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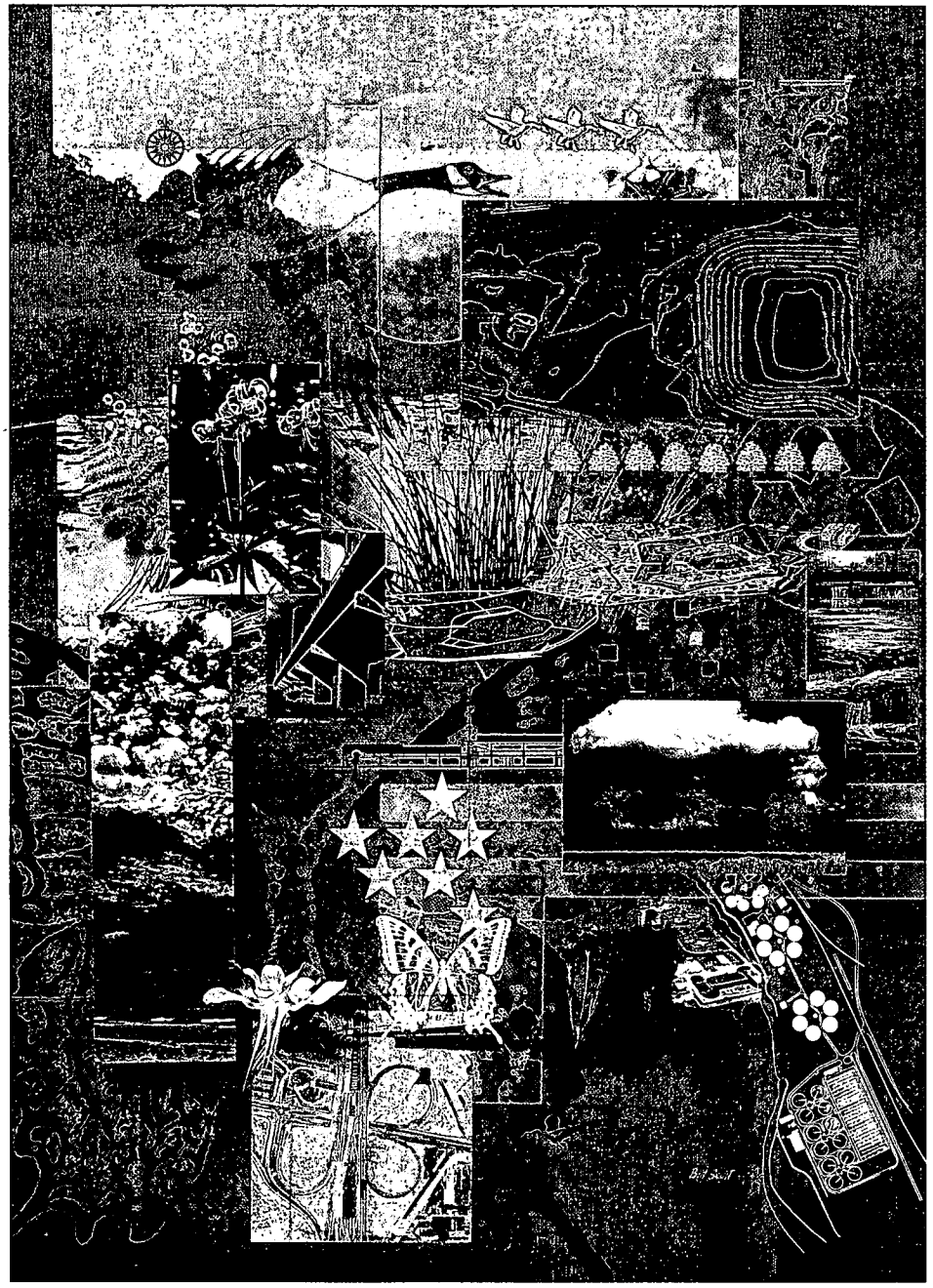

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FINAL
Technical Memorandum

Groundwater Trend Analysis:

Ammunition Burning Ground, Demolition Range, and Old Rifle Range

Naval Surface Warfare Center
Crane Division

Crane, Indiana

Prepared for:

Southern Division
Naval Facilities
Engineering Command
Charleston, South Carolina

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1.0 INTRODUCTION

1.1 PURPOSE OF THIS TECHNICAL MEMORANDUM

This Technical Memorandum (Ground Water Trend Analysis) was prepared for the Southern Division, Naval Facilities Engineering Command by Rust Environment & Infrastructure (Rust) in preparation for the human health risk assessment of three Solid Waste Management Units (SWMUs) at the Naval Surface Warfare Center, Crane Division, Crane, Indiana (NAVSURFWARCENDIV). The three SWMUs under evaluation as part of the risk assessment are #03/10 Ammunition Burning Ground (ABG), #07/09 Old Rifle Range (ORR), and #06/09 Demolition Range (DR). ABG also includes two areas outside of the SWMU: the Jeep Trail Area and the boundary wells, located along Little Sulfur Creek.

The purpose of this Technical Memorandum is to present the results of a temporal trend analysis of ground water quality at ABG, ORR, and DR. This Technical Memorandum details the methodologies that were used by Rust in performing this analysis. The Risk Assessment Work Plan prepared by Rust (Halliburton NUS, 1995) described the procedures that will be used to assess the potential risks to human health from contact with ground water contaminants at these SWMUs. Historically, numerous field investigations and ground water sampling events have been conducted at the SWMUs. The Work Plan indicated that if there is a temporal trend in these historical data in terms of contaminant levels, the most recent data would be proposed as the most appropriate data for calculating the exposure concentration term in the risk assessment. However, if no trend is present, it was proposed that a time-weighted average concentration be calculated for each analyte in a given well for use in the risk assessment.

The results of this Technical Memorandum (Ground Water Trend Analysis) will be used in the decision process for selecting the appropriate ground water database for use in the risk assessment.

1.2 ORGANIZATION OF THIS TECHNICAL MEMORANDUM

This Technical Memorandum begins with a listing of the available documentation for the project database for ground water: the reports, the analytical documents and the electronic files received (Chapter 2.0 - Project Database). This Technical Memorandum then discusses the methods used to assemble, standardize and tabulate the analytical data received in electronic format (Section 3.0 - Data Management). Analyte selections, monitoring well selections, and statistical procedures are presented along with the results of the trend analysis in Section 4.0. This Technical Memorandum summarizes the study's conclusions (Section 5.0 - Conclusions) and identifies follow-up issues (Section 6.0 - Outstanding Issues) yet remaining to be resolved prior to the completion of the risk assessment.

2.0 PROJECT DATABASE

The first step in the Ground Water Trend Analysis was to obtain the ground water analytical data to be evaluated for potential use in the risk assessment. This Section of the Technical Memorandum presents the project information/database for ground water: the reports, the analytical documents and the electronic files received by Rust from two main contacts. These two project contacts are W.L. Murphy (US Army Corps of Engineers) and T. Brent (NAVSURFWARCENDIV).

2.1 REPORTS AND ANALYTICAL DOCUMENTS RECEIVED

Table 2-1 summarizes the reports received for use on this project, which include the presentation of ground water quality data for various sampling events as well as discussions of the nature and extent of potential contamination at ABG, ORR, and DR. The reports for ABG include data for samples collected from 1987 through 1992 and for one sampling event in 1993. The reports for ORR and DR include data for samples collected from 1990 through 1992 and for one sampling event in 1993. The summary information provided in these reports was used to select the analytes and monitoring wells of potential concern for the trend analysis (as discussed in Section 4.0). These reports were also reviewed to assess the level of data validation and the availability of laboratory QC data (as discussed in Section 6.0).

Table 2-2 summarizes the laboratory analytical documentation received for use on this project. Seventeen analytical documents, prepared by three laboratories, represent 'hard copy' versions of ground water quality data collected for various sampling events from 1992 through 1995. These documents were reviewed for this project to assess the level of data validation and the availability of laboratory QC data (as discussed in Section 6.0).

2.2 ELECTRONIC FILES RECEIVED

Prior to the trend analysis of the project groundwater data, a total of 189 electronic data files were received (Table 2-3; also see detailed listing in Appendix A). The files were received from W.L.Murphy at the Army Corps of Engineers-Vicksburg, Mississippi; T. Brent at NAVSURFWARCENDIV, Crane, Indiana; and the Rust E&I computer facilities in Sheboygan, Wisconsin. 'Hard copy' documentation corresponding to some of the data files were also received (as outlined previously in Section 2.1).

These electronic files contained a total of 128,626 electronic records documenting ground water sampling events from 1981/87/90 through 1995 at the three SWMUs. These files required further consolidation and standardization of the data format following our initial screening of the file contents. This process is described in the next section, under 'Data Management' (Section 3.0). Once the Data Management process was completed for the project, these electronic files served as the primary database for the Ground Water Trend Analysis. It was discovered, however, that the electronic database lacked some of the data provided as 'hard copy' documentation. Nevertheless, the trend analysis was conducted on the electronic version of the data.

TABLE 2-1
SUMMARY OF GROUND WATER
REPORTS
RECEIVED FOR POTENTIAL USE IN THE RISK ASSESSMENT
CRANE, INDIANA

SITE	REPORT NAME	AUTHOR	MONITORING WELL SAMPLING DATES
ABG	FINAL REPORT (May 1994): RCRA Facility Investigation Phase III Ground Water Release Characterization SWMU 03/10.	W.L. Murphy (US Army Corps of Engineers)	1987 through 1992
	ADMINISTRATIVE REPORT (1993): Quality Control Data and Analytical Data for Ground Water at the Ammunition Burning Ground, Naval Warfare Center, Crane Division, Crane Indiana.	M.R. Risch (US Dept. of the Interior, US Geological Survey)	August - September 1993
ORR/DR	DRAFT REPORT (February 1994): RCRA Facility Investigation Phase III Ground Water Release Characterization SWMU 07/09 and RCRA Facility Investigation Phase II Ground Water Release Assessment SWMU 06/09.	W.L.Murphy & R. Wade (US Army Corps of Engineers)	November 1990 through December 1992
	ADMINISTRATIVE REPORT (1993): Quality Assurance, Quality Control and Analytical Data for Ground Water at the Demolition Area and the Old Rifle Range, Naval Warfare Center, Crane Division, Crane Indiana.	M.R. Risch (US Dept. of the Interior, US Geological Survey)	July 1993

TABLE 2-2
SUMMARY OF GROUND WATER
LABORATORY ANALYTICAL DOCUMENTATION
RECEIVED FOR POTENTIAL USE IN THE RISK ASSESSMENT
CRANE, INDIANA
PAGE 1 OF 3

SITE	DOCUMENT DATE	MONITORING WELL SAMPLING DATES	LABORATORY	GENERAL SUMMARY OF ANALYTICAL DOCUMENT
ORR/DR	July 1993	July 1993	Enseco	Approximately 12 wells for 20 metals, RCRA Appendix IX VOCs, SVOCs, pesticides/PCBs, herbicides, explosives, and TICs.
ORR	July 1994	July 1994	Synergic	Approximately 8 wells for WQ, metals, phenols and explosives.
	Jan 1995	Jan 1995	Synergic	Approximately 11 wells for WQ, metals, and explosives.
	July 1995	Aug 1995	Synergic	Approximately 11 wells for WQ, metals, and explosives.
ORR/DR	July 1993	July 1993	Enseco	Approximately 10 wells for 20 metals, RCRA Appendix IX VOCs, SVOCs, pesticides/PCBs, herbicides, and TICs.
DR	July 1994	July 1994	Synergic	Approximately 11 wells for WQ, phenols and metals.
	Jan 1995	Jan-Feb 1995	Synergic	Approximately 13 wells for WQ and metals.
	July 1995	Aug 1995	Synergic	Approximately 12 wells for WQ and metals.
ABG	Sept 1993	Aug-Sept 1993	Enseco	Approximately 30 wells and 3 springs for 20 metals, RCRA Appendix IX VOCs, SVOCs, pesticides/PCBs, herbicides, explosives, and TICs.
	July 1994	July 1994	Synergic	Approximately 27 wells and 3 springs for WQ, coliform, metals, explosives, VOCs, gross alpha/beta, phenols, phthalates, Method 8080 pesticides, and Method 8151 herbicides.

TABLE 2-2
SUMMARY OF GROUND WATER
LABORATORY ANALYTICAL DOCUMENTATION
RECEIVED FOR POTENTIAL USE IN THE RISK ASSESSMENT
CRANE, INDIANA
PAGE 2 OF 3

SITE	DOCUMENT DATE	MONITORING WELL SAMPLING DATES	LABORATORY	GENERAL SUMMARY OF ANALYTICAL DOCUMENT
ABG continued	Jan 1995	Jan-Feb 1995	Synergic	Approximately 32 wells and 3 springs for WQ, coliform, metals, explosives, VOCs, gross alpha/beta, phenols, phthalates, Method 8080 pesticides, and Method 8151 herbicides.
	July 1995	July 1995	Synergic	Approximately 8 wells and 3 springs for WQ, coliform, metals, explosives, VOCs, gross alpha/beta, phenols, phthalates, and Method 8080 pesticides.
ABG, ORR, and DR	Jan 1992	Jan 1992	Anacon	>50 wells and approximately 7 springs. Most samples analyzed for metals, WQ, explosives, VOCs, and phthalates. Select samples also analyzed for Method 8080 pesticides, herbicides, and radionuclides.
	April 1992	April 1992	Anacon	Well list at beginning of report. >50 wells and approximately 7 springs sampled. Well samples generally analyzed for metals, WQ, TCE, 1,1,1-TCA, explosives, and phthtalates. Spring samples also analyzed for Method 8080 pesticides, herbicides, and radionuclides.
	July 1992	July 1992	Anacon	Well list at beginning of report. >50 wells and approximately 7 springs sampled. Most samples analyzed for metals, WQ, explosives, VOCs, phthalates, Method 8080 pesticides, herbicides, and radionuclides.

TABLE 2-2
SUMMARY OF GROUND WATER
LABORATORY ANALYTICAL DOCUMENTATION
RECEIVED FOR POTENTIAL USE IN THE RISK ASSESSMENT
CRANE, INDIANA
PAGE 3 OF 3

SITE	DOCUMENT DATE	MONITORING WELL SAMPLING DATES	LABORATORY	GENERAL SUMMARY OF ANALYTICAL DOCUMENT
ABG, ORR, and DR continued	Oct 1992	Oct 1992	Anacon	Well list at beginning of report. >50 wells and approximately 3 springs sampled. Well samples generally analyzed for metals, WQ, TCE, 1,1,1-TCA, explosives, and phthtalates. Spring samples also analyzed for Method 8080 pesticides, herbicides, and radionuclides.
	Jan 1993	Jan 1993	Anacon	Well list at beginning of report. >50 wells and approximately 3 springs sampled. Samples generally analyzed for metals, WQ, TCE, 1,1,1-TCA, and explosives.
	Jan 1994	March 1994	Anacon	>50 wells and approximately 3 springs sampled. Samples generally analyzed for metals, WQ, TCE, 1,1,1-TCA, and explosives.

Notes:

VOCs - Volatile organic compounds.
SVOCs - Semivolatile organic compounds.
WQ - Water quality parameters. May include analytes such as pH, conductivity, temperature, total organic carbon (TOC), total organic halides (TOX), sulfate, chloride, nitrate, etc. Lists for WQ parameters were not consistant.
TCE - Trichloroethylene
1,1,1-TCA - 1,1,1-Trichloroethane
TICs - Tentatively identified compounds.
Metals - The list varied from approximately three select metals to a list of 20 metals.

TABLE 2-3
SUMMARY OF GROUND WATER
ELECTRONIC DATA
RECEIVED FOR POTENTIAL USE IN THE RISK ASSESSMENT
CRANE, INDIANA

SITE	TOTAL ELECTRONIC RECORDS	NUMBER OF ELECTRONIC FILES[A]	SOURCE OF FILES	MONITORING WELL SAMPLING DATES
ABG/ORR/DR	44777	14 Files in '.dbf' Format	T. Brent (NAVSURFWAR-CENDIV)	1981 -- 1995
	991	54 Files in EXCEL Format	T. Brent (NAVSURFWAR-CENDIV)	March 1994
	8163	1 File in '.dbf' Format	Rust E & I	August 1995
ABG	32758	7 Files in '.dbf' Format	W.L. Murphy (US Army Corps of Engineers)	1987 -- 1992
	1534	9 Files in '.dbf' Format	W.L. Murphy (US Army Corps of Engineers)	September 1994
ORR/DR	40403	104 Files in '.dbf' Format	W.L. Murphy (US Army Corps of Engineers)	1991 -- 1992

NOTES: [A] Appendix A provides a summary listing of all electronic files received for use in this project.

3.0 DATA MANAGEMENT

3.1 DATA ASSEMBLY

The data which were received in electronic format and which were selected for the trend analysis required significant reformatting and standardization. As a first step in this process, the initial electronic data files were screened for file contents and format. The data files consisted of 5 typical formats in either database (.dbf), ASCII text, or Excel spreadsheet format. The database files were combined into larger files where the database table structure was found to be similar. A few ASCII text files required uploading to the database format due to missing ".dbf" format files for the corresponding data. Using spreadsheet macros, the Excel spreadsheet format was rearranged into a spreadsheet tabular format and then uploaded into the ".dbf" database format. This consolidation process resulted in six database files with a combined total of over 128,000 records. Data covered analyses conducted from 1981 to the present. Once the six files resulting from the consolidation were constructed, the data required standardization of the various important data fields.

3.2 FORMAT STANDARDIZATION

For the trend analysis, standardization of data format was necessary for a number of electronic file fields including **analytes**, **well names**, **sampling dates**, **results**, **units**, and **result qualifier codes**. To begin this process, all duplicate records within each of the six database files were removed. Following this process, numerous spelling, punctuation and typographical differences were found to be present in the analytes and well names. These required standardization of names among all files.

Analyte names required the consolidation and standardization of several hundred analytes among the electronic data files. For some metals results, it was not possible to quickly determine if analyte names (and corresponding results) were for the 'total' or 'dissolved' constituents. In these cases, 'total' was used as the default assumption.

Well names were also checked versus site maps to standardize names among files. A limited number of wells, deemed appropriate to the trend analysis (described in Section 4.1 below), were chosen to focus the scope of the trend analysis. Data corresponding to these limited number of wells were then pulled from the six database files into six temporary data files. Data corresponding to the analytes of interest for these wells were next pulled from the six temporary files. This further narrowed the amount of data in the six temporary files selected for the trend analysis.

These focused data files still consisted of six separate table structures. Dates of sampling events were addressed next in the standardization process. Two data formats for dates were encountered in the electronic data files. Also, a significant number of dates were missing or located in the wrong data field. When missing dates could not be quickly replaced from other sources, these records were omitted from the final analysis. The total data records involving missing-dates that were removed were not considered to be significant when compared to the total number of data records retained. Dates were also grouped into sampling events based on an assumed month and year. The sampling

dates were scanned for groups of similar dates and then grouped within a month and year (e.g. 12/31/92, 1/03/93, and 1/04/93 were grouped as January, 1993 and labeled "93-01").

Similar to dates, blank results (i.e., data records with blank entries for the analytical result) were eliminated from the database files. The various formats among files required rearrangement of results data due to inclusion of method detection limits in some files and not in others. The final results field used in the trend analysis either included the reported result as a 'hit,' the method detection limit (if available) for 'non-hits,' or a zero value for those results listed as 'ND' (or 'not detected'). In the trend analysis, nondetects were considered as zero values; therefore, results reported only as 'ND' were acceptable for use in the analysis.

Between all six focused data files, concentration units were then standardized. All results were analyzed for trend using milligram per liter (mg/L) units. Those analytical results not reported in these units required conversion to proper units. Some of the data files did not contain any units; however, further inquiry into other sources of information to obtain the appropriate units did allow further use of these data in the trend analysis.

Result qualifier codes were the next data field item to be standardized among all six focused data files. For the purposes of this trend analysis, only the difference between detects and nondetects was important. All Rust data from Fall 1995 were previously validated and detects were considered for 'J', 'D' (for diluted samples), and no codes. Nondetects were considered for 'UJ' and 'U' codes. All other data was characterized by only laboratory QC codes, and thus, only those codes included with the data from the labs were considered for judging detects versus nondetects. Codes containing at least '<', 'U', or 'ND' were considered as nondetects. All others were considered as detects. This approach, when attempting to find trends, places additional validity on results that may not be truly detects due to coding or incomplete independent validation. As a result of this approach, trends are expected to appear more frequently than normally anticipated.

Once all of the above standardization was achieved on the six data files, the data in the relevant fields required for the trend analysis were pulled from each of the six files and first checked for any duplicate records. For any duplicate records, the highest detect was left in the data file for the trend analysis. Following removal of duplicates from the six files, all six were consolidated into one file for use in the trend analysis. The consolidated file was then checked for duplicate records which could have been received from more than one source and format.

For the trend analysis, only data from sampling dates from 1987/90 through 1995 were used since older data did not exist (ORR/DR), was incomplete, or had not been included in the RFI reports prepared by USACE (Murphy, 1994; Murphy and Wade, 1994). Only those data for these dates were included in the final consolidated data file. Also, only the chemicals of interest that had at least one 'hit' over these sampling dates were included in the final database because there was no point in conducting a trend analysis on all nondetect data. Those chemicals not meeting this criteria were removed from the consolidated database. The full original data set consisting of over 128,000 records was gleaned down to about 3700 records following the process described above.

3.3 DATA TABULATION

The data to be used for the trend analysis were compiled into tables from the finalized database described in the above section. The data were compiled in summary tables for analyte versus date for each well. A total of 41 wells and one spring were analyzed for trend based on the data in these tables. For tabulation purposes, the data were also further grouped by SWMU and then by aquifer within each SWMU. The summary tables that were prepared for this project are included in Appendix B. In addition, as discussed in Section 4.0 (below), a table was compiled based on the trend analysis that shows the results as '*YES*' or '*NO*' indicating a trend or no trend, respectively.

4.0 TREND ANALYSIS

4.1 ANALYTE AND WELL SELECTION

The reports listed previously in Table 2-1 (Section 2.1) were reviewed in order to select 'high priority' analytes and 'high priority' monitoring wells for the Ground Water Trend Analysis. The total electronic data available to this project are enormous and represent samples collected from 119 wells (72 wells at ABG and 47 wells at ORR/DR, screened in several aquifers) from one to numerous sampling events per year, conducted over several years (from 7 up to 15 years). The analytical parameter list varied but a total of approximately 250 analytes were monitored at least intermittently over the several-year sampling period. Therefore, in order to ensure that the trend analysis was feasible and manageable task, analytes and wells were prioritized. Forty-five wells, one spring, and a total of 28 analytes were selected for the trend analysis of ground water.

Analyte Selection

Table 4-1 lists the analytical parameters on a SWMU-specific basis that were selected for the trend analysis. The reports referenced previously (Table 2-1), which provide summary information and interpretations of the nature and extent of potential contamination at each SWMU, were used to identify these high priority parameters. The two criteria that were used to select these 'high priority' analytes were; (a) the analyte must have been detected on repeated rounds at a specific well and (b) the analyte was present often at concentrations above its Maximum Contaminant Level and/or background threshold.

For the trend analysis of ground water at ABG, 12 analytes were selected. These included trichloroethylene, 1,2-dichloroethane, 1,2-dichloroethylene, 1,1,1-trichloroethane, barium, mercury, zinc, bis(2-ethylhexyl)phthalate, di-N-butyl phthalate, TNT, HMX, and RDX. Four parameters, were selected for the Jeep Trail Area, as shown on Table 4-1, and eight analytes were selected for the boundary well area (south of the Jeep Trail Area along Little Sulfur Creek).

For the trend analysis of ground water at ORR, 22 analytes were selected including TNT, HMX, RDX and numerous metals. Nineteen parameters were chosen for DR, and these parameters consist of metals, as shown on Table 4-1.

Well Selection

Table 4-2 lists the monitoring wells on a SWMU-specific and aquifer-specific basis that were selected for the trend analysis. The summarized data and interpretations regarding the nature and extent of contamination, presented in the reports referenced previously (Table 2-1), were used to identify these high priority monitoring wells. A total of 41 wells and one spring were selected for the trend analysis. Table 4-2 also provides the rationale for the selection of each well. In general, wells were selected based on one or more of the following criteria:

- Elevated chemical(s) concentrations detected on numerous rounds;

TABLE 4-1
ANALYTICAL PARAMETERS SELECTED
FOR THE TREND ANALYSIS
CRANE, INDIANA
PAGE 1 OF 3

SELECTED ANALYTICAL PARAMETER[A]	ABG	JEEP TRAIL AREA	BOUNDARY WELLS	ORR	DR
1,1,1-Trichloroethane	X	X	X		
1,2-Dichloroethane	X	X	X		
1,2-Dichloroethylene (Total)	X	X	X		
2,4,6-Trinitrotoluene (TNT)	X			X	
Aluminum				X	X
Antimony				X	X
Arsenic				X	X
Barium	X		X	X	X
Beryllium				X	X
Bis(2-ethylhexyl) phthalate	X				
Cadmium				X	X
Chromium				X	X
cis-1,2-Dichloroethylene	X	X	X		

TABLE 4-1
ANALYTICAL PARAMETERS SELECTED
FOR THE TREND ANALYSIS
CRANE, INDIANA
PAGE 2 OF 3

SELECTED ANALYTICAL PARAMETER[A]	ABG	JEEP TRAIL AREA	BOUNDARY WELLS	ORR	DR
Cobalt				X	X
Copper				X	X
Di-n-butyl phthalate	X				
HMX	X			X	
Iron				X	X
Lead				X	X
Manganese			X	X	X
Mercury	X			X	X
Nickel				X	X
RDX	X		X	X	
Selenium				X	X
Silver				X	X
Tin				X	X
trans-1,2-Dichloroethylene	X	X	X		

TABLE 4-1
ANALYTICAL PARAMETERS SELECTED
FOR THE TREND ANALYSIS
CRANE, INDIANA
PAGE 3 OF 3

SELECTED ANALYTICAL PARAMETER[A]	ABG	JEEP TRAIL AREA	BOUNDARY WELLS	ORR	DR
Trichloroethylene	X	X	X		
Vanadium				X	X
Zinc	X			X	X

NOTES:

[A] For each metal, both the dissolved and total constituent were evaluated as separate parameters.
X: Parameter was selected for the ground water trend analysis at this site.

TABLE 4-2
MONITORING WELLS SELECTED
FOR THE TREND ANALYSIS
CRANE, INDIANA
PAGE 1 OF 4

SWMU/AREA	AQUIFER	WELL(S)	RATIONALE FOR SELECTION
ABG, ON-SITE	BEECH CREEK	03C03P2	RELATIVELY HIGH AVERAGE TCE, RDX AND BARIUM CONCENTRATIONS, WHEN COMPARED TO OTHER WELLS (MURPHY, 1994); RELATIVELY HIGH 2,4,6-TNT LEVELS; POSITIVE DETECTIONS OF HMX (MURPHY, 1994).
		03C08AP2	RELATIVELY HIGH AVERAGE RDX AND BARIUM CONCENTRATIONS, WHEN COMPARED TO OTHER WELLS (MURPHY, 1994); POSITIVE DETECTIONS OF HMX; FREQUENT TCE DETECTIONS, POSSIBLY INCREASING SINCE OCT. '91 (HALLIBURTON NUS, 1995).
		03C20	RELATIVELY HIGH AVERAGE TCE AND RDX CONCENTRATIONS, WHEN COMPARED TO OTHER WELLS; MAXIMUM ON-SITE TCE LEVEL (OCT. '90) AND VERY FREQUENT DETECTIONS OF TCE (MURPHY, 1994).
		03C09P2	CONSISTENT AND PERSISTENT TCE DETECTIONS; USUALLY THE HIGHEST LEVELS FOR WESTERN ONE-THIRD OF SITE; FREQUENT RDX DETECTIONS (HALLIBURTON NUS, 1995).
		03C11	CONSISTENTLY DEMONSTRATED SECOND HIGHEST TCE LEVELS ON-SITE, WITH LEVELS POSSIBLY INCREASING SINCE APRIL '91 (HALLIBURTON NUS, 1995).
		03C12	DOWNGRADIENT OF 03C11; SELECTED TO CONFIRM OBSERVATIONS AT 03C11.
		03C04	POINT-OF-COMPLIANCE MONITORING WELL; ELEVATED Zn, BIS(2-ETHYLHEXYL)PHTHALATE (RISCH, 1993A).
		03C06	POINT-OF-COMPLIANCE MONITORING WELL (RISCH, 1993A).
		03C13	FREQUENT TCE DETECTIONS UPGRADIENT OF 'ABG-proper' (HALLIBURTON NUS, 1995).
		03C21	SELECTED TO BE REPRESENTATIVE OF SOUTHWESTERN ONE-THIRD OF SITE; FREQUENT TCE DETECTIONS (MURPHY, 1994).

TABLE 4-2
MONITORING WELLS SELECTED
FOR THE TREND ANALYSIS
CRANE, INDIANA
PAGE 2 OF 4

SWMU/AREA	AQUIFER	WELL(S)	RATIONALE FOR SELECTION
ABG continued	BEECH CREEK	03C28	POINT-OF-COMPLIANCE MONITORING WELL; ELEVATED Ba (RISCH, 1993A).
ABG	BIG CLIFTY	03-38	UPGRADIENT PORTION OF SWMU WITH OVERLYING INDIAN SPRINGS SHALE PRESENT; VERY FREQUENT DETECTIONS OF TCE AND RDX (MURPHY, 1994).
		03-33	ZONE OF COLLAPSE OF BIG CLIFTY DUE TO SOLUTION CAVERNS IN BEECH CREEK; FREQUENT TCE AND OCCASIONAL 1,1,1-TCA DETECTIONS (MURPHY, 1994).
	GOLCONDA/ HANEY	03C08AP3	MOST FREQUENT (AND MAXIMUM) DETECTIONS OF BARIUM IN THIS AQUIFER; THREE DETECTIONS OF TCE (MURPHY, 1994).
		03C22	MOST FREQUENT (AND MAXIMUM) DETECTIONS OF TCE IN THIS AQUIFER; THREE DETECTIONS OF TCE (MURPHY, 1994).
	BEAVER BEND	03C09	HIGHEST CONCENTRATIONS & MOST FREQUENT DETECTIONS OF TCE FOR WELLS IN THIS AQUIFER (MURPHY, 1994); RDX DETECTED IN OCT. '89 AT 0.23 mg/L; BARIUM DETECTED IN FOUR SAMPLING EVENTS.
JEEP TRAIL AREA	ALLUVIUM	03-07	FREQUENT TCE DETECTIONS (MURPHY, 1994).
LITTLE SULFUR CREEK	BEECH CREEK	SPRING-A	A PRIMARY OUTLET FOR ABG GROUND WATER; FREQUENT RDX AND BARIUM DETECTIONS (MURPHY, 1994).
BOUNDARY WELL AREA	ALLUVIUM	03B02	RELATIVELY HIGH AVERAGE BARIUM CONCENTRATIONS (MURPHY, 1994); SELECTED FOR EXPOSURE POINT CALCULATIONS IN THE RISK ASSESSMENT WORK PLAN (HALLIBURTON NUS, 1995).
		03B03	RELATIVELY HIGH AVERAGE BARIUM CONCENTRATIONS & FREQUENT MANGANESE DETECTIONS (MURPHY, 1994).

TABLE 4-2
MONITORING WELLS SELECTED
FOR THE TREND ANALYSIS
CRANE, INDIANA
PAGE 3 OF 4

SWMU/AREA	AQUIFER	WELL(S)	RATIONALE FOR SELECTION
BOUNDARY WELL AREA	BEECH CREEK	03B10	SELECTED FOR EXPOSURE POINT CALCULATIONS IN THE RISK ASSESSMENT WORK PLAN (HALLIBURTON NUS, 1995).
ORR/DR UPGRADIENT	BEECH CREEK	06C08	STATISTICALLY ELEVATED Al AND As CONCENTRATIONS IN 4 OF 4 HISTORICAL SAMPLING ROUNDS (MURPHY & WADE, 1994); INTERMITTANTLY ELEVATED Zn & Ni; POSSIBLY DECREASING Cu LEVELS.
ORR	LOWER BIG CLIFTY--BEECH CREEK	06C12	STATISTICALLY ELEVATED Mn CONCENTRATIONS IN 4 OF 4 HISTORICAL SAMPLING ROUNDS, POSSIBLY INCREASING; PERSISTENT LOW LEVEL Ba (MURPHY & WADE, 1994).
		06C14	STATISTICALLY ELEVATED Mn CONCENTRATIONS IN 4 OF 4 HISTORICAL SAMPLING ROUNDS , POSSIBLY DECREASING; Sb ABOVE MCL IN 2 OF 4 SAMPLING ROUNDS (MURPHY & WADE, 1994).
		06C11	ELEVATED & FLUCTUATING LEVELS OF Cu, Ba, Sb, As, Mn. LOWER PRIORITY THAN WELLS LISTED ABOVE FOR THIS AQUIFER.
	SURFICIAL ZONE	06-20	ONLY WELL WITH ELEVATED LEVELS OF RDX (MURPHY & WADE, 1994); VERY HIGH Ni, POSSIBLY INCREASING.
		06-22	ONLY WELL WITH ELEVATED LEVELS OF TNT, POSSIBLY DECREASING (MURPHY & WADE, 1994).
		06C18P2	SIGNIFICANT STATISTICAL EVIDENCE OF As CONTAMINATION, POSSIBLY INCREASING; POSSIBLY DECREASING Zn; STATISTICAL EVIDENCE OF Mn CONTAMINATION, POSSIBLY DECREASING; POSSIBILY DECREASING Sb (MURPHY & WADE, 1994); VERY ELEVATED LEVELS OF IRON (HALLIBURTON NUS, 1995).
		06C13P2	STATISTICALLY ELEVATED Mn LEVELS; ELEVATED As IN 3 OF 4 ROUNDS (MURPHY & WADE, 1994).
		06-17	ELEVATED Cu, Cr, Ba, Ni, Sb, Pb, Zn, Al (MURPHY & WADE, 1994).

TABLE 4-2
MONITORING WELLS SELECTED
FOR THE TREND ANALYSIS
CRANE, INDIANA
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SWMU/AREA	AQUIFER	WELL(S)	RATIONALE FOR SELECTION
DR	LOWER BIG CLIFTY--BEECH CREEK	06C04	INCREASING Pb LEVELS; STATISTICALLY ELEVATED Mn (MURPHY & WADE, 1994).
		06C03	STATISTICALLY ELEVATED Mn; PERSISTENTLY ELEVATED As & Ba; ELEVATED Fe; POSSIBLY DECREASING Cu & Pb (MURPHY & WADE, 1994).
		06C01	ONLY ON-SWMU WELL FOR THIS AQUIFER; VERY HIGH Mn (2.4 mg/L) 2nd ROUND; DECREASING Zn; PERSISTENT Ba (MURPHY & WADE, 1994).
		06C06	DOWNGRADIENT OF ARMY DETONATION AREA; ELEVATED Mn, Pb, Sb; LOWER PRIORITY THAN OTHER WELLS LISTED FOR GROUP.
	SURFICIAL ZONE	06-07	CENTRALLY LOCATED IN AREA OF NAVAL ACTIVITIES; THIS WELL SHOWS THE GREATEST, STATISTICALLY SIGNIFICANT METALS CONCENTRATIONS (Al, As, Be, Co, Mn, Ni, Zn) FOR THIS AQUIFER/LOCATION (MURPHY & WADE, 1994); ALSO HIGH Fe, V, Cd, Cu, Cr, Sb.
		06C02P2	DOWNGRADIENT OF NAVY DETONATION AREA; NOT PART OF STATISTICAL ANALYSIS IN MURPHY & WADE (1994).
		06C03P2	DOWNGRADIENT OF NAVY DETONATION AREA; SEVERAL METALS DETECTED IN JULY 1993 (RISCH, 1993B).
		06-09, 06-10, 06-11	SELECTED TO BE REPRESENTATIVE OF ON-SITE ARMY DETONATION AREA.
		06C06P2	DOWNGRADIENT OF ARMY DETONATION AREA; LOWER PRIORITY THAN OTHER WELLS LISTED FOR GROUP.
	GOLCONDA/ HANEY	06C04P2	DOWNGRADIENT OF ORR & DR; ELEVATED LEVELS Cu, Ba, Sb, Zn, Mg (MURPHY & WADE, 1994).

NOTES:
TCE: TRICHLOROETHYLENE
2,4,6-TNT: 2,4,6-TRINITROTOLUENE

- Frequent/consistent/persistent chemical(s) detections;
- Unique chemical(s) detected, with respect to other wells in its vicinity or within the same aquifer;
- Critical location (i.e., well considered to be representative of a particular aquifer and/or screened in a hydrogeologically sensitive location).

4.2 STATISTICAL PROCEDURES

Statistical procedures were then used to assess potential trends in chemical concentrations over time (Gilbert, 1987). The purpose of this statistical evaluation was to identify, if present, a trend in the historical ground water data (either up or down) in terms of contaminant levels.

The Mann-Kendall Test (MKT) was selected for this evaluation. The MKT is analogous to a test for zero slope of the linear regression of time-ordered data versus time (Gilbert, 1987). The MKT was chosen for this project primarily because this statistical procedure:

- is nonparametric (i.e., the test outcome is not affected by the data's distribution);
- allows the use of missing values (i.e., omitted or skipped sampling rounds);
- allows the use of non-detect values.

The MKT was used to evaluate the data collected from the 41 high priority wells (and one spring) at ABG, the Jeep Trail Area, the boundary well area, ORR and DR. For the first three areas, analytical data (i.e., the high priority analytes) representing 1987 through 1995 were tested statistically. For ORR and DR, high priority analytes representing 1990 through 1995 were tested statistically.

The specific methodology that comprises the MKT is included as Appendix C. For this project, two-tailed tests were used in order to detect either a statistically significant upward or downward trend when compared to the null hypothesis of 'no trend.' The significance level for these tests was 95 percent (i.e., $\alpha = 0.05$).

4.3 RESULTS

Table 4-3 summarizes the results of the Ground Water Trend Analysis. This table shows the results as '*YES*' or '*NO*' indicating a trend or no trend, respectively, at a significance level of $\alpha = 0.05$. Nine of the 41 wells evaluated statistically did show an upward or downward trend in the concentration of a single analyte (Table 4-3). One other well demonstrated a trend with respect to three analytes. In addition, the spring located along Little Sulfur Creek also showed a trend with respect to a single analyte. However, for most of the wells and analytes evaluated (for 96% of the tests run in this study), there was no statistically significant trend in chemical concentrations monitored over time.

Significant trends (at $\alpha = 0.05$) were observed for the following analytes: trichloroethylene in three Beech Creek wells at ABG (03C08AP2, 03C11, 03C20); barium in two Beech Creek wells at ABG (03C12, 03C28); RDX in a Beech Creek spring along Little Sulfur Creek (03-Spring-A); aluminum

in one Golconda-Haney well at DR (06C04P2); iron in two surficial zone wells at DR (06C03P2, 06C06P2); antimony in one Beech Creek well at ORR (06C12); and arsenic, iron and manganese in one Beech Creek well upgradient of ORR/DR (06C08). The majority of these trends were upward (i.e., increasing analyte concentrations over time).

TABLE 4-3
RESULTS OF THE GROUND WATER TREND ANALYSIS
FOR POTENTIAL USE IN THE RISK ASSESSMENT
CRANE, INDIANA
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CORRESPONDING TABLE NO. IN APPENDIX B	SWMU/ AREA	AQUIFER	WELL	ANALYTE	IS A TREND PRESENT?
1	ABG	BEAVER BEND	03C09	2,4,6-TRINITROTOLUENE (TNT)	NO
				BARIUM, TOTAL	NO
				BIS(2-ETHYLHEXYL)PHTHALATE	NO
				DI-N-BUTYL PHTHALATE	NO
				MERCURY, TOTAL	NO
				RDX	NO
				TRICHLOROETHENE	NO
				ZINC, TOTAL	Insuff. data
2	ABG	BEECH CREEK	03C03P2	1,1,1-TRICHLOROETHANE	NO
				1,2-DICHLOROETHANE	Insuff. data
				1,2-DICHLOROETHENE, TOTAL	Insuff. data
				2,4,6-TRINITROTOLUENE (TNT)	NO
				BARIUM, TOTAL	NO
				CIS-1,2-DICHLOROETHENE	Insuff. data
				DI-N-BUTYL PHTHALATE	NO
				HMX	NO
				RDX	NO
				TRICHLOROETHENE	NO
3	ABG	BEECH CREEK	03C04	2,4,6-TRINITROTOLUENE (TNT)	NO
				BARIUM, TOTAL	NO
				BIS(2-ETHYLHEXYL)PHTHALATE	NO
				RDX	NO
				TRICHLOROETHENE	NO
				ZINC, DISSOLVED	Insuff. data
				ZINC, TOTAL	Insuff. data

TABLE 4-3
RESULTS OF THE GROUND WATER TREND ANALYSIS
FOR POTENTIAL USE IN THE RISK ASSESSMENT
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CORRESPONDING TABLE NO. IN APPENDIX B	SWMU/ AREA	AQUIFER	WELL	ANALYTE	IS A TREND PRESENT?
4	ABG	BEECH CREEK	03C06	2,4,6-TRINITROTOLUENE (TNT)	NO
				BARIUM, TOTAL	NO
				TRICHLOROETHENE	NO
				ZINC, TOTAL	Insuff. data
5	ABG	BEECH CREEK	03C08AP2	1,1,1-TRICHLOROETHANE	NO
				BARIUM, TOTAL	NO
				BIS(2-ETHYLHEXYL)PHTHALATE	NO
				DI-N-BUTYL PHTHALATE	NO
				HMX	NO
				RDX	NO
				TRICHLOROETHENE	YES
				ZINC, DISSOLVED	Insuff. data
				ZINC, TOTAL	Insuff. data
6	ABG	BEECH CREEK	03C09P2	1,1,1-TRICHLOROETHANE	NO
				1,2-DICHLOROETHANE	Insuff. data
				2,4,6-TRINITROTOLUENE (TNT)	NO
				BARIUM, TOTAL	NO
				BIS(2-ETHYLHEXYL)PHTHALATE	NO
				DI-N-BUTYL PHTHALATE	NO
				MERCURY, TOTAL	NO
				RDX	NO
				TRICHLOROETHENE	NO
				ZINC, DISSOLVED	Insuff. data

TABLE 4-3
RESULTS OF THE GROUND WATER TREND ANALYSIS
FOR POTENTIAL USE IN THE RISK ASSESSMENT
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CORRESPONDING TABLE NO. IN APPENDIX B	SWMU/ AREA	AQUIFER	WELL	ANALYTE	IS A TREND PRESENT?
7	ABG	BEECH CREEK	03C11	2,4,6-TRINITROTOLUENE (TNT)	NO
				BARIUM, TOTAL	NO
				BIS(2-ETHYLHEXYL)PHTHALATE	NO
				CIS-1,2-DICHLOROETHENE	Insuff. data
				DI-N-BUTYL PHTHALATE	NO
				RDX	NO
				TRICHLOROETHENE	YES
				ZINC, TOTAL	Insuff. data
8	ABG	BEECH CREEK	03C12	2,4,6-TRINITROTOLUENE (TNT)	NO
				BARIUM, DISSOLVED	Insuff. data
				BARIUM, TOTAL	YES
				BIS(2-ETHYLHEXYL)PHTHALATE	NO
				DI-N-BUTYL PHTHALATE	NO
				HMX	NO
				RDX	NO
				TRICHLOROETHENE	NO
				ZINC, TOTAL	Insuff. data
9	ABG	BEECH CREEK	03C13	RDX	NO
				TRICHLOROETHENE	NO
10	ABG	BEECH CREEK	03C20	1,1,1-TRICHLOROETHANE	NO
				2,4,6-TRINITROTOLUENE (TNT)	NO
				CIS-1,2-DICHLOROETHENE	Insuff. data
				HMX	NO
				RDX	NO
				TRICHLOROETHENE	YES

TABLE 4-3
RESULTS OF THE GROUND WATER TREND ANALYSIS
FOR POTENTIAL USE IN THE RISK ASSESSMENT
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CORRESPONDING TABLE NO. IN APPENDIX B	SWMU/ AREA	AQUIFER	WELL	ANALYTE	IS A TREND PRESENT?
11	ABG	BEECH CREEK	03C21	RDX	NO
				TRICHLOROETHENE	NO
12	ABG	BEECH CREEK	03C28	BARIUM, TOTAL	YES
				BIS(2-ETHYLHEXYL)PHTHALATE	NO
				DI-N-BUTYL PHTHALATE	NO
				MERCURY, DISSOLVED	Insuff. data
				MERCURY, TOTAL	NO
				TRICHLOROETHENE	NO
				ZINC, DISSOLVED	Insuff. data
13	ABG	BIG CLIFTY	03-33	1,1,1-TRICHLOROETHANE	NO
				2,4,6-TRINITROTOLUENE (TNT)	NO
				RDX	NO
				TRICHLOROETHENE	NO
14	ABG	BIG CLIFTY	03-38	1,1,1-TRICHLOROETHANE	NO
				1,2-DICHLOROETHANE	Insuff. data
				BIS(2-ETHYLHEXYL)PHTHALATE	NO
				DI-N-BUTYL PHTHALATE	NO
				RDX	NO
				TRICHLOROETHENE	NO
15	ABG	GOLCONDA/ HANEY	03C08AP3	BARIUM, TOTAL	NO
				DI-N-BUTYL PHTHALATE	NO
				RDX	NO
				TRICHLOROETHENE	NO

TABLE 4-3
RESULTS OF THE GROUND WATER TREND ANALYSIS
FOR POTENTIAL USE IN THE RISK ASSESSMENT
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CORRESPONDING TABLE NO. IN APPENDIX B	SWMU/ AREA	AQUIFER	WELL	ANALYTE	IS A TREND PRESENT?
16	ABG	GOLCONDA/ HANEY	03C22	BARIUM, TOTAL	NO
				BIS(2-ETHYLHEXYL)PHTHALATE	NO
				DI-N-BUTYL PHTHALATE	NO
				TRICHLOROETHENE	NO
17	BOUNDARY	ALLUVIUM	03B02	BARIUM, TOTAL	NO
				MANGANESE, DISSOLVED	Insuff. data
				MANGANESE, TOTAL	NO
				TRICHLOROETHENE	NO
18	BOUNDARY	ALLUVIUM	03B03	BARIUM, TOTAL	NO
				MANGANESE, TOTAL	NO
				TRICHLOROETHENE	NO
19	BOUNDARY	BEECH CREEK	03B10	1,1,1-TRICHLOROETHANE	NO
				BARIUM, TOTAL	NO
				MANGANESE, DISSOLVED	Insuff. data
				MANGANESE, TOTAL	NO
				TRICHLOROETHENE	NO
20	BOUNDARY	BEECH CREEK	03-SPRING-A	BARIUM, DISSOLVED	Insuff. data
				BARIUM, TOTAL	NO
				MANGANESE, TOTAL	NO
				RDX	YES
				TRICHLOROETHENE	NO

TABLE 4-3
RESULTS OF THE GROUND WATER TREND ANALYSIS
FOR POTENTIAL USE IN THE RISK ASSESSMENT
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CORRESPONDING TABLE NO. IN APPENDIX B	SWMU/ AREA	AQUIFER	WELL	ANALYTE	IS A TREND PRESENT?
21	DR	BEECH CREEK	06C01	ALUMINUM, TOTAL	NO
				ANTIMONY, TOTAL	NO
				BARIUM, TOTAL	NO
				CHROMIUM, TOTAL	NO
				COBALT, TOTAL	NO
				COPPER, TOTAL	NO
				IRON, TOTAL	NO
				MANGANESE, TOTAL	NO
				NICKEL, TOTAL	NO
				VANADIUM, TOTAL	NO
				ZINC, TOTAL	NO
22	DR	BEECH CREEK	06C03	ALUMINUM, TOTAL	NO
				ANTIMONY, TOTAL	NO
				ARSENIC, DISSOLVED	Insuff. data
				ARSENIC, TOTAL	NO
				BARIUM, DISSOLVED	Insuff. data
				BARIUM, TOTAL	NO
				CHROMIUM, TOTAL	NO
				COBALT, TOTAL	NO
				COPPER, TOTAL	NO
				IRON, DISSOLVED	Insuff. data
				IRON, TOTAL	NO
				LEAD, TOTAL	NO
				MANGANESE, DISSOLVED	NO
				MANGANESE, TOTAL	NO
				ZINC, TOTAL	NO

TABLE 4-3
RESULTS OF THE GROUND WATER TREND ANALYSIS
FOR POTENTIAL USE IN THE RISK ASSESSMENT
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CORRESPONDING TABLE NO. IN APPENDIX B	SWMU/ AREA	AQUIFER	WELL	ANALYTE	IS A TREND PRESENT?
23	DR	BEECH CREEK	06C04	ANTIMONY, TOTAL	NO
				BARIUM, DISSOLVED	Insuff. data
				BARIUM, TOTAL	NO
				COBALT, TOTAL	NO
				IRON, DISSOLVED	Insuff. data
				IRON, TOTAL	NO
				LEAD, TOTAL	NO
				MANGANESE, DISSOLVED	NO
				MANGANESE, TOTAL	NO
				ZINC, DISSOLVED	Insuff. data
				ZINC, TOTAL	NO
24	DR	BEECH CREEK	06C06	ALUMINUM, TOTAL	NO
				ANTIMONY, TOTAL	NO
				BARIUM, TOTAL	NO
				COBALT, TOTAL	NO
				IRON, DISSOLVED	Insuff. data
				IRON, TOTAL	NO
				LEAD, TOTAL	NO
				MANGANESE, DISSOLVED	NO
				MANGANESE, TOTAL	NO
				ZINC, DISSOLVED	Insuff. data
				ZINC, TOTAL	NO

TABLE 4-3
RESULTS OF THE GROUND WATER TREND ANALYSIS
FOR POTENTIAL USE IN THE RISK ASSESSMENT
CRANE, INDIANA
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CORRESPONDING TABLE NO. IN APPENDIX B	SWMU/ AREA	AQUIFER	WELL	ANALYTE	IS A TREND PRESENT?
25	DR	GOLCONDA/ HANEY	06C04P2	ALUMINUM, TOTAL	YES
				ANTIMONY, TOTAL	NO
				ARSENIC, TOTAL	NO
				BARIUM, DISSOLVED	Insuff. data
				BARIUM, TOTAL	NO
				BERYLLIUM, TOTAL	NO
				CADMIUM, TOTAL	NO
				CHROMIUM, TOTAL	NO
				COBALT, TOTAL	NO
				COPPER, TOTAL	NO
				IRON, DISSOLVED	Insuff. data
				IRON, TOTAL	NO
				LEAD, TOTAL	NO
				MANGANESE, DISSOLVED	Insuff. data
				MANGANESE, TOTAL	NO
				NICKEL, TOTAL	NO
				SELENIUM, DISSOLVED	Insuff. data
				VANADIUM, TOTAL	NO
				ZINC, TOTAL	NO
26	DR	SURFICIAL ZONE	06-09	BARIUM, TOTAL	Insuff. data
				IRON, TOTAL	NO
				MANGANESE, TOTAL	Insuff. data
27	DR	SURFICIAL ZONE	06-10	IRON, TOTAL	NO
				MANGANESE, TOTAL	NO

TABLE 4-3
RESULTS OF THE GROUND WATER TREND ANALYSIS
FOR POTENTIAL USE IN THE RISK ASSESSMENT
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CORRESPONDING TABLE NO. IN APPENDIX B	SWMU/ AREA	AQUIFER	WELL	ANALYTE	IS A TREND PRESENT?
28	DR	SURFICIAL ZONE	06-11	IRON, TOTAL	NO
				MANGANESE, TOTAL	NO
29	DR	SURFICIAL ZONE	06-07	ALUMINUM, TOTAL	NO
				ANTIMONY, TOTAL	NO
				ARSENIC, TOTAL	NO
				BARIUM, TOTAL	NO
				BERYLLIUM, TOTAL	NO
				CADMIUM, TOTAL	NO
				CHROMIUM, TOTAL	NO
				COBALT, TOTAL	NO
				COPPER, TOTAL	NO
				IRON, TOTAL	NO
				LEAD, TOTAL	NO
				MANGANESE, TOTAL	NO
				NICKEL, TOTAL	NO
				TIN, TOTAL	NO
				VANADIUM, TOTAL	NO
				ZINC, TOTAL	NO
30	DR	SURFICIAL ZONE	06C02P2	ANTIMONY, TOTAL	NO
				BARIUM, TOTAL	Insuff. data
				CHROMIUM, TOTAL	NO
				COBALT, TOTAL	NO
				COPPER, TOTAL	NO
				MANGANESE, TOTAL	Insuff. data

TABLE 4-3
RESULTS OF THE GROUND WATER TREND ANALYSIS
FOR POTENTIAL USE IN THE RISK ASSESSMENT
CRANE, INDIANA
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CORRESPONDING TABLE NO. IN APPENDIX B	SWMU/ AREA	AQUIFER	WELL	ANALYTE	IS A TREND PRESENT?
31	DR	SURFICIAL ZONE	06C03P2	ALUMINUM, DISSOLVED	Insuff. data
				ALUMINUM, TOTAL	NO
				ANTIMONY, TOTAL	NO
				ARSENIC, TOTAL	NO
				BARIUM, TOTAL	NO
				BERYLLIUM, TOTAL	NO
				CHROMIUM, TOTAL	NO
				COBALT, TOTAL	NO
				COPPER, TOTAL	NO
				IRON, DISSOLVED	Insuff. data
				IRON, TOTAL	YES
				LEAD, DISSOLVED	Insuff. data
				LEAD, TOTAL	NO
				MANGANESE, DISSOLVED	NO
				MANGANESE, TOTAL	NO
				NICKEL, TOTAL	NO
				VANADIUM, TOTAL	NO
				ZINC, TOTAL	NO
32	DR	SURFICIAL ZONE	06C06P2	ALUMINUM, TOTAL	NO
				ANTIMONY, TOTAL	NO
				ARSENIC, TOTAL	NO
				BARIUM, TOTAL	NO
				BERYLLIUM, TOTAL	NO
				CHROMIUM, TOTAL	NO
				COBALT, TOTAL	NO
				COPPER, TOTAL	NO

TABLE 4-3
RESULTS OF THE GROUND WATER TREND ANALYSIS
FOR POTENTIAL USE IN THE RISK ASSESSMENT
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CORRESPONDING TABLE NO. IN APPENDIX B	SWMU/ AREA	AQUIFER	WELL	ANALYTE	IS A TREND PRESENT?
32 (continued)	DR	SURFICIAL ZONE	06C06P2	IRON, TOTAL	YES
				LEAD, DISSOLVED	Insuff. data
				LEAD, TOTAL	NO
				MANGANESE, DISSOLVED	NO
				MANGANESE, TOTAL	NO
				NICKEL, TOTAL	NO
				VANADIUM, TOTAL	NO
				ZINC, DISSOLVED	Insuff. data
				ZINC, TOTAL	NO
33	JEEP TRAIL	ALLUVIUM	03-07	1,2-DICHLOROETHENE,TOTAL	Insuff. data
				CIS-1,2-DICHLOROETHENE	Insuff. data
				TRICHLOROETHENE	NO
34	ORR	BEECH CREEK	06C08	ALUMINUM, DISSOLVED	Insuff. data
				ALUMINUM, TOTAL	NO
				ANTIMONY, TOTAL	NO
				ARSENIC, TOTAL	YES
				BARIUM, TOTAL	NO
				CHROMIUM, TOTAL	NO
				COBALT, TOTAL	NO
				COPPER, TOTAL	NO
				IRON, DISSOLVED	Insuff. data
				IRON, TOTAL	YES
				LEAD, DISSOLVED	Insuff. data
				LEAD, TOTAL	NO
				MANGANESE, DISSOLVED	NO
				MANGANESE, TOTAL	YES

TABLE 4-3
RESULTS OF THE GROUND WATER TREND ANALYSIS
FOR POTENTIAL USE IN THE RISK ASSESSMENT
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CORRESPONDING TABLE NO. IN APPENDIX B	SWMU/ AREA	AQUIFER	WELL	ANALYTE	IS A TREND PRESENT?
34 (continued)	ORR	BEECH CREEK	06C08	NICKEL, TOTAL	NO
				TIN, TOTAL	NO
				VANADIUM, TOTAL	NO
				ZINC, DISSOLVED	Insuff. data
				ZINC, TOTAL	NO
35	ORR	BEECH CREEK	06C11	ALUMINUM, DISSOLVED	Insuff. data
				ALUMINUM, TOTAL	NO
				ANTIMONY, TOTAL	NO
				ARSENIC, TOTAL	NO
				BARIUM, DISSOLVED	Insuff. data
				BARIUM, TOTAL	NO
				CHROMIUM, TOTAL	NO
				COBALT, TOTAL	NO
				COPPER, TOTAL	NO
				IRON, DISSOLVED	Insuff. data
				IRON, TOTAL	NO
				LEAD, TOTAL	NO
				MANGANESE, DISSOLVED	NO
				MANGANESE, TOTAL	NO
				ZINC, TOTAL	NO

TABLE 4-3
RESULTS OF THE GROUND WATER TREND ANALYSIS
FOR POTENTIAL USE IN THE RISK ASSESSMENT
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CORRESPONDING TABLE NO. IN APPENDIX B	SWMU/ AREA	AQUIFER	WELL	ANALYTE	IS A TREND PRESENT?
36	ORR	BEECH CREEK	06C12	ANTIMONY, TOTAL	YES
				ARSENIC, TOTAL	NO
				BARIUM, DISSOLVED	Insuff. data
				BARIUM, TOTAL	NO
				COBALT, TOTAL	NO
				COPPER, TOTAL	NO
				IRON, DISSOLVED	Insuff. data
				IRON, TOTAL	NO
				LEAD, TOTAL	NO
				MANGANESE, DISSOLVED	Insuff. data
				MANGANESE, TOTAL	NO
				NICKEL, TOTAL	NO
				SELENIUM, TOTAL	NO
				ZINC, TOTAL	NO
37	ORR	BEECH CREEK	06C14	ALUMINUM, DISSOLVED	Insuff. data
				ALUMINUM, TOTAL	NO
				ANTIMONY, TOTAL	NO
				BARIUM, TOTAL	NO
				CADMIUM, TOTAL	NO
				CHROMIUM, TOTAL	NO
				COPPER, TOTAL	NO
				HMX	NO
				IRON, DISSOLVED	Insuff. data
				IRON, TOTAL	NO
				MANGANESE, DISSOLVED	Insuff. data
				MANGANESE, TOTAL	NO

TABLE 4-3
RESULTS OF THE GROUND WATER TREND ANALYSIS
FOR POTENTIAL USE IN THE RISK ASSESSMENT
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CORRESPONDING TABLE NO. IN APPENDIX B	SWMU/ AREA	AQUIFER	WELL	ANALYTE	IS A TREND PRESENT?
37 (continued)	ORR	BEECH CREEK	06C14	NICKEL, TOTAL	NO
				ZINC, TOTAL	NO
38	ORR	SURFICIAL ZONE	06-17	ALUMINUM, TOTAL	NO
				ANTIMONY, TOTAL	NO
				BARIUM, TOTAL	NO
				CADMIUM, TOTAL	NO
				CHROMIUM, TOTAL	NO
				COBALT, TOTAL	NO
				COPPER, TOTAL	NO
				IRON, TOTAL	NO
				LEAD, TOTAL	NO
				MANGANESE, TOTAL	NO
				NICKEL, TOTAL	NO
				VANADIUM, TOTAL	NO
				ZINC, TOTAL	NO
39	ORR	SURFICIAL ZONE	06-20	ANTIMONY, TOTAL	NO
				BARIUM, TOTAL	NO
				COBALT, TOTAL	NO
				COPPER, TOTAL	NO
				MANGANESE, TOTAL	NO
				NICKEL, TOTAL	NO
				RDX	NO
				VANADIUM, TOTAL	NO

TABLE 4-3
RESULTS OF THE GROUND WATER TREND ANALYSIS
FOR POTENTIAL USE IN THE RISK ASSESSMENT
CRANE, INDIANA
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CORRESPONDING TABLE NO. IN APPENDIX B	SWMU/ AREA	AQUIFER	WELL	ANALYTE	IS A TREND PRESENT?
40	ORR	SURFICIAL ZONE	06-22	2,4,6-TRINITROTOLUENE (TNT)	NO
				ANTIMONY, TOTAL	NO
				ARSENIC, TOTAL	NO
				BARIUM, TOTAL	NO
				COBALT, TOTAL	NO
				COPPER, TOTAL	NO
				IRON, TOTAL	NO
				MANGANESE, TOTAL	NO
				SILVER, TOTAL	NO
				VANADIUM, TOTAL	NO
				ZINC, TOTAL	NO
41	ORR	SURFICIAL ZONE	06C13P2	ALUMINUM, TOTAL	NO
				ANTIMONY, TOTAL	NO
				ARSENIC, DISSOLVED	Insuff. data
				ARSENIC, TOTAL	NO
				BARIUM, TOTAL	NO
				BERYLLIUM, TOTAL	NO
				CHROMIUM, TOTAL	NO
				COBALT, TOTAL	NO
				IRON, DISSOLVED	Insuff. data
				IRON, TOTAL	NO
				MANGANESE, DISSOLVED	NO
				MANGANESE, TOTAL	NO
				ZINC, DISSOLVED	Insuff. data
				ZINC, TOTAL	NO

TABLE 4-3
RESULTS OF THE GROUND WATER TREND ANALYSIS
FOR POTENTIAL USE IN THE RISK ASSESSMENT
CRANE, INDIANA
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CORRESPONDING TABLE NO. IN APPENDIX B	SWMU/ AREA	AQUIFER	WELL	ANALYTE	IS A TREND PRESENT?
42	ORR	SURFICIAL ZONE	06C18P2	ALUMINUM, DISSOLVED	Insuff. data
				ALUMINUM, TOTAL	NO
				ANTIMONY, TOTAL	NO
				ARSENIC, DISSOLVED	Insuff. data
				ARSENIC, TOTAL	NO
				BARIUM, DISSOLVED	Insuff. data
				BARIUM, TOTAL	NO
				BERYLLIUM, DISSOLVED	Insuff. data
				BERYLLIUM, TOTAL	NO
				CHROMIUM, TOTAL	NO
				COBALT, TOTAL	NO
				COPPER, TOTAL	NO
				IRON, DISSOLVED	Insuff. data
				IRON, TOTAL	NO
				MANGANESE, DISSOLVED	Insuff. data
				MANGANESE, TOTAL	NO
				SELENIUM, TOTAL	NO
				SILVER, TOTAL	NO
				VANADIUM, TOTAL	NO
				ZINC, TOTAL	NO

5.0 CONCLUSIONS

This Technical Memorandum documents the results of a temporal trend analysis of historical ground water quality data collected at ABG, ORR, and DR from 1987 or 1990 through 1995. These results will be used in the decision process for selecting the appropriate ground water database for use in the risk assessment of these SWMUs. The Risk Assessment Work Plan prepared by Rust (Halliburton NUS, 1995) described the procedures that will be used to assess the potential risks of ground water contamination to human health, based on the results of numerous field investigations and sampling events that have been conducted at the SWMUs. The Work Plan indicated that if there is a trend in the historical data (either up or down) in terms of contaminant concentrations, the most recent data would be viewed as the most appropriate data for the risk assessment. However, if there is no obvious trend, it was proposed that all of the data for a given well be averaged for use in the risk assessment.

Forty-one monitoring wells and one spring were evaluated for four to 22 analytical parameters in five areas. The results of a statistical procedure, the Mann-Kendall Test, indicate that for most of the wells and analytes evaluated (for 96% of the tests run in this study), there were no statistically significant trends in chemical concentrations (either up or down) monitored over time (at the significance level of $\alpha = 0.05$). The only statistically significant trends found in the database were for the following analytes: trichloroethylene in three Beech Creek wells at ABG; barium in two Beech Creek wells at ABG; RDX in a Beech Creek spring along Little Sulfur Creek; aluminum in one Golconda-Haney well at DR; iron in two surficial zone wells at DR; antimony in one Beech Creek well at ORR; and arsenic, iron and manganese in one Beech Creek well upgradient of ORR/DR.

6.0 OUTSTANDING ISSUES

The results of this Ground Water Trend Analysis indicate that, for most of the wells and analytes evaluated in this study, there were no statistically significant trends in chemical concentrations (either up or down) monitored over time. The Risk Assessment Work Plan prepared by Rust (Halliburton NUS, 1995) proposed that if there is no obvious trend, all of the data for a given well be averaged for use in the risk assessment. Thus, four outstanding issues that need to be resolved before proceeding with the risk assessment are:

- How much of the historical ground water data (representing which sampling rounds/years) should be used to determine exposure point concentrations in the risk assessment?
- Is validation of historical data (for all media) necessary for the risk assessment?
- For the historical ground water data chosen for use in the risk assessment, how should data gaps be treated in calculating the concentration term (i.e., sampling rounds in which specific analytes were not evaluated by the laboratory)?
- How should the historical ground water data be statistically evaluated to derive representative analyte concentrations for each well and for each well grouping?

Historical Ground Water Data

The first outstanding issue is to decide how much of the historical ground water data (1981/87/90 through 1995) should be used quantitatively in the risk assessment. In general, due to the size of the files, their complexity and non-uniformity, we propose limiting the risk assessment database to the four most recent years: data collected in 1992, 1993, 1994 and 1995. Also, since most of the historical ground water data have not been independently validated (see below), the data selected for validation, if required, should be limited to a manageable database size. For ORR and DR, the risk assessment database would also include the samples collected during 1990-1992, since this data subset was already validated by USACE, as explained below.

Data Validation

The next outstanding issue is to decide if the historical data (selected for use in the risk assessment) should be independently validated. Table 6-1 summarizes the analytical data available for potential use in the risk assessment. This table indicates the extent of laboratory quality control review, the availability of lab QC data (when known) and the level of independent data validation (when conducted). The only data that have received independent validation to date are the results for those soil, sediment, surface water and ground water samples collected by Rust in August/September 1995 and the results for ground water at ORR/DR collected from 1990 through 1992 (as documented in Murphy and Wade, 1994).

TABLE 6-1
SUMMARY OF ANALYTICAL DATA EVALUATED FOR
POTENTIAL USE IN THE RISK ASSESSMENT
CRANE, INDIANA
PAGE 1 OF 6

SITE	MATRIX	SAMPLING DATES	CORRESPONDING REPORT, LABORATORY ANALYTICAL DOCUMENTATION AND/OR DATA SOURCE	VALIDATION
ABG	Soil	1990 (12 borings)	USACE (Oct. 1992) Part I RFI Phase III Report	Lab QC only; no formal "outside " validation.
		August 1993	WES Part II Phase III Report	Lab QC only; no formal "outside" validation.
		August 1995	Rust E&I	Level IV by Rust E&I. Full CLP data/val SW Lab
	Surface water and sediment	03/17/92 & 07/17/92	DRAFT REPORT (March 1994): RCRA Facility Investigation Phase II Release Assessment for Surface Water SWMU 03/10 ABG by W.L. Murphy (US Army Corps of Engineers).	Lab QC only; no formal "outside" validation.
	Springs	1987 through 1992	FINAL REPORT (May 1994): RCRA Facility Investigation Phase III Ground Water Release Characterization SWMU 03/10 by W.L.Murphy (US Army Corps of Engineers).	Lab QC only; no formal "outside" validation.
		August 1995	Rust E&I	Level IV by Rust E&I.

TABLE 6-1
SUMMARY OF ANALYTICAL DATA EVALUATED FOR
POTENTIAL USE IN THE RISK ASSESSMENT
CRANE, INDIANA
PAGE 2 OF 6

SITE	MATRIX	SAMPLING DATES	CORRESPONDING REPORT, LABORATORY ANALYTICAL DOCUMENTATION AND/OR DATA SOURCE	VALIDATION
ABG continued	Ground Water	1987 through 1992	FINAL REPORT (May 1994): RCRA Facility Investigation Phase III Ground Water Release Characterization SWMU 03/10 by W.L.Murphy (US Army Corps of Engineers).	Lab QC only; no formal "outside" validation.
		August - September 1993	ADMINISTRATIVE REPORT (1993): Quality Control Data and Analytical Data for Ground Water at the Ammunition Burning Ground, Naval Warfare Center, Crane Division, Crane Indiana by M.R. Risch (US Dept. of the Interior, US Geological Survey).	Report includes analytical data along with summary QC forms sufficient for level III validation. Data review performed by USGS and data qualifiers, defined in footnotes to the data tables, were used to indicate QC problems.
		July 1994	Laboratory Documentation by Synergic Analytics, Inc.	None.
		Jan 1995	Laboratory Documentation by Synergic Analytics, Inc.	None.
		July 1995	Laboratory Documentation by Synergic Analytics, Inc.	None.
		August 1995	Rust E&I	Level IV by Rust E&I.
Little Sulfur Creek at Jeep Trail Area	Ground Water	September 1994	WES (Bill Murphy, USACE)	None.
		August 1995	Rust E&I	Level IV by Rust E&I.

TABLE 6-1
SUMMARY OF ANALYTICAL DATA EVALUATED FOR
POTENTIAL USE IN THE RISK ASSESSMENT
CRANE, INDIANA
PAGE 3 OF 6

SITE	MATRIX	SAMPLING DATES	CORRESPONDING REPORT, LABORATORY ANALYTICAL DOCUMENTATION AND/OR DATA SOURCE	VALIDATION
ORR	Soil	1990 (13 borings)	USACE (April 1991) RFI Phase II Report	None; Laboratory documentation along with associated QC provided in 'non-standard' format.
		August 1995	Rust E&I (Charlie Zeal)	Level IV by Rust E&I.
	Surface water and sediment	August 1995	Rust E&I (Charlie Zeal)	Level IV by Rust E&I.
	Ground Water	1990 through 1992	DRAFT REPORT (February 1994): RCRA Facility Investigation Phase III Ground Water Release Characterization Report SWMU 07/09 by W.L.Murphy & R. Wade (US Army Corps of Engineers).	USEPA Type II, similar to level III.
		July 1994	Laboratory Documentation by Synergic Analytics, Inc.	None.
		Jan 1995	Laboratory Documentation by Synergic Analytics, Inc.	None.
		July 1995	Laboratory Documentation by Synergic Analytics, Inc.	None.
		August 1995	Rust E&I	Level IV by Rust E&I.

TABLE 6-1
SUMMARY OF ANALYTICAL DATA EVALUATED FOR
POTENTIAL USE IN THE RISK ASSESSMENT
CRANE, INDIANA
PAGE 4 OF 6

SITE	MATRIX	SAMPLING DATES	CORRESPONDING REPORT, LABORATORY ANALYTICAL DOCUMENTATION AND/OR DATA SOURCE	VALIDATION
DR	Soil	August 1995	Rust E&I	Level IV by Rust E&I.
	Surface water and sediment	August 1995	Rust E&I	Level IV by Rust E&I.
	Ground Water	1990 through 1992	DRAFT REPORT (February 1994): RCRA Facility Investigation Phase II Ground Water Release Assessment SWMU 06/09 by W.L.Murphy & R. Wade (US Army Corps of Engineers).	USEPA Type II, similar to level III.
		July 1994	Laboratory Documentation by Synergic Analytics, Inc.	None.
		Jan 1995	Laboratory Documentation by Synergic Analytics, Inc.	None.
		July 1995	Laboratory Documentation by Synergic Analytics, Inc.	None.
		August 1995	Rust E&I	Level IV by Rust E&I.

TABLE 6-1
SUMMARY OF ANALYTICAL DATA EVALUATED FOR
POTENTIAL USE IN THE RISK ASSESSMENT
CRANE, INDIANA
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SITE	MATRIX	SAMPLING DATES	CORRESPONDING REPORT, LABORATORY ANALYTICAL DOCUMENTATION AND/OR DATA SOURCE	VALIDATION
ABG/ORR/DR	Ground Water and Springs	Jan 1992	Laboratory Documentation by Anacon, Inc.	Laboratory QC provided at a frequency of approximately 10%. Included lab blanks, duplicates, and spikes. No formal "outside" validation.
		April 1992	Laboratory Documentation by Anacon, Inc.	Laboratory QC provided at a frequency of approximately 10%. Included lab blanks, duplicates, and spikes. No formal "outside" validation.
		July 1992	Laboratory Documentation by Anacon, Inc.	Almost no QC data. No formal "outside" validation.
		Oct 1992	Laboratory Documentation by Anacon, Inc.	Almost no QC data. No formal "outside" validation.
		Jan 1993	Laboratory Documentation by Anacon, Inc.	Almost no QC data. No formal "outside" validation.
		Jan 1994	Laboratory Documentation by Anacon, Inc.	Almost no QC data. No formal "outside" validation.

TABLE 6-1
SUMMARY OF ANALYTICAL DATA EVALUATED FOR
POTENTIAL USE IN THE RISK ASSESSMENT
CRANE, INDIANA
PAGE 6 OF 6

SITE	MATRIX	SAMPLING DATES	CORRESPONDING REPORT, LABORATORY ANALYTICAL DOCUMENTATION AND/OR DATA SOURCE	VALIDATION
ORR/DR	Ground Water	July 1993	ADMINISTRATIVE REPORT (1993): Quality Assurance, Quality Control and Analytical Data for Ground Water at the Demolition Area and the Old Rifle Range, Naval Warfare Center, Crane Division, Crane Indiana by M.R. Risch (US Dept. of the Interior, US Geological Survey).	Data reviewed by USGS, however, no standard procedure used for qualifying data with problems. Report includes analytical data along with summary QC forms sufficient for level III validation.

Appendix D presents a summary memorandum that describes the validation procedures performed on the existing historical data , as indicated in reports by USACE and USGS received for potential use in the risk assessment.

Data Gaps

For the ground water data to be used in the risk assessment, i.e., in calculating time-weighted averages, how should data gaps be handled? Data gaps are meant to refer to sampling rounds in which specific analytes were not evaluated by the laboratory. We propose to calculate a surrogate value for each missing data point by taking the arithmetic average of the analytical result collected chronologically before the data gap and the first available value after the data gap.

Representative Analyte Concentrations

How should the historical ground water data be used to derive representative analyte concentrations for each well and for each well grouping? In other words, what statistical methodology is appropriate ultimately to estimate exposure point concentrations in the risk assessment when using historical data that may be correlated temporally and when combining these data among wells within a grouping?

As an example of the type of data groupings previously proposed for ground water, the following excerpt from the Risk Assessment Work Plan (Halliburton NUS, 1995) discusses the calculation of exposure point concentrations for the On-SWMU Residents Under Scenario C:

> The exposure point concentrations for groundwater at each SWMU will be based on monitoring well data aggregated separately for each aquifer, and these data will be averaged for those monitoring wells located within a reasonable, theoretical capture zone for a hypothetical future water supply well designed for use by a single residence. If the capture zone appears to be small in size relative to the total area of the SWMU and/or the current monitoring well field, then several theoretical capture zones (and well groupings) per aquifer will be used to calculate separate exposure point concentrations for various locations across the SWMU. In this case, the receptor doses related to the different well groupings will not be summed but will be carried through the risk characterization as distinct ground water exposure scenarios. If the capture zone appears to be large in size relative to the total area of the SWMU and/or the current monitoring well field, then a single well grouping per aquifer, representing the average of the well data for the entire SWMU, will be used to calculate ground water exposure point concentrations.

The exposure point concentration, which is used in the dose/intake equation in the exposure assessment, is typically an estimate of the arithmetic average concentration for a chemical based on a set of project sampling results (U.S. EPA, 1992). We propose to calculate the 'regional mean' and to use the 95 percent upper confidence limit (UCL) of this mean as the exposure point concentration for each aquifer-specific well grouping in the risk assessment. The data will be assumed to be normally distributed. The 'regional mean' and UCL will be calculated following the procedures outlined in Gilbert (1987). First, the arithmetic mean of the historical data collected at each well will be determined by averaging the detected concentration(s) with one-half of the sample quantitation limits for any nondetect results. Then, an estimate of the regional mean (e.g., for the well grouping)

will be calculated by averaging all of the mean concentrations representing each well within the grouping.

7.0 REFERENCES

Gilbert, R. O. 1987. Statistical Methods for Environmental Pollution Monitoring. Pacific Northwest Laboratory. Van Nostrand Reinhold. New York, New York.

Halliburton NUS. 1995. Risk Assessment Work Plan for Solid Waste Management Units #03/10, #06/09, and #07/09, Naval Surface Warfare Center, Crane Division, Crane Indiana. Comprehensive Long-term Environmental Action Navy (CLEAN) Program. Prepared by Rust E&I for Halliburton NUS Corp. Contract No. N62472-90-D-1298. Contract Task Order 0076.

Murphy, W.L. 1994. FINAL REPORT: RCRA Facility Investigation Phase III Ground Water Release Characterization SWMU 03/10 Ammunition Burning Ground. US Army Corps of Engineers.

Murphy, W.L. and R. Wade. 1994. DRAFT REPORT (February 1994): RCRA Facility Investigation Phase III Ground Water Release Characterization SWMU 07/09 Old Rifles Range and RCRA Facility Investigation Phase II Ground Water Release Assessment SWMU 06/09 Demolition Area. US Army Corps of Engineers.

Risch, M.R. 1993a. ADMINISTRATIVE REPORT: Quality Control Data and Analytical Data for Ground Water at the Ammunition Burning Ground, Naval Warfare Center, Crane Division, Crane Indiana. US Dept. of the Interior, US Geological Survey.

Risch, M.R. 1993b. ADMINISTRATIVE REPORT: Quality Assurance, Quality Control and Analytical Data for Ground Water at the Demolition Area and the Old Rifle Range, Naval Warfare Center, Crane Division, Crane Indiana. US Dept. of the Interior, US Geological Survey.

U.S. EPA (U.S. Environmental Protection Agency). 1992. Supplemental Guidance to RAGS: Calculating the Concentration Term, Intermittent Bulletin, Volume 1, Number 1. Office of Solid Waste and Emergency Response, Washington, DC. PB92-963373.

APPENDIX A

LISTING OF ELECTRONIC DATA FILES RECEIVED

NAVAL SURFACE WARFARE CENTER, CRANE DIVISION
LIST OF ELECTRONIC FILES CONTAINING GROUND WATER DATA

FILE NAME	SITE	SOURCE
ABG92.DBF	ABG/ORR/DR	Thomas J. Brent
DEM_AR.DBF	ABG/ORR/DR	Thomas J. Brent
OLD_RR.DBF	ABG/ORR/DR	Thomas J. Brent
ABGDBF.DBF	ABG/ORR/DR	Thomas J. Brent
DAORR.DBF	ABG/ORR/DR	Thomas J. Brent
GWDAT2.DBF	ABG/ORR/DR	Thomas J. Brent
CRJAN93.DBF	ABG/ORR/DR	Thomas J. Brent
CRJAN92.DBF	ABG/ORR/DR	Thomas J. Brent
CRAPR92.DBF	ABG/ORR/DR	Thomas J. Brent
CRJUL92.DBF	ABG/ORR/DR	Thomas J. Brent
CROCT92.DBF	ABG/ORR/DR	Thomas J. Brent
CRANE795.DBF	ABG/ORR/DR	Thomas J. Brent
CRANE93.DBF	ABG/ORR/DR	Thomas J. Brent
CRN1-95.DBF	ABG/ORR/DR	Thomas J. Brent
02P2.XLS	ABG/ORR/DR	Thomas J. Brent
03.XLS	ABG/ORR/DR	Thomas J. Brent
03C-03.XLS	ABG/ORR/DR	Thomas J. Brent
03P2.XLS	ABG/ORR/DR	Thomas J. Brent
04.XLS	ABG/ORR/DR	Thomas J. Brent
05.XLS	ABG/ORR/DR	Thomas J. Brent
06.XLS	ABG/ORR/DR	Thomas J. Brent
0602.XLS	ABG/ORR/DR	Thomas J. Brent
0603.XLS	ABG/ORR/DR	Thomas J. Brent
0603P2.XLS	ABG/ORR/DR	Thomas J. Brent
0604.XLS	ABG/ORR/DR	Thomas J. Brent
0605.XLS	ABG/ORR/DR	Thomas J. Brent
0606.XLS	ABG/ORR/DR	Thomas J. Brent
0606P2.XLS	ABG/ORR/DR	Thomas J. Brent
0607.XLS	ABG/ORR/DR	Thomas J. Brent
0608.XLS	ABG/ORR/DR	Thomas J. Brent
37.XLS	ABG/ORR/DR	Thomas J. Brent

NAVAL SURFACE WARFARE CENTER, CRANE DIVISION
LIST OF ELECTRONIC FILES CONTAINING GROUND WATER DATA

FILE NAME	SITE	SOURCE
A.XLS	ABG/ORR/DR	Thomas J. Brent
B.XLS	ABG/ORR/DR	Thomas J. Brent
B02.XLS	ABG/ORR/DR	Thomas J. Brent
B10.XLS	ABG/ORR/DR	Thomas J. Brent
C.XLS	ABG/ORR/DR	Thomas J. Brent
31.XLS	ABG/ORR/DR	Thomas J. Brent
33.XLS	ABG/ORR/DR	Thomas J. Brent
35.XLS	ABG/ORR/DR	Thomas J. Brent
0608P2.XLS	ABG/ORR/DR	Thomas J. Brent
0611.XLS	ABG/ORR/DR	Thomas J. Brent
0611P2.XLS	ABG/ORR/DR	Thomas J. Brent
0612.XLS	ABG/ORR/DR	Thomas J. Brent
0613.XLS	ABG/ORR/DR	Thomas J. Brent
0613P2.XLS	ABG/ORR/DR	Thomas J. Brent
0614.XLS	ABG/ORR/DR	Thomas J. Brent
0614P2.XLS	ABG/ORR/DR	Thomas J. Brent
0615.XLS	ABG/ORR/DR	Thomas J. Brent
0616.XLS	ABG/ORR/DR	Thomas J. Brent
0618.XLS	ABG/ORR/DR	Thomas J. Brent
0618P2.XLS	ABG/ORR/DR	Thomas J. Brent
07.XLS	ABG/ORR/DR	Thomas J. Brent
08A.XLS	ABG/ORR/DR	Thomas J. Brent
08AP2.XLS	ABG/ORR/DR	Thomas J. Brent
09.XLS	ABG/ORR/DR	Thomas J. Brent
09P2.XLS	ABG/ORR/DR	Thomas J. Brent
10.XLS	ABG/ORR/DR	Thomas J. Brent
11.XLS	ABG/ORR/DR	Thomas J. Brent
12.XLS	ABG/ORR/DR	Thomas J. Brent
14.XLS	ABG/ORR/DR	Thomas J. Brent
15.XLS	ABG/ORR/DR	Thomas J. Brent
17.XLS	ABG/ORR/DR	Thomas J. Brent
20.XLS	ABG/ORR/DR	Thomas J. Brent
25.XLS	ABG/ORR/DR	Thomas J. Brent

NAVAL SURFACE WARFARE CENTER, CRANE DIVISION
LIST OF ELECTRONIC FILES CONTAINING GROUND WATER DATA

FILE NAME	SITE	SOURCE
26.XLS	ABG/ORR/DR	Thomas J. Brent
27.XLS	ABG/ORR/DR	Thomas J. Brent
28.XLS	ABG/ORR/DR	Thomas J. Brent
30.XLS	ABG/ORR/DR	Thomas J. Brent
ABG87.DBF	ABG	Bill Murphy
ABG88.DBF	ABG	Bill Murphy
ABG89.DBF	ABG	Bill Murphy
ABG90.DBF	ABG	Bill Murphy
ABG91.DBF	ABG	Bill Murphy
ABG92.DBF	ABG	Bill Murphy
ABG_GW.DBF	ABG	Bill Murphy
48721.DBF	ABG	Bill Murphy
48709.DBF	ABG	Bill Murphy
48705.DBF	ABG	Bill Murphy
48701.DBF	ABG	Bill Murphy
48700.DBF	ABG	Bill Murphy
48685.DBF	ABG	Bill Murphy
48670.DBF	ABG	Bill Murphy
48655.DBF	ABG	Bill Murphy
48641.DBF	ABG	Bill Murphy
JEEP_GW.DBF	ABG	Bill Murphy
08214.DBF	ORR/DR	Bill Murphy
08220.DBF	ORR/DR	Bill Murphy
08226.DBF	ORR/DR	Bill Murphy
08232.DBF	ORR/DR	Bill Murphy
08238.DBF	ORR/DR	Bill Murphy
08244.DBF	ORR/DR	Bill Murphy

NAVAL SURFACE WARFARE CENTER, CRANE DIVISION
LIST OF ELECTRONIC FILES CONTAINING GROUND WATER DATA

FILE NAME	SITE	SOURCE
08267.DBF	ORR/DR	Bill Murphy
08280.DBF	ORR/DR	Bill Murphy
08294.DBF	ORR/DR	Bill Murphy
08308.DBF	ORR/DR	Bill Murphy
08322.DBF	ORR/DR	Bill Murphy
08336.DBF	ORR/DR	Bill Murphy
08352.DBF	ORR/DR	Bill Murphy
08368.DBF	ORR/DR	Bill Murphy
08384.DBF	ORR/DR	Bill Murphy
08400.DBF	ORR/DR	Bill Murphy
08416.DBF	ORR/DR	Bill Murphy
08432.DBF	ORR/DR	Bill Murphy
10015.DBF	ORR/DR	Bill Murphy
10030.DBF	ORR/DR	Bill Murphy
10045.DBF	ORR/DR	Bill Murphy
10060.DBF	ORR/DR	Bill Murphy
10075.DBF	ORR/DR	Bill Murphy
10095.DBF	ORR/DR	Bill Murphy
10110.DBF	ORR/DR	Bill Murphy
10125.DBF	ORR/DR	Bill Murphy
10130.DBF	ORR/DR	Bill Murphy
10135.DBF	ORR/DR	Bill Murphy
10140.DBF	ORR/DR	Bill Murphy
10145.DBF	ORR/DR	Bill Murphy
10150.DBF	ORR/DR	Bill Murphy
10155.DBF	ORR/DR	Bill Murphy
19576.DBF	ORR/DR	Bill Murphy
19598.DBF	ORR/DR	Bill Murphy
19620.DBF	ORR/DR	Bill Murphy
19642.DBF	ORR/DR	Bill Murphy
19672.DBF	ORR/DR	Bill Murphy
19692.DBF	ORR/DR	Bill Murphy
19652.DBF	ORR/DR	Bill Murphy

NAVAL SURFACE WARFARE CENTER, CRANE DIVISION
LIST OF ELECTRONIC FILES CONTAINING GROUND WATER DATA

FILE NAME	SITE	SOURCE
ORRDR_GW.DBF	ORR/DR	Bill Murphy
12767.DBF	ORR/DR	Bill Murphy
12797.DBF	ORR/DR	Bill Murphy
12811.DBF	ORR/DR	Bill Murphy
12824.DBF	ORR/DR	Bill Murphy
12837.DBF	ORR/DR	Bill Murphy
12850.DBF	ORR/DR	Bill Murphy
12865.DBF	ORR/DR	Bill Murphy
12879.DBF	ORR/DR	Bill Murphy
16700.DBF	ORR/DR	Bill Murphy
16716.DBF	ORR/DR	Bill Murphy
16732.DBF	ORR/DR	Bill Murphy
16748.DBF	ORR/DR	Bill Murphy
16766.DBF	ORR/DR	Bill Murphy
16784.DBF	ORR/DR	Bill Murphy
16805.DBF	ORR/DR	Bill Murphy
16820.DBF	ORR/DR	Bill Murphy
16835.DBF	ORR/DR	Bill Murphy
16849.DBF	ORR/DR	Bill Murphy
16863.DBF	ORR/DR	Bill Murphy
16878.DBF	ORR/DR	Bill Murphy
16893.DBF	ORR/DR	Bill Murphy
16911.DBF	ORR/DR	Bill Murphy
16965.DBF	ORR/DR	Bill Murphy
16684.DBF	ORR/DR	Bill Murphy
16992.DBF	ORR/DR	Bill Murphy
17019.DBF	ORR/DR	Bill Murphy
17047.DBF	ORR/DR	Bill Murphy
17075.DBF	ORR/DR	Bill Murphy
19523.DBF	ORR/DR	Bill Murphy
19532.DBF	ORR/DR	Bill Murphy
19541.DBF	ORR/DR	Bill Murphy
19554.DBF	ORR/DR	Bill Murphy

NAVAL SURFACE WARFARE CENTER, CRANE DIVISION
LIST OF ELECTRONIC FILES CONTAINING GROUND WATER DATA

FILE NAME	SITE	SOURCE
10157.DBF	ORR/DR	Bill Murphy
10159.DBF	ORR/DR	Bill Murphy
10161.DBF	ORR/DR	Bill Murphy
10163.DBF	ORR/DR	Bill Murphy
10165.DBF	ORR/DR	Bill Murphy
12351.DBF	ORR/DR	Bill Murphy
12358.DBF	ORR/DR	Bill Murphy
12365.DBF	ORR/DR	Bill Murphy
12372.DBF	ORR/DR	Bill Murphy
12379.DBF	ORR/DR	Bill Murphy
12387.DBF	ORR/DR	Bill Murphy
12394.DBF	ORR/DR	Bill Murphy
12407.DBF	ORR/DR	Bill Murphy
12447.DBF	ORR/DR	Bill Murphy
12466.DBF	ORR/DR	Bill Murphy
12427.DBF	ORR/DR	Bill Murphy
12485.DBF	ORR/DR	Bill Murphy
12506.DBF	ORR/DR	Bill Murphy
12526.DBF	ORR/DR	Bill Murphy
12553.DBF	ORR/DR	Bill Murphy
12572.DBF	ORR/DR	Bill Murphy
12588.DBF	ORR/DR	Bill Murphy
12604.DBF	ORR/DR	Bill Murphy
12620.DBF	ORR/DR	Bill Murphy
12636.DBF	ORR/DR	Bill Murphy
12652.DBF	ORR/DR	Bill Murphy
12668.DBF	ORR/DR	Bill Murphy
12684.DBF	ORR/DR	Bill Murphy
12700.DBF	ORR/DR	Bill Murphy
12716.DBF	ORR/DR	Bill Murphy
12732.DBF	ORR/DR	Bill Murphy
12751.DBF	ORR/DR	Bill Murphy

APPENDIX B

GROUND WATER DATA COMPILATION

TABLE 1. WELL: 03C09

DATES: YEAR-MONTH	87-10	88-02	88-04	88-07	88-10	88-11	89-01	89-04	89-07	89-10	90-01
2,4,6-TRINITROTOLUENE (TNT)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
BARIUM, TOTAL	ND	ND	ND	0.056	ND	ND	0.05	0.05	0.05		
BIS(2-ETHYLHEXYL)PHTHALATE	ND	ND	ND	ND	ND	0.02	ND	0.011	ND	ND	ND
DI-N-BUTYL PHTHALATE	ND	ND	ND	ND	ND	ND	ND	ND	0.02	ND	ND
MERCURY, TOTAL	ND	0.014	ND	ND	ND	ND	ND	ND	ND		
RDX	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.23	ND
TRICHLOROETHENE	ND	0.02	ND	0.01	ND	ND	0.01	0.002	ND	0.001	ND
ZINC, TOTAL											

NOTES:
Units in mg/l.
ND = Not detected.
Blanks indicate no data available.

TABLE 1. WELL: 03C09

DATES: YEAR-MONTH	90-04	90-07	90-10	91-01	91-04	91-07	91-10	92-01	92-04	92-07	92-10
2,4,6-TRINITROTOLUENE (TNT)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
BARIUM, TOTAL										ND	0.05
BIS(2-ETHYLHEXYL)PHTHALATE	ND	ND	ND	ND	ND	ND	ND	ND	ND		
DI-N-BUTYL PHTHALATE	ND	ND	ND	ND	ND	ND	ND	ND	ND		
MERCURY, TOTAL										ND	ND
RDX	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TRICHLOROETHENE	ND	ND	ND	ND	0.007	0.003	ND	ND	ND		0.004
ZINC, TOTAL											

NOTES:
Units in mg/l.
ND = Not detected.
Blanks indicate no data available.

TABLE 1. WELL: 03C09

DATES: YEAR-MONTH	93-01	93-08	94-03	94-07	95-01
2,4,6-TRINITROTOLUENE (TNT)	ND	ND	0.06		ND
BARIUM, TOTAL	0.06	ND	ND		ND
BIS(2-ETHYLHEXYL)PHTHALATE		0.0018		ND	ND
DI-N-BUTYL PHTHALATE		ND		ND	ND
MERCURY, TOTAL	ND	ND	ND		ND
RDX	ND	ND	ND		ND
TRICHLOROETHENE	ND	ND	ND		ND
ZINC, TOTAL		0.01			

NOTES:
Units in mg/l.
ND = Not detected.
Blanks indicate no data available.

TABLE 2. WELL: 03C03P2

DATES: YEAR-MONTH	87-10	88-02	88-04	88-07	88-10	89-01	89-04	89-07	89-10	90-01	90-04
1,1,1-TRICHLOROETHANE	0.004	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-DICHLOROETHANE	0.002										
1,2-DICHLOROETHENE(TOTAL)											
2,4,6-TRINITROTOLUENE (TNT)	ND	ND	0.039	0.01	ND	ND	ND	ND	ND	ND	ND
BARIUM, TOTAL	0.07	0.07	0.065		ND	0.08	0.06	0.06			
CIS-1,2-DICHLOROETHENE											
DI-N-BUTYL PHTHALATE	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.03	ND
HMX	0.15	0.14	ND	ND	ND	ND	ND	ND	ND	ND	ND
RDX	ND	ND	0.709	0.14	ND	ND	0.23	0.3	0.26	0.25	0.13
TRICHLOROETHENE	0.2	0.27	0.321	0.13	0.23	0.16	0.115	0.136	0.18	0.16	0.17

NOTES:
Units in mg/l.
ND = Not detected.
Blanks indicate no data available.

TABLE 2. WELL: 03C03P2

DATES: YEAR-MONTH	90-07	90-10	91-01	91-04	91-07	91-10	92-01	92-04	92-07	92-10	93-01
1,1,1-TRICHLOROETHANE	ND	0.0016	ND	ND	ND	ND	ND	ND		ND	ND
1,2-DICHLOROETHANE											
1,2-DICHLOROETHENE(TOTAL)											
2,4,6-TRINITROTOLUENE (TNT)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.04
BARIUM, TOTAL									0.08	0.07	ND
CIS-1,2-DICHLOROETHENE											
DI-N-BUTYL PHTHALATE	ND	ND	ND	ND	0.06	ND	ND	ND			
HMX	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
RDX	0.4	0.09	0.02	0.28	0.17	0.21	0.12	0.03	0.1	ND	0.26
TRICHLOROETHENE	0.096	0.126	0.14	0.151	0.171	0.183	0.062	0.05		0.062	0.127

NOTES:
Units in mg/l.
ND = Not detected.
Blanks indicate no data available.

TABLE 2. WELL: 03C03P2

DATES: YEAR-MONTH	93-08	94-03	94-07	95-01
1,1,1-TRICHLOROETHANE	ND	ND		ND
1,2-DICHLOROETHANE	0.0094			0.008
1,2-DICHLOROETHENE(TOTAL)	0.034			
2,4,6-TRINITROTOLUENE (TNT)	ND	0.03		ND
BARIUM, TOTAL	ND	ND		0.3
CIS-1,2-DICHLOROETHENE				0.027
DI-N-BUTYL PHTHALATE	ND		ND	ND
HMX	0.0335	ND		0.032
RDX	0.31	0.03		0.52
TRICHLOROETHENE	0.2	0.17		0.12

NOTES:
Units in mg/l.
ND = Not detected.
Blanks indicate no data available.

TABLE 3. WELL: 03C04

DATES: YEAR-MONTH	87-10	88-02	88-04	88-07	89-01	89-04	89-07	89-10	90-01	90-04	90-07
2,4,6-TRINITROTOLUENE (TNT)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
BARIUM, TOTAL	ND	0.05	0.075		ND	ND	0.04				
BIS(2-ETHYLHEXYL)PHTHALATE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
RDX	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.4
TRICHLOROETHENE	ND	0.027	0.008	ND	ND	0.012	0.001	0.089	ND	ND	ND
ZINC, DISSOLVED											
ZINC, TOTAL											

NOTES:
Units in mg/l.
ND = Not detected.
Blanks indicate no data available.

TABLE 3. WELL: 03C04

DATES: YEAR-MONTH	90-10	91-01	91-04	91-07	91-10	92-01	92-04	92-07	92-10	93-01	93-08
2,4,6-TRINITROTOLUENE (TNT)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
BARIUM, TOTAL								ND	0.09	0.06	ND
BIS(2-ETHYLHEXYL)PHTHALATE	ND	ND	ND	ND	ND	ND	ND				0.034
RDX	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
TRICHLOROETHENE	ND	0.001	ND	ND	ND	ND	ND		ND	ND	ND
ZINC, DISSOLVED											0.63
ZINC, TOTAL											0.04

NOTES:
Units in mg/l.
ND = Not detected.
Blanks indicate no data available.

TABLE 3. WELL: 03C04

DATES: YEAR-MONTH	94-03	94-07	95-01
2,4,6-TRINITROTOLUENE (TNT)	0.03		ND
BARIUM, TOTAL	ND		0.33
BIS(2-ETHYLHEXYL)PHTHALATE		ND	ND
RDX	ND		ND
TRICHLOROETHENE	ND		ND
ZINC, DISSOLVED			
ZINC, TOTAL			

NOTES:
Units in mg/l.
ND = Not detected.
Blanks indicate no data available.

TABLE 4. WELL: 03C06

DATES: YEAR-MONTH	87-11	88-02	88-04	88-07	88-10	89-01	89-04	89-07	89-10	90-01	90-04
2,4,6-TRINITROTOLUENE (TNT)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
BARIUM, TOTAL	ND	0.07	ND		ND	0.05	ND	0.04			
TRICHLOROETHENE	ND	0.006	0.003	ND	ND	ND	0.004	0.04	0.086	ND	ND
ZINC, TOTAL											

NOTES:
Units in mg/l.
ND = Not detected.
Blanks indicate no data available.

TABLE 4. WELL: 03C06

DATES: YEAR-MONTH	90-07	90-10	91-01	91-04	91-07	91-10	92-01	92-04	92-07	92-10	93-01
2,4,6-TRINITROTOLUENE (TNT)	ND	ND	ND	ND	ND	ND	ND	ND	0.031	ND	ND
BARIUM, TOTAL									ND	0.06	ND
TRICHLOROETHENE	ND	ND	0.002	ND	0.03	0.009	ND	ND		ND	ND
ZINC, TOTAL											

NOTES:
Units in mg/l.
ND = Not detected.
Blanks indicate no data available.

TABLE 4. WELL: 03C06

DATES: YEAR-MONTH	93-08	94-03	95-01
2,4,6-TRINITROTOLUENE (TNT)	ND	0.02	ND
BARIUM, TOTAL	ND	ND	ND
TRICHLOROETHENE	ND	0.001	ND
ZINC, TOTAL	0.18		

NOTES:
Units in mg/l.
ND = Not detected.
Blanks indicate no data available.

TABLE 5. WELL: 03C08AP2

DATES: YEAR-MONTH	87-11	88-02	88-04	88-07	88-10	89-01	89-04	89-07	89-10	90-01	90-04
1,1,1-TRICHLOROETHANE	ND	4.005	ND	ND	ND	ND	ND	ND	ND	ND	ND
BARIUM, TOTAL	0.09	0.12	0.08		ND	0.15	0.12	0.06			
BIS(2-ETHYLHEXYL)PHTHALATE	ND	ND	0.07	0.01	ND	ND	ND	ND	ND	ND	ND
DI-N-BUTYL PHTHALATE	ND	ND	ND	ND	ND	ND	ND	0.01	ND	ND	ND
HMX	0.08	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
RDX	ND	0.15	0.263	0.2	0.09	ND	ND	0.3	0.11	0.09	0.16
TRICHLOROETHENE	0.02	0.021	0.039	0.03	0.03	0.01	0.009	0.023	0.008	0.027	0.016
ZINC, DISSOLVED											
ZINC, TOTAL											

NOTES:
Units in mg/l.
ND = Not detected.
Blanks indicate no data available.

TABLE 5. WELL: 03C08AP2

DATES: YEAR-MONTH	90-07	90-10	91-01	91-04	91-07	91-10	92-01	92-04	92-07	92-10	93-01
1,1,1-TRICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND		ND	ND
BARIUM, TOTAL									0.08	0.09	0.07
BIS(2-ETHYLHEXYL)PHTHALATE	ND	ND	ND	ND	ND	ND	ND	ND			
DI-N-BUTYL PHTHALATE	ND	ND	ND	ND	ND	ND	ND	ND			
HMX	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
RDX	0.2	0.1	0.19	0.08	0.06	0.06	ND	ND	ND	ND	0.65
TRICHLOROETHENE	0.041	0.036	0.031	ND	0.04	0.052	0.05	0.11		0.096	0.047
ZINC, DISSOLVED											
ZINC, TOTAL											

NOTES:
Units in mg/l.
ND = Not detected.
Blanks indicate no data available.

TABLE 5. WELL: 03C08AP2

DATES: YEAR-MONTH	93-08	94-03	94-07	95-01
1,1,1-TRICHLOROETHANE	ND	ND		ND
BARIUM, TOTAL	ND	ND		0.28
BIS(2-ETHYLHEXYL)PHTHALATE	ND		ND	ND
DI-N-BUTYL PHTHALATE	ND		ND	ND
HMX		ND		0.03
RDX	0.14	0.13		0.1
TRICHLOROETHENE	0.051	0.025		0.029
ZINC, DISSOLVED	0.013			
ZINC, TOTAL	0.032			

NOTES:
Units in mg/l.
ND = Not detected.
Blanks indicate no data available.

TABLE 6. WELL: 03C09P2

DATES: YEAR-MONTH	87-10	88-02	88-04	88-07	88-10	89-01	89-04	89-07	89-10	90-01	90-04
1,1,1-TRICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-DICHLOROETHANE	0.003										
2,4,6-TRINITROTOLUENE (TNT)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
BARIUM, TOTAL	ND	ND	ND		ND	ND	ND	ND			
BIS(2-ETHYLHEXYL)PHTHALATE	ND	ND	ND	0.01	0.04	ND	0.014	ND	ND	ND	ND
DI-N-BUTYL PHTHALATE	ND	ND	ND	ND	0.05	ND	ND	ND	ND	0.03	ND
MERCURY, TOTAL	ND	ND	0.124		ND	ND	ND	ND			
RDX	ND	0.05	0.03	0.03	ND	ND	0.03	0.04	0.05	0.05	0.05
TRICHLOROETHENE	0.11	0.116	0.105	0.1	0.11	0.08	0.08	0.077	0.077	0.076	0.051
ZINC, DISSOLVED											

NOTES:
Units in mg/l.
ND = Not detected.
Blanks indicate no data available.

TABLE 6. WELL: 03C09P2

DATES: YEAR-MONTH	90-07	90-10	91-01	91-04	91-07	91-10	92-01	92-04	92-07	92-10	93-01
1,1,1-TRICHLOROETHANE	ND	ND	0.001	ND	ND	ND	ND	ND		ND	ND
1,2-DICHLOROETHANE											
2,4,6-TRINITROTOLUENE (TNT)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
BARIUM, TOTAL									ND	0.06	0.07
BIS(2-ETHYLHEXYL)PHTHALATE	ND	ND	ND	ND	ND	ND	ND	ND			
DI-N-BUTYL PHTHALATE	ND	ND	ND	ND	ND	ND	ND	ND			
MERCURY, TOTAL									ND	ND	ND
RDX	0.05	0.07	0.07	0.02	0.02	0.02	ND	ND	ND	0.07	ND
TRICHLOROETHENE	0.087	0.085	0.052	0.136	0.081	0.109	0.06	0.05		0.056	0.093
ZINC, DISSOLVED											

NOTES:
Units in mg/l.
ND = Not detected.
Blanks indicate no data available.

TABLE 6. WELL: 03C09P2

DATES: YEAR-MONTH	93-08	94-03	94-07	95-01
1,1,1-TRICHLOROETHANE	ND	ND		ND
1,2-DICHLOROETHANE	0.0073			0.009
2,4,6-TRINITROTOLUENE (TNT)	ND	0.04		ND
BARIUM, TOTAL	ND	ND		ND
BIS(2-ETHYLHEXYL)PHTHALATE	0.0016		ND	ND
DI-N-BUTYL PHTHALATE	ND		ND	ND
MERCURY, TOTAL	ND	ND		ND
RDX	0.076	0.06		0.086
TRICHLOROETHENE	0.084	0.057		0.16
ZINC, DISSOLVED	0.023			

NOTES:
Units in mg/l.
ND = Not detected.
Blanks indicate no data available.

TABLE 7. WELL: 03C11

DATES: YEAR-MONTH	87-10	88-02	88-04	88-07	88-10	89-01	89-04	89-07	89-10	90-01	90-04
2,4,6-TRINITROTOLUENE (TNT)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
BARIUM, TOTAL	0.06	ND	ND		ND	ND	ND	ND			
BIS(2-ETHYLHEXYL)PHTHALATE	ND	ND	0.16	ND	ND	ND	ND	ND	ND	ND	ND
CIS-1,2-DICHLOROETHENE											
DI-N-BUTYL PHTHALATE	ND	ND	ND	ND	ND	ND	ND	0.02	ND	ND	ND
RDX	0.02	0.04	ND	0.03	ND	ND	ND	ND	0.02	0.02	ND
TRICHLOROETHENE	0.009	0.89	0.582	0.93	0.687	0.979	0.7	0.8	0.592	0.648	0.132
ZINC, TOTAL											

NOTES:
Units in mg/l.
ND = Not detected.
Blanks indicate no data available.

TABLE 7. WELL: 03C11

DATES: YEAR-MONTH	90-07	90-10	91-01	91-04	91-07	91-10	92-01	92-04	92-07	92-10	93-01
2,4,6-TRINITROTOLUENE (TNT)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
BARIUM, TOTAL									ND	0.14	ND
BIS(2-ETHYLHEXYL)PHTHALATE	ND	ND	ND	ND	ND	ND	ND	ND			
CIS-1,2-DICHLOROETHENE											
DI-N-BUTYL PHTHALATE	ND	ND	ND	ND	ND	ND	ND	ND			
RDX	ND	ND	0.15	ND	ND	ND	ND	ND	ND	ND	0.32
TRICHLOROETHENE	1	1.063	0.569	1.292	1.235	1.235	1.2	1.41		0.477	1.4
ZINC, TOTAL											

NOTES:
Units in mg/l.
ND = Not detected.
Blanks indicate no data available.

TABLE 7. WELL: 03C11

DATES: YEAR-MONTH	93-08	94-03	94-07	95-01
2,4,6-TRINITROTOLUENE (TNT)	ND	0.02		ND
BARIUM, TOTAL	ND	ND		4.1
BIS(2-ETHYLHEXYL)PHTHALATE	0.0029		ND	ND
CIS-1,2-DICHLOROETHENE				0.017
DI-N-BUTYL PHTHALATE	ND		ND	ND
RDX	0.02	0.06		0.025
TRICHLOROETHENE	1.4	0.042		1.9
ZINC, TOTAL	0.022			

NOTES:
Units in mg/l.
ND = Not detected.
Blanks indicate no data available.

TABLE 8. WELL: 03C12

DATES: YEAR-MONTH	87-10	88-02	88-04	88-07	88-10	89-01	89-04	89-07	89-10	90-01	90-04
2,4,6-TRINITROTOLUENE (TNT)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
BARIUM, DISSOLVED											
BARIUM, TOTAL	ND	0.07	0.1		ND	0.113	0.11	0.1			
BIS(2-ETHYLHEXYL)PHTHALATE	ND	ND	0.1	ND	ND	ND	0.037	ND	ND	ND	ND
DI-N-BUTYL PHTHALATE	ND	ND	ND	ND	ND	ND	ND	0.01	ND	ND	ND
HMX	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
RDX	0.03	ND	0.026	0.02	ND	ND	ND	ND	ND	ND	ND
TRICHLOROETHENE	0.7	0.027	0.04	0.01	0.01	0.04	0.15	0.008	0.002	0.021	0.02
ZINC, TOTAL											

NOTES:
Units in mg/l.
ND = Not detected:
Blanks indicate no data available.

TABLE 8. WELL: 03C12

DATES: YEAR-MONTH	90-07	90-10	91-01	91-04	91-07	91-10	92-01	92-04	92-07	92-10	93-01
2,4,6-TRINITROTOLUENE (TNT)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
BARIUM, DISSOLVED											
BARIUM, TOTAL									0.11	0.17	0.13
BIS(2-ETHYLHEXYL)PHTHALATE	ND	ND	ND	ND	ND	ND	ND	ND			
DI-N-BUTYL PHTHALATE	ND	ND	ND	ND	ND	ND	ND	ND			
HMX	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
RDX	ND	ND	0.03	ND	0.02	ND	ND	ND	0.03	0.03	ND
TRICHLOROETHENE	0.011	0.018	0.026	0.016	0.005	0.106	0.027	0.045		0.019	0.022
ZINC, TOTAL											

NOTES:
Units in mg/l.
ND = Not detected.
Blanks indicate no data available.

TABLE 8. WELL: 03C12

DATES: YEAR-MONTH	93-08	94-03	94-07	95-01
2,4,6-TRINITROTOLUENE (TNT)	ND	0.07		ND
BARIUM, DISSOLVED	ND	0.11		ND
BARIUM, TOTAL	0.13	0.19		ND
BIS(2-ETHYLHEXYL)PHTHALATE	ND		ND	ND
DI-N-BUTYL PHTHALATE	ND		ND	ND
HMX		ND		0.04
RDX	0.029	ND		0.022
TRICHLOROETHENE	0.02	0.011		0.014
ZINC, TOTAL	0.11			

NOTES:
Units in mg/l.
ND = Not detected.
Blanks indicate no data available.

TABLE 9. WELL: 03C13

DATES: YEAR-MONTH	87-11	88-02	88-04	88-07	88-10	89-01	89-04	89-07	89-10	90-01	90-04
RDX	ND	0.02	ND	0.01	ND	ND	ND	ND	0.01	ND	ND
TRICHLOROETHENE	0.049	0.05	0.019	0.06	0.05	0.03	0.04	0.038	0.044	0.057	0.04

NOTES:
Units in mg/l.
ND = Not detected.
Blanks indicate no data available.

TABLE 9. WELL: 03C13

DATES: YEAR-MONTH	90-07	90-10	91-01	91-04	91-07	91-10	92-01	92-04	92-07
RDX	ND	ND	ND	ND	ND	ND	ND	0.02	ND
TRICHLOROETHENE	0.061	0.051	0.064	0.079	0.053	0.069	ND	0.035	

NOTES:
Units in mg/l.
ND = Not detected.
Blanks indicate no data available.

TABLE 10. WELL: 03C20

DATES: YEAR-MONTH	87-10	88-02	88-04	88-07	88-10	89-01	89-04	89-07	89-10	90-01	90-04
1,1,1-TRICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	0.62	ND	ND
2,4,6-TRINITROTOLUENE (TNT)	ND	ND	ND	ND	ND	ND	ND	ND	0.01	ND	ND
CIS-1,2-DICHLOROETHENE											
HMX	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
RDX	ND	0.02	0.11	0.13	0.04	ND	0.11	ND	0.13	0.18	0.09
TRICHLOROETHENE	0.76	1.511	2.528	1.84	2.516	2.46	1.93	1.99	2.2	4.04	2.836

NOTES:
Units in mg/l.
ND = Not detected.
Blanks indicate no data available.

TABLE 10. WELL: 03C20

DATES: YEAR-MONTH	90-07	90-10	91-01	91-04	91-07	91-10	92-01	92-04	92-07	92-10	93-01
1,1,1-TRICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND		ND	ND
2,4,6-TRINITROTOLUENE (TNT)	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.01	ND
CIS-1,2-DICHLOROETHENE											
HMX	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
RDX	0.1	ND	ND	0.08	0.07	0.06	0.03	ND	0.03	0.16	0.09
TRICHLOROETHENE	1.31	17.84	ND	3.462	1.829	3.062	2.488	2.14		2.86	3.727

NOTES:
Units in mg/l.
ND = Not detected.
Blanks indicate no data available.

TABLE 10. WELL: 03C20

DATES: YEAR-MONTH	93-08	94-03	95-01
1,1,1-TRICHLOROETHANE	ND	ND	ND
2,4,6-TRINITROTOLUENE (TNT)	ND	0.03	ND
CIS-1,2-DICHLOROETHENE			0.056
HMX		ND	0.021
RDX	0.12	0.13	0.14
TRICHLOROETHENE	4.3	1.27	4.8

NOTES:
Units in mg/l.
ND = Not detected.
Blanks indicate no data available.

TABLE 11. WELL: 03C21

DATES: YEAR-MONTH	87-11	88-02	88-04	88-07	88-10	89-01	89-04	89-07	89-10	90-01	90-04
RDX	ND	ND	ND	ND	0.04	ND	ND	ND	ND	ND	ND
TRICHLOROETHENE	ND	ND	ND	ND	0.01	ND	0.022	0.009	0.009	0.076	ND

NOTES:
Units in mg/l.
ND = Not detected.
Blanks indicate no data available.

TABLE 11. WELL: 03C21

DATES: YEAR-MONTH	90-07	90-10	91-01	91-04	91-07	91-10	92-01	92-04	92-07
RDX	ND	ND	ND	ND	ND	ND	ND	ND	ND
TRICHLOROETHENE	ND	ND	ND	0.03	ND	0.07	ND	ND	

NOTES:
Units in mg/l.
ND = Not detected.
Blanks indicate no data available.

TABLE 12. WELL: 03C28

DATES: YEAR-MONTH	87-10	88-02	88-04	88-07	88-10	89-01	89-04	89-07	89-10	90-01	90-04
BARIUM, TOTAL	ND	ND	ND	0.05	ND	ND	ND	0.03			
BIS(2-ETHYLHEXYL)PHTHALATE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
DI-N-BUTYL PHTHALATE	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.02	ND
MERCURY, DISSOLVED											
MERCURY, TOTAL	ND	0.01	ND	ND	ND	ND	ND	ND			
TRICHLOROETHENE	ND	ND	ND	ND	ND	ND	0.014	ND	0.003	0.005	ND
ZINC, DISSOLVED											

NOTES:
Units in mg/l.
ND = Not detected.
Blanks indicate no data available.

TABLE 12. WELL: 03C28

DATES: YEAR-MONTH	90-07	90-10	91-01	91-04	91-07	91-10	92-01	92-04	92-07	92-10	93-01
BARIUM, TOTAL									ND	0.17	0.14
BIS(2-ETHYLHEXYL)PHTHALATE	ND	ND	ND	ND	ND	ND	ND	ND			
DI-N-BUTYL PHTHALATE	ND	ND	ND	ND	ND	ND	ND	ND			
MERCURY, DISSOLVED											
MERCURY, TOTAL									ND	ND	ND
TRICHLOROETHENE	ND	ND	ND	0.011	0.008	0.007	ND	ND		ND	ND
ZINC, DISSOLVED											

NOTES:
Units in mg/l.
ND = Not detected.
Blanks indicate no data available.

TABLE 12. WELL: 03C28

DATES: YEAR-MONTH	93-08	94-03	94-07	95-01
BARIUM, TOTAL	0.43	ND		0.22
BIS(2-ETHYLHEXYL)PHTHALATE	0.0018		ND	ND
DI-N-BUTYL PHTHALATE	ND		ND	ND
MERCURY, DISSOLVED	0.0008	ND		ND
MERCURY, TOTAL	0.0012	ND		ND
TRICHLOROETHENE	ND	0.001		ND
ZINC, DISSOLVED	0.012			

NOTES:
Units in mg/l.
ND = Not detected.
Blanks indicate no data available.

TABLE 13. WELL: 03-33

DATES: YEAR-MONTH	87-11	88-02	89-07	89-10	90-01	90-04	90-07	90-10	91-01	91-04	92-04
1,1,1-TRICHLOROETHANE	0.005	ND	ND	ND	ND	ND	0.002	ND	ND	ND	ND
2,4,6-TRINITROTOLUENE (TNT)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
RDX	0.05	0.05	ND	0.054	0.06	0.05	ND	ND	0.01	ND	ND
TRICHLOROETHENE	ND	0.06	0.035	0.012	0.002	0.005	0.003	ND	0.001	0.005	0.005

NOTES:
Units in mg/l.
ND = Not detected.
Blanks indicate no data available.

TABLE 13. WELL: 03-33

DATES: YEAR-MONTH	92-07
1,1,1-TRICHLOROETHANE	ND
2,4,6-TRINITROTOLUENE (TNT)	0.04
RDX	0.05
TRICHLOROETHENE	ND

NOTES:
Units in mg/l.
ND = Not detected.
Blanks indicate no data available.

TABLE 14. WELL: 03-38

DATES: YEAR-MONTH	87-11	88-02	88-04	88-10	89-01	89-04	89-07	89-10	90-01	90-04	90-07
1,1,1-TRICHLOROETHANE	0.005	ND	ND	ND	ND	ND	0.002	ND	ND	ND	ND
1,2-DICHLOROETHANE	0.004										
BIS(2-ETHYLHEXYL)PHTHALATE	ND	ND	0.01	0.14	ND	ND	ND	ND	ND	ND	ND
DI-N-BUTYL PHTHALATE	ND	0.01	ND	ND	ND	ND	ND	ND	ND	ND	ND
RDX	0.02	0.03	0.028	ND	ND	0.02	ND	0.015	0.02	0.04	ND
TRICHLOROETHENE	0.036	0.053	0.055	0.05	0.05	0.039	0.037	0.041	0.042	0.038	0.045

NOTES:
Units in mg/l.
ND = Not detected.
Blanks indicate no data available.

TABLE 14. WELL: 03-38

DATES: YEAR-MONTH	90-10	91-01	91-04	91-07	91-10	92-01	92-04	92-07
1,1,1-TRICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	
1,2-DICHLOROETHANE								
BIS(2-ETHYLHEXYL)PHTHALATE	ND	ND	ND	ND	ND	ND	ND	
DI-N-BUTYL PHTHALATE	ND	ND	ND	ND	ND	ND	ND	
RDX	ND	ND	0.02	ND	ND	ND	ND	ND
TRICHLOROETHENE	0.051	0.036	0.066	0.035	0.042	ND	0.029	

NOTES:
Units in mg/l.
ND = Not detected.
Blanks indicate no data available.

TABLE 15. WELL: 03C08AP3

DATES: YEAR-MONTH	87-11	88-02	88-04	88-07	88-10	89-01	89-04	89-07	89-10	90-01	90-04
BARIUM, TOTAL	0.09	0.14	ND		ND	0.1	0.07	0.06			
DI-N-BUTYL PHTHALATE	ND	ND	ND	ND	ND	ND	ND	0.02	ND	ND	ND
RDX	ND	ND	0.03	0.02	ND	ND	ND	ND	ND	ND	ND
TRICHLOROETHENE	ND	ND	ND	ND	ND	ND	0.003	0.002	ND	ND	ND

NOTES:
Units in mg/l.
ND = Not detected.
Blanks indicate no data available.

TABLE 15. WELL: 03C08AP3

DATES: YEAR-MONTH	90-07	90-10	91-01	91-04	91-07	91-10	92-01	92-04	92-07
BARIUM, TOTAL									0.08
DI-N-BUTYL PHTHALATE	ND	ND	ND	ND	ND	ND	ND	ND	
RDX	ND	ND	ND	ND	0.02	ND	ND	ND	ND
TRICHLOROETHENE	ND	0.016	ND	ND	ND	ND	ND	ND	

NOTES:
Units in mg/l.
ND = Not detected.
Blanks indicate no data available.

TABLE 16. WELL: 03C22

DATES: YEAR-MONTH	87-11	88-02	88-04	88-07	88-10	89-01	89-04	89-07	89-10	90-01	90-04
BARIUM, TOTAL	ND	ND	ND		ND	0.05	ND	0.03			
BIS(2-ETHYLHEXYL)PHTHALATE	ND	ND	ND	ND	0.02	ND	ND	ND	ND	ND	ND
DI-N-BUTYL PHTHALATE	ND	ND	ND	ND	0.03	ND	ND	0.02	ND	ND	ND
TRICHLOROETHENE	ND	ND	ND	ND	ND	0.3	0.002	ND	0.036	ND	ND

NOTES:
Units in mg/l.
ND = Not detected.
Blanks indicate no data available.

TABLE 16. WELL: 03C22

DATES: YEAR-MONTH	90-10	91-01	91-04	91-07	91-10	92-01	92-04	92-07
BARIUM, TOTAL								ND
BIS(2-ETHYLHEXYL)PHTHALATE	ND	ND	ND	ND	ND	ND	ND	
DI-N-BUTYL PHTHALATE	ND	ND	ND	ND	ND	ND	ND	
TRICHLOROETHENE	ND	ND	0.003	ND	0.003	ND	ND	

NOTES:
Units in mg/l.
ND = Not detected.
Blanks indicate no data available.

TABLE 17. WELL: 03B02

DATES: YEAR-MONTH	87-09	88-01	88-04	88-07	88-10	89-01	89-04	89-07	89-10	90-02	90-04
BARIUM, TOTAL	ND	0.11	0.12	0.348	ND	0.13	0.11	0.11			
MANGANESE, DISSOLVED											
MANGANESE, TOTAL	2.1	1.15	1.56	1.46	0.91	0.645	1.3	1.2		0.8	
TRICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	0.007	ND	ND

NOTES:
Units in mg/l.
ND = Not detected.
Blanks indicate no data available.

TABLE 17. WELL: 03B02

DATES: YEAR-MONTH	90-07	90-10	91-01	91-04	91-07	91-10	92-01	92-04	92-07	92-10	93-01
BARIUM, TOTAL									0.1	0.09	0.1
MANGANESE, DISSOLVED											
MANGANESE, TOTAL			1.27		1.12		0.97		1.484		
TRICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND		ND	ND

NOTES:
Units in mg/l.
ND = Not detected.
Blanks indicate no data available.

TABLE 17. WELL: 03B02

DATES: YEAR-MONTH	93-08	94-03	94-07	95-01
BARIUM, TOTAL	ND	ND		ND
MANGANESE, DISSOLVED	0.93		0.92	1.5
MANGANESE, TOTAL	1			0.24
TRICHLOROETHENE	ND	ND		ND

NOTES:
Units in mg/l.
ND = Not detected.
Blanks indicate no data available.

TABLE 18. WELL: 03B03

DATES: YEAR-MONTH	87-09	88-01	88-04	88-07	88-10	89-01	89-04	89-07	89-10	90-02	90-04
BARIUM, TOTAL	0.05	0.16	0.14	0.164	ND	0.21	0.15	0.15			
MANGANESE, TOTAL	3.7	3	2.6	2	2.75	2.8	2.3	2.3		2	
TRICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	0.03	ND	ND

NOTES:
Units in mg/l.
ND = Not detected.
Blanks indicate no data available.

TABLE 18. WELL: 03B03

DATES: YEAR-MONTH	90-07	90-10	91-01	91-04	91-07	91-10	92-01	92-04	92-07
BARIUM, TOTAL									0.21
MANGANESE, TOTAL			2.39		2.08		3.26		3.606
TRICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND	

NOTES:
Units in mg/l.
ND = Not detected.
Blanks indicate no data available.

TABLE 19. WELL: 03B10

DATES: YEAR-MONTH	87-11	88-04	88-07	88-10	89-01	89-04	89-07	89-10	90-02	90-04	90-07
1,1,1-TRICHLOROETHANE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
BARIUM, TOTAL	ND	0.03	ND	ND	ND	ND	0.03				
MANGANESE, DISSOLVED											
MANGANESE, TOTAL	ND	0.1	ND	ND	ND	ND	ND		0.018		
TRICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	0.004	0.002	ND	ND

NOTES:
Units in mg/l.
ND = Not detected.
Blanks indicate no data available.

TABLE 19. WELL: 03B10

DATES: YEAR-MONTH	90-10	91-01	91-04	91-07	91-10	92-04	92-07	92-10	93-01	93-08	94-03
1,1,1-TRICHLOROETHANE	ND	ND	ND	0.006	ND	ND		ND	ND	ND	ND
BARIUM, TOTAL							ND	0.16	0.09	0.41	ND
MANGANESE, DISSOLVED										ND	
MANGANESE, TOTAL		0.01		0.01			ND			3.8	
TRICHLOROETHENE	ND	ND	ND	0.002	ND	ND		ND	ND	ND	ND

NOTES:
Units in mg/l.
ND = Not detected.
Blanks indicate no data available.

TABLE 19. WELL: 03B10

DATES: YEAR-MONTH	94-07	95-01
1,1,1-TRICHLOROETHANE	ND	ND
BARIUM, TOTAL		ND
MANGANESE, DISSOLVED	0.09	0.4
MANGANESE, TOTAL		0.62
TRICHLOROETHENE	ND	ND

NOTES:
Units in mg/l.
ND = Not detected.
Blanks indicate no data available.

TABLE 20. WELL: 03-SPRING-A

DATES: YEAR-MONTH	87-12	89-07	89-10	90-02	91-04	91-10	92-01	92-04	92-07	92-10	93-01
BARIUM, DISSOLVED											
BARIUM, TOTAL	0.14			ND	0.06	0.07	ND	0.05	0.12	0.14	0.06
MANGANESE, TOTAL	ND			ND	ND	ND	ND	ND	ND		
RDX	0.14	0.07	0.06	ND	ND	0.04	0.04	0.03	ND	0.06	0.04
TRICHLOROETHENE	ND	ND	ND	ND	ND	ND	ND	ND		0.006	ND

NOTES:
Units in mg/l.
ND = Not detected.
Blanks indicate no data available.

TABLE 20. WELL: 03-SPRING-A

DATES: YEAR-MONTH	93-08	94-03	95-01	95-09
BARIUM, DISSOLVED	0.12	ND	ND	
BARIUM, TOTAL	0.11	ND	ND	0.136
MANGANESE, TOTAL	ND		0.006	0.0092
RDX		ND	ND	ND
TRICHLOROETHENE	ND	ND	ND	ND

NOTES:
Units in mg/l.
ND = Not detected.
Blanks indicate no data available.

TABLE 21. WELL: 06C01

DATES: YEAR-MONTH	90-11	91-05	91-11	92-03	95-09
ALUMINUM, TOTAL	ND	0.02	ND	ND	0.0279
ANTIMONY, TOTAL	0.0044	0.0066	0.0044	ND	ND
BARIUM, TOTAL	0.124	0.12	0.1	0.108	0.0953
CHROMIUM, TOTAL	ND	ND	ND	ND	0.0027
COBALT, TOTAL	ND	ND	0.012	ND	ND
COPPER, TOTAL	ND	ND	ND	0.019	0.00195
IRON, TOTAL	0.012	0.045	0.012	ND	ND
MANGANESE, TOTAL	0.029	2.44	0.062	0.111	0.0633
NICKEL, TOTAL	ND	0.006	ND	ND	ND
VANADIUM, TOTAL	ND	ND	ND	ND	0.00145
ZINC, TOTAL	0.043	0.02	ND	ND	0.00795

NOTES:
Units in mg/l.
ND = Not detected.
Blanks indicate no data available.

TABLE 22. WELL: 06C03

DATES: YEAR-MONTH	91-03	91-05	91-11	92-04	92-10	93-01	93-07	94-03	94-07	95-01	95-09
ALUMINUM, TOTAL	ND	ND	ND	ND	ND	0.09	ND	ND		ND	ND
ANTIMONY, TOTAL	0.0054	0.0127	ND	ND	ND	ND	ND	ND		ND	ND
ARSENIC, DISSOLVED							0.012	ND		0.016	
ARSENIC, TOTAL	0.0099	0.0123	0.0107		ND	ND	0.012	ND		0.009	0.0131
BARIUM, DISSOLVED							ND	ND		0.21	
BARIUM, TOTAL	0.084	0.075	0.084		0.08	0.12	ND	ND		ND	0.0845
CHROMIUM, TOTAL	ND	0.005	ND	ND	ND	ND	ND	ND		ND	ND
COBALT, TOTAL	0.009	0.008	0.012	ND	ND		ND	ND		ND	ND
COPPER, TOTAL	0.016	0.005	ND	ND	ND	ND	ND	ND		ND	ND
IRON, DISSOLVED							7.7		0.42	6.6	
IRON, TOTAL	6.75	7.21	7.09		7.28	7.25	12			6.6	7.03
LEAD, TOTAL	0.0016	ND	ND	ND	ND	ND	ND			0.018	ND
MANGANESE, DISSOLVED							0.41	0.43	0.19	0.37	
MANGANESE, TOTAL	0.404	0.364	0.405			0.41	0.35	0.42	0.41	0.31	0.384
ZINC, TOTAL	ND	0.007	ND	ND	ND	ND	0.014			0.17	ND

NOTES:
Units in mg/l.
ND = Not detected.
Blanks indicate no data available.

TABLE 23. WELL: 06C04

DATES: YEAR-MONTH	91-03	91-05	91-11	92-04	92-10	93-01	93-07	94-03	94-07	95-01
ANTIMONY, TOTAL	0.0067	0.0129	0.0034	ND	ND	ND	ND	ND		ND
BARIUM, DISSOLVED							ND	0.14		0.41
BARIUM, TOTAL	0.122	0.132	0.145		0.14	0.15	0.14	0.14		0.36
COBALT, TOTAL	0.008	0.01	0.019	ND	ND		ND	ND		ND
IRON, DISSOLVED							1.7		ND	2.2
IRON, TOTAL	1.18	1.17	1.41		1.53	1.55	1.6			1.5
LEAD, TOTAL	ND	ND	ND		ND	ND	ND			0.006
MANGANESE, DISSOLVED							0.14	0.12	0.12	0.16
MANGANESE, TOTAL	0.081	0.108	0.151			0.14	0.13	0.12	0.22	0.14
ZINC, DISSOLVED							ND			0.12
ZINC, TOTAL	0.011	ND	ND	ND	ND	ND	0.028			0.048

NOTES:
Units in mg/l.
ND = Not detected.
Blanks indicate no data available.

TABLE 24. WELL: 06C06

DATES: YEAR-MONTH	91-03	91-05	91-11	92-04	92-10	93-01	93-07	94-03	94-07	95-01	95-09
ALUMINUM, TOTAL	ND	0.013	ND	ND	ND	ND	ND	ND		ND	ND
ANTIMONY, TOTAL	ND	0.0036	0.0049	ND	ND	ND	ND	ND		ND	ND
BARIUM, TOTAL	0.043	0.014	0.045		ND	0.07	ND	ND		ND	0.0423
COBALT, TOTAL	0.008	ND	0.027	ND	ND		ND	ND		ND	ND
IRON, DISSOLVED							0.19		ND	ND	
IRON, TOTAL	ND	ND	0.038		2.9	0.5	0.26			0.32	0.329
LEAD, TOTAL	ND	ND	ND	ND	ND	ND	ND			0.011	ND
MANGANESE, DISSOLVED							0.084	ND	0.034	0.044	
MANGANESE, TOTAL	0.113	0.025	0.075			0.12	0.087	ND	ND	0.044	0.0585
ZINC, DISSOLVED							0.013			ND	
ZINC, TOTAL	0.006	ND	ND	ND	ND	ND	0.014			0.071	ND

NOTES:
Units in mg/l.
ND = Not detected.
Blanks indicate no data available.

TABLE 25. WELL: 06C04P2

DATES: YEAR-MONTH	91-03	91-05	91-11	92-04	92-10	93-01	93-07	94-07	95-01	95-09
ALUMINUM, TOTAL	ND	ND	ND	ND	3.08	1.69	1.4		18	2.34
ANTIMONY, TOTAL	0.0068	0.0123	0.0199	ND	ND	ND	ND		ND	ND
ARSENIC, TOTAL	ND	ND	ND	ND	ND	ND	ND		0.015	0.0036
BARIUM, DISSOLVED							ND		1.1	
BARIUM, TOTAL	ND	ND	0.022		0.82	0.07	ND		1.5	0.0337
BERYLLIUM, TOTAL	ND	ND	ND	ND	ND	ND	ND		0.001	ND
CADMIUM, TOTAL	ND	ND	0.0003	ND	ND	ND	ND		ND	ND
CHROMIUM, TOTAL	ND	ND	ND	ND	ND	ND	ND		0.025	0.0086
COBALT, TOTAL	0.011	0.013	0.031	ND	ND		ND		ND	0.0016
COPPER, TOTAL	ND	0.005	0.085		ND	ND	ND		ND	0.006
IRON, DISSOLVED							0.061	ND	0.53	
IRON, TOTAL	0.011	ND	0.064	ND	11.4	7.7	4.9		48	4.57
LEAD, TOTAL	ND	ND	ND	ND	ND	ND	ND		0.029	0.0033
MANGANESE, DISSOLVED							0.023	0.072	0.5	
MANGANESE, TOTAL	0.024	0.049	0.069			1.54	0.69	4.2	3	0.499
NICKEL, TOTAL	ND	ND	ND	ND		ND	ND		0.057	0.0088
SELENIUM, DISSOLVED							0.0081			
VANADIUM, TOTAL	ND	ND	ND	ND			ND			0.0028
ZINC, TOTAL	0.019	ND	ND	ND	ND	ND	0.043		0.2	0.0206

NOTES:
Units in mg/l.
ND = Not detected.
Blanks indicate no data available.

TABLE 26. WELL: 06-09

DATES: YEAR-MONTH	89-07	90-02	90-07	91-01
BARIUM, TOTAL	0.022	ND	ND	
IRON, TOTAL	ND	0.73	3.26	1.56
MANGANESE, TOTAL	7.7	5.68		5.87

NOTES:
Units in mg/l.
ND = Not detected.
Blanks indicate no data available.

TABLE 27. WELL: 06-10

DATES: YEAR-MONTH	89-07	90-02	90-07	91-01	92-01
IRON, TOTAL	24	32	25	29.03	48.59
MANGANESE, TOTAL	4.2	5.09		6.25	6.15

NOTES:
Units in mg/l.
ND = Not detected.
Blanks indicate no data available.

TABLE 28. WELL: 06-11

DATES: YEAR-MONTH	89-07	90-02	90-07	91-01	92-01
IRON, TOTAL	0.6	107	122	18.49	183
MANGANESE, TOTAL	9.2	8.93		5.27	16.7

NOTES:
Units in mg/l.
ND = Not detected.
Blanks indicate no data available.

TABLE 29. WELL: 06-07

DATES: YEAR-MONTH	89-07	90-02	90-07	90-11	91-01	91-05	91-11	92-01	92-03	95-09
ALUMINUM, TOTAL				145		78.6	139		76.1	81.8
ANTIMONY, TOTAL				0.0051		0.0184	0.0082		ND	ND
ARSENIC, TOTAL	0.07	ND	ND	0.0084		0.0066	0.002	ND	0.0029	0.035
BARIUM, TOTAL	ND	ND	ND	ND		ND	ND	ND	ND	0.0148
BERYLLIUM, TOTAL				0.013		0.014	0.012		0.01	0.0091
CADMIUM, TOTAL	ND	ND	ND	ND		0.008	0.0102	ND	0.0083	0.0058
CHROMIUM, TOTAL	ND	ND	ND	0.032		0.016	0.022	ND	ND	0.0193
COBALT, TOTAL				0.577		0.466	0.665		0.388	0.265
COPPER, TOTAL				ND		ND	0.05		0.007	0.0066
IRON, TOTAL	69	57	68	78.5	44.69	50.1	84.2	8.9	49.2	46.7
LEAD, TOTAL	ND	ND	ND	0.0014		0.0027	ND	ND	ND	0.002
MANGANESE, TOTAL	12	10.8		12.4	13.8	10.4	12.7	12.54	8.19	6.64
NICKEL, TOTAL				1.98		1.59	2		1.12	1.06
TIN, TOTAL				0.041		ND	ND		ND	
VANADIUM, TOTAL				ND		0.013	ND		0.014	0.0163
ZINC, TOTAL				3		2.61	2.74		1.82	1.82

NOTES:
Units in mg/l.
ND = Not detected.
Blanks indicate no data available.

TABLE 30. WELL: 06C02P2

DATES: YEAR-MONTH	91-03	91-05	91-11	92-04
ANTIMONY, TOTAL	ND	0.0137	0.0033	ND
BARIUM, TOTAL	0.022	0.011	0.026	
CHROMIUM, TOTAL	ND	ND	0.005	ND
COBALT, TOTAL	ND	0.016	ND	ND
COPPER, TOTAL	0.011	ND	ND	ND
MANGANESE, TOTAL	0.011	0.019	0.036	

NOTES:
Units in mg/l.
ND = Not detected.
Blanks indicate no data available.

TABLE 31. WELL: 06C03P2

DATES: YEAR-MONTH	91-03	91-05	91-11	92-04	92-10	93-01	93-07	94-03	94-07	95-01	95-09
ALUMINUM, DISSOLVED							ND	ND		1.1	
ALUMINUM, TOTAL	ND	ND	ND	ND	7.1	9.31	12.7	ND		23	1.44
ANTIMONY, TOTAL	0.0066	0.0113	0.0084	ND	ND	ND	ND	ND		ND	ND
ARSENIC, TOTAL	ND	ND	ND	ND	ND	ND	0.0057	ND		0.017	ND
BARIUM, TOTAL	0.046	0.049	0.081		0.23	0.24	0.13	ND		0.38	0.0611
BERYLLIUM, TOTAL	ND	ND	ND	ND	ND	ND	ND	ND		0.001	ND
CHROMIUM, TOTAL	ND	ND	ND	ND	ND	ND	0.03	ND		0.031	0.0242
COBALT, TOTAL	0.006	0.009	0.014	ND	ND		ND	ND		ND	0.0019
COPPER, TOTAL	0.015	ND	0.028	ND	ND	ND	ND	ND		ND	ND
IRON, DISSOLVED							ND		ND	1.6	
IRON, TOTAL	0.025	0.014	0.028	ND	11.5	14.1	16			20	1.69
LEAD, DISSOLVED							ND			0.005	
LEAD, TOTAL	ND	ND	ND	ND	ND	ND	0.015			0.047	ND
MANGANESE, DISSOLVED							ND	0.01	0.012	0.76	
MANGANESE, TOTAL	0.031	0.028	0.009			0.32	0.19	0.17	0.19	0.61	0.0375
NICKEL, TOTAL	ND	ND	ND	ND		ND	0.05	ND		ND	0.0096
VANADIUM, TOTAL	ND	ND	ND	ND			ND				0.0017
ZINC, TOTAL	ND	ND	ND	ND	ND	ND	0.052			0.093	0.0119

NOTES:
Units in mg/l.
ND = Not detected.
Blanks indicate no data available.

TABLE 32. WELL: 06C06P2

DATES: YEAR-MONTH	91-03	91-05	91-11	92-04	92-10	93-01	93-07	94-03	94-07	95-01	95-09
ALUMINUM, TOTAL	0.025	ND	ND	ND	4.39	1.92	ND	ND		24	3.58
ANTIMONY, TOTAL	ND	0.0187	0.008	ND	ND	ND	ND	ND		ND	ND
ARSENIC, TOTAL	ND	ND	ND	ND	ND	ND	ND	ND		0.019	0.005
BARIUM, TOTAL	ND	0.019	0.014	ND	ND	ND	ND	ND		ND	0.0425
BERYLLIUM, TOTAL	ND	ND	ND	ND	ND	ND	ND	ND		0.002	ND
CHROMIUM, TOTAL	ND	0.005	ND	ND	ND	ND	ND	ND		0.045	0.0183
COBALT, TOTAL	ND	0.016	ND	ND	ND		ND	ND		ND	0.0032
COPPER, TOTAL	ND	0.012	0.043		ND	ND	ND	ND		ND	0.0104
IRON, TOTAL	ND	0.022	0.041	ND	4.63	2.09	0.091			48	8.31
LEAD, DISSOLVED							ND			0.2	
LEAD, TOTAL	ND	0.0013	ND		ND	ND	ND			0.044	ND
MANGANESE, DISSOLVED							ND	ND	ND	0.009	
MANGANESE, TOTAL	0.008	0.125	0.017			0.05	ND	ND	0.038	0.45	0.0903
NICKEL, TOTAL	ND	ND	0.007	ND		ND	ND	ND		ND	0.0091
VANADIUM, TOTAL	ND	ND	ND	ND			ND				0.0093
ZINC, DISSOLVED							0.018			ND	
ZINC, TOTAL	ND	ND	ND	ND	ND	ND	0.016			0.18	0.0317

NOTES:
Units in mg/l.
ND = Not detected.
Blanks indicate no data available.

TABLE 33. WELL: 03-07

DATES: YEAR-MONTH	88-01	89-07	89-10	90-02	90-04	90-07	90-10	91-01	91-04	91-07	91-10
1,2-DICHLOROETHENE(TOTAL)											
CIS-1,2-DICHLOROETHENE											
TRICHLOROETHENE	4.179	2.577	1.239	0.25	1.066	0.443	0.341	0.021	0.429	3.338	7.102

NOTES:
Units in mg/l.
ND = Not detected.
Blanks indicate no data available.

TABLE 33. WELL: 03-07

DATES: YEAR-MONTH	92-01	92-04	94-09	95-09
1,2-DICHLOROETHENE(TOTAL)				1.2
CIS-1,2-DICHLOROETHENE			1	
TRICHLOROETHENE	0.876	3.58	4	2.2

NOTES:
Units in mg/l.
ND = Not detected.
Blanks indicate no data available.

TABLE 34. WELL: 06C08

DATES: YEAR-MONTH	90-11	91-05	91-11	92-03	92-10	93-01	93-07	94-03	94-07	95-01
ALUMINUM, DISSOLVED							7.2	ND		0.41
ALUMINUM, TOTAL	0.178	0.107	0.096	0.154	4.97	4.21	1.5	ND		5.3
ANTIMONY, TOTAL	0.0057	0.0206	0.0048	ND	ND	ND	ND	ND		ND
ARSENIC, TOTAL	0.0121	0.0059	0.0079	0.0052	ND	ND	ND	ND		0.005
BARIUM, TOTAL	ND	ND	0.011	0.032	0.21	0.2	ND	ND		0.36
CHROMIUM, TOTAL	ND	ND	ND	ND	ND	ND	ND	ND		0.019
COBALT, TOTAL	0.015	ND	0.045	0.043	ND		ND	ND		ND
COPPER, TOTAL	ND	0.017	ND	0.013	ND	ND	ND	ND		ND
IRON, DISSOLVED							2.3		ND	0.28
IRON, TOTAL	0.049	0.142	0.013	0.335	10.6	0.41	1.9			11
LEAD, DISSOLVED							ND			0.01
LEAD, TOTAL	ND	ND	ND	ND	ND	0.05	0.0061			0.071
MANGANESE, DISSOLVED							0.016	ND	ND	0.009
MANGANESE, TOTAL	ND	0.01	ND	0.025		0.16	0.051	0.06	0.15	0.17
NICKEL, TOTAL	ND	ND	0.007	0.007		ND	ND	ND		ND
TIN, TOTAL	0.068	ND	ND	ND			ND			
VANADIUM, TOTAL	ND	0.005	0.013	ND			ND			
ZINC, DISSOLVED							0.026			0.043
ZINC, TOTAL	0.005	0.07	ND	0.058	0.45	0.3	0.083			0.5

NOTES:
Units in mg/l.
ND = Not detected.
Blanks indicate no data available.

TABLE 35. WELL: 06C11

DATES: YEAR-MONTH	91-03	91-06	91-11	92-04	92-10	93-01	93-07	94-03	94-07	95-01
ALUMINUM, DISSOLVED							1.5	ND		1.7
ALUMINUM, TOTAL	ND	ND	0.169	ND	0.67	2.48	ND	ND		1.8
ANTIMONY, TOTAL	0.0091	0.019	0.0227	ND	ND	ND	ND	ND		ND
ARSENIC, TOTAL	ND	ND	0.0044		ND	ND	ND	ND		ND
BARIUM, DISSOLVED							ND	ND		0.54
BARIUM, TOTAL	0.07	0.135	0.031		0.08	0.51	ND	ND		0.31
CHROMIUM, TOTAL	ND	0.005	ND	ND	ND	ND	ND	ND		0.009
COBALT, TOTAL	0.005	ND	0.027	ND	ND		ND	ND		ND
COPPER, TOTAL	0.018	0.014	0.063		ND	ND	ND	ND		ND
IRON, DISSOLVED							0.72			1
IRON, TOTAL	0.61	0.05	0.618	ND	0.87	5.73	0.3			2.4
LEAD, TOTAL	ND	ND	ND	ND	ND	ND	ND			0.017
MANGANESE, DISSOLVED							0.076	0.02	0.022	0.033
MANGANESE, TOTAL	0.147	0.145	0.015			0.16	0.072	0.04	0.11	0.044
ZINC, TOTAL	ND	0.007	ND	ND	ND	0.11	0.019			0.11

NOTES:
Units in mg/l.
ND = Not detected.
Blanks indicate no data available.

TABLE 36. WELL: 06C12

DATES: YEAR-MONTH	91-03	91-06	91-11	92-03	92-10	93-01	93-07	94-03	94-07	95-01	95-09
ANTIMONY, TOTAL	0.0098	0.009	0.0084	ND	ND	ND		ND		ND	ND
ARSENIC, TOTAL	ND	ND	ND	ND	ND	ND	ND	ND		ND	0.0036
BARIUM, DISSOLVED							ND	ND		0.27	
BARIUM, TOTAL	0.065	0.065	0.06	0.076	0.08	ND		ND		ND	0.0528
COBALT, TOTAL	ND	ND	0.015	ND	ND		ND	ND		ND	ND
COPPER, TOTAL	ND	0.011	0.021	ND	ND	ND	ND	ND		ND	ND
IRON, DISSOLVED							0.69			0.19	
IRON, TOTAL	0.54	0.464	0.512	0.771	0.79	0.72	0.7			0.74	0.58
LEAD, TOTAL	ND	0.001	ND	ND	ND	ND	ND			0.021	ND
MANGANESE, DISSOLVED							0.31	0.21		0.36	
MANGANESE, TOTAL	0.267	0.253	0.24	0.294		0.36	0.31	0.19	0.32	0.32	0.326
NICKEL, TOTAL	ND	0.005	ND	ND		ND	ND	ND		ND	ND
SELENIUM, TOTAL	ND	ND	ND	ND			ND				0.0026
ZINC, TOTAL	ND	ND	ND	ND	ND	ND	0.068			ND	ND

NOTES:
Units in mg/l.
ND = Not detected.
Blanks indicate no data available.

TABLE 37. WELL: 06C14

DATES: YEAR-MONTH	90-11	91-06	91-11	92-03	92-04	92-10	93-01	93-07	94-03	95-01
ALUMINUM, DISSOLVED								ND	ND	0.37
ALUMINUM, TOTAL	ND	ND	ND		ND	8.12	4.57	0.78	ND	5.5
ANTIMONY, TOTAL	0.0124	0.0094	0.0134		ND	ND	ND	ND	ND	ND
BARIUM, TOTAL	0.037	0.032	0.039			0.2	0.12	ND	ND	ND
CADMIUM, TOTAL	ND	0.008	ND		ND	ND	ND	ND		
CHROMIUM, TOTAL	ND	ND	ND		ND	ND	ND	ND	ND	0.018
COPPER, TOTAL	ND	ND	0.044		ND	ND	ND	ND	ND	ND
HMX	ND	ND		ND		ND	0.02	ND		ND
IRON, DISSOLVED								0.18		2.4
IRON, TOTAL	0.064	0.228	0.209			67.3	26.51	9		33
MANGANESE, DISSOLVED								0.092	0.04	0.35
MANGANESE, TOTAL	0.315	0.145	0.238				1.49	0.81	0.15	2.5
NICKEL, TOTAL	ND	0.005	0.006		ND		ND	ND	ND	ND
ZINC, TOTAL	ND	0.023	0.01		ND	0.13	0.06	0.04		0.12

NOTES:
Units in mg/l.
ND = Not detected.
Blanks indicate no data available.

TABLE 38. WELL: 06-17

DATES: YEAR-MONTH	89-07	90-02	90-07	90-11	91-01	91-06	91-11	92-01	92-03	95-09
ALUMINUM, TOTAL				ND		ND	0.295		ND	0.329
ANTIMONY, TOTAL				0.0058		0.0191	0.0149		ND	ND
BARIUM, TOTAL	0.04	0.06	0.07	0.071		0.058	0.034	ND	0.08	0.0752
CADMIUM, TOTAL	ND	ND	ND	ND		ND	ND	ND	0.0009	ND
CHROMIUM, TOTAL	ND	ND	ND	0.016		ND	ND	ND	ND	0.0149
COBALT, TOTAL				0.005		ND	ND		ND	0.0017
COPPER, TOTAL				ND		ND	0.028		0.086	ND
IRON, TOTAL	ND	ND	0.22	0.132	ND	ND	0.95	ND	ND	0.775
LEAD, TOTAL	ND	ND	ND	0.0389		ND	ND	ND	ND	ND
MANGANESE, TOTAL	0.294	0.029		0.051	0.02	0.044	0.038	0.067	0.064	0.244
NICKEL, TOTAL				0.027		0.014	0.016		0.019	0.0277
VANADIUM, TOTAL				ND		ND	ND		ND	0.001
ZINC, TOTAL				0.027		0.019	0.019		0.02	0.0249

NOTES:
Units in mg/l.
ND = Not detected.
Blanks indicate no data available.

TABLE 39. WELL: 06-20

DATES: YEAR-MONTH	89-07	90-02	90-07	90-11	91-01	91-06	91-11	92-01	92-03
ANTIMONY, TOTAL				0.013		0.0143	0.0146		ND
BARIUM, TOTAL	ND	ND	ND	0.025		0.025	0.024	ND	0.028
COBALT, TOTAL				0.008		0.01	0.03		ND
COPPER, TOTAL				ND		ND	0.033		ND
MANGANESE, TOTAL	ND	ND		0.006	0.02	ND	0.011	ND	ND
NICKEL, TOTAL				ND		ND	0.006		0.182
RDX	ND	ND	ND	ND	ND	0.034	0.035	0.04	ND
VANADIUM, TOTAL				ND		ND	0.017		ND

NOTES:
Units in mg/l.
ND = Not detected.
Blanks indicate no data available.

TABLE 40. WELL: 06-22

DATES: YEAR-MONTH	89-07	90-02	90-11	91-01	91-06	91-07	91-11	92-01	92-03	95-09
2,4,6-TRINITROTOLUENE (TNT)	ND	ND	0.148	ND	0.131	0.11	0.098	0.19	0.088	0.111
ANTIMONY, TOTAL			0.0058		0.0131		0.0196		ND	ND
ARSENIC, TOTAL	ND	ND	ND		ND		ND	ND	ND	0.0021
BARIUM, TOTAL	0.023	ND	0.019		0.027		0.034	ND	0.024	0.0241
COBALT, TOTAL			ND		ND		0.026		ND	ND
COPPER, TOTAL			ND		0.006		0.054		ND	ND
IRON, TOTAL	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.572
MANGANESE, TOTAL	0.016	0.01	ND	0.01	0.005		0.04	ND	ND	0.0644
SILVER, TOTAL	ND	ND	ND		ND		ND	ND	ND	0.001
VANADIUM, TOTAL			ND		ND		0.011		ND	0.0011
ZINC, TOTAL			ND		0.012		ND		ND	ND

NOTES:
Units in mg/l.
ND = Not detected.
Blanks indicate no data available.

TABLE 41. WELL: 06C13P2

DATES: YEAR-MONTH	90-11	91-06	91-11	92-04	92-10	93-01	93-07	94-03	94-07	95-01
ALUMINUM, TOTAL	ND	ND	ND	ND	0.75	0.86	ND	ND		30
ANTIMONY, TOTAL	0.0109	0.0139	0.0031	ND	ND	ND	ND	ND		ND
ARSENIC, DISSOLVED							0.025	ND		0.007
ARSENIC, TOTAL	ND	0.028	0.027		ND	ND	0.028	ND		0.068
BARIUM, TOTAL	0.025	0.076	0.07		0.1	0.08	ND	ND		0.52
BERYLLIUM, TOTAL	ND	ND	ND	ND	ND	ND	ND	ND		0.008
CHROMIUM, TOTAL	ND	ND	0.005	ND	ND	ND	ND	ND		0.064
COBALT, TOTAL	0.005	0.011	0.041	ND	ND		ND	ND		ND
IRON, DISSOLVED							11.9			2.2
IRON, TOTAL	0.03	11.5	13		16.1	13.7	7.3			120
MANGANESE, DISSOLVED							0.36	0.24	0.32	0.3
MANGANESE, TOTAL	0.052	0.388	0.414			0.36	0.39	0.26	0.42	1.6
ZINC, DISSOLVED							ND			0.047
ZINC, TOTAL	ND	0.008	ND	ND	ND	ND	ND			0.2

NOTES:
Units in mg/l.
ND = Not detected.
Blanks indicate no data available.

TABLE 42. WELL: 06C18P2

DATES: YEAR-MONTH	90-11	91-06	91-11	92-04	92-10	93-01	93-07	94-03	94-07	95-01	95-09
ALUMINUM, DISSOLVED							ND	ND		1.3	
ALUMINUM, TOTAL	ND	ND	ND	ND	ND	6.13	ND	ND		13	0.5
ANTIMONY, TOTAL	ND	0.015	0.0086	ND	ND	ND	ND	ND		ND	ND
ARSENIC, DISSOLVED							0.015	ND		0.019	
ARSENIC, TOTAL	0.011	0.0156	0.0124		ND	ND	0.015	ND		0.036	0.0196
BARIUM, DISSOLVED							0.14	0.1		0.38	
BARIUM, TOTAL	0.181	0.123	0.087		0.17	0.26	0.13	0.1		0.36	0.113
BERYLLIUM, DISSOLVED							ND	ND		0.001	
BERYLLIUM, TOTAL	ND	0.002	ND	ND	ND	ND	ND	ND		0.003	ND
CHROMIUM, TOTAL	ND	0.007	ND	ND	ND	ND	ND	ND		0.039	0.0049
COBALT, TOTAL	0.008	ND	0.025	ND	ND		ND	ND		ND	ND
COPPER, TOTAL	ND	0.01	0.039	ND	ND	ND	ND	ND		ND	ND
IRON, DISSOLVED							55.9	30.92		80	
IRON, TOTAL	70.5	51.2	20.3		74.4	91.14	55.6	47.08		130	33.4
MANGANESE, DISSOLVED							0.62	0.45		0.82	
MANGANESE, TOTAL	0.864	0.552	0.349			1.06	0.61	0.48	0.94	1.4	0.54
SELENIUM, TOTAL	ND	ND	ND	ND			ND				0.0023
SILVER, TOTAL	ND	ND	ND	ND			ND				0.0012
VANADIUM, TOTAL	ND	ND	0.01	ND			ND				0.0021
ZINC, TOTAL	0.101	0.016	ND	ND	ND	ND	0.14			0.22	0.0061

NOTES:
Units in mg/l.
ND = Not detected.
Blanks indicate no data available.

APPENDIX C

MANN-KENDALL TEST

Statistical Methods for Environmental Pollution Monitoring

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16.4 MANN-KENDALL TEST

In this section we discuss the nonparametric Mann-Kendall test for trend (Mann, 1945; Kendall, 1975). This procedure is particularly useful since missing values are allowed and the data need not conform to any particular distribution. Also, data reported as trace or less than the detection limit can be used (if it is acceptable in the context of the population being sampled) by assigning them a common value that is smaller than the smallest measured value in the data set. This approach can be used because the Mann-Kendall test (and the seasonal Kendall test in Chapter 17) use only the relative magnitudes of the data rather

than their measured values. We note that the Mann-Kendall test can be viewed as a nonparametric test for zero slope of the linear regression of time-ordered data versus time, as illustrated by Hollander and Wolfe (1973, p. 201).

16.4.1 Number of Data 40 or Less

If n is 40 or less, the procedure in this section may be used. When n exceeds 40, use the normal approximation test in Section 16.4.2. We begin by considering the case where only one datum per time period is taken, where a time period may be a day, week, month, and so on. The case of multiple data values per time period is discussed in Section 16.4.3.

The first step is to list the data in the order in which they were collected over time: $x_1, x_2, \ldots, x_n$, where x_i is the datum at time i. Then determine the sign of all $n(n-1)/2$ possible differences $x_j - x_k$, where $j > k$. These differences are $x_2 - x_1, x_3 - x_1, \ldots, x_n - x_1, x_3 - x_2, x_4 - x_2, \ldots, x_n - x_{n-2}, x_n - x_{n-1}$. A convenient way of arranging the calculations is shown in Table 16.1.

Let $\text{sgn}(x_j - x_k)$ be an indicator function that takes on the values 1, 0, or -1 according to the sign of $x_j - x_k$:

$$\begin{aligned} \text{sgn}(x_j - x_k) &= 1 \quad \text{if } x_j - x_k > 0 \\ &= 0 \quad \text{if } x_j - x_k = 0 \\ &= -1 \quad \text{if } x_j - x_k < 0 \end{aligned} \qquad \textbf{16.1}$$

Then compute the Mann-Kendall statistic

$$S = \sum_{k=1}^{n-1} \sum_{j=k+1}^{n} \text{sgn}(x_j - x_k) \qquad \textbf{16.2}$$

which is the number of positive differences minus the number of negative differences. These differences are easily obtained from the last two columns of Table 16.1. If S is a large positive number, measurements taken later in time tend to be larger than those taken earlier. Similarly, if S is a large negative number, measurements taken later in time tend to be smaller. If n is large, the computer code in Appendix B may be used to compute S. This code also computes the tests for trend discussed in Chapter 17.

Suppose we want to test the null hypothesis, H_0, of no trend against the alternative hypothesis, H_A, of an upward trend. Then H_0 is rejected in favor of H_A if S is positive and if the probability value in Table A18 corresponding to the computed S is less than the a priori specified α significance level of the test. Similarly, to test H_0 against the alternative hypothesis H_A of a downward trend, reject H_0 and accept H_A if S is negative and if the probability value in the table corresponding to the absolute value of S is less than the a priori specified α value. If a two-tailed test is desired, that is, if we want to detect either an upward or downward trend, the tabled probability level corresponding to the absolute value of S is doubled and H_0 is rejected if that doubled value is less than the a priori α level.

EXAMPLE 16.1

We wish to test the null hypothesis H_0, of no trend versus the alternative hypothesis, H_A, of an upward trend at the $\alpha = 0.10$

Table 16.1 Differences in Data Values Needed for Computing the Mann-Kendall Statistic S to Test for Trend

Data Values Listed in the Order Collected Over Time							*No. of + Signs*	*No. of − Signs*
x_1	x_2	x_3	x_4	$\cdots$	x_{n-1}	x_n		
	$x_2 - x_1$	$x_3 - x_1$	$x_4 - x_1$	$\cdots$	$x_{n-1} - x_1$	$x_n - x_1$		
		$x_3 - x_2$	$x_4 - x_2$	$\cdots$	$x_{n-1} - x_2$	$x_n - x_2$		
			$x_4 - x_3$	$\cdots$	$x_{n-1} - x_3$	$x_n - x_3$		
				$\ddots$	$\vdots$	$\vdots$		
					$x_{n-1} - x_{n-2}$	$x_n - x_{n-2}$		
						$x_n - x_{n-1}$		
						$S =$	$\overline{\left(\begin{matrix}\text{sum of}\\ +\text{ signs}\end{matrix}\right)}$	$+ \overline{\left(\begin{matrix}\text{sum of}\\ -\text{ signs}\end{matrix}\right)}$

Table 16.2 Computation of the Mann-Kendall Trend Statistic S for the Time Ordered Data Sequence 10, 15, 14, 20

Time	*1*	*2*	*3*	*4*		*No. of +*		*No. of −*
Data	*10*	*15*	*14*	*20*		*Signs*		*Signs*
		15 − 10	14 − 10	20 − 10		3		0
			14 − 15	20 − 15		1		1
				20 − 14		1		0
				S	=	5	−	1 = 4

significance level. For ease of illustration suppose only 4 measurements are collected in the following order over time or along a line in space: 10, 15, 14, and 20. There are 6 differences to consider: 15 − 10, 14 − 10, 20 − 10, 14 − 15, 20 − 15, and 20 − 14. Using Eqs. 16.1 and 16.2, we obtain $S = +1 + 1 + 1 - 1 + 1 + 1 = +4$, as illustrated in Table 16.2. (Note that the sign, not the magnitude of the difference is used.) From Table A18 we find for $n = 4$ that the tabled probability for $S = +4$ is 0.167. This number is the probability of obtaining a value of S equal to +4 or larger when $n = 4$ and when no upward trend is present. Since this value is greater than 0.10, we cannot reject H_0.

If the data sequence had been 18, 20, 23, 35, then $S = +6$, and the tabled probability is 0.042. Since this value is less than 0.10, we reject H_0 and accept the alternative hypothesis of an upward trend.

Table A18 gives probability values only for $n \leq 10$. An extension of this table up to $n = 40$ is given in Table A.21 in Hollander and Wolfe (1973).

Table A18 Probabilities for the Mann-Kendall Nonparametric Test for Trend

S	Values of n: 4	5	8	9	S	Values of n: 6	7	10
0	0.625	0.592	0.548	0.540	1	0.500	0.500	0.500
2	0.375	0.408	0.452	0.460	3	0.360	0.386	0.431
4	0.167	0.242	0.360	0.381	5	0.235	0.281	0.364
6	0.042	0.117	0.274	0.306	7	0.136	0.191	0.300
8		0.042	0.199	0.238	9	0.068	0.119	0.242
10		$0.0^{2}83$	0.138	0.179	11	0.028	0.068	0.190
12			0.089	0.130	13	$0.0^{2}83$	0.035	0.146
14			0.054	0.090	15	$0.0^{2}14$	0.015	0.108
16			0.031	0.060	17		$0.0^{2}54$	0.078
18			0.016	0.038	19		$0.0^{2}14$	0.054
20			$0.0^{2}71$	0.022	21		$0.0^{3}20$	0.036
22			$0.0^{2}28$	0.012	23			0.023
24			$0.0^{3}87$	$0.0^{2}63$	25			0.014
26			$0.0^{3}19$	$0.0^{2}29$	27			$0.0^{2}83$
28			$0.0^{4}25$	$0.0^{2}12$	29			$0.0^{2}46$
30				$0.0^{3}43$	31			$0.0^{2}23$
32				$0.0^{3}12$	33			$0.0^{2}11$
34				$0.0^{4}25$	35			$0.0^{3}47$
36				$0.0^{5}28$	37			$0.0^{3}18$
					39			$0.0^{4}58$
					41			$0.0^{4}15$
					43			$0.0^{5}28$
					45			$0.0^{6}28$

Source: From Kendall, 1975. Used by permission.

Repeated zeros are indicated by powers; for example, $0.0^{3}47$ stands for 0.00047.

Each table entry is the probability that the Mann-Kendall statistic S equals or exceeds the specified value of S when no trend is present.

This table is used in Section 16.4.1.

Table A.21. Upper tail probabilities for the null distribution of Kendall's K statistic: $n = 4(1)40$

For a given n, the entry in the table for the point x is $P_0\{K > x\}$. Under these conditions, if x is such that $P_0\{K > x\} \doteq \alpha$, then $k(\alpha, n) = x$. For certain n, the entries are terminated at x_n, where x_n is the smallest possible value of x such that $P_0\{K > x\}$ is zero to three decimal places. [For $n = 4(4)40$ or $n = 5(4)37$ all even integers between $-n(n-1)/2$ and $n(n-1)/2$ have positive probability and for $n = 6(4)38$ or $n = 7(4)39$ all odd integers between $-n(n-1)/2$ and $n(n-1)/2$ have positive probability.]

	n								
x	4	5	8	9	12	13	16	17	20
0	.625	.592	.548	.540	.527	.524	.518	.516	.513
2	.375	.408	.452	.460	.473	.476	.482	.484	.487
4	.167	.242	.360	.381	.420	.429	.447	.452	.462
6	.042	.117	.274	.306	.369	.383	.412	.420	.436
8		.042	.199	.238	.319	.338	.378	.388	.411
10		.008	.138	.179	.273	.295	.345	.358	.387
12			.089	.130	.230	.255	.313	.328	.362
14			.054	.090	.190	.218	.282	.299	.339
16			.031	.060	.155	.184	.253	.271	.315
18			.016	.038	.125	.153	.225	.245	.293
20			.007	.022	.098	.126	.199	.220	.271
22			.002	.012	.076	.102	.175	.196	.250
24			.001	.006	.058	.082	.153	.174	.230
26			.000	.003	.043	.064	.133	.154	.211
28				.001	.031	.050	.114	.135	.193
30				.000	.022	.038	.097	.118	.176
32					.016	.029	.083	.102	.159
34					.010	.021	.070	.088	.144
36					.007	.015	.058	.076	.130
38					.004	.011	.048	.064	.117
40					.003	.007	.039	.054	.104
42					.002	.005	.032	.046	.093
44					.001	.003	.026	.038	.082
46					.000	.002	.021	.032	.073
48						.001	.016	.026	.064
50						.001	.013	.021	.056
52						.000	.010	.017	.049
54							.008	.014	.043
56							.006	.011	.037
58							.004	.009	.032
60							.003	.007	.027
62							.002	.005	.023
64							.002	.004	.020
66							.001	.003	.017
68							.001	.002	.014
70							.001	.002	.012

Table A.21 (continued)

	n								
x	4	5	8	9	12	13	16	17	20
72							.000	.001	.010
74								.001	.008
76								.001	.007
78								.000	.006
80									.005
82									.004
84									.003
86									.002
88									.002
90									.002
92									.001
94									.001
96									.001
98									.001
100									.000

	n									
x	21	24	25	28	29	32	33	36	37	40
0	.512	.510	.509	.508	.507	.506	.506	.505	.505	.505
2	.488	.490	.491	.492	.493	.494	.494	.495	.495	.495
4	.464	.471	.472	.477	.478	.481	.482	.484	.484	.486
6	.441	.451	.454	.461	.463	.468	.469	.473	.474	.477
8	.417	.432	.436	.446	.448	.455	.457	.462	.464	.468
10	.394	.413	.418	.430	.434	.442	.445	.452	.453	.459
12	.371	.394	.400	.415	.419	.430	.433	.441	.443	.449
14	.349	.375	.382	.400	.405	.417	.421	.430	.433	.440
16	.327	.356	.364	.385	.390	.405	.409	.420	.423	.431
18	.306	.338	.347	.370	.376	.392	.397	.409	.413	.422
20	.285	.320	.330	.355	.362	.380	.385	.399	.403	.413
22	.265	.303	.314	.341	.348	.368	.373	.388	.393	.404
24	.246	.286	.297	.326	.334	.356	.362	.378	.383	.395
26	.228	.270	.282	.312	.321	.344	.350	.368	.373	.386
28	.210	.254	.266	.298	.308	.332	.339	.358	.363	.377
30	.193	.238	.251	.285	.295	.320	.328	.347	.353	.369
32	.177	.223	.237	.272	.282	.309	.317	.338	.344	.360
34	.162	.209	.222	.259	.270	.298	.306	.328	.334	.351
36	.147	.195	.209	.246	.257	.287	.295	.318	.325	.343
38	.134	.181	.196	.234	.246	.276	.285	.308	.315	.334
40	.121	.169	.183	.222	.234	.265	.274	.299	.306	.326
42	.109	.156	.171	.211	.223	.255	.264	.290	.297	.318
44	.098	.145	.159	.200	.212	.244	.254	.280	.288	.309

Table A.21 (continued)

	n									
x	21	24	25	28	29	32	33	36	37	40
46	.088	.134	.148	.189	.201	.234	.244	.271	.279	.301
48	.079	.123	.138	.178	.191	.224	.235	.262	.271	.293
50	.070	.113	.128	.168	.181	.215	.225	.254	.262	.285
52	.062	.104	.118	.158	.171	.206	.216	.245	.254	.277
54	.055	.095	.109	.149	.162	.197	.207	.237	.245	.270
56	.049	.087	.101	.140	.153	.188	.199	.228	.237	.262
58	.043	.079	.093	.131	.144	.179	.190	.220	.229	.255
60	.037	.072	.085	.123	.136	.171	.182	.212	.222	.247
62	.032	.066	.078	.115	.128	.163	.174	.204	.214	.240
64	.028	.059	.071	.108	.120	.155	.166	.197	.206	.233
66	.024	.054	.065	.101	.112	.147	.158	.189	.199	.226
68	.021	.048	.059	.094	.105	.140	.151	.182	.192	.219
70	.018	.044	.054	.087	.099	.133	.144	.175	.185	.212
72	.015	.039	.049	.081	.092	.126	.137	.168	.178	.205
74	.013	.035	.044	.075	.086	.119	.130	.161	.171	.199
76	.011	.031	.040	.070	.080	.113	.124	.155	.165	.192
78	.009	.028	.036	.065	.075	.107	.117	.148	.158	.186
80	.008	.025	.032	.060	.070	.101	.111	.142	.152	.180
82	.007	.022	.029	.055	.065	.095	.106	.136	.146	.174
84	.005	.019	.026	.051	.060	.090	.100	.130	.140	.168
86	.005	.017	.023	.047	.056	.085	.095	.124	.134	.162
88	.004	.015	.021	.043	.052	.080	.090	.119	.129	.156
90	.003	.013	.018	.039	.048	.075	.085	.114	.123	.151
92	.002	.011	.016	.036	.044	.070	.080	.108	.118	.146
94	.002	.010	.014	.033	.041	.066	.075	.103	.113	.140
96	.002	.009	.013	.030	.037	.062	.071	.099	.108	.135
98	.001	.007	.011	.027	.034	.058	.067	.094	.103	.130
100	.001	.006	.010	.025	.031	.054	.063	.089	.098	.125
102	.001	.006	.009	.023	.029	.051	.059	.085	.094	.121
104	.001	.005	.008	.021	.026	.048	.055	.081	.090	.116
106	.001	.004	.007	.019	.024	.044	.052	.077	.085	.111
108	.000	.003	.006	.017	.022	.041	.049	.073	.081	.107
110		.003	.005	.015	.020	.039	.046	.069	.077	.103
112		.003	.004	.014	.018	.036	.043	.066	.074	.099
114		.002	.004	.012	.017	.033	.040	.062	.070	.095
116		.002	.003	.011	.015	.031	.037	.059	.067	.091
118		.001	.003	.010	.014	.029	.035	.056	.063	.087
120		.001	.002	.009	.012	.027	.032	.053	.060	.083
122		.001	.002	.008	.011	.025	.030	.050	.057	.080
124		.001	.002	.007	.010	.023	.028	.047	.054	.076
126		.001	.001	.006	.009	.021	.026	.044	.051	.073
128		.001	.001	.006	.008	.019	.024	.042	.048	.070
130		.000	.001	.005	.007	.018	.023	.039	.046	.067
132			.001	.004	.007	.016	.021	.037	.043	.064

Table A.21 (continued)

	n									
x	21	24	25	28	29	32	33	36	37	40
134			.001	.004	.006	.015	.019	.035	.041	.061
136			.001	.003	.005	.014	.018	.033	.039	.058
138			.000	.003	.005	.013	.017	.031	.037	.055
140				.003	.004	.012	.015	.029	.034	.053
142				.002	.004	.011	.014	.027	.032	.050
144				.002	.003	.010	.013	.025	.031	.048
146				.002	.003	.009	.012	.024	.029	.046
148				.002	.003	.008	.011	.022	.027	.043
150				.001	.002	.007	.010	.021	.025	.041
152				.001	.002	.007	.009	.020	.024	.039
154				.001	.002	.006	.008	.018	.022	.037
156				.001	.002	.006	.008	.017	.021	.035
158				.001	.001	.005	.007	.016	.020	.034
160				.001	.001	.005	.006	.015	.018	.032
162				.001	.001	.004	.006	.014	.017	.030
164				.000	.001	.004	.005	.013	.016	.029
166					.001	.003	.005	.012	.015	.027
168					.001	.003	.004	.011	.014	.026
170					.001	.003	.004	.010	.013	.024
172					.001	.002	.004	.010	.012	.023
174					.000	.002	.003	.009	.011	.022
176						.002	.003	.008	.011	.020
178						.002	.003	.008	.010	.019
180						.002	.002	.007	.009	.018
182						.001	.002	.006	.009	.017
184						.001	.002	.006	.008	.016
186						.001	.002	.006	.007	.015
188						.001	.002	.005	.007	.014
190						.001	.001	.005	.006	.014
192						.001	.001	.004	.006	.013
194						.001	.001	.004	.005	.012
196						.001	.001	.004	.005	.011
198						.001	.001	.003	.005	.011
200						.000	.001	.003	.004	.010
202							.001	.003	.004	.009
204							.001	.003	.004	.009
206							.001	.002	.003	.008
208							.001	.002	.003	.008
210							.000	.002	.003	.007
212								.002	.003	.007
214								.002	.002	.006
216								.001	.002	.006
218								.001	.002	.005
220								.001	.002	.005

Table A.21 (continued)

	n									
x	21	24	25	28	29	32	33	36	37	40
222								.001	.002	.005
224								.001	.002	.004
226								.001	.001	.004
228								.001	.001	.004
230								.001	.001	.004
232								.001	.001	.003
234								.001	.001	.003
236								.001	.001	.003
238								.000	.001	.003
240									.001	.002
242									.001	.002
244									.001	.002
246									.001	.002
248									.000	.002
250										.002
252										.002
254										.001
256										.001
258										.001
260										.001
262										.001
264										.001
266										.001
268										.001
270										.001
272										.001
274										.001
276										.001
278										.001
280										.000

Table A.21 (continued)

	n								
x	6	7	10	11	14	15	18	19	22
1	.500	.500	.500	.500	.500	.500	.500	.500	.500
3	.360	.386	.431	.440	.457	.461	.470	.473	.478
5	.235	.281	.364	.381	.415	.423	.441	.445	.456
7	.136	.191	.300	.324	.374	.385	.411	.418	.434
9	.068	.119	.242	.271	.334	.349	.383	.39[illegible]	.412
11	.028	.068	.190	.223	.295	.313	.354	.365	.390
13	.008	.035	.146	.179	.259	.279	.327	.339	.369
15	.001	.015	.108	.141	.225	.248	.300	.314	.348
17		.005	.078	.109	.194	.218	.275	.290	.328
19		.001	.054	.082	.165	.190	.250	.267	.308
21		.000	.036	.060	.140	.164	.227	.245	.289
23			.023	.043	.117	.141	.205	.223	.270
25			.014	.030	.096	.120	.184	.203	.252
27			.008	.020	.079	.101	.165	.184	.234
29			.005	.013	.063	.084	.147	.166	.217
31			.002	.008	.050	.070	.130	.149	.201
33			.001	.005	.040	.057	.115	.133	.186
35			.000	.003	.031	.046	.100	.119	.171
37				.002	.024	.037	.088	.105	.157
39				.001	.018	.029	.076	.093	.144
41				.000	.013	.023	.066	.082	.131
43					.010	.018	.056	.072	.120
45					.007	.014	.048	.062	.109
47					.005	.010	.041	.054	.099
49					.003	.008	.034	.047	.089
51					.002	.006	.029	.040	.080
53					.002	.004	.024	.034	.072
55					.001	.003	.020	.029	.064
57					.001	.002	.016	.025	.058
59					.000	.001	.013	.021	.051
61						.001	.011	.017	.045
63						.001	.009	.014	.040
65						.000	.007	.012	.035
67							.005	.010	.031
69							.004	.008	.027
71							.003	.006	.024
73							.003	.005	.021
75							.002	.004	.018
77							.001	.003	.015
79							.001	.003	.013
81							.001	.002	.011
83							.001	.002	.010
85							.000	.001	.008
87								.001	.007

Table A.21 (continued)

	n								
x	6	7	10	11	14	15	18	19	22
89								.001	.005
91								.001	.005
93								.000	.004
95									.003
97									.003
99									.002
101									.002
103									.002
105									.001
107									.001
109									.001
111									.001
113									.001
115									.000

	n								
x	23	26	27	30	31	34	35	38	39
1	.500	.500	.500	.500	.500	.500	.500	.500	.500
3	.479	.483	.484	.486	.487	.488	.489	.490	.490
5	.458	.465	.467	.472	.473	.477	.478	.480	.481
7	.438	.448	.451	.458	.460	.465	.466	.470	.472
9	.417	.431	.434	.444	.446	.453	.455	.460	.462
11	.397	.414	.418	.430	.433	.442	.444	.450	.452
13	.377	.397	.402	.416	.420	.430	.433	.440	.443
15	.357	.380	.386	.402	.407	.418	.422	.431	.433
17	.338	.363	.371	.389	.394	.407	.411	.421	.424
19	.319	.347	.355	.375	.381	.396	.400	.411	.414
21	.301	.331	.340	.362	.368	.384	.389	.401	.405
23	.283	.316	.325	.349	.355	.373	.378	.392	.396
25	.265	.300	.310	.336	.343	.362	.368	.382	.387
27	.248	.235	.296	.323	.331	.351	.357	.373	.377
29	.232	.270	.281	.310	.318	.340	.347	.363	.368
31	.216	.256	.268	.298	.306	.329	.336	.354	.359
33	.201	.242	.254	.286	.295	.319	.326	.345	.350
35	.187	.229	.241	.274	.283	.308	.316	.336	.341
37	.173	.216	.228	.262	.272	.298	.306	.327	.333
39	.160	.203	.216	.251	.261	.288	.296	.318	.324
41	.147	.191	.204	.239	.250	.278	.286	.309	.315
43	.135	.179	.192	.228	.239	.268	.277	.300	.307
45	.124	.168	.181	.218	.229	.259	.267	.291	.298
47	.114	.157	.170	.208	.219	.249	.258	.283	.290

Table A.21 (continued)

	n								
x	23	26	27	30	31	34	35	38	39
49	.104	.147	.160	.198	.209	.240	.249	.274	.282
51	.094	.137	.150	.188	.199	.231	.240	.266	.274
53	.086	.127	.141	.178	.190	.222	.232	.258	.266
55	.078	.118	.132	.169	.181	.213	.223	.250	.258
57	.070	.110	.123	.160	.172	.205	.215	.242	.250
59	.063	.102	.115	.152	.164	.196	.206	.234	.243
61	.057	.094	.107	.144	.155	.188	.198	.227	.235
63	.051	.087	.099	.136	.147	.180	.191	.219	.228
65	.046	.080	.092	.128	.140	.173	.183	.212	.221
67	.041	.073	.085	.121	.132	.165	.176	.205	.214
69	.036	.067	.079	.114	.125	.158	.168	.198	.207
71	.032	.062	.073	.107	.118	.151	.161	.191	.200
73	.028	.057	.067	.100	.112	.144	.154	.184	.193
75	.025	.052	.062	.094	.105	.137	.148	.177	.187
77	.022	.047	.057	.088	.099	.131	.141	.171	.180
79	.019	.043	.052	.083	.093	.125	.135	.165	.174
81	.017	.039	.048	.077	.088	.119	.129	.158	.168
83	.015	.035	.044	.072	.082	.113	.123	.152	.162
85	.013	.032	.040	.067	.077	.107	.117	.147	.156
87	.011	.029	.036	.063	.072	.102	.112	.141	.150
89	.009	.026	.033	.059	.068	.097	.107	.135	.145
91	.008	.023	.030	.054	.063	.092	.101	.130	.139
93	.007	.021	.027	.051	.059	.087	.096	.125	.134
95	.006	.019	.025	.047	.055	.082	.092	.120	.129
97	.005	.017	.022	.043	.052	.078	.087	.115	.124
99	.004	.015	.020	.040	.048	.074	.083	.110	.119
101	.004	.013	.018	.037	.045	.070	.078	.105	.114
103	.003	.012	.016	.034	.041	.066	.074	.101	.109
105	.003	.010	.015	.032	.038	.062	.070	.096	.105
107	.002	.009	.013	.029	.036	.058	.066	.092	.101
109	.002	.008	.012	.027	.033	.055	.063	.088	.096
111	.001	.007	.010	.025	.031	.052	.059	.084	.092
113	.001	.006	.009	.023	.028	.049	.056	.080	.088
115	.001	.005	.008	.021	.026	.046	.053	.076	.084
117	.001	.005	.007	.019	.024	.043	.050	.073	.081
119	.001	.004	.006	.017	.022	.040	.047	.069	.077
121	.000	.004	.006	.016	.020	.038	.044	.066	.074
123		.003	.005	.014	.019	.035	.042	.063	.070
125		.003	.004	.013	.017	.033	.039	.060	.067
127		.002	.004	.012	.016	.031	.037	.057	.064
129		.002	.003	.011	.014	.029	.034	.054	.061
131		.002	.003	.010	.013	.027	.032	.051	.058
133		.001	.003	.009	.012	.025	.030	.049	.055
135		.001	.002	.008	.011	.023	.028	.046	.053

Table A.21 (continued)

	n								
x	23	26	27	30	31	34	35	38	39
137		.001	.002	.007	.010	.022	.026	.044	.050
139		.001	.002	.006	.009	.020	.025	.041	.048
141		.001	.001	.006	.008	.019	.023	.039	.045
143		.001	.001	.005	.007	.017	.022	.037	.043
145		.001	.001	.005	.007	.016	.020	.035	.041
147		.000	.001	.004	.006	.015	.019	.033	.039
149			.001	.004	.006	.014	.017	.031	.037
151			.001	.003	.005	.013	.016	.029	.035
153			.001	.003	.004	.012	.015	.028	.033
155			.000	.003	.004	.011	.014	.026	.031
157				.002	.004	.010	.013	.025	.029
159				.002	.003	.009	.012	.023	.028
161				.002	.003	.008	.011	.022	.026
163				.002	.003	.008	.010	.021	.025
165				.001	.002	.007	.010	.019	.023
167				.001	.002	.007	.009	.018	.022
169				.001	.002	.006	.008	.017	.021
171				.001	.002	.005	.007	.016	.020
173				.001	.001	.005	.007	.015	.018
175				.001	.001	.005	.006	.014	.017
177				.001	.001	.004	.006	.013	.016
179				.001	.001	.004	.005	.012	.015
181				.000	.001	.003	.005	.011	.014
183					.001	.003	.005	.011	.014
185					.001	.003	.004	.010	.013
187					.001	.003	.004	.009	.012
189					.001	.002	.003	.009	.011
191					.000	.002	.003	.008	.010
193						.002	.003	.008	.010
195						.002	.003	.007	.009
197						.002	.002	.007	.009
199						.001	.002	.006	.008
201						.001	.002	.006	.007
203						.001	.002	.005	.007
205						.001	.002	.005	.006
207						.001	.001	.004	.006
209						.001	.001	.004	.006
211						.001	.001	.004	.005
213						.001	.001	.004	.005
215						.001	.001	.003	.004
217						.001	.001	.003	.004
219						.000	.001	.003	.004
221							.001	.003	.004
223							.001	.002	.003

Table A.21 (continued)

	n								
x	23	26	27	30	31	34	35	38	39
225							.001	.002	.003
227							.001	.002	.003
229							.000	.002	.003
231								.002	.002
233								.002	.002
235								.001	.002
237								.001	.002
239								.001	.002
241								.001	.002
243								.001	.001
245								.001	.001
247								.001	.001
249								.001	.001
251								.001	.001
253								.001	.001
255								.001	.001
257								.001	.001
259								.000	.001
261									.001
263									.001
265									.001
267									.001
269									.000

Adapted from L. Kaarsemaker and A. van Wijngaarden, Tables for use in rank correlation, *Statist. Neerl.* 7, 41-54 (1953), with the permission of the authors, and the editors of *Statistica Neerlandica.*

APPENDIX D

VALIDATION PROCEDURES FOR CRANE HISTORICAL DATA

MEMORANDUM/Appendix D

December 29, 1995

To: Charlie Zeal
Rust, Sheboygan

From: Risk Assessment Staff
Rust, Minneapolis

Subject: Validation Procedures for Crane Historical Data

1. **Part 1 RFI Phase III Soils Report For Ammunition Burning Ground, SWMU #03/10 USACE, 1992**

Lab: Unknown

Investigation Dates: August 1990

Validation: Page 18: Indicates Navel Energy and Environmental Support Activity (NESSA) QC Level C.

Only data qualifiers assigned by the laboratory are on the data tables.

According to the Table of Contents, a Data Validation Report was provided in Appendix D. However, Appendix D only contained Tables from Section 5.0. This memo was not located.

Metals data were coded with "W" indicating post digestion spike recovery outside control limits; "N" to indicate the sample spike recovery was not within control limits, and * to indicate the duplicate analysis was outside limits. No further judgement on the usability of the data was observed.

Analytical Methods: SW-846 Methods

2. Installation Restoration Program - Corrective Actions
Internal Draft
Part 2 RFI Phase III
Soils Report:
Ammunition Burning Ground, SWMU #03/10
Naval Surface Warfare Center, Crane Indiana
USACE September 1995

Lab: Based on other documents, appears to be Analytical Lab Group (under direction of Ann Strong), however, no specific reference was found.

Investigation Dates: Aug. 1993

Validation: Page 28: NEESA Level C .

No indication of third party validation is included in the report. One page data validation report provided in Appendix E, appears to be from USACE laboratory which performed the analyses.

VOC results qualified with a B code by the laboratory to account for associated blank contamination. No further evaluation was done for the data base (comparison of sample concentration to blank concentration), to determine if the site or sampling/analytical procedures were the likely source of the contaminant.

Metals data were coded by the laboratory with a "W" indicating post digestion spike recovery outside control limits; "N" to indicate the sample spike recovery was not within control limits, and * to indicate the duplicate analysis was outside limits. No further judgement on the usability of the data was observed, however, <u>these results were not used for some summary statistics for data evaluation in the report.</u>(e.g. Appendix A Table 5.2.15 and 5.3.22) Validation may indicate some of these results are usable. In one instance a lead result of 4940 mg/kg (sample 31.1) was not used for further evaluation due to a lab duplicate out of control. Instead, the highest lead concentration detected was reported as 361 mg/kg.

Validation information for this report faxed to Lisa Smith (Rust, Sheboygan). Her impression was that no third party validation had occurred.

Analytical Methods: SW-846 Methods

3. **Draft Report: RCRA Facility Investigation**
Phase II Release Assessment for Surface Water
SWMU 03/10 Ammunition Burning Ground
March 1994

Lab: Analytical Lab Group (under direction of Ann Strong)

Investigation Dates: 3/92 and 7/92

Validation: No third party validation, or discussion of validation is included in the report. An extensive evaluation of blank contamination was performed to draw conclusions for the report, however, the results of this evaluation were not included in the data base. Only laboratory assigned codes are in the data base.

Analytical Methods: P. 21 - Used SW-846 methodologies

4. **Final Report, RCRA Facility**
Phase III, Groundwater Release Characterization
SWMU 03/10, Ammunition Burning Ground
USACE, May 1994

Lab: Anacon, Inc of Pasedena, Texas (p 25)

Investigation Dates: Sept. 1987 to Jan. 1992

Data Validation: No mention of independent validation. QC performed discussed in the Ground Water Monitoring Plan presented in Appendix L.

Analytical Methods: (Figure 10)

VOCs	624
1,1,1-TCA	601
TCE	601
Di-n-butyl-Phthalate & BEHP	606
TNT, RDX,& HMX	HPLC
Metals	200.7/206.2, 239.2, 245.1, 270.2,
Pesticides	608/509B
Radionuclides	900/903
PCB	608

Comments: Monitoring in accordance with 40 CFR Part 265, section 265.90, Subpart F. Page 28 - Solvents di-N-butyl phthalate and bis(2-ethylhexyl) phthalate not considered significant due to their presence in analytical and sampling equipment. It is unknown if this is reflected in the data tables.

5. RFI Phase II
Old Rifle Range Report for SWMU 03/10
Navel Weapons Support Center,
Crane, Indiana
USACE, April 1991

Lab: Analytical Lab Group

Investigation Dates: Summer, 1990

Validation: Page I and 14: Indicate Navel Energy and Environmental Support Activity (NESSA) QC Level C. Guidance 20.2-047b "Sampling and Chemical Analysis Quality Assurance Requirements for the Navy Installation Restoration Program".

No indication of third party validation is included in the report. The two page validation memo in Appendix D is from the laboratory performing the analyses.
Only data qualifiers assigned by the laboratory are on the data tables.

Validation information for this report faxed to Lisa Smith (Rust, Sheboygan). Her impression was that no third party validation had occurred.

Analytical Methods:

VOCs	8240
SVOCs	8270
Explosives	Colorimetry? (Page I)
Metals	SW846 methods

6. Draft RCRA Facility Investigation Phase II Groundwater Release Assessment, SWMU 06/09 Demolition Area and Phase III Release Characterization Report SWMU 07/09 Old Rifle Range USACE, February 1994

Lab: Analytical Lab Group (under direction of Ann Strong)

Investigation Dates: Nov. 1989 to Dec. 1992

Validation: Performed by Roy Wade of the Water Supply and Waste Treatment Group, Environmental Laboratory, WES.

Level of Validation: USEPA Type II data Validation. Followed criteria in the "Functional Guidelines for Evaluating Organics Analyses" February 1988; "Functional Guidelines for Evaluation Inorganics Analyses" July 1988; and the "National Functional Guidelines for Organic Data Review: Multi-Media-Concentration (OLM01.0) and Low concentration Water (OLC01.0)" June 1991 revision.

Analytical Methods:

VOCs	8240
SVOCs	8270
PCB/Pest	8080
Organo Pest	8140
Chlorinated Herb	8150
Explosives	8330
Metals	6010/7000

Comments: Based on the validation memo, qualification of the data did not always follow the guidelines referenced. (E.g. p. 54. Low toluene d8 surrogate recoveries, all data coded non detected. However, based on the recovery, guidance specifies either a J code or an R code because the sample data are biased low. A nondetect code could allow for false negatives) No specific discussion regarding validation of the metals or explosive analytes.

7. Quality-Assurance, Quality-Control and Analytical Data for Ground-Water at the Demolition Area and the Old Rifle Range USGS, July 1993

Lab: Ensenco Rocky Mountain Analytical Laboratory

Investigation Dates: July 13-29, 1993

Validation: Data QC review appears to have been performed by the USGS.

Level of Validation: No formal process was cited, however, the text went into an extensive discussion regarding QC associated with the project samples. No changes or data qualifiers were added to the data tables. In general, QC appeared to be acceptable, but in some instances data evaluation for the report included information from the data review which was not reflected on the data tables.

Analytical Methods:

VOCs	8240
SVOCs	8270
PCB/Pest	8080
Chlorinated Herb	8150
Explosives	HPLC
Metals	6010/7000

8. Quality-Control Data and Analytical Data for Ground-Water at the Ammunition Burning Ground USGS, August and September, 1993

Lab: Ensenco Rocky Mountain Analytical Laboratory

Investigation Dates: Aug-Sept, 1993

Validation: Data QC review appears to have been performed by the USGS.

Level of Validation: No formal process was cited, however, the text went into an extensive discussion regarding QC associated with the project samples. Data tables appear to be coded based on the validation use. Footnotes were used to define the data qualifiers.

Analytical Methods:

VOCs	8240
SVOCs	8270

PCB/Pest	8080
Chlorinated Herb	8150
Explosives	HPLC (UW-14; from U.S. Army Toxic and Had. Agency.
Metals	6010/7000

DEFINITIONS:

NEESA Level C

A site requiring level C QC would be a site near a populated area, not on the NPL, and not likely to be undergoing litigation. The Level C QC includes review and approval of the laboratory A and the site work plan. The laboratory must successfully analyze a performance sample, undergo an audit, correct deficiencies found during the audit and provide MARS on A. The laboratory that performs Level C QC must have passed the performance sample furnished by the Superfund C.P. in the past year. The laboratory does not need to be receiving C.P. bid lots of samples.
Level C allows the use of non-C.P. methods but requires that the methods be accepted EPA methods listed in Tables 7.1 through 7.5. All methods used must be EPA methods or be equivalent to EPA methods. Further discussion about these methods is presented in Sect.7. The laboratory must successfully analyze a performance sample, undergo an audit, correct deficiencies found during the audit, and provide MPRS on A. These audits will be administered and evaluated by the NC. The Navy audit and performance sample are required in addition to any specified by the EPA Superfund Program.