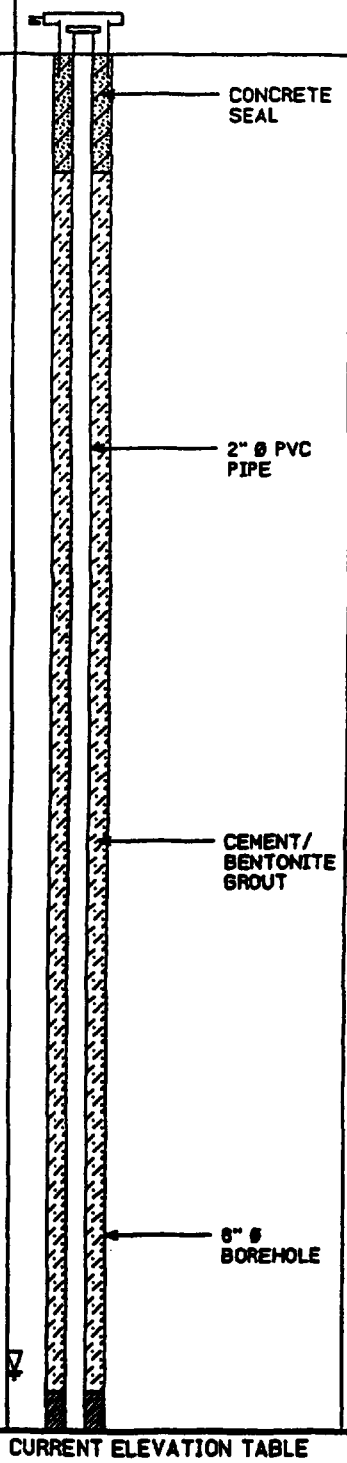
NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE
WATER FOUND ⊽ STATIC WATER LEVEL ⊽

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: FOUR COUNTY LANDFILL
PROJECT NUMBER: 5369-51
CLIENT:
LOCATION:

HOLE DESIGNATION: MW110
DATE COMPLETED: APRIL 3, 1996
DRILLING METHOD: 6" Ø ROTOSONIC
CRA SUPERVISOR: V. FITZGERALD

DEPTH ft. BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft. AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE STATE	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
	REFERENCE POINT (Top of Riser) GROUND SURFACE	*762.72* *760.5*					
	For stratigraphic details, please refer to MW-112.						
2.5							
5.0							
7.5							
10.0							
12.5							
15.0							
17.5							
20.0							
22.5							
25.0							
27.5							
30.0							
32.5							



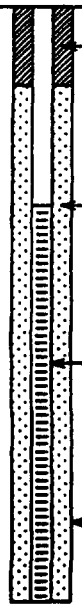
NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE
WATER FOUND ▼ STATIC WATER LEVEL ▼

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: FOUR COUNTY LANDFILL
PROJECT NUMBER: 5369-51
CLIENT:
LOCATION:

HOLE DESIGNATION: MW110
DATE COMPLETED: APRIL 3, 1996
DRILLING METHOD: 6" Ø ROTOSONIC
CRA SUPERVISOR: V. FITZGERALD

DEPTH ft. BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft. AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE STATE	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
37.5			BENTONITE PELLETS				
40.0			SAND PACK				
42.5							
45.0			WELL SCREEN				
47.5			6" Ø BOREHOLE				
50.0	END OF HOLE @ 50ft BGS	710.5					
52.5							
55.0							
57.5							
60.0							
62.5							
65.0							
67.5							



SCREEN DETAILS
Screened Interval:
40 to 50ft BGS
Length: 10.0ft
Diameter: 2"
Slot Size: #10
Material: PVC
Sand Pack:
37 to 50ft BGS
Material: #00N Sand

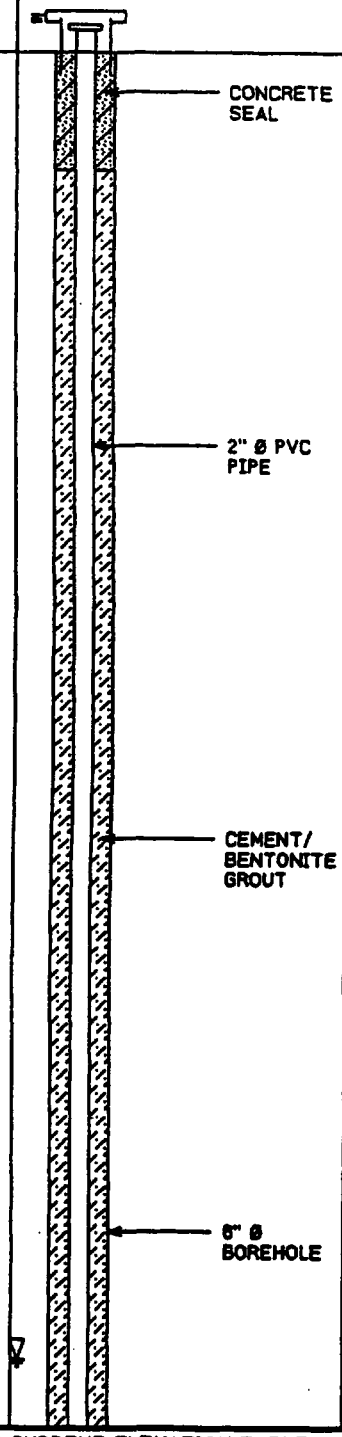
NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE
WATER FOUND ▼ STATIC WATER LEVEL ▼

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: FOUR COUNTY LANDFILL
PROJECT NUMBER: 5369-51
CLIENT:
LOCATION:

HOLE DESIGNATION: MW111
DATE COMPLETED: APRIL 3, 1996
DRILLING METHOD: 6" Ø ROTOSONIC
CRA SUPERVISOR: V. FITZGERALD

DEPTH ft. BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft. AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE STATE	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
	REFERENCE POINT (Top of Riser) GROUND SURFACE	*762.49* *760.3*					
	For stratigraphic details, please refer to MW-112.						
2.5							
5.0							
7.5							
10.0							
12.5							
15.0							
17.5							
20.0							
22.5							
25.0							
27.5							
30.0							
32.5							



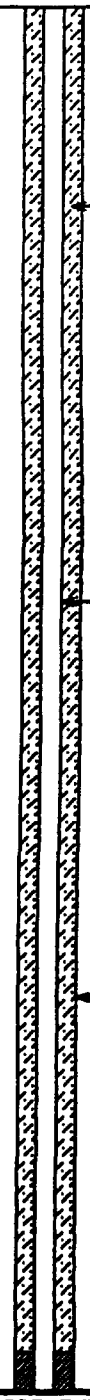
NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE
WATER FOUND ▼ STATIC WATER LEVEL ▼

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: FOUR COUNTY LANDFILL
PROJECT NUMBER: 5369-51
CLIENT:
LOCATION:

HOLE DESIGNATION: MW111
DATE COMPLETED: APRIL 3, 1996
DRILLING METHOD: 6" Ø ROTOSONIC
CRA SUPERVISOR: V. FITZGERALD

DEPTH ft. BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft. AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	STATE	'N' VALUE	PID (ppm)
37.5							
40.0			CEMENT/ BENTONITE GROUT				
42.5							
45.0							
47.5							
50.0			2" Ø PVC PIPE				
52.5							
55.0							
57.5							
60.0			6" Ø BOREHOLE				
62.5							
65.0							
67.5							



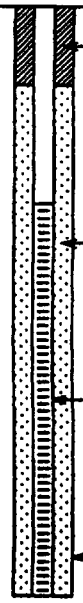
NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE
WATER FOUND ▼ STATIC WATER LEVEL ▼

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: FOUR COUNTY LANDFILL
PROJECT NUMBER: 5369-51
CLIENT:
LOCATION:

HOLE DESIGNATION: MW111
DATE COMPLETED: APRIL 3, 1996
DRILLING METHOD: 6" Ø ROTOSONIC
CRA SUPERVISOR: V. FITZGERALD

DEPTH ft. BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft. AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE STATE	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
72.5			BENTONITE PELLETS				
75.0			SAND PACK				
77.5							
80.0			WELL SCREEN				
82.5			6" Ø BOREHOLE				
85.0	END OF HOLE @ 85ft BGS	675.3					
87.5							
90.0							
92.5							
95.0							
97.5							
100.0							
102.5							



SCREEN DETAILS
Screened Interval:
75 to 85ft BGS
Length: 10.0ft
Diameter: 2"
Slot Size: #10
Material: PVC
Sand Pack:
72 to 85ft BGS
Material: #00N Sand

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE
WATER FOUND ▼ STATIC WATER LEVEL ▼

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: FOUR COUNTY LANDFILL
PROJECT NUMBER: 5369-51
CLIENT:
LOCATION:

HOLE DESIGNATION: MW112
DATE COMPLETED: APRIL 2, 1996
DRILLING METHOD: 6" Ø ROTOSONIC
CRA SUPERVISOR: V. FITZGERALD

DEPTH ft. BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft. AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE STATE	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
	REFERENCE POINT (Top of Riser) GROUND SURFACE	761.70 759.6					
	CL-CLAY, little silt, brown to dark brown, dry		CONCRETE SEAL				
2.5		756.6		1CS			0.2
	SP-SAND, medium grained, brown, dry	756.1					
	ML-SILT, little clay, dark brown, damp						
5.0		754.6					
	CL-CLAY, little sand, black to brown, moist - no sand, trace gravel, gray brown						
7.5				2CS			0.2
10.0	- gray, damp		2" Ø PVC PIPE				
12.5				3CS			0
15.0	- some silt, gray with orange mottling						
17.5				4CS			0.6
20.0		739.6	CEMENT/ BENTONITE GROUT				
	ML-SILT, trace gravel, gray, dry						
22.5				5CS			0.2
25.0		734.6					
	CL-CLAY, trace gravel, gray, moist						
		732.6					
27.5	ML-SILT, little clay and sand, trave gravel, brown gray, dry			6CS			0
30.0		729.6	6" Ø BOREHOLE				
	SW-SAND, trace gravel, fine to coarse grained, yellow brown, dry - tan						
32.5				7CS			0.1

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE
WATER FOUND ▼ STATIC WATER LEVEL ▼

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: FOUR COUNTY LANDFILL
PROJECT NUMBER: 5369-51
CLIENT:
LOCATION:

HOLE DESIGNATION: MW112
DATE COMPLETED: APRIL 2, 1996
DRILLING METHOD: 6" Ø ROTOSONIC
CRA SUPERVISOR: V. FITZGERALD

DEPTH ft. BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft. AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE STATE	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
	SP-SAND, fine grained, tan, wet	724.6					
	SW-SAND, trace gravel, fine to coarse grained, black, wet to saturated	723.6					
37.5				8CS			0.3
40.0	SP-SAND, fine grained, gray brown, wet to saturated	719.6	CEMENT/ BENTONITE GROUT				
42.5				9CS			0.1
45.0	ML-SILT, gray, wet	714.6					
	SP-SAND, fine grained, gray, wet	713.1					
47.5	SW-SAND, trace gravel, fine to coarse grained, gray, wet	712.1		10CS			0.4
	SP-SAND, fine grained, gray, wet	711.1					
50.0			2" Ø PVC PIPE				
52.5				11CS			0.1
	ML-SILT, gray, moist	705.6					
55.0	SP-SAND, fine grained, gray, saturated	704.6					
57.5				12CS			0
60.0			6" Ø BOREHOLE				
62.5				13CS			0
	ML-SILT, gray, very moist	698.6					
	SP-SAND, fine grained, gray, wet	695.6					
65.0							
67.5				14CS			0.1

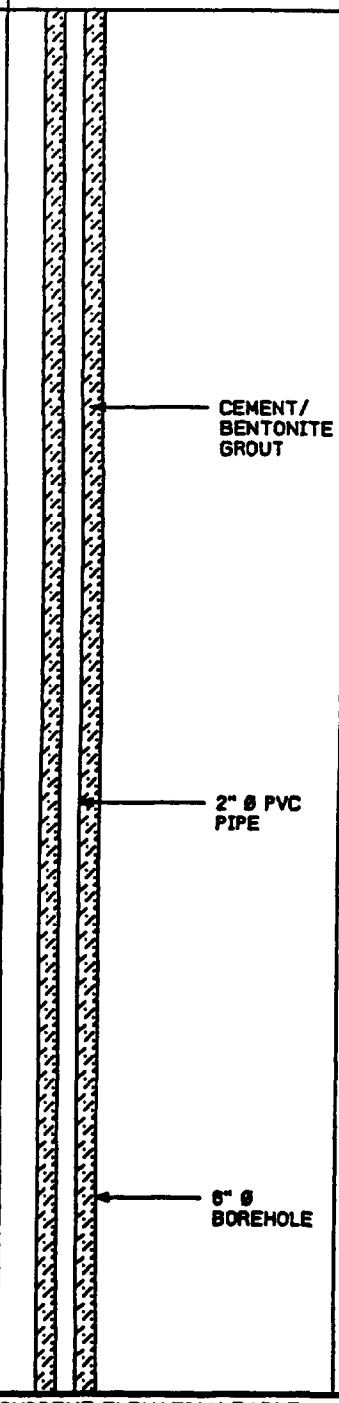
NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE
WATER FOUND ▼ STATIC WATER LEVEL ▼

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: FOUR COUNTY LANDFILL
PROJECT NUMBER: 5369-51
CLIENT:
LOCATION:

HOLE DESIGNATION: MW112
DATE COMPLETED: APRIL 2, 1996
DRILLING METHOD: 6" Ø ROTOSONIC
CRA SUPERVISOR: V. FITZGERALD

DEPTH ft. BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft. AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE STATE	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
72.5				15CS			0.3
75.0	SW-SAND, fine to medium grained, gray, saturated	684.6					
77.5				16CS			0.6
80.0	- trace gravel, fine to coarse grained		CEMENT/ BENTONITE GROUT				
82.5				17CS			0.4
85.0	- No recovery						
87.5				18CS			—
90.0	- No recovery		2" Ø PVC PIPE				
92.5				19CS			—
95.0	- no gravel, brown						
97.5				20CS			0
100.0			6" Ø BOREHOLE				
102.5	SP-SAND fine grained, brown, saturated	656.6		21CS			0



NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE
WATER FOUND ▼ STATIC WATER LEVEL ▼

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: FOUR COUNTY LANDFILL
PROJECT NUMBER: 5369-51
CLIENT:
LOCATION:

HOLE DESIGNATION: MW112
DATE COMPLETED: APRIL 2, 1996
DRILLING METHOD: 6" Ø ROTOSONIC
CRA SUPERVISOR: V. FITZGERALD

DEPTH ft. BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft. AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE STATE	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
	SW-SAND, trace gravel, fine to coarse grained, brown, saturated	654.6	CEMENT/ BENTONITE GROUT				
107.5				22CS			0
110.0			BENTONITE PELLETS				
112.5				23CS			0
			SAND PACK				
115.0	GW-GRAVEL, multi-colored, wet, 1 to 2 inches across	645.1					
117.5				24CS			0
			WELL SCREEN				
120.0	– No recovery						
122.5				25CS			--
			6" Ø BOREHOLE				
125.0	END OF HOLE @ 125ft BGS	634.6					
127.5							
130.0							
132.5							
135.0							
137.5							

SCREEN DETAILS
Screened Interval:
115 to 125ft BGS
Length: 10.0ft
Diameter: 2"
Slot Size: #10
Material: PVC
Sand Pack:
112 to 125ft BGS
Material: #00N Sand

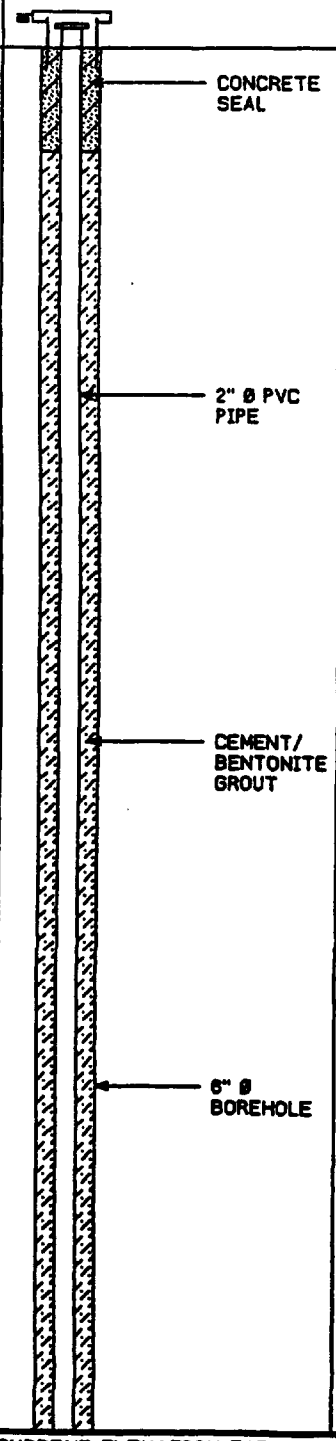
NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE
WATER FOUND ▼ STATIC WATER LEVEL ▼

STRATIGRAPHIC AND INSTRUMENTATION LOG (OVERBURDEN)

PROJECT NAME: FOUR COUNTY LANDFILL
PROJECT NUMBER: 5369-51
CLIENT:
LOCATION:

HOLE DESIGNATION: MW113
DATE COMPLETED: MARCH 24, 1996
DRILLING METHOD: 6" Ø ROTOSONIC
CRA SUPERVISOR: V. FITZGERALD

DEPTH ft. BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft. AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE STATE	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
	REFERENCE POINT (Top of Riser) GROUND SURFACE	*774.57* *772.3*					
	For stratigraphic details, please refer to MW-114.						
-2.5							
-5.0							
-7.5							
-10.0							
-12.5							
-15.0							
-17.5							
-20.0							
-22.5							
-25.0							
-27.5							
-30.0							
-32.5							
-35.0							
-37.5							



NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE
WATER FOUND ▼ STATIC WATER LEVEL ▼

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: FOUR COUNTY LANDFILL
PROJECT NUMBER: 5369-51
CLIENT:
LOCATION:

HOLE DESIGNATION: MW113
DATE COMPLETED: MARCH 24, 1996
DRILLING METHOD: 6" Ø ROTOSONIC
CRA SUPERVISOR: V. FITZGERALD

DEPTH ft. BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft. AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE STATE	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
42.5			CEMENT/ BENTONITE GROUT				
45.0							
47.5			2" Ø PVC PIPE				
50.0			6" Ø BOREHOLE				
52.5							
55.0			BENTONITE PELLETS				
57.5							
60.0			SAND PACK				
62.5							
65.0			WELL SCREEN				
67.5							
70.0	END OF HOLE @ 70ft BGS	702.3					
72.5							
75.0							
77.5							

SCREEN DETAILS
Screened Interval:
60 to 70ft BGS
Length: 10.0ft
Diameter: 2"
Slot Size: #10
Material: PVC
Sand Pack:
57 to 70ft BGS
Material: #00N Sand

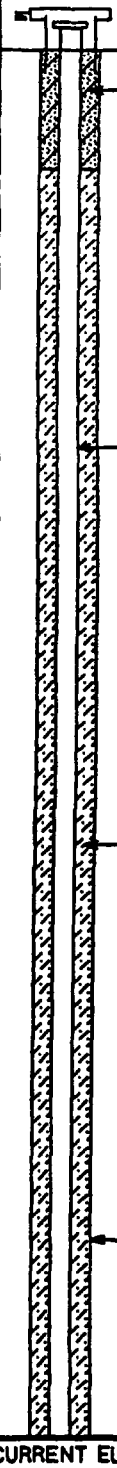
NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE
WATER FOUND ▼ STATIC WATER LEVEL ▼

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: FOUR COUNTY LANDFILL
PROJECT NUMBER: 5369-51
CLIENT:
LOCATION:

HOLE DESIGNATION: MW114
DATE COMPLETED: MARCH 23, 1996
DRILLING METHOD: 6" Ø ROTOSONIC
CRA SUPERVISOR: V. FITZGERALD

DEPTH ft. BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft. AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE STATE	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
	REFERENCE POINT (Top of Riser) GROUND SURFACE	774.12 771.8					
	SC-SAND/CLAY, brown to black, dry, little orgaincs		CONCRETE SEAL				
2.5	CL-CLAY, trace gravel, brown, moist	769.3		1CS			0
5.0	- some silt, gray mottling, damp						
7.5				2CS			0
10.0			2" Ø PVC PIPE				
12.5				3CS			0
15.0	- little sand, gray						
17.5				4CS			0
20.0	ML-SILT, trace gravel, gray, dry	751.8	CEMENT/ BENTONITE GROUT				
22.5				5CS			0
25.0							
27.5				6CS			0
30.0			6" Ø BOREHOLE				
32.5				7CS			0
	SW-SAND, some gravel, fine to coarse grained, brown, dry	738.3					



NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE
WATER FOUND ⚳ STATIC WATER LEVEL ⚳

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: FOUR COUNTY LANDFILL
PROJECT NUMBER: 5369-51
CLIENT:
LOCATION:

HOLE DESIGNATION: MW114
DATE COMPLETED: MARCH 23, 1996
DRILLING METHOD: 6" Ø ROTOSONIC
CRA SUPERVISOR: V. FITZGERALD

DEPTH ft. BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft. AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE STATE	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
	CL-CLAY, little sand, trace gravel, gray, wet	736.8					
37.5				8CS			0
40.0			CEMENT/ BENTONITE GROUT				
42.5	SW-SAND, trace gravel, fine to medium grained, brown, moist	729.8		9CS			0
45.0	- No recovery		▽				
47.5				10CS			--
50.0	SP-SAND, trace gravel, fine grained, brown, wet	721.8	2" Ø PVC PIPE				
	ML-SILT, brown, very moist	720.8					
52.5				11CS			0
	SW-SAND, fine to coarse grained, brown, wet	717.8					
55.0	SP-SAND, medium grained, gray, wet	716.8					
	ML-SILT, brown, wet	715.8					
57.5				12CS			0
	SW-SAND, fine to coarse grained, brown, wet	712.8					
60.0	- gray		6" Ø BOREHOLE				
	SP-SAND, fine grained, brown, wet	710.8					
62.5				13CS			0
65.0							
67.5				14CS			0

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE
WATER FOUND ▽ STATIC WATER LEVEL ▼

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: FOUR COUNTY LANDFILL
PROJECT NUMBER: 5369-51
CLIENT:
LOCATION:

HOLE DESIGNATION: MW114
DATE COMPLETED: MARCH 23, 1996
DRILLING METHOD: 6" Ø ROTOSONIC
CRA SUPERVISOR: V. FITZGERALD

DEPTH ft. BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft. AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE STATE	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
		700.3	CEMENT/ BENTONITE GROUT				
	SW-SAND, fine to medium grained, brown, wet						
72.5				15CS			0
75.0		696.8					
	SP-SAND, trace gravel, fine grained, brown, wet						
		694.8					
77.5	SW-SAND, trace gravel, fine to coarse grained, brown, wet			16CS			0
	- no gravel, fine to medium grained						
80.0			2" Ø PVC PIPE				
	- gray						
82.5				17CS			0
85.0		688.8					
	SP-SAND, fine grained, brown, saturated						
87.5				18CS			0
90.0	- No recovery		6" Ø BOREHOLE				
92.5				19CS			—
95.0			BENTONITE PELLETS				
		674.8					
97.5	SW-SAND, little gravel, fine to coarse grained, brown, saturated			20CS			0
			SAND PACK				
100.0	- No recovery						
102.5			WELL SCREEN	21CS			—

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE
WATER FOUND ▼ STATIC WATER LEVEL ▼

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: FOUR COUNTY LANDFILL
PROJECT NUMBER: 5369-51
CLIENT:
LOCATION:

HOLE DESIGNATION: MW114
DATE COMPLETED: MARCH 23, 1996
DRILLING METHOD: 6" Ø ROTOSONIC
CRA SUPERVISOR: V. FITZGERALD

DEPTH ft. BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft. AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE STATE	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
107.5			SAND PACK	22CS			0.6
110.0			WELL SCREEN				
112.5			6" Ø BOREHOLE	23CS			--
115.0	END OF HOLE @ 115ft BGS	656.8					
117.5							
120.0							
122.5							
125.0							
127.5							
130.0							
132.5							
135.0							
137.5							

SCREEN DETAILS
Screened Interval:
100 to 110ft BGS
Length: 10.0ft
Diameter: 2"
Slot Size: #10
Material: PVC
Sand Pack:
97 to 115ft BGS
Material: #00N Sand

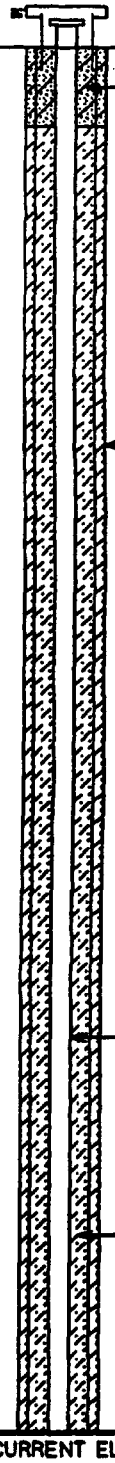
NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE
WATER FOUND ▼ STATIC WATER LEVEL ▼

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: FOUR COUNTY LANDFILL
PROJECT NUMBER: 5369-51
CLIENT:
LOCATION: DELONG, INDIANA

HOLE DESIGNATION: MW115
DATE COMPLETED: AUGUST 14, 1996
DRILLING METHOD: 6" Ø ROTOSONIC
CRA SUPERVISOR: V. FITZGERALD

DEPTH ft. BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft. AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE STATE	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
	REFERENCE POINT (Top of Riser) GROUND SURFACE	*784.82* *782.5*					
	CL-CLAY, trace gravel, brown, moist		CONCRETE SEAL				
2.5				1CB			580
5.0	- gray mottling, drier						
7.5				2CB			1900
10.0	- some silt, gray, dry		6" Ø BOREHOLE				
12.5				3CB			980
15.0							
17.5				4CB			58
20.0							
22.5				5CB			60
25.0			2" Ø PVC PIPE				
27.5	- little sand			6CB			1640
30.0			CEMENT/ BENTONITE GROUT				
32.5				7CB			520



NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE
WATER FOUND ⊻ STATIC WATER LEVEL ⊻

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: FOUR COUNTY LANDFILL
PROJECT NUMBER: 5369-51
CLIENT:
LOCATION: DELONG, INDIANA

HOLE DESIGNATION: MW115
DATE COMPLETED: AUGUST 14, 1996
DRILLING METHOD: 6" Ø ROTOSONIC
CRA SUPERVISOR: V. FITZGERALD

DEPTH ft. BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft. AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE STATE	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
	~~No recovery~~						
37.5				8CB			—
40.0	- No recovery		8" Ø BOREHOLE				
42.5				9CB			—
45.0	ML-SILT, little clay, trace gravel, gray, wet	737.5					
47.5				10CB			980
50.0			2" Ø PVC PIPE				
52.5				11CB			>2000
	SW-SAND, fine to medium grained, gray, moist	728.5					
55.0			CEMENT/ BENTONITE GROUT				
	- gray-brown, wet						
57.5				12CB			>2000
60.0	- No recovery		8" Ø BLACK STEEL CASING SET @ 60ft BGS				
62.5				13CB			—
65.0	ML-SILT, little sand, gray, slightly moist	717.5	6" Ø BOREHOLE				
67.5				14CB			1000
	SW-SAND, fine to medium grained, gray, wet	713.5					

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE
WATER FOUND ⊽ STATIC WATER LEVEL ⊽

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: FOUR COUNTY LANDFILL
PROJECT NUMBER: 5369-51
CLIENT:
LOCATION: DELONG, INDIANA

HOLE DESIGNATION: MW115
DATE COMPLETED: AUGUST 14, 1996
DRILLING METHOD: 6" Ø ROTOSONIC
CRA SUPERVISOR: V. FITZGERALD

DEPTH ft. BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft. AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE STATE	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
72.5				15CB			>2000
75.0			6" Ø BOREHOLE				
77.5				16CB			440
80.0							
82.5				17CB			>2000
85.0	- No recovery		CEMENT/ BENTONITE GROUT				
87.5				18CB			--
90.0	- No recovery						
92.5				19CB			--
95.0	- trace gravel, medium to coarse grained, brown, saturated		2" Ø PVC PIPE				
97.5				20CB			>2000
100.0	- No recovery		BENTONITE PELLETS				
102.5			SAND PACK	21CB			--

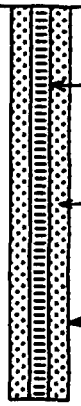
NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE
WATER FOUND ▼ STATIC WATER LEVEL ▼

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: FOUR COUNTY LANDFILL
PROJECT NUMBER: 5369-51
CLIENT:
LOCATION: DELONG, INDIANA

HOLE DESIGNATION: MW115
DATE COMPLETED: AUGUST 14, 1996
DRILLING METHOD: 6" Ø ROTOSONIC
CRA SUPERVISOR: V. FITZGERALD

DEPTH ft. BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft. AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE STATE	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
107.5			WELL SCREEN	22CB			>2000
110.0			SAND PACK				
112.5			6" Ø BOREHOLE	23CB			>2000
115.0	END OF HOLE @ 115ft BGS	667.5					
117.5							
120.0							
122.5							
125.0							
127.5							
130.0							
132.5							
135.0							
137.5							



SCREEN DETAILS
Screened Interval:
105 to 115ft BGS
Length: 10.0ft
Diameter: 2"
Slot Size: #10
Material: PVC
Sand Pack:
102 to 115ft BGS
Material: #7 Sand

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE
WATER FOUND ▼ STATIC WATER LEVEL ▼

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: FOUR COUNTY LANDFILL
PROJECT NUMBER: 5369-51
CLIENT:
LOCATION: DELONG, INDIANA

HOLE DESIGNATION: MW116
DATE COMPLETED: AUGUST 15, 1996
DRILLING METHOD: 6" Ø ROTOSONIC
CRA SUPERVISOR: V. FITZGERALD

DEPTH ft. BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft. AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE STATE	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
	REFERENCE POINT (Top of Riser) GROUND SURFACE	*784.98* *782.7*					
	For stratigraphic details, please refer to MW-115.						
-2.5							
-5.0							
-7.5							
-10.0							
-12.5							
-15.0							
-17.5							
-20.0							
-22.5							
-25.0							
-27.5							
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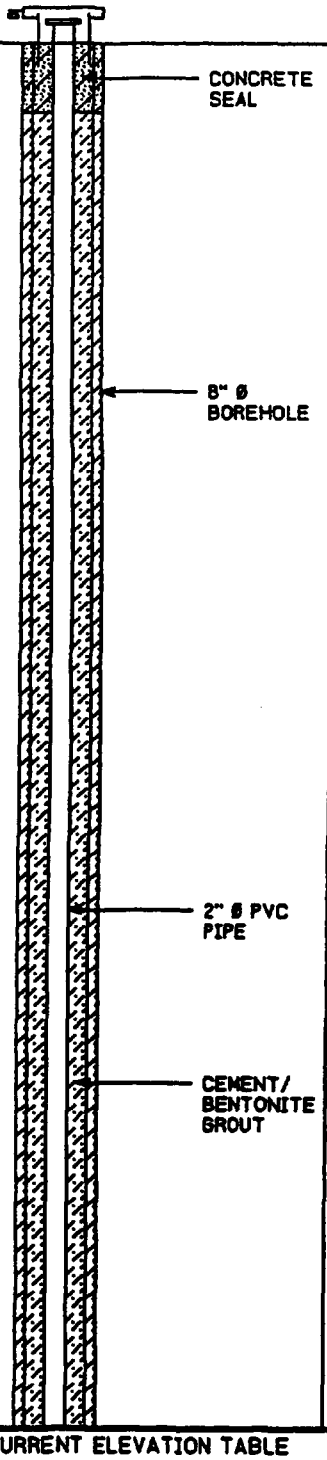
-32.5							
-35.0							
-37.5							



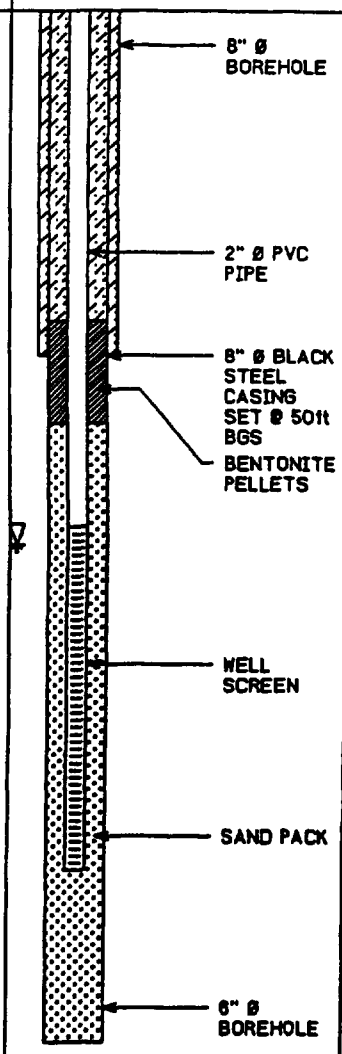
NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE
WATER FOUND ▼ STATIC WATER LEVEL ▼

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: FOUR COUNTY LANDFILL
PROJECT NUMBER: 5369-51
CLIENT:
LOCATION: DELONG, INDIANA

HOLE DESIGNATION: MW116
DATE COMPLETED: AUGUST 15, 1996
DRILLING METHOD: 6" Ø ROTOSONIC
CRA SUPERVISOR: V. FITZGERALD

DEPTH ft. BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft. AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE STATE	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
42.5			8" Ø BOREHOLE				
45.0							
47.5			2" Ø PVC PIPE				
50.0			8" Ø BLACK STEEL CASING SET @ 50ft BGS				
52.5			BENTONITE PELLETS				
55.0			▽				
57.5							
60.0			WELL SCREEN				
62.5							
65.0			SAND PACK				
67.5							
70.0	END OF HOLE @ 70ft BGS	712.7	6" Ø BOREHOLE				
72.5							
75.0							
77.5							



SCREEN DETAILS
Screened Interval:
55 to 65ft BGS
Length: 10.0ft
Diameter: 2"
Slot Size: #10
Material: PVC
Sand Pack:
52 to 70ft BGS
Material: #7 Sand

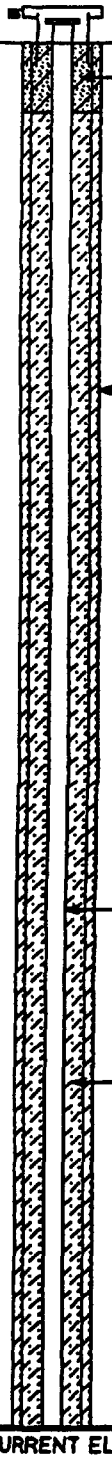
NOTES: MEASURING POINT ELEVATIONS MAY CHANGE: REFER TO CURRENT ELEVATION TABLE
WATER FOUND ▼ STATIC WATER LEVEL ▼

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: FOUR COUNTY LANDFILL
PROJECT NUMBER: 5369-51
CLIENT:
LOCATION: DELONG, INDIANA

HOLE DESIGNATION: MW117
DATE COMPLETED: AUGUST 20, 1996
DRILLING METHOD: 6" Ø ROTOSONIC
CRA SUPERVISOR: V. FITZGERALD

DEPTH ft. BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft. AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE STATE	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
	REFERENCE POINT (Top of Riser) GROUND SURFACE	784.96 781.8					
	ML-SILT, trace grvel, brown, dry		CONCRETE SEAL				
2.5	CL-CLAY, little silt, trace gravel, brown, slightly moist	779.3		1CB			17.8
5.0							
7.5				2CB			200
10.0	- gray		8" Ø BOREHOLE				
12.5				3CB			62
15.0							
17.5				4CB			111
20.0							
22.5				5CB			172
25.0	ML-SILT, little clay, trace gravel, gray, dry	758.8	2" Ø PVC PIPE				
27.5				6CB			178
30.0			CEMENT/ BENTONITE GROUT				
32.5				7CB			200
35.0							
37.5				8CB			320



NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE
WATER FOUND ▼ STATIC WATER LEVEL ▼

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: FOUR COUNTY LANDFILL
PROJECT NUMBER: 5369-51
CLIENT:
LOCATION: DELONG, INDIANA

HOLE DESIGNATION: MW117
DATE COMPLETED: AUGUST 20, 1996
DRILLING METHOD: 6" Ø ROTOSONIC
CRA SUPERVISOR: V. FITZGERALD

DEPTH ft. BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft. AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE STATE	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
-42.5			8" Ø BOREHOLE	9CB			210
-45.0							
-47.5				10CB			200
	SP-SAND, trace gravel, fine grained, gray, dry	733.3					
-50.0			8" Ø BLACK STEEL CASING SET @ 50ft BGS				
		729.8					
-52.5	ML-SILT, trace gravel, gray, dry			11CB			140
	SP-SAND, fine grained, tan, slightly moist	728.8					
-55.0	SW-SAND, fine to medium grained, tan, wet	728.8	2" Ø PVC PIPE				
-57.5				12CB			88
-60.0			CEMENT/ BENTONITE GROUT				
-62.5				13CB			42
-65.0			6" Ø BOREHOLE				
-67.5				14CB			1
-70.0							
-72.5				15CB			198
-75.0							
-77.5				16CB			22

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE
WATER FOUND ▼ STATIC WATER LEVEL ▼

STRATIGRAPHIC AND INSTRUMENTATION LOG (OVERBURDEN)

PROJECT NAME: FOUR COUNTY LANDFILL
PROJECT NUMBER: 5369-51
CLIENT:
LOCATION: DELONG, INDIANA

HOLE DESIGNATION: MW117
DATE COMPLETED: AUGUST 20, 1996
DRILLING METHOD: 6" Ø ROTOSONIC
CRA SUPERVISOR: V. FITZGERALD

DEPTH ft. BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft. AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE STATE	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
	- fine to coarse grained						
82.5	SP-SAND, fine grained, tan, wet	699.3		17CB			280
85.0	SW-SAND, trace gravel, fine to medium grained, tan, wet	696.8	6" Ø BOREHOLE				
87.5				18CB			19.8
90.0			CEMENT/ BENTONITE GROUT				
92.5				19CB			58
95.0	- fine to coarse grained, saturated		2" Ø PVC PIPE				
97.5				20CB			128
100.0	- No recovery						
102.5				21CB			—
105.0			BENTONITE PELLETS				
107.5	- some gravel		SAND PACK	22CB			38
110.0	- No recovery						
112.5				23CB			—
115.0	- trace gravel		WELL SCREEN				
117.5	GW-GRAVEL, 1/8" to 1 1/2" diameter, multi-colored, wet	685.3		24CB			164
	SW-SAND, trace gravel, fine to medium grained, brown, wet	684.8					

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE
WATER FOUND ▼ STATIC WATER LEVEL ▼

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: FOUR COUNTY LANDFILL
PROJECT NUMBER: 5369-51
CLIENT:
LOCATION: DELONG, INDIANA

HOLE DESIGNATION: MW117
DATE COMPLETED: AUGUST 20, 1996
DRILLING METHOD: 6" Ø ROTOSONIC
CRA SUPERVISOR: V. FITZGERALD

DEPTH ft. BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft. AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE STATE	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
122.5	- dry		SAND PACK	25CB			62
125.0	CL-CLAY, some silt, little gravel, gray-brown, moist	656.8					
	SW-SAND, trace gravel, fine to coarse grained, gray-brown, wet	655.6					
127.5	CL-CLAY, some silt, little gravel, gray-brown, wet	654.5		26CB			210
130.0			6" Ø BOREHOLE				
	SW-SAND, trace gravel, fine to coarse grained, brown, wet	650.8					
132.5	ML-SILT, little clay, trace gravel, gray, moist to dry	649.5		27CB			194
135.0	END OF HOLE @ 135ft BGS	646.8					
137.5							
140.0							
142.5							
145.0							
147.5							
150.0							
152.5							
155.0							
157.5							

SCREEN DETAILS
Screened Interval:
110 to 120ft BGS
Length: 10.0ft
Diameter: 2"
Slot Size: #10
Material: PVC
Sand Pack:
107 to 135ft BGS
Material: #7 Sand

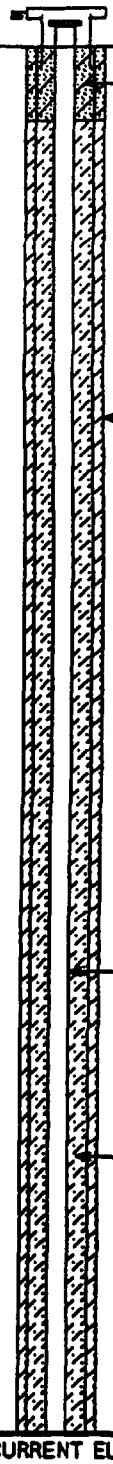
NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE
WATER FOUND ▼ STATIC WATER LEVEL ▼

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: FOUR COUNTY LANDFILL
PROJECT NUMBER: 5369-51
CLIENT:
LOCATION: DELONG, INDIANA

HOLE DESIGNATION: MW118
DATE COMPLETED: AUGUST 21, 1996
DRILLING METHOD: 6" Ø ROTOSONIC
CRA SUPERVISOR: V. FITZGERALD

DEPTH ft. BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft. AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE STATE	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
	REFERENCE POINT (Top of Riser) GROUND SURFACE	*784.84* *782.7*					
	For stratigraphic details, please refer to MW-117.						
2.5							
5.0							
7.5							
10.0							
12.5							
15.0							
17.5							
20.0							
22.5							
25.0							
27.5							
30.0							
32.5							
35.0							



NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE
WATER FOUND ▼ STATIC WATER LEVEL ▼

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: FOUR COUNTY LANDFILL
PROJECT NUMBER: 5369-51
CLIENT:
LOCATION: DELONG, INDIANA

HOLE DESIGNATION: MW118
DATE COMPLETED: AUGUST 21, 1996
DRILLING METHOD: 6" Ø ROTOSONIC
CRA SUPERVISOR: V. FITZGERALD

DEPTH ft. BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft. AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE STATE	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
40.0			8" Ø BLACK STEEL CASING SET @ 40ft BGS				
42.5							
45.0							
47.5			2" Ø PVC PIPE				
50.0			BENTONITE PELLETS				
52.5							
55.0			WELL SCREEN				
57.5			SAND PACK				
60.0							
62.5			6" Ø BOREHOLE				
65.0							
67.5							
70.0	END OF HOLE @ 70ft BGS	712.7					
72.5							

SCREEN DETAILS
Screened interval:
55 to 65ft BGS
Length: 10.0ft
Diameter: 2"
Slot Size: #10
Material: PVC
Sand Pack:
52 to 65ft BGS
Material: #7 Sand

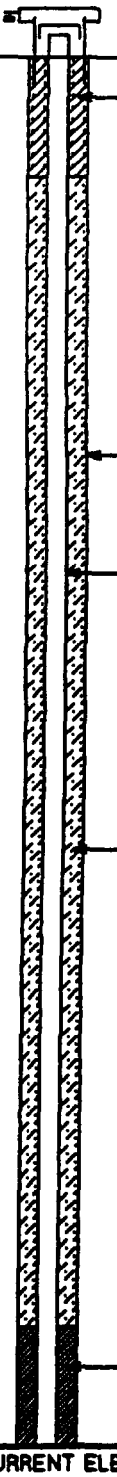
NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE
WATER FOUND ▼ STATIC WATER LEVEL ▼

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: FOUR COUNTY LANDFILL
PROJECT NUMBER: 5369
CLIENT:
LOCATION: FULTON COUNTY, INDIANA
DRILLING CONTRACTOR: BOART LONGYEAR

HOLE DESIGNATION: MW119
DATE COMPLETED: NOVEMBER 9, 1997
DRILLING METHOD: 6" Ø ROTOSONIC
CRA SUPERVISOR: K. DUWAL
DRILLER: DALE

DEPTH ft. BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft. AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE STATE	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
	REFERENCE POINT (Top of Riser) GROUND SURFACE	765.71 763.3					
	FOR STRATIGRAPHIC DETAILS, SEE LOG FOR MW-120		CONCRETE SEAL				
2.5							
5.0							
7.5							
10.0			6" Ø BOREHOLE				
12.5			2" Ø PVC PIPE				
15.0							
17.5							
20.0			BENTONITE GROUT				
22.5							
25.0							
27.5							
30.0							
32.5			BENTONITE PELLETS				



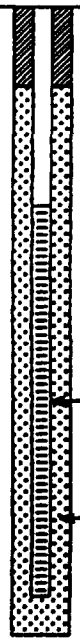
NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE
WATER FOUND ▼ STATIC WATER LEVEL ▼

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: FOUR COUNTY LANDFILL
PROJECT NUMBER: 5369
CLIENT:
LOCATION: FULTON COUNTY, INDIANA
DRILLING CONTRACTOR: BOART LONGYEAR

HOLE DESIGNATION: MW119
DATE COMPLETED: NOVEMBER 9, 1997
DRILLING METHOD: 6" Ø ROTOSONIC
CRA SUPERVISOR: K. DUWAL
DRILLER: DALE

DEPTH ft. BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft. AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE STATE	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
37.5							
40.0							
42.5							
45.0			WELL SCREEN				
47.5			SAND PACK				
50.0		712.3					
	END OF HOLE @ 51ft BGS						
52.5							
55.0							
57.5							
60.0							
62.5							
65.0							
67.5							



SCREEN DETAILS
Screened Interval:
40 to 50ft BGS
Length: 10.0ft
Diameter: 2"
Slot Size: #10
Material: PVC
Sand Pack:
37 to 51ft BGS
Material: #5 Sand

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE
WATER FOUND ▼ STATIC WATER LEVEL ▼

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: FOUR COUNTY LANDFILL
PROJECT NUMBER: 5369
CLIENT:
LOCATION: FULTON COUNTY, INDIANA
DRILLING CONTRACTOR: BOART LONGYEAR

HOLE DESIGNATION: MW120
DATE COMPLETED: NOVEMBER 8, 1997
DRILLING METHOD: 6" Ø ROTOSONIC
CRA SUPERVISOR: K. DUWAL
DRILLER: DALE

DEPTH ft. BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft. AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE STATE	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
	REFERENCE POINT (Top of Riser) GROUND SURFACE	765.30 763.0					
	Grass and dark brown clayey soil	762.7					
2.5	(CL) CLAY, silty, little to some very fine sand, low plasticity, brown with gray mottling, saturated		CONCRETE SEAL	1CS			0
5.0							
7.5			6" Ø BOREHOLE	2CS			0
10.0							
	- large rocks, up to 2" diameter, very loose material						
12.5	- (12') silty and sandy	750.0		3CS			0
15.0	(SP) SAND, silty, fine grained, trace to little medium grained, poorly graded, brown-gray, saturated						
17.5				4CS			0
20.0							
22.5				5CS			0
25.0			2" Ø PVC PIPE				
	- perched water ends	737.0					
27.5	(ML) SILT, tan, dry to moist - (27') darker brown, very fine sand mixed with the silt			6CS			0
30.0	- (28.5') decrease in sand, increase in clay content		BENTONITE GROUT				
	- (31') 6" seam of dark brown very fine sand						
32.5				7CS			0
35.0	- (35') saturated						
37.5				8CS			0
40.0	- decrease in clay, all silt						
42.5				9CS			0

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE
WATER FOUND ▼ STATIC WATER LEVEL ▼

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: FOUR COUNTY LANDFILL
PROJECT NUMBER: 5369
CLIENT:
LOCATION: FULTON COUNTY, INDIANA
DRILLING CONTRACTOR: BOART LONGYEAR

HOLE DESIGNATION: MW120
DATE COMPLETED: NOVEMBER 8, 1997
DRILLING METHOD: 6" Ø ROTOSONIC
CRA SUPERVISOR: K. DUWAL
DRILLER: DALE

DEPTH ft. BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft. AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE STATE	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
	- color changing to mottled gray - (48') gray with tan mottling			10CS			0
48.5	(SP) SAND, silty, fine grained, poorly graded, tan/gray, saturated	714.0					
51.0	- (50') grain size increase to fine to medium	712.0		11CS			0
53.5	(SW/GW) SAND AND GRAVEL, medium to coarse sand, well graded, tan/gray, saturated - (52') grain size increase, coarse sand and gravel, but more finer grained sand also	710.0					
56.0	(SP) SAND, silty, very fine grained, trace to little fine sand, tan, saturated			12CS			0
58.5							
61.0			6" Ø BOREHOLE	13CS			0
63.5	- some fine grained sand						
66.0	- fine grained sand, trace to little medium sand			14CS			0
68.5	- little to some medium sand - fine to medium grained sand, little to some coarse sand and gravel						
71.0				15CS			0
73.5							
76.0	- 8" seam of coarse sand and gravel mixed in, rocks up to 2-3 cm diameter - (76') decrease back to fine sand		BENTONITE PELLETS	16CS			0
78.5							
81.0	(SW/GW) SAND AND GRAVEL, coarse sand, rocks 2-3 cm diameter with some up to 1" diameter, well graded, gray, saturated	683.0 681.5		17CS			0
83.5	(SP) SAND, poorly graded, medium grained decreasing to fine grained, gray/brown, saturated						
86.0	- (85.5') 6" seam of medium to coarse sand, little gravel	677.0	WELL SCREEN	18CS			0
88.5	(SP) SAND, silty, poorly graded, very fine grained, silty, trace to little fine grained, gray, saturated		SAND PACK				

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE
WATER FOUND ▼ STATIC WATER LEVEL ▼

STRATIGRAPHIC AND INSTRUMENTATION LOG (OVERBURDEN)

PROJECT NAME: FOUR COUNTY LANDFILL
PROJECT NUMBER: 5369
CLIENT:
LOCATION: FULTON COUNTY, INDIANA
DRILLING CONTRACTOR: BOART LONGYEAR

HOLE DESIGNATION: MW120
DATE COMPLETED: NOVEMBER 8, 1997
DRILLING METHOD: 6" Ø ROTOSONIC
CRA SUPERVISOR: K. DUWAL
DRILLER: DALE

DEPTH ft. BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft. AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE STATE	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
94.5			6" Ø BOREHOLE	19CS			0
97.0	– fine grained sand			20CS			0
99.5			NATURAL CAVE-IN				
102.0				21CS			0
104.5							
107.0				22CS			0
109.5							
112.0				23CS			0
114.5	– trace to little medium sand, but predominantly fine grained						
117.0	(CL) CLAY, silty, low plasticity, gray, saturated	647.0		24CS			0
119.5							
122.0	– less silt, hard, moist to wet			25CS			0
124.5							
127.0	END OF HOLE @ 127ft BGS	636.0					
129.5							
132.0							
134.5							

SCREEN DETAILS
Screened Interval:
86 to 95ft BGS
Length: 10.0ft
Diameter: 2"
Slot Size: #10
Material: PVC
Sand Pack:
79 to 96ft BGS
Material: #5 Sand

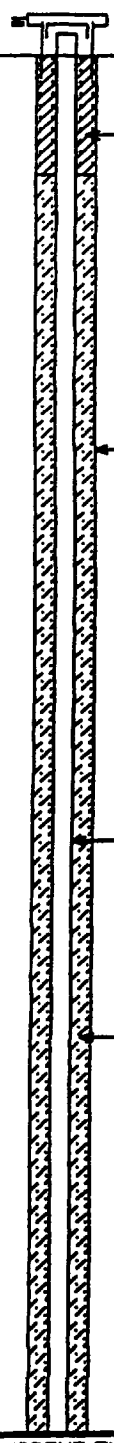
NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE
WATER FOUND ⚲ STATIC WATER LEVEL ⚲

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: FOUR COUNTY LANDFILL
PROJECT NUMBER: 5369
CLIENT:
LOCATION: FULTON COUNTY, INDIANA
DRILLING CONTRACTOR: BOART LONGYEAR

HOLE DESIGNATION: MW121
DATE COMPLETED: NOVEMBER 10, 1997
DRILLING METHOD: 6" Ø ROTOSONIC
CRA SUPERVISOR: K. DUWAL
DRILLER: DALE

DEPTH ft. BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft. AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE STATE	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
	REFERENCE POINT (Top of Riser) GROUND SURFACE	*768.92* *766.5*					
	FOR STRATIGRAPHIC DETAILS, SEE LOG FOR MW122						
2.5			CONCRETE SEAL				
5.0							
7.5							
10.0			6" Ø BOREHOLE				
12.5							
15.0							
17.5							
20.0			2" Ø PVC PIPE				
22.5							
25.0			BENTONITE GROUT				
27.5							
30.0							
32.5							



NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE
WATER FOUND ▼ STATIC WATER LEVEL ▼

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: FOUR COUNTY LANDFILL
PROJECT NUMBER: 5369
CLIENT:
LOCATION: FULTON COUNTY, INDIANA
DRILLING CONTRACTOR: BOART LONGYEAR

HOLE DESIGNATION: MW121
DATE COMPLETED: NOVEMBER 10, 1997
DRILLING METHOD: 6" Ø ROTOSONIC
CRA SUPERVISOR: K. DUWAL
DRILLER: DALE

DEPTH ft. BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft. AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE STATE	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
37.5			BENTONITE PELLETS				
40.0							
42.5							
45.0			WELL SCREEN				
47.5							
50.0			SAND PACK				
52.5							
55.0	END OF HOLE @ 54ft BGS	712.5	SCREEN DETAILS Screened Interval: 43 to 53ft BGS Length: 10.0ft Diameter: 2" Slot Size: #10 Material: PVC Sand Pack: 40 to 54ft BGS Material: #5 Sand				
57.5							
60.0							
62.5							
65.0							
67.5							

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE
WATER FOUND ▼ STATIC WATER LEVEL ▼

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

(CL-68)
Page 1 of 2

PROJECT NAME: FOUR COUNTY LANDFILL
PROJECT NUMBER: 5369
CLIENT:
LOCATION: FULTON COUNTY, INDIANA
DRILLING CONTRACTOR: BOART LONGYEAR

HOLE DESIGNATION: MW122
DATE COMPLETED: NOVEMBER 10, 1997
DRILLING METHOD: 6" Ø ROTOSONIC
CRA SUPERVISOR: K. DUWAL
DRILLER: DALE

DEPTH ft. BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft. AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE STATE	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
	REFERENCE POINT (Top of Riser) GROUND SURFACE	768.48 766.1					
	Grass and silty/sandy/clayey soil, dark brown	765.8					
2.5	(CL) CLAY, silty, little to some sand, low plasticity, trace rocks, tan/brown, saturated		CONCRETE SEAL	1CS			0
5.0							
7.5				2CS			0
10.0			8" Ø BOREHOLE				
12.5	- less sand, firmer - 2" silty and sandy seam, saturated			3CS			0
15.0	- color change to gray with brown mottling						
17.5				4CS			0
20.0	- tan colored silt mottling						
22.5		742.6		5CS			0
25.0	(SW) SAND, silty, fine grained to medium grained, little to some very fine grained, trace to little coarser sand and gravel, well graded, tan, moist		2" Ø PVC PIPE				
27.5				6CS			0
30.0	- (23.5') 3" layer of some sand and gravel mixed in, saturated		BENTONITE GROUT				
32.5				7CS			0
35.0							
37.5	- small zone of coarse sand, saturated			8CS			0
40.0	(SP) SAND, silty, poorly graded, fine grained, little to some medium grained, tan, saturated	727.1					
42.5	- (42') finer grained sand, silty			9CS			0
45.0	- (43') 6" zone which is clayey, tan, with coarser sand just above	722.6 721.1					
47.5	(SW/GW) SAND AND GRAVEL, well graded, little to some silt and fine sand, tan/dark brown, saturated, rocks up to 2 cm diameter			10CS			0
50.0	(ML) SILT, clayey, gray with brown mottling						
52.5	- (46') no mottling, gray			11CS			0
55.0	- (50') decrease clay, increase very fine sand						
57.5	- (57') changing to very fine sand, silty - (58') little to some tan colored fine sand	707.1		12CS			0
60.0	(SP) SAND, silty, poorly graded, fine grained, little to some very fine sand, tan, saturated						
62.5				13CS			0
65.0	- coarsening, trace to little fine to medium grained sand						
67.5				14CS			0
	- decrease back to very fine to fine sand, more silt						

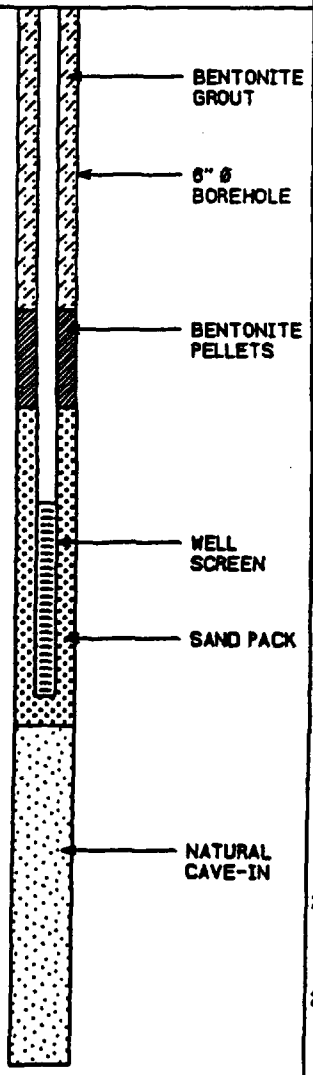
NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE
WATER FOUND ▼ STATIC WATER LEVEL ▼

STRATIGRAPHIC AND INSTRUMENTATION LOG (OVERBURDEN)

PROJECT NAME: FOUR COUNTY LANDFILL
PROJECT NUMBER: 5369
CLIENT:
LOCATION: FULTON COUNTY, INDIANA
DRILLING CONTRACTOR: BOART LONGYEAR

HOLE DESIGNATION: MW122
DATE COMPLETED: NOVEMBER 10, 1997
DRILLING METHOD: 6" Ø ROTOSONIC
CRA SUPERVISOR: K. DUWAL
DRILLER: DALE

DEPTH ft. BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft. AMSL
74.0		
76.5		
79.0		
81.5	– coarsening, fine to medium grained, trace coarse sand	
84.0	– (82') little coarse sand, trace to little gravel, trace rocks	682.6
86.5	(SW/GW) coarse SAND AND GRAVEL, with silt and finer sand	680.6
89.0	(SP) SAND, poorly graded, fine grained, tan, saturated	
91.5	– (90') fine to medium sand, trace to little coarse sand	
94.0	– medium sand, some coarse sand	
96.5	– coarse sand, more well graded, some gravel, rocks up to 1 cm diameter	
99.0	– back to fine sand with very fine sand and silt	
101.5	– 6" gravelly seam	
104.0	(GW) GRAVEL, with (SW) SAND, fine to coarse grained, rocks up to 1" diameter	662.1
106.5	– (105') coarse gravel	
109.0	– (106') decrease to fine gravel with coarse sand	658.1
111.5	(SP) SAND, poorly graded, fine to medium grained, little to some coarse sand and gravel, tan/gray	
114.0		
116.5	– (109') decrease to fine grained sand, gray/tan	
119.0		
121.5	(ML) SILT, with very fine sand, gray	645.1
124.0		
126.5	END OF HOLE @ 126ft BGS	640.1
129.0		
131.5		
134.0		
136.5		
139.0		



SCREEN DETAILS
Screened interval:
97 to 107ft BGS
Length: 10.0ft
Diameter: 2"
Slot Size: #10
Material: PVC
Sand Pack:
92 to 108.5ft BGS
Material: #5 Sand

SAMPLE NUMBER	STATE	'N' VALUE	PID (ppm)
15CS			0
16CS			0
17CS			0
18CS			0
19CS			0
20CS			0
21CS			0
22CS			0
23CS			0
24CS			0
25CS			0

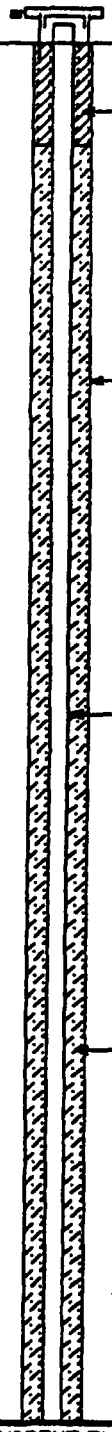
NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE
WATER FOUND ▼ STATIC WATER LEVEL ▼

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: FOUR COUNTY LANDFILL
PROJECT NUMBER: 5369
CLIENT:
LOCATION: FULTON COUNTY, INDIANA
DRILLING CONTRACTOR: BOART LONGYEAR

HOLE DESIGNATION: MW123
DATE COMPLETED: NOVEMBER 5, 1997
DRILLING METHOD: 6" Ø ROTOSONIC
CRA SUPERVISOR: K. DUWAL
DRILLER: DALE

DEPTH ft. BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft. AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE STATE	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
	REFERENCE POINT (Top of Riser) GROUND SURFACE	*773.88* *772.1*					
	FOR STRATIGRAPHIC DETAILS, SEE LOG FOR MW124						
2.5			CONCRETE SEAL				
5.0							
7.5							
10.0			6" Ø BOREHOLE				
12.5							
15.0							
17.5							
20.0			2" Ø PVC PIPE				
22.5							
25.0							
27.5							
30.0			BENTONITE GROUT				
32.5							
35.0							
37.5							



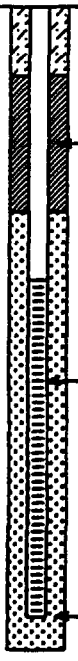
NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE
WATER FOUND ▼ STATIC WATER LEVEL ▼

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: FOUR COUNTY LANDFILL
PROJECT NUMBER: 5369
CLIENT:
LOCATION: FULTON COUNTY, INDIANA
DRILLING CONTRACTOR: BOART LONGYEAR

HOLE DESIGNATION: MW123
DATE COMPLETED: NOVEMBER 5, 1997
DRILLING METHOD: 6" Ø ROTOSONIC
CRA SUPERVISOR: K. DUWAL
DRILLER: DALE

DEPTH ft. BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft. AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE STATE	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
43.5			BENTONITE PELLETS				
46.0							
48.5							
51.0			WELL SCREEN				
53.5							
56.0							
58.5			SAND PACK				
61.0	END OF HOLE @ 60ft BGS	712.1					
63.5							
66.0							
68.5							
71.0							
73.5							
76.0							
78.5							



SCREEN DETAILS
Screened Interval:
49 to 59ft BGS
Length: 10.0ft
Diameter: 2"
Slot Size: #10
Material: PVC
Sand Pack:
47 to 60ft BGS
Material: #5 Sand

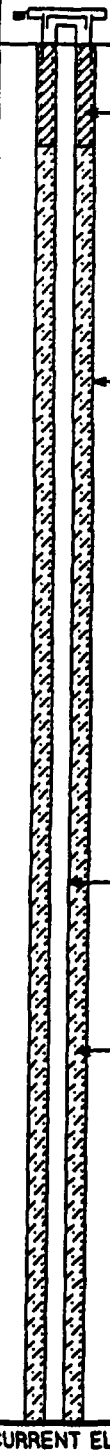
NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE
WATER FOUND ▼ STATIC WATER LEVEL ▼

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: FOUR COUNTY LANDFILL
PROJECT NUMBER: 5369
CLIENT:
LOCATION: FULTON COUNTY, INDIANA
DRILLING CONTRACTOR: BOART LONGYEAR

HOLE DESIGNATION: MW124
DATE COMPLETED: NOVEMBER 4, 1997
DRILLING METHOD: 6" Ø ROTOSONIC
CRA SUPERVISOR: K. DUWAL
DRILLER: DALE

DEPTH ft. BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft. AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE STATE	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
	REFERENCE POINT (Top of Riser) GROUND SURFACE	774.03 772.3					
2.5	(CL) CLAY, some silt to silty, low plasticity, trace to little very fine sand, hard, dry, brown/gray/whitish/bluish, trace rocks		CONCRETE SEAL	1CS			0
5.0	- brown, wet, red-orange oxidation						
7.5	- increasing sand content, silty clay			2CS			0
10.0	(ML/CL) SILT/CLAY, trace to little very fine sand	762.3	6" Ø BOREHOLE				
12.5	- grading into a clay			3CS			0
15.0							
17.5	(CL) CLAY, silty, low plasticity, moist, trace rocks	755.3		4CS			0
20.0	- silt content decreasing to little to some						
22.5				5CS			0
25.0	- brown silt mixed with the clay	746.8	2" Ø PVC PIPE				
27.5	(ML) SILT, some very fine sand to sandy, brown, moist, little to some rock fragments, rounded fragments up to 2 cm diameter - (27') less very fine sand, all silt			6CS			0
30.0	- (30') 8" clay seam, brown/gray/pinkish, many rocks mixed with the tan silt - (31') 2 ft layer of clayey and sandy silt		BENTONITE GROUT				
32.5		739.3		7CS			0
35.0	(SP) SAND, some silt to silty, poorly graded, fine grained, trace to little gravel, tan						
37.5	- (37'-44') several well graded sand zones (SW), fine to medium grained, wet, silty			8CS			0



NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE
WATER FOUND ▼ STATIC WATER LEVEL ▼

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: FOUR COUNTY LANDFILL
PROJECT NUMBER: 5369
CLIENT:
LOCATION: FULTON COUNTY, INDIANA
DRILLING CONTRACTOR: BOART LONGYEAR

HOLE DESIGNATION: MW124
DATE COMPLETED: NOVEMBER 4, 1997
DRILLING METHOD: 6" Ø ROTOSONIC
CRA SUPERVISOR: K. DUWAL
DRILLER: DALE

DEPTH ft. BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft. AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE STATE	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
43.5				9CS	X		0
46.0							
	– saturated						
48.5	(SW) SAND, well graded, fine to medium grained, little to some coarse grained, tan, wet	724.8		10CS	X		0
	(ML) SILT, clayey, gray, saturated	722.8					
51.0	– less clay						
53.5				11CS	X		0
56.0							
	– (57'–62') tan very fine sand mixed with the silt			12CS	X		0
58.5							
61.0							
63.5				13CS	X		0
66.0							
	(SP) SAND, some silt, poorly graded, very fine to fine grained, grayish	705.3		14CS	X		0
68.5							
71.0							
73.5				15CS	X		0
76.0							
78.5				16CS	X		0
			2" Ø PVC PIPE				

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE
WATER FOUND ▼ STATIC WATER LEVEL ▼

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: FOUR COUNTY LANDFILL
PROJECT NUMBER: 5369
CLIENT:
LOCATION: FULTON COUNTY, INDIANA
DRILLING CONTRACTOR: BOART LONGYEAR

HOLE DESIGNATION: MW124
DATE COMPLETED: NOVEMBER 4, 1997
DRILLING METHOD: 6" Ø ROTOSONIC
CRA SUPERVISOR: K. DUWAL
DRILLER: DALE

DEPTH ft. BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft. AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE STATE	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
				17CS			0
84.5	(SW/GW) SAND AND GRAVEL, well graded, medium grained sand up to gravel, large angular pieces, gray speckled, saturated	688.3	BENTONITE GROUT				
87.0	(SP) SAND, poorly graded, fine grained, gray, trace large rounded rocks	686.3		18CS			0
89.5							
92.0				19CS			0
94.5	- fine to medium grained, increasing gravel						
97.0				20CS			0
99.5							
102.0	- decreasing grain size back to fine grained			21CS			0
104.5							
107.0				22CS			0
109.5							
112.0				23CS			0
114.5			BENTONITE PELLETS				
117.0	(SW/GW) SAND AND GRAVEL, well graded, coarse grained, large rocks up to 2" diameter	655.3		24CS			0
119.5			WELL SCREEN	25CS			0

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE
WATER FOUND ▼ STATIC WATER LEVEL ▼

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: FOUR COUNTY LANDFILL
PROJECT NUMBER: 5369
CLIENT:
LOCATION: FULTON COUNTY, INDIANA
DRILLING CONTRACTOR: BOART LONGYEAR

HOLE DESIGNATION: MW124
DATE COMPLETED: NOVEMBER 4, 1997
DRILLING METHOD: 6" Ø ROTOSONIC
CRA SUPERVISOR: K. DUWAL
DRILLER: DALE

DEPTH ft. BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft. AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE STATE	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
125.5	- (126'-128') mainly gravel (GW) with sand, large rocks		SAND PACK				
128.0	- (128'-130') medium to coarse sand with rocks		6" Ø BOREHOLE	26CS			0
130.5	(CL/ML) CLAY, grading into a SILT, gray - (132') SILT	642.3					
133.0				27CS			0
135.5	- very fine sand mixed with silt		NATURAL CAVE-IN				
138.0				28CS			0
140.5	END OF HOLE @ 141ft BGS	631.3					
143.0							
145.5							
148.0							
150.5							
153.0							
155.5							
158.0							
160.5							

SCREEN DETAILS
Screened interval:
118 to 128ft BGS
Length: 10.0ft
Diameter: 2"
Slot Size: #10
Material: PVC
Sand Pack:
116 to 129ft BGS
Material: #5 Sand

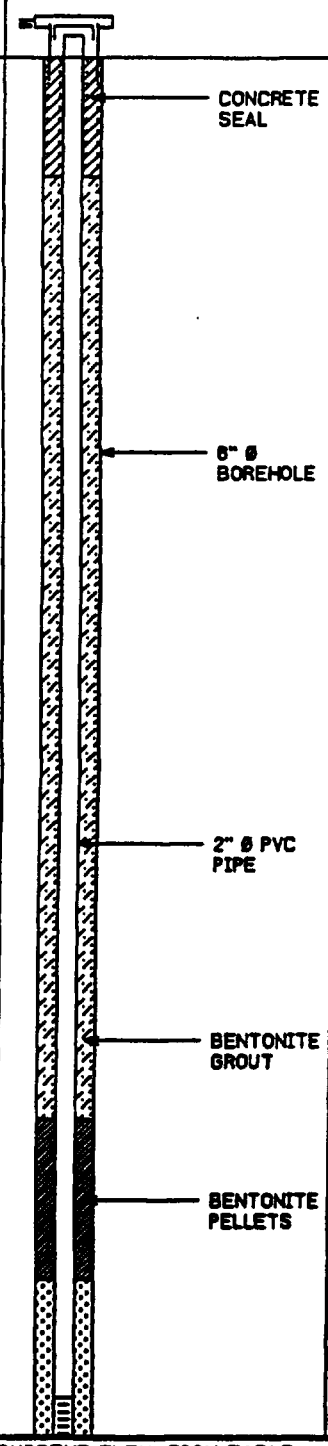
NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE
WATER FOUND ▼ STATIC WATER LEVEL ▼

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: FOUR COUNTY LANDFILL
PROJECT NUMBER: 5369
CLIENT:
LOCATION: FULTON COUNTY, INDIANA
DRILLING CONTRACTOR: BOART LONGYEAR

HOLE DESIGNATION: MW125
DATE COMPLETED: NOVEMBER 7, 1997
DRILLING METHOD: 6" Ø ROTOSONIC
CRA SUPERVISOR: K. DUWAL
DRILLER: DALE

DEPTH ft. BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft. AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE STATE	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
	REFERENCE POINT (Top of Riser) GROUND SURFACE	*759.34* *758.9*					
	FOR STRATIGRAPHIC DETAILS, SEE LOG FOR MW126						
2.5							
5.0							
7.5							
10.0							
12.5							
15.0							
17.5							
20.0							
22.5							
25.0							
27.5							
30.0							
32.5							

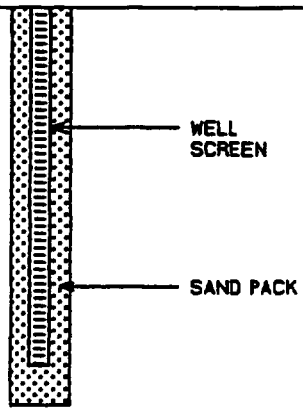


NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE
WATER FOUND ▼ STATIC WATER LEVEL ▼

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: FOUR COUNTY LANDFILL
PROJECT NUMBER: 5369
CLIENT:
LOCATION: FULTON COUNTY, INDIANA
DRILLING CONTRACTOR: BOART LONGYEAR

HOLE DESIGNATION: MW125
DATE COMPLETED: NOVEMBER 7, 1997
DRILLING METHOD: 6" Ø ROTOSONIC
CRA SUPERVISOR: K. DUWAL
DRILLER: DALE

DEPTH ft. BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft. AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE STATE	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
37.5							
40.0							
42.5							
45.0	END OF HOLE @ 45ft BGS	711.9	**SCREEN DETAILS** Screened Interval: 34 to 44ft BGS Length: 10.0ft Diameter: 2" Slot Size: #10 Material: PVC Sand Pack: 31 to 45ft BGS Material: #5 Sand				
47.5							
50.0							
52.5							
55.0							
57.5							
60.0							
62.5							
65.0							
67.5							

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE
WATER FOUND ▼ STATIC WATER LEVEL ▼

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: FOUR COUNTY LANDFILL
PROJECT NUMBER: 5369
CLIENT:
LOCATION: FULTON COUNTY, INDIANA
DRILLING CONTRACTOR: BOART LONGYEAR

HOLE DESIGNATION: MW126
DATE COMPLETED: NOVEMBER 7, 1997
DRILLING METHOD: 6" Ø ROTOSONIC
CRA SUPERVISOR: K. DUWAL
DRILLER: DALE

DEPTH ft. BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft. AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE STATE	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
	REFERENCE POINT (Top of Riser) GROUND SURFACE	759.07 757.0					
2.5 5.0	SOIL, loamy, clayey, little to some silt and sand, dark gray to black, saturated, trace rocks, typical wetlands soil, vegetative material	753.0	CONCRETE SEAL	1CS			0
7.5 10.0 12.5 15.0 17.5 20.0 22.5	(CL) CLAY, silty, trace to little sand, gravel, and rocks, low plasticity soft, brown with gray mottling, wet - (4.5') color change to gray/blue/olive green with brown mottling, silty and sandy, trace large rocks - (10') dry, increase in silt, sand, and gravel - all gray color, less sand and gravel - tan colored silt mixed in clay	733.0	6" Ø BOREHOLE	2CS 3CS 4CS 5CS			0 0 0 0
25.0 27.5 30.0 32.5 35.0 37.5 40.0 42.5 45.0 47.5 50.0 52.5 55.0 57.5 60.0 62.5	(SP) SAND, little silt, fine grained with little very fine grained, dry, tan, rounded grains - (24') 8" of gray silt and clay mixed with the sand, large rocks up to 1"-2" diameter - (26') increase in gravel, coarsening to fine to medium grained, more well graded - (30') decreasing grain size to fine, increasing silt content (ML) SILT, tan, moist, trace to little very fine sand - (32') sandy, very fine sand (SM), saturated (SW/GW) SAND AND GRAVEL, fine sand to coarse gravel, well graded, tan/ gray (ML) SILT, trace to little very fine sand, tan - (38') 2 ft zone of gray mottling (SW/GW) SAND AND GRAVEL, well graded, fine to medium sand with coarse gravel, tan - (42') 2 ft silty zone with very fine sand (ML) SILT, little to some very fine sand, tan - 12" zone of silt mixed with sand and gravel - less very fine sand, color change to gray - sandy, very fine sand	726.0 722.5 720.0 718.0 712.0	2" Ø PVC PIPE BENTONITE GROUT 6" Ø BOREHOLE	6CS 7CS 8CS 9CS 10CS 11CS 12CS 13CS			0 0 0 0 0 0 0 0
65.0 67.5	(SP) SAND, silty, poorly graded, very fine grained, gray, saturated - decreasing silt content to trace to little, little to some fine grained sand, occasional rock	693.0		14CS			0

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE
WATER FOUND ▼ STATIC WATER LEVEL ▼

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: FOUR COUNTY LANDFILL
PROJECT NUMBER: 5369
CLIENT:
LOCATION: FULTON COUNTY, INDIANA
DRILLING CONTRACTOR: BOART LONGYEAR

HOLE DESIGNATION: MW126
DATE COMPLETED: NOVEMBER 7, 1997
DRILLING METHOD: 6" Ø ROTOSONIC
CRA SUPERVISOR: K. DUWAL
DRILLER: DALE

DEPTH ft. BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft. AMSL
74.0		
76.5	- increasing fine sand	
79.0	- fine grained, some very fine sand - trace to little medium sand	
81.5	- fine to medium grained sand, trace to little coarse sand and gravel	
84.0		
86.5		
89.0		
91.5	- 8" zone of sand and gravel with rocks up to 1" diameter	
94.0	- sand and gravel seams	
96.5	- fine grained sand, little to some medium grained	
99.0		
101.5	- (101'-103') sand and gravel mixed with the fine to medium sand, rocks up to 1" diameter	
104.0	- decrease grain size to fine sand	
106.5		
109.0		
111.5		845.0
114.0	(SW/GW) coarse sand and gravel with large rocks	843.5
116.5	(CL/ML) gray CLAY grading into a SILT - (115') all silt with clay	
119.0		
121.5		
124.0		
126.5		830.0
129.0	END OF HOLE @ 127ft BGS	
131.5		
134.0		
136.5		
139.0		

SCREEN DETAILS
Screened Interval:
103 to 113ft BGS
Length: 10.0ft
Diameter: 2"
Slot Size: #10
Material: PVC
Sand Pack:
99 to 114ft BGS
Material: #5 Sand

SAMPLE NUMBER	STATE	'N' VALUE	PID (ppm)
15CS	X		0
16CS	X		0
17CS	X		0
18CS	X		0
19CS	X		0
20CS	X		0
21CS	X		0
22CS	X		0
23CS	X		0
24CS	X		0
25CS	X		0

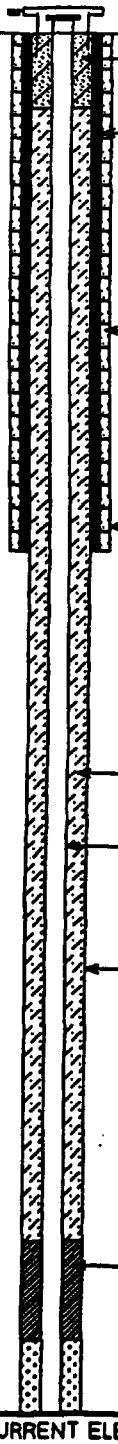
NOTES: MEASURING POINT ELEVATIONS MAY CHANGE: REFER TO CURRENT ELEVATION TABLE
WATER FOUND ▼ STATIC WATER LEVEL ▼

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: FOUR COUNTY LANDFILL
PROJECT NUMBER: 5369-53
CLIENT: FOUR COUNTY LANDFILL
LOCATION: FULTON COUNTY, INDIANA
DRILLING CONTRACTOR: BOART LONGYEAR

HOLE DESIGNATION: GS-128/MW-127
DATE COMPLETED: APRIL 9, 1999
DRILLING METHOD: 6" Ø ROTO SONIC
CRA SUPERVISOR: S. CORDIER
DRILLER: R. BUCKENBURGER

DEPTH ft. BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft. AMSL
	REFERENCE POINT (Top of Riser)	783.03
	GROUND SURFACE	780.8
	ML-SILT, little clay, trace sand and gravel, brown, stiff, moist, brick and concrete fragments (fill)	
2.5		
5.0	- 6" zone of coarse sand and silt mixture, wet	
		774.8
7.5	CL-CLAY, trace sand and gravel, trace to little silt, hard, low plasticity, gray with lighter gray mottlings, moist	
10.0	- increase in sand and gravel component to little, brown, wet	
12.5	- stiff, increase in sand content to some, saturated	768.8
	- color change to dark brown, roots	
15.0	SW-SAND, silty, medium dense, well graded, fine to medium grained, trace gravel, dark brown, saturated, brick fragments, (fill)	765.8
17.5	- 1' seam of fine grained sand	
20.0	SP-SAND, little gravel, trace silt, fine grained, poorly graded, dense, light tan, dry	
22.5	- 6" seam of silty gravel, dry	
	- 4' seam of silt with trace gravel and sand, hard, yellowish tan, dry	
25.0	- set 8-inch low carbon steel casing	
27.5	- silt component no longer present, color change to light gray	
30.0	- 2' seam of light tan silty, dry	
32.5	- dense	
35.0		
37.5	- 6" zone of coarse sand and gravel, dry	
40.0	ML-SILT, stiff, orange brown, saturated	740.8
42.5		
45.0		
47.5		
50.0		
52.5	- 3' seam of fine sand, orange brown	



SAMPLE NUMBER	STATE	'N' VALUE	PID (ppm)
1SS	X	15	0
2SS	X	22	0
3SS	X	32	0
4SS	X	16	0
5SS	X	10	0
6SS	X	12	0
7SS	X	38	0
8SS	X	48	0
9SS	X	66	0
10SS	X	71	0
11SS	X	76	0
12SS	X	61	0
13SS	X	39	0
14SS	X	50	0
15SS	X	60	0
16SS	X	40	0
17SS	X	37	0
18SS	X	50	0
19CS	X		20

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE
WATER FOUND ▼ STATIC WATER LEVEL ▼

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: FOUR COUNTY LANDFILL
PROJECT NUMBER: 5369-53
CLIENT: FOUR COUNTY LANDFILL
LOCATION: FULTON COUNTY, INDIANA
DRILLING CONTRACTOR: BOART LONGYEAR

HOLE DESIGNATION: GS-128/MW-127
DATE COMPLETED: APRIL 9, 1999
DRILLING METHOD: 6" Ø ROTO SONIC
CRA SUPERVISOR: S. CORDIER
DRILLER: R. BUCKENBURGER

DEPTH ft. BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft. AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE STATE	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
58.5	- gradual color change to gray						
61.0	SP-SAND, trace to little silt, fine grained, poorly graded, gray, saturated	719.8	WELL SCREEN				
63.5	- orange mottlings			20CS			30
66.0	- orange brown, increase in grain size to medium						
68.5							
71.0	- silt component decreases to trace		6" Ø BOREHOLE				
73.5							
76.0				21CS			10.2
78.5							
81.0	- color change to light brown		BENTONITE				
83.5	- well graded sand seam, fine to coarse						
86.0				22CS			0
88.5							
91.0	- increase in medium sand to little						
93.5							
96.0				23CS			0
98.5							
101.0							
103.5	SW-SAND, little gravel, trace silt, well graded, fine to coarse grained, multicolored grains, saturated, subangular	677.8					
106.0	- 3"-5" diameter cobbles, rounded			24CS			0
108.5							
	- fine grained sand decrease to trace						

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE: REFER TO CURRENT ELEVATION TABLE
WATER FOUND ⊽ STATIC WATER LEVEL ⊽

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: FOUR COUNTY LANDFILL
PROJECT NUMBER: 5369-53
CLIENT: FOUR COUNTY LANDFILL
LOCATION: FULTON COUNTY, INDIANA
DRILLING CONTRACTOR: BOART LONGYEAR

HOLE DESIGNATION: GS-128/MW-127
DATE COMPLETED: APRIL 9, 1999
DRILLING METHOD: 6" Ø ROTO SONIC
CRA SUPERVISOR: S. CORDIER
DRILLER: R. BUCKENBURGER

DEPTH ft. BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft. AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE STATE	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
114.5				25CS			0
117.0							
119.5							
122.0		657.8					
124.5	SW-SAND, trace coarse sand and gravel, well graded, fine to medium grained, gray, saturated			26CS			0
127.0	- f' zone of little to some coarse sand						
129.5							
132.0							
134.5				27CS			0
137.0							
139.5		640.8	NATIVE SOIL				
142.0	SW-SAND, trace silt and gravel, well graded, fine to coarse grained, dense, gray, saturated						
144.5				28CS			0
147.0							
149.5		630.8					
152.0	END OF HOLE @ 150.0ft BGS						
154.5							
157.0							
159.5							
162.0							
164.5							

SCREEN DETAILS
Screened Interval:
58.0 to 68.0ft BGS
Length: 10.0ft
Diameter: 2"
Slot Size: #10
Material: PVC
Sand Pack:
53.0 to 70.0ft BGS
Material: Sand 20/40

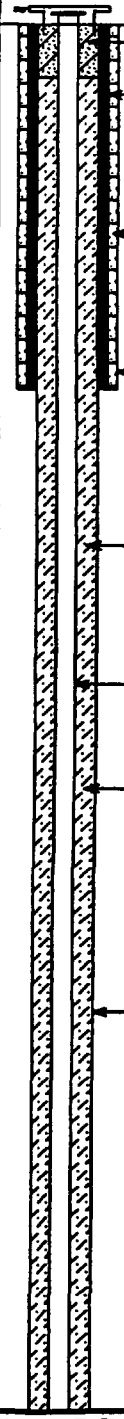
NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE
WATER FOUND ▼ STATIC WATER LEVEL ▼

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: FOUR COUNTY LANDFILL
PROJECT NUMBER: 5369-53
CLIENT: FOUR COUNTY LANDFILL
LOCATION: FULTON COUNTY, INDIANA
DRILLING CONTRACTOR: BOART LONGYEAR

HOLE DESIGNATION: MW-128
DATE COMPLETED: APRIL 9, 1999
DRILLING METHOD: 10 1/4" HSA, 6"Ø ROTO SONIC
CRA SUPERVISOR: S. CORDIER
DRILLER: R. BUCKENBURGER

DEPTH ft. BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft. AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE STATE	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
	REFERENCE POINT (Top of Riser) GROUND SURFACE	*782.87* *780.9*					
2.5	FOR STRATIGRAPHIC DETAILS REFER TO MW-127 LOG		CONCRETE				
5.0			8" LOW CARBON STEEL CASING				
7.5							
10.0							
12.5			CEMENT /BENTONITE GROUT				
15.0							
17.5							
20.0	- set 8-inch low carbon steel casing		16" Ø BOREHOLE				
22.5							
25.0							
27.5							
30.0			BENTONITE GROUT				
32.5							
35.0							
37.5			2" Ø WELL CASING				
40.0							
42.5							
45.0			BENTONITE GROUT				
47.5							
50.0							
52.5							
55.0							
57.5			6" Ø BOREHOLE				
60.0							
62.5							
65.0							
67.5							
70.0							
72.5							
75.0							
77.5							



NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE
WATER FOUND ▽ STATIC WATER LEVEL ▼

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: FOUR COUNTY LANDFILL
PROJECT NUMBER: 5369-53
CLIENT: FOUR COUNTY LANDFILL
LOCATION: FULTON COUNTY, INDIANA
DRILLING CONTRACTOR: BOART LONGYEAR

HOLE DESIGNATION: MW-128
DATE COMPLETED: APRIL 9, 1999
DRILLING METHOD: 10 1/4" HSA, 6"Ø ROTO SONIC
CRA SUPERVISOR: S. CORDIER
DRILLER: R. BUCKENBURGER

DEPTH ft. BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft. AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE STATE	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
82.5							
85.0							
87.5							
90.0			BENTONITE GROUT				
92.5							
95.0							
97.5							
100.0			2" Ø WELL CASING				
102.5							
105.0							
107.5							
110.0							
112.5							
115.0			BENTONITE PELLETS				
117.5							
120.0			SAND PACK				
122.5							
125.0			WELL SCREEN				
127.5							
130.0	END OF HOLE @ 129.0ft BGS	851.9					
132.5							
135.0							
137.5							
140.0							
142.5							
145.0							
147.5							
150.0							
152.5							
155.0							
157.5							

SCREEN DETAILS
Screened Interval:
118.0 to 128.0ft BGS
Length: 10.0ft
Diameter: 2"
Slot Size: #10
Material: PVC
Sand Pack:
115.0 to 129.0ft BGS
Material: Sand 20/40

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE
WATER FOUND ▼ STATIC WATER LEVEL ▼

STRATIGRAPHIC AND INSTRUMENTATION LOG (OVERBURDEN)

PROJECT NAME: FOUR COUNTY LANDFILL
PROJECT NUMBER: 5369-53
CLIENT: FOUR COUNTY LANDFILL
LOCATION: FULTON COUNTY, INDIANA
DRILLING CONTRACTOR: BOART LONGYEAR

HOLE DESIGNATION: GS-6/MW129
DATE COMPLETED: MARCH 28, 1999
DRILLING METHOD: 6" Ø ROTO SONIC
CRA SUPERVISOR: S. CORDIER
DRILLER: R. BUCKENBURGER

DEPTH ft. BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft. AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE STATE	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
	REFERENCE POINT (Top of Riser) GROUND SURFACE	*770.98* *768.6*					
2.5	CL-CLAY, little to some silt, trace medium sand and gravel, stiff, low plasticity, brown, slight gray mottling, moist		CONCRETE	1CS			0
5.0	- color change to uniform brown, slight increase in gravel content						
7.5	- color change to gray						
10.0			2" Ø WELL CASING	2CS			0
12.5	- 1" sand seam-fine grained	*756.4*					
15.0	ML-SILT, trace clay, coarse sand and gravel (fine to medium) hard, gray, moist		BENTONITE GROUT				
17.5							
20.0			6" Ø BOREHOLE	3CS			0
22.5							
25.0							
27.5							
30.0	- clay component increases to little			4CS			0
32.5							
35.0	- 1.5' seam of sand-fine grained, moist						
37.5	6" seam of fine sand, moist						
40.0	- fine grained sand (some) present, coarse gravel and 3" to 4" diameter cobbles present (trace), sand component continues to increase downward			5CS			0
42.5							
45.0	- sandy	*724.6*					
47.5	SP-SAND, trace silt, medium to coarse sand, fine to medium, gravel poorly graded, fine grained, gray, saturated						
50.0				6CS			0
52.5	- 3' seam of well graded sand, little gravel and cobble up to 3" diameter						
55.0	- 6" seam of poorly graded sand (fine) little, silt						
57.5	- medium to coarse sand and gravel no longer present						
60.0				7CS			0
62.5	- 2' seam of well graded sand						
65.0							
67.5							
70.0				8CS			0
72.5	- 10" seam of well graded sand, little gravel						
75.0							
77.5				9CS			0
	- 1' seam of well graded sand	*689.6*					

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE
WATER FOUND ▽ STATIC WATER LEVEL ▼

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: FOUR COUNTY LANDFILL
PROJECT NUMBER: 5369-53
CLIENT: FOUR COUNTY LANDFILL
LOCATION: FULTON COUNTY, INDIANA
DRILLING CONTRACTOR: BOART LONGYEAR

HOLE DESIGNATION: GS-6/MW129
DATE COMPLETED: MARCH 28, 1999
DRILLING METHOD: 6" Ø ROTO SONIC
CRA SUPERVISOR: S. CORDIER
DRILLER: R. BUCKENBURGER

DEPTH ft. BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft. AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE STATE	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
84.5	- 6" seam of silt, gray, saturated		BENTONITE GROUT	10CS			0
87.0	SW-SAND, little silt, little to some well graded gravel, fine to coarse grained, well graded, angular, multicolored grains, saturated gravel is subrounded						
89.5							
92.0							
94.5	- 2' seam of fine grained sand		2" Ø WELL CASING	11CS			0.3
97.0							
99.5			BENTONITE PELLETS				
102.0							
104.5	SP-SAND, trace silt, trace medium to coarse sand and gravel, medium dense, gray, saturated (fine grained)	664.6	SAND PACK				
107.0							
109.5	- 6" seam of silty medium to coarse gravel		WELL SCREEN				
112.0	- 3' seam of well graded sand						
114.5				12CS			1
117.0	ML-SILT, trace coarse sand and gravel, hard, dark brown, moist	652.6					
119.5	- fine to medium grained sand seam						
122.0	- sandy silt seam						
124.5			NATIVE SOIL	13CS			0
127.0							
129.5	END OF HOLE @ 130.0ft BGS	638.6					
132.0							
134.5							
137.0							
139.5							
142.0							
144.5							
147.0							
149.5							
152.0							
154.5							
157.0							
159.5							

SCREEN DETAILS
Screened interval:
105.0 to 115.0ft BGS
Length: 10.0ft
Diameter: 2"
Slot Size: #10
Material: PVC
Sand Pack:
101.0 to 117.0ft BGS
Material: Sand 20/40

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE
WATER FOUND ▽ STATIC WATER LEVEL ▼

STRATIGRAPHIC AND INSTRUMENTATION LOG (OVERBURDEN)

PROJECT NAME: FOUR COUNTY LANDFILL
PROJECT NUMBER: 5369-53
CLIENT: FOUR COUNTY LANDFILL
LOCATION: FULTON COUNTY, INDIANA
DRILLING CONTRACTOR: BOART LONGYEAR

HOLE DESIGNATION: GS-1/MW13O
DATE COMPLETED: MARCH 25, 1999
DRILLING METHOD: 6" Ø ROTO SONIC
CRA SUPERVISOR: S. CORDIER
DRILLER: R. BUCKENBURGER

DEPTH ft. BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft. AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE STATE	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
	REFERENCE POINT (Top of Riser) GROUND SURFACE	*772.14* *768.5*					
2.5	CL-CLAY, little silt and gravel, stiff, brown with slight gray mottling, roots - saturated		CONCRETE	1CS			0
5.0							
7.5	- hard, color change to gray, silt component increase to silty, moist						
10.0			2" Ø WELL CASING	2CS			0
12.5	- seam of fine grained silty sand						
15.0			BENTONITE GROUT				
17.5							
20.0	- gradational change to silt		6" Ø BOREHOLE	3CS			0
22.5							
25.0	ML-SILT, trace clay, little gravel, hard, dark gray, moist to wet	*743.5*					
27.5	- trace coarse sand present						
30.0				4CS			0
32.5							
35.0	- decrease in gravel content to trace						
37.5							
40.0				5CS			0
42.5							
45.0	- increase in fine grained sand to some. scattered sandy seams, little gravel up to 2cm in diameter, stiff, gray						
47.5							
50.0	- brown, silt and sand mixture (49-52 ft. BGS)			6CS			0
52.5							
55.0							
57.5							
60.0	- (3') zone of silty medium and coarse sand			7CS			0
62.5							
65.0							
67.5							
				8CS			0

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE
WATER FOUND ▼ STATIC WATER LEVEL ▼

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: FOUR COUNTY LANDFILL
PROJECT NUMBER: 5369-53
CLIENT: FOUR COUNTY LANDFILL
LOCATION: FULTON COUNTY, INDIANA
DRILLING CONTRACTOR: BOART LONGYEAR

HOLE DESIGNATION: GS-1/MW130
DATE COMPLETED: MARCH 25, 1999
DRILLING METHOD: 6" Ø ROTO SONIC
CRA SUPERVISOR: S. CORDIER
DRILLER: R. BUCKENBURGER

DEPTH ft. BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft. AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE STATE	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
74.5	SW-SAND, trace silt and gravel, well graded, fine to coarse grained, gray, medium dense, saturated	694.5					
77.0				9CS			0
79.5	SP-SAND, trace silt and gravel, fine grained, poorly graded, dense, gray, saturated	688.5					
82.0							
84.5				10CS			0
87.0							
89.5			BENTONITE GROUT				
92.0							
94.5	- coarse sand and gravel gradually increase to little (94-98 ft. BGS)			11CS			0
97.0	- 2' seam of coarse sand and gravel. 1" to 3" diameter cobble also present						
99.5			2" Ø WELL CASING				
102.0	- 6" seam of well graded sand						
104.5			BENTONITE PELLETS	12CS			0
107.0	- 3' seam of coarse sand and gravel						
109.5			6" Ø BOREHOLE				
112.0	- 6"seam of silty clay, little sand and gravel						
114.5	- 6" seam of coarse gravel		SAND PACK	13CS			0
117.0	- sand becomes silty	652.5	WELL SCREEN				
119.5	SW-SAND, trace silt, trace to little gravel, well graded, fine to coarse grained, dense, sub rounded, multicolored grains						
122.0							
124.5	ML-SILT, some fine and medium grained sand, trace clay, hard, gray, moist	645.5	NATIVE SOIL	14CS			0
127.0	- sand decrease to trace, trace coarse sand and gravel present						
129.5	- 6" seam of sand and gravel	638.5					
132.0	END OF HOLE @ 130.0ft BGS						
134.5							
137.0							
139.5							

SCREEN DETAILS
Screened interval:
112.0 to 122.0ft BGS
Length: 10.0ft
Diameter: 2"
Slot Size: #10
Material: PVC
Sand Pack:
108.0 to 129.0ft BGS
Material: Sand 20/40

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE
WATER FOUND ▼ STATIC WATER LEVEL ▼

APPENDIX E

HEALTH AND SAFETY PLAN

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TABLE 2	SITE HAZARD ANALYSIS
TABLE 3	EMERGENCY CONTACTS

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ATTACHMENT II	CONTAMINANT SPECIFIC INFORMATION
ATTACHMENT III	RESPIRATORY PROTECTION PROGRAM
ATTACHMENT IV	HEAT STRESS AND COLD STRESS PROCEDURES

1.0 GENERAL

The investigative activities will involve drilling and sampling inside and outside the limits of the Four County Landfill Site (Site) in Fulton County, Indiana. During these operations, personnel may come in contact with soils, groundwater and debris which potentially contain hazardous materials. To ensure that any direct contact with potentially contaminated material by Site personnel is minimized, a Site-specific Health and Safety Plan (HSP) has been developed, as presented herein. This HSP has been developed to ensure the following:

i) that Site personnel are not adversely exposed to the compounds of concern as well as the physical and biological hazards present on-Site;

ii) that public welfare or the environment are not adversely impacted by off-Site migration of contaminated materials due to work activities at the Site; and

iii) that all operations, procedures and equipment at the Site are in compliance with applicable governmental and non-governmental (American Conference of Governmental Industrial Hygienist) regulations and guidelines. In particular, the amended rules of the Occupational Safety and Health Act for Subpart H of Part 1910 (Title 29 Code of Federal Regulations (CFR) Part 1910.120) will be implemented for all Site work.

For the purpose of this HSP, all sampling and investigative activities carried out on Site involving contact with potentially contaminated materials will be considered contaminated operations requiring personal protective equipment (PPE). Similar activities occurring off Site are considered non-contaminated operations requiring a modified level of PPE from that for on-Site work. A detailed description of the PPE required is presented in Section 8.0.

All sampling and investigative operations at the Site will be conducted in accordance with the provisions of this HSP. Cost and/or scheduling considerations will not be considered as justification for modifying this plan.

2.0 SITE CHARACTERIZATION AND HAZARD ANALYSIS

The Site is located at the intersection of State Highway 17 and County Highway 525 North as depicted in Figure 1.

The Site occupies approximately 61.5 acres of land. State Highway 17 divides the Site into an eastern and a western parcel. Disposal activities were conducted on approximately 30 acres of the western parcel.

The Site was used as a sanitary landfill from 1972 to 1977. During that time, unlined waste deposits were covered with backfill. From 1978 to 1984 the Site accepted "separate area waste" including paint sludge, municipal wastewater treatment sludge, asbestos and liquids. This "separate area waste" was also deposited in unlined cells. From 1980 to 1989 the Site accepted RCRA hazardous wastes which were deposited in synthetically-lined disposal cells (A, B and C).

Based on various historical investigations, volatile organic compounds (VOCs), semi-volatile organic compounds (SVOC) and inorganic compounds have been detected in the sampled media that is associated with the Site. A summary of the contaminants of concern and their associated Recommended Exposure Limits (RELs) and PELs are presented in Table 1 of this HSP. Chemical specific information is presented in Attachment II of this HSP.

The activities to be performed as part of the SOW may include:

i) borehole advancement;

ii) monitoring well/piezometer installation;

iii) sampling activities.

Risks associated with these activities will be minimized by implementing engineering controls and the proper use of personal protective equipment (PPE). Table 2 summarizes the potential hazards associated with activities at the Site.

3.0 BASIS

The Occupational Safety and Health Administration (OSHA) Standards and Regulations contained in Title 29, CFR, Parts 1910 and 1926 (29 CFR 1910 and 1926) including the amended sections in 29 CFR 1910.120 and current RELs as provided by the American Conference of Governmental Industrial Hygienists (ACGIH) provide the basis for this Health and Safety Plan. Some of the specifications within this section are in addition to OSHA regulations and reflect the positions of the USEPA, the National Institute for Occupational Safety and Health (NIOSH) and the United States Coast Guard (USCG) regarding procedures required to ensure safe operations at potential hazardous waste sites.

The safety and health of the public and on-Site personnel and the protection of the environment will take precedence over cost and schedule considerations for all project work.

4.0 RESPONSIBILITIES AND ADMINISTRATION

The following individuals are designated to carry out stated job responsibilities related to this project.

-Project Manager:	Steven Wanner
-Project Coordinator:	Sean Cordier
-Project Geologist(s):	Chicago Office Staff
-Project Engineer(s):	Chicago Office Staff
-Project Industrial Hygienist:	Matthew Lazaric

The Site maintenance contractor will designate an on-Site individual as Site Health and Safety Officer (HSO) to implement the HSP during Site maintenance activities. CRA will ensure that an on-Site individual is designated as HSO to implement the HSP during field activities. The HSOs will be responsible for decisions regarding when work will be stopped or started for health or safety considerations.

The HSO will supervise the implementation of the HSP and will be responsible for all decisions regarding operations and work stoppages due to health and safety considerations.

The responsibilities of the HSO are as follows:

i) be responsible for implementation of the HSP at the initiation of Site work;

ii) conduct the initial briefing sessions for all on-Site personnel with regard to the HSP and other safety requirements to be observed during field sampling, including:

   a) potential hazards,
   b) personal hygiene principles,
   c) personal protective equipment,
   d) respiratory protection equipment usage, and
   e) emergency procedures dealing with fire and medical situations;

iii) review and modify the HSP as more information becomes available concerning the hazardous materials involved, and review all monitoring reports;

iv) supervision and enforcement of safety equipment usage;

v) supervision and inspection of equipment cleaning;

vi) personnel training in safety equipment usage and emergency procedures;

vii) monitoring of the health and safety program under direction of an industrial hygienist;

viii) suspend work activity if unsafe working conditions develop;

ix) inform workers of the nature of chemical exposure risk as required by the "Right-to-Know" Law;

x) recommend medical examination when worker appears to require it;

xi) coordination of emergency procedures;

xii) assure that safety equipment is provided, maintained and accessible to Site personnel; and

xiii) maintain a log with a sign in/out sheet for personnel performing activities and visitors entering the Site.

5.0 MEDICAL SURVEILLANCE

In accordance with requirements detailed in 29 CFR 1910.120(f) and 29 CFR 1910.134, all Site personnel (including contractors and subcontractors) who may be exposed to potentially contaminated materials will have received, within one year prior to starting field activities, medical surveillance by a licensed physician or physician's group.

Medical records for all on-Site sampling personnel will be maintained by their respective employers. The medical records will detail the tests that were taken and will include a copy of the consulting physician's statement regarding the tests and the employee's suitability for work.

Each employer will ensure that its personnel involved in on-Site work will have all necessary medical examinations prior to commencing work which requires respiratory protection or exposure to hazardous materials. Personnel not obtaining medical certification will not perform work within contaminated areas.

Interim medical surveillance will be completed if an individual exhibits poor health or high stress responses due to on-Site activity or if an accidental exposure to elevated concentrations of contaminants occurs.

6.0 TRAINING

CRA will require that all personnel actively engaged in on-Site activities, prior to entering the Site, complete training sessions in accordance with 29 CFR 1910.120. This training shall consist of a minimum of 40 hours of instruction off Site and three days of actual field inspection under direct supervision. Each employer will maintain documentation stating that its on-Site personnel have complied with this regulation.

Prior to commencing Site activities, a Site-specific pre-entry safety briefing will be conducted. This session will be used to instruct the on-Site personnel as to what the potential Site hazards are. Topics covered will include:

i) Site-specific health and safety hazards;
ii) level of PPE required;
iii) safe use of equipment;
iv) decontamination procedures; and
v) emergency response procedures.

All personnel who attend this briefing will sign the Health and Safety Plan Acknowledgment Form presented as Attachment I.

7.0 WORK AREAS

The HSO will delineate work areas in the field and will limit equipment, operations and personnel in each of the areas as defined below:

i) Exclusion Zone - This zone will include all areas where potentially contaminated soils or materials are to be handled and all areas where contaminated equipment or personnel travel. The Exclusion Zone will be delineated in the field at active drilling locations prior to commencing work at each location.

   Access to the Exclusion Zone will be restricted to personnel who are wearing the proper PPE, have received the required medical examination, and have undergone the required training. Eating, drinking, or smoking is prohibited in this area.

ii) Contamination Reduction Zone - this zone will occur at the interface of the EZ and Support Zone and will provide access for the transfer of construction material and Site equipment to the EZ, the decontamination of personnel and equipment prior to leaving the EZ, and for the physical segregation of the EZ and the Support Zone.

iii) Support Zone - This area is the portion of the Site defined as the area outside the zone of significant contamination. The Support Zone as it exists now is the area in the vicinity of the Site maintenance building.

8.0 PERSONAL PROTECTIVE EQUIPMENT

CRA will require that engineering controls and work practices, designed to reduce and maintain employee exposure at or below the permissible exposure limits (PEL) for the contaminants of concern, will be implemented. Whenever engineering controls and work practices are not feasible, a reasonable combination of engineering controls, work practices and PPE shall be used to reduce and maintain employee exposure at or below the PEL for the contaminants of concern.

All on-Site personnel are required to be equipped with PPE appropriate for the nature of work being completed. All safety equipment and protective clothing will be inspected regularly to ensure the integrity of the equipment and will be kept clean and well-maintained.

Safety equipment and apparel as required on Site will be Level D or Level C protective equipment within the Exclusion Zone.

For work conducted beyond the Site boundary, it is anticipated that Level D PPE will be required.

The Level D protective equipment consists of the following:

i) work boots with steel toe and shank;
ii) hard hat;
iii) cotton gloves; and
iv) safety glasses and/or goggles.

Level C protective equipment may be used on Site if the action levels in Section 9.0 are exceeded. Level C PPE consists of the following:

i) individually assigned full-facepiece air-purifying respirators (NIOSH approved), with the appropriate cartridges for organic vapors and particulates;

ii) chemical-resistant disposable coveralls;

iii) latex and/or nitrile inner gloves;

iv) nitrile and/or leather outer gloves;

v) work boots with steel toe and shank;

vi) chemical-resistant overboots or booties;

vii) hard hat; and

viii) safety glasses and/or chemical-resistant goggles.

Additional protective equipment usage guidelines to be implemented include:

i) prescription eyeglasses in use on the Site will be safety glasses;

ii) contact lenses will not be permitted;

iii) all disposable or reusable nitrile, latex and/or cotton gloves worn on the Site will be changed, decontaminated or discarded at the end of each day;

iv) during periods of respirator usage, respirator cartridges and filters will be changed daily, or upon breakthrough, whichever occurs first;

v) on-Site personnel who have not passed a respirator fit test will not be permitted to enter or work in the Exclusion Zone. Personnel will not be permitted to have beards, long sideburns or mustaches that interfere with the proper fit of the respirator;

vi) all PPE worn on Site will be decontaminated or discarded at the end of each work day;

vii) duct tape will be used to ensure that disposable coveralls and gloves are tightly secured when personnel are working within the Exclusion Zone; and

vii) no watches, rings or other accessories will be permitted during drilling and sampling activities.

9.0 RESPIRATOR PROGRAM

Prior to arriving at the Site, all personnel will have received training in the use of, and have been fit tested for a full-facepiece respirator. Companies employing individuals required to perform intrusive work at the Site shall have a written respiratory program that complies with 29 CFR 1910.134.

At a minimum, air monitoring will be conducted using a photo-ionization detector (PID) to determine if organic vapors and some inorganic gases are present. A background reading will be established prior to commencing work activities at each work location.

Vapor monitoring action levels to determine the level of respiratory protection necessary during field activities will be:

Sustained Photoionization Organic Vapor Reading Above Background	*Protection Level*
0 - 1 ppm	Level D
1 - 25 ppm	full-facepiece air purifying respirator (Level C)
>25 ppm	shut down activities

Work will be stopped and the work area will be allowed to vent if monitoring indicates that any of the following conditions exist:

i) organic vapors are present at concentrations which present Immediate Danger to Life and Health (IDLH) conditions, or in excess of the protection factor afforded by the air purifying respirator (whichever is lower); or

ii) organic vapor concentrations in the breathing zone exceed 25 ppm; and

Air monitoring should continue, at a safe distance, if operations are stopped due to action level exceedences, to determine if a threat to the surrounding community exists.

10.0 JUSTIFICATION

These action levels assume that all NIOSH criteria for using an air purifying respirator (APR) have been met. An APR can typically be worn in concentrations of up to 50 times the REL for a given contaminant. All of the contaminants of concern have RELs or PELs higher than 1 ppm. Because of differences in sensitivities with direct reading instruments, a 50 percent safety factor is included when determining action levels. Therefore, the calculation to determine when a respirator could no longer be used would be:

1 ppm (REL) x 50 (protection factor) x 0.5 (50% safety factor) = 25 ppm

The primary routes of exposure of contaminants to individuals performing field investigative tasks include direct contact, ingestion and inhalation. The risk of exposure due to direct contact and ingestion will be minimized through the proper use of PPE as described in Section 8.0 and by exercising ordinary caution during sampling activities. In order to minimize exposure by the inhalation pathway, the respirator and air monitoring programs discussed in Sections 9.0 and 12.0 will be undertaken.

Table 1 presents a summary of the contaminants of concern for the inhalation pathway and the associated RELs and PELs for these compounds. The contaminants of concern list was developed using a worst-case scenario on the basis of data developed during sampling rounds at the Site. Concentrations of VOCs were compared against their respective RELs and PELs. It was assumed that the entire concentration of VOCs would volatilize into the air and would be present at their maximum concentration (in parts per million), observed in groundwater, within the breathing zone of the work area. VOCs with concentrations that could possibly exceed their REL or PEL were therefore, selected as contaminants of concern.

11.0 PERSONAL HYGIENE

All personnel performing or supervising work within the Exclusion Zone are required to observe and adhere to the personal hygiene-related provisions of this section.

On-Site personnel found to be disregarding the personal hygiene-related provisions of this HSP will, at the discretion of the HSO, be removed from the Site.

The following equipment/facilities will be made available for the personal hygiene of all on-Site personnel:

i) suitable disposable outerwear, gloves, respiratory protection and footwear on a daily basis for the use of on-Site personnel;

ii) disposal containers for used disposable outerwear; and

iii) potable water and a suitable sanitation facility.

The HSO will enforce the following regulations for personnel actively participating in the field sampling program and Site maintenance activities:

i) on-Site personnel will wear appropriate PPE when in the Exclusion Zone;

ii) used disposable outerwear will not be reused if deemed to be unsuitable to provide the necessary protection, and when removed, will be placed inside disposal containers provided for that purpose;

iii) smoking, eating and drinking will be prohibited within the Exclusion Zone. These activities will be permitted only within the area of the Support Zone; and

iv) on-Site personnel will thoroughly cleanse their hands, face, neck area and other exposed areas before smoking, eating or drinking and before leaving the Site.

12.0 AIR MONITORING

During the progress of active work, air quality will be monitored. Monitoring will be conducted on a continuous basis during intrusive activities and periodically during non-intrusive activities. Specific air monitoring requires are provided below:

The daily monitoring program will consist of monitoring with a PID for organic vapors.

Operation and calibration procedures will be according to manufacturers' instructions. Calibration and maintenance records will be kept in the field log.

Identification of volatile organic vapor levels in excess of the action levels cited in Section 9.0 shall be reported to the HSO, who will determine when PPE should be upgraded or operations be shut down and restarted.

If work is stopped because action levels have been exceeded, air monitoring will continue from a safe distance to determine if there is a threat to the surrounding community.

13.0 COMMUNICATIONS

Emergency numbers including police, fire, ambulance, hospital and appropriate regulatory agencies (Table 3) will be prominently posted near the Site telephone(s).

A route map to the nearest emergency medical facility (Figure 1) will be posted in each vehicle. Prior to initiating Site activities, the emergency medical facility will be notified of Site activities to ensure preparedness to respond to any Site-related injuries.

To ensure familiarity with the hospital route, at least one site representative must drive the route to the hospital, prior to Site activities.

14.0 EMERGENCY AND FIRST AID EQUIPMENT

Safety equipment will be available for use by Site personnel and will be located and maintained on Site. The safety equipment will include, but is not limited to, the following:

i) portable emergency eye wash;

ii) two ABC type dry chemical fire extinguishers; and

iii) approved first-aid kit for a minimum of ten personnel.

15.0 EMERGENCY RESPONSE PLAN

The HSO will be responsible for implementing the emergency response plan. The HSO will be thoroughly familiar with all aspects of the Site including facility layout, all operations and activities at the Site, and the location and characteristics of waste handled.

Emergency Response

The HSO will ensure that an employee alarm system is in place prior to conducting activities at the Site. The alarm system shall consist of an air horn and/or visual signals such as hand/arm gestures. The HSO shall establish evacuation routes and review the potential for emergencies.

In the event of injury to on-Site personnel, the following protocol will be followed:

i) notify the Health and Safety Officer;

ii) contact the designated hospital;

iii) decontaminate personnel if possible, and administer appropriate first aid. If personnel cannot be decontaminated, alert hospital to possible problems of contamination; and

iv) transport personnel to the medical facility along the predefined route.

In the event of an emergency on Site, the following protocol will be followed:

i) notify the Health and Safety Officer;

ii) evacuate the work area;

iii) the HSO will perform a head-count to ensure that all personnel have exited the area;

iv) the HSO will notify the appropriate emergency response personnel; and

v) provide the HSO and emergency response personnel with useful information.

The HSO shall assess the need for assistance from outside emergency response entities and shall contact those entities as required.

Community Notification Plan

On-Site activities to be conducted as part of the investigation presented in the Work Plan are considered to be of limited risk to the population surrounding the Site. Nevertheless, a community notification plan is presented herein in the event a major fire, explosion and/or chemical release occurs which threatens the population surrounding the Site. This emergency notification plan has been prepared with the input of emergency planning and response agencies located in Fulton County. The community notification plan summarized herein, is compatible with the Fulton County Hazardous/Toxic Chemicals Emergency Response Plan and utilizes the communication and response structure which reportedly has been carefully planned and implemented by Fulton County emergency response planning officials to address emergency situations which may arise within the County. The existing response structure involves reciprocal agreements between response authorities within Fulton County and between Fulton County and outside response entities (located in surrounding counties) in order to provide the appropriate equipment and properly trained personnel in the event of a major emergency within the County.

During field activities, communication between CRA and the Indiana Department of Environmental Management's (IDEM's) assigned project manager will occur on an as-needed basis. This communication will apprise IDEM of activities planned at the Site, schedule for implementation and whether these activities are intrusive in nature. IDEM or IDEM's designated contractor may be on-Site during field activities. Although IDEM will discuss the progress of Site activities with local representatives through IDEM's normal community relations activities, IDEM's project manager may decide to discuss in detail with a designated community representative, the activities planned, the schedule for implementation and the procedures to be utilized during the work. This type of communication will be a normal part of day-to-day project coordination and management.

Figure 2 depicts the flow of communication and response in the event of an emergency at the Site which may threaten the surrounding community. In the event the HSO determines that an incident requires the assistance of emergency response agencies, the HSO shall, after stopping work activities and appropriately evacuating the work areas, first contact the Fulton County Sheriff's Department and immediately thereafter, contact the Leiter's Ford Fire Department. The HSO will provide a detailed account of the

incident to the Sheriff and Fire Departments, advise as to whether there are any serious injuries which require immediate medical attention, and discuss the perceived need for evacuation of the surrounding community. Upon arrival to the Site, the Leiter's Ford Fire Department and the Fulton County Sheriff's Department will assess the situation with the assistance of the HSO. If necessary, the HSO will contact the National Response Center and IDEM's emergency response spill reporting hotline.

The Leiter's Ford Fire Department and the Fulton County Sheriff's Departments shall assess their capability to respond to the emergency at the Site. In the event that an initial assessment indicates that the situation is beyond the response capabilities of the Leiter's Ford Fire Department, the Leiter's Ford Fire Department will call for the appropriate back up from fire departments in the area. The Sheriff's Department is responsible for assessing their capability to respond to an emergency in a timely manner on the basis of manpower availability and proximity of units to the Site. Should back-up police units from the surrounding area be required, the Sheriff's Department will coordinate such assistance.

Upon determining that a major emergency exists at the Site, the Fulton County Sheriff's Department shall notify the Fulton County Local Emergency Planning Coordinator (LEPC) and the Fulton County Board of Health Environmental Sanitarian. The decision to evacuate the population surrounding the Site will be a joint decision between the incident commander, the LEPC, the Fulton County Environmental Sanitarian and responding agencies at the Site. The Fulton County Sheriff has the responsibility to coordinate his police units and police units assisting the Sheriff's Department, to evacuate the surrounding population as quickly, as orderly, and as safely as possible. Individual police units will evacuate the area by siren and loudspeaker. Emergency response officials at the Site will also assess the need for ambulance service, the magnitude of this need, and coordinate with appropriate hospitals to service any injured parties. A flag or wind sock will be placed on the maintenance building prior to commencing intrusive activities, to assist authorities in identifying wind direction during an emergency.

The population surrounding the Site may wish to designate a community coordinator. Should the surrounding population decide to name a community coordinator, the name of the community coordinator will be provided to IDEM. IDEM shall provide the name of this individual to CRA. The community coordinator may assist IDEM in disseminating information to interested parties in the surrounding community. The community coordinator will be responsible for disseminating information from IDEM to interested parties in the surrounding community. The community coordinator may also

assist CRA and the emergency response authorities by providing a list of special needs people, located within a 1/2-mile radius of the Site (Figure 3), that may require special assistance in the event an evacuation of the Site is ordered by the appropriate authorities. If provided to CRA, a copy of the list of special needs people will be kept at the Site by the HSO in the event of an emergency. The community coordinator may also provide additional information as requested by emergency response authorities in order to enhance the efficiency of the response.

16.0 EQUIPMENT AND PERSONNEL DECONTAMINATION

During the initiation of the investigative program, procedures will be implemented to reduce the amount of contact of both personnel and equipment with the waste constituents. These procedures include the following:

i) proper work practices that would lead to minimal direct contact with potentially contaminated material; and

ii) proper use of disposable equipment and clothing.

All equipment leaving the Exclusion Zone, which was exposed to potentially contaminated material will be decontaminated.

Personnel decontamination, if required, will take place at the exit from the Exclusion Zone and will, as a minimum, consist of a glove wash with detergent and removal of gloves, disposable suit, and hard hat.

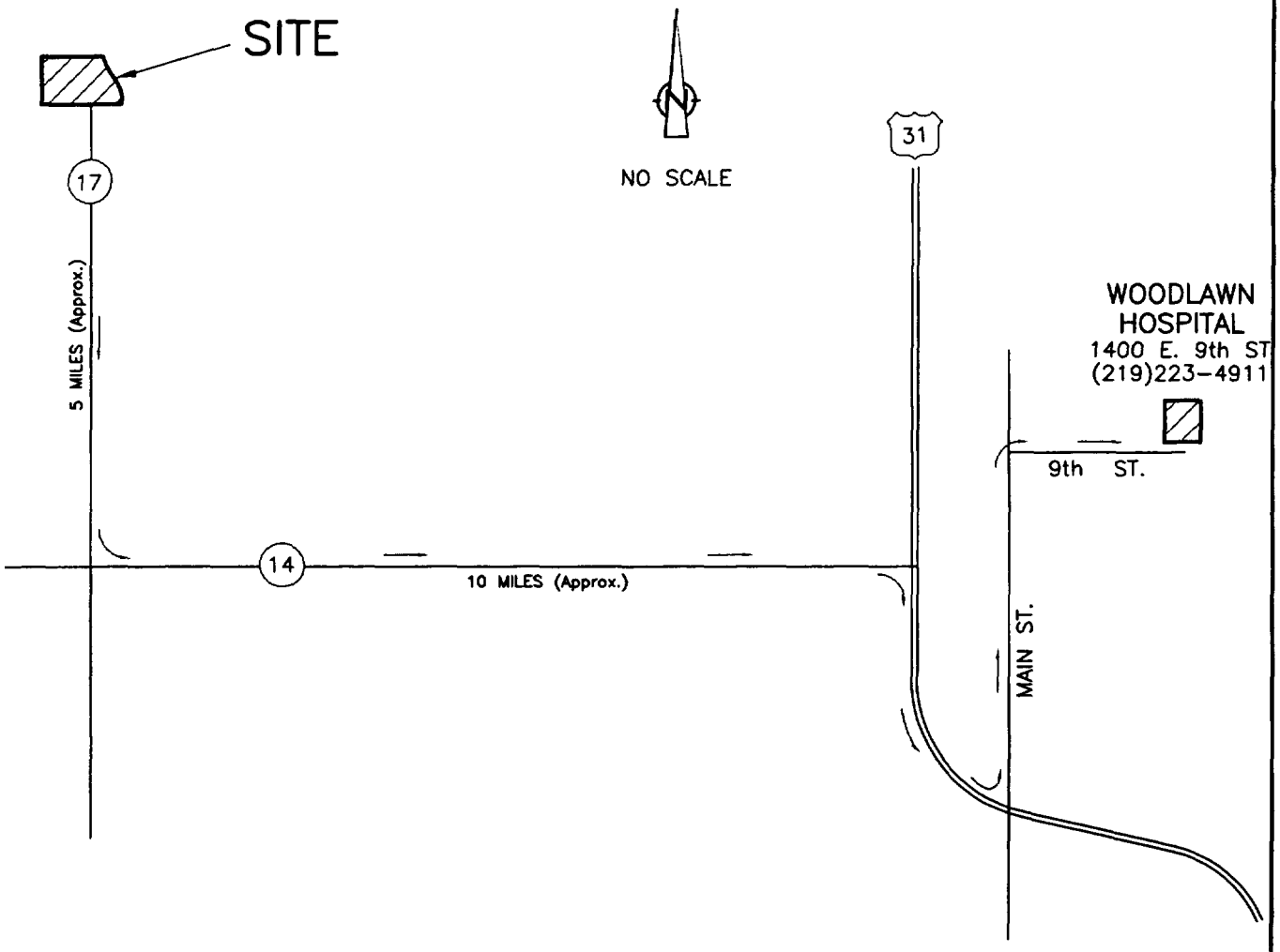
All personnel will remove their protective clothing and wash their hands, face, neck area and other exposed areas before entering the lunch and break areas to eat, drink or smoke.

Used PPE will be placed in plastic bags and then stored in 55-gallon drums. PPE will be segregated from general refuse and disposed of in accordance with federal, state and local requirements.

17.0 CONTAMINATION MIGRATION CONTROL

All vehicles and equipment used within the Exclusion Zone will be decontaminated on Site as determined necessary by the HSO prior to leaving the Site. Decontamination, when required, will consist of the thorough cleaning of those parts of the equipment which come in contact with potentially contaminated material. The HSO will certify that each piece of equipment is clean or has been decontaminated prior to removal from the Site.

Personnel engaged in vehicle decontamination will wear protective equipment including suitable disposable clothing, respiratory protection and face shields.



DIRECTIONS TO THE HOSPITAL

TAKE 17 SOUTH TO 14
TURN LEFT ON 14 AND PROCEED SOUTH
ONTO US ROUTE 31
EXIT ROUTE 31 AT MAIN ST. AND PROCEED NORTH
GO NORTH ON MAIN ST. TO 9TH ST.
TURN RIGHT (EAST) ON 9TH ST.
THE HOSPITAL IS LOCATED ON 9TH ST.
ON THE LEFT SIDE OF THE ROAD.

figure 1

ROUTE T HOSPITAL
FOUR COUNTY LANDFILL SITE
Fulton County, Indiana

CRA

05369-76(APP-E-24)GN-CO003 MAY 30/2000

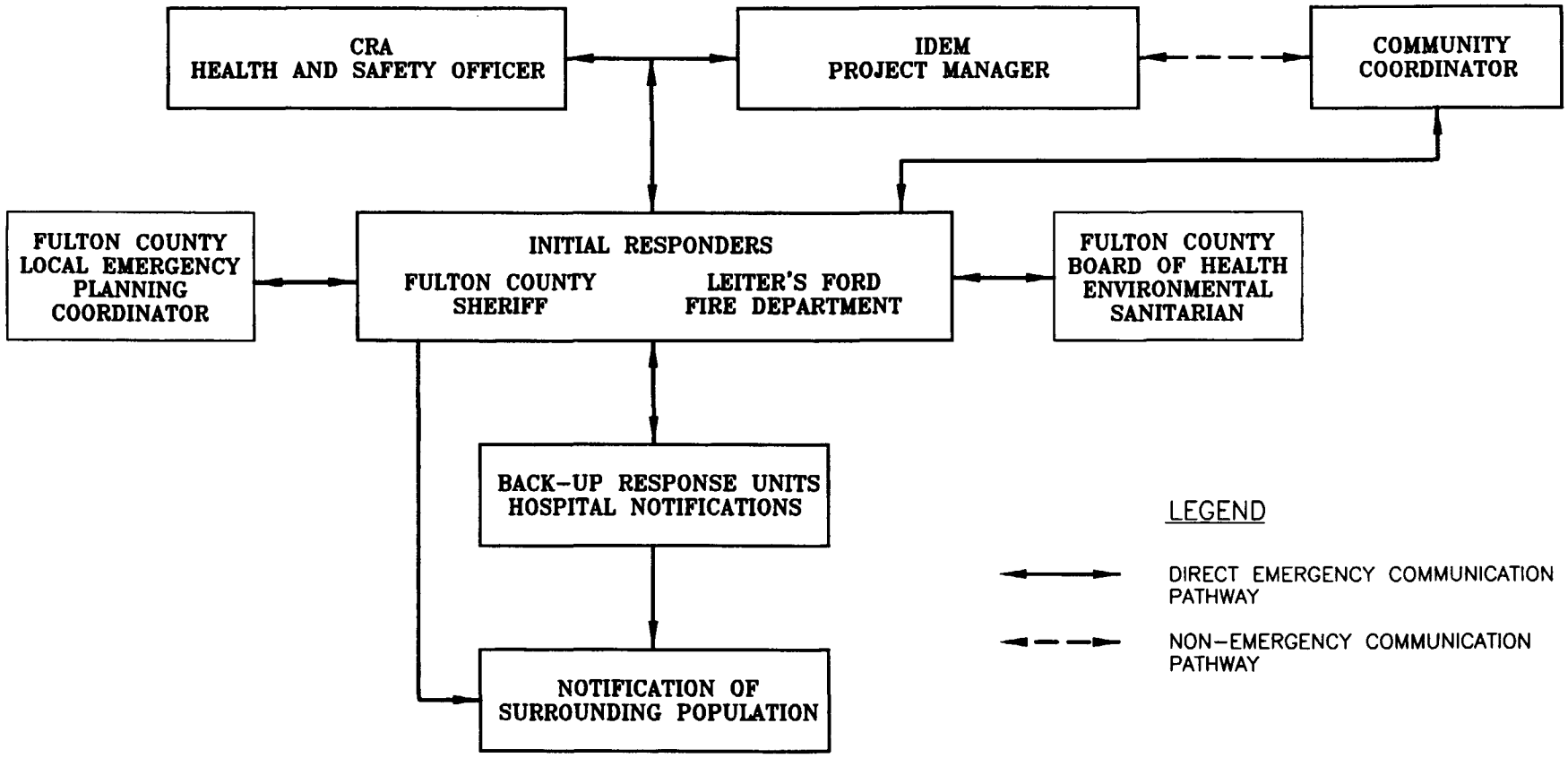
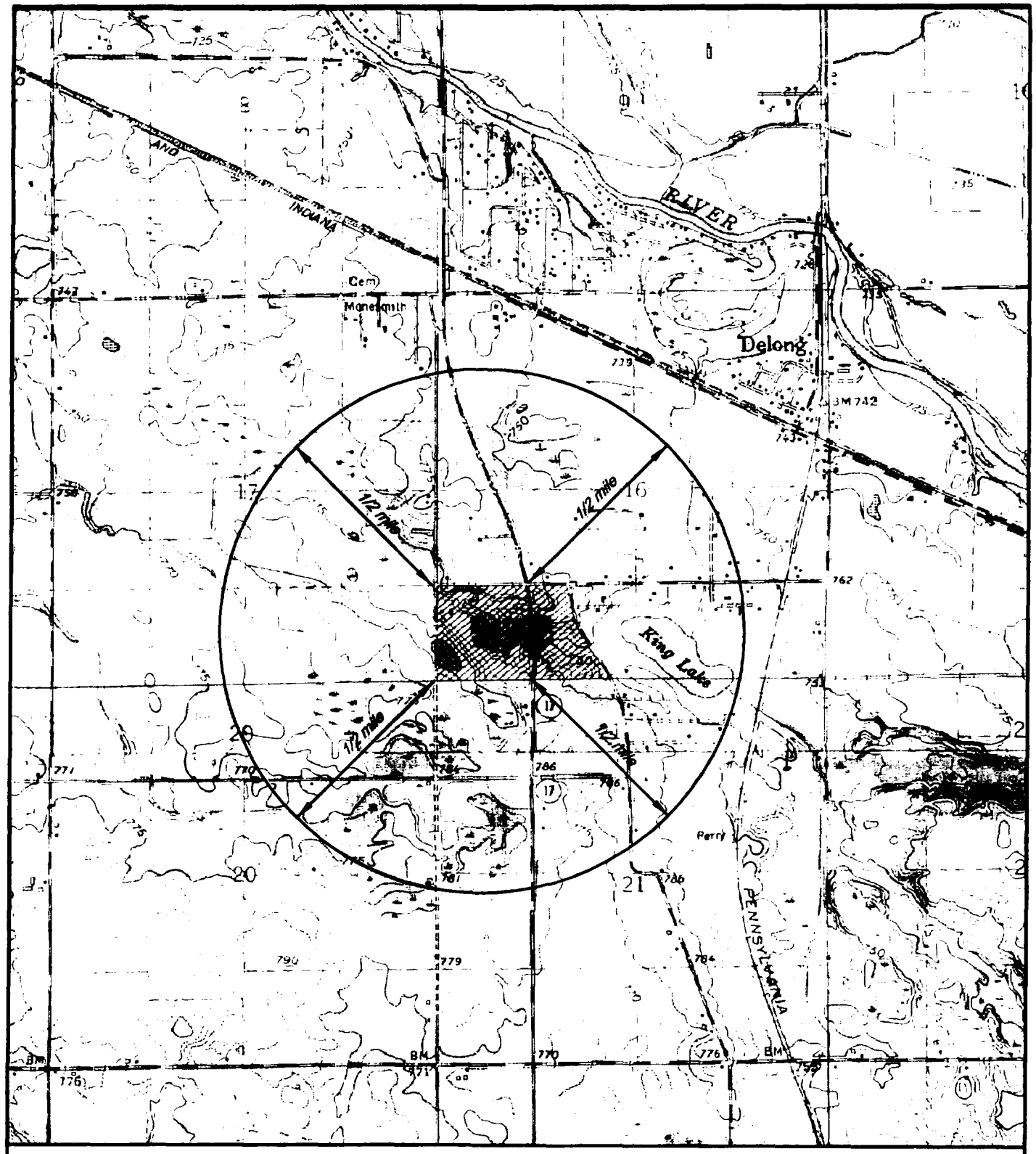


figure 2

EMERGENCY COMMUNICATION PLAN
REMEDIAL INVESTIGATION
FOUR COUNTY LANDFILL SITE
Fulton County, Indiana

CRA

05369-76(APP-E-24)GN-CO002 MAY 30/2000



BASE SOURCE: USGS 7.5 MINUTE TOPOGRAPHIC QUADRANGLE; CULVER 1980 AND KEWANNA 1977

0 1/4 1/2 mile

figure 3

1/2 MILE RADIUS MAP
FOUR COUNTY LANDFILL
Fulton County, Indiana

CRA

05369-76(APP-E-24)GN-CO001 MAY 30/2000

TABLE 1

CONTAMINANTS OF CONCERN
FOUR COUNTY LANDFILL SITE
FULTON COUNTY, INDIANA

Compound	*REL (ppm)*	*PEL (ppm)*
1,2-Dichloroethane	1	50
2-Butanone	200	200
Acetone	250	1,000
Benzene	0.1	1
Carbon Tetrachloride	2	10
Chloroform	2	50
Dichloromethane	NL	25
Vinyl Chloride	NL	1

Chemical specific information is presented as Attachment II of this HSP.

TABLE 2

SITE HAZARD ANALYSIS
FOUR COUNTY LANDFILL SITE
FULTON COUNTY, INDIANA

Site Activities	*Hazards*	*Prevention*
Sampling Activities	Chemical hazards due to inhalation and dermal contact	Proper use of PPE
	Exposure to temperature extremes	Monitor for heat or cold stress
	Physical hazards including steep grades and unstable surfaces	Use "buddy system" during Site activities
	Biological Hazards	Proper PPE, exercising ordinary caution, use of "buddy system" during Site activities
Borehole Advancement and Monitoring Well Installation	Chemical hazards due to inhalation and dermal contact	Proper use of PPE
	Physical hazards assciated with operation of a drill rig	Maintain a safe distance from augers when in use
		Avoid wearing loose fitting clothing
		Avoid overhead power lines (20 feet)
		Check and mark underground utilities

TABLE 2

SITE HAZARD ANALYSIS
FOUR COUNTY LANDFILL SITE
FULTON COUNTY, INDIANA

Site Activities	*Hazards*	*Prevention*
Borehole Advancement and Monitoring Well Installation	Exposure to temperature extremes	Monitor for heat or cold stress
	Slip, trip, fall	Clear walkways and work area of obstructions
	High noise levels	Use hearing protection
Monitoring Well and Borehole Installation (continued)	Physical hazards including steep grades and unstable surfaces	Use "buddy system" during Site activities
	Biological Hazards	Proper PPE, exercising ordinary caution, use of "buddy system" during Site activities

TABLE 3

EMERGENCY CONTACTS
FOUR COUNTY LANDFILL
FULTON COUNTY, INDIANA

Agency/Firm	*Emergency Telephone Number*	*Business Telephone Number*
Leiters Ford Fire Department	(219) 542-4491	--
Fulton County Sheriff	(219) 223-2819	--
Ambulance	(219) 223-4911	--
Woodlawn Hospital	(219) 223-4911	(219) 223-3141
Poison Control Center	(800) 942-5969	--
National Response Center	(800) 424-8802	--
CRA Industrial Hygiene		
-Chicago (Matt Lazaric)	--	(773) 380-9933
-Corporate (Mitch Bergner)	--	(615) 639-0913
CRA Project Manager (Steven Wanner)	--	(773) 380-9933
CRA Project Coordinator (Sean Cordier)		(773) 380-9933
IDEM Emergency Reponse		
24-Hour Spill Reporting Hotline	(317) 233-7745	--

ATTACHMENT I

HEALTH AND SAFETY PLAN
ACKNOWLEDGMENT FORM

HEALTH AND SAFETY PLAN ACKNOWLEDGEMENT FORM

The following employees have read and understood the attached Health and Safety Plan:

Name	*Employer*	*Date*

ATTACHMENT II

CONTAMINANT SPECIFIC INFORMATION

Material Safety Data Sheet

From Genium's Reference Collection
Genium Publishing Corporation
1145 Catalyn Street
Schenectady, NY 12303-1836 USA
(518) 377-8855

GENIUM PUBLISHING CORP.

No. 359
ETHYLENE DICHLORIDE
(Formerly 1,2-Dichloroethane)
(Revision C)
Issued: November 1978
Revised: August 1987

SECTION 1. MATERIAL IDENTIFICATION

CHEMICAL NAME: ETHYLENE DICHLORIDE (Changed to reflect common industrial practice)
DESCRIPTION (Origin/Uses): Made from acetylene and HCl. Used as a degreaser, a scavenger in leaded gasoline, as an intermediate in the manufacture of vinyl chloride, in paint removers, in wetting and penetration agents, in ore flotation processes, as a fumigant, and as a solvent for fats, oils, waxes, and gums.
OTHER DESIGNATIONS: 1,2-Dichloroethane; *sym*-Dichloroethane; Dutch Liquid; Dutch Oil; EDC; Ethane Dichloride; Ethylene Chloride; 1,2-Ethylene Dichloride; Glycol Dichloride; $C_2H_4Cl_2$; NIOSH *RTECS* KI0525000; CAS #0107-06-2
MANUFACTURERS/SUPPLIERS: Available from several suppliers, including: Dow Chemical USA, 2020 Dow Center, Midland, MI 48640; Telephone: (517) 636-1000

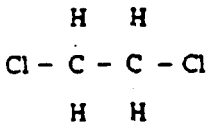
COMMENTS: Ethylene dichloride is a flammable, toxic liquid.

HMIS		R	I
H	1	I	4
F	3	S	2
R	0	K	4
PPE*			

* See Sect. 8

SECTION 2. INGREDIENTS AND HAZARDS

	%	HAZARD DATA
Ethylene Dichloride, CAS #0107-06-2; NIOSH *RTECS* #KI0525000	100	ACGIH Values 1987-88 TLV-TWA: 10 ppm, 40 mg/m^3 OSHA PEL* 1986-87 8-Hr TWA: 50 ppm; Ceiling: 100 ppm (15 Min.) NIOSH REL 1986-87 10-Hr TWA: 1 ppm Ceiling: 2 ppm (15 Min.) Toxicity Data Man, Inhalation, TC_{Lo}: 4000 ppm/1 Hr Human, Oral, TD_{Lo}: 428 mg/kg Man, Oral, TD_{Lo}: 892 mg/kg Man, Oral, LD_{Lo}: 714 mg/kg Rat, Oral, LD_{50}: 670 mg/kg



*The maximum allowable peak concentration (above the ceiling level value) of ethylene dichloride is 200 ppm for 5 minutes in any 3-hour period.
COMMENTS: Additional data concerning toxic doses and tumorigenic, reproductive, and mutagenic effects is listed (with references) in the NIOSH *RTECS* 1983-84 supplement, pages 865-66.

SECTION 3. PHYSICAL DATA

Boiling Point ... 182.3°F (83.5°C)
Vapor Pressure ... 87 Torr at 77°F (25°C)
Water Solubility ... Soluble in about 120 Parts Water
Vapor Density (Air = 1) ... 3.4
Evaporation Rate (n-BuAc = 1) ... Not Listed
Specific Gravity ... 1.2569 at 69°F (20°C)
Freezing Point ... -31.9°F (-35.5°C)
Molecular Weight ... 98.96 Grams/Mole

Appearance and odor: Colorless, clear liquid. Sweet, chloroformlike odor is typical of chlorinated hydrocarbons. The recognition threshold (100% of test panel) for ethylene dichloride is 40 ppm. Odor detection probably indicates an excessive exposure to vapor. High volatility and flammability, coupled with its toxicity and carcinogenic potential, make this material a major health hazard.
COMMENTS: Ethylene dichloride is miscible with alcohol, chloroform, and ether.

SECTION 4. FIRE AND EXPLOSION DATA

Flash Point and Method	Autoignition Temperature	Flammability Limits in Air	LOWER	UPPER
See Below	775°F (413°C)	% by Volume	6.2	15.9

EXTINGUISHING MEDIA: Use chemical, carbon dioxide, alcohol foam, water spray/fog, or dry sand to fight fires involving ethylene dichloride. Direct water sprays may be ineffective extinguishing agents, but they may be successfully used to cool fire-exposed containers. Use a smothering effect to extinguish fires involving this material. UNUSUAL FIRE/EXPLOSION HAZARDS: Ethylene dichloride is a dangerous fire and explosion hazard when exposed to sources of ignition such as heat, open flames, sparks, etc. Its vapors are heavier than air and can flow along surfaces to distant, low-lying sources of ignition and flash back. If it is safe to do so, remove this material from the fire area. Ethylene dichloride burns with a smoky flame.
SPECIAL FIRE-FIGHTING PROCEDURES: Wear a self-contained breathing apparatus with a full facepiece operated in a pressure-demand or another positive-pressure mode.
COMMENTS: Flash Point and Method: 56°F (13°C) CC; 65°F (18°C) OC.
OSHA Flammability Class (29 CFR 1910.106): IB. DOT Flammability Class (49 CFR 173.115): Flammable Liquid

SECTION 5. REACTIVITY DATA

Ethylene dichloride is stable. Hazardous polymerization cannot occur.

CHEMICAL INCOMPATIBILITIES include strong oxidizing agents. Explosions have occurred with mixtures of this material and liquid ammonia or dimethylaminopropylamine. Finely divided aluminum or magnesium metal may be hazardous in contact with ethylene dichloride.
CONDITIONS TO AVOID: Eliminate sources of ignition such as excessive heat, open flames, or electrical sparks, particularly in low-lying areas, because the explosive, heavier-than-air vapors will concentrate there.
PRODUCTS OF HAZARDOUS DECOMPOSITION can include vinyl chloride, chloride fumes, and phosgene. Phosgene is an extremely poisonous gas. Products of thermal-oxidative degradation (i.e., fire conditions) must be treated with appropriate caution.

SECTION 6. HEALTH HAZARD INFORMATION

Ethylene dichloride is listed as an anticipated human carcinogen by the NTP and as a probable human carcinogen (Group 2B), by the IARC. It was found to be an animal-positive carcinogen by the IARC. NCI reported positive results (mouse, rat) from its carcinogenesis bioassay. SUMMARY OF RISKS: Ethylene dichloride is considered to be one of the more toxic of the common chlorinated hydrocarbons. Deaths from accidental ingestion of this material have been reported. Inhalation of vapors reportedly caused three fatalities. Excessive inhalation of ethylene dichloride vapors can cause respiratory irritation, intoxication, narcotic and anesthetic effects, vomiting, dizziness, depression, and diarrhea. The hepatoxic (injurious to liver) effects of this material are significant. The systemic effects from overexposure can appear in the liver, kidneys, digestive tract, blood, lungs, adrenal glands, and the central nervous system. Tests on animals have revealed reproductive failure and fetal resorption. There may be increased risk to nursing infants of exposed mothers. TARGET ORGANS: Central nervous system, eyes, kidneys, liver, heart, adrenal glands, and skin. PRIMARY ENTRY: Inhalation, absorption through skin, oral, or eye contact. ACUTE EFFECTS: Skin contact causes irritation, defatting, and, if repeated or prolonged, burning. Eye contact causes irritation and serious injury (clouding of the cornea) if it is not removed promptly. CHRONIC EFFECTS: Injuries to the liver (hepatoxicity) and kidneys, weight loss, low blood pressure, jaundice, oliguria (reduced excretion of urine), or anemia. MEDICAL CONDITIONS AGGRAVATED BY LONG-TERM EXPOSURE: Persons taking anticoagulants could experience an increase in tendency to bleed. Persons taking insulin face an increased risk of lowered blood sugar. FIRST AID: Be prepared to restrain a hyperactive victim. EYE CONTACT: Flush eyes, including under the eyelids, gently but thoroughly with plenty of running water for at least 15 minutes. Get medical help.* SKIN CONTACT: Immediately flush the affected area with water. Wash thoroughly with soap and water. Remove and launder contaminated clothing before wearing it again; clean material from shoes and equipment. Get medical help.* INHALATION: Remove victim to fresh air; restore and/or support his breathing as needed. Get medical help.* INGESTION: Never give anything by mouth to someone who is unconscious or convulsing. Rinse victim's mouth with water. Oxygen and artificial respiration may be needed. Get medical help.* * GET MEDICAL ASSISTANCE = IN PLANT, PARAMEDIC, COMMUNITY. Get prompt medical assistance for further treatment, observation, and support after first aid.

SECTION 7. SPILL, LEAK, AND DISPOSAL PROCEDURES

SPILL/LEAK: Before using ethylene dichloride, it is essential that proper emergency procedures be established and made known to all personnel involved in handling it. Notify safety personnel of ethylene dichloride spills or leaks and implement containment procedures. Remove and eliminate all possible sources of ignition such as heat, sparks, and open flames from the area. Cleanup personnel should use protection against inhalation of vapors and contact with liquid. Contain spills by using an absorbent material such as dry sand or vermiculite. Use nonsparking tools to mix waste material thoroughly with absorbent and place it in an appropriate container for disposal. Flush trace residues with large amounts of water. Do not flush waste to sewers or open waterways. WASTE DISPOSAL: Consider reclamation, recycling, or destruction rather than disposal in a landfill. Waste may be burned in an approved incinerator equipped with an afterburner and a scrubber. Follow Federal, state, and local regulations.

Ethylene dichloride is designated as a hazardous substance by the EPA (40 CFR 116.4). Ethylene dichloride is reported in the 1983 EPA TSCA Inventory.

EPA Hazardous Waste Number (40 CFR 261.33): U077

EPA Reportable Quantity (40 CFR 117.3): 5000 lbs (2270 kgs)

Aquatic Toxicity Rating, TLm 96: 1000 - 100 ppm

SECTION 8. SPECIAL PROTECTION INFORMATION

GOGGLES: Always wear protective eyeglasses or chemical safety goggles. Ethylene dichloride is particularly harmful to the eyes, and direct contact results in corneal opacity (permanent clouding of the eye). GLOVES: Wear impervious rubber gloves to prevent skin contact. RESPIRATOR: Use a NIOSH-approved respirator per the NIOSH *Pocket Guide to Chemical Hazards* (Genium ref. 88) for the maximum-use concentrations and/or the exposure limits cited in section 2. Follow the respirator guidelines in 29 CFR 1910.134. Any detectable concentration of ethylene dichloride requires an SCBA, full facepiece, and pressure-demand/positive-pressure modes. Warning: Air-purifying respirators will not protect workers from oxygen-deficient atmospheres. OTHER: Wear rubber boots, aprons, and other protective clothing suitable for use conditions to prevent skin contact. Remove contaminated clothing and launder it before wearing it again. Discard contaminated shoes. VENTILATION: Provide maximum explosion-proof local fume exhaust ventilation systems to maintain the airborne concentrations of ethylene dichloride vapors below the exposure limits cited in section 2. Install properly designed hoods that maintain a minimum face velocity of 100 lfm (linear feet per minute). SAFETY STATIONS: Make eyewash stations, washing facilities, and safety showers available in areas of use and handling. SPECIAL CONSIDERATIONS: Vapors are heavier than air and will collect in low-lying areas. Eliminate sources of ignition in these areas and again provide good ventilation there. COMMENTS: Practice good personal hygiene. Keep materials off of your clothes and equipment. Avoid transferring this material from hands to mouth while eating, drinking, or smoking. Immediately remove ethylene dichloride-saturated clothing to avoid flammability and health hazards. Contact lenses pose a special hazard; soft lenses may absorb irritants, and all lenses concentrate them.

SECTION 9. SPECIAL PRECAUTIONS AND COMMENTS

STORAGE SEGREGATION: Store ethylene dichloride in tightly closed containers in a cool, dry, well-ventilated area away from sources of ignition. Protect containers from physical damage and from exposure to excessive heat. Avoid direct physical contact with strong acids, bases, oxidizing agents, and reducing agents. SPECIAL HANDLING/STORAGE: Use nonsparking tools. Outside or detached storage is preferred. Store and handle ethylene dichloride in accordance with the regulations concerning OSHA class IB flammable liquids. ENGINEERING CONTROLS: During transfer operations involving ethylene dichloride, the liquid and its vapors must not be exposed to nearby sources of ignition from engineering systems that are not explosion proof. Preplan emergency response procedures.

TRANSPORTATION DATA (per 49 CFR 172.101-2):

DOT Hazard Class: Flammable Liquid

DOT Label: Flammable Liquid

IMO Class: 3.2

DOT Shipping Name: Ethylene Dichloride

DOT ID No. UN 1184

IMO Label: Flammable Liquid, Poison

References: 1-9, 12, 19, 21, 26, 43, 47, 73, 87-102. CK

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Approvals: J.O. Recchio

Indust. Hygiene/Safety: DW 11-18-87

Medical Review: [illegible] 11-30-87

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MAIL TO:

21224602
CANONIE ENVIRONMENTAL
800 CANONIE DRIVE

PORTER IN 46304

ORDER NO: 210745254
PROD NO: 04006155

VAN WATERS & ROGERS INC. 1600 NORTON BLDG. SEATTLE, WA 98104-1564

EMERGENCY ASSISTANCE

FOR EMERGENCY ASSISTANCE INVOLVING CHEMICALS CALL CHEMTREC (800) 424-9300.

FOR PRODUCT AND SALES INFORMATION

CONTACT YOUR LOCAL VAN WATERS & ROGERS BRANCH OFFICE

PRODUCT IDENTIFICATION

PRODUCT NAME: ACETONE
COMMON NAMES/SYNONYMS: ACETONE; 2-PROPANONE
FORMULA: C3 H6 O
HAZARD RATING (NFPA 704)
HEALTH: 1
FIRE: 3
REACTIVITY: 0
SPECIAL: NONE

CAS NO.: 67-64-1
VW&R CODE: T1018

DATE ISSUED: 12/88
SUPERCEDES: 08/87
HAZARD RATING SCALE:
0=MINIMAL 3=SERIOUS
1=SLIGHT 4=SEVERE
2=MODERATE

HAZARDOUS INGREDIENTS

COMPONENT	%	EXPOSURE LIMITS, PPM OSHA PEL	ACGIH TLV	OTHER LIMIT	HAZARD
ACETONE	>99	1000	750	1000 (ACGIH STEL)	FLAMMABLE; IRRITANT

PHYSICAL/CHEMICAL CHARACTERISTICS

BOILING POINT, DEG F: 133
MELTING POINT, DEG F: -142
SPECIFIC GRAVITY (WATER=1): 0.79
APPEARANCE AND ODOR: CLEAR, COLORLESS LIQUID; SWEET ODOR

VAPOR PRESSURE, MM HG/20 DEG C: 184
VAPOR DENSITY (AIR=1): 2.0
WATER SOLUBILITY, %: 100
EVAPORATION RATE (BUTYL ACETATE=1): 14

FIRST AID MEASURES

IF INHALED: REMOVE TO FRESH AIR. GIVE ARTIFICIAL RESPIRATION IF NOT BREATHING. GET IMMEDIATE MEDICAL ATTENTION.

IN CASE OF EYE CONTACT: IMMEDIATELY FLUSH EYES WITH LOTS OF RUNNING WATER FOR 15 MINUTES, LIFTING THE UPPER AND LOWER EYELIDS OCCASIONALLY. GET IMMEDIATE MEDICAL ATTENTION.

IN CASE OF SKIN CONTACT: IMMEDIATELY WASH SKIN WITH LOTS OF SOAP AND WATER. REMOVE CONTAMINATED CLOTHING AND SHOES; WASH BEFORE REUSE. GET MEDICAL ATTENTION IF IRRITATION PERSISTS AFTER WASHING.

IF SWALLOWED: IF CONSCIOUS, IMMEDIATELY INDUCE VOMITING BY GIVING 2

GLASSES OF WATER AND STICKING A FINGER DOWN THE THROAT. GET IMMEDIATE MEDICAL ATTENTION. DO NOT GIVE ANYTHING TO AN UNCONSCIOUS OR CONVULSING PERSON.

HEALTH HAZARD INFORMATION

PRIMARY ROUTES OF EXPOSURE: INHALATION, SKIN OR EYE CONTACT.

SIGNS AND SYMPTOMS OF EXPOSURE

INHALATION: PROLONGED OR REPEATED EXPOSURE OR BREATHING VERY HIGH CONCENTRATIONS MAY CAUSE HEADACHES, NAUSEA, VOMITING, DIZZINESS, OTHER CENTRAL NERVOUS SYSTEM EFFECTS, CONVULSIONS, AND IN EXTREME CASES, UNCONSCIOUSNESS AND DEATH.

EYE CONTACT: VAPORS WILL IRRITATE THE EYES. LIQUID AND MISTS WILL IRRITATE AND MAY BURN THE EYES.

SKIN CONTACT: BRIEF CONTACT MAY DRY THE SKIN. PROLONGED OR REPEATED CONTACT MAY IRRITATE THE SKIN, CAUSING DERMATITIS.

SWALLOWED: SWALLOWING LARGE QUANTITIES CAUSES HEADACHES, NAUSEA, VOMITING, AND PERHAPS UNCONSCIOUSNESS. CAN ALSO CAUSE LIVER AND KIDNEY INJURY.

CHRONIC EFFECTS OF EXPOSURE: NO SPECIFIC INFORMATION AVAILABLE.

MEDICAL CONDITIONS GENERALLY AGGRAVATED BY EXPOSURE: PREEXISTING EYE OR SKIN DISORDERS MAY BE AGGRAVATED BY ACETONE EXPOSURE. ALSO, USE OF ALCOHOLIC BEVERAGES ENHANCES TOXIC EFFECTS.

TOXICITY DATA

ORAL: RAT LD50 = 9750 MG/KG

DERMAL: RABBIT LD50 = 20 G/KG

INHALATION: RAT LC50 = 16,000 PPM/4 HR

CARCINOGENICITY: THIS MATERIAL IS NOT CONSIDERED TO BE A CARCINOGEN BY THE NATIONAL TOXICOLOGY PROGRAM, THE INTERNATIONAL AGENCY FOR RESEARCH ON CANCER, OR THE OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION

OTHER DATA: INHALATION HUMAN TCLO = 500 PPM (EYE)

PERSONAL PROTECTION

VENTILATION: LOCAL MECHANICAL EXHAUST VENTILATION CAPABLE OF MAINTAINING EMISSIONS AT THE POINT OF USE BELOW THE PEL.

RESPIRATORY PROTECTION: IF USE CONDITIONS GENERATE VAPORS OR MISTS, WEAR A NIOSH-APPROVED RESPIRATOR APPROPRIATE FOR THOSE EMISSION LEVELS. APPROPRIATE RESPIRATORS MAY BE A FULL FACEPIECE OR A HALF MASK AIR-PURIFYING CARTRIDGE RESPIRATOR EQUIPPED FOR ORGANIC VAPORS/MISTS, A SELF-CONTAINED BREATHING APPARATUS IN THE PRESSURE DEMAND MODE, OR A SUPPLIED-AIR RESPIRATOR.

EYE PROTECTION: CHEMICAL GOGGLES UNLESS A FULL FACEPIECE RESPIRATOR IS ALSO WORN. IT IS GENERALLY RECOGNIZED THAT CONTACT LENSES SHOULD NOT BE WORN WHEN WORKING WITH CHEMICALS BECAUSE CONTACT LENSES MAY CONTRIBUTE TO THE SEVERITY OF AN EYE INJURY.

PROTECTIVE CLOTHING: LONG-SLEEVED SHIRT, TROUSERS, SAFETY SHOES, RUBBER GLOVES, AND RUBBER APRON.

OTHER PROTECTIVE MEASURES: AN EYEWASH AND SAFETY SHOWER SHOULD BE NEARBY AND READY FOR USE.

FIRE AND EXPLOSION INFORMATION

FLASH POINT, DEG F: 0
METHOD USED: TCC

FLAMMABLE LIMITS IN AIR, %
LOWER: 2 UPPER: 13

OTHER REGULATORY INFORMATION

DO NOT DETACH THIS SECTION FROM THE MSDS AND BE SURE TO INCLUDE THIS SECTION WHEN COPYING THE MSDS.

THIS PRODUCT IS A TOXIC CHEMICAL SUBJECT TO THE REPORTING REQUIREMENTS OF SECTION 313 OF TITLE III OF THE SUPERFUND AMENDMENTS AND REAUTHORIZATION ACT OF 1986 AND 40 CFR PART 372.

THIS PRODUCT CONTAINS THE FOLLOWING CHEMICAL(S) CONSIDERED BY THE STATE OF CALIFORNIA'S SAFE DRINKING WATER AND TOXIC ENFORCEMENT ACT OF 1986 (PROPOSITION 65) AS CAUSING CANCER OR REPRODUCTIVE TOXICITY AND FOR WHICH WARNINGS ARE NOW REQUIRED:

CHEMICAL	CAS NO.
BENZENE	71-43-2

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REVISION

08/87: REPORTED ADDITIONAL PERSONAL EXPOSURE LIMIT.

12/88: ADDED OTHER REGULATORY INFORMATION.

**** E N D O F M S D S ****

PROD: 04006155 01:57:20 16 JUN 1989 CUST: 21224602 INVOICE: 210745254

Material Safety Data Sheet
MSDS: 22577 - BENZENE
========== 2/20/92

Status: Current Revised: 10/23/90

Formula: C6H6 Part Number:
Specification: NOAA# 2577 Keyword:
Synonyms:
Stock Items:

Manufacturer
DATA FROM CAMEO/NOAA
7600 SAND POINT WAY N.E. Phone: (206) 526-6317
SEATTLE, WA 98115 Emergency:

Supplier
DATA FROM CAMEO/NOAA
7600 SAND POINT WAY N.E. Phone: (206) 526-6317
SEATTLE, WA 98115 Emergency:

Physical/Chemical Characteristics

Boiling Point .....:	176 F	@ 760 mm Hg
Melting Point .....:	42 F	
Freezing Point .....:		
Pour Point .....:		
Softening Point .....:		
Specific Gravity .....:	0.879	@ 68 Deg F
Vapor Pressure .....:	79.38	@ 70 Deg F
at Temperature ....:	70 F	
Vapor Density .....:		
Percent Volatiles ....:		
Evaporation Rate .....:		
pH .....:		
Molecular Weight .....:	78.11	
Viscosity .....:		
Solubility in Water ..:		

Odor/Appearance/Other Characteristics:

Fire and Explosion Data

Closed Cup Flash Pt. .:	12 F
Open Cup Flash Point .:	
Fire Point .....:	
Auto Ignition .....:	1097 F
Lower Explosion Limit :	1.3
Upper Explosion Limit :	7.9

Shipping Regulations
UN/NA Number: UN1114
DOT Hazard Class:
Shipping Label: FLAMMABLE LIQUID
Shipping Name:

epared
Preparer's Name & Title:
Preparation Date: 10/01/87

Component(s):
BENZENE
OSHA Pel:
ACGIH TLV: 10 ppm
STEL: 25 ppm
Percent of Product: CAS No.: 71432

Text Section(s)

Full Chemical Name

BENZENE
CAS number: 71432

Registry of Toxic Effects of Chemical Substances

CY1400000

Standard Transportation Commodities Code

4908110

List of synonyms for the chemical

BENZENE
\[6]ANNULENE
\BENZOL
\BENZOLE
\COAL NAPHTHA
\CYCLOHEXATRIENE
\PHENE
\PHENYL HYDRIDE
\PYROBENZOL
\PYROBENZOLE
\(6)ANNULENE
\BENZEEN (DUTCH)
\BENZEN (POLISH)
\BENZENE (ACGIH,DOT)
\BENZIN (OBS)
\BENZINE (OBS)
\BENZOL (DOT)
\BENZOLENE
\BENZOLO (ITALIAN)
\BICARBURET OF HYDROGEN
\CARBON OIL

\FENZEN (CZECH)
\MINERAL NAPHTHA
\MOTOR BENZOL
\NCI-C55276
\NITRATION BENZENE
\RCRA WASTE NUMBER U019
\UN 1114 (DOT)

DOT label

FLAMMABLE LIQUID

NFPA

NFPA rating for Health Hazard --
2
NFPA rating for Flammability Hazard --
3
NFPA rating for Reactivity Hazard --
0

General description of a chemical

Benzene is a clear colorless liquid with a characteristic aromatic odor. It is used to make other chemicals, as a solvent, and as a gasoline additive. It has a flash point of 12 deg F., and solidifies at 42 deg F. It is lighter than water and insoluble in water. Its vapors are heavier than air. ((C)AAR, 1986)

Fire and Explosion Hazards Information

Fire and explosion hazards --
FLAMMABLE. Flashback along vapor trail may occur. Vapor may explode if ignited in an enclosed area. Vapor is heavier than air and may travel considerable distance to a source of ignition and flash back. (USCG, 1985)
Fire fighting techniques --
Do not extinguish fire unless flow can be stopped. Use water in flooding quantities as fog. Solid streams of water may spread fire. Cool all affected containers with flooding quantities of water. Apply water from as far a distance as possible. Use foam, carbon dioxide or dry chemical. ((C)AAR, 1986)

Protective clothing recommendations

Avoid breathing vapors. Keep upwind. Wear boots, protective gloves, and goggles. Do not handle broken packages without protective equipment. Wash away any material which may have contacted the body with copious amounts of water or soap and water. ((C)AAR, 1986)

Compatibility

Compatibility with Butyl Rubber --
Poor Resistance/Good Data.
Compatibility with chlorinated natural rubber --
Poor Resistance/Limited Data.
Compatibility with chlorinated polyehtylene --
Poor Resistance/Limited Data.
Compatibility with ethyl vinyl (14%)/Polyethylene (86%) coated fabric --
Poor Resistance/Limited Data.
Compatibility with Teflon --
Poor Resistance/Good Data.
Compatibility with nitrile/butadiene coated fabric --
Good Resistance/Limited Data.
Compatibility with neoprene --
Poor Resistance/Good Data.
Compatibility with neoprene/natural rubber blend --
Poor Resistance/Good Data.
Compatibility with neoprene/SBR coated nylon or cotton --
Poor Resistance/Limited Data.
Compatibility with nitrile coated fabric --
Poor Resistance/Good Data.
Compatibility with nitrile/PVC coated fabric --
Good Resistance/Good Data.
Compatibility with polyethylene --
Poor Resistance/Good Data.
Compatibility with polyurethane --
Poor Resistance/Good Data.
Compatibility with polyvinyl alcohol --
Poor Resistance/Good Data.
Compatibility with polyvinyl chloride --
Poor Resistance/Good Data.
Compatibility with natural rubber --
Poor Resistance/Good Data.
Compatibility with Saranex coated tyvex --
Poor Resistance/Limited Data.
Compatibility with styrene/butadiene coated fabric --
Poor Resistance/Good Data.
Compatibility with Viton --
Good Resistance/Limited Data.

Evacuation information

Isolate for 1/2 mile in all directions if tank car or truck is involved in fire. (DOT, 1984)

Non-Fire response information

Keep sparks, flames, and other sources of ignition away. Keep material out of water sources and sewers. Build dikes to contain flow as necessary. Attempt to stop leak if without hazard. Use water spray to knock-down vapors. Land spill: Dig a pit, pond, lagoon, holding area to contain liquid or solid material. Dike surface flow using soil, sand bags, foamed polyurethane, or foamed concrete. Absorb bulk liquid with fly ash, cement powder, sawdust, or commercial sorbents. Apply fluorocarbon-water foam to diminish vapor and fire hazard. Water spill: Use natural barriers or oil spill control booms to limit spill motion. Use surface active agent (e.g. detergent, soaps, alcohols) to compress and thicken spilled material. Inject "universal" gelling agent to solidify encircled spill and increase effectiveness of booms. If dissolved, apply activated carbon at ten times the spilled amount in region of 10 ppm or greater concentration. Remove trapped material with suction hoses. Use mechanical dredges or lifts to remove immobilized masses of pollutants and precipitates. Air spill: Apply water spray or mist to knock down vapors. ((C)AAR, 1986)

Health hazard information

VAPOR: Irritating to eyes, nose and throat. If inhaled, will cause headache, difficult breathing, or loss of consciousness. LIQUID: Irritating to skin and eyes. Harmful if swallowed. (USCG, 1985)

First aid information

If this chemical comes in contact with the eyes, immediately wash the eyes with large amounts of water, occasionally lifting the lower and upper lids. Get medical attention immediately. Contact lenses should not be worn when working with this chemical. If this chemical comes in contact with the skin, promptly wash the contaminated skin with soap and water. If this chemical penetrates through the clothing, promptly remove the clothing and wash the skin with soap and water. Get medical attention promptly. If a person breathes in large amounts of this chemical, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible. If this chemical has been swallowed, get medical attention immediately. (NIOSH, 1987)

Fire and Explosion Data

Flash point of chemical --
12 Deg F c.c. (USCG, 1985)
Lower explosive limit --
1.3 % (USCG, 1985)
Upper explosive limit --
7.9 % (USCG, 1985)
Auto-ignition temperature --
1097 Deg F (USCG, 1985)

Physical / Chemical Characteristics

Melting point --
42 Deg F (USCG, 1985)
Vapor pressure --
79.38 mm Hg @ 70 Deg F (USCG, 1985)
Specific gravity of vapor form --
2.7 (USCG, 1985)
Specific gravity of liquid form --
0.879 @ 68 Deg F (USCG, 1985)
Boiling point --
176 Deg F @ 760 mm Hg (USCG, 1985)
Molecular weight --
78.11 (USCG, 1985)

Exposure Limits

NIOSH Immediately Dangerous to Life and Health value --
Not applicable, potential human carcinogen. (NIOSH, 1987)
Time Weighted Average of the Threshold Limit Value --
10 ppm ((C)ACGIH, 1986)
Short Term (15 minute) Exposure limit of the Threshold Limit Value --
25 ppm ((C)ACGIH, 1986)

End of MSDS

.S04260

SECTION 1 CHEMICAL PRODUCTS & COMPANY IDENTIFICATION

OCCUPATIONAL HEALTH SERVICES, INC.
11 WEST 42ND STREET, 12TH FLOOR
NEW YORK, NEW YORK 10036
1-800-445-MSDS (1-800-445-6737) OR
1-212-789-3535

FOR EMERGENCY SOURCE INFORMATION
CONTACT: 1-615-366-2000

CAS NUMBER: 124-38-9
RTECS NUMBER: FF6400000

SUBSTANCE: CARBON DIOXIDE, GAS

TRADE NAMES/SYNONYMS:
CARBONIC ACID GAS; CARBONIC ANHYDRIDE; CARBON DIOXIDE; CARBON OXIDE; CARBON DIOXIDE GAS; STCC 4904535; UN 1013; CO2; OHS04260

CHEMICAL FAMILY:
Oxide of carbon

CREATION DATE: 02/11/85 REVISION DATE: 08/12/93

SECTION 2 COMPOSITION/INFORMATION ON INGREDIENTS

COMPONENT : CARBON DIOXIDE, GAS
CAS NUMBER: 124-38-9
PERCENTAGE: 100

OTHER CONTAMINANTS: NONE

SECTION 3 HAZARDS IDENTIFICATION

CERCLA RATINGS (SCALE 0-3): HEALTH=1 FIRE=0 REACTIVITY=0 PERSISTENCE=0
NFPA RATINGS (SCALE 0-4): HEALTH=U FIRE=0 REACTIVITY=0

EMERGENCY OVERVIEW:
CARBON DIOXIDE IS AN ODORLESS, COLORLESS GAS.
May affect respiration. Container may rupture in heat of fire.
Keep away from heat and flame. Avoid breathing gas. Do not puncture container.
Use only with adequate ventilation.

POTENTIAL HEALTH EFFECTS:
INHALATION:
SHORT TERM EFFECTS: May cause suffocation, ringing in the ears, nausea, high blood pressure, irregular heartbeat, headache, weakness, drowsiness, dizziness, confusion, restlessness, sleeplessness, tingling sensation, twitching, intolerance of the eyes to light, visual disturbances, convulsions, unconsciousness and coma. May also cause reproductive effects.
LONG TERM EFFECTS: In addition to effects from short term exposure, may

cause reproductive effects.

SKIN CONTACT:

SHORT TERM EFFECTS: May cause blisters, frostbite and numbness.

LONG TERM EFFECTS: No information available on significant adverse effects.

EYE CONTACT:

SHORT TERM EFFECTS: May cause irritation. Additional effects may include frostbite and blurred vision.

LONG TERM EFFECTS: No information available on significant adverse effects.

INGESTION:

SHORT TERM EFFECTS: May cause frostbite.

LONG TERM EFFECTS: No information is available.

CARCINOGEN STATUS:
OSHA: N
NTP: N
IARC: N

SECTION 4 FIRST AID MEASURES

INHALATION:
FIRST AID- Remove from exposure area to fresh air immediately. If breathing has stopped, give artificial respiration. Maintain airway and blood pressure and administer oxygen if available. Keep affected person warm and at rest. Treat symptomatically and supportively. Administration of oxygen should be performed by qualified personnel. Get medical attention immediately.

SKIN CONTACT:
FIRST AID- It is unlikely that emergency treatment will be required. If adverse effects occur, get medical attention.
In case of frostbite, warm affected skin in warm water at a temperature of 107 F. If warm water is not available or impractical to use, gently wrap affected part in blankets. Encourage victim to exercise affected part while it is being warmed. Allow circulation to return naturally (Matheson Gas, 6th Ed.). Get medical attention immediately.

EYE CONTACT:
FIRST AID- It is unlikely that contact with the gas form will require emergency treatment. If contact with liquefied or compressed gas occurs, wash with large amounts of warm water until no evidence of chemical remains (approximately 15-20 minutes). Get medical attention immediately.

INGESTION:
FIRST AID- It is unlikely that emergency treatment will be required. If adverse effects occur, treat symptomatically and supportively and get medical attention.

NOTE TO PHYSICIAN
ANTIDOTE:
no data available

SECTION 5 FIRE FIGHTING MEASURES

FIRE AND EXPLOSION HAZARD:
Negligible fire hazard when exposed to heat or flame.

EXTINGUISHING MEDIA:
Dry chemical or carbon dioxide
(1990 Emergency Response Guidebook, DOT P 5800.5).

For larger fires, use water spray, fog or regular foam
(1990 Emergency Response Guidebook, DOT P 5800.5).

FIREFIGHTING:
Move container from fire if you can do it without risk. Apply cooling water to sides of containers that are exposed to flames until well after fire is out. Stay away from ends of tanks. Withdraw immediately in case of rising sound from venting safety device or any discoloration of tank due to fire. Some of these materials, if spilled, may evaporate leaving a flammable residue. Isolate for 1/2 mile in all directions if tank, rail car or tank truck is involved in fire (1990 Emergency Response Guidebook, DOT P 5800.5, Guide Page 12).

Extinguish using agent indicated. Cool cylinders with flooding amounts of water from as far a distance as possible. Do not use water directly on material. Use water spray to absorb vapors. Avoid breathing vapors; keep upwind. Consider evacuation of downwind area if material is leaking.

HAZARDOUS COMBUSTION PRODUCTS:
Temperatures above 1700 C may cause decomposition and the release of oxygen and highly toxic carbon monoxide.

SECTION 6 ACCIDENTAL RELEASE MEASURES

OCCUPATIONAL SPILL:
Stop leak if you can do it without risk. Keep unnecessary people away; isolate hazard area and deny entry. Stay upwind; keep out of low areas.

SECTION 7 HANDLING AND STORAGE

Observe all federal, state and local regulations when storing this substance.

Store in accordance with 29 CFR 1910.101.

Store away from incompatible substances.

SECTION 8 EXPOSURE CONTROLS/PERSONAL PROTECTION

EXPOSURE LIMITS:
CARBON DIOXIDE:
5000 ppm (9000 mg/m3) OSHA TWA
5000 ppm (9000 mg/m3) ACGIH TWA; 30,000 ppm (54,000 mg/m3) ACGIH STEL

5000 ppm (9000 mg/m3) NIOSH recommended TWA;
30,000 ppm (54,000 mg/m3) NIOSH recommended STEL
5000 ppm (9000 mg/m3) DFG MAK TWA;
10,000 ppm (18,000 mg/m3) DFG MAK 60 minute peak, momentary value, 3 times/shift

Measurement method: Gas collection bag; gas chromatography with flame ionization detection; (NIOSH Vol. II(3) # S249).

VENTILATION:
Provide local exhaust ventilation system to meet published exposure limits.

EYE PROTECTION:
Eye protection not required, but advisable.

CLOTHING:
For the gas form, protective clothing not required.
If contact with the liquid form is possible, employee must wear appropriate protective clothing and equipment to prevent skin from freezing.

GLOVES:
Protective gloves are not required but recommended.

RESPIRATOR:
The following respirators and maximum use concentrations are recommendations by the U.S. Department of Health and Human Services, NIOSH pocket guide to chemical hazards; NIOSH criteria documents or by the U.S. Department of Labor, 29 CFR 1910 Subpart Z.
The specific respirator selected must be based on contamination levels found in the work place, must not exceed the working limits of the respirator and be jointly approved by the National Institute for Occupational Safety and Health and the Mine Safety and Health Administration (NIOSH-MSHA).

CARBON DIOXIDE:

50,000 ppm- Any supplied-air respirator.
Any self-contained breathing apparatus.

Escape- Any appropriate escape-type, self-contained breathing apparatus.

FOR FIREFIGHTING AND OTHER IMMEDIATELY DANGEROUS TO LIFE OR HEALTH CONDITIONS:

Any self-contained breathing apparatus that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode.

Any supplied-air respirator that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode in combination with an auxiliary self-contained breathing apparatus operated in pressure-demand or other positive-pressure mode.

SECTION 9 PHYSICAL AND CHEMICAL PROPERTIES

DESCRIPTION: Colorless, odorless gas, with a slight acidic taste.

MOLECULAR WEIGHT: 44.01
MOLECULAR FORMULA: C-O2
BOILING POINT: -109 F (-79 C) (sublimes)
MELTING POINT: -70.6 F (-57 C) @ 4000 mmHg
VAPOR PRESSURE: 43700 mmHg @ 21 C
VAPOR DENSITY: 1.5
SPECIFIC GRAVITY: 1.522 @ 21 C
WATER SOLUBILITY: soluble
PH: acidic in solution
SOLVENT SOLUBILITY: Soluble in alcohol, acetone, hydrocarbons, most organic liquids

VAPOR DENSITY: 1.977 g/L @ 750 mmHg and 0 C.

SECTION 10 STABILITY AND REACTIVITY

REACTIVITY:
Stable under normal temperatures and pressures.

CONDITIONS TO AVOID:
Do not permit physical damage or overheating of containers. Contents are under pressure; containers may violently rupture and travel a considerable distance.

INCOMPATIBILITIES:
CARBON DIOXIDE:
ACRYLALDEHYDE: Exothermic polymerization.
BARIUM PEROXIDE: Incandescent reaction.
CESIUM OXIDE: Ignition.
DIETHYL MAGNESIUM: Ignition.
ETHYLENEIMINE: Explosive polymerization.
HYDRAZINE: Decomposition.
METAL ACETYLIDES: Ignition or incandescence.
METAL HYDRIDES: Reduction reaction.
METALS: Dusts of many metals suspended in carbon dioxide atmospheres are ignitable and explosive; some bulk metals will burn in the gas at elevated temperatures.
POTASSIUM: Mixtures of the solids are impact-sensitive.
POTASSIUM-SODIUM ALLOY: Mixtures of the solids are impact-sensitive.
SODIUM: Mixtures of the solids are impact-sensitive.
SODIUM PEROXIDE: Highly exothermic reaction; may be explosive in the presence of metals.

HAZARDOUS DECOMPOSITION:
Temperatures above 1700 C may cause decomposition and the release of oxygen and highly toxic carbon monoxide.

POLYMERIZATION:
Hazardous polymerization has not been reported to occur under normal temperatures and pressures.

SECTION 11 TOXICOLOGY INFORMATION

CARBON DIOXIDE:
TOXICITY DATA: 9 pph/5 minutes inhalation-human LCLo; 90000 ppm/5 minutes inhalation-mammal LCLo; reproductive effects data (RTECS).
CARCINOGEN STATUS: None.
ACUTE TOXICITY LEVEL: Insufficient data.
TARGET EFFECTS: Simple asphyxiant. Poisoning may affect the respiratory and nervous systems and heart.
AT INCREASED RISK FROM EXPOSURE: Persons with a history of cardiovascular or pulmonary impairment.

HEALTH EFFECTS
INHALATION:
CARBON DIOXIDE:
SIMPLE ASPHYXIANT. 50,000 ppm Immediately Dangerous to Life or Health.
ACUTE EXPOSURE- In the solid or liquid form carbon dioxide is very volatile, readily releasing the gas. At concentrations from 2-10% it may cause acidic taste, dyspnea, headache, vertigo, nausea, labored breathing, weakness, drowsiness, mental confusion, and increase in blood pressure, pulse, and respiratory rate. Exposure to 10% for a few minutes has been reported to cause visual disturbances, tinnitus, tremors, profuse perspiration, restlessness, paresthesias, general feeling of discomfort, loss of consciousness, and coma. Concentrations of 25-30% may cause coma and convulsions within one minute. Tachycardia and arrhythmias are possible. Concentrations of 50% may cause symptoms of hypocalcemia including carpopedal spasms. Excessive carbon dioxide for a time period of not more than 5 minutes was reported to cause effects on vision with constriction of visual fields, enlargement of blind spots, photophobia, loss of convergence and accommodation, and deficient dark adaptation as well as headache, insomnia, and personality changes, largely depression and irritability. Even when there is sufficient oxygen present to prevent simple asphyxiation by carbon dioxide, high concentrations may cause adverse effects by interfering with its normal elimination from the body. Initially, exposure to increased carbon dioxide concentrations results in a compensatory increase in both rate and depth of ventilation. Beyond a certain point, however, this may reverse to hypoventilation resulting in respiratory acidosis. Death from asphyxia may occur if the concentration and duration of exposure are sufficient. Reproductive effects have been reported in animals.
CHRONIC EXPOSURE- It has been reported that persons may tolerate 1.5% in inhaled air for prolonged periods without adverse effects, but calcium/phosphorus metabolism may be affected with serum levels of calcium and urinary phosphorus progressively falling. At 2% concentration, deepened respiration may occur. At 3% impairment of performance has been noted. It has, however, been demonstrated that the development of tolerance may occur during prolonged exposure to low levels. Reproductive effects have been reported in animals.

SKIN CONTACT:
CARBON DIOXIDE:
ACUTE EXPOSURE- No adverse effects have been reported from exposure to the gas. Due to rapid evaporation, the liquid or solid may cause frostbite with redness, tingling and pain or numbness. In more severe cases, the skin may become hard and white and develop blisters.

CHRONIC EXPOSURE- No adverse effects are expected from exposure at low levels.

EYE CONTACT:
CARBON DIOXIDE:
ACUTE EXPOSURE- At high concentrations in air, carbon dioxide may cause a stinging sensation of the eyes. 200,000 ppm of the gas may cause irritation. Due to rapid evaporation, the liquid or solid may cause frostbite with redness, pain, and blurred vision.
CHRONIC EXPOSURE- No adverse effects are expected from exposure to low levels.

INGESTION:
CARBON DIOXIDE:
ACUTE EXPOSURE- Ingestion of a gas is unlikely. If the liquid or solid is swallowed, frostbite damage of the lips, mouth and mucous membranes may occur.
CHRONIC EXPOSURE- No data available.

SECTION 12 ECOLOGICAL INFORMATION

ENVIRONMENTAL IMPACT RATING (0-4): no data available

ACUTE AQUATIC TOXICITY: no data available

DEGRADABILITY: no data available

LOG BIOCONCENTRATION FACTOR (BCF): no data available

LOG OCTANOL/WATER PARTITION COEFFICIENT: no data available

SECTION 13 DISPOSAL INFORMATION

Observe all federal, state and local regulations when disposing of this substance.

SECTION 14 TRANSPORTATION INFORMATION

DEPARTMENT OF TRANSPORTATION HAZARD CLASSIFICATION 49-CFR 172.101:
Nonflammable gas

Department of Transportation labeling requirements 49-CFR 172.101 and SUBPART E:
Nonflammable gas

DEPARTMENT OF TRANSPORTATION PACKAGING REQUIREMENTS: 49-CFR 173.302 and 49-CFR 173.304
EXCEPTIONS: 49-CFR 173.306

Final rule on hazardous materials regulations (HMR, 49 CFR parts 171-180), docket numbers HM-181, HM-181a, HM-181b, HM-181c, HM-181d and HM-204.

effective date October 1, 1991. However, compliance with the regulations is authorized on and after January 1, 1991. (55 FR 52402, 12/21/90)

Except for explosives, inhalation hazards, and infectious substances, the effective date for hazard communication requirements is extended to October 1, 1993. (56 FR 47158, 09/18/91)

U.S. DEPARTMENT OF TRANSPORTATION SHIPPING NAME-ID NUMBER, 49 CFR 172.101:
Carbon dioxide-UN 1013

U.S. DEPARTMENT OF TRANSPORTATION HAZARD CLASS OR DIVISION, 49 CFR 172.101:
2.2 - Non-flammable compressed gas

U.S. DEPARTMENT OF TRANSPORTATION LABELING REQUIREMENTS, 49 CFR 172.101 AND SUBPART E:
Nonflammable gas

U.S. DEPARTMENT OF TRANSPORTATION PACKAGING AUTHORIZATIONS:
EXCEPTIONS: 49 CFR 173.306
NON-BULK PACKAGING: 49 CFR 173.302 and 49 CFR 173.304
BULK PACKAGING: 49 CFR 173.302; 49 CFR 173.314 and 49 CFR 173.315

U.S. DEPARTMENT OF TRANSPORTATION QUANTITY LIMITATIONS 49 CFR 172.101:
PASSENGER AIRCRAFT OR RAILCAR: 75 kg
CARGO AIRCRAFT ONLY: 150 kg

SECTION 15 REGULATORY INFORMATION

TSCA STATUS: Y

CERCLA SECTION 103 (40CFR302.4):	N
SARA SECTION 302 (40CFR355.30):	N
SARA SECTION 304 (40CFR355.40):	N
SARA SECTION 313 (40CFR372.65):	N
OSHA PROCESS SAFETY (29CFR1910.119):	N
CALIFORNIA PROPOSITION 65:	N

SARA HAZARD CATEGORIES, SARA SECTIONS 311/312 (40 CFR 370.21)

ACUTE HAZARD:	Y
CHRONIC HAZARD:	N
FIRE HAZARD:	N
REACTIVITY HAZARD:	N
SUDDEN RELEASE HAZARD:	Y

SECTION 16 OTHER

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HS04290

SECTION 1 CHEMICAL PRODUCTS & COMPANY IDENTIFICATION

OCCUPATIONAL HEALTH SERVICES, INC.
11 WEST 42ND STREET, 12TH FLOOR
NEW YORK, NEW YORK 10036
1-800-445-MSDS (1-800-445-6737) OR
1-212-789-3535

FOR EMERGENCY SOURCE INFORMATION
CONTACT: 1-615-366-2000

CAS NUMBER: 630-08-0
RTECS NUMBER: FG3500000

SUBSTANCE: CARBON MONOXIDE

TRADE NAMES/SYNONYMS:
CARBON OXIDE; CARBON OXIDE (CO); STCC 4905709; UN 1016; CO; OHS04290

CHEMICAL FAMILY:
Inorganic gas

CREATION DATE: 02/08/85 REVISION DATE: 07/14/93

SECTION 2 COMPOSITION/INFORMATION ON INGREDIENTS

COMPONENT : CARBON MONOXIDE
CAS NUMBER: 630-08-0
PERCENTAGE: 100.0

OTHER CONTAMINANTS: NONE

SECTION 3 HAZARDS IDENTIFICATION

CERCLA RATINGS (SCALE 0-3): HEALTH=3 FIRE=3 REACTIVITY=0 PERSISTENCE=0
NFPA RATINGS (SCALE 0-4): HEALTH=2 FIRE=4 REACTIVITY=0

EMERGENCY OVERVIEW:
CARBON MONOXIDE IS AN ODORLESS GAS.
May damage blood cells. Flammable gas. May cause flash fire.
Keep away from all ignition sources. Avoid breathing gas. Avoid contact with eyes, skin and clothing. Do not puncture container. Keep container tightly closed. Wash thoroughly after handling. Use only with adequate ventilation.

POTENTIAL HEALTH EFFECTS:
INHALATION:
SHORT TERM EFFECTS: May cause suffocation, redness of the skin, blisters, nausea, vomiting, involuntary defecation and/or urination, chest pain, headache, weakness, drowsiness, dizziness, fainting, confusion, incoordination, twitching, muscle spasm, hallucinations, hearing loss, dilated pupils, blindness, lung damage, blood disorders, liver enlargement, liver and kidney damage, nerve effects, convulsions, coma and heart failure.

May also cause reproductive effects.
LONG TERM EFFECTS: In addition to effects from short term exposure, lack of appetite, muscle pain and loss of memory may occur. May also cause reproductive effects.

SKIN CONTACT:
SHORT TERM EFFECTS: May cause blisters, frostbite and numbness.
LONG TERM EFFECTS: No information is available.

EYE CONTACT:
SHORT TERM EFFECTS: May cause frostbite and blurred vision.
LONG TERM EFFECTS: No information is available.

INGESTION:
SHORT TERM EFFECTS: May cause frostbite.
LONG TERM EFFECTS: No information is available.

CARCINOGEN STATUS:
OSHA: N
NTP: N
IARC: N

SECTION 4 FIRST AID MEASURES

INHALATION:
FIRST AID- Remove from exposure area to fresh air immediately. If breathing has stopped, give artificial respiration. Maintain airway and blood pressure and administer oxygen if available. Keep affected person warm and at rest. Treat symptomatically and supportively. Administration of oxygen should be performed by qualified personnel. Get medical attention immediately.

SKIN CONTACT:
FIRST AID- It is unlikely that emergency treatment will be required. If adverse effects occur, get medical attention.
In case of frostbite, warm affected skin in warm water at a temperature of 107 F. If warm water is not available or impractical to use, gently wrap affected part in blankets. Encourage victim to exercise affected part while it is being warmed. Allow circulation to return naturally (Matheson Gas, 6th Ed.). Get medical attention immediately.

EYE CONTACT:
FIRST AID- It is unlikely that contact with the gas form will require emergency treatment. If contact with liquefied or compressed gas occurs, wash with large amounts of warm water until no evidence of chemical remains (approximately 15-20 minutes). Get medical attention immediately.

INGESTION:
FIRST AID- It is unlikely that emergency treatment will be required. If adverse effects occur, treat symptomatically and supportively and get medical attention.

NOTE TO PHYSICIAN
NTIDOTE:
o data available

SECTION 5 FIRE FIGHTING MEASURES

FIRE AND EXPLOSION HAZARD:
Dangerous explosion hazard when exposed to heat or flame.

Vapor-air mixtures are explosive.

Cylinder may explode in heat of fire.

Vapors are only slightly lighter than air and may travel to a source of ignition and flash back.

EXTINGUISHING MEDIA:
Let burn unless leak can be stopped immediately
(1990 Emergency Response Guidebook, DOT P 5800.5).

For larger fires, use water spray, fog or regular foam
(1990 Emergency Response Guidebook, DOT P 5800.5).

FIREFIGHTING:
Move container from fire area if you can do it without risk. Apply cooling water to sides of containers that are exposed to flames until well after fire is out. Stay away from ends of tanks. For massive fire in cargo area, use unmanned hose holder or monitor nozzles; if this is impossible, withdraw from area and let fire burn. Withdraw immediately in case of rising sound from venting safety device or any discoloration of tank due to fire. Isolate for 1/2 mile in all directions if tank, rail car or tank truck is involved in fire (1990 Emergency Response Guidebook, DOT P 5800.5, Guide Page 18).

Extinguish only if flow can be stopped, use water in flooding amounts as a fog. Cool containers with flooding quantities of water, apply from as far a distance as possible. Evacuate to a radius of 1500 ft. for uncontrollable fire. Evacuate downwind area if material is leaking.

Stop flow of gas (NFPA 325M, Fire Hazard Properties of Flammable Liquids, Gases, and Volatile Solids, 1991).

LOWER FLAMMABLE LIMIT: 12.5%
UPPER FLAMMABLE LIMIT: 74%
AUTOIGNITION: 1128 F (609 C)

HAZARDOUS COMBUSTION PRODUCTS:
Thermal decomposition products may include toxic oxides of carbon.

SECTION 6 ACCIDENTAL RELEASE MEASURES

OCCUPATIONAL SPILL:
Shut off ignition souces. Stop leak if you can do it without risk. Use water spray to reduce vapors. Isolate area until gas has dispersed. No smoking, flames or flares in hazard area! Keep unnecessary people away; isolate hazard area and deny entry. Ventilate closed spaces before entering them. Evacuate

area endangered by gas.

WATER SPILL:
The California Safe Drinking Water and Toxic Enforcement Act of 1986 (Proposition 65) prohibits contaminating any known source of drinking water with substances known to cause cancer and/or reproductive toxicity.

SECTION 7 HANDLING AND STORAGE

Observe all federal, state and local regulations when storing this substance.

Store in accordance with 29 CFR 1910.101.

Store away from incompatible substances.

SECTION 8 EXPOSURE CONTROLS/PERSONAL PROTECTION

EXPOSURE LIMITS:
CARBON MONOXIDE:
35 ppm (40 mg/m3) OSHA TWA; 200 ppm (229 mg/m3) OSHA ceiling
25 ppm (29 mg/m3) ACGIH TWA
35 ppm (40 mg/m3) NIOSH recommended 8 hour TWA;
200 ppm (229 mg/m3) NIOSH recommended ceiling
30 ppm (33 mg/m3) DFG MAK TWA;
60 ppm (66 mg/m3) DFG MAK 30 minute peak, average value, 4 times/shift

Measurement method: Gas collection bag; electrochemical analysis; (NIOSH Vol. II(4) # S340).

Subject to California Proposition 65 cancer and/or reproductive toxicity warning and release requirements- (July 1, 1989)

OSHA revoked the final rule limits of January 19, 1989 in response to the 11th Circuit Court of Appeals decision (AFL-CIO v. OSHA) effective June 30, 1993. See 29 CFR 1910.1000 (58 FR 35338)

VENTILATION:
Provide local exhaust ventilation to meet published exposure limits. Ventilation equipment must be explosion-proof.

EYE PROTECTION:
For the gas form eye protection is not required but recommended. Where there is any possibility of contact with the liquid form, employee must wear splash-proof safety goggles and a faceshield to prevent contact with this substance. Contact lenses should not be worn.

Emergency wash facilities:
Where there is any possibility that an employee's eyes and/or skin may be exposed to the liquid form of this substance, the employer should provide an eye wash fountain and quick drench shower within the immediate work area for emergency use.

CLOTHING:
For the gas form, protective clothing not required.
If contact with the liquid form is possible, employee must wear appropriate protective clothing and equipment to prevent skin from freezing.

GLOVES:
Wear full protective, cold insulating gloves.

RESPIRATOR:
The following respirators and maximum use concentrations are recommendations by the U.S. Department of Health and Human Services, NIOSH pocket guide to chemical hazards; NIOSH criteria documents or by the U.S. Department of Labor, 29 CFR 1910 Subpart Z.
The specific respirator selected must be based on contamination levels found in the work place, must not exceed the working limits of the respirator and be jointly approved by the National Institute for Occupational Safety and Health and the Mine Safety and Health Administration (NIOSH-MSHA).

CARBON MONOXIDE:

350 ppm- Any supplied-air respirator.
Any self-contained breathing apparatus.

875 ppm- Any supplied-air respirator operated in a continuous flow mode.

1500 ppm- Any self-contained breathing apparatus with a full facepiece.
Any supplied-air respirator with a full facepiece.
Any air-purifying, full-facepiece respirator (gas mask) with a chin-style, front- or back-mounted canister providing protection against carbon monoxide.

Escape- Any air-purifying, full-facepiece respirator (gas mask) with a chin-style, front- or back-mounted canister providing protection against carbon monoxide.
Any appropriate escape-type, self-contained breathing apparatus.

FOR FIREFIGHTING AND OTHER IMMEDIATELY DANGEROUS TO LIFE OR HEALTH CONDITIONS:

Any self-contained breathing apparatus that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode.

Any supplied-air respirator that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode in combination with an auxiliary self-contained breathing apparatus operated in pressure-demand or other positive-pressure mode.

SECTION 9 PHYSICAL AND CHEMICAL PROPERTIES

DESCRIPTION: Odorless, tasteless, colorless gas.
MOLECULAR WEIGHT: 28.01
MOLECULAR FORMULA: C-O
BOILING POINT: -314 F (-192 C)
MELTING POINT: -326 F (-199 C)

VAPOR PRESSURE: 760 mmHg @ -191 C
VAPOR DENSITY: 0.968
SPECIFIC GRAVITY: 1.250 g/L @ 0 C
WATER SOLUBILITY: 2.3% @ 20 C
SOLVENT SOLUBILITY: Soluble in alcohol, benzene, acetic acid, ethyl acetate, chloroform, cuprous chloride solutions.

VISCOSITY: 0.01657 cP @ 0 C

SECTION 10 STABILITY AND REACTIVITY

REACTIVITY:
Stable under normal temperatures and pressures.

CONDITIONS TO AVOID:
Avoid contact with heat, sparks, flames, or other ignition sources. Vapors may be explosive. Material is extremely poisonous; avoid inhalation of vapors or contact with skin. Do not allow material to contaminate water sources.

INCOMPATIBILITIES:
CARBON MONOXIDE:
- BARIUM PEROXIDE: Violent reaction.
- BROMINE PENTAFLUORIDE: Violent reaction and possible ignition.
- BROMINE TRIFLUORIDE: Explosion hazard.
- CESIUM MONOXIDE: Ignites in the presence of moisture or when heated.
- CHLORINE: Violent reaction.
- CHLORINE DIOXIDE: Explodes.
- CHLORINE TRIFLUORIDE: Explosive reaction.
- DINITROGEN OXIDE: Fire and explosion hazard.
- FLUORINE + OXYGEN: May explode above 30 C.
- IODINE HEPTAFLUORIDE: Ignition.
- IRON(III) OXIDE: Possible explosion hazard.
- LITHIUM: Forms compound which detonates violently on contact with water.
- NITROGEN TRIFLUORIDE: Explosive reaction upon ignition.
- OXYGEN (LIQUID): Forms explosive mixture.
- OXYGEN DIFLUORIDE: Explodes when sparked.
- PEROXODISULFURYL DIFLUORIDE: Explosive reaction above 20 C.
- POTASSIUM: Forms explosive compound.
- SILVER(I) OXIDE: Extremely exothermic reaction.
- SODIUM: Forms explosive, shock-sensitive compound.

HAZARDOUS DECOMPOSITION:
Thermal decomposition products may include toxic oxides of carbon.

POLYMERIZATION:
Hazardous polymerization has not been reported to occur under normal temperatures and pressures.

SECTION 11 TOXICOLOGY INFORMATION

CARBON MONOXIDE:
TOXICITY DATA: 4000 ppm/30 minutes inhalation-man LCLo; 650 ppm/45 minutes

inhalation-man TCLo; 5000 ppm/5 minutes inhalation-human LCLo; 600 mg/m3/10 minutes inhalation-human TCLo; 1807 ppm/4 hours inhalation-rat LC50; 2444 ppm/4 hours inhalation-mouse LC50; 4000 ppm/46 minutes inhalation-dog LCLo; 4000 ppm inhalation-rabbit LCLo; 5718 ppm/4 hours inhalation-guinea pig LC50; 5000 ppm/5 minutes inhalation-mammal LCLo; mutagenic data (RTECS); reproductive effects data (RTECS).

CARCINOGEN STATUS: None.

ACUTE TOXICITY LEVEL: Moderately toxic by inhalation.

TARGET EFFECTS: Chemical asphyxiant. Poisoning may affect the central nervous, cardiovascular and respiratory systems, and the kidneys.

AT INCREASED RISK FROM EXPOSURE: Smokers, pregnant women; persons with anemia, hyperthyroidism, bronchitis or asthma, and cardiovascular disease.

ADDITIONAL DATA: The use of alcoholic beverages or working at high altitudes or in a hot environment may enhance the toxic effects.

HEALTH EFFECTS

INHALATION:

CARBON MONOXIDE:

CHEMICAL ASPHYXIANT/MODERATELY TOXIC.

1500 ppm Immediately Dangerous to Life or Health.

ACUTE EXPOSURE- Carbon monoxide is not detectable by odor and headache should be taken as a warning that a dangerous concentration is being inhaled. In sudden exposures to high concentrations, weakness and dizziness may be the only symptoms preceding collapse. The amount of carboxyhemoglobin formed in the blood is dependent on concentration and duration of exposure, ambient temperature, physical exertion, health, and individual metabolism. Symptoms are usually not noticeable until the carboxyhemoglobin level reaches 10%. At 10-40%, symptoms may include increasingly severe headache, dyspnea on exertion, decreased manual dexterity, impaired judgement and memory, irritability, emotional instability, dizziness, fatigue, drowsiness, confusion, nausea, vomiting, palpitations, and impaired vision and hearing. With continuing exposure, there is a progressive worsening of all symptoms. At 40-60%, anginal pain, incoordination, hallucinations, lethargy, syncope and collapse, and increased respiration and pulse may occur. At 60-80% there may be decreased respiration, blood pressure and pulse, and deepening coma with intermittent convulsions and incontinence of urine and feces. Rarely, there may be a pink or red skin discoloration, but cyanosis or pallor is more common. Other reported signs and symptoms include increased temperature, dilated pupils, perspiration, muscle spasms, hyperreflexia, aching limbs, and retinal hemorrhage or venous engorgement. Above 70-80%, rapid death from respiratory or cardiac arrest usually occurs. Death may also be caused by myocardial or cerebral infarction. Cerebral edema may also occur. In non-fatal cases or when death is not immediate, primary or secondary effects of tissue hypoxia and some atypical reactions may develop. There may be myocarditis, pulmonary edema, bronchopneumonia, pancreatitis, hepatomegaly, liver and kidney damage, albuminuria, glycosuria, and oliguria. Hemolytic anemia, thrombocytopenic purpura, polycythemia and leukocytosis have been reported. Rhabdomyolysis with myoglobinuria and acute renal failure are possible, especially with pressure injury. Erythema, edema and blisters may develop, especially over pressure areas. Eye effects may include retrobulbar neuritis with neuroretinal edema and partial or complete, temporary or permanent blindness. Temporary or permanent hearing loss may also occur. Complete

recovery is the usual course. However, signs and symptoms of nerve or brain injury with nouropathies and various motor and mental defects, some of which resemble multiple sclerosis or parkinsonism, may develop several days to weeks after apparent recovery, especially from prolonged hypoxic coma. The onset may be sudden with numerous possible effects, including dementia, deterioration of neurological status and sometimes slowly resolving or permanent disability or death. A study of 63 patients 3 years after carbon monoxide poisoning indicated that 13% showed gross neuropsychiatric damage; 33% showed deterioration of personality; and 43% reported memory impairment. Carbon monoxide readily crosses the placental barrier. Acute non-lethal intoxication may result in miscarriage or permanent neurologic sequelae such, as cerebral palsy, in the newborn.

CHRONIC EXPOSURE- Although carbon monoxide is not a cumulative poison, chronic exposure to low to moderate levels may result in repeated bouts of oxygen deprivation and resultant effects including cardiovascular or central nervous system damage. Reported signs and symptoms include polycythemia, lassitude, malaise, anorexia, nausea, vomiting, headache, dizziness, ataxia, syncope, glycosuria, weakness of the limbs, joint and neuromuscular pain, muscle spasm, loss of sensation in the fingers, positive Romberg's sign, auditory and visual disturbances and impaired vigilance. Irritability, personality changes, impaired memory and difficulty concentrating are also possible. The development of atherosclerosis may be facilitated. The development of congestive heart failure may be indicated by dyspnea, anginal pain and cardiac irregularities. Relatively long and severe exposure may cause cerebral congestion and adema resulting in long-lasting mental or nervous damage. During pregnancy, prolonged exposure to low levels, as in smoking, has been associated with smaller babies and increased neonatal mortalities. Rats exposed prenatally to low levels had offspring that exhibited signs of functional deficit in the central nervous system; minor skeletal anomalies were noted in mice. Other reproductive effects have been reported in animals.

SKIN CONTACT:
CARBON MONOXIDE:

ACUTE EXPOSURE- No adverse effects have been reported from the gas. Due to rapid evaporation, the liquid may cause frostbite with redness, tingling and pain or numbness. In more severe cases, the skin may become hard and white and blisters may develop.

CHRONIC EXPOSURE- No data available.

EYE CONTACT:
CARBON MONOXIDE:

ACUTE EXPOSURE- No adverse effects have been reported from the gas. Due to rapid evaporation, the liquid may cause frostbite with redness, pain and blurred vision.

CHRONIC EXPOSURE- No data available.

INGESTION:
CARBON MONOXIDE:

ACUTE EXPOSURE- Ingestion of a gas in unlikely. If liquid is swallowed, frostbite damage to the lips, mouth and mucous membranes may occur.

CHRONIC EXPOSURE- No data available.

SECTION 12 ECOLOGICAL INFORMATION

ENVIRONMENTAL IMPACT RATING (0-4): no data available

ACUTE AQUATIC TOXICITY: no data available

DEGRADABILITY: no data available

LOG BIOCONCENTRATION FACTOR (BCF): no data available

LOG OCTANOL/WATER PARTITION COEFFICIENT: no data available

SECTION 13 DISPOSAL INFORMATION

Observe all federal, state and local regulations when disposing of this substance.

Disposal must be in accordance with standards applicable to generators of hazardous waste, 40 CFR 262. EPA Hazardous Waste Number D001.
100 pound CERCLA Section 103 Reportable Quantity.

SECTION 14 TRANSPORTATION INFORMATION

DEPARTMENT OF TRANSPORTATION HAZARD CLASSIFICATION 49-CFR 172.101:
Flammable gas

Department of Transportation labeling requirements 49-CFR 172.101 and SUBPART E:
Flammable gas

DEPARTMENT OF TRANSPORTATION PACKAGING REQUIREMENTS: 49-CFR 173.302
EXCEPTIONS: 49-CFR 173.306

Final rule on hazardous materials regulations (HMR, 49 CFR parts 171-180), docket numbers HM-181, HM-181a, HM-181b, HM-181c, HM-181d and HM-204. Effective date October 1, 1991. However, compliance with the regulations is authorized on and after January 1, 1991. (55 FR 52402, 12/21/90)

Except for explosives, inhalation hazards, and infectious substances, the effective date for hazard communication requirements is extended to October 1, 1993. (56 FR 47158, 09/18/91)

U.S. DEPARTMENT OF TRANSPORTATION SHIPPING NAME-ID NUMBER, 49 CFR 172.101:
Carbon monoxide-UN 1016

U.S. DEPARTMENT OF TRANSPORTATION HAZARD CLASS OR DIVISION, 49 CFR 172.101:
2.3 - Poisonous gas

U.S. DEPARTMENT OF TRANSPORTATION LABELING REQUIREMENTS, 49 CFR 172.101 AND SUBPART E:
Poison gas, flammable gas

U.S. DEPARTMENT OF TRANSPORTATION PACKAGING AUTHORIZATIONS:
EXCEPTIONS: None
NON-BULK PACKAGING: 49 CFR 173.302
BULK PACKAGING: None

U.S. DEPARTMENT OF TRANSPORTATION QUANTITY LIMITATIONS 49 CFR 172.101:
PASSENGER AIRCRAFT OR RAILCAR: Forbidden
CARGO AIRCRAFT ONLY: 25 kg

SECTION 15 REGULATORY INFORMATION

TSCA STATUS: Y

CERCLA SECTION 103 (40CFR302.4): N
SARA SECTION 302 (40CFR355.30): N
SARA SECTION 304 (40CFR355.40): N
SARA SECTION 313 (40CFR372.65): N
OSHA PROCESS SAFETY (29CFR1910.119): N
CALIFORNIA PROPOSITION 65: Y

SARA HAZARD CATEGORIES, SARA SECTIONS 311/312 (40 CFR 370.21)
ACUTE HAZARD: Y
CHRONIC HAZARD: N
FIRE HAZARD: Y
REACTIVITY HAZARD: N
SUDDEN RELEASE HAZARD: Y

SECTION 16 OTHER

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Material Safety Data Sheet
MSDS: 22828 - CARBON TETRACHLORIDE
========== 3/12/92
Status: Current Revised: 10/23/90

Formula: CCl4 Part Number:
Specification: NOAA# 2828 Keyword:
Synonyms:
Stock Items:

Manufacturer
DATA FROM CAMEO/NOAA
7600 SAND POINT WAY N.E. Phone: (206) 526-6317
SEATTLE, WA 98115 Emergency:

Supplier
DATA FROM CAMEO/NOAA
7600 SAND POINT WAY N.E. Phone: (206) 526-6317
SEATTLE, WA 98115 Emergency:

Physical/Chemical Characteristics

Boiling Point .....:	170 F	@ 760 mm Hg
Melting Point .....:	-9.4 F	
Freezing Point .....:		
Pour Point .....:		
Softening Point .....:		
Specific Gravity .....:	1.59	@ 68 Deg F
Vapor Pressure .....:	96.91	@ 70 Deg F
at Temperature ....:	70 F	
Vapor Density .....:		
Percent Volatiles ....:		
Evaporation Rate .....:		
pH .....:		
Molecular Weight .....:	153.83	
Viscosity .....:		
Solubility in Water ..:		

Odor/Appearance/Other Characteristics:

Fire and Explosion Data

Closed Cup Flash Pt. .:	NA	Not flammable.
Open Cup Flash Point .:		
Fire Point .....:		
Auto Ignition .....:	NA	Not flammable.
Lower Explosion Limit :	NA	Not flammable.
Upper Explosion Limit :	NA	Not flammable.

Shipping Regulations
UN/NA Number: UN1846
DOT Hazard Class:
Shipping Label: ORM-A
Shipping Name:

Prepared
Preparer's Name & Title:
Preparation Date: 10/01/87

Component(s):
CARBON TETRACHLORIDE
OSHA Pel:
ACGIH TLV: 5 ppm
STEL:
Percent of Product: CAS No.: 56235

Text Section(s)

Full Chemical Name

CARBON TETRACHLORIDE
CAS number: 56235

Registry of Toxic Effects of Chemical Substances

FG4900000

Standard Transportation Commodities Code

4940320

List of synonyms for the chemical

METHANE, TETRACHLORO-
\BENZINOFORM
\CARBONA
\CARBON CHLORIDE (CCL4)
\CARBON TETRACHLORIDE
\FLUKOIDS
\NECATORINA
\PERCHLOROMETHANE
\R 10
\R 10 (REFRIGERANT)
\TETRACHLOROMETHANE
\TETRAFINOL
\TETRAFORM
\TETRASOL
\UNIVERM
\VERMOESTRICID
\CARBON CHLORIDE
\CARBON TET
\CARBON TETRACHLORIDE (ACGIH,DOT)
\CZTEROCHLOREK WEGLA (POLISH)
\ENT 4,705

\FASCIOLIN
\METHANE TETRACHLORIDE
\NECATORINE
\RCRA WASTE NUMBER U211
\TETRACHLOORKOOLSTOF (DUTCH)
\TETRACHLOORMETAAN
\TETRACHLORKOHLENSTOFF, TETRA (GERMAN)
\TETRACHLORMETHAN (GERMAN)
\TETRACHLOROCARBON
\TETRACHLORURE DE CARBONE (FRENCH)
\TETRACLOROMETANO (ITALIAN)
\TETRACLORURO DI CARBONIO (ITALIAN)
\UN 1846 (DOT)

DOT label

ORM-A

NFPA

NFPA rating for Health Hazard --
3
NFPA rating for Flammability Hazard --
0
NFPA rating for Reactivity Hazard --
0

General description of a chemical

Carbon tetrachloride is a clear colorless heavy liquid with a characteristic odor. It is used as a solvent, in the manufacture of other chemicals, as an agricultural fumigant, and for many other uses. It is heavier than water and insoluble in water. It is non-combustible. It can cause illness by inhalation, skin absorption and/or ingestion. ((C)AAR, 1986)

Fire and Explosion Hazards Information

Fire and explosion hazards --
Not flammable. POISONOUS AND IRRITATING GASES ARE PRODUCED WHEN HEATED. Forms poisonous phosgene gas when exposed to open flames. Decomposes to form chlorine and phosgene. (USCG, 1985)
Fire fighting techniques --
Extinguish fire using agent suitable for type of surrounding fire (material itself does not burn or burns with difficulty). ((C)AAR, 1986)

Protective clothing recommendations

Keep upwind. Wear boots, protective gloves, and goggles. Avoid breathing vapors or dusts. Wash away any material which may have contacted the body with copious amounts of water or soap and water. ((C)AAR, 1986)

Compatibility

Compatibility with Butyl Rubber --
Poor Resistance/Good Data.
Compatibility with chlorinated polyehtylene --
Poor Resistance/Limited Data.
Compatibility with nitrile/butadiene coated fabric --
Good Resistance/Limited Data.
Compatibility with neoprene --
Poor Resistance/Good Data.
Compatibility with neoprene/natural rubber blend --
Poor Resistance/Good Data.
Compatibility with neoprene/SBR coated nylon or cotton --
Poor Resistance/Limited Data.
Compatibility with nitrile coated fabric --
Good Resistance/Good Data.
Compatibility with nitrile/PVC coated fabric --
Good Resistance/Limited Data.
Compatibility with polyethylene --
Poor Resistance/Good Data.
Compatibility with polyurethane --
Poor Resistance/Limited Data.
Compatibility with polyvinyl alcohol --
Good Resistance/Good Data.
Compatibility with polyvinyl chloride --
Poor Resistance/Good Data.
Compatibility with natural rubber --
Poor Resistance/Good Data.
Compatibility with styrene/butadiene coated fabric --
Poor Resistance/Good Data.
Compatibility with Viton --
Good Resistance/Limited Data.

Non-Fire response information

Keep material out of water sources and sewers. Build dikes to contain flow as necessary. Land spill: Dig a pit, pond, lagoon, holding area to contain liquid or solid material. Dike surface flow using soil, sand bags, foamed polyurethane, or foamed concrete. Absorb bulk liquid with fly ash or cement powder. Apply "universal" gelling agent to immobilize spill. Water spill: Use natural deep water pockets, excavated lagoons, or sand bag barriers to trap material at bottom. Remove trapped material with suction hoses. If dissolved, apply activated carbon at ten times the spilled amount in region of 10 ppm or greater concentration. Use mechanical dredges or lifts to remove immobilized masses of pollutants and precipitates. Air spill: Apply water spray or mist to knock down vapors. Vapor knockdown water is corrosive or toxic and should be diked for containment. Thermal decomposition to phosgene can occur. ((C)AAR, 1986)

Health hazard information

VAPOR: POISONOUS IF INHALED. Irritating to eyes Move to fresh air.
LIQUID: POISONOUS IF SWALLOWED. Irritating to skin and eyes. (USCG, 1985)

First aid information

If this chemical comes in contact with the eyes, immediately wash the eyes with large amounts of water, occasionally lifting the lower and upper lids. Get medical attention immediately. Contact lenses should not be worn when working with this chemical. If this chemical comes in contact with the skin, immediately wash the contaminated skin with soap and water. If this chemical penetrates through the clothing, immediately remove the clothing, wash the skin with soap and water, get medical attention promptly. If a person breathes in large amounts of this chemical, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible. If this chemical has been swallowed, get medical attention immediately. (NIOSH, 1987)

Fire and Explosion Data

Flash point of chemical --
    Not Applicable. Not flammable. (USCG, 1985)
Lower explosive limit --
    Not Applicable. Not flammable. (USCG, 1985)
Upper explosive limit --
    Not Applicable. Not flammable. (USCG, 1985)
Auto-ignition temperature --
    Not Applicable. Not flammable. (USCG, 1985)

Physical / Chemical Characteristics

Melting point --
-9.4 Deg F (USCG, 1985)
Vapor pressure --
96.91 mm Hg @ 70 Deg F (USCG, 1985)
Specific gravity of vapor form --
5.3 (USCG, 1985)
Specific gravity of liquid form --
1.59 @ 68 Deg F (USCG, 1985)
Boiling point --
170 Deg F @ 760 mm Hg (USCG, 1985)
Molecular weight --
153.83 (USCG, 1985)

Exposure Limits

NIOSH Immediately Dangerous to Life and Health value --
Not applicable, potential human carcinogen. (NIOSH, 1987)
Time Weighted Average of the Threshold Limit Value --
5 ppm Skin. ((C)ACGIH, 1986)

OHS04770

SECTION 1 CHEMICAL PRODUCTS & COMPANY IDENTIFICATION

OCCUPATIONAL HEALTH SERVICES, INC.
11 WEST 42ND STREET, 12TH FLOOR
NEW YORK, NEW YORK 10036
1-800-445-MSDS (1-800-445-6737) OR
1-212-789-3535

FOR EMERGENCY SOURCE INFORMATION
CONTACT: 1-615-366-2000

CAS NUMBER: 67-66-3
RTECS NUMBER: FS9100000

SUBSTANCE: CHLOROFORM

TRADE NAMES/SYNONYMS:
TRICHLOROMETHANE; METHANE TRICHLORIDE; R 20; FREON 20; METHANE, TRICHLORO-; METHYL TRICHLORIDE; TRICHLOROFORM; R 20 (REFRIGERANT); METHENYL TRICHLORIDE; RCRA U044; STCC 4940310; UN 1888; CHCL3; OHS04770

CHEMICAL FAMILY:
Halogen compound, aliphatic

CREATION DATE: 10/01/84 REVISION DATE: 10/06/93

SECTION 2 COMPOSITION/INFORMATION ON INGREDIENTS

COMPONENT : CHLOROFORM
CAS NUMBER: 67-66-3
PERCENTAGE: >99

OTHER CONTAMINANTS: MAY CONTAIN TRACES OF A STABILIZER.

SECTION 3 HAZARDS IDENTIFICATION

CERCLA RATINGS (SCALE 0-3): HEALTH=3 FIRE=0 REACTIVITY=0 PERSISTENCE=3
NFPA RATINGS (SCALE 0-4): HEALTH=2 FIRE=0 REACTIVITY=0

EMERGENCY OVERVIEW:
CHLOROFORM IS A CLEAR LIQUID WITH A SWEET ODOR. IF YOU CAN SMELL IT YOU MAY BE EXCEEDING THE EXPOSURE LIMIT.
Suspect cancer hazard (contains material which can cause cancer in animals). Risk of cancer depends on duration and level of exposure. May cause liver damage. May damage kidneys. May affect the central nervous system. Causes respiratory tract, skin and eye irritation. No known fire or reactivity hazard.
Avoid breathing vapor or mist. Avoid contact with eyes, skin and clothing. Keep container tightly closed. Wash thoroughly after handling. Use only with adequate ventilation.

POTENTIAL HEALTH EFFECTS:

INHALATION:
SHORT TERM EFFECTS: May cause irritation. Additional effects may include drunkeness, drooling, nausea, vomiting, low blood pressure, irregular heartbeat, headache, weakness, fainting, disorientation, excitation or drowsiness, numbness, dilated pupils, liver and kidney damage, convulsions, unconsciousness and coma.
LONG TERM EFFECTS: In addition to effects from short term exposure, thirst, dry mouth, lack of appetite, digestive disorders, anemia, confusion, tingling sensation, twitching, loss of memory, blurred vision and liver enlargement may occur.

SKIN CONTACT:
SHORT TERM EFFECTS: May cause irritation. Additional effects may include weight loss.
LONG TERM EFFECTS: Same effects as short term exposure.

EYE CONTACT:
SHORT TERM EFFECTS: May cause irritation. Additional effects may include tearing, numbness and spastic winking.
LONG TERM EFFECTS: Same effects as short term exposure.

INGESTION:
SHORT TERM EFFECTS: May cause drunkeness, liver damage, kidney damage, lack of appetite, nausea, vomiting, diarrhea, blood in the urine, difficulty breathing, low blood pressure, dilated pupils, bluish skin color, lung damage and unconsciousness.
LONG TERM EFFECTS: In addition to effects from short term exposure, liver and kidney damage may occur. May also cause reproductive effects and cancer.

CARCINOGEN STATUS:
OSHA: N
NTP: Y
IARC: Y

SECTION 4 FIRST AID MEASURES

INHALATION:
FIRST AID- Remove from exposure area to fresh air immediately. If breathing has stopped, perform artificial respiration. Keep person warm and at rest. Treat symptomatically and supportively. Get medical attention immediately.

SKIN CONTACT:
FIRST AID- Remove contaminated clothing and shoes immediately. Wash affected area with soap or mild detergent and large amounts of water until no evidence of chemical remains (approximately 15-20 minutes). Get medical attention immediately.

EYE CONTACT:
FIRST AID- Wash eyes immediately with large amounts of water or normal saline, occasionally lifting upper and lower lids, until no evidence of chemical remains (approximately 15-20 minutes). Get medical attention immediately.

INGESTION:
FIRST AID- Treat symptomatically and supportivaly. Get medical attention immediately. If vomiting occurs, keep head lower than hips to prevent

aspiration.

NOTE TO PHYSICIAN
ANTIDOTE:
No specific antidote. Treat symptomatically and supportively.

SECTION 5 FIRE FIGHTING MEASURES

FIRE AND EXPLOSION HAZARD:
Negligible fire hazard when exposed to heat or flame.

EXTINGUISHING MEDIA:
Dry chemical, water spray or regular foam
(1990 Emergency Response Guidebook, DOT P 5800.5).

For larger fires, use water spray, fog or regular foam
(1990 Emergency Response Guidebook, DOT P 5800.5).

FIREFIGHTING:
Move container from fire area if you can do it without risk. Fight fire from maximum distance. Stay away from ends of tanks. Dike fire-control water for later disposal; do not scatter the material (1990 Emergency Response Guidebook, DOT P 5800.5, Guide Page 55).

Extinguish using agents suitable for type of fire. Avoid breathing vapors or dusts, keep upwind.

AUTOIGNITION: >1832 F (>1000 C)

HAZARDOUS COMBUSTION PRODUCTS:
CHLOROFORM:
Thermal decomposition may release toxic or corrosive vapors, including oxides of chlorine and carbon, phosgene, chlorine gas and hydrogen chloride.

SECTION 6 ACCIDENTAL RELEASE MEASURES

OCCUPATIONAL SPILL:
Do not touch spilled material. Stop leak if you can do it without risk. Use water spray to reduce vapors. For small spills, take up with sand or other absorbent material and place into containers for later disposal. For small dry spills, with a clean shovel place material into clean, dry containers and cover. Move containers from spill area. For larger spills, dike far ahead of spill for later disposal. Keep unnecessary people away. Isolate hazard area and deny entry. Ventilate closed spaces before entering.

Reportable Quantity (RQ):
The Superfund Amendments and Reauthorization Act (SARA) Section 304 requires that a release equal to or greater than the reportable quantity established for that substance be immediately reported to the local emergency planning committee and the state emergency response commission (40 CFR 355.40). If the release of this substance is reportable under CERCLA Section 103, the National Response Center must be notified immediately at (800) 424-8802 or

(202) 426-2675 in the metropolitan Washington, D.C. area (40 CFR 302.6).

SOIL SPILL:
Dig a holding area such as a pit, pond or lagoon to contain spill and dike surface flow using barrier of soil, sandbags, foamed polyurethane or foamed concrete. Absorb liquid mass with fly ash or cement powder.

Immobilize spill with universal gelling agent.

AIR SPILL:
Combustion products include corrosive or toxic vapors.

WATER SPILL:
Trap spilled material at bottom in deep water pockets, excavated holding areas or within sand bag barriers.

Use suction hoses to remove trapped spill material.

Use mechanical dredges or lifts to extract immobilized masses of pollution and precipitates.

If dissolved, at a concentration of 10 ppm or greater, apply activated carbon at ten times the amount that has been spilled.

The California Safe Drinking Water and Toxic Enforcement Act of 1986 (Proposition 65) prohibits contaminating any known source of drinking water with substances known to cause cancer and/or reproductive toxicity.

SECTION 7 HANDLING AND STORAGE

Observe all federal, state and local regulations when storing this substance.

Threshold Planning Quantity (TPQ):
The Superfund Amendments and Reauthorization Act (SARA) Section 302 requires that each facility where any extremely hazardous substance is present in a quantity equal to or greater than the TPQ established for that substance notify the state emergency response commission for the state in which it is located. Section 303 of SARA requires these facilities to participate in local emergency response planning (40 CFR 355.30).

Store in a cool, dry, well-ventilated location. Separate from strong alkalis (NFPA 49, Hazardous Chemicals Data, 1975).

Store away from incompatible substances.

Keep container tightly closed. Protect from exposure to air or light.

SECTION 8 EXPOSURE CONTROLS/PERSONAL PROTECTION

EXPOSURE LIMITS:
CHLOROFORM:
2 ppm (9.78 mg/m3) OSHA TWA

10 ppm (49 mg/m3) ACGIH TWA
ACGIH A2-Suspected Human Carcinogen.
2 ppm (9.78 mg/m3) NIOSH recommended 60 minute STEL
10 ppm (49 mg/m3) DFG MAK TWA;
20 ppm (98 mg/m3) DFG MAK 30 minute peak, average value, 4 times/shift

Measurement method: Charcoal tube; carbon disulfide: gas chromatography with flame ionization detection; (NIOSH Vol. III # 1003, Halogenated Hydrocarbons).

10,000 pounds SARA Section 302 Threshold Planning Quantity
5000 pounds SARA Section 304 Reportable Quantity
10 pounds CERCLA Section 103 Reportable Quantity
Subject to SARA Section 313 Annual Toxic Chemical Release Reporting
Subject to California Proposition 65 cancer and/or reproductive toxicity warning and release requirements- (October 1, 1987)

OSHA revoked the final rule limits of January 19, 1989 in response to the 11th Circuit Court of Appeals decision (AFL-CIO v. OSHA) effective June 30, 1993. See 29 CFR 1910.1000 (58 FR 35338)

VENTILATION:
Provide local exhaust or process enclosure ventilation to meet published exposure limits.

EYE PROTECTION:
Employee must wear splash-proof or dust-resistant safety goggles and a faceshield to prevent contact with this substance.

Emergency wash facilities:
Where there is any possibility that an employee's eyes and/or skin may be exposed to this substance, the employer should provide an eye wash fountain and quick drench shower within the immediate work area for emergency use.

CLOTHING:
Employee must wear appropriate protective (impervious) clothing and equipment to prevent repeated or prolonged skin contact with this substance.

GLOVES:
Employee must wear appropriate protective gloves to prevent contact with this substance.

RESPIRATOR:
The following respirators and maximum use concentrations are recommendations by the U.S. Department of Health and Human Services, NIOSH pocket guide to chemical hazards; NIOSH criteria documents or by the U.S. Department of Labor, 29 CFR 1910 Subpart Z.
The specific respirator selected must be based on contamination levels found in the work place, must not exceed the working limits of the respirator and be jointly approved by the National Institute for Occupational Safety and Health and the Mine Safety and Health Administration (NIOSH-MSHA).

CHLOROFORM:

At any detectable concentration:
Any self-contained breathing apparatus that has a full facepiece and is operated in a pressure-demand or other positive pressure-mode.
Any supplied-air respirator with a full facepiece and is operated in a pressure-demand or other positive-pressure mode in combination with an auxiliary self-contained breathing apparatus operated in pressure-demand or other positive-pressure mode.

Escape:
Any air-purifying, full-facepiece respirator (gas mask) with a chin-style, front- or back-mounted organic vapor canister.
Any appropriate escape-type, self-contained breathing apparatus.

FOR FIREFIGHTING AND OTHER IMMEDIATELY DANGEROUS TO LIFE OR HEALTH CONDITIONS

Any self-contained breathing apparatus that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode.

Any supplied-air respirator that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode in combination with an auxiliary self-contained breathing apparatus operated in pressure-demand or other positive-pressure mode.

SECTION 9 PHYSICAL AND CHEMICAL PROPERTIES

DESCRIPTION: Clear, colorless, heavy, volatile liquid with a sweet pleasant ethereal taste and odor.
MOLECULAR WEIGHT: 119.38
MOLECULAR FORMULA: C-H-CL3
BOILING POINT: 143 F (62 C)
MELTING POINT: -82 F (-64 C)
VAPOR PRESSURE: 160 mmHg @ 20 C
VAPOR DENSITY: 4.12
SPECIFIC GRAVITY: 1.4832
WATER SOLUBILITY: 0.82% @ 20 C
VOLATILITY: 100%
ODOR THRESHOLD: 200 ppm
EVAPORATION RATE: (butyl acetate=1) 11.6
SOLVENT SOLUBILITY: Soluble in alcohol, ether, acetone, benzene, ligroin, solvent naphtha, petroleum ether, carbon tetrachloride, carbon disulfide, oils, other organic solvents.

VISCOSITY: 56.3 cP @ 20 C

SECTION 10 STABILITY AND REACTIVITY

REACTIVITY:
Stable under normal temperatures and pressures.

CONDITIONS TO AVOID:
May burn but does not ignite readily. Containers may explode in heat of fire.

INCOMPATIBILITIES:
CHLOROFORM:
ALUMINUM (POWDERED): Explosion on contact.
BIS(DIMETHYLAMINO)DIMETHYLSTANNANE: Explosion when heated.
DINITROGEN TETRAOXIDE: Explosive mixture.
DISILANE: Vigorous incandescent reaction.
FLUORINE: Explosive reaction.
KETONES + ALKALIES: Vigorous exothermic reaction.
LITHIUM: Forms shock-sensitive mixture.
MAGNESIUM (POWDER): Explodes on contact.
METALS + WATER: May be attacked.
METHANOL + ALKALIES: Exothermic reaction.
NITROMETHANE: Forms explosive mixture.
PERCHLORIC ACID + PHOSPHOROUS PENTOXIDE: Violent explosion.
PLASTICS, RUBBER, COATINGS: May be attacked.
POTASSIUM: Explosive reaction.
POTASSIUM TERT-BUTOXIDE (VAPOR): Ignites on contact.
SODIUM: Explosive reaction.
SODIUM METHOXIDE: Incompatible.
TRIISOPROPYLPHOSPHINE: Vigorous reaction.

HAZARDOUS DECOMPOSITION:
CHLOROFORM:
Thermal decomposition may release toxic or corrosive vapors, including oxides of chlorine and carbon, phosgene, chlorine gas and hydrogen chloride.

POLYMERIZATION:
Hazardous polymerization has not been reported to occur under normal temperatures and pressures.

SECTION 11 TOXICOLOGY INFORMATION

CHLOROFORM:
IRRITATION DATA: 10 mg/24 hours open skin-rabbit mild; 500 mg/24 hours skin-rabbit mild; 148 mg eye-rabbit; 20 mg/24 hours eye-rabbit moderate.
TOXICITY DATA: 25,000 ppm/5 minutes inhalation-human LCLo; 10 mg/m3/1 year inhalation-human TCLo; 5000 mg/m3/7 minutes inhalation-human TCLo; 47,702 mg/m3/4 hours inhalation-rat LC50; 50 ppm/7 hours/26 weeks intermittent inhalation-rat TCLo; 28 gm/m3 inhalation-mouse LCLo; 59 gm/m3 inhalation-rabbit LCLo; 35 gm/m3/4 hours inhalation-cat LCLo; 100 gm/m3 inhalation-dog LCLo; 20,000 ppm/2 hours inhalation-guinea pig LCLo; 25 ppm/7 hours/26 weeks intermittent inhalation-guinea-pig TCLo; 25,000 ppm/5 minutes inhalation-mammal LCLo; >20 gm/kg skin-rabbit LD50; >4000 mg/kg skin-rabbit LD50 (Dow MSDS); 908 mg/kg oral-rat LD50; 36 mg/kg oral-mouse LD50; 1000 mg/kg oral-dog LDLo; 500 mg/kg oral-rabbit LDLo; 820 mg/kg oral-guinea pig LD50; 704 mg/kg subcutaneous-mouse LD50; 800 mg/kg subcutaneous-rabbit LDLo; 75 mg/kg intravenous-dog LDLo; 894 mg/kg intraperitoneal-rat LD50; 623 mg/kg intraperitoneal-mouse LD50; 1000 mg/kg intraperitoneal-dog LD50; 546 mg/kg unreported-man LDLo; mutagenic data (RTECS); reproductive effects data (RTECS); tumorigenic data (RTECS).
CARCINOGEN STATUS: Anticipated Human Carcinogen (NTP); Human Inadequate Evidence, Animal Sufficient Evidence (IARC Group-2B). Chloroform produced

benign and malignant tumors of the liver and kidney in mice following oral gavage. Administration to rats by gavage or in drinking-water increased the incidences of kidney and thyroid tumors and of neoplastic nodules of the liver.

LOCAL EFFECTS: Irritant- inhalation, skin, eye.

ACUTE TOXICITY LEVEL: Moderately toxic by ingestion; slightly toxic by inhalation and dermal absorption.

TARGET EFFECTS: Central nervous system depressant; hepatotoxin, nephrotoxin. Poisoning may also affect the heart.

AT INCREASED RISK FROM EXPOSURE: Alcoholics and persons with chronic skin, eye, liver, kidney, heart or respiratory disorders.

ADDITIONAL DATA: Use of, or exposure to, alcohol, steroids, polybrominated biphenyls, acetone, or chlordecone may enhance the toxic effects. May be excreted in breast milk. Stimulants such as epinephrine may induce ventricular fibrillation.

HEALTH EFFECTS

INHALATION:

CHLOROFORM:

IRRITANT/NARCOTIC/HEPATOTOXIN/NEPHROTOXIN.

ACUTE EXPOSURE- May cause irritation of the upper respiratory tract. Central nervous system depression may be preceded by excitation and inebriation. 1,000-2,000 ppm may cause dizziness, headache, fatigue, salivation, and nausea; 4,000 ppm may cause vomiting, serious disorientation, and a fainting feeling; 14,000-16,000 ppm may cause anesthesia and rapid loss of consciousness; more than 20,000 ppm may cause respiratory failure, cardiac arrhythmias, and death. Other symptoms may include a feeling of warmth, malaise, drowsiness, mydriasis with diminished light reflex, toxemia, loss of tendon reflexes, stupor, convulsions, coma and hypotension. Fatty changes and centrilobular necrosis of the liver and fatty degenerative changes of the kidney and heart may occur. If death does not occur immediately from respiratory arrest or ventricular fibrillation, it may occur later from liver and kidney damage.

CHRONIC EXPOSURE- Repeated exposure to 77-237 ppm has caused lassitude, dullness, urinary frequency, and gastrointestinal disturbances. Other reported symptoms include dry mouth, thirst, malaise, anorexia, headache, depression, confusion, weakness, blurred vision, paresthesias, loss of sense of balance, memory loss, tremors, anemia, kidney damage, and fatty degeneration of the liver. 17 of 68 workers exposed to 10-200 ppm for 1-4 years exhibited hepatomegaly and increased susceptibility to viral hepatitis. Exposure of rats on days 6-15 of gestation caused a high rate of resorptions, retarded fetal development, decreased fetal body measurements, and a low incidence of acaudate fetuses with imperforate anus. Mice exposed on days 8-15 of gestation had offspring with a significant increase of cleft palate. One noncorroborated study reports abnormal spermatozoa in mice exposed to levels above the TLV.

SKIN CONTACT:

CHLOROFORM:

IRRITANT.

ACUTE EXPOSURE- May cause irritation with inflammation, destruction of the epithelium, and prurulent blebs. Application to rabbit skin for 24

hours caused hyperemia and moderate necrosis. Some absorption occurred resulting in weight loss and degenerative kidney changes, however doses as high as 3980 mg/kg were survived.

CHRONIC EXPOSURE- Repeated or prolonged exposure may cause dermatitis with drying, cracking, and redness. If sufficient amounts are absorbed, systemic effects may occur.

EYE CONTACT:
CHLOROFORM:
IRRITANT.

ACUTE EXPOSURE- High vapor concentrations may cause stinging, irritation, and blepharospasm. Contact with the liquid may also cause burning pain, lacrimation, and redness. The corneal epithelium may be injured and partially lost, however, the eyes return to normal in 1-3 days. Long exposure of the cornea during general anesthesia has caused persistent injury.

CHRONIC EXPOSURE- Repeated or prolonged contact with irritants may cause conjunctivitis.

INGESTION:
CHLOROFORM:
NARCOTIC/HEPATOTOXIN/NEPHROTOXIN/CARCINOGEN.

ACUTE EXPOSURE- May cause burning of the mouth, throat, esophagus, and stomach, nausea, vomiting, diarrhea, abdominal and substernal pain, cold, clammy skin, cyanosis of the extremities and face, muscle cramps, mydriasis, hypotension, peripheral vasodilation, irregular respiration, respiratory failure, unconsciousness, and liver damage. The mean lethal dose in humans is about 1 ounce. Aspiration may occur and result in chemical pneumonitis. 250 mg/kg caused depression, profound sleep, dyspnea, anorexia, hematuria, and liver and kidney changes in rats.

CHRONIC EXPOSURE- Repeated ingestion may cause liver and kidney damage. In feeding studies, there was an increased incidence of benign and malignant tumors of the liver and kidneys in mice and of tumors of the kidney and thyroid and neoplastic nodules in the liver in rats. Reproductive effects have been reported in animals.

SECTION 12 ECOLOGICAL INFORMATION

ENVIRONMENTAL IMPACT RATING (0-4): no data available

ACUTE AQUATIC TOXICITY: no data available

DEGRADABILITY: no data available

LOG BIOCONCENTRATION FACTOR (BCF): no data available

LOG OCTANOL/WATER PARTITION COEFFICIENT: no data available

SECTION 13 DISPOSAL INFORMATION

Observe all federal, state and local regulations when disposing of this substance.

Disposal must be in accordance with standards applicable to generators of hazardous waste, 40CFR 262. EPA hazardous waste number uo44.

Chloroform - Regulatory level: 6.0 mg/l (TCLP-40 CFR 261 Appendix II) materials which contain the above substance at or above the TCLP regulatory level meet the EPA toxicity characteristic, and must be disposed of in accordance with 40 CFR part 262. EPA Hazardous Waste Number D022.

US EPA RCRA Hazardous Waste Number: RCRA U044

SECTION 14 TRANSPORTATION INFORMATION

DEPARTMENT OF TRANSPORTATION HAZARD CLASSIFICATION 49-CFR 172.101:
ORM-A

Department of Transportation labeling requirements 49-CFR 172.101 and SUBPART E:
None

DEPARTMENT OF TRANSPORTATION PACKAGING REQUIREMENTS: 49-CFR 173.630
EXCEPTIONS: 49-CFR 173.505

Final rule on hazardous materials regulations (HMR, 49 CFR parts 171-180), docket numbers HM-181, HM-181a, HM-181b, HM-181c, HM-181d and HM-204. Effective date October 1, 1991. However, compliance with the regulations is authorized on and after January 1, 1991. (55 FR 52402, 12/21/90)

Except for explosives, inhalation hazards, and infectious substances, the effective date for hazard communication requirements is extended to October 1, 1993. (56 FR 47158, 09/18/91)

U.S. DEPARTMENT OF TRANSPORTATION SHIPPING NAME-ID NUMBER, 49 CFR 172.101:
Chloroform-UN 1888

U.S. DEPARTMENT OF TRANSPORTATION HAZARD CLASS OR DIVISION, 49 CFR 172.101:
6.1 - Poisonous materials

U.S. DEPARTMENT OF TRANSPORTATION PACKING GROUP, 49 CFR 172.101:
PG II

U.S. DEPARTMENT OF TRANSPORTATION LABELING REQUIREMENTS, 49 CFR 172.101 AND SUBPART E:
Poison

U.S. DEPARTMENT OF TRANSPORTATION PACKAGING AUTHORIZATIONS:
EXCEPTIONS: None
NON-BULK PACKAGING: 49 CFR 173.202
BULK PACKAGING: 49 CFR 173.241

U.S. DEPARTMENT OF TRANSPORTATION QUANTITY LIMITATIONS 49 CFR 172.101:
PASSENGER AIRCRAFT OR RAILCAR: 5 l
CARGO AIRCRAFT ONLY: 60 l

Material Safety Data Sheet

from Genium's Reference Collection
Genium Publishing Corporation
1145 Catalyn Street
Schenectady, NY 12303-1836 USA
(518) 377-8855

GENIUM PUBLISHING CORP.

No. 310
METHYLENE CHLORIDE
(Revision F)

Issued: September 1985
Revised: November 1988

SECTION 1. MATERIAL IDENTIFICATION

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Material Name: METHYLENE CHLORIDE

Description (Origin/Uses): Used widely in paint removers, as a solvent for plastics, as a degreasing agent, in propellant mixtures for aerosol sprays, and as a blowing agent in foams.

Other Designations: Dichloromethane; Freon 30®; Methane Dichloride; Methylene Bichloride; Methylene Dichloride; CH_2Cl_2; CAS No. 0075-09-2

Manufacturer: Contact your supplier or distributor. Consult the latest edition of the *Chemicalweek Buyers' Guide* (Genium ref. 73) for a list of suppliers.

HMIS
H 2
F 1
R 0
PPG*
*See sect. 8

R 1
I 3
S 3
K 1

NFPA

SECTION 2. INGREDIENTS AND HAZARDS/EXPOSURE LIMITS

Methylene Chloride, ca 100%

OSHA PEL
8-Hour TWA: 500 ppm
Ceiling: 1000 ppm Acceptable Maximum Peak above the Ceiling: 2000 ppm for 5 Minutes in Any 2-Hour Period

ACGIH TLV, 1988-89
TLV-TWA: 50 ppm, 175 mg/m³
(Adopted 1988-89)

Toxicity Data*
Rat, Oral, LD_{50}: 2136 mg/kg
Human, Inhalation, TC_{Lo}: 500 ppm (8 Hours)

*See NIOSH, *RTECS* (PA8050000), for additional data with references to irritative, reproductive, mutagenic, and tumorigenic effects.

SECTION 3. PHYSICAL DATA

Boiling Point: 103.55°F (39.75°C) at 76 Torrs
Melting Point: -142°F (-96.7°C)
Vapor Density (Air = 1): 2.9
Vapor Pressure: 440 Torrs at 77°F (25°C)
Molecular Weight: 84.94 Grams/Mole
Solubility in Water (%): 1% by Weight
Specific Gravity (H_2O = 1): 1.3255 at 68°F (20°C)
% Volatile by Volume: Ca 100

Appearance and Odor: A clear, colorless, volatile liquid; distinctive, penetrating, ethereal odor. The odor will not serve as a useful warning property because concentrations of 100 ppm are not easily perceptible. Most persons can detect this odor at above 300 ppm.

SECTION 4. FIRE AND EXPLOSION DATA

Flash Point*	Autoignition Temperature: 1033°F (556°C)	LEL: 12% v/v	UEL: 19% v/v

Extinguishing Media: *Methylene chloride is not flammable under ordinary conditions. However, flammable vapor-air mixtures can form at approximately 212°F (100°C). Use water spray to cool fire-exposed containers and to flush spills away from exposures. Use extinguishing agents that will put out the surrounding fire. **Unusual Fire or Explosion Hazards:** Methylene chloride vapor is heavier than air and may collect and concentrate in low-lying, confined spaces. The high vapor pressure of methylene chloride means that when it is spilled, its vapor concentration in air can increase rapidly. If this vapor is heated, an explosion hazard is associated with the vapor-air mixture. Containers of this material may rupture violently if they are involved in fires. **Special Fire-fighting Procedures:** Wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in the pressure-demand or positive-pressure mode.

SECTION 5. REACTIVITY DATA

Stability/Polymerization: Methylene chloride is stable in closed containers during routine operations. Hazardous polymerization cannot occur. **Chemical Incompatibilities:** Methylene chloride can react dangerously with nitrogen tetroxide, liquid oxygen, potassium, sodium, sodium-potassium alloys, lithium, potassium hydroxide with N-methyl-N-nitroso urea, potassium *t*-butoxide, and finely powdered aluminum and magnesium. **Conditions to Avoid:** Avoid all exposure to sources of ignition, heat, and incompatible chemicals. Prolonged exposure to water may cause hydrolysis to highly corrosive hydrochloric acid when the temperature is above 140°F (60°C). In oxygen-enriched atmospheres or when heated (>212°F [100°C]), methylene chloride vapor can be readily ignited. **Hazardous Products of Decomposition:** Exposure to high temperature (from open flame, hot surfaces, uninsulated steam lines, welding arcs, etc.) can produce toxic and corrosive thermal-oxidative products of decomposition such as hydrogen chloride, carbon monoxide, and even small quantities of phosgene gas, which is extremely poisonous.

SECTION 6. HEALTH HAZARD INFORMATION

Carcinogenicity: Methylene chloride is listed as a suspected human carcinogen by the ACGIH (which classifies it as a group A2 carcinogen). **Summary of Risks:** Accidental contact of liquid methylene chloride with skin or eyes causes painful irritation and possible burns if not promptly removed. Exposure by way of contaminated gloves, clothing, or paint remover formulations can produce these same irritant effects. Long-term exposure to mild or moderate doses of methylene chloride may cause a delayed (24 to 48 hours) onset of dizziness, headache, mental confusion, slurred speech, double vision, and sleeplessness. Medical recovery can be slow. Overexposure to methylene chloride can cause elevated levels of carboxy hemoglobin in the blood (this same effect results from overexposure to carbon monoxide). **Medical Conditions Aggravated by Long-Term Exposure:** None reported. **Target Organs:** Skin, eyes, respiratory system, CNS, liver, kidneys, and blood. **Primary Entry:** Inhalation, skin contact/absorption. **Acute Effects:** Headache, giddiness, stupor, irritability, fatigue, tingling in the limbs, and narcosis that is not usually fatal if the exposure is terminated before anesthetic death occurs. **Chronic Effects:** The ACGIH classification of this material as a suspected human carcinogen implies that cancer is a possible effect of chronic exposure to methylene chloride. **FIRST AID:** Eyes. Immediately flush eyes, including under the eyelids, gently but thoroughly with

SECTION 6. HEALTH HAZARD INFORMATION, cont.

flooding amounts of running water for at least 15 minutes. **Skin.** Rinse the affected area with flooding amounts of water and then wash it with soap and water. **Inhalation.** Remove the exposed person to fresh air; restore and/or support his or her breathing as needed. Have qualified medical personnel administer oxygen as required. **Note to Attending Physician:** Do not administer adrenalin. **Ingestion.** Unlikely. Should this type of exposure occur, do not induce vomiting because of the danger of aspiration. If spontaneous vomiting should occur, position the exposed person's head below his or her trunk to resist aspiration. **Get medical help (in plant, paramedic, community) for all exposures.** Seek prompt medical assistance for further treatment, observation, and support after first aid. **Note to Physician:** Absorbed methylene chloride is stored in body fat and metabolizes to carbon monoxide. This produced carbon monoxide increases and sustains carboxyhemoglobin levels in the blood, which concommitantly reduces the oxygen-carrying capacity of the blood. NIOSH advises preplacement and annual medical exams that emphasize liver, kidney, eye, skin, CNS, and respiratory system functions and a complete blood count. Simultaneous exposure to tobacco smoke, alcohol, and carbon monoxide, along with heavy manual labor, increases the body burden of a worker as well as the toxic hazards of the methylene chloride. In significant exposures, serum methylene chloride levels are of no clinical importance. Neurologic and hepatic status as well as carboxy hemoglobin should be monitored.

SECTION 7. SPILL, LEAK, AND DISPOSAL PROCEDURES

Spill/Leak: Notify safety personnel, evacuate unnecessary personnel, eliminate all sources of ignition immediately, and provide adequate explosion-proof ventilation. Cleanup personnel need protection against this liquid's contact with the skin or eyes as well as inhalation of its vapor. Contain large spills and collect waste or absorb it with an inert material such as sand, earth, or vermiculite. Use nonsparking tools to place waste liquid or absorbent into closable containers for disposal. Keep waste out of sewers, watersheds, and waterways. **Waste Disposal:** Contact your supplier or a licensed contractor for detailed recommendations. Follow Federal, state, and local regulations.

OSHA Designations
Listed as an Air Contaminant (29 CFR 1910.1000 Subpart Z).
EPA Designations (40 CFR 302.4)
RCRA Hazardous Waste, NO. U080
CERCLA Hazardous Substance, Reportable Quantity: 1000 lbs (454 kg), per the Clean Water Act (CWA), § 307 (a), and the Resource Conservation and Recovery Act (RCRA), § 3001.

SECTION 8. SPECIAL PROTECTION INFORMATION

Goggles: Always wear protective eyeglasses or chemical safety goggles. Where splashing is possible, wear a full face shield. Follow OSHA eye- and face-protection regulations (29 CFR 1910.133). **Respirator:** Use a NIOSH-approved respirator per Genium reference 88 for the maximum-use concentrations and/or exposure limits cited in section 2. Follow OSHA respirator regulations (29 CFR 1910.134). For emergency or nonroutine operations (spills or cleaning reactor vessels and storage tanks), wear an SCBA. **Warning:** Air-purifying respirators will *not* protect workers in oxygen-deficient atmospheres. **Other:** Wear impervious neoprene, PVA, or Viton gloves, boots, aprons, and gauntlets, etc., to prevent any skin contact with liquid methylene chloride. **Ventilation:** Install and operate general and local maximum, explosion-proof ventilation systems powerful enough to maintain airborne levels of acetone below the exposure limits cited in section 2. Local exhaust ventilation is preferred because it prevents dispersion of the contaminant into the general work area by eliminating it at its source. Consult the latest edition of Genium reference 103 for detailed recommendations. Floor or sump ventilation may be necessary. **Safety Stations:** Make emergency eyewash stations, safety/quick-drench showers, and washing facilities available in work areas. **Contaminated Equipment:** Contact lenses pose a special hazard; soft lenses may absorb irritants, and all lenses concentrate them. Do *not* wear contact lenses in any work area. Remove contaminated clothing and launder it before wearing it again; clean this material from shoes and equipment. **Other:** Because the health effects of carbon monoxide and methylene chloride are additive (see sect. 6), workplaces should be equipped with automatic sensing equipment that identifies workroom atmospheric levels of both of these materials. **Comments:** Practice good personal hygiene; always wash thoroughly after using this material and before eating, drinking, smoking, using the toilet, or applying cosmetics. Keep it off your clothing and equipment. Avoid transferring it from your hands to your mouth while eating, drinking, or smoking. Do *not* eat, drink, or smoke in any work area. Do not inhale methylene chloride vapor.

SECTION 9. SPECIAL PRECAUTIONS AND COMMENTS

Storage/Segregation: Store methylene chloride in closed, moisture-proof containers in a cool, dry, well-ventilated area away from sources of ignition, strong oxidizers, caustics, and incompatible chemicals (see sect. 5). Protect containers from physical damage. **Special Handling/Storage:** Prevent moist air from entering storage containers. Provide ventilation at the floor level in storage areas because methylene chloride vapor is denser than air. Installation of a dryer and a safety seal on each tank is recommended. Aluminum is not recommended for use as a storage material; appropriate storage materials include galvanized iron, black iron, or steel. **Engineering Controls:** Make sure all engineering systems (production, transportation) are of maximum explosion-proof design. Electrically ground and bond all containers and pipelines used in shipping, transferring, reacting, production, and sampling operations to prevent generating static sparks.

Transportation Data (49 CFR 172.101-2)
DOT Shipping Name: Dichloromethane *or* Methylene Chloride
DOT Hazard Class: ORM-A
ID No. UN1593
DOT Packaging Requirements: 49 CFR 173.605
DOT Packaging Exceptions: 49 CFR 173.505

IMO Shipping Name: Dichloromethane
IMO Hazard Class: 6.1
IMO Label: Saint Andrew's Cross (X)*
IMDG Packaging Group: III

*Harmful-Stow away from Foodstuffs.

References: 1, 26, 38, 84-94, 100, 116, 117, 120, 122.

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Prepared by PJ Igoe, BS
Industrial Hygiene Review: DJ Wilson, CIH
Medical Review: MJ Hardies, MD

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OHS04770

SECTION 15 REGULATORY INFORMATION

TSCA STATUS: Y

CERCLA SECTION 103 (40CFR302.4):	Y	10	pounds RQ
SARA SECTION 302 (40CFR355.30):	Y	10,000	pounds TPQ
SARA SECTION 304 (40CFR355.40):	Y	5000	pounds RQ
SARA SECTION 313 (40CFR372.65):	Y		
OSHA PROCESS SAFETY (29CFR1910.119):	N		
CALIFORNIA PROPOSITION 65:	Y		

SARA HAZARD CATEGORIES, SARA SECTIONS 311/312 (40 CFR 370.21)

ACUTE HAZARD:	Y
CHRONIC HAZARD:	Y
FIRE HAZARD:	N
REACTIVITY HAZARD:	N
SUDDEN RELEASE HAZARD:	N

SECTION 16 OTHER

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Material Safety Data Sheets MESSER MG Industries

SECTION 1 CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

MG INDUSTRIES
3 GREAT VALLEY PARKWAY
MALVERN, PENNSYLVANIA 19355
PHONE: 610-695-7400
FAX: 610-695-7596

EMERGENCY CONTACT:
CHEMTREC:
1-800-424-9300

SUBSTANCE: VINYL CHLORIDE
TRADE NAMES/SYNONYMS:
CHLOROETHYLENE; CHLOROETHENE; CHLORETHENE; TROVIDUR; ETHYLENE MONOCHLORIDE; MONOCHLOROETHYLENE; EXON 470; MONOCHLORO ETHENE; VINYL CHLORIDE MONOMER; VINYL CHLORIDE, INHIBITED; STCC 4905792; RCRA U043; UN 1086; C2H3CL; MGI24940; RTECS KU9625000
CHEMICAL FAMILY: halogenated, aliphatic
CREATION DATE: May 07 1990
REVISION DATE: Sep 16 1999

SECTION 2 COMPOSITION, INFORMATION ON INGREDIENTS

COMPONENT: VINYL CHLORIDE
CAS NUMBER: 75-01-4
EC NUMBER (EINECS): 200-831-0
EC INDEX NUMBER: 602-023-00-7
PERCENTAGE: >99.9
OTHER CONTAMINANTS:
MAY CONTAIN TRACES OF PHENOL OR OTHER INHIBITORS

SECTION 3 HAZARDS IDENTIFICATION

NFPA RATINGS (SCALE 0-4): HEALTH=2 FIRE=4 REACTIVITY=1
EC CLASSIFICATION (ASSIGNED):
F+ Extremely Flammable
Carcinogen Category 1
R 12-45
EC Classification may be inconsistent with independently-researched data.
EMERGENCY OVERVIEW:
PHYSICAL DESCRIPTION: Colorless gas with a mild, sweet odor.
MAJOR HEALTH HAZARDS: harmful if swallowed, skin irritation, eye irritation, central nervous system depression, cancer hazard (in humans)
PHYSICAL HAZARDS: Flammable gas. May cause flash fire. May polymerize.

Containers may rupture or explode.
POTENTIAL HEALTH EFFECTS:
INHALATION:
SHORT TERM EXPOSURE: irritation, nausea, difficulty breathing, irregular heartbeat, headache, drowsiness, symptoms of drunkenness, disorientation, joint pain, hearing loss, lung congestion
LONG TERM EXPOSURE: impotence, bluish skin color, blood disorders, liver damage, cancer
SKIN CONTACT:
SHORT TERM EXPOSURE: irritation, blisters
LONG TERM EXPOSURE: same as effects reported in short term exposure
EYE CONTACT:
SHORT TERM EXPOSURE: irritation, eye damage
LONG TERM EXPOSURE: same as effects reported in short term exposure
INGESTION:

SHORT TERM EXPOSURE: frostbite
LONG TERM EXPOSURE: cancer
CARCINOGEN STATUS:
OSHA: Y
NTP: Y
IARC: Y

SECTION 4 FIRST AID MEASURES

INHALATION: When safe to enter area, remove from exposure. Use a bag valve mask or similar device to perform artificial respiration (rescue breathing) if needed. Keep warm and at rest. Get medical attention immediately.
SKIN CONTACT: Wash if needed. If frostbite, freezing, or cryogenic burns occur, warm affected area in warm water. If this is not available, gently wrap affected parts in blankets. Allow circulation to return naturally. Get medical attention immediately.
EYE CONTACT: Wash eyes immediately with large amounts of water, occasionally lifting upper and lower lids, until no evidence of chemical remains. Get medical attention immediately.
INGESTION: Contact local poison control center or physician immediately. Never make an unconscious person vomit or drink fluids. When vomiting occurs, keep head lower than hips to help prevent aspiration. If person is unconscious, turn head to side. Get medical attention immediately.
NOTE TO PHYSICIAN: For inhalation, consider oxygen. For ingestion, consider gastric lavage, activated charcoal slurry and catharsis.

SECTION 5 FIRE FIGHTING MEASURES

FIRE AND EXPLOSION HAZARDS: Severe fire hazard. Severe explosion hazard. The vapor is heavier than air. Vapors or gases may ignite at distant ignition sources and flash back. Vapor/air mixtures are explosive. Electrostatic

discharges may be generated by flow or agitation resulting in ignition or explosion.
EXTINGUISHING MEDIA: carbon dioxide, regular dry chemical
Large fires: Use regular foam or flood with fine water spray.
FIRE FIGHTING: Move container from fire area if it can be done without risk. For fires in cargo or storage area: Cool containers with water from unmanned hose holder or monitor nozzles until well after fire is out. If this is impossible then take the following precautions: Keep unnecessary people away, isolate hazard area and deny entry. Let the fire burn. Withdraw immediately in case of rising sound from venting safety device or any discoloration of tanks due to fire. For tank, rail car or tank truck: Stop leak if possible without personal risk. Let burn unless leak can be stopped immediately. For smaller tanks or cylinders, extinguish and isolate from other flammables. Evacuation radius: 800 meters (1/2 mile). Stop flow of gas.
FLASH POINT: -108 F (-78 C)
LOWER FLAMMABLE LIMIT: 3.6%
UPPER FLAMMABLE LIMIT: 33%
AUTOIGNITION: 882 F (472 C)

SECTION 6 ACCIDENTAL RELEASE MEASURES

WATER RELEASE:
Subject to California Safe Drinking Water and Toxic Enforcement Act of 1986 (Proposition 65). Keep out of water supplies and sewers.
OCCUPATIONAL RELEASE:
Avoid heat, flames, sparks and other sources of ignition. Stop leak if possible without personal risk. Reduce vapors with water spray. Keep unnecessary people away, isolate hazard area and deny entry. Remove sources of ignition. Ventilate closed spaces before entering. Notify Local Emergency Planning Committee and State Emergency Response Commission for release greater than or equal to RQ (U.S. SARA Section 304). If release occurs in the U.S. and

is reportable under CERCLA Section 103, notify the National Response Center at (800)424-8802 (USA) or (202)426-2675 (USA).

SECTION 7 HANDLING AND STORAGE

Store and handle in accordance with all current regulations and standards. Subject to storage regulations: U.S. OSHA 29 CFR 1910.101. Protect from physical damage. Store outside or in a detached building. Inside storage: Store in a cool, dry place. Store in a well-ventilated area. Avoid heat, flames, sparks and other sources of ignition. Keep separated from incompatible substances. Grounding and bonding required. Keep separated from incompatible substances.

SECTION 8 EXPOSURE CONTROLS, PERSONAL PROTECTION

EXPOSURE LIMITS:
VINYL CHLORIDE:
1.0 ppm OSHA TWA
5 ppm OSHA ceiling 15 minute(s)
0.5 ppm OSHA action level
5 ppm (13 mg/m3) ACGIH TWA
5 mg/m3 (2 ml/m3) AGS MAK 4 times/shift
7 ppm UK OES TWA
MEASUREMENT METHOD: Charcoal tube (2); Carbon disulfide; Gas chromatography with flame ionization detection; NIOSH III # 1007

VENTILATION: Provide local exhaust or process enclosure ventilation system. Ventilation equipment should be explosion-resistant if explosive concentrations of material are present. Ensure compliance with applicable exposure limits.

EYE PROTECTION: Wear splash resistant safety goggles with a faceshield. Provide an emergency eye wash fountain and quick drench shower in the immediate work area.

CLOTHING: Wear appropriate chemical resistant clothing.

GLOVES: For the gas: Wear appropriate chemical resistant gloves. For the liquid: Wear insulated gloves. OSHA REGULATED SUBSTANCES: U.S. OSHA 29 CFR 1910.1017.

RESPIRATOR: The following respirators and maximum use concentrations are drawn from NIOSH and/or OSHA.

10 p/m
Any supplied-air respirator with full facepiece and operated in a pressure-demand or other positive-pressure mode in combination with a separate escape supply.
Any supplied-air respirator with a full facepiece that is operated in a pressure-demand or other positive-pressure mode.
Any chemical cartridge respirator with cartridge(s) providing protection against this substance.

25 p/m
Any powered, air-purifying respirator with a full facepiece and cartridge(s) providing protection against this substance.
Any air-purifying respirator with a full facepiece, a canister providing protection against this substance and a high-efficiency particulate filter.

100 p/m
Any supplied-air respirator with full facepiece and operated in a pressure-demand or other positive-pressure mode in combination with a separate escape supply.
Any self-contained breathing apparatus that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode.
Any supplied-air respirator with a full facepiece that is operated in a pressure-demand or other positive-pressure mode.

1000 p/m
Any supplied-air respirator with full facepiece and operated in a

pressure-demand or other positive-pressure mode in combination with a separate escape supply.
Any supplied-air respirator operated in a continuous-flow mode.
Any supplied-air respirator with a full facepiece.
Any supplied-air respirator operated in a continuous-flow mode.
3600 p/m
Any supplied-air respirator with full facepiece and operated in a pressure-demand or other positive-pressure mode in combination with a separate escape supply.
For Unknown Concentrations or Immediately Dangerous to Life or Health -
Any self-contained breathing apparatus that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode.

SECTION 9 PHYSICAL AND CHEMICAL PROPERTIES

PHYSICAL DESCRIPTION: Colorless gas with a mild, sweet odor.
MOLECULAR WEIGHT: 62.50
MOLECULAR FORMULA: C-H2-C-H-CL
BOILING POINT: 9 F (-13 C)
FREEZING POINT: -245 F (-154 C)
VAPOR PRESSURE: 2515.6 mmHg @ 21.1 C
VAPOR DENSITY (air=1): 2.2
SPECIFIC GRAVITY (water=1): 0.9106
WATER SOLUBILITY: 0.25%
PH: Not applicable
VOLATILITY: Not applicable
ODOR THRESHOLD: 260 ppm
EVAPORATION RATE: Not applicable
VISCOSITY: 0.01072 cP @ 20 C
COEFFICIENT OF WATER/OIL DISTRIBUTION: Not applicable
SOLVENT SOLUBILITY:
Soluble: alcohol, ether, carbon tetrachloride, benzene

SECTION 10 STABILITY AND REACTIVITY

REACTIVITY: May polymerize. Avoid contact with light or storage and use above room temperature.
CONDITIONS TO AVOID: Avoid heat, flames, sparks and other sources of ignition. Containers may rupture or explode if exposed to heat.
INCOMPATIBILITIES: metal carbide, metals, oxidizing materials, peroxides
VINYL CHLORIDE:
ACETYLIDE-FORMING MATERIALS: May form explosive compounds.
ALUMINUM: May cause polymerization.
COPPER AND ALLOYS: May form explosive compounds.
IRON: May corrode in the presence of water.
MONEL: May form explosive compound.

NITROGEN OXIDES: Explodes.
OXIDIZERS (STRONG): Fire and explosion hazard.
PEROXIDES: May initiate polymerization.
STEEL: May corrode in the presence of water.
HAZARDOUS DECOMPOSITION:
Thermal decomposition products: phosgene, halogenated compounds, oxides of carbon
POLYMERIZATION: May polymerize. Avoid contact with heat, light, air, water or incompatible materials. Closed containers may rupture violently.

SECTION 11 TOXICOLOGICAL INFORMATION

VINYL CHLORIDE:
TOXICITY DATA:
500 mg/kg oral-rat LD50; 18 pph/15 minute(s) inhalation-rat LC50; 20 pph/30 minute(s) inhalation-mouse LCLo; 30 pph/30 minute(s) inhalation-guinea pig LCLo; 200 ppm/18 minute(s) inhalation-mammal LCLo; 23400 mg/kg/13 week(s)

intermittent oral-rat TDLo; 30 mg/m3/4 hour(s)-26 week(s) intermittent inhalation-rat TCLo; 5000 ppm/7 hour(s)-52 week(s) intermittent inhalation-rat TCLo; 400 mg/m3/24 hour(s)-14 week(s) continuous inhalation-rat TCLo; 28000 ppm/7 hour(s)-6 week(s) intermittent inhalation-rat TCLo; 2000 ppm/8 hour(s)-92 day(s) intermittent inhalation-rat TCLo; 9 gm/m3/4 hour(s)-22 week(s) intermittent inhalation-rabbit TCLo; 30 mg/m3/26 week(s) intermittent inhalation-rabbit TCLo

CARCINOGEN STATUS: OSHA: Carcinogen; NTP: Known Human Carcinogen; IARC: Human Sufficient Evidence, Animal Sufficient Evidence, Group 1; ACGIH: A1 -Confirmed Human Carcinogen; EC: Category 1; TRGS 905: K 1
Studies show occupational exposure resulted in a significant increase in angiosarcomas of the liver, and also tumors of the brain, lung, and hematopoietic systems. Vinyl chloride was carcinogenic in rats, mice, and hamsters following oral and inhalation exposure, producing angiosarcomas of the liver and also tumors at various sites, and was carcinogenic in rats following prenatal exposure.

LOCAL EFFECTS:
Irritant: skin, eye

ACUTE TOXICITY LEVEL:
Toxic: ingestion
Relatively Non-toxic: inhalation

TARGET ORGANS: central nervous system

TUMORIGENIC DATA:
200 ppm inhalation-man TCLo/14 year(s) intermittent; 3463 mg/kg oral-rat TDLo/52 week(s) intermittent; 1 ppm inhalation-rat TCLo/4 hour(s)-52 week(s) intermittent; 10000 ppm inhalation-rat TCLo/4 hour(s) 12-18 day(s) pregnant female continuous; 21 mg/kg intraperitoneal-rat TDLo/65 week(s) intermittent; 21 mg/kg subcutaneous-rat TDLo/67 week(s) intermittent; 50 ppm inhalation-mouse TCLo/30 week(s) intermittent; 50 ppm inhalation-hamster TCLo/4 hour(s)-30 week(s) intermittent; 50 ppm inhalation-rat TC/7 hour(s)-26 week(s) continuous; 100 ppm inhalation-rat TC/7 hour(s)-26 week(s) continuous; 50 ppm inhalation-mouse TC/47 week(s) intermittent; 34 gm/kg oral-rat TD/3 year(s) intermittent; 50 ppm inhalation-mouse TC/6

hour(s)-4 week(s) intermittent; 50 ppm inhalation-mouse TC/4 hour(s)-30 week(s) intermittent; 250 ppm inhalation-rat TC/2 year(s) intermittent; 5 ppm inhalation-rat TC/4 hour(s)-52 week(s) intermittent; 50 ppm inhalation-rat TC/6 hour(s)-43 week(s) intermittent

MUTAGENIC DATA:
mutation in microorganisms - Salmonella typhimurium 2000 ppm (+S9) 48 hour(s); mutation in microorganisms - Salmonella typhimurium 1 pph (-S9); mutation in microorganisms - Escherichia coli 10600 umol/L (+S9); DNA repair - Escherichia coli 100 ug/plate; sex chromosone loss and non disjunction - Drosophila melanogaster inhalation 1 pph; gene conversion and miotic recombination - Saccharomyes cerevisae 48 mmol/L 3 hour(s); mutation in microorganisms - Schizosaccharomyces pombe 16 mmol/L (+S9) 30 minute(s); cytogenetic analysis - human HeLa cell 10 mmol/L; morphological transformation - rat inhalation 2000 ppm 14 week(s)-intermittent; DNA adduct - rat oral 18 gm/kg 2 year(s)-continuous; DNA damage - rat inhalation 205 ppm 5 hour(s); unscheduled DNA synthesis - rat liver 2100 umol/L; DNA inhibition - rat intravenous 9500 ug/kg; cytogenetic analysis - rat inhalation 150 ug/m3 14 week(s)-continuous; host-mediated assay - rat Saccharomyes cerevisae 1 pph 24 hour(s)-continuous; micronucleus test - mouse inhalation 5 pph 4 hour(s); morphological transformation - mouse embryo 75 mg/L; host-mediated assay - mouse Schizosaccharomyces pombe 700 mg/kg; host-mediated assay - mouse Saccharomyes cerevisae 700 mg/kg; micronucleus test - hamster embryo 30 pph; mutation in microorganisms - hamster lung 20 pph (+S9) 5 hour(s); cytogenetic analysis - hamster inhalation 12500 ppm 6 hour(s); cytogenetic analysis - hamster multiple 600 mg/kg; sister chromatid exchange - hamster inhalation 12500 ppm 6 hour(s); mutation in mammalian somatic cells - hamster ovary 10 pph

REPRODUCTIVE EFFECTS DATA:
30 mg/m3 inhalation-man TCLo 5 year(s) male; 100 ppm inhalation-rat TCLo/6

hour(s) 26 week(s) male; 500 ppm inhalation-rat TCLo/7 hour(s) 6-15 day(s) pregnant female continuous; 1500 ppm inhalation-rat TCLo/24 hour(s) 1-9 day(s) pregnant female continuous; 500 ppm inhalation-rat TCLo/7 hour(s) 6-15 day(s) pregnant female continuous; 250 ppm inhalation-rat TCLo/6 hour(s) 55 day(s) pre pregnancy continuous; 30000 ppm inhalation-mouse TCLo/6 hour(s) 5 day(s) male; 500 ppm inhalation-mouse TCLo/7 hour(s) 6-15 day(s) pregnant female continuous; 500 ppm inhalation-rabbit TCLo/7 hour(s) 6-18 day(s) pregnant female continuous

ADDITIONAL DATA: Stimulants such as epinephrine may induce ventricular fibrillation.

HEALTH EFFECTS:

INHALATION:

ACUTE EXPOSURE:

VINYL CHLORIDE: May be irritating. Exposure to 1000-16,000 ppm may cause central nervous system depression with drowsiness, vertigo, staggering gait, tingling and numbness of hands and feet, impaired hearing and vision, cardiac arrhythmias and possibly unconsciousness; 20,000-25,000 ppm for 3-5 minutes may cause dizziness, lightheadedness, disorientation, nausea and burning sensation of the soles of the feet; and 120,000 ppm may be fatal. Additional effects may include narcolepsy, headache, undue fatigue, muscle and joint pain, dyspnea, and anesthesia. Death may be due to respiratory paralysis with cardiac arrest. Human and animal pathologic reports show pulmonary edema, hyperemia of kidneys and liver, and hepatic degeneration.

CHRONIC EXPOSURE:

VINYL CHLORIDE: Repeated exposure may result in dose-related sensory disorders, autonomic nervous system polyneuritis, spastic angioneuritis, leukopenia, thrombocytopenia, splenomegaly, hepatitis-like liver changes, liver malfunction with portal fibrosis, impotence and pulmonary insufficiency. Workers involved in the polymerization process may exhibit a peculiar triad of symptoms: Modification of peripheral circulation resulting in pallor, cyanosis, and then redness (Raynaud's phenomenon); skeletal changes of distal phalanges (acro-osteolysis); and scleroderma like skin changes. Pseudo-clubbing of the fingers may also occur. Occupational exposure has produced angiosarcomas of the liver and is associated with tumor production at other sites. Animal studies show that vinyl chloride is carcinogenic in rats following prenatal exposure. One study suggested an increased fetal mortality due to exposure of the fathers to vinyl chloride. Several studies have reported an increased rate of birth defects, especially central nervous system anomalies, in the children of parents residing in commumities where vinyl chloride production and polymerization plants are located.

SKIN CONTACT:

ACUTE EXPOSURE:

VINYL CHLORIDE: Contact may cause irritation with redness and pain. Due to rapid evaporation, the liquid may cause frostbite with redness, tingling, and pain or numbness. In more severe cases, the skin may become hard and white and develop blisters.

CHRONIC EXPOSURE:

VINYL CHLORIDE: Workers handling vinyl chloride have exhibited a peculiar triad of symptoms: Raynaud's phenomenon, acro-osteolysis, and scleroderma like skin changes. Repeated or prolonged exposure to irritants may cause dermatitis.

EYE CONTACT:

ACUTE EXPOSURE:

VINYL CHLORIDE: Contact may cause immediate and severe irritation, and corneal injury with complete recovery in 48 hours. Due to rapid evaporation, the liquid may cause frostbite with redness, pain and blurred vision.

CHRONIC EXPOSURE:

VINYL CHLORIDE: Repeated or prolonged exposure to irritants may cause conjunctivitis.

INGESTION:

ACUTE EXPOSURE:
VINYL CHLORIDE: The reported lethal dose in rats is 500 mg/kg. The symptoms were not reported. If the liquid is swallowed, frostbite damage to the lips, mouth and mucous membranes may occur.
CHRONIC EXPOSURE:
VINYL CHLORIDE: Oral administration to rats, mice, and hamsters resulted in tumor production at various sites, including angiosarcomas of the liver.

SECTION 12 ECOLOGICAL INFORMATION

ECOTOXICITY DATA:
FISH TOXICITY: 388000 ug/L 10 month(s) LETH (Mortality) Northern pike (Esox lucius)
INVERTEBRATE TOXICITY: 41.74 ug/L 72 day(s) (Residue) Mosquito (Culex pipiens quinquefasciata)
ALGAL TOXICITY: 41.74 ug/L 72 day(s) (Residue) Green algae (Oedogonium cardiacum)

SECTION 13 DISPOSAL CONSIDERATIONS

Subject to disposal regulations: U.S. EPA 40 CFR 262. Hazardous Waste Number(s): U043. Hazardous Waste Number(s): D043. Dispose of in accordance with U.S. EPA 40 CFR 262 for concentrations at or above the Regulatory level. Regulatory level- 0.2 mg/L. Dispose in accordance with all applicable regulations.

SECTION 14 TRANSPORT INFORMATION

U.S. DOT 49 CFR 172.101 SHIPPING NAME-UN NUMBER:
Vinyl chloride, inhibited or Vinyl chloride, stabilized-UN1086
U.S. DOT 49 CFR 172.101 HAZARD CLASS OR DIVISION:
2.1
U.S. DOT 49 CFR 172.101 AND SUBPART E LABELING REQUIREMENTS:
Flammable gas
U.S. DOT 49 CFR 172.101 PACKAGING AUTHORIZATIONS:
EXCEPTIONS: 49 CFR 173.306
NON-BULK PACKAGING: 49 CFR 173.304
BULK PACKAGING: 49 CFR 173.314, 315
U.S. DOT 49 CFR 172.101 QUANTITY LIMITATIONS:
PASSENGER AIRCRAFT OR RAILCAR: Forbidden
CARGO AIRCRAFT ONLY: 150 kg
LAND TRANSPORT ADR/RID:
SUBSTANCE NAME: Vinyl chloride/Vinyl chloride, stabilized
UN NUMBER: UN1086
ADR/RID CLASS: 2
ITEM NUMBER: 3(c)/2F
WARNING SIGN/LABEL: 3/3; 13
HAZARD ID NUMBER: 239
AIR TRANSPORT IATA/ICAO: No classification assigned.
MARITIME TRANSPORT IMDG:

CORRECT TECHNICAL NAME: Vinyl chloride, inhibited
UN/ID NUMBER: UN1086
IMDG CLASS: 2(2.1)
EmS No.: 2-07
MFAG Table No.: 340
MARINE POLLUTANT: N

SECTION 15 REGULATORY INFORMATION

U.S. REGULATIONS:
TSCA INVENTORY STATUS: Y

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  TSCA 12(b) EXPORT NOTIFICATION: Not listed.
  CERCLA SECTION 103 (40CFR302.4): Y
    Vinyl chloride: 1 LBS RQ
  SARA SECTION 302 (40CFR355.30): N
  SARA SECTION 304 (40CFR355.40): N
  SARA SECTION 313 (40CFR372.65): Y
    Vinyl chloride
  SARA HAZARD CATEGORIES, SARA SECTIONS 311/312 (40CFR370.21):
    ACUTE: Y
    CHRONIC: Y
    FIRE: Y
    REACTIVE: Y
    SUDDEN RELEASE: Y
  OSHA PROCESS SAFETY (29CFR1910.119): N
STATE REGULATIONS:
  California Proposition 65: Y
    Known to the state of California to cause the following:
      Vinyl chloride
        Cancer (Feb 27, 1987)
EUROPEAN REGULATIONS:
  EC NUMBER (EINECS): 200-831-0
  EC RISK AND SAFETY PHRASES:
    R 12            Extremely flammable.
    R 45            May cause cancer.
    S 45            In case of accident or if you feel unwell, seek medical
                    advice immediately (show the label where possible).
    S 53            Avoid exposure - obtain special instructions before use.
GERMAN REGULATIONS:
  WATER HAZARD CLASS (WGK): 2 (Official German Classification)
-------------------------------------------------------------------------------
SECTION 16    OTHER INFORMATION
-------------------------------------------------------------------------------
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OHS14550

SECTION 1 CHEMICAL PRODUCTS & COMPANY IDENTIFICATION

OCCUPATIONAL HEALTH SERVICES, INC.
11 WEST 42ND STREET, 12TH FLOOR
NEW YORK, NEW YORK 10036
1-800-445-MSDS (1-800-445-6737) OR
1-212-789-3535

FOR EMERGENCY SOURCE INFORMATION
CONTACT: 1-615-366-2000

CAS NUMBER: 108-10-1
RTECS NUMBER: SA9275000

SUBSTANCE: METHYL ISOBUTYL KETONE

TRADE NAMES/SYNONYMS:
2-PENTANONE, 4-METHYL-; HEXONE; ISOBUTYL METHYL KETONE; ISOPROPYLACETONE; 2-METHYLPROPYL METHYL KETONE; 4-METHYL-2-PENTANONE; MIK; MIBK; RCRA U161; UN 1245; STCC 4909245; C6H12O; OHS14550

CHEMICAL FAMILY:
Ketone, aliphatic

CREATION DATE: 11/12/84 REVISION DATE: 07/14/93

SECTION 2 COMPOSITION/INFORMATION ON INGREDIENTS

COMPONENT : METHYL ISOBUTYL KETONE
CAS NUMBER: 108-10-1
PERCENTAGE: 100.0

OTHER CONTAMINANTS: NONE

SECTION 3 HAZARDS IDENTIFICATION

CERCLA RATINGS (SCALE 0-3): HEALTH=3 FIRE=3 REACTIVITY=0 PERSISTENCE=0
NFPA RATINGS (SCALE 0-4): HEALTH=2 FIRE=3 REACTIVITY=0

EMERGENCY OVERVIEW:
METHYL ISOBUTYL KETONE IS A COLORLESS LIQUID WITH A PLEASANT ODOR.
May affect the central nervous system. Causes respiratory tract, skin and eye irritation. Flammable liquid and vapor. May cause flash fire.
Keep away from all ignition sources. Avoid breathing vapor or mist. Avoid contact with eyes, skin and clothing. Keep container tightly closed. Wash thoroughly after handling. Use only with adequate ventilation.

POTENTIAL HEALTH EFFECTS:
INHALATION:
SHORT TERM EFFECTS: May cause irritation. Additional effects may include drunkeness, lack of appetite, nausea, vomiting, diarrhea, headache, unconsciousness and coma.

LONG TERM EFFECTS: In addition to effects from short term exposure, weakness, drowsiness, sleeplessness, kidney damage and liver enlargement may occur.

SKIN CONTACT:
SHORT TERM EFFECTS: May cause irritation.
LONG TERM EFFECTS: Same effects as short term exposure.

EYE CONTACT:
SHORT TERM EFFECTS: May cause irritation. Additional effects may include tearing.
LONG TERM EFFECTS: Same effects as short term exposure.

INGESTION:
SHORT TERM EFFECTS: May cause drunkeness, coughing, vomiting, digestive disorders and headache.
LONG TERM EFFECTS: No information is available.

ADDITIONAL DATA: Drinking alcohol may worsen the effects.

CARCINOGEN STATUS:
OSHA: N
NTP: N
IARC: N

SECTION 4 FIRST AID MEASURES

INHALATION:
FIRST AID- Remove from exposure area to fresh air immediately. If breathing has stopped, perform artificial respiration. Keep person warm and at rest. Treat symptomatically and supportively. Get medical attention immediately.

SKIN CONTACT:
FIRST AID- Remove contaminated clothing and shoes immediately. Wash affected area with soap or mild detergent and large amounts of water until no evidence of chemical remains (approximately 15-20 minutes). Get medical attention immediately.

EYE CONTACT:
FIRST AID- Wash eyes immediately with large amounts of water or normal saline, occasionally lifting upper and lower lids, until no evidence of chemical remains (approximately 15-20 minutes). Get medical attention immediately.

INGESTION:
FIRST AID- If the person is conscious and not convulsing, induce emesis by giving syrup of ipecac followed by water. (If vomiting occurs keep the head below the hips to prevent aspiration). Repeat in 20 minutes if not effective initially. Give activated charcoal. In patients with depressed respiration or if emesis is not produced, perform gastric lavage cautiously (Dreisbach, Handbook of Poisoning, 12th Ed.). Treat symptomatically and supportively. Gastric lavage should be performed by qualified medical personnel. Get medical attention immediately.

NOTE TO PHYSICIAN
ANTIDOTE:
No specific antidote. Treat symptomatically and supportively.

SECTION 5 FIRE FIGHTING MEASURES

FIRE AND EXPLOSION HAZARD:
Dangerous fire hazard when exposed to heat or flame.

Vapors are heavier than air and may travel a considerable distance to a source of ignition and flash back.

Vapor-air mixtures are explosive.

EXTINGUISHING MEDIA:
Dry chemical, carbon dioxide, water spray or alcohol-resistant foam (1990 Emergency Response Guidebook, DOT P 5800.5).

For larger fires, use water spray, fog or alcohol-resistant foam (1990 Emergency Response Guidebook, DOT P 5800.5).

Alcohol foam
(NFPA 325m, fire hazard properties of flammable liquids, gases, and volatile solids, 1991).

FIREFIGHTING:
Move container from fire area if you can do it without risk. Apply cooling water to sides of containers that are exposed to flames until well after fire is out. Stay away from ends of tanks. For massive fire in cargo area, use unmanned hose holder or monitor nozzles; if this is impossible, withdraw from area and let fire burn. Withdraw immediately in case of rising sound from venting safety device or any discoloration of tank due to fire. Isolate for 1/2 mile in all directions if tank, rail car or tank truck is involved in fire (1990 Emergency Response Guidebook, DOT P 5800.5, Guide Page 26).

Extinguish only if flow can be stopped; use flooding amounts of water as a fog, solid streams may be ineffective. Cool containers with flooding amounts of water, apply from as far a distance as possible. Avoid breathing vapors, keep upwind.

Water may be ineffective (NFPA 325M, Fire Hazard Properties of Flammable Liquids, Gases, and Volatile Solids, 1991)

FLASH POINT: 64 F (18 C) (CC)
LOWER FLAMMABLE LIMIT: 1.4%
UPPER FLAMMABLE LIMIT: 7.5%
AUTOIGNITION: 840 F (448 C)
FLAMMABILITY CLASS(OSHA): IB

HAZARDOUS COMBUSTION PRODUCTS:
Thermal decomposition products may include toxic oxides of carbon.

SECTION 6 ACCIDENTAL RELEASE MEASURES

OCCUPATIONAL SPILL:

Shut off ignition sources. Stop leak if you can do it without risk. Use water spray to reduce vapors. For small spills, take up with sand or other absorbent material and place into containers for later disposal. For larger spills, dike far ahead of spill for later disposal. No smoking, flames or flares in hazard area. Keep unnecessary people away; isolate hazard area and deny entry.

Reportable Quantity (RQ): 5000 pounds
The Superfund Amendments and Reauthorization Act (SARA) Section 304 requires that a release equal to or greater than the reportable quantity for this substance be immediately reported to the local emergency planning committee and the state emergency response commission (40 CFR 355.40). If the release of this substance is reportable under CERCLA Section 103, the National Response Center must be notified immediately at (800) 424-8802 or (202) 426-2675 in the metropolitan Washington, D.C. area (40 CFR 302.6).

SECTION 7 HANDLING AND STORAGE

Observe all federal, state and local regulations when storing this substance.

Store in accordance with 29 CFR 1910.106.

Bonding and grounding: Substances with low electroconductivity, which may be ignited by electrostatic sparks, should be stored in containers which meet the bonding and grounding guidelines specified in NFPA 77-1983, Recommended Practice on Static Electricity.

Storage: Protect against physical damage. Outside or detached storage is preferable. Inside storage should be in a standard flammable liquids storage room or cabinet. Separate from oxidizing materials (NFPA 49, Hazardous Chemicals Data, 1975).

Store away from incompatible substances.

SECTION 8 EXPOSURE CONTROLS/PERSONAL PROTECTION

EXPOSURE LIMITS:
METHYL ISOBUTYL KETONE:
50 ppm (205 mg/m3) OSHA TWA; 75 ppm (307 mg/m3) OSHA STEL
50 ppm (205 mg/m3) ACGIH TWA; 75 ppm (307 mg/m3) ACGIH STEL
50 ppm (205 mg/m3) NIOSH recommended TWA
75 ppm (307 mg/m3) NIOSH recommended STEL
100 ppm (410 mg/m3) DFG MAK TWA;
500 ppm (2050 mg/m3) DFG MAK 30 minute peak, average value, 2 times/shift

Measurement method: Charcoal tube; carbon disulfide; gas chromatography with flame ionization detection; (NIOSH Vol. III # 1300, Ketones I).

5000 pounds CERCLA Section 103 Reportable Quantity
Subject to SARA Section 313 Annual Toxic Chemical Release Reporting

**OSHA revoked the final rule limits of January 19, 1989 in response to the

11th Circuit Court of Appeals decision (AFL-CIO v. OSHA) effective June 30, 1993. See 29 CFR 1910.1000 (58 FR 35338)**

VENTILATION:
Provide local exhaust ventilation to meet published exposure limits. Ventilation equipment must be explosion-proof.

EYE PROTECTION:
Employee must wear splash-proof or dust-resistant safety goggles to prevent eye contact with this substance.

Emergency eye wash: Where there is any possibility that an employee's eyes may be exposed to this substance, the employer should provide an eye wash fountain within the immediate work area for emergency use.

CLOTHING:
Employee must wear appropriate protective (impervious) clothing and equipment to prevent repeated or prolonged skin contact with this substance.

GLOVES:
Employee must wear appropriate protective gloves to prevent contact with this substance.

RESPIRATOR:
The following respirators and maximum use concentrations are recommendations by the U.S. Department of Health and Human Services, NIOSH pocket guide to chemical hazards; NIOSH criteria documents or by the U.S. Department of Labor, 29 CFR 1910 Subpart Z.
The specific respirator selected must be based on contamination levels found in the work place, must not exceed the working limits of the respirator and be jointly approved by the National Institute for Occupational Safety and Health and the Mine Safety and Health Administration (NIOSH-MSHA).

METHYL ISOBUTYL KETONE:

500 ppm- Any chemical cartridge respirator with organic vapor cartridge(s).
Any supplied-air respirator.
Any self-contained breathing apparatus.

1000 ppm- Any powered, air-purifying respirator with organic vapor cartridge(s).
Any chemical cartridge respirator with a full facepiece and organic vapor cartridge(s).

1250 ppm- Any supplied-air respirator operated in a continuous-flow mode.

2500 ppm- Any air-purifying, full-facepiece respirator (gas mask) with a chin-style, front- or back-mounted organic vapor canister.
Any self-contained breathing apparatus with a full facepiece.
Any supplied-air respirator with a full facepiece.
Any supplied-air respirator that has a tight-fitting facepiece and is operated in a continuous-flow mode.

5000 ppm- Any supplied-air respirator that has a full facepiece and is

operated in a pressure-demand or other positive-pressure mode.

Escape- Any air-purifying, full-facepiece respirator (gas mask) with a chin-style, front- or back-mounted organic vapor canister.
Any appropriate escape-type, self-contained breathing apparatus.

FOR FIREFIGHTING AND OTHER IMMEDIATELY DANGEROUS TO LIFE OR HEALTH CONDITIONS:

Any self-contained breathing apparatus that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode.

Any supplied-air respirator that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode in combination with an auxiliary self-contained breathing apparatus operated in pressure-demand or other positive-pressure mode.

SECTION 9 PHYSICAL AND CHEMICAL PROPERTIES

DESCRIPTION: Colorless liquid with a faint, pleasant ketonic and camphor odor.
MOLECULAR WEIGHT: 100.16
MOLECULAR FORMULA: (C-H3)2-C-H-C-H2-C-(O)-C-H3
BOILING POINT: 242 F (117 C)
MELTING POINT: -119 F (-85 C)
VAPOR PRESSURE: 16 mmHg @ 20 C
VAPOR DENSITY: 3.5
SPECIFIC GRAVITY: 0.7978
WATER SOLUBILITY: 2%
VOLATILITY: 100%
ODOR THRESHOLD: 0.3-0.5 ppm
EVAPORATION RATE: (butyl acetate=1) 1.6
SOLVENT SOLUBILITY: Soluble in alcohol, ether, acetone, benzene, chloroform, and most organic solvents.

SECTION 10 STABILITY AND REACTIVITY

REACTIVITY:
Stable under normal temperatures and pressures.

CONDITIONS TO AVOID:
Avoid contact with heat, sparks, flames, or other sources of ignition. Vapors may be explosive and poisonous; do not allow unnecessary personnel in area. Do not overheat containers; containers may violently rupture and travel a considerable distance in heat of fire.

INCOMPATIBILITIES:
METHYL ISOBUTYL KETONE:
ALDEHYDES: Incompatible.
NITRIC ACID: Incompatible.
OXIDIZERS (STRONG): Fire and explosion hazard.
PERCHLORIC ACID: Incompatible.
PLASTICS, RUBBER AND RESINS: May be attacked.
POTASSIUM-TERT-BUTOXIDE: Ignites on contact.

REDUCING MATERIALS: Vigorous reaction.

HAZARDOUS DECOMPOSITION:
Thermal decomposition products may include toxic oxides of carbon.

POLYMERIZATION:
Hazardous polymerization has not been reported to occur under normal temperatures and pressures.

SECTION 11 TOXICOLOGY INFORMATION

METHYL ISOBUTYL KETONE:
IRRITATION DATA: 500 mg/24 hours skin-rabbit mild; 200 ppm/15 minutes eye-human; 40 mg eye-rabbit severe; 500 mg/24 hours eye-rabbit mild.
TOXICITY DATA: 23,300 mg/m3 inhalation-mouse LC50; >20 gm/kg skin-rabbit LD50; 2080 mg/kg oral-rat LD50; 2671 mg/kg oral-mouse LD50; 1600 mg/kg oral-guinea pig LD50; 400 mg/kg intraperitoneal-rat LD50; 268 mg/kg intraperitoneal-mouse LD50; 800 mg/kg intraperitoneal-guinea pig LD50; 1396 mg/kg unreported-mammal LD50; reproductive effects data (RTECS).
CARCINOGEN STATUS: None.
LOCAL EFFECTS: Irritant- inhalation, skin, eye.
ACUTE TOXICITY LEVEL: Moderately toxic by inhalation, ingestion; relatively non-toxic by dermal absorption.
TARGET EFFECTS: Central nervous system depressant. Poisoning may affect the liver and kidneys.
AT INCREASED RISK FROM EXPOSURE: Persons with pre-existing eye or skin disorders, or impaired liver, kidney, or respiratory function.
ADDITIONAL DATA: Alcohol may enhance the toxic effects.

HEALTH EFFECTS
INHALATION:
METHYL ISOBUTYL KETONE:
IRRITANT/NARCOTIC.
3000 ppm Immediately Dangerous to Life or Health.

ACUTE EXPOSURE- Vapor concentrations of 100 ppm may cause headache and nausea. Exposure to 200 ppm may be irritating to the respiratory tract. Exposure to concentrations >50 ppm may cause gastrointestinal effects such as nausea, vomiting, loss of appetite and diarrhea. Higher levels may cause central nervous system depression with lightheadedness, dizziness, dullness, incoordination, ataxia, unconsciousness, coma and death. Exposure of rats to 4000 ppm/4 hours caused death while 2000 ppm/4 hours was not lethal. Fatty livers and congestion of the brain, lungs and spleen were noted in animals dying after exposure to 28000 ppm/45 minutes.

CHRONIC EXPOSURE- Workers exposed to 80-500 ppm for 30 minutes per day complained of throat irritation, weakness, loss of appetite, headache, nausea, and vomiting. A few workers experienced insomnia, somnolence, heartburn, intestinal pain and slight liver enlargement. Exposure of rats to 100 ppm/90 days resulted in heavier livers and kidneys with reversible nephrosis of the kidneys. Exposure of rats to 20-30 ppm/4 hours/day for 4 and 1/2 months caused disturbances in conditioned reflexes, interference with detoxifying function of the liver and elevated eosinophil count. Minimal distal axonal changes resulted from exposure

to 1500 ppm for 5 months. Exposure of pregnant rats and mice to 3000 ppm produced a significant decrease in fetal body weight and retardation of skeletal ossification in the fetuses.

SKIN CONTACT:
METHYL ISOBUTYL KETONE:
IRRITANT.
ACUTE EXPOSURE- Vapor may cause irritation with redness. 500 mg applied to rabbit skin produced moderate irritation with transient erythema.
CHRONIC EXPOSURE- Repeated or prolonged skin contact may cause defatting of the skin with primary irritation and desquamation. Exposure to vapor concentrations of 80-500 ppm has also been reported to cause dermatitis.

EYE CONTACT:
METHYL ISOBUTYL KETONE:
IRRITANT.
ACUTE EXPOSURE- Vapor concentrations of 200 ppm are irritating to the eyes. Direct contact with liquid may cause pain and irritation. Exposure of >1000 ppm to guinea pigs caused severe irritation with lacrimation.
CHRONIC EXPOSURE- Repeated or prolonged contact with irritants may cause conjunctivitis.

INGESTION:
METHYL ISOBUTYL KETONE:
NARCOTIC.
ACUTE EXPOSURE- May cause coughing, gastroenteritis, and central nervous system depression with headache, dizziness, dullness and vomiting.
CHRONIC EXPOSURE- No data available.

SECTION 12 ECOLOGICAL INFORMATION

ENVIRONMENTAL IMPACT RATING (0-4): no data available

ACUTE AQUATIC TOXICITY: no data available

DEGRADABILITY: no data available

LOG BIOCONCENTRATION FACTOR (BCF): no data available

LOG OCTANOL/WATER PARTITION COEFFICIENT: no data available

SECTION 13 DISPOSAL INFORMATION

Observe all federal, state and local regulations when disposing of this substance.

Disposal must be in accordance with standards applicable to generators of hazardous waste, 40CFR 262. EPA Hazardous Waste Number U161.

US EPA RCRA Hazardous Waste Number: RCRA U161

SECTION 14 TRANSPORTATION INFORMATION

DEPARTMENT OF TRANSPORTATION HAZARD CLASSIFICATION 49-CFR 172.101:
Flammable liquid

Department of Transportation labeling requirements 49-CFR 172.101 and SUBPART E:
Flammable liquid

DEPARTMENT OF TRANSPORTATION PACKAGING REQUIREMENTS: 49-CFR 173.119
EXCEPTIONS: 49-CFR 173.118

Final rule on hazardous materials regulations (HMR, 49 CFR parts 171-180), docket numbers HM-181, HM-181a, HM-181b, HM-181c, HM-181d and HM-204. Effective date October 1, 1991. However, compliance with the regulations is authorized on and after January 1, 1991. (55 FR 52402, 12/21/90)

Except for explosives, inhalation hazards, and infectious substances, the effective date for hazard communication requirements is extended to October 1, 1993. (56 FR 47158, 09/18/91)

U.S. DEPARTMENT OF TRANSPORTATION SHIPPING NAME-ID NUMBER, 49 CFR 172.101:
Methyl isobutyl ketone-UN 1245

U.S. DEPARTMENT OF TRANSPORTATION HAZARD CLASS OR DIVISION, 49 CFR 172.101:
3 - Flammable liquid

U.S. DEPARTMENT OF TRANSPORTATION PACKING GROUP, 49 CFR 172.101:
PG II

U.S. DEPARTMENT OF TRANSPORTATION LABELING REQUIREMENTS, 49 CFR 172.101 AND SUBPART E:
Flammable liquid

U.S. DEPARTMENT OF TRANSPORTATION PACKAGING AUTHORIZATIONS:
EXCEPTIONS: 49 CFR 173.150
NON-BULK PACKAGING: 49 CFR 173.202
BULK PACKAGING: 49 CFR 173.242

U.S. DEPARTMENT OF TRANSPORTATION QUANTITY LIMITATIONS 49 CFR 172.101:
PASSENGER AIRCRAFT OR RAILCAR: 5 l
CARGO AIRCRAFT ONLY: 60 l

SECTION 15 REGULATORY INFORMATION

TSCA STATUS: Y

CERCLA SECTION 103 (40CFR302.4):	Y	5000 pounds RQ
SARA SECTION 302 (40CFR355.30):	N	
SARA SECTION 304 (40CFR355.40):	N	
SARA SECTION 313 (40CFR372.65):	Y	
OSHA PROCESS SAFETY (29CFR1910.119):	N	
CALIFORNIA PROPOSITION 65:	N	

SARA HAZARD CATEGORIES, SARA SECTIONS 311/312 (40 CFR 370.21)

ACUTE HAZARD:	Y
CHRONIC HAZARD:	N
FIRE HAZARD:	Y
REACTIVITY HAZARD:	N
SUDDEN RELEASE HAZARD:	N

SECTION 16 OTHER

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ATTACHMENT III

RESPIRATORY PROTECTION PROGRAM

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1.0 RESPIRATORY PROTECTION

1.1 PRACTICE

The primary control of respiratory hazards shall be accomplished, whenever feasible, through the use of engineering controls, hazard substitution, revised work practices or other administrative controls. However, when such controls are not feasible, appropriate respiratory protection shall be used in accordance with the procedures established in this SOP. Any deviation from the requirements set forth must have approval from an IH.

1.1.1 AUTHORIZATION

CRA employees requiring respiratory protection must have authorization from an IH. Office management shall notify an IH of respirator needs. The work situation will then be assessed and a respirator will be issued based on the hazard(s) the individual is exposed to. Reassessment of the hazard and the individual's needs will be repeated periodically.

1.1.2 MEDICAL SURVEILLANCE

All personnel designated to use respirators must successfully complete a physical exam as part of the medical requirements placed on persons exposed to hazardous substances and for users of respiratory protection (29 CFR 1910.134 and 1910.120). The medical exam will be repeated annually. All medical data will be reviewed by a consulting occupational physician. The physician will generate a written opinion on the suitability of the employee to wear a respirator.

1.1.3 AIR QUALITY

When air supplied respirators are used, the breathing air shall meet the Compressed Gas Association (CGA-CG7.1) Standards for Grade D breathing air or better.

1.1.4 AIR CYLINDERS

Cylinders used to supply breathing air are tested and maintained as prescribed in Shipping Container Specifications (49 CFR 178). SCBA cylinders are approximately

2,400 psi pressure when full. Compressed air cylinders are visually inspected annually and hydrostatically tested once every five years for steel cylinders and once every three years for composite cylinders. These test dates are stamped on the cylinder for future reference.

1.2 FIT TESTING

1.2.1 QUALITATIVE OR QUANTITATIVE FIT TESTING

Fit testing of the respirator will be conducted by an IH or other designated, trained personnel following the medical evaluation. All users of respirators must be fit tested to assure proper protection. Only the brand and size a person is fitted for is allowed to be used in the field. DO NOT SUBSTITUTE RESPIRATORS FOR A BRAND AND SIZE THAT YOU HAVE NOT BEEN PROPERLY FITTED FOR. The fit test will be accomplished by the use of irritant smoke (stannic chloride aerosol), Isoamyl Acetate using a standardized testing protocol or quantitatively. Records will be maintained by the Corporate IH with copies available in CRA field offices for audit purposes. After fit testing, the employee will be issued an authorization card. This card serves as a reference for the proper type of respirator to use as well as prima facie proof of proper medical and training clearance for regulatory purposes. The user shall have the card available at any time when on CRA business where respiratory protection is used or hazardous waste cleanup sites are being entered.

1.2.2 POSITIVE & NEGATIVE FIT TESTING

All personnel will be instructed in the proper method of testing respirator fit by use of the Positive & Negative pressure test. This test is to be done by the user each and every time a respirator is donned. This test is performed to help the wearer assess respirator function and find gross leaks between the face and facepiece. This positive-negative pressure test checks the presence and functioning of the respirator valves as well as leakage that may occur due to improper cartridge seal or respirator face fit. This test is required by U.S. Regulation 29 CFR 1910.134 prior to each use of any respirator in a contaminated atmosphere.

1.2.2.1 POSITIVE PRESSURE

1) Block off the exhalation valve cover openings.

   MSA: Exhalation valve cover can be blocked with the palm of the hand.

   Scott: Exhalation valve covers have front openings as well as four small side openings. These openings are difficult to block off with the hands. However, a small piece of flexible material such as Saran wrap or latex can be used.

   North: Exhalation valve cover has long narrow openings around its perimeter. These can be blocked by encircling the fingers around the valve cover.

2) The person exhales gently, creating a slight positive pressure within the facepiece. The positive pressure should be maintained for at least 10 seconds.

3) If no outward leakage is detected, the person has passed the test.

4) If leakage is detected (usually felt as a cool sensation against the skin or a loss of pressure), the respirator is either malfunctioning or a gross leak between the face and facepiece is present. The following should be done when a failure occurs: Re-don or readjust the respirator.

If the facepiece continues to lose pressure, although previous positive or negative pressure tests performed with that respirator had passed, it is probably malfunctioning. Consult Industrial Hygiene. It is also possible that there are new scars or wrinkles, beard growth, missing teeth or dentures, significant weight gain or loss, etc. to cause gross leakage into the facepiece. When such new conditions exist, reevaluation of the respirator in a test atmosphere is necessary.

1.2.2.2 NEGATIVE PRESSURE

1) Block off the respirator cartridge inlet openings.

   MSA: Cartridges can be blocked with the palms of the hands or with disposable latex gloves.

   Scott: Cartridges can be blocked by using the palms of the hands or with gloves.

North: Cartridges can be blocked only with gloves.

2) Inhale gently, holding the negative pressure for at least 10 seconds.

3) If no inward leakage of air is detected, the person has passed the test.

4) If leakage is detected, see 4 above.

1.2.3 EXCEPTIONS

1.2.3.1 FACIAL HAIR

Any individual with facial hair which protrudes into the sealing surface of the masks will be refused fitting. Fitting, issuance and use will be based on clean shaven faces only. Employees with facial hair which interferes with respirator fit are not permitted to work at sites where respiratory protection must be worn.

1.2.3.2 GLASSES

Employees who wear prescription glasses and must wear a full face respirator shall be fitted with special eyeglass adapters. Contact lenses are not permitted to be worn with any type of respiratory protection.

1.3 TRAINING

Proper training of respirator users is required to insure that all respirators will provide adequate protection against respiratory hazards and so that the user will understand the device's limitations. The training will include the following elements:

1) An explanation of the nature of respiratory hazards and what may happen if the respirator is not used properly.
2) A description of what engineering and administrative controls may be utilized to reduce the effects of the respiratory hazard and why respirators are required.
3) An explanation of the various types of respirators and why specific types have been selected.
4) A discussion of the function, capabilities and limitations of respirator cartridges.

5) Instruction in the inspection, fit and maintenance of the respirator.

6) Instructions in recognizing and handling emergency situations.

1.4 MAINTENANCE AND CARE OF RESPIRATORS

A program for the maintenance and care of respirators will include the following:

1) Inspection for defects;

2) Cleaning and disinfecting;

3) Repair/miscellaneous maintenance; and

4) Storage.

1.4.1 INSPECTION FOR DEFECTS

Employees shall inspect their respirators before each use. A respirator that is not routinely used but is kept ready for emergency use shall be inspected after each use and at least monthly to assure that it is in satisfactory condition. SCBA shall be inspected monthly if kept for emergency response (i.e., long duration site remediation).

Inspection shall include a check of the tightness of the connections and the condition of the face piece, headbands, valves, breathing tubes and canisters. Rubber or elastic parts shall be inspected for pliability and signs of deterioration. Any respirator with worn or defective parts will be immediately taken out of service.

Before and after each use, respirators will be inspected for the following:

1) Tightness of connections and condition of the facepiece;

2) The headstraps or head harness should be examined for: breaks, loss of elasticity, broken or malfunctioning buckles and attachments, and excessively worn head-harness serrations that might permit slippage;

3) Valves and valve seats;

4) Connecting tube and canisters, air or oxygen cylinders;

5) Rubber or elastomer parts for pliability and deterioration; and

6) Regulators, fittings and gauges.

The following contains inspection information for various types of respirators.

Air Purifying Respirators

1) Check rubber facepiece for dirt, pliability of rubber, deterioration and cracks, tears, holes or distortion from improper storage.
2) Check straps for breaks, tears, loss of elasticity, broken snaps and proper tightness.
3) Check valves (exhalation and inhalation) for holes, warpage, cracks, etc. After removing its cover, the exhalation valve should be examined for: foreign material, distortion, defective or missing valve cover or improper installation of valve into the valve seat.
4) Check filters or cartridges for dents, corrosion, etc. (loose or missing gaskets, improperly seated cartridges).
5) Check for cracked or badly scratched lenses in full facepieces; incorrectly mounted lens, broken or missing mounting clips.

Atmosphere-Supplying Respirators

1) Check appropriate items above.
2) Check air supply system for breaks or kinks in supply hoses and detachable coupling attachments.
3) Follow manufacturer's recommendations for the specific equipment.
4) Check air supply level and warning devices.

1.4.2 CLEANING AND DISINFECTING

The respirator must be washed after each day's use. If the respirator is shared it must also be disinfected according to the manufacturer's instructions. Organic solvents of any kind must not be used for cleaning. Air purifying filters must not be wetted.

1.4.2.1 CLEANING

1) Remove any filters, cartridges or canisters and, if required by the manufacturer, straps and speaking diaphragms from the facepiece. Remove regulators on airline or SCBA.

2) Wash respirator parts excluding cartridges and canisters in warm (not to exceed 140°F), soapy water or in a product specifically designed by respirator manufacturers for this purpose. A plastic bristle hand brush may be helpful in removing dirt from respirator parts.

3) Rinse all parts thoroughly in warm water.

4) Air dry all parts.

5) Reassemble the respirator and insert new cartridges if needed.

6) Place the respirator in a plastic bag or container and seal it for storage. The respirator facepiece should be stored in its normal position so as not to distort the elastomer.

1.4.2.2 DISINFECTION

1) Disinfection should be done with a cleaner/disinfection agent purchased from the respirator vendor. If that material is not available the following NIOSH procedures can be followed:

   a) Immerse the respirator body for two minutes in a 50 ppm chlorine solution (about 2 ml bleach to 1 liter of water). Rinse thoroughly in clean water and air dry.

   b) Immerse the respirator body for two minutes in an aqueous solution of iodine (add 0.8 ml of iodine in 1 liter water). The iodine is about 7% ammonium and potassium iodide, 45% alcohol and 48% water. Rinse thoroughly in clean water and air dry.

2) Immersion times have to be limited to minimize damage to the respirator. The solutions can age rubber and rust metal parts.

NOTE: The air-purifying elements must be removed from the respirator prior to cleaning and sanitizing the respirator. Never allow the air-purifying elements to come in contact with water or cleaning/sanitizing solution.

1.4.3 STORAGE

Respirators must be stored to protect them from contamination and mechanical damage at all times when not in use. New, cleaned or reconditioned respirators are to be kept in

a clean, sealed plastic bag or container, stored in a normal position. A suitable cabinet or drawer should be used to protect respirators and supplies from dirt, extremes of temperature or bright sunlight. They are not to be left in vehicles or on site perimeter fences, in change sheds, etc.

ATTACHMENT IV

HEAT STRESS AND COLD STRESS PROCEDURES

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1.0 COLD STRESS

1.1 OVERVIEW

Fatal exposures to cold have been reported in employees failing to escape from low environmental air temperatures or from immersion in low temperature water. Hypothermia, a condition in which the body's deep core temperature falls significantly below 98.6°F, can be life threatening. A drop in core temperature to 95°F or lower must be prevented.

Air temperature is not sufficient to determine the cold hazard of the work environment. The wind-chill must be considered as it contributes to the effective temperature. The body's physiologic defense against cold includes constriction of the blood vessels, inhibition of the sweat glands to prevent loss of heat via evaporation, glucose production and involuntary shivering to produce heat by rapid muscle contraction.

The frequency of accidents increases with cold temperature exposures as the body's nerve impulses slow down, individuals react sluggishly and numb extremities make for increased clumsiness. Additional safety hazards include ice, snow blindness, reflections from snow and possible skin burns from contact with cold metal.

There are certain predisposing factors that make an individual more susceptible to cold stress. It is the responsibility of the project team members to inform the Health and Safety Officer to monitor an individual, if necessary, or use other means of preventing/reducing the individual's likelihood of experiencing a cold related illness or disorder.

1.2 PREDISPOSING FACTORS

Predisposing factors that will increase an individual's susceptibility to cold stress are listed below:

- Dehydration: The use of diuretics and/or alcohol, or diarrhea can cause dehydration. Dehydration reduces blood circulation to the extremities.
- Fatigue During Physical Activity: Exhaustion reduces the body's ability to constrict blood vessels. This results in the blood circulation occurring closer to the surface of the skin and the rapid loss of body heat.

- Age: Some older and very young individuals may have an impaired ability to sense cold.
- Alcohol Consumption: Alcohol dilates the blood vessels near the skin surface resulting in excessive body heat loss.
- Sedative Drugs: Sedatives may interfere with the transmission of impulses to the brain, thereby interfering with the body's physiological defense against cold. Some prescription drugs may react the same way.
- Poor Circulation: Vasoconstriction of peripheral vessels reduces blood flow to the skin surface.
- Heavy Work Load: Heavy work loads generate metabolic heat and make an individual perspire even in extremely cold environments. If perspiration is absorbed by the individual's clothing and is in contact with the skin, cooling of the body will occur.
- The Use of PPE: PPE usage which traps sweat inside the PPE may increase an individual's susceptibility to cold stress.
- Lack of Acclimatization: Acclimatization, the gradual introduction of workers into a cold environment, allows the body to physiologically adjust to cold working conditions.
- History of Cold Injury: Previous injury from cold exposures may result in increased cold sensitivity.

1.3 PREVENTION OF COLD STRESS

There are a variety of measures that can be implemented to prevent or reduce the likelihood of employees developing cold related ailments and disorders. These include acclimatization, fluid and electrolyte replenishment, eating a well balanced diet, wearing warm clothing, the provision of shelter from the cold, thermal insulation of metal surfaces, adjusting work schedules and employee education.

- Acclimatization: Acclimatization is the gradual introduction of workers into the cold environment to allow their bodies to physiologically adjust to cold working conditions. However, the physiologic changes are usually minor and require repeated uncomfortably cold exposures to induce them.
- Fluid and Electrolyte Replenishment: Cold, dry air can cause employees to lose significant amounts of water through the skin and lungs. Dehydration affects the flow of blood to the extremities and increases the risk of cold injury. Warm,

sweet, caffeine-free, non-alcoholic drinks and soup are good sources to replenish body fluids.

- Eating a Well-Balanced Diet: Restricted diets including low salt diets can deprive the body of elements needed to withstand cold stress. Eat high energy foods throughout the day.
- Warm Clothing: It is beneficial to maintain air space between the body and outer layers of clothing in order to retain body heat. However, the insulating effect provided by such air spaces is lost when the skin or clothing is wet.

The parts of the body most important to keep warm are the feet, hands, head and face. As much as 40 percent of body heat can be lost when the head is exposed.

Recommended clothing includes:

- Inner layers (t-shirts, shorts, socks) should be of a thin, thermal insulating material.
- Wool or thermal trousers. Denim is not a good protective fabric.
- Felt-lined, rubber-bottomed, leather-upper boots with a removable felt insole is preferred. Change socks when wet.
- Wool shirts/sweaters should be worn over inner layer.
- A wool cap is good head protection. Use a liner under a hard hat.
- Mittens are better insulators than gloves.
- Face masks or scarves are good protection against wind.
- Tyvek/poly-coated Tyvek provides good wind protection.
- Wear loose fitting clothing, especially footwear.
- Carry extra clothing in your vehicle.
- Shelters with heaters should be provided for the employees' rest periods if possible. Sitting in a heated vehicle is a viable option. Care should be taken that the exhaust is not blocked and that windows are partially open to provide ventilation.
- At temperatures of 30°F (-1°C) or lower, cover metal tool handles with thermal insulating material if possible.
- Schedule work during the warmest part of the day if possible, rotate personnel and adjust the work/rest schedule to enable employees to recover from the effects of cold stress.

1.3.1 EMPLOYEE EDUCATION

Employees have already been trained to recognize and treat the effects of cold stress during their 40-hour training. Signs, symptoms and treatment of cold stress should be reviewed in project safety meetings where applicable. The buddy system will help in preventing cold stress once the employees are trained to recognize the signs and symptoms of cold stress.

1.3.2 COLD STRESS PREVENTION GUIDELINES

It may not be practically feasible to implement all the above prevention measures. Follow the guidelines given below when the ambient air temperature is -5°F (-20°) or lower:

- Contact the project manager or the industrial hygienist to determine if the project team should be on-site in such temperatures;
- Dress warm;
- Replenish fluids and electrolytes at regular intervals;
- Provide shelter from the cold; and
- Adjust work/rest schedules.

1.3.3 ADJUST WORK-REST SCHEDULES

Follow the work/rest schedule on Table A.1. It is based on the cooling power of air which is a function of wind speed and ambient air temperature.

1.4 FIRST-AID TREATMENT GUIDELINES

The following describes symptoms of different stages in cold stress and the related first-aid treatment guidelines.

1.4.1 FROSTBITE

Stages

Incipient (frost nip)	May be painless. Tips of ears, nose, cheeks, fingers, toes, chin affected. Skin blanched white.
Superficial	Affects skin/tissue just beneath skin; turns purple as it thaws. Skin is firm, waxy; tissue beneath is soft, numb.
Deep	Tissue beneath skin is solid, waxy, white with purplish tinge. Entire tissue depth is affected.

First-Aid

Incipient	Warm by applying firm pressure - blow warm breath on spot or submerge in warm water (102°F to 110°F) (39°C to 43°C). Do not rub the area.
Superficial	Provide dry coverage, steady warmth; submerge in warm water.
Deep	Hospital care is needed. Do not thaw frostbitten part if needed to walk on. Do not thaw if there is danger of refreezing. Apply dry clothing over frostbite. Submerge in water; do not rub.

1.4.2 GENERAL HYPOTHERMIA

Stages

- Shivering
- Indifference
- Decreased Consciousness

- Unconsciousness
- Death

Symptoms

- Muscle Tension
- Uncontrollable Shivering
- Glassy Stare
- Decreased Muscle Function
- Speech Distortion
- Blue, Puffy Skin
- Slow Pulse
- Shallow Breathing
- Coordination Loss
- Stumbling
- Forgetfulness
- Freezing Extremities
- Dilated Pupils
- Fatigue

Emergency Response

- Keep person dry; replace wet clothing
- Apply external heat to both sides of patient using available heat sources, including other bodies.
- Give warm liquids - not coffee or alcohol - after shivering stops and if conscious.
- Handle gently.
- Transport to medical facility as soon as possible.
- If more than 30 minutes from a medical facility, warm person with other bodies.

Standard Operating Procedure For Semi-Volatile Organic Compounds (SVOC)

Prepared For SIMALABS International
Organics, Organics Laboratory & Main Laboratory

SW-846, 3rd Edition, Method 8270C

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CAUTION

Disclaimer: This Standard Operating Procedure has been prepared for the sole use of SIMALABS International and may not be specifically applicable to the activities of other organizations.

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STANDARD OPERATING PROCEDURES
SEMI-VOLATILE ORGANIC COMPOUNDS (SVOC)

LOCATION:

Organics, Organics Laboratory

REFERENCE:

SW-846, 3rd Edition, Method 8270C
U.S. EPA Method 625

MATRIX:

Water, Leachate, Soil, Solids, Sludge

DETECTION LIMITS:

For EQL's, and MDL's see Table 1-1, attached

RANGE:

Aqueous: 10 ug/L to 160 ug/L without dilution
Non-aqueous: 330 ug/kg to 5300 ug/kg without dilution

PRINCIPLE, SCOPE AND APPLICATION:

Semi-volatile organic compounds are extracted from a water matrix using methylene chloride and separatory funnels. After concentration, the extract is injected into the GC/MS system and analysis computer controlled following the criteria established in SW-846 method 8270B.

INTERFERENCES AND CORRECTIVE ACTION:

Since SW-846 Method 8270B uses extracted ion counts and internal standards, interferences are kept to a minimum. On occasion, an emulsion may form during the extraction procedure. These emulsions may require extra standing time, stirring or centrifugation to break them up.

SAFETY PRECAUTIONS:

Lab coats and safety glasses are to be worn while working with samples, especially during the extraction procedure. While extracting, separatory funnels must be vented frequently to relieve pressure. Standards are stored in crimp top vials in a freezer and other chemicals are stored in a metal cabinet marked *Flammable*.

SAMPLE SIZE, COLLECTION, PRESERVATION AND HANDLING:

Aqueous samples should be collected in 1 liter amber glass containers with teflon lined lids, and cooled to 4 °C until extraction occurs. Holding times are 7 days for extraction and 40 days for analysis for non-aqueous samples.

APPARATUS:

1) HP5890 Series II Gas Chromatograph configured as follows:

Initial Temperature:	40 °C
Initial Time:	4 minutes
Rate:	10 °/ minute
Final Temperature:	270 °C
Final Time	7 minutes

2) HP 5971A Mass Selective Detector configured as follows:

Scan Mode

Mass range 35 to 550

Sampling 2

Threshold 500

3) HP Vectra 386/25 computer with MS Chemstation software, monitor and Laser Jet II printer.

2 L Separatory funnel

Turbo Vap II concentrator tube

1 L and 10 mL graduated cylinders

60 mL funnel

10 uL and 1000 uL syringe

2 mL vials with screw tops

Turbo Vap II evaporator(water bath temperature = 37 °C)
15 mL test tubes with caps

2 mL vials with crimp tops and inserts

ROUTINE MAINTENANCE:

A daily check of the carrier gas is done and the tank is changed when the pressure reaches 300 psi. Pump leaks are checked for quarterly. Changing septa, changing gas filters, changing GC column, cleaning MS source, checking septa for leaks, checking gas flow, cutting capillary column, and replacing liner are all done and recorded in the maintenance log for that system as needed.

REAGENTS AND CALIBRATION STANDARDS:

1)HC Base-Neutral Mix 1-Supelco (or equivalent)

bis (2-chloroethoxy) methane	diethylphthalate
bis (2-chloroethyl) ether	dimethylphthalate
bis (2-ethylhexl) phthalate	di-n-butyl phthalate

bis (2-chloroisopropyl)ether

4-bromophenylphenylether

butylbenzylphthalate

4-chlorophenylphenylether

di-n-octylphthalate

N-nitrosodimethylamine

N-nitrosodi-n-propylamine

N-nitrosodiphenylamine

2,000 ug/mL each component in methylene chloride

2) HC Base-Neutrals Mix 2-Supelco (or equivalent)

azobenzene

2-chloronaphthalene

1,2-dichlorobenzene

1,3-dichlorobenzene

1,4-dichlorobenzene

2,4-dinitrotoluene

2,6-dinitrotoluene

hexachlorobenzene

hexachlorobutadiene

hexachlorocyclopentadiene

hexachloroethane

isophorone

nitrobenzene

1,2,4-trichlorobenzene

2,000 ug/mL each component in methylene chloride

3) HC Phenols Mix-Supelco (or equivalent)

4-chloro-3-methylphenol

2-chlorophenol

2,4-dichlorophenol

2,4-dimethylphenol

2,4-dinitrophenol

2-methyl-4,6-dinitrophenol

2-nitrophenol

4-nitrophenol

pentachlorophenol

phenol

2,4,6-trichlorophenol

2,000 ug/Ml each component in methylene chloride

4) HC PNA Hydrocarbon Mix-Supelco (or equivalent)

acenaphthene	chrysene
acenaphthylene	dibenzo (a,h) anthracene
anthracene	fluoranthene
benzo(a)anthracene	fluorene
benzo(b)fluorathene	indeno (1,2,3-c,d) pyrene
benzo (g,h,i) perylene	naphthalene
benzo (a) pyrene	phenanthrene
benzo(k)fluoranthene	pyrene

2,000 ug/mL each component in methylene chloride:benzene (50:50)

5) HC Internal Standard Mix-Supelco (or equivalent)

acenphthene-d_{10}	naphthalene-d_8
chrysene-d_{12}	perylene-d_{12}
1,4-dichlorobenzene-d_4	phenanthrene-d_{10}

4,000 ug/mL each component in methylene chloride

6) Base-neutral Surrogate Standard Mix - Supelco (or equivalent)

nitrobenzene-d_5	2-fluorobiphenyl
Terphenyl-d_{14}	

1,000 ug/ml each component in methylene chloride

7) Acid Surrogate Standard Mix - Supelco (or equivalent)

phenol-d_6 2,4,6-tribromophenol

2-fluorophenol

2,000 ug/mL each component in methylene chloride

8) Acid Spiking Solution - Supelco (or equivalent)

pentachlorophenol 4-chloro-3-methylphenol

phenol 4-nitrophenol

2-chlorophenol

2,000 ug/mL each component in methylene chloride

9) Base-Neutral Spiking Solution - Supelco (or equivalent)

acenaphthene 1,2,4-trichlorobenzene

N-nitrosodi-n-propylamine 1,4-dichlorobenzene

pyrene 2,4-dinitrotoluene

1,000 ug/mL each component in methylene chloride

10) HC Hazardous Substance Mix-1 - Supelco (or equivalent)

2-methylphenol 2,4,5-trichlorophenol

4-methylphenol

2,000 ug/mL each component in methylene chloride

11) HC Hazardous Substance Mix 2 - Supelco (or equivalent)

aniline 2-methylnaphthalene

benzyl alcohol 2-nitroaniline

4-chloroaniline 3-nitroaniline

dibenzofuran 4-nitroaniline

2,000 ug/mL each component in methylene chloride

12) Decafluorotriphenylphosphine (DFTPP) - Supelco (or equivalent)

25 mg/mL in methylene chloride

13) Acetone, Methylene Chloride

14) sodium sulfate

15) Decafluorotriphenylphosphine (DFTPP) working

- concentration: 50 ug/mL

- Preparation procedure: place 1.0 mL of methylene chloride into a 2 mL vial and cap. Using a 10 uL syringe, add 2 uL of standard 12 to vial.

16) Level 200 Stock

- Concentration: 200 ug/mL for target compounds and acid surrogates, 100 ug/mL for base/neutral surrogates.

- Preparation procedure: add 500 ul of each target mix and surrogate mix to a 15 ml vial and dilute to a final volume of 5 ml.

17) Level 20, 50, 80, 120, and 160 standards

Conc.: 20- 20 ug/ml targets and acid surrogates.
10 ug/ml base/neutral surrogates.
Conc.: 50- 50 ug/ml targets and acid surrogates.
25 ug/ml base/neutral surrogates.
Conc.: 80- 80 ug/ml targets and acid surrogates.
40 ug/ml base/neutral surrogates.
Conc.: 120-120ug/ml targets and acid surrogates.
60 ug/ml base/neutral surrogates.
Conc.: 160-160ug/ml targets and acid surrogates.
80 ug/ml base/neutral surrogates.

- Preparation procedure

Level 20 is prepared by combining 100 ul of level 200 stock, 890 ul of methylene chloride, and 10 ul of internal standard in a 2 ml crimp-top vial.

Level 50 is prepared by combining 250 ul of level 200 stock, 740 ul of methylene chloride, and 10 ul of internal standard in a 2 ml crimp-top vial.

Level 80 is prepared by combining 400 ul of level 200 stock, 590 ul of methylene chloride, and 10 ul of internal standard in a 2 ml crimp-top vial.

Level 120 is prepared by combining 600 ul of level 200 stock, 390 ul of methylene chloride, and 10 ul of internal standard in a 2 ml crimp-top vial.

Level 160 is prepared by combining 800 ul of level 200 stock, 190 ul of methylene chloride, and 10 ul of internal standard in a 2 ml crimp-top vial.

18) Surrogate Working Solution

- Concentration: 100 ug/mL acid surrogates
50 ug/mL base-neutral surrogates
- Preparation procedure: Place 80 ml methylene chloride in a 100 ml volumetric flask and add 5.0 ml of each surrogate standard. Dilute to volume.

19) 1:1 H_2SO_4 - in a 4 oz. squat jar, add and equal volume of sulfuric acid to a known amount of water.

20) 6N NaOH - Dissolve 24 g of sodium hydroxide pellets into 100 mLs of DI water

<u>CALIBRATION PROCEDURES:</u>

An initial 5 pt. calibration is prepared using the level 20, 50, 80, 120 and 160 initial calibration standards. 1 uL from each vial is injected. After the five runs have been completed, response factors (RF) can be calculated for each component (see Data Treatment section).

Prior to analysis of initial or continuing calibrations or samples, 1 uL of the working DFTPP solution must be analyzed to show the instrument is tuned to the following criteria:

Mass	Ion Abundance Criteria
51	30-60% of mass 198
98	<2% of mass 69
70	<2% of mass 69
127	40-60% of mass 198
197	<1% of mass 198
198	Base peak, 100% relative abundance
199	5-9% of mass 198
275	10-30% of mass 198
365	>1% of mass 198
441	Present but less than mass 443
442	>40% of mass 198
443	17-23% of mass 442

The above criteria must be demonstrated for each 12 hour shift.

In addition to a DFTPP check every 12 hours, a continuing calibration check must also be run to show the system is operating correctly and the initial calibration is still valid. This is done by injecting 1 uL of the SPCC, CCC working solution into the GC/MS while running the 625 method built into the software. For specific SPCC and CCC compounds and criteria, see Table 6-1 attached.

SAMPLE PREPARATION:

See SOP-ORG-3510-1 for aqueous matrices.

ANALYSIS PROCEDURE:

Place 200 uL of extract into a vial insert and cap. After adding 2.0 uL of internal standard, the sample is ready to be injected. 1 uL is injected through the septum using the computer controlled auto-sampler. At the end of the run, the computer will extract the necessary target ions - from the total ion chromatogram and using the internal standards and RF values from the initial calibration it will generate a report quantifying the sample.

Table 1

(1) Click on *Tune MS* in main menu.

(2) Click on *Target Tune* under Tune MS.

(3) Click on *DFTPP tune*, under tune file.

(4) After tune is complete, double click on left box in Target Tune menu to exit. Save tune file when prompted to.

(5) Click on *Methods* in main menu.

(6) Click on *Load and Run Method* under Methods.

(7) Click on *DFTPP.m* to load method for DFTPP tune analysis.

(8) Enter date file name as DFTP and date.d (e.i. on July 6 enter DFTP0706.d).

(9) Enter operators name.

(10) Enter sample name as *DFTPP tune for (date).*

(11) Click on *Run Method.*

(12) Allow method to run.

(13) Check ion abundance at peak apex in data analysis window.

Table 2

(1) Run method 8270.

(2) Enter *SPCC + date.d* for file name.

(3) Enter operator's name.

(4) Enter sample name as *Daily Calibration Check for (date).*

(5) Enter miscellaneous information a 1 ul/ from 50 ug/ml continuing calibration surrogate and internal standards.

(6) Click on run method.

(7) Allow to run, retrieve report, check to see that all expected compounds have been calculated at approximately correct concentrations.

(8) Calculate RF values and % drift values for all system performance check compounds and calibration check compounds according to 7.43 and 7.44 of method 8270B in the SW-846 manual.

Table 3

(1) Run method 8270.

(2) Enter *S(last 3 digits of sample log #) and date* for file name.

(3) Enter sample information under sample name.

(4) Click on run method.

(5) Allow to run, retrieve report.

(6) Check each detected component to make sure chromatography is clear, that the peaks for each ion of the compound show the same retention time, and that they are in correct proportions Also check to see that surrogate standards are recovered sufficiently (see Table 3.3 attached).

QUALITY CONTROL:

A blank, matrix spike and matrix spike duplicate are required to be extracted and analyzed for every batch (batch not to exceed 20 samples). In addition a surrogate is spiked into the blank, matrix spike, matrix spike duplicate, and all the samples.

DATA TREATMENT:

The computer report will show the ng of all compounds found in the sample. This number must be calculated to reflect the volume extracted, final volume of extract (including dilutions) and the amount of sample injected.

$$RF = (A_x C_{is}) / (A_{is} C_x)$$

where,

A_x = Area of the characteristic ion for the compound being measured.

A_{is} = Area of the characteristic ion for the specific internal standard.

C_{is} = Concentration of the specific internal standard.

C_x = Concentration of the compound being measured.

$$\% \text{ drift} = \frac{C_i - C_c}{C_i} \times 100$$

where,

C_i = Calibration check compound standard concentration

C_c = Measured concentration

$$\text{concentration} = \frac{(A_x)(I_s)(V_t)}{(A_{is})(RF)(V_o)(V_i)}$$

where,

Ax =	Area of characteristic ion for compound being measured.
Is =	Amount of internal standard injected (ng).
V_t =	Volume of total extract, taking into account dilution (i.e. a 1-to-10 dilution of a 1 ml extract will mean V_t = 10,000 ul. If half the base-neutral extract and half the acid extract are combined, V_t - 2,000.
Ais =	Area of characteristic ion for the internal standard.
RF =	Initial average response factor for compound being measured
Vo =	Volume of water extracted (L).
V_i	= Volume of extract injected (ul).

DATA DELIVERABLES:

Reports to client will include:
- Date of receipt
- Date of preparation
- Date of analysis
- Analyst
- Matrix
- Laboratory I.D. #
- Client I.D. #
- Analytical method and method #
- Blank data
- Concentrations determined and resulting limits
- Surrogate summary form
- Matrix spike summary form
- Blank summary form
- Tune check summary form
- Initial calibration summary form
- Continuing calibration summary form

- IS area/retention time summary form
- All raw data
- Target spectra for all positive hits with corresponding reference spectra
- Preparation records

SEMI-VOLATILE ORGANIC COMPOUNDS DETECTION LIMITS AND REPORTING LEVELSFOR AQUEOUS SAMPLES

Compound	Detection Limit (ug/L)	Reporting Level (ug/L)
3-Nitroaniline	0.795123	10
Acenaphthene	0.713128	10

Debenzofuran	0.615747	10
4-Nitrophenol	7.992884	50
2,4-Dinitrotoluene	0.760592	10
Fluorene	0.593694	10
4-Chlorophenyl-phenylether	0.628974	10
Diethylphthalate	0.675562	10
4-Nitroanaline	1.03114	10
4,6-Dinitro-2-methylphenol	8.209186	50
n-Nitrosodiphenylamine	0.597131	10
4-Bromophenyl-phenylether	0.707466	10
Hexachlorobenzene	0.58431	10
Pentachlorophenol	8.838677	50
Phenanthrene	0.715433	10
Anthracene	0.665248	10
Di-n-butylphthalate	0.764879	10
Fluoranthene	0.66666	10
Pyrene	0.63378	10

SEMI-VOLATILE ORGANIC COMPOUNDS DETECTION LIMITS AND REPORTING LIMITS FOR AQUEOUS SAMPLES

Compound	Detection Limit (ug/L)	Reporting Level (ug/L)
Butylbenzylphthalate	0.610761	10
Benzo[a]anthracene	0.606045	10
3,3'-Dichlorobenzidine	0.469951	20
Chrysene	0.519264	10
Bis(2-Ethylhexyl)phthalate	0.262246	10
Di-n-octylphthalate	0.581162	10
Benzo[b]fluoranthene	0.481129	10
Benzo[k]fluoranthene	1.096667	10
Benzo[a]pyrene	0.651494	10
Benzo[g,h,i]perylene	0.442206	10
Dibenz[a,h]anthracene	0.501146	10
Indeno[1,2,3-cd]pyrene	1.395449	10
2,4-Dinitrophenol	10.00424	50
Pyridine	0.883374	10
Phenol	0.588801	10
Bis(2-Chloroethyl)Ether	1.081897	10
2-Chlorophenol	1.108506	10
1,3-Dichlorobenzene	1.355851	10
1,4-Dichlorobenzene	1.327274	10

SEMI-VOLATILE ORGANIC COMPOUNDS DETECTION LIMITS AND REPORTINF LEVELS FOR AQUEOUS SAMPLES

Compound	Detection Limit (ug/L)	Reporting Level (ug/L)
1,2-Dichlorobenzene	1.268468	10
Benzyl Alcohol	0.82557	10
Bis(2-chloroisopropyl)ether	0.981306	10
2-Methylphenol	0.743295	10
Hexachloroethane	1.211779	10
N-Nitroso-di-n-propylamine	0.856308	10
4-Methylphenol	0.855951	10
Nitrobenzene	1.08357	10
Isophorone	0.793554	10
2-Nitrophenol	0.888551	10
2,4-Dimethylphenol	5.767869	10
Bis(2-chloroethoxy)methane	0.773045	10
2,4-Dichlorophenol	0.898527	10
1,2,4-Trichlorobenzene	1.150772	10
Naphthalene	0.971744	10
4-Chloroaniline	0.332836	10
Hexachlorobutadiene	1.139847	10
4-Chloro-3-Methylphenol	0.62001	10
2-Methylnaphthalene	0.853915	10

SEMI-VOLATILE ORGANIC COMPOUNDS DETECTION LIMITS AND REPORTING LEVELS FOR AQUEOUS SAMPLES

Compound	Detection Limit (ug/L)	Reporting Level (ug/L)
Hexachlorobutadiene	1.139847	10
2,4,5-Trichlorophenol	0.57116	10
2,4,6-Trichlorophenol	0.627214	10
2-Chloronaphthalene	0.529579	10
2-Nitroaniline	0.761211	10
Acenaphthylene	0.616549	10
Dimethylphthalate	0.784282	10
2,6-Dinitrotoluene	0.831333	10

Standard Operating Procedure For Acid Digestion of Aqueous Samples and Extracts For Analysis by Inductively Coupled Argon Plasma Spectroscopy

Prepared For SIMALABS International
Metals, Metals Laboratory

SW-846, 3rd Edition, Method 3005

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CAUTION

<u>Disclaimer:</u> This Standard Operating Procedure has been prepared for the sole use of SIMALABS International and may not be specifically applicable to the activities of other organizations.

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STANDARD OPERATING PROCEDURE
ACID DIGESTION OF AQUEOUS SAMPLES AND EXTRACTS FOR ANALYSIS BY INDUCTIVELY COUPLED ARGON PLASMA SPECTROSCOPY

LOCATION:

Metals, Main Laboratory and Metals Laboratory

REFERENCE:

SW-846, 3rd Edition, method 3005
USEPA CLP SOW ILM02.0

MATRIX:

Water, Leachate

DETECTION LIMITS:

N/A

RANGE:

N/A

PRINCIPLE, SCOPE AND APPLICATION:

This digestion procedure is used for the preparation of aqueous samples, total or dissolved, for analysis by Inductively Coupled Argon Plasma (ICAP) spectroscopy. The following elements can be analyzed using this preparation procedure: Aluminum, Antimony, Arsenic, Barium, Beryllium, Cadmium, Calcium, Chromium, Cobalt, Copper, Iron, Lead, Magnesium, Manganese, Molybdenum, Nickel, Potassium, Selenium, Silver, Sodium, Thallium, Vanadium, and Zinc.

The entire sample is acidified to pH <2, with nitric acid, at time of collection. unless dissolved metals are required. In that instance the sample must be filtered (.45 micron) before preservation or the sample should not be preserved but kept at 4C and the laboratory will filter the sample. For digestion, the sample is combined with acid and heated until volume is greatly reduced. If needed, the digestate is filtered and brought to volume, and is ready for analysis.

INTERFERENCES AND CORRECTIVE ACTION:

The digestion procedure may not be sufficient to completely break-down some metal complexes. Additional digestion time or a more vigorous digestion may be required to facilitate complete digestion.
Precipitation during digestion may cause a suppression of the total Silver content measured in the analysis. If this occurs, dilute the sample prior to digestion to lower the effective concentration of Silver to < 1 ppm.

Cross-contamination and contamination of the sample can be a major source of error. The sample preparation work area should be kept scrupulously clean. All glassware should be cleaned as directed in the procedure section. Pipet tips are a frequent source of contamination. If contamination is suspected, the tips should be soaked with 1:5 nitric acid and rinsed thoroughly with Type II Deionized water.

SAFETY PRECAUTIONS:

Wear lab coat, safety glasses, and gloves. All work involving heated digestates must be conducted under a fume hood.

SAMPLE SIZE, COLLECTION, PRESERVATION AND HANDLING:

Samples should be collected in 500 ml plastic containers, with teflon lined lids. The sample should be preserved immediately upon collection by the addition of nitric acid to lower the pH to < 2, unless dissolved metals are required. In that instance the sample must be filtered (.45 micron) before preservation or the sample should not be preserved but kept at 4C and the laboratory will filter the sample. Samples must be analyzed within 6 months of collection.

APPARATUS:

1) 250 ml beakers

2) Ribbed watch glasses

3) Qualitative filter paper

4) Glass Funnels

5) Class A 100ml graduated cylinders

6) Hot-plate capable of maintaining 90 to 95°C

7) Citrinox soap

8) Class A volumetric pipets

9) Vacuum filtration device

10) .45 micron filters

REAGENTS:

1) Type II deionized water

2) Nitric acid (conc.) trace metals grade (Fisher, AS09-212)

3) Hydrochloric acid (conc.) trace metals grade (Fisher, AS08-212)

4) ICP/Flame Spiking Solution: Using a Class A volumetric flask, transfer 50.0 mL of Spike-1 (Spex, Spike-1) into a 100 mL Class A volumetric flask. Using a 2.00 mL Class A volumetric pipet, transfer 2.00 mL of molybdenum standard (Spex, PLM09-2y), boron (Spex, PLB-2y), strontium (Spex, PLSR2-2y), and silicon (Spex, PLSI9-2y) into the 100 mL Class A volumetric flask with the Spike-1 solution. Dilute to volume.

PROCEDURE:

1) Rinse beakers, graduated cylinders, funnels, and watch glasses with hot tap water. Leave items approximately. half full of water and add a small amount of Citrinox soap. Scrub each item with a brush and rinse with hot water. Place on a rack to dry. Place watch glasses on a clean paper towel to dry. Store items in a segregated cabinet until needed.

2) Prior to use of beakers, graduated cylinders, funnels, filtration device, and watch glasses, rinse with copious amounts of deionized water, followed by 1:1 nitric acid, then with DI water again.

3) Shake sample vigorously and transfer 50 ml of the well mixed sample to a 250 ml beaker, using a Class A graduated cylinder. For dissolved metals filter an adequate amount using the vacuum filtration device unless sample was filtered in the field.

4) Using a 1.00 mL class A volumetric pipet, transfer 1.00 mL of ICP/FL spiking solution into LCS and spike samples. Mix.

5) Using an Oxford Macro pipet, add, under a fume hood, 1ml of concentrated nitric acid and 2.5 ml concentrated hydrochloric acid to the sample. Mix.

6) Cover beaker with a ribbed watch glass and place on a hot-plate to be heated at 95°C for two hours, or until the sample volume is reduced to 15 to 25 ml. **Do not allow the digestate to boil.**

7) Cool the digestate to room temperature. If needed, filter the digestate through qualitative filter paper into a graduated cylinder and using a Class A graduated cylinder, adjust sample volume to 50 ml with DI water.

QUALITY CONTROL:

For each batch of digestions, not to exceed 20, a preparation blank, laboratory control standard, duplicate, and spike will be prepared.

A check blank will be conducted on each new lot of nitric acid and hydrochloric acid prior to use, to verify purity.

DATA DELIVERABLES:

All digestion activities will be recorded on a digestion log sheet. A copy of this sheet will be provided with the analytical data package.

Standard Operating Procedure For Acid Digestion of Aqueous Samples and Extracts For Analysis by Graphite Furnace Atomic Absorption Spectroscopy

Prepared For SIMALABS International
Metals, Metals Laboratory

SW-846, 3rd Edition, Method 3020

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STANDARD OPERATING PROCEDURE
ACID DIGESTION OF AQUEOUS SAMPLES AND EXTRACTS FOR ANALYSIS BY GRAPHITE FURNACE ATOMIC ABSORPTION SPECTROSCOPY

LOCATION:

Metals

SW-846, 3rd Edition, methods 3020A, 7060, and 7740
USEPA CLP SOW ILM02.0

MATRIX:

Water, Leachate

DETECTION LIMITS:

N/A

RANGE:

N/A

PRINCIPLE, SCOPE AND APPLICATION:

This digestion procedure is used for the preparation of aqueous samples, for analysis by Graphite Furnace Atomic Absorption spectroscopy. The following elements can be analyzed using this preparation procedure: Arsenic, Beryllium, Cadmium, Chromium, Cobalt, Lead, Molybdenum, Selenium, Thallium, and Vanadium.

This procedure is used to determine the total amount of the metal of concern in the samples submitted. A mixture of nitric acid , hydrogen peroxide and the sample is heated, initiating the digestion process. After the digestate has been

brought to a low volume, it is cooled and brought to volume in dilute nitric acid, such that the final digestate contains 2 %(V/V) nitric acid and hydrogen peroxide.

INTERFERENCES AND CORRECTIVE ACTION:

Anion interference studies in the graphite furnace indicate that, under conditions other than isothermal, the nitrate anion is preferred. Therefore, nitric acid is preferable for any digestion or solubilization step. If another acid in addition to nitric acid is required, minimum quantities should be used. This applies particularly to hydrochloric and to a lesser extent sulfuric and phosphoric acids.

Cross-contamination and contamination of the sample can be a major source of error because of the extreme sensitivities achieved with the furnace. The sample preparation work area should be kept scrupulously clean. All glassware should be cleaned as directed in the procedure section. Pipet tips are a frequent source of contamination. If contamination is suspected, the tips should be soaked with 1:5 nitric acid and rinsed thoroughly with Type II Deionized water.

SAFETY PRECAUTIONS:

Wear lab coat, safety glasses, and gloves. All work involving heated digestates must be conducted under a fume hood.

SAMPLE SIZE, COLLECTION, PRESERVATION AND HANDLING:

Samples should be collected in 500ml plastic containers, with teflon lined lids. The sample should be preserved immediately upon collection by the addition of nitric acid to lower the pH to < 2. Samples must be analyzed within 6 months of collection.

APPARATUS:

250 ml beakers
Watch glasses
Qualitative filter paper
Funnels

100ml graduated cylinders
Hot-plate capable of maintaining 90 to 95oC

REAGENTS:

Type II deionized water
Nitric acid(conc.) trace metals grade
Hydrogen peroxide(30%)

PROCEDURE:

1) Rinse beakers, graduated cylinders, funnels, and watch glasses with hot tap water. Leave items appx. half full of water and add a small squirt of Citrinox soap. Scrub each item with a brush and rinse with hot water. Place on a rack to dry. Place watch glasses on a clean paper towel to dry. Store items in a segregated cabinet until needed.

2) Prior to use of beakers, graduated cylinders, funnels, and watch glasses, rinse with copious amounts of deionized water, followed by 1:1 nitric acid, then with DI water again.

3) Shake sample vigorously and transfer 50 ml of the well mixed sample to a 250 ml beaker.

4) Add, under a fume hood, 1ml of concentrated nitric acid and 1 ml 30% hydrogen peroxide to the sample.

5) Cover beaker with a watch glass and place on a hot-plate to be heated at 95oC for two hours, or until the sample volume is reduced to 15 to 25 ml. Do not allow the digestate to boil.

6) Cool the digestate to room temperature. If needed, filter the digestate through qualitative filter paper into a graduated cylinder and adjust sample volume to 50 ml with DI water.

QUALITY CONTROL:

For each batch of digestions, not to exceed 20, a preparation blank, laboratory control standard, duplicate, and spike will be prepared.

A check blank will be conducted on each new lot of nitric acid and peroxide prior to use, to verify purity.

DATA DELIVERABLES:

All digestion activities will be recorded on a digestion log sheet. A copy of this sheet will be provided with the analytical data package.

Standard Operating Procedure For Inductively Coupled Plasma Methods For Aqueous Samples

Prepared For SIMALABS International
Metals, Metals Laboratory

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STANDARD OPERATING PROCEDURE
INDUCTIVELY COUPLED PLASMA METHODS

REFERENCE:

SW-846, 3rd Edition, Method 6010A
USEPA CLP SOW ILM02.0

MATRIX:

Water, Leachate, Soil, Solids, Sludge

DETECTION LIMITS:

For EQL's and MDL's see Table 1-1 attached.

RANGE:

The effective range of this method varies per element, and is verified by quarterly linear range studies.

PRINCIPLE, SCOPE AND APPLICATION:

Inductively coupled plasma emission spectroscopy is used in the determination of trace elements, including metals in solution. Prior to analysis, digestion is necessary to place the trace metal elements in solution.

Before analysis can take place, samples must be digested using appropriate preparation methods. Digestion is not required when analyzing dissolved constituents as long as samples are filter and preserved with acid.

The analysis of metals using the ICP is based on the theory of Atomic Emission. Samples are nebulized which creates an aerosol that is transported to the plasma via a torch. The plasma places the element in an atomic state which is then excited and in turn emits a light or spectra which is specific to that particular element. The spectra are separated by a grating and the intensities of the lines are measured by either photo multiplier tubes or in this case, a charged injection devise. In simpler terms, the color or wavelength of light determines which element and the intensity of the light omitted determines concentration. Background light intensity must be measured adjacent to the analyte lines during analysis. The position selected for background measurement will be determined by the complexity of the spectrum adjacent to the analytical line. The position used must be free of spectral interference and reflect the same change in

background intensity as occurs at the analyte wavelength measured. Background correction is not necessary when the analyte wavelength is broad and therefore may be degraded as a result of background correction. Additional interferences discussed in the next section should be appraised so that correlations can be drawn.

INTERFERENCES AND CORRECTIVE ACTION:

Spectral interferences are caused by overlap of spectral lines from another element, unresolved overlap of molecular band spectra, background contribution from continuous or recombination phenomena and stray light from the line emission of high concentration elements. Spectral overlap can be compensated for by computer correction of the raw data after monitoring and measuring the interfering element. Unresolved overlap requires selection of an alternate wavelength. Background contribution and stray light can usually be compensated for by a background correction adjacent to the analyte line. Potential spectral interferences for recommended wavelengths have been documented but may differ for each instrument. Therefore spectral interferences must be measured for a particular instrument by aspirating 100 mg/L of the interfering element in order to measure the false analyte concentration that can arise. A correction factor can then be calculated and stored in the computer for future corrections. For example, aspirating a 100 mg/L standard of AL produces a false signal of 1.3 mg/L of Arsenic at the 193.696 line. Therefore, a correction factor can be used to compensate for this false signal.

Physical interferences are effects associated with the sample nebulization and transport processes. Samples containing high dissolved solids can cause inaccuracies. These inaccuracies can be reduced by dilution and/or a peristaltic pump.

Chemical interferences include molecular compound formation, ionization effects and solute vaporization effects. These effects are not significant with the ICP. They can be minimized by careful selection of operating conditions, by matrix matching and by standard addition.

SAFETY PRECAUTIONS:

Lab coats and safety glasses are to be worn at all times. All instrument vapors are to be vented to exterior of building, and all digestions are to occur under a fume hood.

SAMPLE SIZE, COLLECTION< PRESERVATION AND HANDLING:

Aqueous and leachate samples are to be collected in 500ml plastic containers with teflon lined lids, and preserved to pH $\leq$ 2 with nitric acid. Non-aqueous samples are to be collected in 4 oz. squat jars, with teflon lined lids, and cooled to 4°C until digestion. Samples must be analyzed within 6 months of collection.

APPARATUS:

Inductively coupled argon plasma emission spectrometer which includes a computer controlled emission spectrometer with background correction, and a radio frequency generator compliant with FCC regulations.

Liquid Argon

Operation conditions for simple aqueous samples are as follows:

Nebulizer pressure:	33 psi
Torch flow:	High
Auxiliary gas:	Low
RF power:	1150 W

Class A volumetric flasks

Class A volumetric pipets

ROUTINE MAINTENANCE:

Autosampler components, and tubing are checked daily. Tubing is changed monthly. Filters are cleaned twice yearly. Gas flow checks, and nebulizer cleaning are conducted as needed.

REAGENTS AND CALIBRATION STANDARDS:

Trace metal grade Hydrochloric Acid

Trace metal grade Nitric Acid

Reagent water - use Type II water for the preparation of all reagents and standards.

Standard stock solutions are purchased by supplier.

ICAP Standard Solution 1: Combine 0.10 ml A_2I CAL-1(Inorganic Ventures) and 0.10 ml A_2I CAL-2(Inorganic Ventures) with 2.0 ml concentrated nitric acid and 5.0 ml hydrochloric acid. Bring to final volume of 100 ml in volumetric flask.

ICAP Standard Solution 2: Combine 1.0 ml A_2I CAL-1(Inorganic Ventures) and 1.0 ml A_2I CAL-2(Inorganic Ventures) with 1.9 ml concentrated nitric acid, and 5.0 ml hydrochloric acid. Bring to a final volume of 100 ml in a volumetric flask.

ICAP Standard Solution 3: Combine 10 ml A_2I CAL-1(Inorganic Ventures) and 10 ml A_2I CAL-2(Inorganic Ventures) with 1.3 ml concentrated nitric acid, and 5.0 ml hydrochloric acid. Bring to a final volume of 100 ml in a volumetric flask.

A calibration blank is prepared by acidifying water to the same percentage of acids found in the standards and samples.

A reagent blank or preparatory blank must contain all reagents in the same volume used in the processing of the samples. This blank must be carried through the complete digestion procedure.

The instrument check standards are purchased from supplier and are prepared with the same acid concentrations as samples and standards.

ICP ICSA Solution: Combine 10.0 ml INT-A1(Spex) with 2.0 ml concentrated nitric acid, and 5.0 ml concentrated hydrochloric acid. Bring to a final volume of 100 ml with DI water in a volumetric flask.

ICP ICSAB Solution: Combine 10.0 ml INT-A1(Spex) with 1.0 ml INT-B1(Spex), 2.0 ml concentrated nitric acid, and 5.0 ml concentrated hydrochloric acid. Bring to a final volume of 100 ml with DI water in a volumetric flask.

ICP CCV Solution: Combine 1.0 ml each of CLPP-C1CV-1, CLPP-C1CV-2, CLPP-C1CV-3, with 2.0 ml concentrated nitric acid, and 5.0 ml concentrated hydrochloric acid. Bring to a final volume of 100 ml with DI water in a volumetric flask.

ICP ICV Solution: Combine 0.20 ml each of CLPP-C1CV-1, CLPP-C1CV-2, CLPP-C1CV-3, with 2.0 ml concentrated nitric acid, and 5.0 ml concentrated hydrochloric acid. Bring to a final volume of 100 ml with DI water in a volumetric flask.

CALIBRATION PROCEDURES:

A four point calibration consisting of a blank and three standards is analyzed. An ICV is immediately run after the two point curve. The ICV must recover all elements between 90 - 110 % of their true value for calibration to pass. In addition, an ICB is analyzed and can not demonstrate contamination above the analyte EQL.

A CCV, followed by a CCB, is analyzed after every 10 samples. The CCV must recover within 90 - 110% of true values. The CCB must demonstrate no contamination above the EQL.

Before samples are analyzed in a run, and at the conclusion of each run, interference check samples are analyzed. The analytes of concern must recover within 20 % of their true values.

SAMPLE PREPARATION:

Aqueous: See SOP-MET-3005-1

Non-aqueous: See SOP-MET-3050-1

ANALYSIS PROCEDURE:

1.) Turn hoods on.

2.) Make sure waste bucket is not full.

3.) Turn on computer system, and printer.

4.) Turn on ICP, and autosampler.

5.) Click on applications manager.

6.) Click on analysis

7.) Click on CID control panel.

8.) Reset camera (choose hard reset)

9.) Set the three purge valves to 2.0 L/min.

10.) Place sample draw tube in DI reservoir.

11.) Click ignite.

12.) Once torch ignites, adjust sample tube clamps to get a rate of about 1.3 ml/min.

13.) Let torch warm up for no less than 1 hour.

14.) Turn on autosampler and printer.

15.) Click on method and specify method to be used.

16.) Click on autosample icon with page displayed.

17.) Click on samples.

18.) Click on add set of samples.

19.) Input operator I.D., A_2I sample number and any other pertinent information.

20.) Save sample set.

21.) Click on table.

22.) Click on add a set.

23.) Input type, protocol, method and recall sample set, also set rinse time.

24.) Save table.

25.) Make rinse solution (1 % HNO_3 and 2 % HCI in DI water).

26.) Click on autosample icon with page displayed.

27.) Click on "Manual".

28.) Click "Move to rinse".

29.) Place sample draw tube in autosampler arm position over rinse reservoir.

30.) Set up standards and calibration checks into clean autosampler cups.

31.) Pour out samples into culture tubes and put into correct order, as stated in sample table.

32.) Start run by clicking on auto sampler icon without page.

33.) Open autosample table to be run and click again.

34.) Set starting sample and terminating action.

35.) Click run.

QUALITY CONTROL:

Dilute and reanalyze samples that are more concentrated than the linear range or use an alternate, less sensitive line.

Analyze a reagent or prep blank for every 20 samples. Blank must fall below the EQL. If blank shows contamination a redigestion and analysis shall be performed.

Analyze replicate samples for every 20 samples to verify precision of method. If the concentration is 10 times greater than instrument detection limit, the relative percent difference (RPD) shall be within 15% for waters, and 30 % for non-aqueous samples.

Spiked replicate samples are to be analyzed every 20 samples and recovery is to be within 20% of the actual value for waters, and 30% for non-aqueous samples.

Verify calibration every 10 samples and at the end of the run using the instrument check standard and calibration blank. The check standard should agree within 10% of the actual value. The blank must be less than the EQL. If they do not, the analysis will be terminated and the problem corrected followed by calibration and reanalysis.

DATA TREATMENT:

For determination of metal concentration by ICP, read the metal value in mg/L from the read-out system of the instrument.

If dilution of sample was required:

$$\text{mg/L metal in sample} = A \times \frac{(C + B)}{C}$$

where,

A = mg/L of metal in diluted aliquot from calibration curve
B = Acid blank matrix used for dilution, mL
C = Sample aliquot, mL

For non-aqueous samples, report all concentrations as mg/Kg, hence:

$$\text{mg metal/kg sample} = \frac{A \times V}{W}$$

where,

A = mg/L of metal in processed sample from instrument read out
V = final volume of processed sample, mL
W = weight of sample, g

The relative percent difference is to calculated as follows:

$$RPD = \frac{D_1 - D_2}{(D_1 + D_2)/2} \times 100$$

RPD = Relative Percent Difference
D_1 = First Sample Value
D_2 = Second Sample Value (replicate or duplicate)

The spike recovery is to be calculated as follows:

$$\% R = \frac{SS - S}{SA} \times 100$$

% R = Percent Recovered
SS = Spike Sample Value
S = Sample Value
SA = Spike Added

DATA DELIVERABLES:

Reports to client will include:

- Date of receipt
- Date of preparation
- Date of analysis
- Analyst
- Matrix
- Laboratory ID#
- Client ID#
- Analytical method #
- Concentrations Determined and resulting EQL's
- ICV, CCV Summary form
- ICB, CCB, Prep Blank Summary form
- ICP Interference Check Sample Summary form
- Spike Sample Recovery form
- Duplicate Sample Summary form
- Laboratory Control Sample Summary form
- All Raw Data
- Preparation Records

Standard Operating Procedure For Mercury Analysis and Digestion of Aqueous and Leachable Samples

Prepared For SIMALABS International
Metals, Metals Laboratory

SW-846, 3rd Edition, Method 7470

Revision # 4.0
Issued: March 5, 1999

Immediate Supervisor	3/8/99 Date
Second Supervisor	3/8/99 Date
QA/QC Officer	3/8/99 Date
Analyst	3/8/99 Date

Effective: March 5, 1999

CAUTION

Disclaimer: This Standard Operating Procedure has been prepared for the sole use of SIMALABS International and may not be specifically applicable to the activities of other organizations.

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STANDARD OPERATING PROCEDURE
MERCURY ANALYSIS AND DIGESTION OF AQUEOUS AND LEACHABLE SAMPLES

LOCATION:

Metals, Main Laboratory

REFERENCE:

SW-846, 3rd Edition, method 7470

MATRIX:

Water, Leachable

DETECTION LIMITS:

EQL = 0.20 ug/L, MDL = .14 ug/L

RANGE:

0.2 ug/L to 10.0 ug/L prior to sample dilution

PRINCIPLE, SCOPE AND APPLICATION:

This method is a cold-vapor atomic absorption procedure approved for determining the concentration of organic and inorganic mercury in water and leachate samples. All samples will be subjected to appropriate dissolution procedures prior to analysis. This SOP contains procedures for both preparation and analysis.

This cold-vapor atomic absorption technique is based on the absorption of radiation at 253.7 nm by mercury vapor. Mercury is reduced to its elemental

state and aerated from solution in a closed system. The mercury vapor passes through a cell positioned in the light path of an atomic absorption spectrophotometer. Absorbance (peak height) is measured as a function of mercury concentration.

INTERFERENCES AND CORRECTIVE ACTION:

Potassium permanganate is added to eliminate possible interference from sulfide. Concentrations as high as 20 mg/L of sulfide as sodium sulfide do not interfere with the recovery of mercury in the sample.

Copper has also been reported to create interferences. But, copper concentrations as high as 10 mg/L have no effect on the recovery of mercury from spiked samples.

Seawaters, brines, and industrial discharges high in chlorides require additional permanganate (as much as 25 ml) because, during the oxidation step, chlorides are converted to free chlorine, which also absorbs radiation of 253.7 nm. Care must therefor be taken to ensure that free chlorine is absent before the mercury is reduced and introduced into the cell. This may be accomplished by using excess hydroxylamine hydrochloride reagent.

SAFETY PRECAUTIONS:

Wear lab coat, safety glasses, and gloves. All work involving heated digestates must be conducted under a fume hood. The exit hose to the cold-vapor apparatus must be vented to an exhaust hood.

SAMPLE SIZE, COLLECTION, PRESERVATION AND HANDLING:

Samples should be collected in 500ml plastic containers, with Teflon lined lids. The sample should be preserved immediately upon collection by the addition of nitric acid to lower the pH to < 2. Samples must be analyzed within 28 days of collection.

APPARATUS:

1) 250 ml erlenmeyer flasks

2) 25, 50, 100, & 250 ml Class A graduated cylinders

3) Hot-plate capable of maintaining 90 to 95°C

4) Atomic absorption spectrophotometer: The atomic absorption spectrophotometer unit contains an open presentation area suitable for mounting the absorption cell. Manufacturer recommended instrument settings are followed.

5) Mercury hollow cathode lamp

6) Air Pump: A peristaltic pump capable of delivering 1 liter air/min is used.

7) Aeration tubing: A straight glass frit with coarse porosity is used. Tygon tubing is used to pass the vapor from the sample bottle to the absorption cell.

Due to mercury vapor toxicity, a bypass is included to vent the mercury vapor to an exhaust hood.

8) 10.0, 100, 500, & 1000 mL Class A volumetric flasks

9) 1.00, 5.00, & 10.0 Class A volumetric pipets

10) 10 mL serological pipets

11) 1-5 mL auto pipet

12) 5-10 mL auto pipet

ROUTINE MAINTENANCE:

The gas/liquid phase separator will be cleaned by sonication monthly. Optics will be cleaned twice weekly, and all tubing will be replaced as needed. The Vapor Generation Assembly will be leak checked on a quarterly basis.

REAGENTS:

1) Type II deionized water

2) Nitric acid (conc.) trace metals grade (Fisher, A509-212)

3) Hydrochloric acid (conc.) trace metals grade (Fisher, A300S-212)

4) Sulfuric acid (conc.) trace metals grade (Fisher)

5) Stannous chloride solution: 62.5 g stannous chloride (Fisher, CR ACS, 500 g)and 50 ml concentrated HCl are mixed until the stannous chloride dissolves completely. After the stannous chloride is totally dissolved, add 200 ml DI water and mix well.

6) Sodium chloride-hydroxylamine hydrochloride solution: Dissolve 12.0 g sodium chloride (Fisher, S271-1) and 12.0 g hydroxylamine hydrochloride (Fisher, H330-500) in DI water and dilute to a final volume of 100 ml.

7) 10.0 ppm Stock Mercury Solution (2% HNO_3): Dilute 1,000 ppm mercury standard (Spex, PLHG4-24) 1:99 in reagent water and 2.00 mL of HNO_3 using a 1.00 mL Class A volumetric pipet, 10.0 mL volumetric pipet, and a Class A 100 mL volumetric flask.

8) Mercury Spike: Dilute 10 ppm stock mercury solution 1:9 in reagent water using a 1.00 mL Class A volumetric pipet and a Class A 10.0 mL volumetric flask.

9) Potassium persulfate (5% w/v): Dissolve 50.0 g of potassium persulfate (Fisher, P282-500) in 1 L of reagent water using a 1 L Class A volumetric flask.

10) Potassium permanganate 5% w/v solution: Dissolve 50.0 g of potassium permanganate (Fisher, P279-500) in 1 L of reagent water using a 1 L Class A volumetric flask.

11) 1.00 ppm ICV/CCV stock mercury solution (2% HNO_3): Dilute 20 ppm mercury standard (Inorganic Ventures, TCLP-AA-Hg) 1:19 in reagent water and 2.00 mL of HNO_3 using a 1.00 mL Class A volumetric pipet, 10.0 mL volumetric pipet and a 100 mL volumetric flask.

12) Mercury working ICV/CCV solution: Dilute ICV/CCV stock mercury solution 1:99 in reagent water using a 5.00 mL Class A volumetric pipet and a 500 mL Class A volumetric flask.

13) Mercury Working Calibration Solution: Dilute 10.0 ppm Stock Mercury Solution 1:499 in reagent water using a 1.00 mL Class A Volumetric pipet and a 500 mL Class A volumetric flask.

CALIBRATION PROCEDURE:

A curve consisting of 4 standards and a blank is analyzed with every run. The curve preparation procedures are given below. The curve is plotted by the computer, and is used for calculation of unknowns. The curve must demonstrate a correlation coefficient of $\geq$ 0.995 to be valid. Following successful analysis of a calibration curve, an ICV and ICB are analyzed. The ICV must recover within 20 % of its true value, and the ICB must demonstrate no contamination above the EQL. After every 10 analyses, and at the close of a run, a CCV and CCB are analyzed. The CCV and CCB must pass the same criterion as the ICV and ICB for analysis to proceed.

SAMPLE PREPARATION:

1) Transfer 100 ml, or an aliquot of sample diluted to 100ml, to a 250 ml erlenmeyer flask. Add 1.00 mL of mercury spike to LCS and spike sample using a 1.00 mL volumetric pipet.

2) Add 5 ml of sulfuric acid and 2.5 ml concentrated nitric acid, mixing after each addition.

3) Add 15 ml potassium permanganate solution. Add additional permanganate solution until the purple color persists for at least 15 minutes. Add equivalent amounts of the permanganate solution to standards and blanks.

4) Add 8 ml of potassium persulfate solution and heat for 2 hours in a water bath maintained at 95 °C.

5) Cool and add 6 ml of sodium chloride-hydroxylamine hydrochloride solution to reduce any excess permanganate.

6) Dilute to 150 ml using a Class A 250 mL graduated cylinder.

STANDARD PREPARATION:

1) Transfer 0, 1.0, 5.0, 25.0, and 50.0 ml aliquots of the mercury working standard using a Class A 1.00 mL volumetric flask, and 5.00, 25.0, and 100 mL graduated cylinders, to 250 ml erlenmeyer flasks. Transfer 0 and 50.0 mL aliquots of the ICV/CCV working solution to 250 mL erlenmeyer flasks.

2) Add enough reagent water to each bottle to make a final volume of 100ml.

3) Mix thoroughly, add 5 ml conc. sulfuric acid, and 2.5 ml conc. nitric acid to each bottle using 1-5 and 5-10 mL auto pipets and heat for 2 minutes in the water bath.

4) Add 15 ml of permanganate solution using 5-10 mL auto pipets, or an equivalent volume as used above, to each bottle.

5) Add 8 ml potassium persulfate solution to each bottle using 5-10 auto pipets and heat for 2 hours in a water bath maintained at 95°C.

6) Cool and add 6 ml of sodium chloride-hydroxylamine hydrochloride solution to reduce excess permanganate using 5-10 mL auto pipets.

7) Dilute to 150 ml in a 250 mL Class A graduated cylinder.

ANALYSIS PROCEDURE:

1) Turn on fume hood, instrument, and printer. Press index button and go to 10(Sequence selection). Press clear sequence, and type 26 (Hg program). Press sequence control, then report format. Change date and batch no. then press sample labels, optimization.

2) Optimization: Place mercury lamp in correct position. Set slit width to 5 nm, wavelength to 253.7 nm, and attenuation to out position.

3) Place vapor generation accessory in position, and connect waste tube. Place absorption cell and mounting unit on burner. Connect absorption cell to gas/liquid phase separator with black fluoro-elastomer tubing.

4) Adjust height of cell using vertical adjustment knob until the lamp peak signal is reached(i.e. the optimization line is at its right most position).

5) Adjust horizontal position of cell using the horizontal adjustment knob until lamp peak signal is reached.

6) Adjust the angle of the cell using the arm on the burner, until the lamp peak signal is reached.

7) Adjust the wavelength by turning the wavelength dial until peak signal is reached.

8) Adjust lamp direction by turning the two knobs at the left of the Hg lamp until peak signal is reached.

Note: If the signal reaches the right most point, hit the rescale button, which sets the present setting to the middle of the range.

9) Fill the appropriate containers with stannous chloride solution, rinse water (2 % nitric acid), and DI water.

10) Reagent and sample tubing setup: Place the stannous chloride pump tube into the upper slot and pass the tube over the pump rollers. Stretch the tube and insert the bottom connector into the lower slot. **Be careful not to twist tubing**. Do the same for the DI water and sample pump tubes.

11) Swing the rear tube bed against the stannous chloride and DI water pump tubes. Swing the front tube bed against the sample tube.

12) Turn on the argon gas supply, and the Vapor Generation Accessory(VGA). Place the three tubes in the rinse water.

13) Close the pressure bar on the tube beds and adjust the pressure control screws. Slowly tighten them until rinse water begins to flow through the tubes. Tighten an additional 1/2 turn to obtain optimum flow rate of 6.5 ml/min. for the sample tube, and 1.2 ml/minute for the other tubes. Place the tubes in their respective containers, and let the solutions flow through the system.

14) Place the sample tube in the calibration blank and wait at least one minute. Press optimize signal, followed by instrument zero, then press start and return sample tube to rinse water.

15) Begin the sample run by inserting the sample tube in the calibration blank and pressing read. Place the sample tube in rinse water between each analysis.

Insert the sample tube in each solution as prompted by the computer and press read. Repeat this process until all standards and samples are analyzed.

16) Press stop at the conclusion of the run.

17) Remove tubes and place in rinse water, and flush the system for 2 to 3 minutes. Place the tubes in DI water for an additional 2 minute rinse.

18) Turn off the instrument, VGA, and argon gas supply.

QUALITY CONTROL:

For each batch of digestions, not to exceed 20, a preparation blank, laboratory control standard, duplicate, and spike will be prepared.

A check blank will be conducted on each new lot of acids prior to use, to verify purity.

DATA TREATMENT:

For determination of the mercury concentration by cold-vapor atomic absorption, read the metal concentration in ug/L from the computer print-out. The computer calculates the concentration against the calibration curve.

The final mercury concentration is determined by,

ug/L Mercury = (C * 100/IV) * DF

where,

C = Concentration from curve, ug/L
IV = Initial volume digested, ml
DF = Dilution factor

DATA DELIVERABLES:

The analytical data package will consist of:

A Level I report including;

- Date of sample receipt
- Date of preparation
- Date of analysis
- Analyst
- Matrix
- Laboratory ID #
- Client ID #
- Analytical method number
- Concentrations and EQL's determined

A Level III report including;

- ICV, CCV Summary form
- ICB, CCB, Prep Blank Summary form
- Spike Sample Recovery form
- Duplicate Sample Summary form
- Laboratory Control Sample Summary form
- All Raw Data
- Complete preparation records

Client:	SIMALABS International
SOP ID:	SOP-WET-3502-1
Rev. Number:	4.1
Rev. Date:	6 Feb 1999

Standard Operating Procedure For Ammonia For Aqueous Samples

Prepared For SIMALABS International
Wet Chemistry, Main Laboratory

QuikChem Method 10-107-06-1-A
EPA 600/4-79-020, Method 350.2

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Analyst	3/8/99 Date

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CAUTION

<u>Disclaimer:</u> This Standard Operating Procedure has been prepared for the sole use of SimaLabs International and may not be specifically applicable to the activities of other organizations.

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Standard Operating Procedure For Graphite Furnace Atomic Absorption Analysis of Lead For Aqueous Samples

Prepared For SIMALABS International
Metals, Metals Laboratory

SW-846, 3rd Edition, Method 7421

Revision # 2.0
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CAUTION

<u>Disclaimer:</u> This Standard Operating Procedure has been prepared for the sole use of SIMALABS International and may not be specifically applicable to the activities of other organizations.

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STANDARD OPERATING PROCEDURE
GRAPHITE FURNACE ATOMIC ABSORPTION ANALYSIS OF LEAD FOR AQUEOUS SAMPLES

LOCATION:

Metals, Metals Laboratory

REFERENCE:

SW-846, 3rd Edition, Method 7421

MATRIX:

Water, Leachate

DETECTION LIMITS:

EQL = 5.0 ug/ L; MDL = 0.499 ug/ L

RANGE:

5.0 ug L to 50 ug L without dilution

PRINCIPLE, SCOPE AND APPLICATION:

Lead in solution may be readily determined by graphite furnace atomic absorption spectroscopy. The method is simple, rapid, and applicable to a variety of matrices. Samples for totals analysis require digestion prior to analysis.

Detection limits, sensitivity, and optimum ranges of the metals will vary with the mati<rices and models of atomic absorption spectrophotometers. When using

furnace techniques the analyst should be cautioned as to possible chemical reactions occurring at elevated temperatures which may result in either suppression or enhancement of the analysis element. To ensure valid data with furnace techniques, the analyst must examine each matrix for interference effects.
When using the furnace technique in conjunction with an atomic absorption spectrophotometer, a reqresentative aliquot of a sample is placed in the graphite tube in the furnace, evaporated to dryness, charred, and atomized. Radiation from a given excited element is passed through the vapor containing ground-state atoms of that element. The metal atoms to be measured are placed in the beam of radiation by increasing the temperature of the furnace, thereby causing the injected speciment to be volatilized. A monochromator isolates the dishcarge lamp, and a photosensitive device measures the attenuated transmitted radation.

INTERFERENCES AND CORRECTIVE ACTION:

Although the problem of oxide formation is greatly reduced with furnace procedures because atomization occurs in an inert atmosphere, the technique is still subject to chemical interferences. The composition of the sample matrix can have a major effect on the analysis. It is those effects which must be determined and taken into consideration in the analysis of each different matrix encountered. To help verify the absence of matrix or chemical interference, the serial dilution technique may be used. Those samples which indicate the presence of interference should be treated in one or more of the following ways:

1) Successively dilute and reanalyze the samples to eliminate interferences.

2) Analyze the sample by method of standard addditions while noticing the precautions and limitations of its use.

Gasas generated in the furnace during atomization may have molecular absorption bands encompassing the analytical wavelength. Background correction may also compensate for nonspecific broad-bank absorption interference.

Continuous background correction cannot correct for all types of background interference. When the background interference cannot be compensated for, chemically remove the analyte or use an alternate form of background correction, e.g. Zeeman background correction.

Interference from a smoke-producing sample matrix can sometines be reduced by extending the charring time at a higher temperature or utilizing an ashing cycle in the presence of air. Care must be taken, however, to prevent loss of the analyte.

Samples containing large amounts of organic materials should be oxidized by conventional acid digestion before being placed in the furnace. In this way, broad-band absorption will be minimized.

Anion interference studies in the graphite furnace indicate that, under conditions other than isothermal, the nitrate anion is preferred. Therefore, nitric acid is preferable for any digestion or solubilzation step. If another acid in addition to HNO3 is required, minimum amount should be used. This applies particularly to hydrochloric and to a lesser extent to sulfuric and phosphoric acids.

Cross-contamination and contamination of the sample can be a major source of error. The sample preparation work area should be kept scrupulously clean. Pipet tips are a frequent source of contamination. If contamination is suspected , the tips should be soaked with 1:5 nitric acid and rinsed thoroughly with DI water.

SAFETY PRECAUTIONS:

Lab coats and safety goggles are to be worn while working with samples, especially during degestion procedures. All instrument vapors are to be vented to the exterior of the building, and all digestion are to occur under a fume hood. CAUTION: Lead isextremely toxic! Handle with care. Refer to MSDS for any inquiries about reagents or chemicals used in this test.

SAMPLE SIZE, COLLECTION, PRESERVATION AND HANDLING:

Aqueous and leachate samples are to be collected in 500 mL plastic containers with teflon lined lids, and preserved to pH $\leq$ 2 with nitric acid. Samples should be labeled as being preserved. Samples must be analyzed within 6 months of collection. Samples will be rejected if container is cracked or broken, at which time the immediate supervisor will be notified.

APPARATUS:

1) Varian SpectrAA 400 with double beam, grating monochromator, photomultiplier detector, adjustable slits, wavelength range of 190 to 800 nm, Zeeman background correction, and interfaced with an IBM computer and dot matrix printer.

2) Zeeman Graphte Tube Atomizer provides power to furnace and spectrophotometer. Allows use of two gasses, and requires cooling water. Provides temperature range of 40 - 3000 C and heating times of 0 - 500 seconds. Provides gas control between 0 and 3.1 L/ min.

3) Autosampler with capability of running 45 samples including check standards. Dispenses volumes from 1 to 40 uL.

4) IBM PS/2 Model 30 computer, controls operation of spectrophotometer and provides data manipulation and reporting of samples calculaitons.

5) Citizen dot matrix printer, prints calibration and sample results.

6) Class A volumetric flasks

8) Pipets: Microliter, with disposable tips. Sizes can range from 5 to 100 uL as required. Pipet tips should be checked as a possible source of contamination prior to their use.

9) Class A volumetric pipets

10) Analytical balance

11) Disposable glass serological pipets

ROUTINE MAINTENANCE:

Gasses are checked daily to insure adequate pressure. The autosampler parts are checked daily. Frunace optics are cleaned twice weekly. Plumbing connections, and the furnace are checked as needed. Electrodes are changed as needed. Graphite tube is changed as needed.

REAGENTS AND CALIBRATION STANDARDS:

1) Deionized water - Type II

2) Nitric Acid - concentrated, trace metals grade (Fisher, AS09-212)

3) Furnace Stock Calibration Standard: Using a Class A volumetric pipet, dilute 2.0 mL lead stock (Spex, PLB2-2y), and 4.0 mL concentrated nitric acid, to 200 mL with DI water in a volumetric flask. This will result in a final concentration of 10 ppm lead. Dilute stock calibration standard 1:99 with DI water for daily calibration.

4) Furnace ICV/CCV Solutions: Using a 100 uL micropipet and a 10 mL disposable glass serological pipet, transfer 0.10 mL QC-19 stock (Spex, QC-19, 100 ppm) and 2.0 mL concentrated nitric acid to a 100 mL Class A volumetric flask. Bring to volume. This will result in a 100 ppb final concentration. Dilute 1:1 for a working concentration of 50 ppb.

5) Lead Modifier: Using a Class A volumetric pipet, transfer 1.00 mL phosphoric acid into a Class A volumetric flask, partially filled with DI water. Bring to volume.

CALIBRATION PROCEDURES:

A curve consisting of 5 standards and a blank is analyzed at the beginning of each run The curve must demonstrate a correlation coefficient of $\geq$0.995 to be valid. An ICV followed by an ICB are analyzed prior to sample anlaysis. the ICV must recover within 20 % of true value, and the ICB must show results less than the EQL. After every 10 samples, and at the conclusion of the run, a CCV and CCB are analyzed. The CCB and CCV must meet the above stated criteria for the ICV and ICB.

SAMPLE PREPARATION:

Aqueous: See SOP-MET-3020-1

ANALYSIS PROCEDURE:

1) Turn on monitor, computer, Spectra AA 400, Zeeman, Graphic Tube Atomizer,

T & A cooling unit, hood printer, Argon gas at its source. Press F10 (index) on computer keyboard. Type 10, press F6 (new page) press F1 (clear sequence).

Type the number of the program to be run. Press F6, the program is loaded and the correct lamp is automatically moved into position.

2) Swing toggle lever clockwise to release the furnace right hand housing. Clean furnace housing using a cotton swab and isopropyl rubbing alcohol. Clean a graphite tube and its plateform using a Kimwipe. Position graphite platform inside the plateau tubes so that it is perpendicular to the sample injection hole of the tube. Place the graphite tube in the furnace housing being careful to align the sample introduction hole in the graphite tube to the center of the furnace dhimney. Swing the toggle lever counter-clockwise in order to close the righthand housing onto the tube now positioned inside the furnace housing.

3) Remove rinse bottle and fill to the line with DI H2O. Clean the blank, modifier, and standard cups with DI H2O and 1:1 nitric acid. Fill and place these cups in their labeled positions on the autosampler tray.

4) Press F10 (index). Type 8 and press F6 (new page). Press F2 (align sampler) twice. The sampleing arm will move from its rinse position to the sample 1 position and then to the sample introductrion hole in the graphite tube. Adjust the position of the auto sampler capillary tube inside the hole in the graphite tube so that it is in the center of this hole. use the backwards and forward adjuster along with the sideways adjuster to accomplish the correct positioning.

5) Open syringe compartment door. Put the syringe clear of its mounting and remove the plunger from the syringe. While holding a tissue beneath the syringe press F3 (rinse). Liquid will emerge along with any air bubbles present in the line. Press F3 (rinse) again, and while solution is dripping from the syringe, carefully insert the plunger into the syringe. Reinsert the syringe assembly into its housing and close the compartment door.

6) Press F10 (index). Type 18 and Press F6 (new page). Press F4 (tube clean).
The furnace will heat and clean the graphite tube. Press shift and F11 (start GTA). A trial start will begin. Watch the sampler to ensure it pulls up blank and modifier solution into the capillary and is properly injected onto the plateform inside the graphite tube. Swing the mirror assembly counter-clockwise to force it
in the path of the UV light and thus putting in view the position of the capillary while inside the graphic tube. Ensure that the droplet is placed correctly in the tube. Allow the temperature program to go to completion and note the anlaytical
signal.

7) Press F10 (index). Type 6 and then F6 (new page). Open the Spectra 400 lamp cover and by turning the two knmobs on the left-hand side of the appropriate
lamp adjust the angle until the lamp peak wavelength has been found (i.e. the optimization line is at its furthest most position from the left-hand baseline). Note:
pressing F1 (rescale) allows the wavelength line that may reach a maximum at the right hand edge of the screen to rescale at a point near the middle of the screen. Once the lamp has sufficiently warmed (approximately 20 minutes from the time of the program) the run can be started.

8) Pour samples to be analyzed into sample cups and place them into the autosampler tray. Record position of samples in tray on sample run list log. Pour
check standards into sample cups and place them in their proper positions in the
autosampler tray. Press F10 (index). Type 15 and press F6 (new page). Press F11 (start) to begin sample run.

Specific settings for lead:

Lead: Program #4, Matrix Modifier - Lead Modifier
Standard 1 = 5.00 ppb, 2 = 10.0 ppb, 3 = 25.0 ppb, 4 = 50.0 ppb, 5 = 99.00 ppb
ICV = 50.0 ppb, CCV = 50.0 ppb

QUALITY CONTROL:

All quality control data should be maintained and available for easy reference or inspection.

If 10 or more samples per batch are analyzed, the working standard curve must be verified by running an additional standard at or near the mid-range every 10 samples. Checks must be within ± 20% of true value.

At least one preparatory blank, laboratory standard, spike, and duplicate sample should be run every 20 samples, or with each matrix type to verify precision of the method.

Where the sample matrix is so complex the viscosity, surface tension and components cannot be accurately matched with standards, the method of standard addition may be used. (See below).

Method of standard additions

In the simplest version of this method, equal volumes of sample are added to a DI water blank and to a standard. If a higher degree of accuracy is required, more than one addition should be made. The absorbance of each solution is determined and then plotted on the vertical axis of a graph, with the concentrations of the known standards plotted on the horizontal axis. When the resulting line is extrapolated back to zero absorbance, then the point of interception of the abscissa is the concentration of the unknown. The abscissa on the left of the ordinate is sa\caled the same as on the right side, but in the opposite direction from the ordinate.

The method of standard additions can be very useful; however, for the results to be valid the following limitations must be taken into consideration:

1) The absorbance plot of sample and standards must be linear over the concentration range of concern. for best results, the slope of the plost should be nearly the same as the slope of the aqueous standard curve. If the slope is significantly different (more than 20%), caution should be used.

2) The effect of the interference should not vary as the ratio of analyte concentration to sample matrix changesk, and the standard addition should

respond in a similar manner as the anlayte.

3) The determination must be free of spectral interference and corrected for nonspecific background interference.

The simplest version of this technique is the single addition method, in which two identical aliquots of the sample solution, each of Volume V_x are taken. To the first (labeled A) is added a small valume V_s of a standard analyte solution of concentrate c_s. to the second (labeled B) is added the same volume V_s of the solvent. The analytical signals of A and B are measured and corrected for nonanlyte signals. The unknown sample concentration c_x is calculated:

$$c_x = S_b V_s C_s / (S_a - S_b) V_x$$

where,

S_a and S_b are the analytical signals (corrected for the blank) of solutions a and b respectively. V_s and c_s should be chosen so that S_a is roughly twice S_b on the average. It is best if V_s is made much less than V_x and thus c_s is much greater than c_x to avoid excess dilution of the sample matrix. It a searation or concentration step is used, the additions are best made first and carried throught the entire procedure.

DATA TREATMENT:

For determination of metal concentration by direct aspiration and furnace, read the metal value in ug/L from the calibration curve or directly from the read-out system of the instrument.

If dilution of sample was required:

ug/L metal in sample = (A) [(C + B)/C]

where,

A = ug/L of metal in diluted aliquot from calibration curve

B = acid blank matrix used for dilution, mL
C = sample aliquot, mL

DATA DELIVERABLES:

Reports to clients will include:

-Date of receipt
-Date of preparation
-Date of analysis
-Analyst
-Matrix
-Laboratory ID#
-Client ID#
-Analytical method #
-Concentration determined and resulting EQL
-ICV, CCV, summary form
-ICB, CCB, prep blank summary form
-Spike sample recovery form
-Laboratory control sample summary form
-All raw data
-Preparation records

Standard Operating Procedure For Graphite Furnace Atomic Absorption Analysis of Antimony For Aqueous Samples

Prepared For SIMALABS International
Metals, Metals Laboratory

SW-846, 3rd Edition, Method 7041

Revision # 2.0
Issued: March 1, 1996

Immediate Supervisor	3/8/99 Date
Second Supervisor	3/8/99 Date
QA/QC Officer	3/8/99 Date
Analyst	3/8/99 Date

Effective: March 1, 1996

CAUTION

Disclaimer: This Standard Operating Procedure has been prepared for the sole use of SIMALABS International and may not be specifically applicable to the activities of other organizations.

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STANDARD OPERATING PROCEDURE
GRAPHITE FURNACE ATOMIC ABSORPTION ANALYSIS OF ANTIMONY FOR AQUEOUS SAMPLES

LOCATION:

Metals, Metals Laboratory

REFERENCE:

SW-846, 3rd Edition, Method 7041

MATRIX:

Water, Leachates

QUANTITATION LIMIT:

EQL = 50 ug/L; MDL = 11.5 ug/L.

RANGE:

50 ug/L to 200 ug/L without dilution

PRINCIPLE, SCOPE, AND APPLICATION:

Antimony in solution may be readily determined by graphite furnace atomic absorption spectroscopy. The method is simple, rapid, and applicable to a variety of matrices. Samples for totals analysis require digestion prior to analysis.

Detection limits, sensitivity, and optimum ranges of the metals will vary with the matrices and models of atomic absorption spectrophotometers. When using

furnace techniques the analyst should be cautioned as to possible chemical reactions occurring at elevated temperatures which may result in either suppression or enhancement of the analysis element. To ensure valid data with furnace techniques, the analyst must examine each matrix for interference effects.

When using the furnace technique in conjunction with an atomic absorption spectrophotometer, a representative aliquot of a sample is placed in the graphite tube in the furnace, evaporated to dryness, charred, and atomized. Radiation from a given excited element is passed through the vapor containing ground-state atoms of that element. The metal atoms to be measured are placed in the beam of radiation by increasing the temperature of the furnace, thereby causing the injected specimen to be volatilized. A monochromator isolates the discharge lamp, and a photosensitive device measures the attenuated transmitted radiation.

INTERFERENCES AND CORRECTIVE ACTION:

Although the problem of oxide formation is greatly reduced with furnace procedures because atomization occurs in an inert atmosphere, the technique is still subject to chemical interferences. The composition of the sample matrix can have a major effect on the analysis. It is those effects which must be determined and taken into consideration in the analysis of each different matrix encountered. To help verify the absence of matrix or chemical interference, the serial dilution technique may be used. Those samples which indicate the presence of interference should be treated in one or more of the following ways:

(1) Successively dilute and reanalyze the samples to eliminate interferences.

(2) Analyze the sample by method of standard additions while noticing the precautions and limitations of its use.

Gases generated in the furnace during atomization may have molecular absorption bands encompassing the analytical wavelength. Background correction may also compensate for nonspecific broad-bank absorption interference.

Continuous background correction cannot correct for all types of background interference. When the background interference cannot be compensated for,

chemically remove the analyte or use an alternate form of background correction, e.g. Zeeman background correction.

Interference from a smoke-producing sample matrix can sometimes be reduced by extending the charring time at a higher temperature or utilizing an ashing cycle in the presence of air. Care must be taken, however, to prevent loss of the analyte.

Samples containing large amounts of organic materials should be oxidized by conventional acid digestion before being placed in the furnace. In this way, broad-band absorption will be minimized.

Anion interference studies in the graphite furnace indicate that, under conditions other than isothermal, the nitrate anion is preferred. Therefore, nitric acid is preferable for any digestion or solubilzation step. If another acid in addition to HNO_3 is required, minimum amount should be used. This applies particularly to hydrochloric and to a lesser extent to sulfuric and phosphoric acids.

Cross-contamination and contamination of the sample can be a major source of error. The sample preparation work area should be kept scrupulously clean. Pipet tips are a frequent source of contamination. If contamination is suspected, the tips should be soaked with 1:5 nitric acid and rinsed thoroughly with DI water.

SAFETY PRECAUTIONS:

Lab coats and safety goggles are to be worn while working with samples, especially during digestion procedures. All instrument vapors are to be vented to the exterior of the building, and all digestions are to occur under a fume hood.

SAMPLE SIZE, COLLECTION, PRESERVATION AND HANDLING:

Aqueous and leachate samples are to be collected in 500 ml plastic containers with teflon lined lids, preserved to pH $\leq$ 2 with nitric acid, and cooled to 4°C until digestion. Samples must be analyzed within 6 months of collection.

APPARATUS:

1) Varian SpectrAA 400 with double beam, grating monochromator, photomultiplier detector, adjustable slits, wavelength range of 190 to 800 nm, Zeeman background correction, and interfaced with an IBM computer and dot matrix printer.

2) Zeeman Graphite Tube Atomizer provides power to furnace and spectrophotometer. Allows use of two gasses, and requires cooling water. Provides temperature range of 40 - 3000 °C and heating times of 0 - 500 seconds. Provides gas control between 0 and 3.1 L/min.

3) Autosampler with capability of running 45 samples including check standards. Dispenses volumes from 1 to 40 ul.

4) IBM PS/2 Model 30 computer, controls operation of spectrophotometer and provides data manipulation and reporting of sample calculations.

5) Citizen dot matrix printer, prints calibration and sample results.

6) Class A volumetric pipets

7) Class A volumetric flasks

8) Pipets: Microliter, with disposable tips. sizes can range from 5 to 100 uL as required. Pipet tips should be checked as a possible sources of contamination prior to their use.

9) Analytical balance

10) Disposable glass serological pipets

ROUTINE MAINTENANCE:

Gasses are checked daily to insure adequate pressure. The autosampler parts are checked daily. Furnace optics are cleaned twice weekly. Plumbing connections , and the furnace are checked as needed. Electrodes are changed as needed. Graphite tube is changed as needed.

REAGENTS AND CALIBRATION STANDARDS:

1) Deionized water - Type II

2) Nitric Acid - concentrated, trace metals grade (Fisher, AS09-212)

3) Furnace stock calibration standard: Using a Class A volumetric pipet, dilute 1.0 ml Cadmium Stock (Spex, PLSB7-2y, 1000 ppm), and 4.0 ml concentrated nitric acid, to 200 ml with DI water in a volumetric flask. Bring to volume. This will result in a final concentration of 10 ppm Antimony. Dilute stock calibration standard 1:99 with DI water for daily calibration.

4) Furnace ICV/CCV Solutions: Using a 100 uL micropipet and a 10 mL glass serological pipet, transfer 0.10 ml QC-19 Stock (SPEX , QC-19- 100 ppm) and 2.0 ml concentrated nitric acid to a 100 ml Class A volumetric flask partially filled with DI water. Bring to volume. This will result in a 100 ppb final concentration.

5) Antimony Modifier: Using an analytical balance, weigh 3.00 g NH_4NO_3 (Fisher, A684-500) and transfer to a 100 mL Class A volumetric flask. Dilute to 100 ml with DI water in a volumetric flask.

CALIBRATION PROCEDURES:

A curve consisting of 4 standards and a blank is analyzed at the beginning of each run. The curve must demonstrate a correlation coefficient of $\geq$ 0.995 to be valid. An ICV followed by an ICB are analyzed prior to sample analysis. The ICV must recover within 20 % of true value, and the ICB must show results less than the PQL. After every 10 samples, and at the conclusion of the run, a CCV and CCB are analyzed. The CCV and CCB must meet the above stated criteria for the ICV and ICB.

SAMPLE PREPARATION:

Aqueous: See SOP-MET-3020-1

ANALYSIS PROCEDURE:

1.) Turn on monitor, computer, Spectra AA-400, Zeeman, Graphic Tube Atomizer, T & A cooling unit, hood printer, Argon gas at its source. Press

F10 (index) on computer keyboard. Type 10, press F-6 (new page) press F1 (clear sequence). Type the number of the program to be run. Press F6, the program is loaded and the correct lamp is automatically moved into position.

2.) Swing toggle lever clockwise to release the furnace right hand housing. Clean furnace housing using a cotton swap and isopropyl rubbing alcohol. Clean a graphite tube and it's platform using a Kim wipe. Position graphite platform inside the plateau tubes so that it is perpendicular to the sample injection hole of the tube. Place the graphite tube in the furnace housing being careful to align the sample introduction hole in the graphite tube to the center of the furnace chimney. Swing the toggle lever counter-clockwise in order to close the right-hand housing onto the tube now positioned inside the furnace housing.

3.) Remove rinse bottle and fill to the line with DI H_2O. Clean the Blank, Modifier and Standard cups with DI H_2O and 1:1 Nitric acid. Fill and place these cups in their labeled positions on the autosampler tray.

4.) Press F10 (index). Type 8 and press F6 (new page). Press F2 (align sampler) twice. The sampling arm will move from it's rinse position to the sample 1 position and than to the sample introduction hole in the graphite tube. Adjust the position of the auto sampler capillary tube inside the hole in the graphite tube so that it is in the center of this hole. Use the backwards and forward adjuster along with the sideways adjuster to accomplish the correct positioning.

5.) Open syringe compartment door. Put the syringe clear of it's mounting and remove the plunger from the syringe. While holding a tissue beneath the syringe press F3 (rinse). Liquid will emerge along with any air bubbles present in the line. Press F3 (rinse) again, and while solution is dripping from the syringe, carefully insert the plunger into the syringe. Re-insert the syringe assembly into it's housing and close the compartment door.

6.) Press F10 (index). Type 18 and Press F6 (new page). Press F4 (tube clean). The furnace will heat and clean the graphite tube. Press shift and F11 (start GTA). A trial start will begin. Watch the sampler to ensure it pulls up blank and modifier solution into the capillary and is properly injected onto the platform inside the graphite tube. Swing the mirror assembly counter-clockwise to force it in the path of the UV light

and thus putting in view the position of the capillary while inside the graphic tube. Ensure that the droplet is placed correctly in the tube. Allow the temperature program to go to completion and note the analytical signal.

7.) Press F10 (index). Type 6 and then F6 (new page). Open the Spectra 400 lamp cover and by turning the two knobs on the left-hand side of the appropriate lamp adjust the angle until the lamp peak wavelength has been found (i.e. the optimization line is at its furthest most position from the left-hand baseline.) Note: pressing F1 (rescale) allows the wavelength line that may reach a maximum at the right hand edge of the screen to rescale at a point near the middle of the screen. Once the lamp has sufficiently warmed (approximately 20 minutes from the time of the program) the run can be started.

8.) Pour samples to be analyzed into sample cups and place them into the autosampler tray. Record position of samples in tray on sample run list log. Pour check standards into sample cups and place them in their proper positions in the autosampler tray. Press F10 (index). Type 15 and press F6 (new page). Press F11 (start) to begin sample run.

Specific settings for Antimony:

Antimony: Program #8, Matrix Modifier - Antimony Modifier
Standard 1 =50 ppb, 2 = 100 ppb, 3 = 150 ppb, 4 = 200 ppb
ICV = 100 ppb, CCV = 100 ppb

QUALITY CONTROL:

All quality control data should be maintained and available for easy reference or inspection.

If 10 or more samples per batch are analyzed, the working standard curve must be verified by running an additional standard at or near the mid-range every 10 samples. Checks must be within ± 20% of true value.

At least one preparatory blank, laboratory standard, spike and one duplicate sample should be run every 20 samples, or with each matrix type to verify precision of the method.

Where the sample matrix is so complex the viscosity, surface tension and components cannot be accurately matched with standards, the method of standard addition may be used. (See below.)

Method of standard additions:

In the simplest version of this method, equal volumes of sample are added to a DI water blank and to a standard. If a higher degree of accuracy is required, more than one addition should be made. The absorbance of each solution is determined and then plotted on the vertical axis of a graph, with the concentrations of the known standards plotted on the horizontal axis. When the resulting line is extrapolated back to zero absorbance, then the point of interception of the abscissa is the concentration of the unknown. The abscissa on the left of the ordinate is scaled the same as on the right side, but in the opposite direction from the ordinate.

The method of standard additions can be very useful; however, for the results to be valid the following limitations must be taken into consideration:

1) The absorbance plot of sample and standards must be linear over the concentration range of concern. For best results, the slope of the plot should be nearly the same as the slope of the aqueous standard curve. If the slope is significantly different (more than 20%), caution should be exercised.

2) The effect of the interference should not vary as the ratio of analyte concentration to sample matrix changes, and the standard addition should respond in a similar manner as the analyte.

3) The determination must be free of spectral interference and corrected for nonspecific background interference.

The simplest version of this technique is the single-addition method, in which two identical aliquots of the sample solution, each of Volume V_x, are taken. To the first (labeled A) is added a small volume V_s of a standard analyte solution of concentrate c_s. To the second (labeled B) is added the same volume V_s of the solvent. The analytical signals of A and B are measured and corrected for non-analyte signals. The unknown sample concentration c_x is calculated:

$$c_x = \frac{S_B V_S c_S}{(S_A - S_B) V_X}$$

where,

S_A and S_B are the analytical signals (corrected for the blank) of solutions A and B, respectively. V_S and c_s should be chosen so that S_A is roughly twice S_B on the average. It is best if V_S is made much less than V_X, and thus c_s is much greater than c_x, to avoid excess dilution of the sample matrix. If a separation or concentration step is used, the additions are best made first and carried through the entire procedure.

DATA TREATMENT:

For determination of metal concentration by direct aspiration and furnace; read the metal value in ug/L from the calibration curve or directly from the read-out system of the instrument.

If dilution of sample was required:

$$\text{ug/L metal in sample} = A \times \frac{(C + B)}{C}$$

where,

A = ug/L of metal in diluted aliquot from calibration curve

B = Acid blank matrix used for dilution, mL

C = sample aliquot, mL

DATA DELIVERABLES:

Reports to client will include:

- Date of receipt
- Date of preparation
- Date of analysis
- Analyst
- Matrix

- Laboratory ID#
- Client ID#
- Analytical method #
- Concentration Determined and resulting PQL
- ICV, CCV Summary form
- ICB, CCB, Prep Blank Summary form
- Spike Sample Recovery form
- Laboratory Control Sample Summary form
- All Raw Data
- Preparation Records

Client:	SIMALABS International
SOP ID:	SOP-MET-7060-1
Rev. Number:	2.0
Rev. Date:	March 1, 1996

Standard Operating Procedure For Graphite Furnace Atomic Absorption Analysis of Arsenic For Aqueous Samples

Prepared For SIMALABS International
Metals, Metals Laboratory

SW-846, 3rd Edition, Method 7060

Revision # 2.0
Issued: March 1, 1996

Immediate Supervisor	3/8/99 Date
Second Supervisor	3/8/99 Date
QA/QC Officer	3/8/99 Date
Analyst	3/8/99 Date

Effective: March 1, 1996

CAUTION

<u>Disclaimer:</u> This Standard Operating Procedure has been prepared for the sole use of SIMALABS International and may not be specifically applicable to the activities of other organizations.

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STANDARD OPERATING PROCEDURE
GRAPHITE FURNACE ATOMIC ABSORPTION ANALYSIS OF ARSENIC FOR AQUEOUS SAMPLES

LOCATION:

Metals, Metals Laboratory

REFERENCE:

SW-846, 3rd Edition, Method 7060

MATRIX:

Water, Leachate

DETECTION LIMIT:

EQL = 10 ug/L; MDL = 2.6 ug/L

RANGE:

10 ug/L to 100 ug/L without dilution

PRINCIPLE, SCOPE, AND APPLICATION:

Arsenic in solution may be readily determined by graphite furnace atomic absorption spectroscopy. The method is simple, rapid, and applicable to a variety of matrices. Samples for totals analysis require digestion prior to analysis.

Detection limits, sensitivity, and optimum ranges of the metals will vary with the matrices and models of atomic absorption spectrophotometers. When using furnace techniques the analyst should be cautioned as to possible chemical

reactions occurring at elevated temperatures which may result in either suppression or enhancement of the analysis element. To ensure valid data with furnace techniques, the analyst must examine each matrix for interference effects.

When using the furnace technique in conjunction with an atomic absorption spectrophotometer, a representative aliquot of a sample is placed in the graphite tube in the furnace, evaporated to dryness, charred, and atomized. Radiation from a given excited element is passed through the vapor containing ground-state atoms of that element. The metal atoms to be measured are placed in the beam of radiation by increasing the temperature of the furnace, thereby causing the injected specimen to be volatilized. A monochromator isolates the discharge lamp, and a photosensitive device measures the attenuated transmitted radiation.

INTERFERENCES AND CORRECTIVE ACTION:

Although the problem of oxide formation is greatly reduced with furnace procedures because atomization occurs in an inert atmosphere, the technique is still subject to chemical interferences. The composition of the sample matrix can have a major effect on the analysis. It is those effects which must be determined and taken into consideration in the analysis of each different matrix encountered. To help verify the absence of matrix or chemical interference, the serial dilution technique may be used. Those samples which indicate the presence of interference should be treated in one or more of the following ways:

(1) Successively dilute and reanalyze the samples to eliminate interferences.

(2) Analyze the sample by method of standard additions while noticing the precautions and limitations of its use.

Gases generated in the furnace during atomization may have molecular absorption bands encompassing the analytical wavelength. Background correction may also compensate for nonspecific broad-bank absorption interference.

Continuous background correction cannot correct for all types of background interference. When the background interference cannot be compensated for,

chemically remove the analyte or use an alternate form of background correction, e.g. Zeeman background correction.

Interference from a smoke-producing sample matrix can sometimes be reduced by extending the charring time at a higher temperature or utilizing an ashing cycle in the presence of air. Care must be taken, however, to prevent loss of the analyte.

Samples containing large amounts of organic materials should be oxidized by conventional acid digestion before being placed in the furnace. In this way, broad-band absorption will be minimized.

Anion interference studies in the graphite furnace indicate that, under conditions other than isothermal, the nitrate anion is preferred. Therefore, nitric acid is preferable for any digestion or solubilzation step. If another acid in addition to HNO_3 is required, minimum amount should be used. This applies particularly to hydrochloric and to a lesser extent to sulfuric and phosphoric acids.

Cross-contamination and contamination of the sample can be a major source of error. The sample preparation work area should be kept scrupulously clean. Pipet tips are a frequent source of contamination. If contamination is suspected, the tips should be soaked with 1:5 nitric acid and rinsed thoroughly with DI water.

SAFETY PRECAUTIONS:

Lab coats and safety goggles are to be worn while working with samples, especially during digestion procedures. All instrument vapors are to be vented to the exterior of the building, and all digestions are to occur under a fume hood.

SAMPLE SIZE, COLLECTION, PRESERVATION AND HANDLING:

Aqueous and leachate samples are to be collected in 500 ml plastic containers with teflon lined lids, and preserved to pH $\leq$ 2 with nitric acid, and cooled to 4°C until digestion. Samples must be analyzed within 6 months of collection.

APPARATUS:

1) Varian SpectrAA 400 with double beam, grating monochromator, photomultiplier detector, adjustable slits, wavelength range of 190 to 800 nm, Zeeman background correction, and interfaced with an IBM computer and dot matrix printer.

2) Zeeman Graphite Tube Atomizer provides power to furnace and spectrophotometer. Allows use of two gasses, and requires cooling water. Provides temperature range of 40 - 3000 °C and heating times of 0 - 500 seconds. Provides gas control between 0 and 3.1 L/min.

3) Autosampler with capability of running 45 samples including check standards. Dispenses volumes from 1 to 40 ul.

4) IBM PS/2 Model 30 computer, controls operation of spectrophotometer and provides data manipulation and reporting of sample calculations.

5) Citizen dot matrix printer, prints calibration and sample results.

6) Class A volumetric pipets

7) Class A volumetric flasks

8) Pipets: Microliter, with disposable tips. sizes can range from 5 to 100 uL as required. Pipet tips should be checked as a possible sources of contamination prior to their use.

9) Analytical balance

10) Disposable galss serological pipets

ROUTINE MAINTENANCE:

Gasses are checked daily to insure adequate pressure. The autosampler parts are checked daily. Furnace optics are cleaned twice weekly. Plumbing connections , and the furnace are checked as needed. Electrodes are changed as needed. Graphite tube is changed as needed.

REAGENTS AND CALIBRATION STANDARDS:

1) Deionized water - Type II

2) Nitric Acid - concentrated, trace metals grade (Fisher, AS09-212)

3) Furnace stock calibration standard: Using a Class A volumetric pipet, dilute 2.0 ml Arsenic Stock (Spex, PLAS2-2y), and 4.0 ml concentrated nitric acid, to 200 ml with DI water in a Class A volumetric flask. This will result in a final concentration of 10 ppm Arsenic. Dilute stock calibration standard 1:99 with DI water for daily calibration.

4) Furnace ICV/CCV Solutions: Using a 100 uL micropipet and a 10 mL glass serological pipet, transfer 0.10 ml QC-19 Stock (SPEX, QC-19, 100 ppm) and 2.0 mL concentrated nitric acid to a100 ml Class A volumetric flask partially filled with DI water. Bring to volume. This will result in a 100 ppb final concentration. Dilute 1:1 for a working concentration of 50 ppb.

5) Nickel Nitrate Modifier: Using an analytical balance, weigh 0.4950 g $Ni(NO_3)*6H_2O$ (Malinckrodt, UN2725). Using a 10 mL glass disposable serological pipet, transfer 5.0 ml concentrated nitric acid into a Class A volumetric flask partially filled with DI water. Transfer weighed $Ni(NO_3)*6\ H_2O$ into the flask. Bring to volume and mix until dissolved.

CALIBRATION PROCEDURES:

A curve consisting of 4 standards and a blank is analyzed at the beginning of each run. The curve must demonstrate a correlation coefficient of $\geq$ 0.995 to be valid. An ICV followed by an ICB are analyzed prior to sample analysis. The ICV must recover within 20 % of true value, and the ICB must show results less than the EQL. After every 10 samples, and at the conclusion of the run, a CCV and CCB are analyzed. The CCV and CCB must meet the above stated criteria for the ICV and ICB.

SAMPLE PREPARATION:

Aqueous: See SOP-MET-3020-1

ANALYSIS PROCEDURE:

1.) Turn on monitor, computer, Spectra AA-400, Zeeman, Graphic Tube Atomizer, T & A cooling unit, hood printer, Argon gas at its source. Press F10 (index) on computer keyboard. Type 10, press F-6 (new page) press F1 (clear sequence). Type the number of the program to be run. Press F6, the program is loaded and the correct lamp is automatically moved into position.

2.) Swing toggle lever clockwise to release the furnace right hand housing. Clean furnace housing using a cotton swap and isopropyl rubbing alcohol. Clean a graphite tube and it's platform using a Kim wipe. Position graphite platform inside the plateau tubes so that it is perpendicular to the sample injection hole of the tube. Place the graphite tube in the furnace housing being careful to align the sample introduction hole in the graphite tube to the center of the furnace chimney. Swing the toggle lever counter-clockwise in order to close the right-hand housing onto the tube now positioned inside the furnace housing.

3.) Remove rinse bottle and fill to the line with DI H_2O. Clean the Blank, Modifier and Standard cups with DI H_2O and 1:1 Nitric acid. Fill and place these cups in their labeled positions on the autosampler tray.

4.) Press F10 (index). Type 8 and press F6 (new page). Press F2 (align sampler) twice. The sampling arm will move from it's rinse position to the sample 1 position and than to the sample introduction hole in the graphite tube. Adjust the position of the auto sampler capillary tube inside the hole in the graphite tube so that it is in the center of this hole. Use the backwards and forward adjuster along with the sideways adjuster to accomplish the correct positioning.

5.) Open syringe compartment door. Put the syringe clear of it's mounting and remove the plunger from the syringe. While holding a tissue beneath the syringe press F3 (rinse). Liquid will emerge along with any air bubbles present in the line. Press F3 (rinse) again, and while solution is dripping from the syringe, carefully insert the plunger into the syringe. Re-insert the syringe assembly into it's housing and close the compartment door.

6.) Press F10 (index). Type 18 and Press F6 (new page). Press F4 (tube clean). The furnace will heat and clean the graphite tube. Press shift and F11 (start GTA). A trial start will begin. Watch the sampler to ensure it pulls up blank and modifier solution into the capillary and is

properly injected onto the platform inside the graphite tube. Swing the mirror assembly counter-clockwise to force it in the path of the UV light and thus putting in view the position of the capillary while inside the graphic tube. Ensure that the droplet is placed correctly in the tube. Allow the temperature program to go to completion and note the analytical signal.

7.) Press F10 (index). Type 6 and then F6 (new page). Open the Spectra 400 lamp cover and by turning the two knobs on the left-hand side of the appropriate lamp adjust the angle until the lamp peak wavelength has been found (i.e. the optimization line is at its furthest most position from the left-hand baseline.) Note: pressing F1 (rescale) allows the wavelength line that may reach a maximum at the right hand edge of the screen to rescale at a point near the middle of the screen. Once the lamp has sufficiently warmed (approximately 20 minutes from the time of the program) the run can be started.

8.) Pour samples to be analyzed into sample cups and place them into the autosampler tray. Record position of samples in tray on sample run list log. Pour check standards into sample cups and place them in their proper positions in the autosampler tray. Press F10 (index). Type 15 and press F6 (new page). Press F11 (start) to begin sample run.

Specific settings for Arsenic:

Arsenic: Program #2, Matrix Modifier - Nickel Nitrate
Standard 1 = 10ppb, 2 = 25ppb, 3 = 50ppb, 4 = 100ppb
ICV = 50ppb, CCV = 50ppb

QUALITY CONTROL:

All quality control data should be maintained and available for easy reference or inspection.

If 10 or more samples per batch are analyzed, the working standard curve must be verified by running an additional standard at or near the mid-range every 10 samples. Checks must be within ± 20% of true value.

At least one preparatory blank, laboratory standard, spike and duplicate sample should be run every 20 samples, or with each matrix type to verify precision of the method.

Where the sample matrix is so complex the viscosity, surface tension and components cannot be accurately matched with standards, the method of standard addition may be used. (See below.)

Method of standard additions:

In the simplest version of this method, equal volumes of sample are added to a DI water blank and to a standard. If a higher degree of accuracy is required, more than one addition should be made. The absorbance of each solution is determined and then plotted on the vertical axis of a graph, with the concentrations of the known standards plotted on the horizontal axis. When the resulting line is extrapolated back to zero absorbance, then the point of interception of the abscissa is the concentration of the unknown. The abscissa on the left of the ordinate is scaled the same as on the right side, but in the opposite direction from the ordinate.

The method of standard additions can be very useful; however, for the results to be valid the following limitations must be taken into consideration:

(a) The absorbance plot of sample and standards must be linear over the concentration range of concern. For best results, the slope of the plot should be nearly the same as the slope of the aqueous standard curve. If the slope is significantly different (more than 20%), caution should be exercised.

(b) The effect of the interference should not vary as the ratio of analyte concentration to sample matrix changes, and the standard addition should respond in a similar manner as the analyte.

(c) The determination must be free of spectral interference and corrected for nonspecific background interference.

The simplest version of this technique is the single-addition method, in which two identical aliquots of the sample solution, each of Volume V_x, are taken. To the first (labeled A) is added a small volume V_s of a standard analyte solution of concentrate c_s. To the second (labeled B) is added the same volume V_s of the solvent. The analytical signals of A and B are measured and corrected for non-analyte signals. The unknown sample concentration c_x is calculated:

$$c_x = \frac{S_B V_S c_S}{(S_A - S_B) V_X}$$

where,

S_A and S_B are the analytical signals (corrected for the blank) of solutions A and B, respectively. V_S and c_s should be chosen so that S_A is roughly twice S_B on the average. It is best if V_S is made much less than V_X, and thus c_s is much greater than c_x, to avoid excess dilution of the sample matrix. If a separation or concentration step is used, the additions are best made first and carried through the entire procedure.

DATA TREATMENT:

For determination of metal concentration by direct aspiration and furnace; read the metal value in ug/L from the calibration curve or directly from the read-out system of the instrument.

If dilution of sample was required:

$$\text{ug/L metal in sample} = A \times \frac{(C + B)}{C}$$

where,

A = ug/L of metal in diluted aliquot from calibration curve
B = Acid blank matrix used for dilution, mL
C = sample aliquot, mL

DATA DELIVERABLES:

Reports to client will include:

- Date of receipt
- Date of preparation
- Date of analysis
- Analyst
- Matrix

- Laboratory ID#
- Client ID#
- Analytical method #
- Concentration Determined and resulting EQL
- ICV, CCV Summary form
- ICB, CCB, Prep Blank Summary form
- Spike Sample Recovery form
- Laboratory Control Sample Summary form
- All Raw Data
- Preparation Records

Client:	SIMALABS International
SOP ID:	SOP-MET-7841-1
Rev. Number:	2.0
Rev. Date:	March 1, 1996

Standard Operating Procedure For Graphite Furnace Atomic Absorption Analysis of Thallium For Aqueous Samples

Prepared For SIMALABS International
Metals, Metals Laboratory

SW-846, 3rd Edition, Method 7841

Revision # 2.0
Issued: March 1, 1996

Immediate Supervisor	3/8/99 Date
Second Supervisor	3/8/99 Date
QA/QC Officer	3/8/99 Date
Analyst	3/8/99 Date

Effective: March 1, 1996

CAUTION

<u>Disclaimer:</u> This Standard Operating Procedure has been prepared for the sole use of SIMALABS International and may not be specifically applicable to the activities of other organizations.

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STANDARD OPERATING PROCEDURE
GRAPHITE FURNACE ATOMIC ABSORPTION ANALYSIS OF THALLIUM FOR AQUEOUS SAMPLES

LOCATION:

Metals, Metals Laboratory

REFERENCE:

SW-846, 3rd Edition, Method 7841

MATRIX:

Water, Leachate

DETECTION LIMIT:

EQL = 5 ug/L; MDL = 0.71 ug/L

RANGE:

5 ug/L to 50 ug/L without dilution

PRINCIPLE, SCOPE, AND APPLICATION:

Thallium in solution may be readily determined by graphite furnace atomic absorption spectroscopy. The method is simple, rapid, and applicable to a variety of matrices. Samples for totals analysis require digestion prior to analysis.

Detection limits, sensitivity, and optimum ranges of the metals will vary with the matrices and models of atomic absorption spectrophotometers. When using furnace techniques the analyst should be cautioned as to possible chemical reactions occurring at elevated temperatures which may result in either suppression or enhancement of the analysis element. To ensure valid data with furnace techniques, the analyst must examine each matrix for interference effects.

When using the furnace technique in conjunction with an atomic absorption spectrophotometer, a representative aliquot of a sample is placed in the graphite tube in the furnace, evaporated to dryness, charred, and atomized. Radiation from a given excited element is passed through the vapor containing ground-state atoms of that element. The metal atoms to be measured are placed in the beam of radiation by increasing the temperature of the furnace, thereby causing the injected specimen to be volatilized. A monochromator isolates the discharge lamp, and a photosensitive device measures the attenuated transmitted radiation.

INTERFERENCES AND CORRECTIVE ACTION:

Although the problem of oxide formation is greatly reduced with furnace procedures because atomization occurs in an inert atmosphere, the technique is still subject to chemical interferences. The composition of the sample matrix can have a major effect on the analysis. It is those effects which must be determined and taken into consideration in the analysis of each different matrix encountered. To help verify the absence of matrix or chemical interference, the serial dilution technique may be used. Those samples which indicate the presence of interference should be treated in one or more of the following ways:

(1) Successively dilute and reanalyze the samples to eliminate interferences.

(2) Analyze the sample by method of standard additions while noticing the precautions and limitations of its use.

Gases generated in the furnace during atomization may have molecular absorption bands encompassing the analytical wavelength. Background correction may also compensate for nonspecific broad-bank absorption interference.

Continuous background correction cannot correct for all types of background interference. When the background interference cannot be compensated for, chemically remove the analyte or use an alternate form of background correction, e.g. Zeeman background correction.

Interference from a smoke-producing sample matrix can sometimes be reduced by extending the charring time at a higher temperature or utilizing an ashing cycle in the presence of air. Care must be taken, however, to prevent loss of the analyte.

Samples containing large amounts of organic materials should be oxidized by conventional acid digestion before being placed in the furnace. In this way, broad-band absorption will be minimized.

Anion interference studies in the graphite furnace indicate that, under conditions other than isothermal, the nitrate anion is preferred. Therefore, nitric acid is preferable for any digestion or solubilzation step. If another acid in addition to HNO_3 is required, minimum amount should be used. This applies particularly to hydrochloric and to a lesser extent to sulfuric and phosphoric acids.

Cross-contamination and contamination of the sample can be a major source of error. The sample preparation work area should be kept scrupulously clean. Pipet tips are a frequent source of contamination. If contamination is suspected, the tips should be soaked with 1:5 nitric acid and rinsed thoroughly with DI water.

SAFETY PRECAUTIONS:

Lab coats and safety goggles are to be worn while working with samples, especially during digestion procedures. All instrument vapors are to be vented to the exterior of the building, and all digestions are to occur under a fume hood.

SAMPLE SIZE, COLLECTION, PRESERVATION AND HANDLING:

Aqueous and leachate samples are to be collected in 500 ml plastic containers with teflon lined lids, and preserved to pH $\leq$ 2 with nitric acid, and cooled to 4°C until digestion. Samples must be analyzed within 6 months of collection.

APPARATUS:

1) Varian SpectrAA 400 with double beam, grating monochromator, photomultiplier detector, adjustable slits, wavelength range of 190 to 800 nm, Zeeman background correction, and interfaced with an IBM computer and dot matrix printer.

2) Zeeman Graphite Tube Atomizer provides power to furnace and spectrophotometer. Allows use of two gasses, and requires cooling water. Provides temperature range of 40 - 3000 °C and heating times of 0 - 500 seconds. Provides gas control between 0 and 3.1 L/min.

3) Autosampler with capability of running 45 samples including check standards. Dispenses volumes from 1 to 40 ul.

4) IBM PS/2 Model 30 computer, controls operation of spectrophotometer and provides data manipulation and reporting of sample calculations.

5) Citizen dot matrix printer, prints calibration and sample results.

6) Class A volumetric pipets

7) Class A volumetric flasks

8) Pipets: Microliter, with disposable tips. sizes can range from 5 to 100 uL as required. Pipet tips should be checked as a possible sources of contamination prior to their use.

9) Analytical balance

10) Disposable glass serological pipets

ROUTINE MAINTENANCE:

Gasses are checked daily to insure adequate pressure. The autosampler parts are checked daily. Furnace optics are cleaned twice weekly. Plumbing connections , and the furnace are checked as needed. Electrodes are changed as needed. Graphite tube is changed as needed.

REAGENTS AND CALIBRATION STANDARDS:

1) Deionized water - Type II

2) Nitric Acid - concentrated, trace metals grade (FISHER AS09-212)

3) Furnace stock calibration standard: Using a Class A volumetric pipet, dilute 1.0 ml Thallium Stock (Spex, QC-19 - 100 ppm), and 4.0 ml concentrated nitric acid, to 200 ml with DI water in a Class A volumetric flask. This will result in a final concentration of 5 ppm Thallium. Dilute stock calibration standard 1:99 with DI water for daily calibration.

4) Furnace ICV/CCV Solutions: Using a 100 uL micropipet and a 10 mL glass serological pipet, transfer 0.10 ml QC-19 Stock (SPEX - QC-19, 100 ppm) and 2.0 ml concentrated nitric acid to a 100 ml Class A volumetric flask partially filled with DI water. Bring to volume. Dilute this solution 1:3, which will result in a 25 ppb final concentration.

5) Citric Acid & Palladium Modifier: Using an analytical balance, weigh 5.00g Citric Acid. (Fisher, A104-500) and transfer to a 100 mL Class A volumetric flask. Dilute to volume. Combine with 100 ml of 1000 ppm Palladium stock (Fisher, PLPD3-2y).

CALIBRATION PROCEDURES:

A curve consisting of 4 standards and a blank is analyzed at the beginning of each run. The curve must demonstrate a correlation coefficient of $\geq$ 0.995 to be valid. An ICV followed by an ICB are analyzed prior to sample analysis. The ICV must recover within 20 % of true value, and the ICB must show results less than the EQL. After every 10 samples, and at the conclusion of the run, a CCV and CCB are analyzed. The CCV and CCB must meet the above stated criteria for the ICV and ICB.

SAMPLE PREPARATION:

Aqueous: See SOP-MET-3020-1

ANALYSIS PROCEDURE:

1.) Turn on monitor, computer, Spectra AA-400, Zeeman, Graphic Tube Atomizer, T & A cooling unit, hood printer, Argon gas at its source. Press F10 (index) on computer keyboard. Type 10, press F-6 (new page) press F1 (clear sequence). Type the number of the program to be run. Press F6, the program is loaded and the correct lamp is automatically moved into position.

2.) Swing toggle lever clockwise to release the furnace right hand housing. Clean furnace housing using a cotton swap and isopropyl rubbing alcohol. Clean a graphite tube and it's platform using a Kim wipe. Position graphite platform inside the plateau tubes so that it is perpendicular to the sample injection hole of the tube. Place the graphite tube in the furnace housing being careful to align the sample introduction hole in the graphite

tube to the center of the furnace chimney. Swing the toggle lever counter-clockwise in order to close the right-hand housing onto the tube now positioned inside the furnace housing.

3.) Remove rinse bottle and fill to the line with DI H_2O. Clean the Blank, Modifier and Standard cups with DI H_2O and 1:1 Nitric acid. Fill and place these cups in their labeled positions on the autosampler tray.

4.) Press F10 (index). Type 8 and press F6 (new page)._Press F2_(align sampler) twice. The sampling arm will move from it's rinse position to the sample 1 position and than to the sample introduction hole in the graphite tube. Adjust the position of the auto sampler capillary tube inside the hole in the graphite tube so that it is in the center of this hole. Use the backwards and forward adjuster along with the sideways adjuster to accomplish the correct positioning.

5.) Open syringe compartment door. Put the syringe clear of it's mounting and remove the plunger from the syringe. While holding a tissue beneath the syringe press F3 (rinse). Liquid will emerge along with any air bubbles present in the line. Press F3 (rinse) again, and while solution is dripping from the syringe, carefully insert the plunger into the syringe. Re-insert the syringe assembly into it's housing and close the compartment door.

6.) Press F10 (index). Type 18 and Press F6 (new page). Press F4 (tube clean). The furnace will heat and clean the graphite tube. Press shift and F11 (start GTA). A trial start will begin. Watch the sampler to ensure it pulls up blank and modifier solution into the capillary and is properly injected onto the platform inside the graphite tube. Swing the mirror assembly counter-clockwise to force it in the path of the UV light and thus putting in view the position of the capillary while inside the graphic tube. Ensure that the droplet is placed correctly in the tube. Allow the temperature program to go to completion and note the analytical signal.

7.) Press F10 (index). Type 6 and then F6 (new page). Open the Spectra 400 lamp cover and by turning the two knobs on the left-hand side of the appropriate lamp adjust the angle until the lamp peak wavelength has been found (i.e. the optimization line is at its furthest most position from the left-hand baseline.) Note: pressing F1 (rescale) allows the wavelength line that may reach a maximum at the right hand edge of the screen to rescale at a point near the middle of the screen. Once the lamp has sufficiently warmed (approximately 20 minutes from the time of the program) the run can be started.

8.) Pour samples to be analyzed into sample cups and place them into the autosampler tray. Record position of samples in tray on sample run list log. Pour check standards into sample cups and place them in their proper positions in the autosampler tray. Press F10 (index). Type 15 and press F6 (new page). Press F11 (start) to begin sample run.

Specific settings for Thallium:

Thallium: Program #5, Matrix Modifier - Citric Acid & Palladium
Standard 1 = 5 ppb, 2 = 10 ppb, 3 = 25 ppb, 4 = 50 ppb
ICV = 25 ppb, CCV = 25 ppb

QUALITY CONTROL:

All quality control data should be maintained and available for easy reference or inspection.

If 10 or more samples per batch are analyzed, the working standard curve must be verified by running an additional standard at or near the mid-range every 10 samples. Checks must be within ± 20% of true value.

At least one preparatory blank, laboratory standard, spike and duplicate sample should be run every 20 samples, or with each matrix type to verify precision of the method.

Where the sample matrix is so complex the viscosity, surface tension and components cannot be accurately matched with standards, the method of standard addition may be used. (See below.)

Method of standard additions:

In the simplest version of this method, equal volumes of sample are added to a DI water blank and to a standard. If a higher degree of accuracy is required, more than one addition should be made. The absorbance of each solution is determined and then plotted on the vertical axis of a graph, with the concentrations of the known standards plotted on the horizontal axis. When the resulting line is extrapolated back to zero absorbance, then the point of interception of the abscissa is the concentration of the unknown. The abscissa on the left of the ordinate is scaled the same as on the right side, but in the opposite direction from the ordinate.

The method of standard additions can be very useful; however, for the results to be valid the following limitations must be taken into consideration:

1) The absorbance plot of sample and standards must be linear over the concentration range of concern. For best results, the slope of the plot should be nearly the same as the slope of the aqueous standard curve. If the slope is significantly different (more than 20%), caution should be exercised.

2) The effect of the interference should not vary as the ratio of analyte concentration to sample matrix changes, and the standard addition should respond in a similar manner as the analyte.

3) The determination must be free of spectral interference and corrected for nonspecific background interference.

The simplest version of this technique is the single-addition method, in which two identical aliquots of the sample solution, each of Volume V_x, are taken. To the first (labeled A) is added a

small volume V_s of a standard analyte solution of concentrate c_s. To the second (labeled B) is added the same volume V_s of the solvent. The analytical signals of A and B are measured and corrected for non-analyte signals. The unknown sample concentration c_x is calculated:

$$c_x = \frac{S_B V_S c_S}{(S_A - S_B) V_X}$$

where,

S_A and S_B are the analytical signals (corrected for the blank) of solutions A and B, respectively. V_S and c_s should be chosen so that S_A is roughly twice S_B on the average. It is best if V_S is made much less than V_X, and thus c_s is much greater than c_x, to avoid excess dilution of the sample matrix. If a separation or concentration step is used, the additions are best made first and carried through the entire procedure.

DATA TREATMENT:

For determination of metal concentration by direct aspiration and furnace; read the metal value in ug/L from the calibration curve or directly from the read-out system of the instrument.

If dilution of sample was required:

$$\text{ug/L metal in sample} = A \times \frac{(C + B)}{C}$$

where,

A = ug/L of metal in diluted aliquot from calibration curve
B = Acid blank matrix used for dilution, mL
C = sample aliquot, mL

DATA DELIVERABLES:

Reports to client will include:

- Date of receipt
- Date of preparation
- Date of analysis
- Analyst
- Matrix
- Laboratory ID#
- Client ID#
- Analytical method #
- Concentration Determined and resulting EQL
- ICV, CCV Summary form
- ICB, CCB, Prep Blank Summary form
- Spike Sample Recovery form
- Laboratory Control Sample Summary form
- All Raw Data
- Preparation Records

Client:	SIMALABS INTERNATIONAL
SOP ID:	SOP-MET-7740-1
Rev. Number:	2.0
Rev. Date:	March 1, 1996

Standard Operating Procedure For Graphite Furnace Atomic Absorption Analysis of Selenium For Aqueous Samples

Prepared For SimaLabs International
Metals, Metals Laboratory

SW-846, 3rd Edition, Method 7740

Revision # 2.0
Issued: March 1, 1996

Immediate Supervisor	3/8/99 Date
Second Supervisor	3/8/99 Date
QA/QC Officer	3/8/99 Date
Analyst	3/8/99 Date

Effective: March 1, 1996

CAUTION

<u>Disclaimer:</u> This Standard Operating Procedure has been prepared for the sole use of SimaLabs International and may not be specifically applicable to the activities of other organizations.

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STANDARD OPERATING PROCEDURE
GRAPHITE FURNACE ATOMIC ABSORPTION ANALYSIS OF SELENIUM FOR AQUEOUS SAMPLES

LOCATION:

Metals, Metals Laboratory

REFERENCE:

SW-846, 3rd Edition, Method 7740

MATRIX:

Water, Leachate

DETECTION LIMIT:

EQL = 5 ug/L; MDL = 1.6 ug/L

RANGE:

5.00 ug/L to 50.0 ug/L without dilution

PRINCIPLE, SCOPE, AND APPLICATION:

Selenium in solution may be readily determined by graphite furnace atomic absorption spectroscopy. The method is simple, rapid, and applicable to a variety of matrices. Samples for totals analysis require digestion prior to analysis.

Detection limits, sensitivity, and optimum ranges of the metals will vary with the matrices and models of atomic absorption spectrophotometers. When using furnace techniques the analyst should be cautioned as to possible chemical reactions occurring at elevated temperatures which may result in either

suppression or enhancement of the analysis element. To ensure valid data with furnace techniques, the analyst must examine each matrix for interference effects.

When using the furnace technique in conjunction with an atomic absorption spectrophotometer, a representative aliquot of a sample is placed in the graphite tube in the furnace, evaporated to dryness, charred, and atomized. Radiation from a given excited element is passed through the vapor containing ground-state atoms of that element. The metal atoms to be measured are placed in the beam of radiation by increasing the temperature of the furnace, thereby causing the injected specimen to be volatilized. A monochromator isolates the discharge lamp, and a photosensitive device measures the attenuated transmitted radiation.

INTERFERENCES AND CORRECTIVE ACTION:

Although the problem of oxide formation is greatly reduced with furnace procedures because atomization occurs in an inert atmosphere, the technique is still subject to chemical interferences. The composition of the sample matrix can have a major effect on the analysis. It is those effects which must be determined and taken into consideration in the analysis of each different matrix encountered. To help verify the absence of matrix or chemical interference, the serial dilution technique may be used. Those samples which indicate the presence of interference should be treated in one or more of the following ways:

(1) Successively dilute and reanalyze the samples to eliminate interferences.

(2) Analyze the sample by method of standard additions while noticing the precautions and limitations of its use.

Gases generated in the furnace during atomization may have molecular absorption bands encompassing the analytical wavelength. Background correction may also compensate for nonspecific broad-bank absorption interference.

Continuous background correction cannot correct for all types of background interference. When the background interference cannot be compensated for, chemically remove the analyte or use an alternate form of background correction, e.g. Zeeman background correction.

Interference from a smoke-producing sample matrix can sometimes be reduced by extending the charring time at a higher temperature or utilizing an ashing cycle in the presence of air. Care must be taken, however, to prevent loss of the analyte.

Samples containing large amounts of organic materials should be oxidized by conventional acid digestion before being placed in the furnace. In this way, broad-band absorption will be minimized.

Anion interference studies in the graphite furnace indicate that, under conditions other than isothermal, the nitrate anion is preferred. Therefore, nitric acid is preferable for any digestion or solubilzation step. If another acid in addition to HNO_3 is required, minimum amount should be used. This applies particularly to hydrochloric and to a lesser extent to sulfuric and phosphoric acids.

Cross-contamination and contamination of the sample can be a major source of error. The sample preparation work area should be kept scrupulously clean. Pipet tips are a frequent source of contamination. If contamination is suspected, the tips should be soaked with 1:5 nitric acid and rinsed thoroughly with DI water.

SAFETY PRECAUTIONS:

Lab coats and safety goggles are to be worn while working with samples, especially during digestion procedures. All instrument vapors are to be vented to the exterior of the building, and all digestions are to occur under a fume hood.

SAMPLE SIZE, COLLECTION, PRESERVATION AND HANDLING:

Aqueous samples are to be collected in 500 mL plastic containers with teflon lined lids, preserved to pH $\leq$ 2 with nitric acid, and cooled to 4°C until digestion. Samples must be analyzed within 6 months of collection.

APPARATUS:

1) Varian SpectrAA 400 with double beam, grating monochromator, photomultiplier detector, adjustable slits, wavelength range of 190 to 800 nm, Zeeman background correction, and interfaced with an IBM computer and dot matrix printer.

2) Zeeman Graphite Tube Atomizer provides power to furnace and spectrophotometer. Allows use of two gasses, and requires cooling water. Provides temperature range of 40 - 3000 °C and heating times of 0 - 500 seconds. Provides gas control between 0 and 3.1 L/min.

3) Autosampler with capability of running 45 samples including check standards. Dispenses volumes from 1 to 40 ul.

4) IBM PS/2 Model 30 computer, controls operation of spectrophotometer and provides data manipulation and reporting of sample calculations.

5) Citizen dot matrix printer, prints calibration and sample results.

6) Class A volumetric pipets

7) Class A volumetric flasks

8) Pipets: Microliter, with disposable tips. sizes can range from 5 to 100 uL as required. Pipet tips should be checked as a possible sources of contamination prior to their use.

9) Analytical balance

10) Disposable glass serological pipets

ROUTINE MAINTENANCE:

Gasses are checked daily to insure adequate pressure. The autosampler parts are checked daily. Furnace optics are cleaned twice weekly. Plumbing connections , and the furnace are checked as needed. Electrodes are changed as needed. Graphite tube is changed as needed.

REAGENTS AND CALIBRATION STANDARDS:

1) Deionized water - Type II

2) Nitric Acid - concentrated, trace metals grade (Fisher, AS09-212)

3) Furnace stock calibration standard: Using a Class A volumetric pipet, dilute 1.0 ml Selenium Stock (Spex, PLSE2-2y - 100 ppm), and 4.0 ml concentrated

nitric acid, to 200 ml with DI water in a volumetric flask. This will result in a final concentration of 5 ppm Selenium. Dilute stock calibration standard 1:99 with DI water for daily calibration.

4) Furnace ICV/CCV Solutions: Using a 100 uL micropipet and a 10 mL glass serological disposable pipet, transfer 0.10 ml QC-19 Stock (SPEX , QC-19, 100 ppm) and 2.0 ml concentrated nitric acid to 100 ml with DI water in a volumetric flask. This will result in a 100 ppb final concentration. Dilute 1:3 for a working concentration of 25 ppb.

5) Nickel Nitrate Modifier: Using an analytical balance, weigh 0.4950 g $Ni(NO_3)*6H_2O$ (Malinckrodt, UN2725). Using a 10 mL glass disposable serological pipet, transfer 5.0 ml concentrated nitric acid into a Class A volumetric flask partially filled with DI water. Transfer weighed $Ni(NO_3) * 6 H_2O$ into the flask. Bring to volume and mix until dissolved.

CALIBRATION PROCEDURES:

A curve consisting of 4 standards and a blank is analyzed at the beginning of each run. The curve must demonstrate a correlation coefficient of $\geq$ 0.995 to be valid. An ICV followed by an ICB are analyzed prior to sample analysis. The ICV must recover within 20 % of true value, and the ICB must show results less than the EQL. After every 10 samples, and at the conclusion of the run, a CCV and CCB are analyzed. The CCV and CCB must meet the above stated criteria for the ICV and ICB.

SAMPLE PREPARATION:

Aqueous: See SOP-MET-3020-1

ANALYSIS PROCEDURE:

1.) Turn on monitor, computer, Spectra AA-400, Zeeman, Graphic Tube Atomizer, T & A cooling unit, hood printer, Argon gas at its source. Press F10 (index) on computer keyboard. Type 10, press F-6 (new page) press F1 (clear sequence). Type the number of the program to be run. Press F6, the program is loaded and the correct lamp is automatically moved into position.

2.) Swing toggle lever clockwise to release the furnace right hand housing. Clean furnace housing using a cotton swap and isopropyl rubbing alcohol. Clean a graphite tube and it's platform using a Kim wipe. Position graphite platform inside the plateau tubes so that it is perpendicular to the sample injection hole of the tube. Place the graphite tube in the furnace housing being careful to align the sample introduction hole in the graphite tube to the center of the furnace chimney. Swing the toggle lever counter-clockwise in order to close the right-hand housing onto the tube now positioned inside the furnace housing.

3.) Remove rinse bottle and fill to the line with DI H_2O. Clean the Blank, Modifier and Standard cups with DI H_2O and 1:1 Nitric acid. Fill and place these cups in their labeled positions on the autosampler tray.

4.) Press F10 (index). Type 8 and press F6 (new page). Press F2 (align sampler) twice. The sampling arm will move from it's rinse position to the sample 1 position and than to the sample introduction hole in the graphite tube. Adjust the position of the auto sampler capillary tube inside the hole in the graphite tube so that it is in the center of this hole. Use the backwards and forward adjuster along with the sideways adjuster to accomplish the correct positioning.

5.) Open syringe compartment door. Put the syringe clear of it's mounting and remove the plunger from the syringe. While holding a tissue beneath the syringe press F3 (rinse). Liquid will emerge along with any air bubbles present in the line. Press F3 (rinse) again, and while solution is dripping from the syringe, carefully insert the plunger into the syringe. Re-insert the syringe assembly into it's housing and close the compartment door.

6.) Press F10 (index). Type 18 and Press F6 (new page). Press F4 (tube clean). The furnace will heat and clean the graphite tube. Press shift and F11 (start GTA). A trial start will begin. Watch the sampler to ensure it pulls up blank and modifier solution into the capillary and is properly injected onto the platform inside the graphite tube. Swing the mirror assembly counter-clockwise to force it in the path of the UV light and thus putting in view the position of the capillary while inside the graphic tube. Ensure that the droplet is placed correctly in the tube. Allow the temperature program to go to completion and note the analytical signal.

7.) Press F10 (index). Type 6 and then F6 (new page). Open the Spectra 400 lamp cover and by turning the two knobs on the left-hand side of the appropriate lamp adjust the angle until the lamp peak wavelength has been found (i.e. the optimization line is at its furthest most position from the left-hand baseline.) Note: pressing F1 (rescale) allows the wavelength line that may reach a maximum at the right hand edge of the screen to rescale at a point near the middle of the screen. Once the lamp has sufficiently warmed (approximately 20 minutes from the time of the program) the run can be started.

8.) Pour samples to be analyzed into sample cups and place them into the autosampler tray. Record position of samples in tray on sample run list log. Pour check standards into sample cups and place them in their proper positions in the autosampler tray. Press F10 (index). Type 15 and press F6 (new page). Press F11 (start) to begin sample run.

Specific settings for Selenium:

Selenium: Program #10, Matrix Modifier - Nickel Nitrate
Standard 1 = 5ppb, 2 = 10ppb, 3 = 25ppb, 4 = 50ppb
ICV = 25ppb, CCV = 25ppb

QUALITY CONTROL:

All quality control data should be maintained and available for easy reference or inspection.

If 10 or more samples per batch are analyzed, the working standard curve must be verified by running an additional standard at or near the mid-range every 10 samples. Checks must be within ± 20% of true value.

At least one preparatory blank, laboratory standard, spike and duplicate sample should be run every 20 samples, or with each matrix type to verify precision of the method.

Where the sample matrix is so complex the viscosity, surface tension and components cannot be accurately matched with standards, the method of standard addition may be used. (See below.)

Method of standard additions:

In the simplest version of this method, equal volumes of sample are added to a DI water blank and to a standard. If a higher degree of accuracy is required, more than one addition should be made. The absorbance of each solution is determined and then plotted on the vertical axis of a graph, with the concentrations of the known standards plotted on the horizontal axis. When the resulting line is extrapolated back to zero absorbance, then the point of interception of the abscissa is the concentration of the unknown. The abscissa on the left of the ordinate is scaled the same as on the right side, but in the opposite direction from the ordinate.

The method of standard additions can be very useful; however, for the results to be valid the following limitations must be taken into consideration:

(a) The absorbance plot of sample and standards must be linear over the concentration range of concern. For best results, the slope of the plot should be nearly the same as the slope of the aqueous standard curve. If the slope is significantly different (more than 20%), caution should be exercised.

(b) The effect of the interference should not vary as the ratio of analyte concentration to sample matrix changes, and the standard addition should respond in a similar manner as the analyte.

(c) The determination must be free of spectral interference and corrected for nonspecific background interference.

The simplest version of this technique is the single-addition method, in which two identical aliquots of the sample solution, each of Volume V_x, are taken. To the first (labeled A) is added a small volume V_s of a standard analyte solution of concentrate c_s. To the second (labeled B) is added the same volume V_s of the solvent. The analytical signals of A and B are measured and corrected for non-analyte signals. The unknown sample concentration c_x is calculated:

$$c_x = \frac{S_B V_S c_S}{(S_A - S_B)\, V_X}$$

where,

S_A and S_B are the analytical signals (corrected for the blank) of solutions A and B, respectively. V_S and c_s should be chosen so that S_A is roughly twice S_B on the average. It is best if V_S is made much less than V_X, and thus c_s is much greater than c_x, to avoid excess dilution of the sample matrix. If a separation or

concentration step is used, the additions are best made first and carried through the entire procedure.

DATA TREATMENT:

For determination of metal concentration by direct aspiration and furnace; read the metal value in ug/L from the calibration curve or directly from the read-out system of the instrument.

If dilution of sample was required:

$$\text{ug/L metal in sample} = A \times \frac{(C + B)}{C}$$

where,

A = ug/L of metal in diluted aliquot from calibration curve.
B = Acid blank matrix used for dilution, mL
C = Sample aliquot, mL

DATA DELIVERABLES:

Reports to client will include:

- Date of receipt
- Date of preparation
- Date of analysis
- Analyst
- Matrix
- Laboratory ID#
- Client ID#
- Analytical method #
- Concentration Determined and resulting EQL
- ICV, CCV Summary form
- ICB, CCB, Prep Blank Summary form
- Spike Sample Recovery form
- Laboratory Control Sample Summary form
- All Raw Data
- Preparation Records

STANDARD OPERATING PROCEDURES
AMMONIA
FOR AQUEOUS SAMPLES

LOCATION:

Wet Chemistry, Main Laboratory

REFERENCE:

QuikChem Method 10-107-06-1-A
350.2 EPA 600/4-79-020 4500 NH_3A, 4500NH_3B, 4500NH_3C Standard Methods for Examination of Water and Wastewater, 17th edition.

MATRIX:

Aqueous, waters, wastewaters, and leachates

DETECTION LIMITS:

0.10 mg/L

RANGE:

0.10 - 20 mg/L

PRINCIPLE, SCOPE AND APPLICATION:

This method is based on Berthelot reaction. Ammonia reacts with alkaline phenol and subsequently with sodium hypochlorite to form indophenol blue. Sodium nitroprusside is added to enhance the sensitivity. The absorbance of the reaction product is measured at 630 nm and is directly proportional to the original ammonia concentration.

This method covers the determination of ammonia in drinking and surface waters and is based on reactions that are specific for the ammonia ion.

INTERFERENCES AND CORRECTIVE ACTION:

Calcium and magnesium ions may precipitate if present in sufficient concentrations; tartrate or EDTA can be added to the sample in-line in order to prevent this problem.

Color, turbidity and certain organic species can interfere. Turbidity is removed by manual filtration and color may be corrected by running the samples through the manifold without color formation.

SAFETY PRECAUTIONS:

Wear lab coat, safety glasses and gloves. Glassware is slippery when wet. Handle with care. Refer to MSDS if any inquiries/concerns about chemicals used for this test. The MSDS is located in the Main Laboratory.

SAMPLE SIZE, COLLECTION, PRESERVATION AND HANDLING:

Sample (1000 ml) should be collected in 1 L glass jar. Samples will be kept at 4°C until analysis. Aqueous samples will be preserved with 2 ml H_2SO_4. Samples will be labeled as being preserved. Holding time is 28 days from time of collection. Sample will be rejected if container is cracked or broken, at which time the immediate supervisor will be notified.

APPARATUS:

1) Oxford 1-5 ml and 5-10 ml autopipets

2) 13 X 100 mm disposable borosilicate glass culture tubes

3) Lachat QuickChem 8000 FIA instrument including sampler, multichannel proportioning pump, reaction manifold, calorimetric detector, and data system.

4) Heating unit.

5) 1 L distillation flasks (long neck) and condenser units

6) Heating mantles

7) 250 ml graduated cylinders

8) pH meter

9) Boiling stones

10) 450 ml beakers

REAGENTS AND CALIBRATION STANDARDS:

1) DI water. Use for all solutions.

2) Sodium Phenolate. Dissolve 88 ml of 88% liquefied phenol in approximately 600 ml water in a 1 L volumetric flask. While stirring, slowly add 32 g $NaOH$. Cool, dilute to mark, and invert to mix.

3) Sodium Hypochlorite. Dilute 250 ml Regular Clorox Bleach to mark of 500 ml volumetric flask with water. Invert to mix.

4) Buffer. In a 1 L volumetric flask, dissolve 50.0 g disodium ethylenediamine tetaacetate and 5.5 g $NaOH$ in about 900 ml water. Dilute to mark and invert to mix.

5) Sodium Nitroprusside. Dissolve 3.5 g sodium nitroprusside in a 1 L volumetric flask.

6) 20 ppm stock standard. In a 1 L volumetric flask, combine 10.0 g of 1000 ppm N as NH_3 stock standard with 0.50 ml H_2SO_4. Dilute to mark and mix.

7) 0.1% H_2SO_4 carrier solution. In a 1 L volumetric flask, add 1.0 ml of concentrated H_2SO_4. Dilute to mark and invert to mix.

8) NH_3/TKN standard (100 ppm). Add 50 ml Nitrogen standard (for ammonia at 1000 ppm) to approximate 300 ml DI water in a 500 ml volumetric flask. Add 0.50 ml H_2SO_4. Bring up to mark and mix.

9) 0.04 N H2SO4. In a 1 L volumetric flask, add 40 ml of 1 N H2SO4. Dilute to mark with reagent water and invert to mix.

SAMPLE PREPARATION

1) 50 ml of 0.04 N H_2SO_4 is poured into a 400 ml beaker and is placed under the condenser unit so as to submerge the outlet of the distillation unit in the solution.

2) Pour 250 ml of sample into a distillation flask.

3) 12.5 ml of borate buffer is then added to the distillation flask and the pH is adjusted to a pH range of 9 - 10 using NaOH or 1:1 H_2SO_4.

4) The distillation flask is then placed on the heating mantel and connected to the condenser unit and the cooling water is turned on.

5) Turn the heating mantle on "high" and allow the distillate to collect until the volume of the same is at 225 mls.

6) Remove the beaker so as to collect distillate merging from the condenser outlet but so that the outlet is no longer submerged in the distillate.

7) Turn off the heating mantle and collect the remaining drops of distillate.

8) When no more distillate emerges from the outlet, turn off the cooling water. DO NOT TURN OFF HEATING MANTEL WHILE CONDENSER OUTLET IS SUBMERGED. COOLING OF DISTILLATION FLASK WILL CAUSE A VACUUM AND WILL EVACUATE DISTILLATE INTO DISTILLATION FLASK.

9) Bring volume of distillate to 250 ml using reagent water.

CALIBRATION AND ANALYSIS PROCEDURE

I. Set up QuikChem 8000 manifold

Remove Lachat NH_3 manifold from storage box and install on instrument in Channel 2 position. Insert 630 nm interference filter into detector module and connect sample loop (13 cm) in injection valve at the 1 and 4 positions. Detach pump tubing at the pump tube adaptor on the carrier line. Connect manifold to 650 cm of tubing wrapped around heater block, set for 60 C, allow 15 min for heating unit to warm up. Insert the tubing that is still attached to the manifold into the number 3 position on the injection valve and then attach the tubing from

the number 2 position on the valve to remaining carrier line. Attach reagent and sample lines to pump with cassettes and switch on power to the instrument.

II. Input data system information/Place sample and standards into autosampler.

Log into Omnion. Open the NH_3 method (File, Open Method...) and the NH_3 tray (File, Open Tray..). Place reagent lines into DI water and pump through manifold until analysis is ready to start at which time the lines are placed into appropriate reagent containers. Check for leaks and smooth flow. Allow the system to equilibrate until a stable baseline is achieved.

Prepare a series of working standard containing, 0, 0.100, 0.200, 0.400, 2.00, 10, and 20 mg/L of N for NH_3 by diluting this stock standard with Reagent 7. These working standards are then poured into the 20 ml plastic vials and placed in the autosampler with the highest concentration first.

For all determinations, this laboratory analysis a mid-range check standard and a calibration blank immediately following initial calibration, after every tenth sample, and at the end of the sample run. The check standard for NH_3 is at a concentration of 10.00 ppm and is prepared from a 100 ppm second source standard (reagent 8). The blank is an aliquot of the carrier, which in this case is 0.1% H_2SO_4.
These standards and blanks are inserted into the tray and included in the tray table prior to initiation of the run. All control samples and distilled samples are poured into disposable culture tubes and placed in their respective positions in the tray of the autosampler, which positions are entered into the tray table and saved (File, Save Tray).

III. Run the analysis.

Place reagent transmission lines into the appropriate containers and allow to pump through manifold for several minutes. Select Run Tray. The instrument is calibrated by first injecting the standards. Check the Replication % RSD by selecting Review in the Main Menu. Print calibration report and curve from Review menu.

If calibration is greater than or equal to 0.995 correlation coefficient, the instrument will automatically begin analyzing the samples in the order set out in the tray table. If sample concentrations are greater than the high standard, the sample should be diluted with 0.1% H_2SO_4. This dilution is then inserted into the

tray at the end of the original run and its addition is added and saved in the tray table immediately (File, Save Tray).

Once the analytical run is complete, the sampler will either stop automatically or can be manually terminated by selecting "Stop" in the main menu toolbar.

QUALITY CONTROL REQUIREMENTS:

See Table I attached for QA/QC procedures.

DATA ANALYSIS AND CALCULATIONS:

Calibration is done by injecting standards. The data system will then prepare a calibration curve by plotting response versus standard concentration. Sample concentration is calculated from the regression equation.

Values reported are only those which fall between the lowest and highest calibration standards. Answers are multiplied by applicable dilution factors.

Results are reported in mg N/L

DATA DELIVERABLES:

TABLE II
DATA DELIVERABLES

Reports to client will include:

-Date of receipt
-Date of preparation
-Date of analysis
-Analyst
-Matrix
-Laboratory I.D. #
-Client I.D. #
-Analytical method #
-Concentrations determined and limits
-Continuing calibration verification forms
-Continuing calibration blank forms
-Preparation blank forms
-Laboratory control sample forms
-Matrix spike/Matrix spike duplicate summary forms

-Duplicate summary forms
-All raw data.

Client:	SIMALABS International
SOP ID:	SOP-WET-3754-1
Rev. Number:	4.0
Rev. Date:	October 14, 1997

Standard Operating Procedure For Sulfate For Aqueous Samples

Prepared For SIMALABS International
Wet Chemistry, Main Laboratory

QuikChem Method 10-116-10-1-A
EPA 600/4-79-020, Method 375.4

Revision # 4.0
Issued: October 14, 1997

Immediate Supervisor	3/8/99 Date
Second Supervisor	3/8/99 Date
QA/QC Officer	3/8/99 Date
Analyst	3/8/99 Date

Effective: October 14, 1997

CAUTION

<u>Disclaimer:</u> This Standard Operating Procedure has been prepared for the sole use of SimaLabs International and may not be specifically applicable to the activities of other organizations.

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STANDARD OPERATING PROCEDURES
SULFATE
FOR AQUEOUS SAMPLES

LOCATION:

Wet Chemistry, Main Laboratory

REFERENCE:

QuikChem Method 10-116-10-1-A
375.4 EPA 600/4-79-020, 1978, SW-846, 3rd edition, Sept. 1986 method 9038, Vol. 1-C

MATRIX:

Water, Leachate, Aqueous, and Wastewaters

DETECTION LIMITS

10 mg/L

RANGE:

10 - 300 mg/L

PRINCIPLE, SCOPE AND APPLICATION:

This method determines the sulfate content of water and wastewaters samples through the precipitation of sulfate with barium chloride. The precipitate is suspended as a colloid with gelatin and polyvinyl alcohol which then scatters light at 420 nm to produce a signal proportional to sulfate concentration.

INTERFERENCES AND CORRECTIVE ACTION:

Color and suspended particulates will interfere as well as silicate in excess of 500 mg SiO_2/L and large qualitites of organic matter. Sulfates and sulfides may oxidize and then precipitate as barium sulfate.

SAFETY PRECAUTIONS:

Wear a lab coat, safety glasses and gloves. Glassware is very slippery when wet. Handle with care. Refer to MSDS for concerns or inquiries about reagents/chemicals used for this test. The MSDS is located in the Main Laboratory.

SAMPLE SIZE, COLLECTION, PRESERVATION AND HANDLING:

Samples (500 ml) should be collected in 500 ml plastic bottles and kept at 4°C until analysis. Holding time for sulfates is 28 days from collection. No preservation is necessary. Samples are rejected if bottle is cracked or broken.

APPARATUS:

1) 1-5 and 5-10 ml Oxford Autopipets.

2) Hot-Plate

3) Glassware - Class A volumetric flasks.

4) 13 X 100 mm disposable borosilicate glass culture tubes.

5) Lachat QuickChem 8000 FIA instrument including sampler, multichannel proportioning pump, reaction manifold, colormetric detector, and data system.

REAGENTS AND CALIBRATION STANDARDS:

1) DI water (Culligan). Use for all solutions.

2) Hydrochloric Acid, 0.10 M (Fisher A508-212)

3) Barium Chloride Solution. This reagent should be prepared the day before analysis to allow it to cool slowly to room temperature, but should be discarded after two days.

In a 100 mL beaker place 4.0 g 225 bloom calf skin gelatin (Aldrich 27,162-4) and 40 mL of water. Allow this mixture to soften for 15 min.

In a 250 mL beaker suspend by stirring, 1.2 g PVA [poly(vinyl acholol)], 98-99% hydrolyzed in 100 mL of water. Allow to stir for 15 minutes. The PVA will not completely dissolve at this point.

In a 1L beaker with graduations, place about 800 mL of water. Bring to a boil using a hotplate. The water should be hot enough to produce steam above the beaker. Add the PVA suspension. The PVA in the small beaker will not be completely dissolved. Transfer the dissolved and undissolved PVA to the hot water while the hot water is stirred. Add the softened gelatin to the hot water. It is not necessary to transfer these quantitatively. Continue to heat and stir until all of the solid material dissolves. This may take as long as one hour. Make the volume up to 1L using a graduated cylinder or a volumetric flasks.

Filter through DI rinsed glass wool into a 1L container. Add 50.0 g barium chloride dihydrate (Aldrich 21,756-5, ACS Reagent Grade) and stir to dissolve. The barium chloride reagent should be allowed to cool to room temperature before use.

4) SO_4stock standard 300 ppm. In a 1 L volumetric flask dissolve 0.4437 g anhydrous sodium sulfate that has been dried for two hours at 110 degrees C in approximately 800 ml of water. Dilute to mark and invert to mix.

5) SO_4 stock standard (1000 ppm.) Add 20.8 ml of 1.00 N H_2SO_4 to 800 ml of Di in 1 L volumetric flask. Bring up to mark and invert to mix.

SAMPLE PREPARATION:

1) Samples containing particulates are filtered through a glass fiber filter before analysis.

2) Samples are mixed well to ensure homogenicity.

CALIBRATION AND ANALYSIS PROCEDURE:

I. Set up QuikChem 8000 manifold

Remove Lachat Sulfate manifold from storage box and install on instrument in Channel 2 position. Attach 200 cm X 0.5 mm (0.22) id back pressure loop by adding another union fitting to the waste line origination from the detector module. Insert 420 nm interference filter into detector module and connect sample loop (100 cm X .08 mm id) in injection valve at the 1 and 4 positions. Detach pump tubing at the pump tube adaptor on the carrier line. Insert the tubing that is still attached to the manifold into the number 3 position on the injection valve and then attach the tubing from the number 2 position on the valve to remaining carrier line. Attach reagent and sample lines to pump with cassettes and switch on power to the instrument.

II. Input data system information/Place sample and standards into autosampler.

Log into Omnion. Open the sulfate method (File, Open Method...) and the sulfate tray (File, Open Tray..). Place reagent lines into DI water and pump through manifold until analysis is ready to start at which time the lines are placed into appropriate reagent containers. Check for leaks and smooth flow. Allow the system to equilibriate until a stable baseline is achieved.

Prepare a series of standards containing, 0, 3, 9, 75, 150, and 300 mg/L of sulfate by diluting the 300 ppm stock standard. These working standards are then poured into the 20 ml plastic vials and placed in the standards rack of the autosampler with the highest concentration first.

For all determinations, this laboratory analysis a mid-range check standard and a calibration blank immediately following initial calibration, after every tenth sample, and at the end of the sample run. The check standard for sulfate is at a concentration of 150 ppm and is prepared from a 1000 ppm second source standard (reagent 5). The blank is an aliquot of the carrier, which in this method is DI water. These standards and blanks are inserted into the tray and included in the tray table prior to initiation of the run. All control standard and samples are poured into disposable culture tubes and placed in their respective positions in the tray of the autosampler, which positions are entered into the tray table and saved (File, Save Tray).

III. Run the analysis.

Place reagent transmission lines into the appropriate containers and allow to pump through manifold for several minutes. Select Run Tray. The instrument is calibrated by first injecting the standards. Check the Replication % RSD by selecting Review in the Main Menu. Print calibration report and curve from Review menu.

If calibration is greater than or equal to 0.995 correlation coefficient, the instrument will automatically begin analyzing the samples in the order set out in the tray table. If sample concentrations are greater than the high standard, the sample should be diluted with DI water and reanalyzed. This dilution is then inserted into the tray at the end of the original run and its addition is added and saved in the tray table immediately (File, Save Tray).

Once the analytical run is complete, the sampler will either stop automatically or can be manually terminated by selecting "Stop" in the main menu toolbar.

DATA ANALYSIS AND CALCULATIONS:

The QuikChem data system prepares a calibration curve by plotting response of the injected standards versus standard concentration. The calibration fits a third order polynomial. Sample concentration is calculated from the regression equation.

Only values that fall between the lowest and highest calibration standards are reported.

Results are reported in mg SO4/L

QUALITY CONTROL REQUIREMENTS:

See Table I attached for QA/QC procedures.

DATA DELIVERABLE:

See Table II attached for data deliverables.

Client:	SIMALABS International
SOP ID:	SOP-WET-3253-1
Rev. Number:	3.0
Rev. Date:	January 30, 1999
Page:	

Standard Operating Procedure For Chloride For Aqueous Samples

Prepared For SIMALABS International
Wet Chemistry, Main Laboratory

SW-846, 3rd Edition, Method 9253
EPA 600/4-79-020, Method 325.3

Revision # 3.0
Issued January 30, 1999

Immediate Supervisor	3/8/99 Date
Second Supervisor	3/8/99 Date
QA/QC Officer	3/8/99 Date
Analyst	3-8-99 Date

Effective: January 30, 1999

CAUTION

<u>Disclaimer:</u> This Standard Operating Procedure has been prepared for the sole use of SimaLabs International and may not be specifically applicable to the activities of other organizations.

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STANDARD OPERATING PROCEDURES
CHLORIDE
FOR AQUEOUS SAMPLES

LOCATION:

Wet Chemistry, Main Laboratory

REFERENCE:

SW-846, Method 9252, Sept. 1994, Vol. 1-C. Standard Methods for Examination of Water and Wastewater 17th Edition, Method 4500-Cl^-(C). EPA 600/4-79-020, Method 325.3, 1982.

MATRIX:

Water, wastewater, aqueous, and leachates

DETECTION LIMITS:

1.0 mg/L

RANGE:

1.0 to 250 mg/L

PRINCIPLE, SCOPE AND APPLICATION:

This method for chloride determination uses mercuric nitrate and diphenylcarbazone indicator. The mercuric nitrate first reacts selectively with all chloride in the form of Cl^- ion to produce mercuric chloride and free nitrate ions. Once all the chloride present in the sample has been complexed, excess mercuric ions combine with diphenylcarbazone to form a purple-colored complex indicating end point of titration.

INTERFERENCES AND CORRECTIVE ACTION:

Chromate, ferric iron, and sulfite in excess of 10 mg/l cause interference. Sulfite interference can be eliminated by adding three drops of 30% hydrogen peroxide per 100 ml of sample before running the test. High alkaline samples should be adjusted to a pH of approximately 2.5 with 5.25 N sulfuric acid before testing. If significant amounts of acid are used, a volume correction should be used in calculations.

SAFETY PRECAUTIONS:

Wear lab coat, gloves and safety glasses. Mercuric Nitrite can be harmful if in contact with the skin. Glassware is slippery when wet. Handle with care. Refer to MSDS if any inquiries about reagents/chemicals used in this test. The MSDS is located in the Main Laboratory.

SAMPLE SIZE, COLLECTION, PRESERVATION AND HANDLING:

Samples (500ml) should be collected in 1 L plastic containers and kept at 4°C until analysis. Holding time is 28 days from collection. No preservation is necessary. Sample will be rejected if bottle is cracked or broken, at which time the immediate supervisor will be notified.

APPARATUS:

1) 50 ml volumetric buret. (Fisher, 03-700-22C)

2) Two 250 ml beakers. (Fisher, 02-540K)

3) Magnetic stir plate and 2 stirbars.

4) 100 ml graduated cylinder. (Fisher, 08-0557D)

ROUTINE MAINTENANCE:

Remove and clean stop cock from buret, check tip for cracks or breakage, and rinse thoroughly before and after use.

REAGENTS AND CALIBRATION STANDARDS:

1) Diphenylcarbazone indicator (HACH CAT # 836-99).

2) Mercuric Nitrate Standard Solution 0.0141 N (HACH CAT # 285-16).

3) Hydrogen Peroxide (30%) (Fisher, H325-100)

4) H2SO4: (Fisher, A300SI-212)

5) 5.25 N H_2SO_4: Mix 146 ml of concentrated H_2SO_4 with reagent water and bring volume to 1 L.

6) NaCl (Fisher, S271-500)

7) NaCl standard: Dissolve 824.0 mg NaCl (dried at 140°C) in reagent water and
dilute to 1000 ml. 1.00 ml = 500 ug Cl.

CALIBRATION PROCEDURES:

N/A

SAMPLE PREPARATION:

Samples containing sulfite should be treated with 3 drops of 30% Hydrogen Peroxide per 100 ml of sample before running.
Samples with high pH should be adjusted to pH 2.5 with 5.25 N H_2SO_4 before analysis.

ANALYSIS PROCEDURE:

1) 100 ml of sample is poured into a beaker. A stir bar is added, and the beaker is placed on a stir plate.

2) Diphenylcarbazone pillow is added to sample and stirred till dissolved.

3) Sample is titrated with mercuric nitrate (0.0141 N) until color changes from yellow to a faint pink.

4) The amount of titrant used is recorded.
5) Steps 1,2,3,4, are repeated for the same sample.

6) The 2 volumes are averaged. This average is to be used in calculating the concentration of chloride.

Note: Be sure to allow the sample to mix after the addition of aliquots of titrant. One does not want to overtitrate past the endpoint. This will give inaccurate Cl- concentrations. Be sure to stop titrating when the first sign of faint pink begins to appear. It is sometimes helpful to put a piece of white paper underneath the beaker on the stirplate to better observe the color change.

QUALITY CONTROL REQUIREMENTS:

See Table I attached for QA/QC procedures.

CALCULATIONS:

mg/l Chloride = A x 5

Where A = Average Volume of tritrant used.

DATA DELIVERABLES:

See Table II attached for Data Deliverables.

TABLE I
QUALITY CONTROL LIMITS

QC Analysis	Frequency	Control Limits % Recovery
Calibration Curve	N/A	N/A
ICV	N/A	N/A
CCV	N/A	N/A
LCS	1 per 10 samples	90 - 110
ICB	N/A	N/A
CCB	N/A	N/A
Preparation Blank	1 per 10 samples	<1.00
Matrix Spike	1 per 10 samples	90 - 110
Matrix SpikeDuplicate	1 per 10 samples	90 - 110 10 % RPD

Client:	SIMALABS International
SOP ID:	SOP-WET-1601-1
Rev. Number:	2.0
Rev. Date:	6 Feb 1999

Standard Operating Procedure For Total Dissolved Solids For Aqueous Samples

Prepared For SIMALABS International
Wet Chemistry, Main Laboratory

EPA 600/4-79-020, Method 160.1

Revision # 2.0
Issued: 6 February 1999

Immediate Supervisor	3/8/99 Date
Second Supervisor	3 MAR 99 Date
QA/QC Officer	3/8/99 Date
Analyst	3-8-99 Date

Effective: 6 February 1999

CAUTION

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SOP ID: SOP-WET-1602-1
Rev. Number: 2.0
Rev. Date: 6 Feb 1999

STANDARD OPERATING PROCEDURES
TOTAL DISSOLVED SOLIDS
FOR AQUEOUS SAMPLES

LOCATION:

Wet Chemistry, Main Laboratory

REFERENCE:

2540 C - Standard Methods for the Examination of Water & Wastewater 17th Edition. EPA 600/9-79-020, method 160.1, 1971

MATRIX:

Water, Wastewater, Leachate, & Aqueous Samples

DETECTION LIMITS:

10.0 mg/L

RANGE:

10.0 mg/L to 10,000 mg/L

PRINCIPLE, SCOPE AND APPLICATION:

A well-mixed sample is filtered through a standard glass fibre filter and the filtrate is evaporated to dryness in a preweighed evaporating dish at 180°C. The increase in dish weight represents the total dissolved solids.

INTERFERENCES AND CORRECTIVE ACTION:

Highly mineralized water with a considerable calcium, magnesium, chloride and/or sulfate content may be hygroscopic and require prolonged drying, proper dessication, and rapid weighing. Samples high in bicarbonate require careful and possibly prolonged drying at 180°C to insure complete conversion of bicarbonate to carbonate.

SAFETY PRECAUTIONS:

Wear safety glasses, lab coats and gloves while working with samples. Glassware is very slippery when wet. Be careful when handling to avoid breakage and cuts.

SAMPLE SIZE, COLLECTION, PRESERVATION AND HANDLING:

No preservation is necessary. Samples (500 ml) may be collected in glass or plastic containers. Samples will be stored at 4 C until analyzed. Holding time is 7 days from collection. Sample will be rejected if container is broken or cracked. At which point the immediate supervisor will be notified.

APPARATUS:

1) 125 ml Evaporating Dishes (Fisher, 08-710B)

2) Dessicator

3) Colored Indicator Dessicant (Fisher, 07-758-4A)

4) Non-Indicating Dessicant (Fisher, 07-577-4A)

5) Drying Oven: 180 C +/- 2 C.

6) Buchner Funnel (Fisher, 10-356E. Plate diameter is 114 mm. Perferated area
is 95mm).

7) 500 mL Vacuum Flask (Fisher, 10-180E)

8) Whatman Glass Microfibre Filters. (Fisher, 09-874-16C. Diameter is 110 mm.)

9) Analytical Balance to 0.0001 g.

ROUTINE MAINTENANCE:

Daily calibration of balance with varying weights, yearly professional calibration of balance. Dishes are checked for cracks. Oven is calibrated 180°C +/- 2 C daily.

REAGENT AND CALIBRATION STANDARDS:

1) Reagent water

2) 1000 mg/L NaCl: 1.000g NaCl dissolved in DI water and brought up to 1 L in a volumetric flask.

CALIBRATION PROCEDURES:

Daily calibration of balance with varying weights. Yearly professional calibration of balance. Oven is calibrated at 108°C +/- 2 C daily.

SAMPLE PREPARATION:

Sample is ready for analysis. Sample is shaken well to mix.

ANALYSIS PROCEDURE:

1) Place filter disc in filtration apparatus and wash three 20 ml portions of reagent water through. Discard washings.

2) Heat clean evaporating dish to 180 C +/- 2 C for at least 1 hour in oven. Dessicate at least 1/2 hour to cool.

3) Weigh dish immediately before use.

4) With vacuum on, filter a measured volume of sample (usually 100 ml) through filter.

5) Wash cylinder with three 20 ml portions of reagent water and apply vacuum suction until filter is dry.

6) Transfer filtrate to a preweighed evaporating dish.

7) Place dish in oven and dry completely at 180 C +/- 2 C.

8) Cool in a dessicator for at least 1/2 hour and weigh.

9) Samples having more than 200 mg of residue are re-analyzed using a reduced initial sample volume.

QUALITY CONTROL:

See Table I attached for QA/QC procedures.

CALCULATIONS:

$$\text{mg total dissolved solids / L} = \frac{A - B}{\text{Sample vol., L}} \times 1{,}000$$

Where A = Weight of dish + sample (g)
B = Weight of dish (g)

DATA DELIVERABLE:

See Table II for data deliverables.

TABLE I
QUALITY CONTROL LIMITS

QC Analysis	Frequency	Control Limits % Recovery
Calibration Curve	N/A	N/A
ICV	N/A	N/A
CCV	N/A	N/A
LCS	1 per 10 samples	80 - 120
ICB	N/A	N/A
CCB	N/A	N/A
Preparation Blank	1 per 10 samples	<10.0
Matrix Spike	N/A	N/A
Matrix Duplicate	1 per 10 samples	80 - 120 20 % RPD

Standard Operating Procedure For Total Suspended Solids For Aqueous Samples

Prepared For SIMALABS International
Wet Chemistry, Main Laboratory

EPA 600/4-79-020, Method 160.2

Revision # 2.1
Issued: 6 February 1999

Immediate Supervisor	3/8/99 Date
Second Supervisor	3/8/99 Date
QA/QC Officer	3/8/99 Date
Analyst	3-8-99 Date

Effective: 6 February 1999

CAUTION

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Client:	SIMALABS International
SOP ID:	SOP-WET-1602-1
Rev. Number:	2.1
Rev. Date:	6 Feb 1999

STANDARD OPERATING PROCEDURES
TOTAL SUSPENDED SOLIDS
FOR AQUEOUS SAMPLES

LOCATION:

Wet Chemistry, Main Laboratory

REFERENCE:

2540 D Standard Methods for the Examination of Water and Wastewater, 17th Edition.
160.2 EPA 600/4-79-020, 1971

MATRIX:

Wastewater, Water, Aqueous and Leachates.

DETECTION LIMITS:

10.0 mg/L

RANGE:

10.0 mg/L to 10,000 mg/L

PRINCIPLE, SCOPE AND APPLICATION:

The concentration of total suspended solids in a sample is determined by filtering a well-mixed sample through a preweighed glass fiber filter, and drying the filter in a 105 C oven to a constant weight. After dessication, the increase in weight of the filter represents the total suspended solids.

INTERFERENCES AND CORRECTIVE ACTION:

Suspended material may clog the filter and prolong filtration. The difference between the total solids and the total dissolved solids may provide an estimate of the total suspended solids. See 2540 B Standard Methods 17th Edition and 2540 C Standard Methods 17th Edition.
Exclude large, floating particles or submerged agglomerates of nonhomogeneous materials from the sample, if it is determined that their inclusion is not desired in the final result. Because excessive residue on the filter may form a water entrapping crust, limit the sample size to that yielding no more than 200 mg residue. For samples high in dissolved solids, thoroughly rinse the filter with DI water to ensure removal of the dissolved material.

SAFETY PRECAUTIONS:

Wear lab coats, gloves and safety glasses when handling samples.
Glass containers may become very slippery when wet. Handle with care to avoid breakage and cuts.

SAMPLE SIZE, COLLECTION, PRESERVATION AND HANDLING:

Samples (500 ml) may be collected in either glass or plastic containers. 100 ml is essential for running the test, using more or less depending on matrix. Samples are stored at 4 C until analysis. No preservation is necessary. Holding time is 7 days from collection. Samples will be rejected if the container is broken or cracked, at which time the immediate supervisor will be notified.

APPARATUS:

1) Buchner Funnel (Fisher, 10-356E. Plate diameter is 114 mm, perferated area is 95 mm)

2) 500 ml Vacuum flask (Fisher, 10-180e)

3) Glass microfibre filter (Fisher, 09-874 16C. Diameter is 11.0 cm).

4) Dessicator, provided with colored dessicant indicating moisture presence. (Fisher, 07-758-4 & 07-577-4A)

5) Oven at 105 C.

6) Analytical balance weighing up to 0.0001g.

7) 100 ml graduated cylinder (Fisher, 08-577D)

ROUTINE MAINTENANCE:

Filters are checked to be free of holes. Balance is calibrated daily. Yearly balance maintenance by professionals. Dessicant is checked and replaced when necessary. Ovens are checked daily to ensure temperature is ranged 103 C to 105 C.

REAGENTS AND CALIBRATION STANDARDS:

DI Water

CALIBRATION PROCEDURES:

Balances are calibrated daily. Ovens are calibrated to be at 103 C to 105 C. Yearly professional maintenance is done on the analytical balance.

SAMPLE PREPARATION:

Sample is ready to test. Thorough mixing is done before pouring out measured volume for testing.

ANALYSIS PROCEDURES:

Preparation of glass microfibre filter disc:

1) Filter is numbered with permanent ink, then placed in the filtration apparatus.
2) Apply vacuum and wash filter with three 20 ml portions of DI water. Continue suction till all traces of water are removed.

3) With tweezers, remove filter from filtration apparatus and place in 105 C oven.

4) Dry overnight (or minimum 3 hours) and place in dessicator when ready to use.

Sample analysis:

1) Weigh desiccated filter disc and record weight.

2) Place disc in filtration apparatus. Wet disc with DI water and apply vacuum.

3) Filter a measured portion (250 ml) of sample through the filter disc.

4) Wash cylinder with three 20 ml portions of DI water and allow suction to continue until water is drained completely from filter disc.

5) Carefully remove filter disc from filtration apparatus and place in 105 C oven. Dry for at least 3 hours, preferably overnight.

6) Cool in dessicator and weigh.

7) Samples having more than 200 mg of residue are re-analyzed using a reduced initial sample volume.

QUALITY CONTROL:

See Table I attached for QA/QC procedures.

CALCULATIONS:

$$\text{mg total suspended solids/L} = \frac{(A - B)}{\text{sample volume (mL)}} \times 10\ 6$$

Where A = Weight of disk + sample
B = Weight of disk

DATA DELIVERABLES:

See Table II for data deliverables.

Standard Operating Procedure For Total Sulfide For Aqueous Samples

Prepared For SIMALABS International
Wet Chemistry, Main Laboratory

SW-846, 3rd Edition, Method 9030

Revision # 2.0
Issued: March 1, 1996

Immediate Supervisor	Date 3/8/99
Second Supervisor	Date 8 MAR 99
QA/QC Officer	Date 3/8/99
Analyst	Date 8 MAR 99

Effective: March 1, 1996

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STANDARD OPERATING PROCEDURES
TOTAL SULFIDE
IN AQUEOUS SAMPLES

LOCATION:

Wet Chemistry, Main Laboratory

REFERENCE:

SW-846, 3rd Edition, Method 9030

MATRIX:

Aqueous, Waters, Wastewaters, and Leachates

DETECTION LIMITS:

0.050 mg/L

RANGE:

0.050 to 1.00 mg/L without dilution.

PRINCIPLE, SCOPE AND APPLICATION:

This method is based on the ability of hydrogen sulfide and acid-soluable metallic sulfides to convert N,N-dimethyl-p-phenylenediamine oxalate directly to methylene blue. The intensity of the methylene blue is directly proportional to the amount of sulfide present in the original sample. This method is applicable for determining sulfide in aqueous and solid matrices.

INTERFERENCES AND CORRECTIVE ACTION:

Upon collection of the sample, zinc acetate and NaOH are added as preservatives as well as to remove sulfide interferences. Strong reducing agents also interfere in the methylene blue test by preventing formation of the blue color.

SAFETY PRECAUTIONS:

Lab coat, safety glasses and gloves should be worn at all times. All distillations should be done in an exhaust hood due to possible release of poisonous H2S gas. Glassware is very slippery when wet. Use caution when washing dishes to avoid breakage. Concentrated sulfuric acid can cause severe burns. Sodium hydroxide is corrosive. Refer to MSDS for concerns or inquiries about reagents/chemicals used for this test, prior to running the test. The MSDS is located in the Main Laboratory.

SAMPLE SIZE, COLLECTION, PRESERVATION AND HANDLING:

Samples (1 L) should be collected in 1 L plastic bottles preserved with zinc acetate and NaOH to pH > 9, and labeled as being preserved. The analyst is responsible for confirming that preservation conditions have been met prior to running the test. Samples will be kept at 4°C until distillation. Holding time for distillation is 7 days from date of receipt. Samples will not be accepted if sample container is broken or cracked, at which point the immediate supervisor will be notified.

APPARATUS:

1) 100 ml graduated cylinders with stoppers

2) Spec 20 spectrophotometer

3) 1" Cuvet (compatible with Spec 20)(Fisher, 07-114-38)

4) Oxford 1-5 and 5-10 ml autopipets

ROUTINE MAINTENANCE:

Spec 20 cuvets and all glassware used for the sulfide test are cleaned before and after every use with 1:1 HCl solution, to ensure thorough cleanliness. Spec 20 lamps are replaced when burnt out, or as a final attempt to troubleshoot un-

acceptable Spectronic 20 calibration results. All glassware is checked daily for cracks and breakage.

REAGENTS AND CALIBRATION STANDARDS:

1) DI water (Culligan)

2) Hydrochloric acid (concentrated) (Fisher, A144S-212)

3) 1:1 HCl for cleaning all glassware

4) Sodium hydroxide (Fisher, S318-3)

5) Sodium hydroxide solution 0.25 N: Dissolve 10 g NaOH in reagent water and dilute to 1 L.

6) Sulfide 1 reagent (Hach, 1816-32)

7) Sulfide 2 reagent (Hach, 1817-32)

8) Sulfide standard solution: Dissolve 4.02 g of $Na_2S \times 9H_2O$ in 1L of reagent water for a concentration of 574 ppm.

9) Zinc acetate solution. Dissolve 220 g $Zn(C_2H_3O_2)_2 \times 2H_2O$ in 870 ml water. Dilute to mark and invert to mix.

10) 6 N NaOH solution.

CALIBRATION PROCEDURES:

Daily Calibration of the Spectronic 20:

1) Set Spec 20 wavelength to 670 nm. (Make sure the proper bulb is inserted into the spectrophotometer. Use the bulb labeled >600 and insert the red filter).

2) While cuvet compartment is empty, set transmittance to 0.

3) Insert cuvet filled with a color developed reagent blank and set transmittance equal to 100%.

(Note: The cuvets commonly pick up fingerprints and smudges. These can

3) Add 5 drops of Sulfide 2 reagent. Swirl.

4) Allow 5 to 10 minutes to color develop.

5) Read and record absorbances.

QUALITY CONTROL:

See Table I attached for QA/QC procedures.

CALCULATIONS:

$$\text{(Total) mg/l S} = \frac{A \times B}{C}$$

Where: A = concentration (mg/l) S from calibration curve.
B = final volume of distillate (ml).
C = original volume of sample (ml).

DATA TREATMENT:

See Table II attached for Data Deliverables.

easily be removed with a Kimwipe, and will greatly increase the accuracy of the test. Make a habit of wiping the cuvet off before insertion into the Spectronic 20.)

Determination of Calibration Curve:

1) Prepare a blank and a series of standards containing 0.01, 0.05, 0.10, 0.25, 0.50 and 1.00 ppm of sulfide.

2) Pipet 10 mL of each into clean cuvets.

3) Add 6 drops of Sulfide 1 reagent and gently swirl.

4) Add 5 drops of Sulfide 2 reagent and gently swirl.

5) Allow 5 to 10 minutes to color develop.

6) Read and record absorbances.

7) From values obtained, plot absorbances vs concentrations (mg/L) of sulfide for the standard curve.

SAMPLE PREPARATION:

Put 0.20 ml zinc acetate solution and 0.30 ml 6N NaOH into a 100 ml cylinder (with stopper), fill with sample, and add 0.30 ml 6N NaOH. Stopper with no air bubbles under stopper and mix by rotating back and forth vigorously. Add enough NaOH to raise the pH above 9. Let precipitate settle for 30 minutes.

Decant as much supernatant as possible without loss of precipitate. Refill cylinder with distilled water, shake to resuspend precipitate, and quickly withdraw a sample. This aliquot is used for the analysis.

ANALYSIS PROCEDURE:

1) Pipet 10 mL of prepared sample into a clean cuvet.

2) Add 6 drops of Sulfide 1 reagent. Swirl.

TABLE I
QUALITY CONTROL LIMITS

QC Analysis	Frequency	Control Limits % Recovery
Calibration Curve	6 months	0.995 Correlation
ICV	1 per batch	60 - 130
CCV	1 per 10 samples	60 - 130
LCS	1 per 10 samples	60 - 130
ICB	1 per batch	<0.050
CCB	1 per 10 samples	<0.050
Preparation Blank	1 per 10 samples	<0.050
Matrix Spike	1 per 10 samples	60 - 130
Matrix Spike Duplicate	1 per 10 samples	70 - 130, 30% RPD

TABLE II
DATA DELIVERABLES

Reports to client will include:

-Date of receipt
-Date of preparation
-Date of analysis
-Analyst
-Matrix
-Laboratory I.D. #
-Client I.D. #
-Analytical method #
-Concentrations determined and limits
-Continuing calibration verification forms
-Continuing calibration blank forms
-Preparation blank forms
-Laboratory control sample forms
-Matrix spike/Matrix spike duplicate summary forms
-Duplicate summary forms
-All raw data
-Preparation records

Standard Operating Procedure For Nitrate-Nitrite For Aqueous Samples

Prepared For SIMALABS International
Wet Chemistry, Main Laboratory

EPA 600/4-79-200, Method 353.3
QUIKCHEM METHOD 10-107-04-1-C

Revision # 2.1
Issued: March 5, 1999

Immediate Supervisor	3/5/99 Date
Second Supervisor	8 MAR 99 Date
QA/QC Officer	3/8/99 Date
Analyst	8 MAR 99 Date

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STANDARD OPERATING PROCEDURES
NITRATE-NITRITE
FOR AQUEOUS SAMPLES

LOCATION:

Wet Chemistry, Main Laboratory

REFERENCE:

353.3 U.S. EPA 600/4-79-200, 1974, SW-846 9200, Sept. 1986 Vol. 1-C
QUIKCHEM METHOD 10-107-0

MATRIX:

Aqueous, waters, wastewaters, and leachates

DETECTION LIMITS:

0.02 mg N/L

RANGE:

0.02 - 2.0 mg N/L

PRINCIPLE, SCOPE AND APPLICATION:

This method determines the Nitrate-Nitrite content of waters and waste waters. Nitrate is quantitatively reduced to nitrite by the sample passing through a copperized cadmium column. The reduced nitrite is then determined by diazotizing with sulfanilamide followed by coupling with N-(1-naphthyl)ethylenediamine dihydrochloride. The result is a water soluble dye with a magenta color that is read at 520 nm.

NOTE: Nitrate can be determined by subtracting the results obtained using SOP-3541 (nitrite) from the results obtained using SOP-3533 (nitrate-nitrite).

INTERFERENCES AND CORRECTIVE ACTION:

Low results may result from samples with high concentrations of iron, copper or other metals. EDTA is added to the buffer in this method to reduce this interference. Residual chlorine can interfere by oxidizing the cadmium column. Sample turbidity may also interfere. Turbidity is removed by filtering sample through a glass microfibre filter.

SAFETY PRECAUTIONS:

Wear a lab coat, gloves and safety glasses. Glassware is slippery when wet. Handle with care. Refer to MSDS for concerns or inquiries about reagents/chemicals used for this test. The MSDS is located in the Main Laboratory.

SAMPLE SIZE, COLLECTION, PRESERVATION AND HANDLING:

Samples (500 mL) should be collected in 500 mL plastic bottles, preserved with H_2SO_4 to a pH below 2 and kept at 4°C until analysis. Samples should be labeled as being preserved. Holding time is 28 days from collection. Sample will be rejected if container is cracked or broken.

APPARATUS:

1) Analytical balance

2) 1000 ml and 250 ml volumetric flasks

3) Oxford 1-5 and 5-10 ml autopipets

4) Lachat QuikChem 8000 FIA instrument including sampler, multichannel proportioning pump, reaction manifold, colorimetric detector, and data system.

5) 13 x 100 mm disposable borosilicate glass culture tubes

ROUTINE MAINTENANCE:

All glassware is cleaned before every use with 1:1 HCl solution.

REAGENTS AND CALIBRATION STANDARDS:

1)DI water. Use for all solutions.

2)Ammonium chloride buffer, pH 8.5. In a 1L volumetric flask, dissolved 85.0 g
- ammonium chloride and 1 g disodium ethylenediamine tetraacetric acid in about 800 mls water. Adjust pH to 8.5 with 15 N NaOH. Dilute to mark and invert to mix.

3) Sulfanilamide color reagent. To a 1 L volumetric flask add about 600 ml water. Then add 100 ml of 85% phosphoric acid, 40 g sulfanilamide, and 1.0 g gN-(1-naphthyl)ethylenediamine dihydrochloride. Shake to wet, and stir to dissolve for 30 minutes. Dilute to mark and invert to mix.

4) Stock Nitrate/Nitrite Standard (10.0 ppm). Add 10 ml of Nitrate standard (1000 ppm) to approximately 800 ml of water in a 1 L volumetric flask. Dilute to mark and invert to mix.

5) Stock Nitrate/Nitrite Standard (50 ppm). Add 50 ml of Nitrate standard (1000 ppm) from a second source to approximately 800 ml of water in a 1 L volumetric flask. Dilute to mark and invert to mix.

SAMPLE PREPARATION:

Be sure to mix sample well to ensure homogenicity.

CALIBRATION AND ANALYSIS PROCEDURE:

I. Set up QuikChem 8000 manifold.

Remove Lachat Nitrate/Nitrite manifold from storage box and install on instrument in channel 2 position. Insert 520 nm interference filter into detector module and connect sample loop (17 cm) in injection valve at the 1 and 4 positions. Detach pump tubing at the pump tube adaptor on the carrier line. Insert the tubing that is still attached to the manifold in the number 3 position on the injection valve and then attach the tubing from the number 2 position on the valve to remaining carrier line.

Attach reagent and sample lines to pump with cassettes and switch on power to the instrument.

II. Input date system information/Place sample and standards into autosampler.

Log into Omnion. Open the NO2/NO3 method (File, Open Method. . .) and the NO2/NO3 tray (File, Open Tray. . .). Place reagent lines into DI water and pump through the manifold with the cadmium column in the closed position. Approximately 10 minutes prior to analysis, place the reagent lines into their respective reagents and allow air to flow through the system before opening the cadmium column. Check for leaks and a smooth flow. Allow the system to equilibrate until a stable baseline is achieved.

Prepare a series of working standards containing 0.0, 0.10, 0.50, 1.0, 5.00, and 10.0 ppm by diluting the 10.0 ppm working standard with DI water which is the carrier reagent for this method. These working standards are then poured into the 20 ml plastic vials and placed in the autosampler with the highest concentration first.

For all determinations, this laboratory utilizes a mid-range check standard and a calibration blank immediately following initial calibration after every tenth sample and at the end of the sample run. The check standard for this method is at a concentration of 5.00 ppm and is prepared from the 50 ppm second source standard (Reagent 5). The blank is an aliquot of the carrier, DI water.

These standards and blanks are inserted into the tray and included in the tray table prior to initiation of the run. All control samples and unknown samples are poured into disposable culture tubes and placed in their respective positions in the tray of the autosampler, which positions are entered into the tray table and saved (File, Save Tray).

III. Run the analysis.

Place reagent transmission lines into the appropriate containers and allow to pump through the manifold for several minutes. Select Run Tray. The instrument is calibrated by first injecting the standards. Check the Replication % RSD by selecting Review in the Main Menu. Print calibration report and curve from the Review menu.

If calibration is greater than or equal to 0.995 correlation coefficient, the instrument will automatically begin analyzing the samples in the order set out in the tray table. If sample concentrations are greater than 10.0 ppm, the sample should be diluted with DI water. This dilution is then inserted into the tray at the end of the original run and its addition is added and saved in the tray table immediately (File, Save tray).

Once the analytical run is complete, the sampler will either stop automatically or can be manually terminated by selecting "Stop" in the main menu toolbar.

QUALITY CONTROL:

See Table I attached for QA/QC procedures.

CALCULATIONS:

Calibration is done by injecting standards. The data system will then prepare a calibration curve by plotting response versus standard concentration.

Values reported are only those which fall between the lowest and highest calibration standards. Answers are multiplied by applicable dilution factors.

Results are reported in mg NO2/NO3/L.

DATA DELIVERABLES:

See Table II for data deliverables.

TABLE I
QUALITY CONTROL LIMITS

QC Analysis	Frequency	Control Limits % Recovery
Calibration Curve	6 months	0.995 Correlation
ICV	1 per batch	80 - 120
CCV	1 per 10 samples	80 - 120
LCS	1 per 10 samples	80 - 120
ICB	1 per batch	<0.500
CCB	1 per 10 samples	<0.500
Preparation Blank	1 per 10 samples	<0.500
Matrix Spike	1 per 10 samples	80 - 120
Matrix SpikeDuplicate	1 per 10 samples	80 - 120 20% RPD

TABLE II
DATA DELIVERABLES

Reports to client will include:

-Date of receipt
-Date of preparation
-Date of analysis
-Analyst
-Matrix
-Laboratory I.D. #
-Client I.D. #
-Analytical method #
-Concentrations determined and limits
-Continuing calibration verification forms
-Continuing calibration blank forms
-Preparation blank forms
-Laboratory control sample forms
-Matrix spike/Matrix spike duplicate summary forms
-Duplicate summary forms
-All raw data
-Preparation records

Standard Operating Procedure For Total Organic Carbon (TOC) For Aqueous Samples

Prepared For SimaLabs International
Organics, Organics Laboratory & Main Laboratory

SW-846, 3rd Edition, Method 9060

Revision # 2.0
Issued: October 14, 1996

Immediate Supervisor	3/8/99 Date
Second Supervisor	3/8/99 Date
QA/QC Officer	3/8/99 Date
Analyst	3/8/99 Date

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STANDARD OPERATING PROCEDURE
TOTAL ORGANIC CARBON (TOC)
AQUEOUS SAMPLES

LOCATION:

Metals Laboratory

REFERENCE:

SW-846, 3rd Edition, Method 9060

MATRIX:

Water, Leachate

DETECTION LIMITS:

1.00 mg/l

RANGE:

1.00 mg/l - 150 mg/l

PRINCIPAL, SCOPE, AND APPLICATION:

This method is used to determine the concentration of organic carbon in ground water, surface and saline waters, and domestic and industrial wastewater.

Organic carbon is measured using a carbonaceous analyzer. This instrument converts the organic carbon in the sample to carbon dioxide by chemical oxidation. The carbon dioxide is then measured directly by an infrared detector. The amount of carbon dioxide in a sample is directly proportional to the concentration of carbonaceous material in the sample.

Carbonaceous analyzers are capable of measuring all forms of carbon in a sample. However, because of various properties of carbon-containing compounds in liquid samples, the manner of preliminary sample treatment as well as instrument settings will determine which forms of carbon are actually measured. The forms of carbon that can be measured by this method:

1. Soluble, nonvolatile organic carbon: e.g., natural sugars.
2. Soluble, volatile organic carbon: e.g., mercaptans, alkanes, low molecular weight alcohols.
3. Insoluble, partially volatile carbon: e.g., low molecular weight oils.
4. Insoluble, particulate carbonaceous materials: e.g. cellulose fibers.
5. Soluble or insoluble carbonaceous materials adsorbed or entrapped on insoluble inorganic suspended matter: e.g., oily matter adsorbed on silt particles.

Carbonate and bicarbonate are inorganic forms of carbon and must be separated from the total organic carbon value. This is accomplished by converting the carbonate and bicarbonate to carbon dioxide and degassing prior to analysis.

INTERFERENCES AND CORRECTIVE ACTION:

Carbonate and bicarbonate carbon represent an interference under the terms of this test and must be accounted for in the final calculation.

This procedure is applicable only to homogeneous samples which can be injected into the apparatus reproducibly by means of a micro liter-type syringe or pipette. The openings of the syringe or pipette limit the maximum size of particle which may be included in the sample.

Removal of carbonate and bicarbonate by acidification and purging with nitrogen, or other inert gas, can result in the loss of volatile organic substances.

Chloride ion can have a profound effect on the oxidation rate of organics in the UV-persulfate system. Normally chloride levels of about 0.10% will be the starting point where the effect is noticeable. If chloride is present or baseline problems exists dilute the sample to reduce the chloride ion concentration.

SAFETY PRECAUTIONS:

Lab coats and safety glasses are to be worn at all times.

SAMPLE SIZE, COLLECTION, PRESERVATION AND HANDLING:

Samples are to be collected in glass 250ml containers with Teflon lined lids, preserved to pH < 2 with H_2SO_4 and kept cool (4C). Samples must be analyzed within 28 days.

APPARATUS AND MATERIALS:

1) Dohrmann DC-80 Total Organic Carbon Analyzer.

2) Micro liter type syringe, 1.0ml

3) Class A volumetric flasks

4) Class A volumetric pipette

ROUTINE MAINTENANCE:

Check gas daily and change when low. Inspect tubing and change as needed.

REAGENTS AND CALIBRATION STANDARDS:

1) Reagent water: ASTM Type II water boiled and cooled to remove CO_2.

2) Potassium Persulfate, 2% solution: Dissolve 20 grams of Potassium Persulfate in 900ml of reagent water add 1ml of concentrated phosphoric acid and dilute to 1 liter.

3) Organic Carbon Standard, 2000 ppm Stock Solution: Dissolve .425 grams of dried Potassium Hydrogen Phthalate in 90ml reagent water, add 0.1 ml of concentrated phosphoric acid, and dilute to 100ml. Store in amber glass container and refrigerate.

4) 150 ppm C standard solution: Add 7.5ml of 2000 ppm stock standard solution to 100ml volumetric flask and dilute to mark with reagent water. Store in amber glass container and refrigerate.

5) 10.0 ppm C standard solution: Add 0.5ml of 2000 ppm stock standard solution to a 100ml volumetric flask and dilute to mark with reagent water. Store in amber glass container and refrigerate.

6) 2.0 ppm C standard solution: Add 0.1ml of 2000 ppm stock standard solution to a 100ml volumetric flask and dilute to mark with reagent water. Store in amber glass container and refrigerate.

7) Blank solution: Same type II water used to make standards.

START-UP PROCEDURES:

1) Turn on white power switches for the main power, pump, lamp, and electronics.

2) Open the gas cylinder and adjust outlet pressure to 30 psi. Measure the gas flow at the detector out port to verify that the flow is in the range of 180-220 ml/min.

3) Verify that the reactor is filled with reagent, printer tape is installed, mode switch is in the TOC position, and the detector switch is in the ppm position.

4) After approximately 10 min warm up and if the detector has been on for two hours or more the instrument is ready to operate. The detector generally should be left on at all times, except when used intermittently, and then it should be turned on the day before use.

5) Clear the calibration factor memory by pressing the "CALIB" button for at least a full second, the light will turn off.

6) Place approximately 15ml of the 10ppm standard in a testube and acidify to pH < 2 with five drops of 10% phosphoric acid and sparge for at least three minutes.

7) Set volume select switch to 1ml. Press the green start button and inject 1ml of the 10 ppm standard. The ready light will go out and the start light will come on.

8) The display will show the integrated signal as a four digit number. Lift the protective cap on the yellow "CALIB" switch. The yellow light will come on.

9) The signal generated by the detector is fed to the microprocessor and it calculates the peak area above the baseline. The peak is multiplied by an arbitrary constant which has previously stored, to obtain a more reasonable number (a_1) which is close to the ppm of the standard. This number is displayed on the meter and printed on the tape at the end of an analysis.

10) The microprocessor compares a_1 with the value preset at the factory to determine whether or not a_1 is a reasonable value. If it is not, the message is printed on the tape, like ABNORMAL HIGH STD.

11) If this is the case stop analysis and check tubing and connections for leaks. Also make sure the correct standard solution was injected.

CALIBRATION PROCEDURES:

1) Place approximately 15ml of blank in a testtube, acidify with five drops of 10% phosphoric acid and sparge for at least three minutes.

2) Withdraw 1ml, push green start button and inject. The ready light will go out and the start light will come on.

3) The digital display will show increasing accumulation of counts. When the detector signal is essentially back to original base line, the analysis will terminate automatically.

4) The ready light will come on and the start light will go off. The display will show the integrated signal as a four digit number and it will also be printed.

5) Repeat steps 1 through 4 with the 2.0ppm, 10ppm, 150ppm standards. Input concentration vs. instrument output into calculator capable of preforming linear regression analysis.
Correlation coefficient must be ≥ 0.995, if not terminate and begin from the start.

SAMPLE PREPARATION AND ANALYSIS PROCEDURE:

1) Place approximately 15ml of samples in a testtube, acidify to pH 2-3 with five drops of 10% phosphoric acid and sparge for at least five minutes.

2) Withdraw 1.0ml of sample, push green start button and inject.

3) The digital display will show increasing accumulation of counts. When the detector signal is essentially back to original base line, the analysis will terminate automatically.

4) The ready light will come on and the start light will go off. The display will show the integrated signal as a four digit number and it will also be printed.

5) Input the result into the calculator. The linear regression will convert the instrument output into concentration of carbon in ppm.

QUALITY CONTROL:

1) This method requires all samples be run in duplicate.

2) Dilute and re-analyze samples that are more concentrated than the high standard.

3) Analyze a matrix spike and matrix spike duplicate every ten samples. The RPD must be within 20%.

4) Verify calibration with a midlevel standard every ten samples. The check standard should agree within 10%. If it does not, analysis will be terminated and instrument recalibrated.

5) Recalibrate every twenty samples.

DATA TREATMENT:

The concentration of Organic Carbon in ppm is calculated from the linear regression (calibration curve).

If dilution was required:

$$\text{ppm or mg/l Organic Carbon in sample} = A \times \frac{(C+B)}{C}$$

where,

A = mg/l of Organic Carbon from calibration curve
B = blank used for dilution, ml
C = sample aliquot, ml

Relative percent difference is calculated as follows:

$$RPD = \frac{D_1 - D_2}{(D_1 - D_2)/2} \times 100$$

RPD = Relative Percent Difference
D_1 = First sample value
D_2 = Second sample value

The spike recovery is calculated as follows:

$$\%R = \frac{SS - S}{SA} \times 100$$

%R = Percent recovered
SS = Spike sample value
S = Sample value
SA = Spike Added

DATA DELIVERABLES:

Reports to client will include:

- Date of receipt
- Date of preparation
- Date of analysis
- Analyst
- Matrix
- Laboratory ID#
- Client ID#
- Analytical method#
- Concentrations determined and EQL's
- CCV summary form
- Spike sample recovery form
- Duplicate spike sample summary form
- All raw data
- Preparation records

Standard Operating Procedure For Alkalinity For Aqueous Samples

Prepared For SIMALABS International
Wet Chemistry, Main Laboratory

EPA 600/4-79-020, Method 310.1

Revision # 2.0
Issued: March 1, 1996

Immediate Supervisor	3/8/99 Date
Second Supervisor	8 MAR 99 Date
QA/QC Officer	3/8/99 Date
Analyst	3-8-99 Date

Effective: March 1, 1996

CAUTION

<u>Disclaimer:</u> This Standard Operating Procedure has been prepared for the sole use of SimaLabs International and may not be specifically applicable to the activities of other organizations.

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ALKALINITY
FOR AQUEOUS SAMPLES

LOCATION:

Wet Chemistry, Main Laboratory

REFERENCE:

310.1 EPA 600/4-79-020, 1978

MATRIX:

Waters, wastewaters, leachates and aqueous

DETECTION LIMIT:

10 mg/L

RANGE:

10.0 to 5000 mg/L

PRINCIPLE, SCOPE, AND APPLICATION:

An aqueous sample is titrated to a potentiometrically determined end point of pH 4.5. The sample must not be filtered, diluted concentrated, or altered in any way. This method is suitable for all concentration ranges of alkalinity; however, appropriate amounts should be used to avoid a titration volume greater than 50 ml.

INTERFERENCES AND CORRECTIVE ACTION:

Substances, such as salts of weak organic and inorganic acids present in large amounts, may cause interference in the electrometric pH measurements. Oil

and grease, by coating the pH electrode, may also interfere, causing a sluggish response.

SAFETY PRECAUTIONS:

Wear lab coat, safety glasses, and gloves. Sulfuric acid can cause severe burns. Handle with care. Glassware is very slippery when wet. Handle with care. Refer to MSDS for inquiries about reagents or chemicals used in this test. The MSDS is located in the Main Laboratory.

SAMPLE SIZE, COLLECTION, PRESERVATION, AND HANDLING:

Samples (500 ml) should be collected in a 500 ml plastic container and kept at 4°C until analysis. Holding time is 7 days from time of collection. Preservation is not necessary. Sample will be rejected if container is cracked or broken, at which time the immediate supervisor will be notified.

APPARATUS:

1) pH meter

2) 25 to 50 ml buret (Fisher, 03-700-22B & 03-700-22C)

3) magnetic stir plate and (2) stir bars

4) (2) 250 ml beakers (Fisher, 02-540K)

5) 100 mL graduated cylinder

ROUTINE MAINTENANCE:

KCl solution is replaced as needed. Probe is kept clean of oils and greases. Buret is rinsed thoroughly before and after use, the tip is checked for cracks and breakage, and the stopcock is checked for leakage.

REAGENTS AND CALIBRATION STANDARDS:

1) Sulfuric acid titrant 0.02 N (Fisher cat# SA226-1)

2) Sulfuric acid titrant 1.00 N (Fisher cat# SA212-1)

3) pH 4.00 buffer (Fisher cat# SB101-20)

4) pH 7.00 buffer (Fisher cat# SB107-20)

5) pH 10.00 buffer (Fisher cat# SB115-20)

CALIBRATION PROCEDURES:

Calibrate pH meter as described in A_2I "STANDARD OPERATING PROCEDURE FOR pH" (SOP-1501).

SAMPLE PREPARATION:

N/A

ANALYSIS PROCEDURE:

1) Put a measured amount of sample (usually 50.0 mL) into a 250 ml beaker. Add a magnetic stir bar, place beaker on a magnetic stir plate, and gently start the sample mixing.

2) Measure the pH of the sample.

3) Fill a 25 mL or 50 mL buret with 0.02 or 1.0 N H2SO4 solution, depending on the alkalinity of the sample.

4) Add titrant in small amounts to begin with, being careful to stir thoroughly to allow pH meter to equilibrate.

5) Titrate to pH 4.5 or 8.3, depending on the initial sample pH.

6) Record volume of titrant used.

QUALITY CONTROL REQUIREMENTS:

See Table I attached for QA/QC procedures.

CALCULATIONS:

$$\text{Alkalinity (mg/L } CaCO_3) = \frac{A \times N \times 50{,}000}{C}$$

where A = amount of titrant (ml)
N = normality of titrant
C= amount of sample (L)

DATA DELIVERABLES:

See Table II for data deliverables.

TABLE I
QUALITY CONTROL LIMITS

QC Analysis	Frequency	Control Limits % Recovery
LCS	1 per 10 samples	80 - 120
Preparation Blank	1 per 10 samples	<10.0
Matrix Spike	1 per 10 samples	N/A
Matrix Duplicate	1 per 10 samples	20% RPD

TABLE II
DATA DELIVERABLES

Reports to client will include:

-Date of receipt
-Date of preparation
-Date of analysis
-Analyst
-Matrix
-Laboratory I.D. #
-Client I.D. #
-Analytical method #
-Concentrations determined and limits
-Continuing calibration verification forms
-Continuing calibration blank forms
-Preparation blank forms
-Laboratory control sample forms
-Matrix spike/Matrix spike duplicate summary forms
-Duplicate summary forms
-All raw data
-Preparation records

Control Copy #: NA

@ AIR TOXIS LIMITED
STANDARD OPERATING PROCEDURE

DISSOLVED GAS ANALYSIS IN WATER SAMPLES USING A GC HEADSPACE EQUILIBRATION TECHNIQUE

SOP # 58

Effective Date: 2/12/99
Revision #: 1
Reason for Revision: To include the use of the Headspace Autosampler

	Signature	Print	Title	Date
Written By:		HEIDI HAYES	TEAM LEADER	2/12/99
Technical Review:		SANDIA KAO	CHEMIST	2/12/99
QA Review:		Marie Jeanne deForest	QA Manager	2/12/99
Laboratory Director:	Linda L. Freeman			2/12/99

1.0 PURPOSE

This method is applicable to the preparation of water samples for analysis of the headspace to quantify part-per-billion levels of dissolved gases in the water sample. This method has been used specifically for determining methane, ethane, and ethylene.

This method is restricted to use by or under the supervision of analysts experienced in sample preparation and in the use of gas chromatography and the interpretation of chromatograms.

2.0 PROCEDURES

2.1 A water sample is collected, in the field or in the laboratory, in a 40 ml VOA vial using a Teflon faced septum and cap of the appropriate size to fit the vial, or equivalent. There must be no headspace in the sample vial. In the laboratory, an aliquot of the sample is injected into a nitrogen-purged vial and placed into a headspace autosampler where each sample is shaken and heated prior to injection. The autosampler then injects an aliquot of headspace onto a gas chromatographic column where the gaseous components are separated and detected by a flame ionization detector.

2.2 Materials, Supplies and Equipment

- 80/100 mesh Poropak N Column
- Gas Chromatograph: HP6890 GC/FID
- HP Chemstation Software
- Scotty Certified Gas Standard
- Ultra High Purity Nitrogen (Local Supplier)
- Ultra High Purity Helium (Local Supplier)
- 5ml Luerlock glass syringe with a 20 gauge needle
- 0.5 or 1.0 ml gas tight syringe
- 20 ml headspace vials (22.5 X 75 mm) or serum bottles
- Rubber Teflon faced septum cap
- 40 ml VOA vials, or equivalent
- HP7694 Headspace Autosampler

2.3 Gas Chromatographic Operating Conditions

- Injection Temperature: 200 C
- Oven Temperature: Isothermal at 50 °C
- Carrier Gas from HP7694: UHP Helium at 18 ml/min
- Make up carrier gas: UHP Helium at 2 ml/min
- Detector Temperatures: 275 C

3.0 SAMPLE COLLECTION

Water samples should be collected in the field by placing the sample in a 40 milliliter (ml) VOA vial. The sample is carefully poured down the side of the vial so as not to agitate or aerate the sample. The vial is filled to the top and capped using a butyl rubber Teflon faced septum cap. Care should be taken so there are no bubbles in the vial. Field samples should be preserved with 1:1 hydrochloric acid to a pH less than 2 before capping sample. Do not add acid if carbon dioxide analysis is to be performed since the acid may convert inorganic carbon to carbon dioxide. Store samples at 4°C and analyze within 14 days of collection.

4.0 SAMPLE PREPARATION AND ANALYSIS

Take several clean, 20 ml headspace vials (22.5 X 75 mm) or serum bottles, and purge with dry, high purity nitrogen for 45 seconds. This displaces ambient air from the vial. Immediately, cap the vial with a rubber Teflon faced septum crimp cap. These vials are used for both the calibration standards and the samples.

Take the sample vials from the refrigerator, immediately invert and remove a 5ml aliquot using a 5ml Luerlock glass syringe with a 20 gauge needle. Slowly inject (i.e., dribble) the 5 ml aliquot into the headspace or serum vial (which has been previously filled with nitrogen). This "injection" is done slowly in order to prevent the sample from atomizing during the process. The headspace or serum vial now contains 5ml of water and 15ml of headspace. The sample vial is then placed on the autosampler equipped with an oven, shaker and 1.0 ml sample loop. The sample is heated and allowed to equilibrate at 40 deg C for 15 minutes with high agitation. The injection is made by pressurizing the vial to 5.4 psi to fill the 1.0 ml sample loop. After the loop is filled the injection is made onto the GC column.

Dilutions of samples which are over the calibration range are accomplished by using an aliquot of sample less than 5.0 ml and bringing to 5.0 ml volume with the laboratory blank DI water. This technique maintains a headspace volume of 15 ml.

After GC analysis is successfully completed, remove the cap from the vial and dispose of the sample in an appropriate manner.

5.0 CALIBRATION

A 5-point calibration is performed using standards prepared as follows. Five 20 ml headspace or serum vials are purged with high purity nitrogen as described above. Five mls of high purity water are placed in headspace or serum vial. Gas phase standards are injected into the water contained in each vial as noted in Attachment A.

The analyte(s) present in the samples will partition between the water and the gas phase according to Henry's law. The concentration present in the gas phase is measured on the GC. A calibration curve of the area counts v. the analyte concentration is plotted and used to obtain an average response factor.

6.0 CONVERSIONS

Conversion from ppmv of gas phase standards to ug/ml of headspace is performed as follows.

Gas phase standard concentration = 100 ppmv
5.0 ml of gas phase standard injected into 5 ml water

Example calculation for methane:

µG (methane) = (100 ppmv)(FW= 16)(5.0 ml methane)/24055
µG (methane) = 0.33 ug/ml

Concentration of Methane in Water = 0.33 µG methane/ 5 ml water = 0.066 µG/ml

7.0 QUALITY CONTROL

8.1 Initial Calibration Curve

The percent relative standard deviation (%RSD) for the initial curve must be less than or equal to 30%. The average response factor for each compound is used to calculate sample results.

8.1.1. Initial Calibration Verification (ICV)

A mid-level standard prepared from a separate source is analyzed following the initial calibration. The recoveries must be 70%-130%. If a compound fails, the system is checked and the standard re-analyzed.

8.2 Continuing Calibration Verification (CCV)

The CCV is compared with the Initial Calibration Curve. The recoveries for this check must be between 70% and 130%. If a compound fails, the system is checked and the standard re-analyzed. If the system is found to be out of control, a new calibration curve is analyzed. CCV is reported as the Method Spike.

The CCV is repeated after approximately every 20 samples. The CCV is followed by a laboratory blank.

8.3 Laboratory (Method) Blank

The laboratory blank, consisting of deionized water prepared in the same type of vial used for the samples, should not contain target analytes at or above reporting limit of 0.01µG/ml. If target analytes are detected above the reporting limit a new laboratory blank is prepared and analyzed.

8.4 Laboratory Duplicates

A laboratory duplicate (prepared from either two separate vials, or two aliquots from the same vial) is analyzed at a frequency of 10%. The relative percent difference (RPD) between the results should be < or = 30%.

8.5 End Check

A calibration check should be run at the end of each analytical batch. The acceptance criteria is ±30%.

8.6 Method Detection Limit Study

The limit of detection is determined in accordance with the guidelines of Appendix B, Part 136 of the Federal Register 40 CFR. The 99% confidence level is used to determine MDLs.

9.0 SAFETY

Normal safety procedures should be followed. The procedures described in this SOP are designed for skilled chemists trained in the safe operation of analytical gas chromatographic equipment and sample handling.

Attachment A - Preparation of Calibration Standards

Attachment A

Bag Blend Standard Preparation Log

@Air Toxics Ltd. Log Book #: 447

Standard ID: 447-83
Analyst: DALE CLUTTER
Preparation Date: N/A
Expiration Date: N/A

Bag Blend Standard Calculation:

$$ppmv = \frac{(\text{Volume added uL})\ (\text{density})\ (1000)\ (24.055)\ (\text{Purity})}{(\text{Formula Weight})\ (\text{Final Volume L})}$$

AC 1/16/99

Final Volur

METHANE

volume of std. injected (mL)	standard concentration (ppmv)	stock standard ID	ug loaded into vial	water volume (mL)	water concentration (ug/mL)
1.000	9760	447-22	6.492	5.0	1.298

ETHYLENE

volume of std. injected (mL)	standard concentration (ppmv)	standard ID	ug loaded into vial	water volume (mL)	water concentration (ug/mL)
1.0	10000	447-23	11.640	5.0	2.328

ETHANE

volume of std. injected (mL)	standard concentration (ppmv)	standard ID	ug loaded into vial	water volume (mL)	water concentration (ug/mL)
1.0	10000	447-24	12.471	5.0	2.494

Compound	ppmv

Procedure/

ug into vial = (ppmv of standard (MW) (mL injected))
24055

Vials spiked with appropriate volumes of standards, shake at high setting and equilibrate in an oven at 40C for 15 minutes using HP 7694 autosampler.

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