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Phase II Ground Water RCRA Facility Investigation Solid Waste Management Unit 30 (Landfarm) Addendum for Soil/Sludge Sampling and Risk Screening

Naval Surface Warfare Center (NSWC)

Crane, Indiana

NAVFAC
Naval Facilities Engineering Command

Southern Division Naval Facilities Engineering Command

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PHASE II GROUND WATER
RCRA FACILITY INVESTIGATION
SOLID WASTE MANAGEMENT UNIT 30
(LANDFARM)
ADDENDUM FOR SOIL/SLUDGE SAMPLING AND RISK SCREENING

NAVAL SURFACE WARFARE CENTER (NSWC)
CRANE, INDIANA

COMPREHENSIVE LONG-TERM
ENVIRONMENTAL ACTION NAVY (CLEAN) CONTRACT

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ACRONYMS/ABBREVIATIONS

ANOVA	Analysis of Variance
BAF	Bioaccumulation Factor
bgs	below grade surface
CLEAN	Comprehensive Long-Term Environmental Action, Navy
COC	Chain-of-Custody or Chemicals of Concern (depending on use)
COPC	Chemicals of Potential Concern
Cr^{+6}	Hexavalent Chromium
CSQG	Canadian Soil Quality Guidelines
CTO	Contract Task Order
DPT	Direct Push Technology
EDQLs	Ecological Data Quality Levels
ERSE	Ecological Risk Screening Evaluation
HHSE	Human Health Risk Screening Evaluation
HQ	Hazard Quotient
IDLs	Instrument Detection Limits
IDW	Investigation-Derived Waste
MDLs	Method Detection Limits
MSL	Mean Sea Level
NAVY	U.S. Department of the Navy
NSWC	Naval Surface Warfare Center
PID	Photoionization Detector
PPE	Personal Protective Equipment
PRG	Preliminary Remediation Goals
QAPP	Quality Assurance Project Plan
RBTL	Risk-Based Target Level
RCRA	Resource Conservation and Recovery Act
RFI	RCRA Facility Investigation
RL	Reporting Limit
SAS	Sludge Application Site
SB	Subsurface soil
SOUTHDIV	Southern Division Naval Facilities Engineering Command
SRIV	Soil Remediation Intervention Values
SRTV	Soil Remediation Target Values

SS	Surface soil
SWMU 30	Solid Waste Management Unit 30 "The Landfarm"
SWMU	Solid Waste Management Unit
TCLP	Toxicity Characteristic Leaching Procedure
TOM	Task Order Manager
TtNUS	Tetra Tech NUS, Inc.
UCL	Upper Confidence Limit
USACEWES	U.S. Army Corps of Engineers Waterways Experiment Station
U.S. EPA	U.S. Environmental Protection Agency
USCS	United Soil Classifications System
VOC	Volatile Organic Compound
WRS	Wilcoxon Rank-Sum

EXECUTIVE SUMMARY

This Soil Addendum Report (addendum) has been prepared as a stand-alone attachment to the Draft Phase II RCRA Facility Investigation Report (RFI) for Solid Waste Management Unit (SWMU) #30 (Landfarm) dated May 2001 (TtNUS, 2001). As described in the draft RFI (TtNUS, 2001), five rounds of ground water data were collected at the Landfarm between October 1999 and October 2000. Results of these data showed that no statistically significant impacts to ground water occurred from operations at this SWMU.

Because of no impact to ground water, the Navy requested No Further Action at this SWMU for all media. The U.S. EPA recommended that the Navy proceed with drafting a risk screening document for this SWMU as part of an official no further action request and also recommended that the Navy collect and analyze soil/sludge samples from the Landfarm. Soil/sludge sampling field investigation activities at the Landfarm were conducted in early March 2002. All of the soil samples were analyzed for the target analyte list metals and cyanide, hexavalent chromium and pH. Additional sampling details are provided in Section 2 of this addendum.

As discussed in Section 3, data evaluation resulted in eliminating aluminum, cyanide and the macronutrients (calcium, magnesium, potassium, and sodium) from the risk screening process. Data sets to be used in the risk screening process were created in accordance with statistical findings and then compared to Base-Wide Background sample sets as well as each other to further investigate chemicals that could show potential concern at SWMU 30. Six analytes were found not to be statistically greater than background in the surface soils (barium, cobalt, manganese, nickel, selenium, and thallium), and only mercury was eliminated by a statistical comparison test (WRS test) as not greater than background in subsurface samples. Antimony, arsenic, beryllium, cadmium, chromium, copper, iron, lead, mercury, silver, vanadium, and zinc were found to be statistically greater than background in grid surface soils. Surface soil samples were found to be different comparing grid samples to the perimeter samples for six analytes (antimony, chromium, copper, mercury, silver, and zinc) showing that the grid samples were elevated in surface soils compared to the perimeter. No evidence was found for any differences between the grid and perimeter samples in subsurface soil.

As part of the HHSE, antimony, arsenic, chromium, iron, manganese, and vanadium were the only metals detected in soils at concentrations exceeding screening levels typically recommended by EPA Region 5 for selection of COPCs for human health risk assessment. Cancer risk estimates developed for the hypothetical future resident and typical industrial worker do not exceed the risk management range

(1E-04 to 1E-06) often used by EPA to determine the need for environmental remediation or to set environmental standards and criteria. Non-cancer risk estimates indicate a marginal exceedance of the EPA non-carcinogenic benchmark (a hazard index of 1) when the hypothetical future resident is evaluated. Non-cancer risk estimates do not exceed the benchmark when the typical industrial worker is evaluated. The non-cancer risk estimates were developed in a very conservative manner - assuming that a human receptor is exposed to the maximum detected concentration and very conservative toxicity benchmarks were used to evaluate iron and manganese. Consequently, the non-cancer risk results are likely to be over estimated.

From an ecological perspective, silver is the only metal detected in the Landfarm surface soils at concentrations that may cause a risk to ecological receptors. Concentrations reported for many sample locations exceed the maximum background concentration by an order of magnitude or more, while samples in two grid cells had silver concentrations greater than the soil remediation intervention value, which is indicative of serious contamination. However, based on a review of the literature, it is unlikely that the silver in the soil will be available and thus toxic to ecological receptors, although there is some uncertainty in this conclusion. Therefore, the elevated detections of silver in the soil do not warrant further evaluation.

While several other metals were also detected at concentrations exceeding background and the EPA Region 5 EDQLs, there were few exceedances of alternative screening values referenced in the ecological risk screening evaluation (Section 5). Also, in most cases the detected concentrations were within 2 or 3 times the maximum Base-Wide Background concentration. Therefore, risks from these other metals are low and do not warrant further evaluation.

Based upon the results of this soil investigation, the Navy believes that human health and ecological risks are within an acceptable range and do not warrant further investigation. The ground water data do not indicate that the soils have adversely impacted ground water quality (TtNUS, 2001) and there are no significant ground water quality problems in the vicinity of the site. Therefore, no remedial actions are warranted for ground water or soils at the site and a recommendation for No Further Action is requested by the Navy. This No Further Action request is for all media based on review of the operational history of the site, wastes that were disposed, the length of time they were disposed, and site analytical data.

1.0 INTRODUCTION

This Soil Addendum Report (addendum) has been prepared as a stand-alone attachment to the Draft Phase II RCRA Facility Investigation Report (RFI) for Solid Waste Management Unit (SWMU) #30 (Landfarm) dated May 2001 (TtNUS, 2001). It is not the purpose of this addendum to repeat information that has already been presented in the draft RFI, but to add to it. The reader should have a copy of the draft RFI (TtNUS, 2001) available while reading this addendum as numerous references are made to sections, tables and figures contained in the draft RFI report. In particular, Section 1 of the draft RFI should be reviewed prior to this addendum to gain a thorough understanding of the site.

As described in the draft RFI (TtNUS, 2001), five rounds of ground water data were collected at the Landfarm between October 1999 and October 2000. Results of these data showed that no statistically significant impacts to ground water occurred from operations at this SWMU.

Wastewater treatment plant sludges were applied at SWMU 30 (Landfarm) from November 1988 through March 1995. Although laboratory analyses were performed on these sludges, the only available data are from January 1990 through July 1992 (refer to Tables 1-2 & 1-3 of the draft RFI; TtNUS, 2001). The primary constituents of concern are several metals including cadmium, chromium, and nickel. The presence of these metals was the original reason Region 5 became concerned about the wastewater treatment plant sludges from electroplating operations as potential F006-listed hazardous waste. [These metals have been detected in sludge samples (1990, 1991) for SWMU 30.] Based on existing site information, wastewater treatment plant sludges were not preferentially applied to any particular sub-area of SWMU 30. The surface and subsurface soil sampling activities discussed in this addendum were intended to determine whether significant quantities of waste materials (metals) had accumulated in the soils as a result of the sludge application.

Because of no impact to ground water, the Navy requested No Further Action at this SWMU for all media. The U.S. EPA responded to this request on October 30, 2001, recommending that the Navy proceed with drafting a risk screening document for this SWMU as part of an official no further action request (as was done for previous NSWC Crane SWMUs such as the Lithium Battery Site). As requested by the U.S. EPA, the risk screening was to be conducted using the Technical Guidance on Corrective Action Activity, Naval Surface Warfare Center Crane, Indiana dated August 1999. The U.S. EPA also recommended that the Navy collect and analyze soil/sludge samples from the Landfarm in order to identify any potential risks that may be present in the soil/sludge exposure pathway. They further suggested that samples should be collected from the surface soil (0 to 1 foot); tested for total metals; and these results compared to the

Basewide Background Soil Investigation levels and risk-based screening levels for soils (human health and ecological). They further added that this would determine what, if any, institutional and/or engineering controls might be necessary for the SWMU should soil/sludge sampling show elevated levels of constituents.

A conference call was conducted on November 8, 2001 to discuss the proposed additional activities for the Landfarm. The following summarizes EPA's recommendations from this conference call:

- No additional risk screening was required for ground water.
- A streamlined Soil Sampling Work Plan Addendum was to be prepared referencing previously approved NSWC Crane QAPPs, including the types, number, locations and depths of samples to be collected. The Old Rifle Range (SWMU 7) QAPP was used to prepare the Work Plan Addendum for the Landfarm.
- If possible, the field crew was to make visual distinction between sludge and soil.
- Analyze only for metals (F006) and any other metals related to F006 including cyanide.
- Sampling depths should include surface (0 to 1-foot bgs) and shallow subsurface (1 to 4 feet bgs).
- Incorporate grid and/or random sampling methods.
- Compare results to Risk Based Screening Levels and Background Values.
- Use both industrial and residential values for comparison.
- May want to perform intermediate risk assessment, which would fall between a quantitative and a qualitative screening.
- The assessment will need to also address ecological factors.

Following this conference call, the Soil Sampling Work Plan Addendum was prepared (TtNUS, 2002), submitted and approved by EPA Region 5.

2.0 FIELD INVESTIGATION ACTIVITIES

2.1 SOIL SAMPLING ACTIVITIES

Soil/sludge sampling field investigation activities at the Landfarm were conducted in early March 2002. Field procedures including sampling methodologies referenced in the Old Rifle Range (SWMU 7) QAPP were used in the Work Plan Addendum for the Landfarm. It should be noted that SWMU 30 is unrelated to SWMU 7 and was used only because it was a QAPP that had been recently approved by EPA Region 5.

TtNUS mobilized to the site and collected surface and subsurface soil samples between March 4 to 8, 2002. Appendix A contains copies of the appropriate pages from the field logbook for that field activity. Appendix B contains all of the soil sample log sheets and boring logs for the Landfarm collected to date. Copies of all of the chain-of-custody forms are provided in Appendix C.

Soil sampling locations shown in Figure 2-1 were selected as follows. SWMU 30 was divided into 12 sub-areas as shown in Table 2-1 (each sub-area represented approximately 9,000 square feet). Each sub-area was divided further into a 10-by-10 array of subcells (i.e., 100 sub-cells approximately 90 square feet each). Five subcells within each sub-area were selected as borehole sampling locations (the borehole was advanced at the approximate center point of the sub-cell). Sub-cells to be sampled were randomly selected using a uniform random number generator [Microsoft Excel 97 SR-2 (h)]. This soil sampling design constituted a stratified random design [as was used in the evaluation of SWMU 1/12 (Mustard Gas Burial Ground) during another NSWC Crane investigation]. Samples collected from each of the five subcells in each sub-area were composited and the composite soil sample were analyzed as described below. Samples were collected at the three depth-intervals described below. Thus, three composite soil samples were submitted to the laboratory from each sub-area [i.e., a total of 36 composite soil samples (i.e., 12 sub-areas; 3 composite samples from each sub-area) were submitted for analysis]. Additionally, 6 borings (18 samples) were advanced just outside the assumed limits of SWMU 30 to confirm the lateral extent of the SWMU and to further investigate potential contaminant migration from the SWMU.

Figure 2-1 of this addendum shows the surveyed sampling locations for soil samples collected at the Landfarm in March 2002.

Based on Crane personnel interviews and historical accounts of the sludge application activities, the sludges were highly liquid and were spread over the ground surface. At the request of the U.S. EPA, an

attempt was made during sampling to differentiate between sludge and native soil. Field personnel indicated that there was no obvious visual distinction between the two at any of the locations sampled. Excess soil cuttings from the borings were placed back in the borehole. Details regarding soil sampling equipment and procedures are discussed in the Work Plan Addendum (TtNUS, 2002).

Three soil samples were collected from each borehole location from the following nominal depth intervals: 0 to 6 inches, 6 inches to 2 feet bgs, and 2 feet to 4 feet bgs. Bedrock was not encountered at these shallow depths, therefore all depth intervals were successfully collected. Surface soils were defined as soils 0 to 2 feet bgs, and subsurface soils were defined as soils greater than 2 feet bgs.

Although subsurface soils were collected (2 to 4 feet bgs); contamination was thought to be most likely in the surface soils (versus subsurface soils) given the fact that the sludges were applied to the surface soils. Initially, samples from the 0 to 6 inch soil interval and the 2 to 4 foot bgs soil interval were analyzed for target analytes. The soil sample from the 6 inch to 2 foot bgs interval would have been analyzed if chemical concentrations in the 2 to 4 foot depth interval had been less than the following screening levels (and background):

- U.S. EPA Region 9 Preliminary Remediation Goals for exposure to soils (residential land use)
- IDEM - Tier I Default Closure Levels for soils for Residential Land Use
- U.S. EPA Soil Screening Levels for Soil Ingestion, Transfer from Soils to Air, and Migration from Soils to Groundwater
- U.S. EPA Region 5 Ecological Data Quality Levels

There were numerous exceedances of these criteria in the 2 to 4 foot interval. Therefore, the additional expense of analyzing the intermediate sampling zone was not felt to be beneficial (it was only 1-1/2 feet thick). A total of 54 samples were collected (i.e., 36 sub-area samples and 18 boundary samples), however as described above, only 36 of these 54 samples were analyzed.

All of the soil samples were analyzed for the target analyte list metals and cyanide, hexavalent chromium and pH. The analytical detection limit requirements, analytical methods and corresponding laboratory SOPs, quality control samples collection frequency, matrix spike and laboratory duplicate control limits, laboratory control sample control limits, and bottleware, preservation, and holding time requirements were specified in the Work Plan Addendum.

2.2 SOIL SAMPLE COLLECTION AT THE LANDFARM

This section describes the specifics concerning sampling locations, sampling procedure, analyses and field operations that were followed as part of soil sample acquisition. Table 2-2 shows the soil target parameters and their respective MDLs, IDLs, RLs, and RBTLs. These values are the ones used for comparison and presentation purposes in preparation of all of the remaining data tables in this section.

2.2.1 Surface Soil Sampling

At the Landfarm, surface soil samples were collected from the ground surface to a depth of 0.5 foot (0 to 6") during advancement of soil borings using a Direct Push Technology (DPT) track-mounted rig.

Upon retrieval, all samples obtained were monitored for volatile organic compounds (VOCs) with a photoionization detector (PID) for health and safety concerns and then examined for visual lithologic classification. Each 0- to 0.5-foot depth interval sample was placed into a stainless steel mixing bowl for compositing with the other locations of the same depth in the same cell (grid). After thorough mixing in the stainless steel mixing bowl, samples were then placed in appropriate sample bottles and then into a cooler of ice immediately after collection.

This process was followed for each grid with 1 surface sample each from 5 borings collected (total of 5 distinct surface samples per grid excluding QA). From those 5 samples, 1 composite sample at this depth was created for analysis.

Boundary surface grab samples were obtained from 6 locations at the same depth noted above.

2.2.2 Subsurface Soil Sampling

All subsurface samples were collected from the same soil boring as the corresponding surface sample. Soil samples were collected at two depth intervals of 0.5 to 2 feet and 2 to 4 feet bgs using a DPT rig.

Upon retrieval, all samples obtained were monitored for volatile organic compounds (VOCs) with a photoionization detector (PID) for health and safety concerns and then examined for visual lithologic classification. Each 0.5 to 2-foot, and 2 to 4-foot depth interval sample was placed into depth-specific stainless steel mixing bowls for compositing with the other locations of the same depth in the same cell (grid). After thorough mixing in the stainless steel mixing bowl, samples were then placed in appropriate sample bottles and then into a cooler of ice immediately after collection.

This process was followed for each grid with 2 subsurface samples each from 5 borings collected (total of 10 distinct subsurface samples per grid excluding QA). From those 10 samples, 2 composite samples at the depths indicated above were created for analysis.

Boundary surface grab samples were obtained from 6 locations at the same depths noted above.

After sampling, the boreholes were abandoned by backfilling the hole with remaining soil cuttings. Because of the shallowness of the holes and samples required, no excess soil was generated.

2.2.3 Borehole and Soil Sample Logging

A lithologic description of each soil sample and a complete log of each boring was maintained by the TtNUS geologist in accordance with the QAPP. Appendix B contains the boring logs and soil sample logs for this investigation. Each boring log contains the following information:

- Boring identification
- Name of geologist logging the boring
- Sample numbers and types
- Sample depths
- Soil density or cohesiveness
- Soil color
- Unified Soil Classification System (USCS) material description
- Location of boring
- DPT problems/deviations from project-specific SAP

In addition, depths of changes in lithology, sample moisture observations, organic vapor (i.e., PID) readings, augering methods, and total depth of each borehole, and other pertinent observations were included on each log.

2.2.4 Field Measurements for Soil Sampling

Throughout the DPT activities, all soil samples were screened for VOCs for health and safety purposes. No readings were obtained that were of a health and safety concern.

Soil samples were classified according to depositional environment and grain size (clay, silt or sand). These classifications were designed to be comparable to those used in the "Base-wide Background Soil

Investigation for NSWC Crane" (TtNUS, 2000) so as to permit accurate comparisons when determining whether site target analyte concentrations exceeded background concentrations.

Soil samples were also characterized with regard to horizontal mapping coordinates (surveyed) (see Figure 2-1).

2.3 DECONTAMINATION

The equipment involved in field sampling activities was decontaminated before beginning work, during drilling and sampling activities, and at the completion of the project. This equipment included the DPT rig and down-hole tools and soil sampling equipment.

All nondedicated reusable sampling equipment used to collect samples was decontaminated before field sampling, between samples, and before leaving the site. This equipment included DPT rods, the macro-core sampler and stainless steel bowls used for sample compositing. The following decontamination steps were taken:

- Potable water, phosphate-free detergent wash (scrub if necessary)
- Potable water rinse
- Deionized (DI) water rinse
- Air dry (if possible)
- Wrap in aluminum foil (if not used immediately)

The DPT rig was cleaned upon site arrival and prior to leaving the site. Additional guidance for decontamination was supplied in SOP CTO56-5 (Appendix B of the QAPP).

Disposable equipment used for sampling activities was decontaminated using a detergent wash and potable water rinse, placed in plastic garbage bags, and discarded in dumpsters on the NSWC Crane facility in accordance with procedures described in SOP CTO 56-5 (Appendix B of the QAPP).

2.4 INVESTIGATION-DERIVED WASTE (IDW) HANDLING

This investigation generated two types of potentially contaminated residues or investigation-derived waste (IDW):

- Personal protection equipment (PPE)
- Equipment decontamination fluids

IDW was handled as described below and in SOP CTO 56-5 (Appendix B of the QAPP):

PPE, DPT Soil Core Liners, Plastic Trowels - All PPE, tubing, DPT sample liners, and plastic trowels were decontaminated and double bagged and placed in trash receptacles at the facility.

Equipment Decontamination Fluids - All DPT and sampling decontamination fluids were stored in 8-gallon plastic containers and discharged into the NSWC permitted sanitary sewer system, in accordance with the QAPP.

2.5 SURVEYING

All soil borings locations associated with this RFI were surveyed (see Figure 2-1). All ground surface elevations were surveyed to the nearest 0.01 foot. Vertical elevations were referenced to the 1988 National Geodetic Vertical Datum (NGVD88). Existing survey monuments around NSWC Crane were used as reference points. Horizontal locations of samples and borings were surveyed to Indiana State Plane coordinates, zone 1302 within the nearest 0.10 foot and referenced to the 1927 North American Datum (NAD27). The survey points are shown in Table 2- 3.

TABLE 2-1

GRID SAMPLING AREAS (1-12) FOR SOIL SAMPLING SWMU 30
NSWC CRANE
CRANE, INDIANA
PAGE 1 OF 2

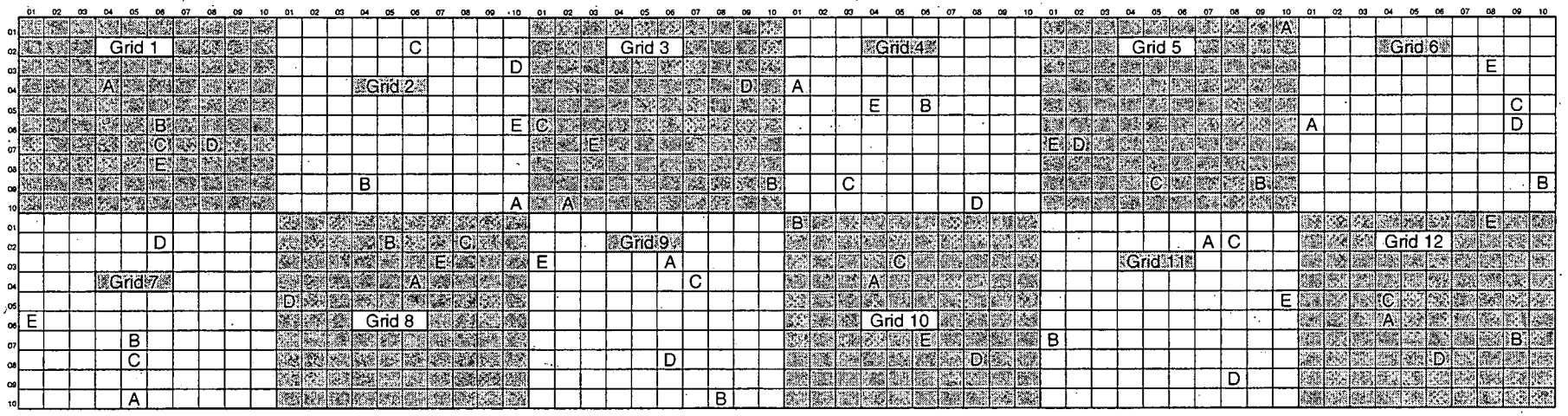


TABLE 2-1

GRID SAMPLING AREAS (1-12) FOR SOIL SAMPLING SWMU 30
NSWC CRANE
CRANE, INDIANA

LOCATION	AREA	X	Y
30CP01A	1	4	4
30CP01B	1	6	6
30CP01C	1	6	7
30CP01D	1	8	7
30CP01E	1	6	8
30CP02A	2	10	10
30CP02B	2	4	9
30CP02C	2	6	2
30CP02D	2	10	3
30CP02E	2	10	6
30CP03A	3	2	10
30CP03B	3	10	9
30CP03C	3	1	6
30CP03D	3	9	4
30CP03E	3	3	7
30CP04A	4	1	4
30CP04B	4	6	5
30CP04C	4	3	9
30CP04D	4	8	10
30CP04E	4	4	5
30CP05A	5	10	1
30CP05B	5	9	9
30CP05C	5	5	9
30CP05D	5	2	7
30CP05E	5	1	7
30CP06A	6	1	6
30CP06B	6	10	9
30CP06C	6	9	5
30CP06D	6	9	6
30CP06E	6	8	3

LOCATION	AREA	X	Y
30CP07A	7	5	10
30CP07B	7	5	7
30CP07C	7	5	8
30CP07D	7	6	2
30CP07E	7	1	6
30CP08A	8	6	4
30CP08B	8	5	2
30CP08C	8	8	2
30CP08D	8	1	5
30CP08E	8	7	3
90CP09A	9	6	3
90CP09B	9	8	10
90CP09C	9	4	7
90CP09D	9	6	8
90CP09E	9	1	3
30CP10A	10	4	4
30CP10B	10	1	1
30CP10C	10	5	3
30CP10D	10	8	8
30CP10E	10	6	7
30CP11A	11	7	2
30CP11B	11	1	7
30CP11C	11	8	2
30CP11D	11	8	9
30CP11E	11	10	5
30CP12A	12	4	6
30CP12B	12	9	7
30CP12C	12	4	5
30CP12D	12	6	8
30CP12E	12	8	1

TABLE 2-2

DETCTION LIMITS VERSUS RISK CRITERIA
NSWC CRANE INDIANA

Parameter	CAS NUMBER	Solid Matrix		
		Laboratory MDL/IDL[1] (mg/kg)	Laboratory RL[1] (mg/kg)	Risk-Based Soil Target Level [2] (mg/kg)
METALS (SW-846 Method 6020 ICP/MS)				
Antimony	7440-36-0	0.05	1*	0.1423
Arsenic	7440-38-2	0.05	1*	0.39
Barium	7440-39-3	0.05	1	1.04
Beryllium	7440-41-7	0.05	1*	0.1
Cadmium	7440-43-9	**0.05**	1*	0.00222
Chromium (total)	7440-47-3	0.05	1	2
Cobalt	7440-48-4	0.05	1*	0.14033
Copper	7440-50-8	0.05	1	2.96
Lead	7439-92-1	0.05	1*	0.05373
Mercury (SW-846 Method 7470A/7471A)	7439-97-6	0.02	0.2*	0.073
Nickel	7440-02-0	0.05	1	7
Selenium	7782-49-2	**0.15**	1*	0.02765
Silver	7440-22-4	0.05	1*	2
Thallium	7440-28-0	**0.05**	1*	0.04
Vanadium	7440-62-2	0.05	1	1.59
Zinc	7440-66-6	0.2	1	6.62
MISCELLANEOUS METALS (SW-846 METHOD 6010B Trace)				
Aluminum	7429-90-5	8.1	20	76000
Calcium	7440-70-2	15	500	--
Iron	7439-89-6	1.3	10	23000
Magnesium	7439-95-4	0.76	500	--
Manganese	7439-96-5	0.02	1.5	1800
Potassium	7440-09-7	1.6	500	--
Sodium	7440-23-5	7.6	500	--
MISCELLANEOUS PARAMETERS				
Cyanide (SW-846 Method 9012A)		0.2	1	1.3
Hexavalent Chromium (SW-846 7196A)		**1.2**	2*	0.4

MDL = method detection limit
IDL = instrument detection limit
RL = reporting limit
µg/L = micrograms per liter.
mg/kg = milligrams per kilogram.
Shaded cells indicate laboratory MDLs that exceed a risk-based target level for the project.
Shaded cells indicate laboratory RLs that exceed a risk-based target level for the project.

* Asterisks indicate those chemicals for which the laboratory RL exceeds the risk-based target level for the project.

1 Method Detection Limits (MDLs) (all parameters except metals), instrument detection limits (IDLs) (metals only), and reporting limits as provided by Laucks Testing Laboratories, Inc. The values may change prior to the SWMU investigations as laboratory MDLs and IDLs are updated.

2 Value is based on the lowest human health or ecological risk-based criteria as presented in Appendix C of the MGBG QAPP TtNUS June 2001, Tables C-2A (solids).

3 Laucks Testing Laboratories is confident that it can reliably report to this PQL, even though this value is less than two times the MDL and/or IDL.

TABLE 2-3

LANDFARM SURVEY POINTS
NAVAL SURFACE WARFARE CENTER
CRANE, INDIANA

SOIL SAMPLING LOCATIONS			
LOCATION	EASTING	NORTHING	ELEVATION
30CP01A	556669.4541	476147.5635	704.70
30CP01B	556690.9143	476125.8310	705.74
30CP01C	556690.0041	476115.9324	705.93
30CP01D	556710.3757	476113.7217	707.03
30CP01E	556689.4048	476106.0314	706.19
30CP02A	556826.3026	476072.3439	708.31
30CP02B	556767.5805	476088.3165	707.59
30CP02C	556796.9268	476155.6925	708.29
30CP02D	556832.9871	476142.3529	708.43
30CP02E	556830.0754	476112.1635	708.35
30CP03A	556847.2162	476070.4970	708.25
30CP03B	556927.1963	476072.6485	706.84
30CP03C	556841.7605	476111.5273	708.47
30CP03D	556922.9194	476123.5926	707.90
30CP03E	556861.7512	476099.1310	707.62
30CP04A	556942.9125	476121.3691	707.31
30CP04B	556993.2940	476106.2643	707.24
30CP04C	556957.7001	476069.6379	706.13
30CP04D	557006.2031	476054.3927	707.44
30CP04E	556973.2979	476108.3544	707.29
30CP05A	557134.9094	476132.6364	710.13
30CP05B	557117.4858	476053.9149	708.30
30CP05C	557077.0581	476058.2818	706.77
30CP05D	557048.8559	476070.4774	707.09
30CP05E	557039.7994	476071.9957	707.17
30CP06A	557142.4795	476082.3440	709.05
30CP06B	557206.3761	476045.0893	710.90
30CP06C	557199.1172	476085.8629	711.09
30CP06D	557198.9373	476076.2631	710.84
30CP06E	557191.9584	476107.0021	711.25
30CP07A	556671.2986	475987.6800	703.68
30CP07B	556673.2309	476017.4245	704.43
30CP07C	556672.7407	476007.4639	704.14
30CP07D	556686.0064	476066.1849	706.25
30CP07E	556634.3158	476031.3588	702.42
30CP08A	556782.7723	476036.1484	706.79
30CP08B	556774.3195	476057.9498	707.28
30CP08C	556804.6044	476054.6036	707.66
30CP08D	556732.5855	476031.4613	706.70
30CP08E	556794.0204	476045.4793	706.48
30CP09A	556884.5678	476037.0161	706.34
30CP09B	556898.9213	475965.8337	704.32
30CP09C	556891.6357	476026.3852	705.76
30CP09D	556880.3297	475986.9280	705.22
30CP09E	556833.9560	476041.0600	706.23

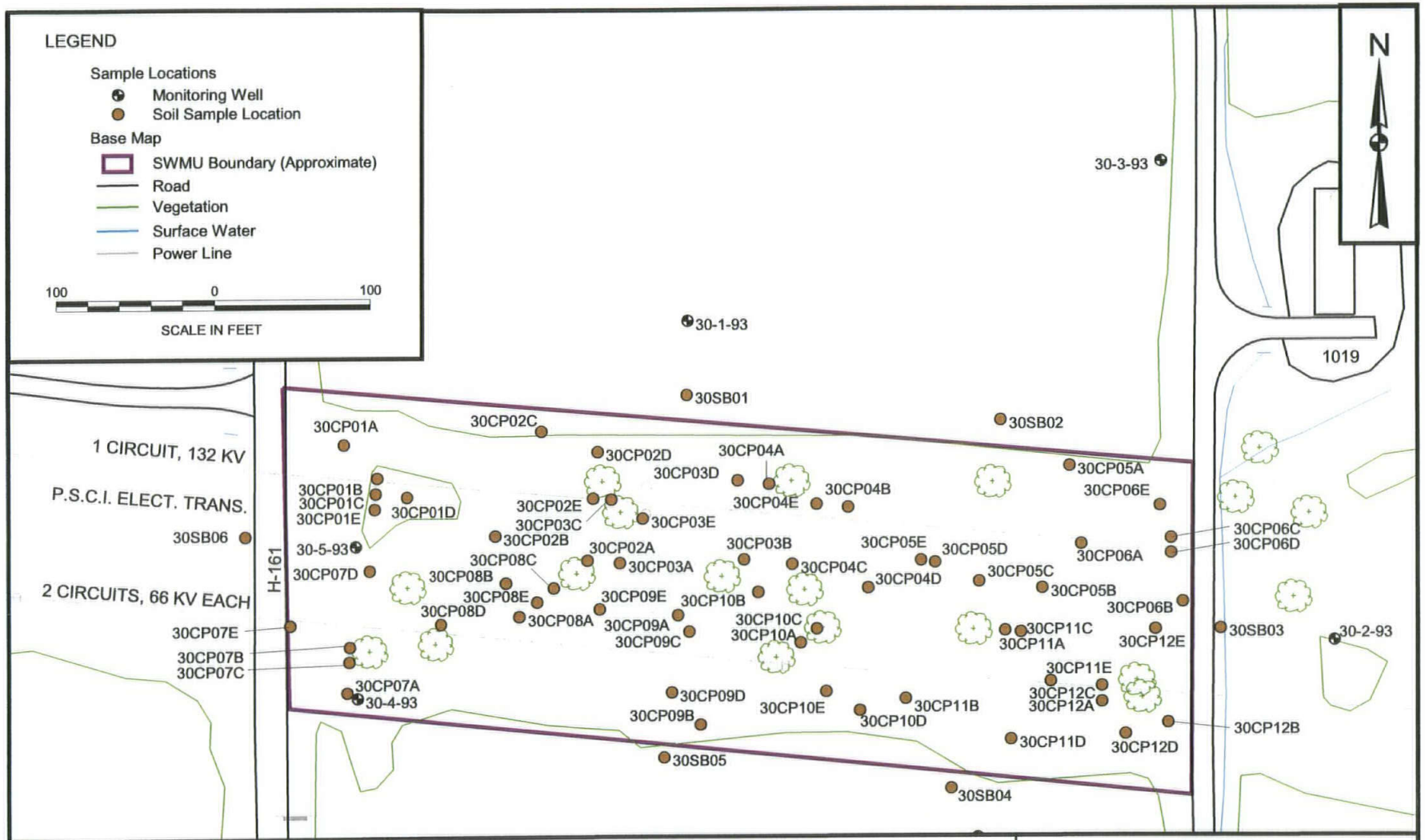
TABLE 2-3

LANDFARM SURVEY POINTS
NAVAL SURFACE WARFARE CENTER
CRANE, INDIANA

SOIL SAMPLING LOCATIONS			
LOCATION	EASTING	NORTHING	ELEVATION
30CP10A	556963.1486	476019.0390	705.90
30CP10B	556936.0063	476051.7091	706.32
30CP10C	556973.4981	476027.9764	705.97
30CP10D	557000.7993	475975.0112	705.07
30CP10E	556979.5554	475987.2932	704.88
30CP11A	557093.7421	476026.6563	707.24
30CP11B	557029.8761	475982.6293	705.43
30CP11C	557103.8340	476025.4990	707.67
30CP11D	557097.4806	475955.9348	706.84
30CP11E	557122.7647	475993.5672	707.35
30CP12A	557155.2966	475980.3594	709.34
30CP12B	557196.9920	475966.4872	709.07
30CP12C	557155.4806	475990.7289	709.53
30CP12D	557170.4786	475959.3788	709.19
30CP12E	557189.1441	476027.2173	710.60
30SB01	556890.3541	476179.0737	709.35
30SB02	557091.0815	476162.3019	709.98
30SB03	557230.4847	476027.7032	711.31
30SB04	557058.9754	475923.9484	705.70
30SB05	556875.5374	475944.7468	703.99
30SB06	556605.8992	476088.4828	702.29

DATUM STATEMENT:
INDIANA STATE PLANE COORDINATES, ZONE 1302, NAD 27; AND
MEAN SEA LEVEL ELEVATIONS, NGVD 88, TAKEN FROM THE FOLLOWING
MONUMENTS:

ARMY CORPS OF ENGINEERS GPS 40 1991 AND AZ. MARK
ARMY CORPS OF ENGINEERS GPS 41 1990



DRAWN BY	DATE
J. LAMEY	7/16/02
CHECKED BY	DATE
COST/SCHEDULE-AREA	
SCALE AS NOTED	

SAMPLE LOCATION MAP
SWMU 30 - LANDFARM
NAVAL SURFACE WARFARE CENTER
CRANE, INDIANA

CONTRACT NUMBER 7393	
APPROVED BY M. FRANCIS	DATE 8/1/02
APPROVED BY R. CLARK	DATE 8/1/02
DRAWING NO. FIGURE 2-1	REV 0

P:\GIS\NSWC_CRANE\APR\N7329.APR LANDFARM SAMPLE LOCATIONS 7/31/02 JAL

3.0 SAMPLING RESULTS AND STATISTICAL ANALYSES

This section presents soil sampling results and statistical analyses conducted for evaluating potential site-related metal contamination. As part of these evaluations comparisons were made to Risk-Based Target Levels (RBTL), Crane Base-wide background concentrations, and specific data sets for those same metals. Supporting tables, figures, and appendices are also provided.

3.1 SOIL SAMPLING RESULTS

Soil samples were collected from the soil borings shown in Figure 2-1 in accordance with the Work Plan Addendum (TtNUS, February 2002). These samples were analyzed for the parameters listed in Table 2-2. Table 3-1 presents all of the soil data obtained during the field investigation with corresponding date, depth, and other pertinent information. Sodium was the only parameter analyzed that had no detections in any samples. Analytical results for soils are summarized further in discussions provided below.

Those parameters with at least one positive result exceeding the RBTL include: antimony, arsenic, barium, beryllium, cadmium, chromium (hexavalent), chromium (total), cobalt, copper, iron, lead, manganese, mercury, nickel, selenium, silver, thallium, vanadium, and zinc. These parameters are noted by shading in Table 3-2. It should be noted that the RBTL for some parameters (antimony, arsenic, beryllium, cadmium, chromium (hexavalent), cobalt, lead, mercury, selenium, silver, and thallium) is lower than the limits of detection by the currently accepted methods of analysis available (see Table 2-2). However, in accordance with the Work Plan Addendum, the RL is the RBTL for parameters in this situation.

The data validation letters for these results are attached to this report as Appendix D.

Statistical evaluation of these results is provided in Section 3.2. Evaluation of risk to human health is discussed in Section 4.0 and evaluation of ecological risk is discussed in Section 5.0.

3.2 STATISTICAL ANALYSIS

In accordance with the Soil Work Plan Addendum (TtNUS, 2002), a stratified random sampling design was used to create a site grid surrounded by six perimeter soil sampling locations (see Table 2-1 and Figure 2-1). Twelve (12) composite soil samples were analyzed at two depths within the site grid. Each of the six perimeter (boundary) locations were also sampled at two depths. The following describes the general methods used to test sampling rationale hypotheses and the conclusions that resulted from the

statistical evaluation. Sample calculations for statistical evaluations performed are provided in Appendix E.

3.2.1 Sampling Rationale Hypotheses

Early hypotheses were formed about the SWMU before sampling was conducted. The six perimeter borings were sampled just outside the site limits of SWMU 30 to bound the data and were assumed to show that their was no migration of site related contaminants (see Figure 2-1). The surface soil (SS) data was sampled at 0 – 6-inches below grade surface (bgs), and subsurface soils (SB) that were analyzed were sampled at approximately 2 - 4 feet bgs. The sampling rationale hypothesis was tested that if contamination exists, it would be more likely to be present in grid surface soils compared to grid subsurface soils given the fact that sludges were applied to the surface soils within the grid.

Six data sets shown below were constructed to best test the hypotheses and to determine whether statistically significant quantities of metals from the sludges accumulated in the soils as a result of the sludge application (landfarming):

1. All SS Samples (0 – 6 inch bgs)
2. All SB Samples (>2 feet bgs)
3. Grid SS Samples (0 – 6 inch bgs)
4. Perimeter SS Samples (0 – 6 inch bgs)
5. Grid SB Samples (>2 feet bgs)
6. Perimeter SB Samples (>2 feet bgs)

Table 3-3 provides the detection statistics for all 6 of these data sets.

3.2.2 Comparisons To RBTLs

An initial focus on the chemicals of concern (COCs) was a comparison of all of the data to its specific RBTL (See Table 3-2). Concentrations that were positive detections and greater than the RBTL were bolded and shaded dark. Aluminum and cyanide were the only two analytes that did not have an exceedance of the RBTL. Further investigation of the comparison showed that antimony exceeded its RBTL in one sample and manganese exceeded its RBTL in two samples. Those analytes were targeted for the next comparison as possibly showing no risk, however, because of an exceedance, they were kept in the data. The macronutrients consisting of calcium, magnesium, potassium, and sodium were also

taken out after the comparison to the RBTLs because these analytes are not generally of great concern from a risk perspective.

After eliminating the parameters discussed above (aluminum, cyanide, calcium, magnesium, potassium, and sodium), Figure 3-1 graphically depicts the range of soil concentrations for each parameter compared to its corresponding RBTL.

3.2.3 Grid and Perimeter Data Set Comparisons

The next investigation on the data tested the hypothesis that the grid surface soil samples, if any contamination did exist, would be greater than the grid subsurface samples as well as to test the assumption that the grid samples (SS & SB) were statistically different than the perimeter samples (SS & SB). Three comparisons (shown below) were run utilizing the non-parametric Wilcoxon Rank-Sum (WRS) test. This two-tailed test was used with alpha equal to 0.05 and the corresponding Z-critical value at ±1.96. These comparisons were run to determine if there was a difference for each analyte in the compared data sets:

1. Grid SS vs. Grid SB
2. Grid SS vs. Perimeter SS
3. Grid SB vs. Perimeter SB

For comparison 1, results of the WRS comparing grid surface soil to grid subsurface soil show that the original hypothesis was correct, (See Table 3-4) grid surface soil concentrations were found to be statistically higher than the grid subsurface soil concentrations. Those analytes that supported this hypothesis were the following: antimony, barium, cadmium, cobalt, lead, manganese, mercury, selenium, silver, and zinc.

The final two comparisons were conducted to support the initial probability plots and analysis on grid samples versus the perimeter samples. The WRS test also proved comparison 2, assuming grid surface soil samples would be statistically greater than the perimeter surface soil samples, correct. The surface soil WRS results indicated six analytes where the grid was greater than perimeter, including five analytes that were constituents of sludge previously applied to the site (chromium, copper, mercury, silver, and zinc – refer to Tables 1-2 and 1-3 of the RFI Report, TtNUS, May 2001). Antimony was the only other metal in this category, but is not listed in the historical sludge data. Comparison 3 was the only test that was disproved showing the evidence of data did not support the original hypothesis that grid subsurface soil samples were statistically higher than perimeter subsurface soil samples.

Supporting evidence can be found in Appendix E Table 6 showing Coefficients of Variation for all of these comparisons. A Shapiro-Wilk W Test Statistic was calculated to find the best representative distribution (normal or lognormal) in order to identify the most appropriate 95% UCL (See Appendix E).

3.2.4 Background Comparisons

As a result of the aforementioned conclusions, the last set of comparisons run on the data was a set of non-parametric Analysis of Variance (ANOVA) tests. The WRS was used in conjunction with the Crane Base-wide Background Investigation Report. The data was analyzed using the six site data sets previously mentioned. The surface soil and subsurface soil samples from SWMU 30 were determined to be from Loess/Glacial parent material. Surface soil results were compared to soil group # 1 from the Crane Base-wide Background Investigation Report. This group contains surface soils from Loess/Glacial parent material regardless of grain size. This surface background data set contains five results. Subsurface soil results were compared to soil group # 2 from the Crane Base-wide Background Investigation Report. This group contains subsurface soils from Loess/Glacial parent material regardless of grain size. This subsurface background data set contains thirteen results. The following comparisons were run and analyzed to make final statistical conclusions on the data that were investigated:

1. All SS vs. Background Soil Group #1
2. All SB vs. Background Soil Group #2
3. Grid SS vs. Background Soil Group #1
4. Grid SB vs. Background Soil Group #2
5. Perimeter SS vs. Background Soil Group #1
6. Perimeter SB vs. Background Soil Group #2

These six comparisons using site data versus background data were conducted using a one-tailed test at alpha equals 0.05 with Z-critical set at +1.645 to determine if each of the specific analytes were statistically greater than the relevant background data set. Table 3-5 presents a summary of the statistical results with regard to these data set comparisons. Table 3-6 presents the results of the WRS comparisons.

With aluminum, cyanide, and the macronutrients (calcium, magnesium, potassium, and sodium) eliminated from the data sets at this point, the results from the surface soil one-tailed tests indicated that barium, cobalt, manganese, nickel, selenium, and thallium were found not to be statistically greater than background in all three comparisons. All other analytes were found to be statistically greater than

background in at least two of the three comparisons. As for the subsurface soil one-tailed tests, the results showed only mercury was found not to be statistically greater than background in all three comparisons.

3.3 SUMMARY

In summary the RBTL comparison eliminated only aluminum and cyanide from both the surface soil and subsurface soil data sets. The macronutrients (calcium, magnesium, potassium, and sodium) were excluded from the data based on analytes that would show limited potential risk. Probability plots and box and whisker plots were initially utilized to find that there was no apparent statistical difference between the grid samples and the perimeter samples, although the WRS test would be utilized to support this conclusion. Those same plots were also used to identify that their was a difference present when looking at the samples incorporating the depth. Data sets were made in accordance with the previous findings and then compared to Base-Wide Background sample sets as well as each other to further investigate chemicals that show potential concern at SWMU 30. Six analytes were found not to be statistically greater than background in the surface soils (barium, cobalt, manganese, nickel, selenium, and thallium), and only mercury was eliminated by the WRS test as not greater than background in subsurface samples. Antimony, arsenic, beryllium, cadmium, chromium, copper, iron, lead, mercury, silver, vanadium, and zinc were found to be statistically greater than background in grid surface soils. Further evidence through results from the WRS test proved that surface soil samples were found to be different comparing grid samples to the perimeter samples for six analytes (antimony, chromium, copper, mercury, silver, and zinc) showing that the grid samples were elevated in surface soils compared the perimeter. No evidence was found for any differences between the grid and perimeter samples in subsurface soil.

TABLE 3-1

SUMMARY OF ANALYTICAL RESULTS IN SURFACE SOIL
LANDFARM
NSWC CRANE
CRANE, INDIANA

SITE	LAND FARM	LAND FARM	LAND FARM	LAND FARM	LAND FARM	LAND FARM	LAND FARM	LAND FARM	LAND FARM	LAND FARM	LAND FARM
LOCATION	30CP01	30CP02	30CP03	30CP04	30CP05	30CP06	30CP07	30CP08	30CP09	30CP10	30CP11
NSAMPLE	30CP010001	30CP020001	30CP030001	30CP040001	30CP050001	30CP060001	30CP070001	30CP080001	30CP090001	30CP100001	30CP110001
SAMPLE	30CP010001	30CP020001	30CP030001	30CP040001	30CP050001	30CP060001	30CP070001	30CP080001	30CP090001	30CP100001	30CP110001
MATRIX	SO	SO	SO	SO	SO	SO	SO	SO	SO	SO	SO
SUBMATRIX	SS	SS	SS	SS	SS	SS	SS	SS	SS	SS	SS
SACODE	NORMAL	ORIG	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	ORIG	NORMAL	ORIG	NORMAL
DEPTH RANGE	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5
SAMPLE DATE	03/07/02 12:	03/07/02 12:	03/07/02 12:	03/07/02 12:	03/07/02 12:	03/06/02 12:	03/08/02 12:	03/07/02 12:	03/07/02 12:	03/07/02 12:	03/06/02 12:
COLLECTION METHOD	COMPOSITE	COMPOSITE	COMPOSITE	COMPOSITE	COMPOSITE	COMPOSITE	COMPOSITE	COMPOSITE	COMPOSITE	COMPOSITE	COMPOSITE
Inorganics (mg/kg)											
ALUMINUM	12400 J	11300	20600	12600 J	14400 J	14700 J	18500 J	14700	16200	19500	16200 J
ANTIMONY	1.0 U	3.8 U	3.8 U	4.4 U	1.1 U	2.7 U	1.1 U	6.0 J	4.5 U	6.0 U	1.6 U
ARSENIC	11.2 J	5.9 J	9.6 J	5.1 J	9.5 J	7.5 J	13.2 J	5.3 J	5.4 J	22.4 J	6.6 J
BARIUM	110 J	114	81.1	159 J	147 J	143 J	86.4 J	144	78.3	180	104 J
BERYLLIUM	0.99 J	0.86 J	0.68 J	0.69 J	1.0 J	0.69 J	0.76 J	0.82 J	0.52 J	1.5 J	0.70 J
CADMIUM	0.81	0.71 UJ	0.69 UJ	1.2 J	0.69 UJ	1.1 J	0.78 U	0.96 J	0.69 UJ	1.6 J	0.74 UJ
CALCIUM	1980 J	5170 J	1910 J	1600 J	22500 J	41000 J	2740 J	39700 J	30100 J	34200 J	1870 J
CHROMIUM	27.9 J	16.6	25.5	20.9 J	24.3 J	25.1 J	29.0 J	19.3	19.9	39.3	22.0 J
COBALT	12.4	12.8 J	11.6 J	9.1	12.0	9.9	5.2	13.9 J	7.2 J	16.9 J	8.5
COPPER	13.5	14.2	14.9	27.3	13.8	23.0	23.4	20.2	13.4	38.7	14.9
IRON	25200 J	13700 J	23800 J	14700 J	26300 J	17800 J	26500 J	12900 J	16000 J	42500 J	19300 J
LEAD	25.8 J	19.2 J	14.3 J	24.5 J	19.0 J	21.8 J	18.7 J	19.0 J	12.0 J	30.7 J	15.6 J
MAGNESIUM	1260 J	1180 J	2390 J	1260 J	1930 J	3590 J	2600 J	2500 J	2270 J	1830 J	1420 J
MANGANESE	994 J	1190 J	403 J	881 J	1200 J	954 J	189 J	1350 J	527 J	1550 J	745 J
MERCURY	0.054 U	0.11	0.05	0.058	0.051	0.11	0.055 U	0.26	0.08	0.41	0.089
NICKEL	14.6 J	14.3	16.1	12.4 J	15.1 J	16.8 J	14.8 J	17.1	13.2	20.6	15.1 J
POTASSIUM	980 J	816 J	1720 J	909 J	1440 J	1650 J	1550 J	1400 J	1530 J	1520 J	1200 J
SELENIUM	0.60	0.48 J	0.39 UJ	0.43 J	0.67 J	0.50 J	0.57	0.47 J	0.40 UJ	0.85 J	0.42 UJ
SILVER	2.2 U	4.4 J	0.75 J	19.4 J	2.8 J	13.4 J	0.38 U	10.6 J	3.9 J	19.7 J	5.8 J
SODIUM	7.1 UJ	71.7 U	98.9 U	20.8 U	112 U	171 U	8.0 UJ	94.7 U	94.0 U	183 U	147 U
THALLIUM	0.27	0.21	0.35	0.21	0.24	0.21	0.37	0.23	0.23	0.24	0.24
VANADIUM	45.0	27.9 J	48.6 J	29.0 J	39.3 J	33.1 J	54.7	30.0 J	35.7 J	60.9 J	38.0 J
ZINC	56.9 J	60.5 J	64.5 J	87.7 J	55.0 J	89.6 J	67.5 J	73.0 J	56.1 J	115 J	56.9 J
Miscellaneous											
CYANIDE (mg/kg)	0.7 U	0.7 U	0.7	0.2 U	0.2 U	0.2 U	0.7 U	0.6 U	0.6 U	0.7 U	0.2 U
HEXAVALENT CHROMIUM (mg/kg)	3 UR	3 UR	3 UR	3 UR	3 UR	3 UR	3 UR	2 UR	3 UR	3 UR	3 UR
PH (S.U.)	6.2	7.5	7.3	5.9	7.8	7.8	7.6	7.4	7.6	7.4	6.8

TABLE 3-1

SUMMARY OF ANALYTICAL RESULTS IN SURFACE SOIL
LANDFARM
NSWC CRANE
CRANE, INDIANA

SITE	LAND FARM	LAND FARM	LAND FARM	LAND FARM	LAND FARM	LAND FARM	LAND FARM
LOCATION	30CP12	30SB01	30SB02	30SB03	30SB04	30SB05	30SB06
NSAMPLE	30CP120001	30SS010001	30SS020001	30SS030001	30SS040001	30SS050001	30SS060001
SAMPLE	30CP120001	30SS010001	30SS020001	30SS030001	30SS040001	30SS050001	30SS060001
MATRIX	SO	SO	SO	SO	SO	SO	SO
SUBMATRIX	SS	SS	SS	SS	SS	SS	SS
SACODE	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL
DEPTH RANGE	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5
SAMPLE DATE	03/06/02 12:	03/07/02 12:	03/07/02 12:	03/06/02 12:	03/06/02 12:	03/07/02 12:	03/07/02 12:
COLLECTION METHOD	COMPOSITE	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB
Inorganics (mg/kg)							
ALUMINUM	16900 J	13600	12300 J	11500 J	11600 J	15600	14600 J
ANTIMONY	2.1 U	1.8 U	0.76 U	2.3 U	1.1 U	0.80 U	1.4 U
ARSENIC	8.9 J	6.3 J	8.8 J	4.8 J	6.4 J	7.0 J	7.3 J
BARIUM	127 J	108	181 J	120 J	114 J	59.3	110 J
BERYLLIUM	0.87 J	0.87 J	1.1 J	0.51 J	0.79 J	0.48 J	0.75 J
CADMIUM	0.67 UJ	0.76 UJ	0.72 UJ	1.0 J	0.66 UJ	0.70 UJ	0.73 U
CALCIUM	2700 J	2210 J	1260 J	124000 J	1250 J	1030 J	12500 J
CHROMIUM	23.1 J	17.9	19.4 J	18.9 J	18.3 J	20.7	23.0 J
COBALT	10.0	12.2 J	12.1	6.2	9.9	6.0 J	7.4
COPPER	14.5	12.0	11.1	16.5	7.4	9.2	15.1
IRON	21900 J	15000 J	20500 J	13300 J	20100 J	20600 J	18500 J
LEAD	18.2 J	19.1 J	21.1 J	16.5 J	14.0 J	10.3 J	16.9 J
MAGNESIUM	1560 J	1360 J	1040 J	5840 J	1080 J	1430 J	2490 J
MANGANESE	1280 J	1120 J	2890 J	384 J	1460 J	312 J	628 J
MERCURY	0.096	0.05	0.047	0.054	0.031	0.05	0.023 U
NICKEL	15.1 J	14.8	14.0 J	15.9 J	10.7 J	10.9	14.0 J
POTASSIUM	1380 J	1090 J	937 J	2230 J	858 J	1090 J	1300 J
SELENIUM	0.53 J	0.43 UJ	0.60 J	0.34 UJ	0.38 UJ	0.40 UJ	0.42 U
SILVER	2.8 J	2.4 J	0.25 U	5.8 J	0.14 U	0.22 J	0.10 U
SODIUM	187 U	89.4 U	29.8 U	176 U	77.0 U	72.5 U	25.4 U
THALLIUM	0.27	0.24	0.28	0.27	0.22	0.21	0.29
VANADIUM	42.1 J	33.3 J	36.6 J	26.7 J	32.8 J	40.2 J	40.7
ZINC	55.8 J	59.2 J	50.4 J	60.5 J	38.9 J	41.8 J	48.8 J
Miscellaneous							
CYANIDE (mg/kg)	0.2 U	0.6 U	0.2	0.2 U	0.2 U	0.5 U	0.6 U
HEXAVALENT CHROMIUM (mg/kg)	3 UR	3 UR	3 UR	2 UR	2 UR	2 UR	2 UR
PH (S.U.)	7.6	6.6	5.3	8	6.9	5.6	7.9

TABLE 3-1

SUMMARY OF ANALYTICAL RESULTS IN SUBSURFACE SOIL
LANDFARM
NSWC CRANE
CRANE, INDIANA

SITE	LAND FARM	LAND FARM	LAND FARM	LAND FARM	LAND FARM	LAND FARM	LAND FARM	LAND FARM	LAND FARM	LAND FARM
LOCATION	30CP01	30CP02	30CP03	30CP04	30CP05	30CP06	30CP07	30CP08	30CP09	30CP10
NSAMPLE	30CP010204	30CP020204	30CP030204	30CP040204	30CP050204	30CP060204	30CP070204	30CP080204	30CP090204	30CP100204
SAMPLE	30CP010204	30CP020204	30CP030204	30CP040204	30CP050204	30CP060204	30CP070204	30CP080204	30CP090204	30CP100204
MATRIX	SO	SO	SO	SO	SO	SO	SO	SO	SO	SO
SUBMATRIX	SB	SB	SB	SB	SB	SB	SB	SB	SB	SB
SACODE	ORIG	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL
DEPTH RANGE	2 - 4	2 - 4	2 - 4	2 - 4	2 - 4	2 - 4	2 - 4	2 - 4	2 - 4	2 - 4
SAMPLE DATE	03/07/02 12:	03/07/02 12:	03/07/02 12:	03/07/02 12:	03/07/02 12:	03/06/02 12:	03/08/02 12:	03/07/02 12:	03/07/02 12:	03/07/02 12:
COLLECTION METHOD	COMPOSITE	COMPOSITE	COMPOSITE	COMPOSITE	COMPOSITE	COMPOSITE	COMPOSITE	COMPOSITE	COMPOSITE	COMPOSITE
Inorganics (mg/kg)										
ALUMINUM	17300 J	19700	18800	21700 J	14100 J	15400 J	13500 J	17900	18200	19100
ANTIMONY	3.0 U	0.58 U	1.4 U	1.9 U	0.68 U	0.56 U	0.75 U	0.92 U	0.89 U	0.53 U
ARSENIC	9.8 J	8.7 J	6.3 J	6.8 J	12.9 J	9.0 J	8.1 J	7.4 J	8.0 J	10.9 J
BARIUM	75.9 J	80.3	72.2	138 J	113 J	93.7 J	84.4 J	90.3	60.1	161
BERYLLIUM	0.65 J	0.80 J	0.97 J	0.92 J	1.0 J	0.72 J	0.83 J	0.76 J	0.69 J	1.4 J
CADMIUM	0.66 U	0.72 J	0.64 UJ	0.71 UJ	0.63 UJ	0.64 UJ	0.62 U	0.66 UJ	0.66 UJ	0.66 UJ
CALCIUM	526 J	821 J	726 J	767 J	923 J	783 J	538 J	1200 J	628 J	1290 J
CHROMIUM	24.5 J	27.2	27.8	23.4 J	18.8 J	21.2 J	27.7 J	25.9	25.5	26.2
COBALT	6.2	6.2 J	6.8 J	5.6	13.1	11.1	6.8	6.9 J	7.0 J	10.9 J
COPPER	20.3	17.2	13.7	15.8	11.8	10.2	15.6	16.2	15.0	11.4
IRON	26100 J	28700 J	28500 J	28400 J	35300 J	25500 J	33000 J	26000 J	29600 J	27600 J
LEAD	17.7 J	13.7 J	11.8 J	13.2 J	21.0 J	16.1 J	18.2 J	13.9 J	13.8 J	17.3 J
MAGNESIUM	2660 J	2970 J	2370 J	2390 J	1310 J	1530 J	2090 J	2680 J	2490 J	1650 J
MANGANESE	232 J	212 J	202 J	426 J	1430 J	955 J	248 J	243 J	310 J	1350 J
MERCURY	0.023 U	0.01 U	0.01	0.012	0.031	0.016	0.010 U	0.03	0.01	0.04
NICKEL	13.9 J	15.2	17.7	15.2 J	14.0 J	12.3 J	13.5 J	15.7	14.3	17.5
POTASSIUM	1550 J	1710 J	1320 J	1500 J	1070 J	1120 J	1040 J	1460 J	1430 J	1860 J
SELENIUM	0.38 U	0.39 UJ	0.37 UJ	0.41 UJ	0.47 J	0.41 J	0.35 U	0.38 UJ	0.38 UJ	0.46 J
SILVER	0.09 U	0.10 J	0.11 J	0.30 U	0.09 U	0.09 U	0.10 U	0.09 UJ	0.09 UJ	0.14 J
SODIUM	17.1 U	186 U	174 U	202 U	146 U	172 U	25.8 U	108 U	141 U	138 U
THALLIUM	0.30	0.25	0.22	0.34	0.23	0.25	0.22	0.23	0.24	0.29
VANADIUM	45.5	47.4 J	41.8 J	40.0 J	40.5 J	41.5 J	45.7	44.5 J	44.8 J	50.6 J
ZINC	53.2 J	53.7 J	47.3 J	64.8 J	45.3 J	38.0 J	44.4 J	52.5 J	53.0 J	53.3 J
Miscellaneous										
CYANIDE (mg/kg)	0.6 U	0.6 U	0.5 U	0.2 U	0.2 U	0.2 U	0.6 U	0.5 U	0.6 U	0.6 U
HEXAVALENT CHROMIUM (mg/kg)	2 UR	2 UR	2 UR	4 J	2 UR	3 UR	2 UR	2 UR	2 UR	2 UR
PH (S.U.)	5.0	4.9	5.1	7.5	5.1	7.6	7.2	5.5	5.4	6.1

TABLE 3-1

SUMMARY OF ANALYTICAL RESULTS IN SUBSURFACE SOIL
LANDFARM
NSWC CRANE
CRANE, INDIANA

SITE	LAND FARM	LAND FARM	LAND FARM	LAND FARM	LAND FARM	LAND FARM	LAND FARM	LAND FARM
LOCATION	30CP11	30CP12	30SB01	30SB02	30SB03	30SB04	30SB05	30SB06
NSAMPLE	30CP110204	30CP120204	30SB010204	30SB020204	30SB030204	30SB040204	30SB050204	30SB060204
SAMPLE	30CP110204	30CP120204	30SB010204	30SB020204	30SB030204	30SB040204	30SB050204	30SB060204
MATRIX	SO	SO	SO	SO	SO	SO	SO	SO
SUBMATRIX	SB	SB	SB	SB	SB	SB	SB	SB
SACODE	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	ORIG	NORMAL	NORMAL
DEPTH RANGE	2 - 4	2 - 4	2 - 4	2 - 4	2 - 4	2 - 4	2 - 4	2 - 4
SAMPLE DATE	03/06/02 12:	03/06/02 12:	03/07/02 12:	03/07/02 12:	03/06/02 12:	03/06/02 12:	03/07/02 12:	03/07/02 12:
COLLECTION METHOD	COMPOSITE	COMPOSITE	GRAB	GRAB	GRAB	GRAB	GRAB	GRAB
Inorganics (mg/kg)								
ALUMINUM	15500 J	18800 J	25300	14300 J	20300 J	18200 J	21200	13600 J
ANTIMONY	0.77 U	0.49 U	0.99 U	0.73 U	0.63 U	0.88 U	0.78 U	0.90 U
ARSENIC	10.2 J	6.3 J	10.6 J	10.3 J	9.3 J	9.8 J	6.6 J	5.3 J
BARIUM	76.3 J	88.6 J	81.8	118 J	73.9 J	87.4 J	64.1	73.0 J
BERYLLIUM	0.75 J	0.58 J	0.84 J	1.3 J	0.53 J	0.63 J	0.64 J	0.97 J
CADMIUM	0.68 UJ	0.60 UJ	0.71 UJ	0.80 UJ	0.66 UJ	0.65 UJ	0.67 UJ	0.61 U
CALCIUM	542 J	492 J	775 J	474 J	768 J	559 J	542 J	1430 J
CHROMIUM	26.2 J	23.5 J	30.7	18.9 J	24.4 J	22.2 J	24.5	26.9 J
COBALT	7.0	5.3	5.7 J	26.2	5.4	5.0	7.3 J	6.4
COPPER	11.2	14.4	19.2	10.1	17.7	14.6	16.8	11.4
IRON	34900 J	25100 J	34600 J	35800 J	26600 J	32100 J	24800 J	28500 J
LEAD	17.1 J	10.4 J	11.2 J	35.0 J	12.5 J	13.8 J	13.4 J	17.9 J
MAGNESIUM	1500 J	2460 J	3520 J	953 J	3100 J	2270 J	2790 J	1370 J
MANGANESE	376 J	190 J	143 J	4690 J	162 J	242 J	343 J	263 J
MERCURY	0.020	0.009 U	0.01 U	0.048	0.010 U	0.028	0.01 U	0.010 U
NICKEL	10.7 J	12.8 J	15.6	10.9 J	13.7 J	11.6 J	13.2	11.4 J
POTASSIUM	1110 J	1530 J	2010 J	717 J	1880 J	1220 J	1720 J	982 J
SELENIUM	0.51 J	0.34 UJ	0.41 UJ	0.58 J	0.38 UJ	0.37 UJ	0.39 UJ	0.35 U
SILVER	0.10 U	0.09 U	0.11 J	0.11 U	0.13 U	0.09 U	0.10 UJ	0.09 U
SODIUM	179 U	220 U	205 U	56.4 U	173 U	183 U	197 U	8.0 U
THALLIUM	0.23	0.27	0.30	0.25	0.30	0.25	0.27	0.19
VANADIUM	44.2 J	38.7 J	55.9 J	44.3 J	45.6 J	42.5 J	43.8 J	44.8
ZINC	42.2 J	49.6 J	68.8 J	36.6 J	55.9 J	52.6 J	62.1 J	33.4 J
Miscellaneous								
CYANIDE (mg/kg)	0.2 U	0.2 U	0.5 U	0.2 U	0.2 U	0.2 U	0.6 U	0.5 U
HEXAVALENT CHROMIUM (mg/kg)	2 UR	2 UR	2 UR	3 UR	2 UR	3 UR	2 UR	2 UR
PH (S.U.)	5.3	5	5.1	5.1	5	5.2	5.5	7.6

J = result is estimated.
U = result is nondetected.
UR = result is nondetected and rejected.
UJ = result is nondetected and estimated.

TABLE 3-2

SUMMARY OF PARAMETERS WITH AT LEAST ONE POSITIVE DETECTION
ABOVE RISK-BASED TARGET LEVELS IN SURFACE SOIL
LANDFARM
NSWC CRANE
CRANE, INDIANA

SITE	RISK BASED TARGET LEVELS	LAND FARM	LAND FARM	LAND FARM	LAND FARM	LAND FARM	LAND FARM	LAND FARM	LAND FARM
LOCATION		30CP01	30CP02	30CP03	30CP04	30CP05	30CP06	30CP07	30CP08
NSAMPLE		30CP010001	30CP020001	30CP030001	30CP040001	30CP050001	30CP060001	30CP070001	30CP080001
SAMPLE		30CP010001	30CP020001	30CP030001	30CP040001	30CP050001	30CP060001	30CP070001	30CP080001
MATRIX		SO	SO	SO	SO	SO	SO	SO	SO
SUBMATRIX		SS	SS	SS	SS	SS	SS	SS	SS
SACODE		NORMAL	ORIG	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	ORIG
DEPTH_RANGE		0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5	0 - 0.5
SAMPLE_DATE		3/7/2002	3/7/2002	3/7/2002	3/7/2002	3/7/2002	3/6/2002	3/8/2002	3/7/2002
COLL. METH.		COMPOSITE	COMPOSITE	COMPOSITE	COMPOSITE	COMPOSITE	COMPOSITE	COMPOSITE	COMPOSITE
Inorganics (mg/kg)									
ANTIMONY	0.1423	1.0 U	3.8 U	3.8 U	4.4 U	1.1 U	2.7 U	1.1 U	6.0 J
ARSENIC	0.39	11.2 J	5.9 J	9.6 J	5.1 J	9.5 J	7.5 J	13.2 J	5.3 J
BARIUM	1.04	110 J	114	81.1	159 J	147 J	143 J	86.4 J	144
BERYLLIUM	0.1	0.99 J	0.86 J	0.68 J	0.69 J	1.0 J	0.69 J	0.76 J	0.82 J
CADMIUM	0.00222	0.81	0.71 UJ	0.69 UJ	1.2 J	0.69 UJ	1.1 J	0.78 U	0.96 J
CHROMIUM	2	27.9 J	16.6	25.5	20.9 J	24.3 J	25.1 J	29.0 J	19.3
COBALT	0.14033	12.4	12.8 J	11.6 J	9.1	12.0	9.9	5.2	13.9 J
COPPER	2.96	13.5	14.2	14.9	27.3	13.8	23.0	23.4	20.2
IRON	23000	25200 J	13700 J	23800 J	14700 J	26300 J	17800 J	26500 J	12900 J
LEAD	0.05373	25.8 J	19.2 J	14.3 J	24.5 J	19.0 J	21.8 J	18.7 J	19.0 J
MANGANESE	1800	994 J	1190 J	403 J	881 J	1200 J	954 J	189 J	1350 J
MERCURY	0.073	0.054 U	0.11	0.05	0.058	0.051	0.11	0.055 U	0.26
NICKEL	7	14.6 J	14.3	16.1	12.4 J	15.1 J	16.8 J	14.8 J	17.1
SELENIUM	0.02765	0.60	0.48 J	0.39 UJ	0.43 J	0.67 J	0.50 J	0.57	0.47 J
SILVER	2	2.2 U	4.4 J	0.75 J	19.4 J	2.8 J	13.4 J	0.38 U	10.6 J
THALLIUM	0.04	0.27	0.21	0.35	0.21	0.24	0.21	0.37	0.23
VANADIUM	1.59	45.0	27.9 J	48.6 J	29.0 J	39.3 J	33.1 J	54.7	30.0 J
ZINC	6.62	56.9 J	60.5 J	64.5 J	87.7 J	55.0 J	89.6 J	67.5 J	73.0 J
Miscellaneous									
PH (S.U.)	---	8.2	7.5	7.3	5.9	7.8	7.8	7.6	7.4
HEXAVALENT CHROMIUM (mg/kg)	0.4	3 UR	3 UR	3 UR	3 UR	3 UR	3 UR	3 UR	2 UR

TABLE 3-2

SUMMARY OF PARAMETERS WITH AT LEAST ONE POSITIVE DETECTION
ABOVE RISK-BASED TARGET LEVELS IN SURFACE SOIL
LANDFARM
NSWC CRANE
CRANE, INDIANA

SITE LOCATION NSAMPLE SAMPLE MATRIX SUBMATRIX SACODE DEPTH_RANGE SAMPLE_DATE COLL. METH.	RISK BASED TARGET LEVELS	LAND FARM 30CP09 30CP090001 30CP090001 SO SS NORMAL 0 - 0.5 3/7/2002 COMPOSITE	LAND FARM 30CP10 30CP100001 30CP100001 SO SS ORIG 0 - 0.5 3/7/2002 COMPOSITE	LAND FARM 30CP11 30CP110001 30CP110001 SO SS NORMAL 0 - 0.5 3/6/2002 COMPOSITE	LAND FARM 30CP12 30CP120001 30CP120001 SO SS NORMAL 0 - 0.5 3/6/2002 COMPOSITE	LAND FARM 30SB01 30SS010001 30SS010001 SO SS NORMAL 0 - 0.5 3/7/2002 GRAB	LAND FARM 30SB02 30SS020001 30SS020001 SO SS NORMAL 0 - 0.5 3/7/2002 GRAB	LAND FARM 30SB03 30SS030001 30SS030001 SO SS NORMAL 0 - 0.5 3/6/2002 GRAB	LAND FARM 30SB04 30SS040001 30SS040001 SO SS NORMAL 0 - 0.5 3/6/2002 GRAB	LAND FARM 30SB05 30SS050001 30SS050001 SO SS NORMAL 0 - 0.5 3/7/2002 GRAB	LAND FARM 30SB06 30SS060001 30SS060001 SO SS NORMAL 0 - 0.5 3/7/2002 GRAB	NUMBER OF DETECTS THAT EXCEED RBTLs IN SURFACE SOIL	RANGE OF MULTIPLIER FOR MIN AND MAX EXCEEDENCE IN SURFACE SOIL
Inorganics (mg/kg)													
ANTIMONY	0.1423	4.5 U	6.0 U	1.6 U	2.1 U	1.8 U	0.76 U	2.3 U	1.1 U	0.80 U	1.4 U	1	42.16
ARSENIC	0.39	5.4 J	22.4 J	6.6 J	8.9 J	6.3 J	8.8 J	4.8 J	6.4 J	7.0 J	7.3 J	18	12.31 - 57.44
BARIUM	1.04	78.3	180	104 J	127 J	108	181 J	120 J	114 J	59.3	110 J	18	57.02 - 174.04
BERYLLIUM	0.1	0.52 J	1.5 J	0.70 J	0.87 J	0.87 J	1.1 J	0.51 J	0.79 J	0.48 J	0.75 J	18	4.8 - 15
CADMIUM	0.00222	0.69 UJ	1.6 J	0.74 UJ	0.67 UJ	0.76 UJ	0.72 UJ	1.0 J	0.66 UJ	0.70 UJ	0.73 U	6	364.86 - 720.72
CHROMIUM	2	19.9	39.3	22.0 J	23.1 J	17.9	19.4 J	18.9 J	18.3 J	20.7	23.0 J	18	8.3 - 19.65
COBALT	0.14033	7.2 J	16.9 J	8.5	10.0	12.2 J	12.1	6.2	9.9	6.0 J	7.4	18	37.06 - 120.43
COPPER	2.96	13.4	38.7	14.9	14.5	12.0	11.1	16.5	7.4	9.2	15.1	18	2.5 - 13.07
IRON	23000	16000 J	42500 J	19300 J	21900 J	15000 J	20500 J	13300 J	20100 J	20600 J	18500 J	5	1.03 - 1.85
LEAD	0.05373	12.0 J	30.7 J	15.6 J	18.2 J	19.1 J	21.1 J	16.5 J	14.0 J	10.3 J	16.9 J	18	191.7 - 571.38
MANGANESE	1800	527 J	1550 J	745 J	1280 J	1120 J	2890 J	384 J	1460 J	312 J	628 J	1	1.61
MERCURY	0.073	0.08	0.41	0.089	0.096	0.05	0.047	0.054	0.031	0.05	0.023 U	7	1.1 - 5.62
NICKEL	7	13.2	20.6	15.1 J	15.1 J	14.8	14.0 J	15.9 J	10.7 J	10.9	14.0 J	18	1.53 - 2.94
SELENIUM	0.02765	0.40 UJ	0.85 J	0.42 UJ	0.53 J	0.43 UJ	0.60 J	0.34 UJ	0.38 UJ	0.40 UJ	0.42 U	10	15.55 - 30.74
SILVER	2	3.9 J	19.7 J	5.8 J	2.8 J	2.4 J	0.25 U	5.8 J	0.14 U	0.22 J	0.10 U	11	1.2 - 9.85
THALLIUM	0.04	0.23	0.24	0.24	0.27	0.24	0.28	0.27	0.22	0.21	0.29	18	5.25 - 9.25
VANADIUM	1.59	35.7 J	60.9 J	38.0 J	42.1 J	33.3 J	36.6 J	26.7 J	32.8 J	40.2 J	40.7	18	16.79 - 38.3
ZINC	6.62	56.1 J	115 J	56.9 J	55.8 J	59.2 J	50.4 J	60.5 J	38.9 J	41.8 J	48.8 J	18	5.88 - 17.37
Miscellaneous													
PH (S.U.)	---	7.6	7.4	6.8	7.6	6.6	5.3	8	6.9	5.6	7.9	---	---
HEXAVALENT CHROMIUM (mg/kg)	0.4	3 UR	3 UR	3 UR	3 UR	3 UR	3 UR	2 UR	2 UR	2 UR	2 UR	0	---

TABLE 3-2

SUMMARY OF PARAMETERS WITH AT LEAST ONE POSITIVE DETECTION
ABOVE RISK-BASED TARGET LEVELS IN SUBSURFACE SOIL
LANDFARM
NSWC CRANE
CRANE, INDIANA

SITE	RISK BASED TARGET LEVELS	LAND FARM	LAND FARM	LAND FARM	LAND FARM	LAND FARM	LAND FARM	LAND FARM	LAND FARM	LAND FARM	LAND FARM
LOCATION		30CP01	30CP02	30CP03	30CP04	30CP05	30CP06	30CP07	30CP08	30CP09	30CP10
NSAMPLE		30CP010204	30CP020204	30CP030204	30CP040204	30CP050204	30CP060204	30CP070204	30CP080204	30CP090204	30CP100204
SAMPLE		30CP010204	30CP020204	30CP030204	30CP040204	30CP050204	30CP060204	30CP070204	30CP080204	30CP090204	30CP100204
MATRIX		SO	SO	SO	SO	SO	SO	SO	SO	SO	SO
SUBMATRIX		SB	SB	SB	SB	SB	SB	SB	SB	SB	SB
SACODE		ORIG	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL
DEPTH_RANGE		2 - 4	2 - 4	2 - 4	2 - 4	2 - 4	2 - 4	2 - 4	2 - 4	2 - 4	2 - 4
SAMPLE_DATE		3/7/2002	3/7/2002	3/7/2002	3/7/2002	3/7/2002	3/6/2002	3/8/2002	3/7/2002	3/7/2002	3/7/2002
COLL. METH.		COMPOSITE	COMPOSITE	COMPOSITE	COMPOSITE	COMPOSITE	COMPOSITE	COMPOSITE	COMPOSITE	COMPOSITE	COMPOSITE
Inorganics (mg/kg)											
ANTIMONY	0.1423	3.0 U	0.58 U	1.4 U	1.9 U	0.68 U	0.56 U	0.75 U	0.92 U	0.89 U	0.53 U
ARSENIC	0.39	9.8 J	8.7 J	6.3 J	6.8 J	12.9 J	9.0 J	8.1 J	7.4 J	8.0 J	10.9 J
BARIUM	1.04	75.9 J	80.3	72.2	138 J	113 J	93.7 J	84.4 J	90.3	60.1	161
BERYLLIUM	0.1	0.65 J	0.80 J	0.97 J	0.92 J	1.0 J	0.72 J	0.83 J	0.76 J	0.69 J	1.4 J
CADMIUM	0.00222	0.66 U	0.72 J	0.64 UJ	0.71 UJ	0.63 UJ	0.64 UJ	0.62 U	0.66 UJ	0.66 UJ	0.66 UJ
CHROMIUM	2	24.5 J	27.2	27.8	23.4 J	18.8 J	21.2 J	27.7 J	25.9	25.5	26.2
COBALT	0.14033	6.2	6.2 J	6.8 J	5.6	13.1	11.1	6.8	6.9 J	7.0 J	10.9 J
COPPER	2.96	20.3	17.2	13.7	15.8	11.8	10.2	15.6	16.2	15.0	11.4
IRON	23000	26100 J	28700 J	28500 J	28400 J	35300 J	25500 J	33000 J	26000 J	29600 J	27600 J
LEAD	0.05373	17.7 J	13.7 J	11.8 J	13.2 J	21.0 J	16.1 J	18.2 J	13.9 J	13.8 J	17.3 J
MANGANESE	1800	232 J	212 J	202 J	426 J	1430 J	955 J	248 J	243 J	310 J	1350 J
MERCURY	0.073	0.023 U	0.01 U	0.01	0.012	0.031	0.016	0.010 U	0.03	0.01	0.04
NICKEL	7	13.9 J	15.2	17.7	15.2 J	14.0 J	12.3 J	13.5 J	15.7	14.3	17.5
SELENIUM	0.02765	0.38 U	0.39 UJ	0.37 UJ	0.41 UJ	0.47 J	0.41 J	0.35 U	0.38 UJ	0.38 UJ	0.46 J
SILVER	2	0.09 U	0.10 J	0.11 J	0.30 U	0.09 U	0.09 U	0.10 U	0.09 UJ	0.09 UJ	0.14 J
THALLIUM	0.04	0.30	0.25	0.22	0.34	0.23	0.25	0.22	0.23	0.24	0.29
VANADIUM	1.59	45.5	47.4 J	41.8 J	40.0 J	40.5 J	41.5 J	45.7	44.5 J	44.8 J	50.6 J
ZINC	6.62	53.2 J	53.7 J	47.3 J	64.8 J	45.3 J	38.0 J	44.4 J	52.5 J	53.0 J	53.3 J
Miscellaneous											
PH (S.U.)	---	5.0	4.9	5.1	7.5	5.1	7.6	7.2	5.5	5.4	6.1
HEXAVALENT CHROMIUM (mg/kg)	0.4	2 UR	2 UR	2 UR	4 J	2 UR	3 UR	2 UR	2 UR	2 UR	2 UR

TABLE 3-2

SUMMARY OF PARAMETERS WITH AT LEAST ONE POSITIVE DETECTION
ABOVE RISK-BASED TARGET LEVELS IN SUBSURFACE SOIL
LANDFARM
NSWC CRANE
CRANE, INDIANA

SITE LOCATION NSAMPLE SAMPLE MATRIX SUBMATRIX SACODE DEPTH_RANGE SAMPLE_DATE COLL. METH.	RISK BASED TARGET LEVELS	LAND FARM 30CP11 30CP110204 30CP110204 SO SB NORMAL 2 - 4 3/6/2002 COMPOSITE	LAND FARM 30CP12 30CP120204 30CP120204 SO SB NORMAL 2 - 4 3/6/2002 COMPOSITE	LAND FARM 30SB01 30SB010204 30SB010204 SO SB NORMAL 2 - 4 3/7/2002 GRAB	LAND FARM 30SB02 30SB020204 30SB020204 SO SB NORMAL 2 - 4 3/7/2002 GRAB	LAND FARM 30SB03 30SB030204 30SB030204 SO SB NORMAL 2 - 4 3/6/2002 GRAB	LAND FARM 30SB04 30SB040204 30SB040204 SO SB ORIG 2 - 4 3/6/2002 GRAB	LAND FARM 30SB05 30SB050204 30SB050204 SO SB NORMAL 2 - 4 3/7/2002 GRAB	LAND FARM 30SB06 30SB060204 30SB060204 SO SB NORMAL 2 - 4 3/7/2002 GRAB	NUMBER OF DETECTS THAT EXCEED RBTLs IN SUBSURFACE SOIL	RANGE OF MULTIPLIER FOR MIN AND MAX EXCEEDENCE IN SUBSURFACE SOIL	NUMBER OF DETECTS THAT EXCEED RBTLs ALL SOILS	RANGE OF MULTIPLIER FOR MIN AND MAX EXCEEDENCE ALL SOILS
Inorganics (mg/kg)													
ANTIMONY	0.1423	0.77 U	0.49 U	0.99 U	0.73 U	0.63 U	0.88 U	0.78 U	0.90 U	0	---	1	42.16
ARSENIC	0.39	10.2 J	6.3 J	10.6 J	10.3 J	9.3 J	9.8 J	6.6 J	5.3 J	18	13.59 - 33.08	36	12.31 - 57.44
BARIUM	1.04	76.3 J	88.6 J	81.8	118 J	73.9 J	87.4 J	64.1	73.0 J	18	57.79 - 154.81	36	57.02 - 174.04
BERYLLIUM	0.1	0.75 J	0.58 J	0.84 J	1.3 J	0.53 J	0.63 J	0.64 J	0.97 J	18	5.3 - 14	36	4.8 - 15
CADMIUM	0.00222	0.68 UJ	0.60 UJ	0.71 UJ	0.80 UJ	0.66 UJ	0.65 UJ	0.67 UJ	0.61 U	1	324.32	7	324.32 - 720.72
CHROMIUM	2	26.2 J	23.5 J	30.7	18.9 J	24.4 J	22.2 J	24.5	26.9 J	18	9.4 - 15.35	36	8.3 - 19.65
COBALT	0.14033	7.0	5.3	5.7 J	26.2	5.4	5.0	7.3 J	6.4	18	35.63 - 186.7	36	35.63 - 186.7
COPPER	2.96	11.2	14.4	19.2	10.1	17.7	14.6	16.8	11.4	18	3.41 - 6.86	36	2.5 - 13.07
IRON	23000	34900 J	25100 J	34600 J	35800 J	26600 J	32100 J	24800 J	28500 J	18	1.08 - 1.56	23	1.03 - 1.85
LEAD	0.05373	17.1 J	10.4 J	11.2 J	35.0 J	12.5 J	13.8 J	13.4 J	17.9 J	18	193.56 - 651.41	36	191.7 - 651.41
MANGANESE	1800	376 J	190 J	143 J	4690 J	162 J	242 J	343 J	263 J	1	2.61	2	1.61 - 2.61
MERCURY	0.073	0.020	0.009 U	0.01 U	0.048	0.010 U	0.028	0.01 U	0.010 U	0	---	7	1.1 - 5.62
NICKEL	7	10.7 J	12.8 J	15.6	10.9 J	13.7 J	11.6 J	13.2	11.4 J	18	1.53 - 2.53	36	1.53 - 2.94
SELENIUM	0.02765	0.51 J	0.34 UJ	0.41 UJ	0.58 J	0.38 UJ	0.37 UJ	0.39 UJ	0.35 U	5	14.83 - 20.98	15	14.83 - 30.74
SILVER	2	0.10 U	0.09 U	0.11 J	0.11 U	0.13 U	0.09 U	0.10 UJ	0.09 U	0	---	11	1.2 - 9.85
THALLIUM	0.04	0.23	0.27	0.30	0.25	0.30	0.25	0.27	0.19	18	4.75 - 8.5	36	4.75 - 9.25
VANADIUM	1.59	44.2 J	38.7 J	55.9 J	44.3 J	45.6 J	42.5 J	43.8 J	44.8	18	24.34 - 35.16	36	16.79 - 38.3
ZINC	6.62	42.2 J	49.6 J	68.8 J	36.6 J	55.9 J	52.6 J	62.1 J	33.4 J	18	5.05 - 10.39	36	5.05 - 17.37
Miscellaneous													
PH (S.U.)	---	5.3	5	5.1	5.1	5	5.2	5.5	7.6	---	---	---	---
HEXAVALENT CHROMIUM (mg/kg)	0.4	2 UR	2 UR	2 UR	3 UR	2 UR	3 UR	2 UR	2 UR	1	10	1	10

BOLD indicates a positive detection above the RBTL.
No RBTL exceedences for ALUMINUM or CYANIDE, and no RBTLs for CALCIUM, MAGNESIUM, POTASSIUM, or SODIUM.
J = result is estimated.
U = result is nondetected.
UR = result is nondetected and rejected.
UJ = result is nondetected and estimated.

TABLE 3-3

DETECTION STATISTICS
ALL SURFACE SOIL SAMPLES
LANDFARM
NSWC CRANE
CRANE, INDIANA

Parameter	Risk-Based Target Level	Mean	Standard Deviation	Minimum Detection	Maximum Detection	Location of Maximum Detection	Frequency of Detection	Minimum Non-Detect	Maximum Non-Detect
Inorganics (mg/kg)									
ALUMINUM	76000	14844	2768	11300	20600	30CP030001	18/18	---	---
ANTIMONY	0.1423	1.45	1.37	6	6	30CP080001	1/18	0.76	6
ARSENIC	0.39	8.40	4.16	4.8	22.4	30CP100001	18/18	---	---
BARIUM	1.04	120	33.8	59.3	181	30SS020001	18/18	---	---
BERYLLIUM	0.1	0.810	0.241	0.48	1.5	30CP100001	18/18	---	---
CADMIUM	0.00222	0.608	0.396	0.81	1.6	30CP100001	6/18	0.66	0.78
CALCIUM	--	18207	30165	1030	124000	30SS030001	18/18	---	---
CHROMIUM	2	22.8	5.37	16.6	39.3	30CP100001	18/18	---	---
COBALT	0.14033	10.2	3.09	5.2	16.9	30CP100001	18/18	---	---
COPPER	2.96	16.8	7.43	7.4	38.7	30CP100001	18/18	---	---
IRON	23000	20478	7035	12900	42500	30CP100001	18/18	---	---
LEAD	0.05373	18.7	4.96	10.3	30.7	30CP100001	18/18	---	---
MAGNESIUM	--	2057	1166	1040	5840	30SS030001	18/18	---	---
MANGANESE	1800	1003	627	189	2890	30SS020001	18/18	---	---
MERCURY	0.073	0.0896	0.0971	0.031	0.41	30CP100001	15/18	0.023	0.055
NICKEL	7	14.8	2.27	10.7	20.6	30CP100001	18/18	---	---
POTASSIUM	--	1311	366	816	2230	30SS030001	18/18	---	---
SELENIUM	0.02765	0.405	0.210	0.43	0.85	30CP100001	10/18	0.34	0.43
SILVER	2	5.19	6.40	0.22	19.7	30CP100001	13/18	0.1	2.2
SODIUM	--	46.3	30.4	---	---	---	0/18	7.1	187
THALLIUM	0.04	0.254	0.0462	0.21	0.37	30CP070001	18/18	---	---
VANADIUM	1.59	38.6	9.22	26.7	60.9	30CP100001	18/18	---	---
ZINC	6.62	63.2	18.5	38.9	115	30CP100001	18/18	---	---
Miscellaneous Parameters									
CYANIDE	1.3	0.247	0.156	0.2	0.7	30CP030001	2/18	0.2	0.7
PH	---	7.07	0.828	5.3	8	30SS030001	18/18	---	---

TABLE 3-3

DETECTION STATISTICS
ALL SUBSURFACE SOIL SAMPLES
LANDFARM
NSWC CRANE
CRANE, INDIANA

Parameter	Risk-Based Target Level	Mean	Standard Deviation	Minimum Detection	Maximum Detection	Location of Maximum Detection	Frequency of Detection	Minimum Non-Detect	Maximum Non-Detect
Inorganics (mg/kg)									
ALUMINUM	76000	17939	3162	13500	25300	30SB010204	18/18	---	---
ANTIMONY	0.1423	0.483	0.305	---	---	---	0/18	0.49	3
ARSENIC	0.39	8.68	1.99	5.3	12.9	30CP050204	18/18	---	---
BARIUM	1.04	90.7	26.2	60.1	161	30CP100204	18/18	---	---
BERYLLIUM	0.1	0.832	0.234	0.53	1.4	30CP100204	18/18	---	---
CADMIUM	0.00222	0.353	0.0944	0.72	0.72	30CP020204	1/18	0.6	0.8
CALCIUM	--	765.8	283	474	1430	30SB060204	18/18	---	---
CHROMIUM	2	24.8	3.09	18.8	30.7	30SB010204	18/18	---	---
COBALT	0.14033	8.27	4.99	5	26.2	30SB020204	18/18	---	---
COPPER	2.96	14.6	3.07	10.1	20.3	30CP010204	18/18	---	---
IRON	23000	29506	3794	24800	35800	30SB020204	18/18	---	---
LEAD	0.05373	16.0	5.52	10.4	35	30SB020204	18/18	---	---
MAGNESIUM	--	2228	704	953	3520	30SB010204	18/18	---	---
MANGANESE	1800	668	1078	143	4690	30SB020204	18/18	---	---
MERCURY	0.073	0.0162	0.0136	0.01	0.048	30SB020204	10/18	0.009	0.023
NICKEL	7	13.8	2.06	10.7	17.7	30CP030204	18/18	---	---
POTASSIUM	--	1402	355	717	2010	30SB010204	18/18	---	---
SELENIUM	0.02765	0.271	0.141	0.41	0.58	30SB020204	5/18	0.34	0.41
SILVER	2	0.0689	0.0358	0.1	0.14	30CP100204	4/18	0.09	0.3
SODIUM	--	70.3	34.3	---	---	---	0/18	8	220
THALLIUM	0.04	0.257	0.0374	0.19	0.34	30CP040204	18/18	---	---
VANADIUM	1.59	44.6	3.99	38.7	55.9	30SB010204	18/18	---	---
ZINC	6.62	50.4	9.48	33.4	68.8	30SB010204	18/18	---	---
Miscellaneous Parameters									
CYANIDE	1.3	0.200	0.0939	0	0		0/18	0.2	0.6
HEXAVALENT CHROMIUM	0.4	4	---	4	4	30CP040204	1/1	---	---
PH	---	5.73	0.999	4.9	7.6	30CP060204, 30SB060204	18/18	---	---

TABLE 3-3

DETECTION STATISTICS
GRID SURFACE SOIL SAMPLES
LANDFARM
NSWC CRANE
CRANE, INDIANA

Parameter	Risk-Based Target Level	Mean	Standard Deviation	Minimum Detection	Maximum Detection	Location of Maximum Detection	Frequency of Detection	Minimum Non-Detect	Maximum Non-Detect
Inorganics (mg/kg)									
ALUMINUM	76000	15667	2888	11300	20600	30CP030001	12/12	---	---
ANTIMONY	0.1423	1.84	1.54	6	6	30CP080001	1/12	1	6
ARSENIC	0.39	9.22	4.88	5.1	22.4	30CP100001	12/12	---	---
BARIUM	1.04	123	32.6	78.3	180	30CP100001	12/12	---	---
BERYLLIUM	0.1	0.840	0.249	0.52	1.5	30CP100001	12/12	---	---
CADMIUM	0.00222	0.680	0.440	0.81	1.6	30CP100001	5/12	0.67	0.78
CALCIUM	--	15456	16590	1600	41000	30CP060001	12/12	---	---
CHROMIUM	2	24.4	5.91	16.6	39.3	30CP100001	12/12	---	---
COBALT	0.14033	10.8	3.15	5.2	16.9	30CP100001	12/12	---	---
COPPER	2.96	19.3	7.74	13.4	38.7	30CP100001	12/12	---	---
IRON	23000	21717	8188	12900	42500	30CP100001	12/12	---	---
LEAD	0.05373	19.9	5.18	12	30.7	30CP100001	12/12	---	---
MAGNESIUM	--	1983	719	1180	3590	30CP060001	12/12	---	---
MANGANESE	1800	939	410	189	1550	30CP100001	12/12	---	---
MERCURY	0.073	0.114	0.112	0.05	0.41	30CP100001	10/12	0.054	0.055
NICKEL	7	15.4	2.10	12.4	20.6	30CP100001	12/12	---	---
POTASSIUM	--	1341	298	816	1720	30CP030001	12/12	---	---
SELENIUM	0.02765	0.475	0.198	0.43	0.85	30CP100001	9/12	0.39	0.42
SILVER	2	7.07	7.02	0.75	19.7	30CP100001	10/12	0.38	2.2
SODIUM	--	49.8	32.4	---	---	---	0/12	7.1	187
THALLIUM	0.04	0.256	0.0528	0.21	0.37	30CP070001	12/12	---	---
VANADIUM	1.59	40.4	10.4	27.9	60.9	30CP100001	12/12	---	---
ZINC	6.62	69.9	18.6	55	115	30CP100001	12/12	---	---
Miscellaneous Parameters									
CYANIDE	1.3	0.267	0.180	0.7	0.7	30CP030001	1/12	0.2	0.7
PH	---	7.24	0.619	5.9	7.8	30CP050001, 30CP060001	12/12	---	---

TABLE 3-3

DETECTION STATISTICS
PERIMETER SURFACE SOIL SAMPLES
LANDFARM
NSWC CRANE
CRANE, INDIANA

Parameter	Risk-Based Target Level	Mean	Standard Deviation	Minimum Detection	Maximum Detection	Location of Maximum Detection	Frequency of Detection	Minimum Non-Detect	Maximum Non-Detect
Inorganics (mg/kg)									
ALUMINUM	76000	13200	1682	11500	15600	30SS050001	6/6	---	---
ANTIMONY	0.1423	0.680	0.302	---	---	---	0/6	0.76	2.3
ARSENIC	0.39	6.77	1.32	4.8	8.8	30SS020001	6/6	---	---
BARIUM	1.04	115	38.9	59.3	181	30SS020001	6/6	---	---
BERYLLIUM	0.1	0.750	0.232	0.48	1.1	30SS020001	6/6	---	---
CADMIUM	0.00222	0.464	0.263	1	1	30SS030001	1/6	0.66	0.76
CALCIUM	--	23708	49333	1030	124000	30SS030001	6/6	---	---
CHROMIUM	2	19.7	1.89	17.9	23	30SS060001	6/6	---	---
COBALT	0.14033	8.97	2.83	6	12.2	30SS010001	6/6	---	---
COPPER	2.96	11.9	3.45	7.4	16.5	30SS030001	6/6	---	---
IRON	23000	18000	3123	13300	20600	30SS050001	6/6	---	---
LEAD	0.05373	16.3	3.81	10.3	21.1	30SS020001	6/6	---	---
MAGNESIUM	--	2207	1856	1040	5840	30SS030001	6/6	---	---
MANGANESE	1800	1132	968	312	2890	30SS020001	6/6	---	---
MERCURY	0.073	0.0406	0.0163	0.031	0.054	30SS030001	5/6	0.023	0.023
NICKEL	7	13.4	2.12	10.7	15.9	30SS030001	6/6	---	---
POTASSIUM	--	1251	503	858	2230	30SS030001	6/6	---	---
SELENIUM	0.02765	0.264	0.165	0.6	0.6	30SS020001	1/6	0.34	0.43
SILVER	2	1.44	2.32	0.22	5.8	30SS030001	3/6	0.1	0.25
SODIUM	--	39.2	27.3	---	---	---	0/6	25.4	176
THALLIUM	0.04	0.252	0.0331	0.21	0.29	30SS060001	6/6	---	---
VANADIUM	1.59	35.1	5.27	26.7	40.7	30SS060001	6/6	---	---
ZINC	6.62	49.9	8.80	38.9	60.5	30SS030001	6/6	---	---
Miscellaneous Parameters									
CYANIDE	1.3	0.208	0.0917	0.2	0.2	30SS020001	1/6	0.2	0.6
PH	---	6.72	1.13	5.3	8	30SS030001	6/6	---	---

TABLE 3-3

DETECTION STATISTICS
GRID SUBSURFACE SOIL SAMPLES
LANDFARM
NSWC CRANE
CRANE, INDIANA

Parameter	Risk-Based Target Level	Mean	Standard Deviation	Minimum Detection	Maximum Detection	Location of Maximum Detection	Frequency of Detection	Minimum Non-Detect	Maximum Non-Detect
Inorganics (mg/kg)									
ALUMINUM	76000	17500	2432	13500	21700	30CP040204	12/12	---	---
ANTIMONY	0.1423	0.520	0.370	---	---	---	0/12	0.49	3
ARSENIC	0.39	8.70	1.99	6.3	12.9	30CP050204	12/12	---	---
BARIUM	1.04	94.5	29.2	60.1	161	30CP100204	12/12	---	---
BERYLLIUM	0.1	0.839	0.217	0.58	1.4	30CP100204	12/12	---	---
CADMIUM	0.00222	0.358	0.115	0.72	0.72	30CP020204	1/12	0.6	0.71
CALCIUM	--	770	260	492	1290	30CP100204	12/12	---	---
CHROMIUM	2	24.8	2.72	18.8	27.8	30CP030204	12/12	---	---
COBALT	0.14033	7.74	2.50	5.3	13.1	30CP050204	12/12	---	---
COPPER	2.96	14.4	2.92	10.2	20.3	30CP010204	12/12	---	---
IRON	23000	29058	3546	25100	35300	30CP050204	12/12	---	---
LEAD	0.05373	15.4	3.04	10.4	21	30CP050204	12/12	---	---
MAGNESIUM	--	2175	547	1310	2970	30CP020204	12/12	---	---
MANGANESE	1800	515	459	190	1430	30CP050204	12/12	---	---
MERCURY	0.073	0.0163	0.0117	0.01	0.04	30CP100204	8/12	0.009	0.023
NICKEL	7	14.4	2.03	10.7	17.7	30CP030204	12/12	---	---
POTASSIUM	--	1392	264	1040	1860	30CP100204	12/12	---	---
SELENIUM	0.02765	0.279	0.137	0.41	0.51	30CP110204	4/12	0.34	0.41
SILVER	2	0.0725	0.0408	0.1	0.14	30CP100204	3/12	0.09	0.3
SODIUM	--	71.2	32.1	---	---	---	0/12	17.1	220
THALLIUM	0.04	0.256	0.0373	0.22	0.34	30CP040204	12/12	---	---
VANADIUM	1.59	43.8	3.41	38.7	50.6	30CP100204	12/12	---	---
ZINC	6.62	49.8	6.97	38	64.8	30CP040204	12/12	---	---
Miscellaneous Parameters									
CYANIDE	1.3	0.208	0.0973	---	---	---	0/12	0.2	0.6
HEXAVALENT CHROMIUM	0.4	4	---	4	4	30CP040204	1/1	---	---
PH	---	5.81	1.03	4.9	7.6	30CP060204	12/12	---	---

TABLE 3-3

DETECTION STATISTICS
PERIMETER SUBSURFACE SOIL SAMPLES
LANDFARM
NSWC CRANE
CRANE, INDIANA

Parameter	Risk-Based Target Level	Mean	Standard Deviation	Minimum Detection	Maximum Detection	Location of Maximum Detection	Frequency of Detection	Minimum Non-Detect	Maximum Non-Detect
Inorganics (mg/kg)									
ALUMINUM	76000	18817	4425	13600	25300	30SB010204	6/6	---	---
ANTIMONY	0.1423	0.409	0.0651	---	---	---	0/6	0.63	0.99
ARSENIC	0.39	8.65	2.18	5.3	10.6	30SB010204	6/6	---	---
BARIUM	1.04	83.0	18.9	64.1	118	30SB020204	6/6	---	---
BERYLLIUM	0.1	0.818	0.285	0.53	1.3	30SB020204	6/6	---	---
CADMIUM	0.00222	0.342	0.0328	---	---	---	0/6	0.61	0.8
CALCIUM	--	758	351.8	474	1430	30SB060204	6/6	---	---
CHROMIUM	2	24.6	4.02	18.9	30.7	30SB010204	6/6	---	---
COBALT	0.14033	9.33	8.30	5	26.2	30SB020204	6/6	---	---
COPPER	2.96	15.0	3.61	10.1	19.2	30SB010204	6/6	---	---
IRON	23000	30400	4452	24800	35800	30SB020204	6/6	---	---
LEAD	0.05373	17.3	8.96	11.2	35	30SB020204	6/6	---	---
MAGNESIUM	--	2334	1004	953	3520	30SB010204	6/6	---	---
MANGANESE	1800	974	1822	143	4690	30SB020204	6/6	---	---
MERCURY	0.073	0.0160	0.0182	0.028	0.048	30SB020204	2/6	0.01	0.01
NICKEL	7	12.7	1.78	10.9	15.6	30SB010204	6/6	---	---
POTASSIUM	--	1422	525	717	2010	30SB010204	6/6	---	---
SELENIUM	0.02765	0.255	0.160	0.58	0.58	30SB020204	1/6	0.35	0.41
SILVER	2	0.0617	0.0248	0.11	0.11	30SB010204	1/6	0.09	0.13
SODIUM	--	68.5	41.7	---	---	---	0/6	8	205
THALLIUM	0.04	0.260	0.0410	0.19	0.3	30SB030204, 30SB010204	6/6	---	---
VANADIUM	1.59	46.2	4.89	42.5	55.9	30SB010204	6/6	---	---
ZINC	6.62	51.6	14.0	33.4	68.8	30SB010204	6/6	---	---
Miscellaneous Parameters									
CYANIDE	1.3	0.183	0.0931	---	---	---	0/6	0.2	0.6
PH	---	5.58	1.00	5	7.6	30SB060204	6/6	---	---

TABLE 3-4

RESULTS OF WILCOXON RANK-SUM COMPARISONS
GRID SURFACE SOIL vs. GRID SUBSURFACE SOIL
LANDFARM
NSWC CRANE
CRANE, INDIANA

PARAMETER	SUBSURFACE RANK	SURFACE RANK	U	Z	p-level	Z-adjusted	p-level	SUBSURFACE SAMPLES	SURFACE SAMPLES	DATASETS DIFFERENT?	DATASET*
ALUMINUM	176.0	124.0	46	1.5011	0.1333	1.5021	0.1331	12	12	NO	---
ANTIMONY	**91.0**	**209.0**	**13**	**-3.4064**	**0.0007**	**-3.4079**	**0.0007**	**12**	**12**	**YES**	**SS**
ARSENIC	158.0	142.0	64	0.4619	0.6442	0.4620	0.6441	12	12	NO	---
BARIUM	**113.0**	**187.0**	**35**	**-2.1362**	**0.0327**	**-2.1362**	**0.0327**	**12**	**12**	**YES**	**SS**
BERYLLIUM	151.0	149.0	71	0.0577	0.9540	0.0578	0.9539	12	12	NO	---
CADMIUM	**90.5**	**209.5**	**13**	**-3.4352**	**0.0006**	**-3.4473**	**0.0006**	**12**	**12**	**YES**	**SS**
CALCIUM	**78.0**	**222.0**	**0**	**-4.1569**	**0.0000**	**-4.1569**	**0.0000**	**12**	**12**	**YES**	**SS**
CHROMIUM	164.5	135.5	58	0.8372	0.4025	0.8375	0.4023	12	12	NO	---
COBALT	**109.0**	**191.0**	**31**	**-2.3671**	**0.0179**	**-2.3687**	**0.0179**	**12**	**12**	**YES**	**SS**
COPPER	127.0	173.0	49	-1.3279	0.1842	-1.3282	0.1841	12	12	NO	---
IRON	201.0	99.0	21	2.9445	0.0032	2.9445	**0.0032**	12	12	YES	SB
LEAD	**105.5**	**194.5**	**28**	**-2.5692**	**0.0102**	**-2.5703**	**0.0102**	**12**	**12**	**YES**	**SS**
MAGNESIUM	168.5	131.5	54	1.0681	0.2855	1.0686	0.2853	12	12	NO	---
MANGANESE	**115.5**	**184.5**	**38**	**-1.9919**	**0.0464**	**-1.9923**	**0.0463**	**12**	**12**	**YES**	**SS**
MERCURY	**84.0**	**216.0**	**6**	**-3.8105**	**0.0001**	**-3.8130**	**0.0001**	**12**	**12**	**YES**	**SS**
NICKEL	133.5	166.5	56	-0.9526	0.3408	-0.9539	0.3402	12	12	NO	---
POTASSIUM	155.0	145.0	67	0.2887	0.7728	0.2888	0.7727	12	12	NO	---
SELENIUM	**99.0**	**201.0**	**21**	**-2.9445**	**0.0032**	**-2.9483**	**0.0032**	**12**	**12**	**YES**	**SS**
SILVER	**78.0**	**222.0**	**0**	**-4.1569**	**0.0000**	**-4.1908**	**0.0000**	**12**	**12**	**YES**	**SS**
SODIUM	179.0	121.0	43	1.6743	0.0941	1.6743	0.0941	12	12	NO	---
THALLIUM	157.5	142.5	65	0.4330	0.6650	0.4368	0.6622	12	12	NO	---
VANADIUM	173.0	127.0	49	1.3279	0.1842	1.3279	0.1842	12	12	NO	---
ZINC	**85.0**	**215.0**	**7**	**-3.7528**	**0.0002**	**-3.7536**	**0.0002**	**12**	**12**	**YES**	**SS**

* The dataset listed is statistically greater than the other depth sampled (SS vs. SB). As can be seen in the Table, only iron was statistically greater in the subsurface (SB); all other parameters that were different were statistically greater in the surface (SS).

TABLE 3-5

SUMMARY OF STATISTICAL RESULTS
LAND FARM
NSWC CRANE
CRANE, INDIANA

ANALYTE	Risk Based Soil Target Level (mg/kg)	Exceedences of RBTLs [1]	All SS > Background Soil Group 1?	Grid SS > Background Soil Group 1?	Perimeter SS > Background Soil Group 1?	All SB > Background Soil Group 2?	Grid SB > Background Soil Group 2?	Perimeter SB > Background Soil Group 2?	Grid SS Different Than Perimeter SS?	Grid SB Different Than Perimeter SB?
Inorganics (mg/kg)										
ALUMINUM	76000	0	X	X		X	X	X		
ANTIMONY	0.1423	1	X	X	X	X	X	X	X	
ARSENIC	0.39	36	X	X	X	X	X	X		
BARIUM	1.04	36				X	X	X		
BERYLLIUM	0.1	36	X	X		X	X	X		
CADMIUM	0.00222	7	X	X	X	X	X	X		
CALCIUM	--	---	X	X	X	X	X	X		
CHROMIUM	2	36	X	X	X	X	X	X	X	
COBALT	0.14033	36				X	X	X		
COPPER	2.96	36	X	X		X	X	X	X	
IRON	23000	23	X	X		X	X	X		
LEAD	0.05373	36	X	X		X	X	X		
MAGNESIUM	--	---		X		X	X			
MANGANESE	1800	2				X	X	X		
MERCURY	0.073	7	X	X					X	
NICKEL	7	36				X	X	X		
POTASSIUM	--	---	X	X		X	X	X		
SELENIUM	0.02765	15				X	X	X		
SILVER	2	11	X	X	X	X	X	X	X	
SODIUM	--	---	X	X	X					
THALLIUM	0.04	36				X	X	X		
VANADIUM	1.59	36	X	X	X	X	X	X		
ZINC	6.62	36	X	X	X	X	X	X	X	
Miscellaneous Parameters (mg/kg)										
CYANIDE	1.3	---	NA	NA	NA	NA	NA	NA	NA	NA
HEXAVALENT CHROMIUM	0.4	1	NA	NA	NA	NA	NA	NA	NA	NA

1 Exceedences are positive detections only.
NA - No background Results were sampled for the analyte

TABLE 3-6

RESULTS OF WILCOXON RANK-SUM COMPARISONS
ALL SURFACE SOIL SAMPLES vs. BACKGROUND SOIL GROUP 1
LANDFARM
NSWC CRANE
CRANE, INDIANA

Metal	ALL SS Rank Sum	ALL SS Valid N	ALL SS Avg Rank	BG1 Rank Sum	BG1 Valid N	BG1 Avg Rank	U	Z	p-level	adjusted Z	p-level	ALL SS above BG1?
Aluminum	**241.5**	**18**	**13.42**	**34.5**	**5**	**6.90**	**19.5**	**1.90**	**0.0574**	**1.90**	**0.0572**	**Yes**
Antimony	**261**	**18**	**14.50**	**15**	**5**	**3.00**	**0**	**3.35**	**0.0008**	**3.36**	**0.0008**	**Yes**
Arsenic	**245**	**18**	**13.61**	**31**	**5**	**6.20**	**16**	**2.16**	**0.0307**	**2.16**	**0.0307**	**Yes**
Barium	212	18	11.78	64	5	12.80	41	-0.30	0.7656	-0.30	0.7653	No
Beryllium	**244.5**	**18**	**13.58**	**31.5**	**5**	**6.30**	**16.5**	**2.12**	**0.0337**	**2.13**	**0.0335**	**Yes**
Cadmium	**261**	**18**	**14.50**	**15**	**5**	**3.00**	**0**	**3.35**	**0.0008**	**3.36**	**0.0008**	**Yes**
Calcium	**260**	**18**	**14.44**	**16**	**5**	**3.20**	**1**	**3.28**	**0.0010**	**3.28**	**0.0010**	**Yes**
Chromium	**261**	**18**	**14.50**	**15**	**5**	**3.00**	**0**	**3.35**	**0.0008**	**3.35**	**0.0008**	**Yes**
Cobalt	186	18	10.33	90	5	18.00	15	-2.24	0.0254	-2.24	0.0253	No
Copper	**254**	**18**	**14.11**	**22**	**5**	**4.40**	**7**	**2.83**	**0.0046**	**2.83**	**0.0046**	**Yes**
Iron	**245**	**18**	**13.61**	**31**	**5**	**6.20**	**16**	**2.16**	**0.0307**	**2.16**	**0.0307**	**Yes**
Lead	**241.5**	**18**	**13.42**	**34.5**	**5**	**6.90**	**19.5**	**1.90**	**0.0574**	**1.90**	**0.0572**	**Yes**
Magnesium	237.5	18	13.19	38.5	5	7.70	23.5	1.60	0.1091	1.60	0.1086	No
Manganese	194	18	10.78	82	5	16.40	23	-1.64	0.1011	-1.64	0.1011	No
Mercury	**240.5**	**18**	**13.36**	**35.5**	**5**	**7.10**	**20.5**	**1.83**	**0.0678**	**1.83**	**0.0668**	**Yes**
Nickel	208.5	18	11.58	67.5	5	13.50	37.5	-0.56	0.5762	-0.56	0.5755	No
Potassium	**246**	**18**	**13.67**	**30**	**5**	**6.00**	**15**	**2.24**	**0.0254**	**2.24**	**0.0253**	**Yes**
Selenium	220	18	12.22	56	5	11.20	41	0.30	0.7656	0.30	0.7653	No
Silver	**260.5**	**18**	**14.47**	**15.5**	**5**	**3.10**	**0.5**	**3.32**	**0.0009**	**3.32**	**0.0009**	**Yes**
Sodium	**246**	**18**	**13.67**	**30**	**5**	**6.00**	**15**	**2.24**	**0.0254**	**2.24**	**0.0254**	**Yes**
Thallium	201.5	18	11.19	74.5	5	14.90	30.5	-1.08	0.2798	-1.09	0.2759	No
Vanadium	**251**	**18**	**13.94**	**25**	**5**	**5.00**	**10**	**2.61**	**0.0091**	**2.61**	**0.0091**	**Yes**
Zinc	**258**	**18**	**14.33**	**18**	**5**	**3.60**	**3**	**3.13**	**0.0017**	**3.13**	**0.0017**	**Yes**

TABLE 3-6

RESULTS OF WILCOXON RANK SUM COMPARISONS
ALL SUBSURFACE SOIL SAMPLES vs. BACKGROUND SOIL GROUP 2
LANDFARM
NSWC CRANE
CRANE, INDIANA

Metal	ALL SB Rank Sum	ALL SB Valid N	ALL SB Avg Rank	BG2 Rank Sum	BG2 Valid N	BG2 Avg Rank	U	Z	p-level	adjusted Z	p-level	ALL SB above BG2?
Aluminum	381	18	21.17	115	13	8.85	24	3.72	0.0002	3.72	0.0002	Yes
Antimony	351.5	18	19.53	144.5	13	11.12	53.5	2.54	0.0110	2.54	0.0110	Yes
Arsenic	401	18	22.28	95	13	7.31	4	4.52	0.0000	4.53	0.0000	Yes
Barium	365	18	20.28	131	13	10.08	40	3.08	0.0021	3.08	0.0021	Yes
Beryllium	399.5	18	22.19	96.5	13	7.42	5.5	4.46	0.0000	4.46	0.0000	Yes
Cadmium	405	18	22.50	91	13	7.00	0	4.68	0.0000	4.71	0.0000	Yes
Calcium	384	18	21.33	112	13	8.62	21	3.84	0.0001	3.84	0.0001	Yes
Chromium	374	18	20.78	122	13	9.38	31	3.44	0.0006	3.44	0.0006	Yes
Cobalt	359	18	19.94	137	13	10.54	46	2.84	0.0045	2.84	0.0045	Yes
Copper	352	18	19.56	144	13	11.08	53	2.56	0.0104	2.56	0.0104	Yes
Iron	396	18	22.00	100	13	7.69	9	4.32	0.0000	4.32	0.0000	Yes
Lead	398	18	22.11	98	13	7.54	7	4.40	0.0000	4.41	0.0000	Yes
Magnesium	353	18	19.61	143	13	11.00	52	2.60	0.0093	2.60	0.0093	Yes
Manganese	361.5	18	20.08	134.5	13	10.35	43.5	2.94	0.0033	2.94	0.0033	Yes
Mercury	228.5	18	12.69	267.5	13	20.58	57.5	-2.38	0.0172	-2.41	0.0161	No
Nickel	384	18	21.33	112	13	8.62	21	3.84	0.0001	3.84	0.0001	Yes
Potassium	391	18	21.72	105	13	8.08	14	4.12	0.0000	4.12	0.0000	Yes
Selenium	378.5	18	21.03	117.5	13	9.04	26.5	3.62	0.0003	3.63	0.0003	Yes
Silver	395.5	18	21.97	100.5	13	7.73	9.5	4.30	0.0000	4.37	0.0000	Yes
Sodium	301.5	18	16.75	194.5	13	14.96	103.5	0.54	0.5889	0.54	0.5889	No
Thallium	380.5	18	21.14	115.5	13	8.88	24.5	3.70	0.0002	3.71	0.0002	Yes
Vanadium	400	18	22.22	96	13	7.38	5	4.48	0.0000	4.48	0.0000	Yes
Zinc	403	18	22.39	93	13	7.15	2	4.60	0.0000	4.60	0.0000	Yes

TABLE 3-6

RESULTS OF WILCOXON RANK-SUM COMPARISONS
GRID SURFACE SOIL SAMPLES vs. BACKGROUND SOIL GROUP 1
LANDFARM
NSWC CRANE
CRANE, INDIANA

Metal	GRID SS Rank Sum	GRID SS Valid N	GRID SS Avg Rank	BG1 Rank Sum	BG1 Valid N	BG1 Avg Rank	U	Z	p-level	adjusted Z	p-level	GRID SS above BG1?
Aluminum	**129**	**12**	**10.75**	**24**	**5**	**4.80**	**9**	**2.21**	**0.0269**	**2.22**	**0.0267**	**Yes**
Antimony	**138**	**12**	**11.50**	**15**	**5**	**3.00**	**0**	**3.16**	**0.0016**	**3.17**	**0.0015**	**Yes**
Arsenic	**127**	**12**	**10.58**	**26**	**5**	**5.20**	**11**	**2.00**	**0.0452**	**2.00**	**0.0452**	**Yes**
Barium	107.5	12	8.96	45.5	5	9.10	29.5	-0.05	0.9580	-0.05	0.9579	No
Beryllium	**130**	**12**	**10.83**	**23**	**5**	**4.60**	**8**	**2.32**	**0.0204**	**2.32**	**0.0203**	**Yes**
Cadmium	**138**	**12**	**11.50**	**15**	**5**	**3.00**	**0**	**3.16**	**0.0016**	**3.18**	**0.0015**	**Yes**
Calcium	**138**	**12**	**11.50**	**15**	**5**	**3.00**	**0**	**3.16**	**0.0016**	**3.16**	**0.0016**	**Yes**
Chromium	**138**	**12**	**11.50**	**15**	**5**	**3.00**	**0**	**3.16**	**0.0016**	**3.16**	**0.0016**	**Yes**
Cobalt	90	12	7.50	63	5	12.60	12	-1.90	0.0578	-1.90	0.0578	No
Copper	**138**	**12**	**11.50**	**15**	**5**	**3.00**	**0**	**3.16**	**0.0016**	**3.16**	**0.0016**	**Yes**
Iron	**128**	**12**	**10.67**	**25**	**5**	**5.00**	**10**	**2.11**	**0.0350**	**2.11**	**0.0350**	**Yes**
Lead	**128.5**	**12**	**10.71**	**24.5**	**5**	**4.90**	**9.5**	**2.16**	**0.0307**	**2.16**	**0.0305**	**Yes**
Magnesium	**125**	**12**	**10.42**	**28**	**5**	**5.60**	**13**	**1.79**	**0.0731**	**1.80**	**0.0724**	**Yes**
Manganese	91	12	7.58	62	5	12.40	13	-1.79	0.0731	-1.79	0.0731	No
Mercury	**130.5**	**12**	**10.88**	**22.5**	**5**	**4.50**	**7.5**	**2.37**	**0.0177**	**2.38**	**0.0173**	**Yes**
Nickel	106.5	12	8.88	46.5	5	9.30	28.5	-0.16	0.8744	-0.16	0.8740	No
Potassium	**130**	**12**	**10.83**	**23**	**5**	**4.60**	**8**	**2.32**	**0.0204**	**2.32**	**0.0204**	**Yes**
Selenium	121.5	12	10.13	31.5	5	6.30	16.5	1.42	0.1547	1.42	0.1545	No
Silver	**138**	**12**	**11.50**	**15**	**5**	**3.00**	**0**	**3.16**	**0.0016**	**3.17**	**0.0015**	**Yes**
Sodium	**126**	**12**	**10.50**	**27**	**5**	**5.40**	**12**	**1.90**	**0.0578**	**1.90**	**0.0578**	**Yes**
Thallium	98	12	8.17	55	5	11.00	20	-1.05	0.2918	-1.06	0.2880	No
Vanadium	**131**	**12**	**10.92**	**22**	**5**	**4.40**	**7**	**2.42**	**0.0153**	**2.42**	**0.0153**	**Yes**
Zinc	**138**	**12**	**11.50**	**15**	**5**	**3.00**	**0**	**3.16**	**0.0016**	**3.16**	**0.0016**	**Yes**

TABLE 3-6

RESULTS OF WILCOXON RANK-SUM COMPARISONS
GRID SUBSURFACE SOIL SAMPLES vs. BACKGROUND SOIL GROUP 2
LANDFARM
NSWC CRANE
CRANE, INDIANA

Metal	GRID SB Rank Sum	GRID SB Valid N	GRID SB Avg Rank	BG2 Rank Sum	BG2 Valid N	BG2 Avg Rank	U	Z	p-level	adjusted Z	p-level	GRID SB above BG2?
Aluminum	219	12	18.25	106	13	8.15	15	3.43	0.0006	3.43	0.0006	Yes
Antimony	198.5	12	16.54	126.5	13	9.73	35.5	2.31	0.0208	2.31	0.0208	Yes
Arsenic	234	12	19.50	91	13	7.00	0	4.24	0.0000	4.25	0.0000	Yes
Barium	209	12	17.42	116	13	8.92	25	2.88	0.0039	2.88	0.0039	Yes
Beryllium	231.5	12	19.29	93.5	13	7.19	2.5	4.11	0.0000	4.11	0.0000	Yes
Cadmium	234	12	19.50	91	13	7.00	0	4.24	0.0000	4.28	0.0000	Yes
Calcium	222	12	18.50	103	13	7.92	12	3.59	0.0003	3.59	0.0003	Yes
Chromium	215	12	17.92	110	13	8.46	19	3.21	0.0013	3.21	0.0013	Yes
Cobalt	207.5	12	17.29	117.5	13	9.04	26.5	2.80	0.0051	2.80	0.0051	Yes
Copper	197.5	12	16.46	127.5	13	9.81	36.5	2.26	0.0240	2.26	0.0239	Yes
Iron	228	12	19.00	97	13	7.46	6	3.92	0.0001	3.92	0.0001	Yes
Lead	230	12	19.17	95	13	7.31	4	4.03	0.0001	4.03	0.0001	Yes
Magnesium	204	12	17.00	121	13	9.31	30	2.61	0.0090	2.61	0.0090	Yes
Manganese	208.5	12	17.38	116.5	13	8.96	25.5	2.86	0.0043	2.86	0.0043	Yes
Mercury	113.5	12	9.46	211.5	13	16.27	35.5	-2.31	0.0208	-2.34	0.0191	No
Nickel	226	12	18.83	99	13	7.62	8	3.81	0.0001	3.81	0.0001	Yes
Potassium	230	12	19.17	95	13	7.31	4	4.03	0.0001	4.03	0.0001	Yes
Selenium	217.5	12	18.13	107.5	13	8.27	16.5	3.35	0.0008	3.35	0.0008	Yes
Silver	227	12	18.92	98	13	7.54	7	3.86	0.0001	3.93	0.0001	Yes
Sodium	165.5	12	13.79	159.5	13	12.27	68.5	0.52	0.6053	0.52	0.6053	No
Thallium	217.5	12	18.13	107.5	13	8.27	16.5	3.35	0.0008	3.35	0.0008	Yes
Vanadium	229	12	19.08	96	13	7.38	5	3.97	0.0001	3.97	0.0001	Yes
Zinc	234	12	19.50	91	13	7.00	0	4.24	0.0000	4.24	0.0000	Yes

TABLE 3-6

RESULTS OF WILCOXON RANK-SUM COMPARISONS
PERIMETER SURFACE SOIL SAMPLES vs. BACKGROUND SOIL GROUP 1
LANDFARM
NSWC CRANE
CRANE, INDIANA

Metal	PERI SS Rank Sum	PERI SS Valid N	PERI SS Avg Rank	BG1 Rank Sum	BG1 Valid N	BG1 Avg Rank	U	Z	p-level	adjusted Z	p-level	PERI SS above BG1?
Aluminum	40.5	6	6.75	25.5	5	5.10	10.5	0.82	0.4113	0.82	0.4103	No
Antimony	**51**	**6**	**8.50**	**15**	**5**	**3.00**	**0**	**2.74**	**0.0062**	**2.74**	**0.0062**	**Yes**
Arsenic	**46**	**6**	**7.67**	**20**	**5**	**4.00**	**5**	**1.83**	**0.0679**	**1.83**	**0.0679**	**Yes**
Barium	32.5	6	5.42	33.5	5	6.70	11.5	-0.64	0.5228	-0.64	0.5219	No
Beryllium	42.5	6	7.08	23.5	5	4.70	8.5	1.19	0.2353	1.19	0.2343	No
Cadmium	**51**	**6**	**8.50**	**15**	**5**	**3.00**	**0**	**2.74**	**0.0062**	**2.76**	**0.0057**	**Yes**
Calcium	**50**	**6**	**8.33**	**16**	**5**	**3.20**	**1**	**2.56**	**0.0106**	**2.56**	**0.0106**	**Yes**
Chromium	**51**	**6**	**8.50**	**15**	**5**	**3.00**	**0**	**2.74**	**0.0062**	**2.74**	**0.0062**	**Yes**
Cobalt	24	6	4.00	42	5	8.40	3	-2.19	0.0285	-2.19	0.0285	No
Copper	44	6	7.33	22	5	4.40	7	1.46	0.1441	1.46	0.1441	No
Iron	45	6	7.50	21	5	4.20	6	1.64	0.1004	1.64	0.1004	No
Lead	41	6	6.83	25	5	5.00	10	0.91	0.3613	0.91	0.3613	No
Magnesium	40.5	6	6.75	25.5	5	5.10	10.5	0.82	0.4113	0.82	0.4103	No
Manganese	31	6	5.17	35	5	7.00	10	-0.91	0.3613	-0.91	0.3613	No
Mercury	38	6	6.33	28	5	5.60	13	0.37	0.7150	0.37	0.7099	No
Nickel	30	6	5.00	36	5	7.20	9	-1.10	0.2733	-1.10	0.2722	No
Potassium	44	6	7.33	22	5	4.40	7	1.46	0.1441	1.46	0.1432	No
Selenium	26.5	6	4.42	39.5	5	7.90	5.5	-1.73	0.0828	-1.74	0.0821	No
Silver	**50.5**	**6**	**8.42**	**15.5**	**5**	**3.10**	**0.5**	**2.65**	**0.0081**	**2.68**	**0.0074**	**Yes**
Sodium	**48**	**6**	**8.00**	**18**	**5**	**3.60**	**3**	**2.19**	**0.0285**	**2.19**	**0.0285**	**Yes**
Thallium	31.5	6	5.25	34.5	5	6.90	10.5	-0.82	0.4113	-0.83	0.4081	No
Vanadium	**48**	**6**	**8.00**	**18**	**5**	**3.60**	**3**	**2.19**	**0.0285**	**2.19**	**0.0285**	**Yes**
Zinc	**48**	**6**	**8**	**18**	**5**	**3.60**	**3**	**2.19**	**0.0285**	**2.19**	**0.0285**	**Yes**

TABLE 3-6

RESULTS OF WILCOXON RANK-SUM COMPARISONS
PERIMETER SUBSURFACE SOIL SAMPLES vs. BACKGROUND SOIL GROUP 2
LANDFARM
NSWC CRANE
CRANE, INDIANA

Metal	PERI SB Rank Sum	PERI SB Valid N	PERI SB Avg Rank	BG2 Rank Sum	BG2 Valid N	BG2 Avg Rank	U	Z	p-level	adjusted Z	p-level	PERI SB above BG2?
Aluminum	90	6	15.0	100	13	7.69	9	2.63	0.0085	2.63	0.0085	Yes
Antimony	81	6	13.5	109	13	8.38	18	1.84	0.0655	1.84	0.0654	Yes
Arsenic	95	6	15.8	95	13	7.31	4	3.07	0.0021	3.07	0.0021	Yes
Barium	84	6	14.0	106	13	8.15	15	2.10	0.0353	2.10	0.0353	Yes
Beryllium	96	6	16.0	94	13	7.23	3	3.16	0.0016	3.16	0.0016	Yes
Cadmium	99	6	16.5	91	13	7.00	0	3.42	0.0006	3.48	0.0005	Yes
Calcium	90	6	15.0	100	13	7.69	9	2.63	0.0085	2.63	0.0085	Yes
Chromium	87	6	14.5	103	13	7.92	12	2.37	0.0179	2.37	0.0178	Yes
Cobalt	79.5	6	13.3	110.5	13	8.50	19.5	1.71	0.0872	1.71	0.0871	Yes
Copper	82.5	6	13.8	107.5	13	8.27	16.5	1.97	0.0485	1.98	0.0483	Yes
Iron	96	6	16.0	94	13	7.23	3	3.16	0.0016	3.16	0.0016	Yes
Lead	96	6	16.0	94	13	7.23	3	3.16	0.0016	3.16	0.0016	Yes
Magnesium	77	6	12.8	113	13	8.69	22	1.49	0.1360	1.49	0.1360	No
Manganese	81	6	13.5	109	13	8.38	18	1.84	0.0655	1.84	0.0655	Yes
Mercury	43	6	7.2	147	13	11.31	22	-1.49	0.1360	-1.54	0.1247	No
Nickel	86	6	14.3	104	13	8.00	13	2.28	0.0226	2.28	0.0225	Yes
Potassium	89	6	14.8	101	13	7.77	10	2.54	0.0110	2.54	0.0110	Yes
Selenium	89	6	14.8	101	13	7.77	10	2.54	0.0110	2.55	0.0109	Yes
Silver	96.5	6	16.1	93.5	13	7.19	2.5	3.20	0.0014	3.27	0.0011	Yes
Sodium	64	6	10.7	126	13	9.69	35	0.35	0.7257	0.35	0.7257	No
Thallium	91	6	15.2	99	13	7.62	8	2.72	0.0066	2.73	0.0063	Yes
Vanadium	99	6	16.5	91	13	7.00	0	3.42	0.0006	3.42	0.0006	Yes
Zinc	97	6	16.2	93	13	7.15	2	3.25	0.0012	3.25	0.0012	Yes

TABLE 3-6

RESULTS OF WILCOXON RANK-SUM COMPARISONS
GRID SURFACE SOIL SAMPLES vs. PERIMETER SURFACE SOIL SAMPLES
LANDFARM
NSWC CRANE
CRANE, INDIANA

Metal	GRID SS Rank Sum	GRID SS Valid N	GRID SS Avg Rank	PERI SS Rank Sum	PERI SS Valid N	PERI SS Avg Rank	U	Z	p-level	adjusted Z	p-level	GRID SS different than PERI SS?
Aluminum	134	12	11.17	37	6	6.17	16	1.87	0.0611	1.88	0.0608	No
Antimony	**136**	**12**	**11.33**	**35**	**6**	**5.83**	**14**	**2.06**	**0.0394**	**2.07**	**0.0389**	**Yes**
Arsenic	126	12	10.50	45	6	7.50	24	1.12	0.2611	1.12	0.2611	No
Barium	118	12	9.83	53	6	8.83	32	0.37	0.7079	0.38	0.7076	No
Beryllium	119.5	12	9.96	51.5	6	8.58	30.5	0.52	0.6065	0.52	0.6061	No
Cadmium	121	12	10.08	50	6	8.33	29	0.66	0.5121	0.66	0.5112	No
Calcium	127	12	10.58	44	6	7.33	23	1.22	0.2234	1.22	0.2234	No
Chromium	**137**	**12**	**11.42**	**34**	**6**	**5.67**	**13**	**2.15**	**0.0312**	**2.15**	**0.0312**	**Yes**
Cobalt	125.5	12	10.46	45.5	6	7.58	24.5	1.08	0.2815	1.08	0.2812	No
Copper	**136**	**12**	**11.33**	**35**	**6**	**5.83**	**14**	**2.06**	**0.0394**	**2.06**	**0.0393**	**Yes**
Iron	123	12	10.25	48	6	8.00	27	0.84	0.3993	0.84	0.3993	No
Lead	128	12	10.67	43	6	7.17	22	1.31	0.1898	1.31	0.1896	No
Magnesium	122	12	10.17	49	6	8.17	28	0.75	0.4537	0.75	0.4535	No
Manganese	115	12	9.58	56	6	9.33	35	0.09	0.9254	0.09	0.9254	No
Mercury	**137**	**12**	**11.42**	**34**	**6**	**5.67**	**13**	**2.15**	**0.0312**	**2.16**	**0.0308**	**Yes**
Nickel	133.5	12	11.13	37.5	6	6.25	16.5	1.83	0.0678	1.83	0.0670	No
Potassium	125	12	10.42	46	6	7.67	25	1.03	0.3029	1.03	0.3027	No
Selenium	133.5	12	11.13	37.5	6	6.25	16.5	1.83	0.0678	1.83	0.0674	No
Silver	**138.5**	**12**	**11.54**	**32.5**	**6**	**5.42**	**11.5**	**2.29**	**0.0218**	**2.30**	**0.0216**	**Yes**
Sodium	122	12	10.17	49	6	8.17	28	0.75	0.4537	0.75	0.4537	No
Thallium	110	12	9.17	61	6	10.17	32	-0.37	0.7079	-0.38	0.7043	No
Vanadium	124	12	10.33	47	6	7.83	26	0.94	0.3490	0.94	0.3490	No
Zinc	**139.5**	**12**	**11.63**	**31.5**	**6**	**5.25**	**10.5**	**2.39**	**0.0169**	**2.39**	**0.0168**	**Yes**
Cyanide	123	12	10.25	48	6	8.00	27	0.84	0.3993	0.88	0.3799	No
PH	121	12	10.08	50	6	8.33	29	0.66	0.5121	0.66	0.5108	No

TABLE 3-6

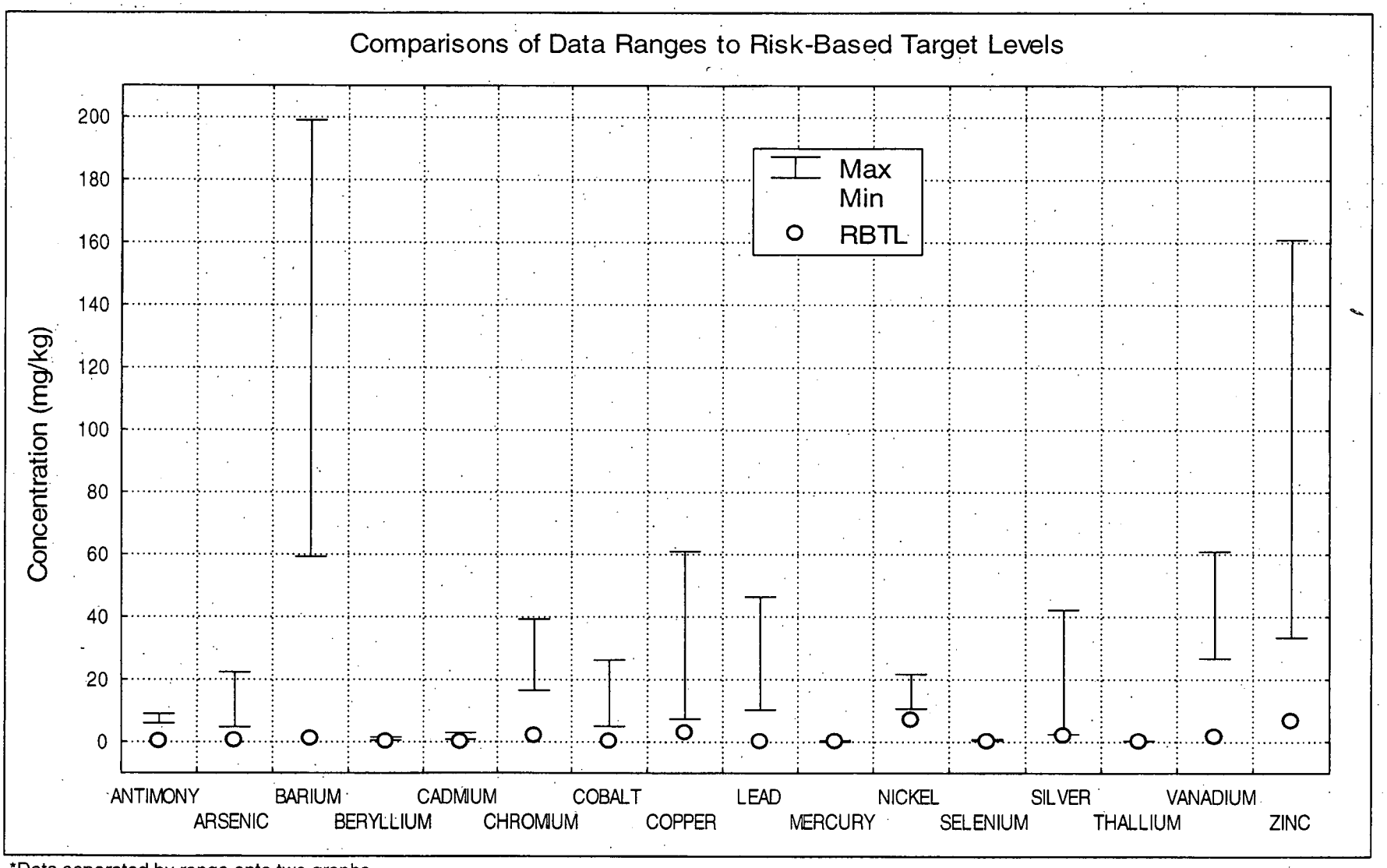
RESULTS OF WILCOXON RANK-SUM COMPARISONS
GRID SUBSURFACE SOIL SAMPLES vs. PERIMETER SUBSURFACE SOIL SAMPLES
LANDFARM
NSWC CRANE
CRANE, INDIANA

Metal	GRID SB Rank Sum	GRID SB Valid N	GRID SB Avg Rank	PERI SB Rank Sum	PERI SB Valid N	PERI SB Avg Rank	U	Z	p-level	adjusted Z	p-level	GRID SB different than PERI SB?
Aluminum	106.5	12	8.88	64.5	6	10.75	28.5	-0.70	0.4824	-0.70	0.4820	No
Antimony	110	12	9.17	61	6	10.17	32	-0.37	0.7079	-0.37	0.7079	No
Arsenic	111.5	12	9.29	59.5	6	9.92	33.5	-0.23	0.8149	-0.23	0.8147	No
Barium	124	12	10.33	47	6	7.83	26	0.94	0.3490	0.94	0.3490	No
Beryllium	119.5	12	9.96	51.5	6	8.58	30.5	0.52	0.6065	0.52	0.6063	No
Cadmium	106.5	12	8.88	64.5	6	10.75	28.5	-0.70	0.4824	-0.71	0.4774	No
Calcium	116.5	12	9.71	54.5	6	9.08	33.5	0.23	0.8149	0.23	0.8148	No
Chromium	117.5	12	9.79	53.5	6	8.92	32.5	0.33	0.7431	0.33	0.7428	No
Cobalt	122	12	10.17	49	6	8.17	28	0.75	0.4537	0.75	0.4530	No
Copper	109.5	12	9.13	61.5	6	10.25	31.5	-0.42	0.6734	-0.42	0.6733	No
Iron	108.5	12	9.04	62.5	6	10.42	30.5	-0.52	0.6065	-0.52	0.6063	No
Lead	117.5	12	9.79	53.5	6	8.92	32.5	0.33	0.7431	0.33	0.7429	No
Magnesium	109	12	9.08	62	6	10.33	31	-0.47	0.6396	-0.47	0.6396	No
Manganese	121	12	10.08	50	6	8.33	29	0.66	0.5121	0.66	0.5121	No
Mercury	121	12	10.08	50	6	8.33	29	0.66	0.5121	0.67	0.5040	No
Nickel	131	12	10.92	40	6	6.67	19	1.59	0.1114	1.59	0.1112	No
Potassium	111	12	9.25	60	6	10.00	33	-0.28	0.7787	-0.28	0.7787	No
Selenium	115.5	12	9.63	55.5	6	9.25	34.5	0.14	0.8883	0.14	0.8875	No
Silver	111.5	12	9.29	59.5	6	9.92	33.5	-0.23	0.8149	-0.25	0.8059	No
Sodium	111	12	9.25	60	6	10.00	33	-0.28	0.7787	-0.28	0.7787	No
Thallium	106.5	12	8.88	64.5	6	10.75	28.5	-0.70	0.4824	-0.71	0.4778	No
Vanadium	105.5	12	8.79	65.5	6	10.92	27.5	-0.80	0.4260	-0.80	0.4257	No
Zinc	109	12	9.08	62	6	10.33	31	-0.47	0.6396	-0.47	0.6396	No
Cyanide	121	12	10.08	50	6	8.33	29	0.66	0.5121	0.70	0.4813	No
PH	116	12	9.67	55	6	9.17	34	0.19	0.8514	0.19	0.8502	No

Bold indicates metal from site1 is statistically different than site2 at a 5% level of signifigance.

FIGURE 3-1

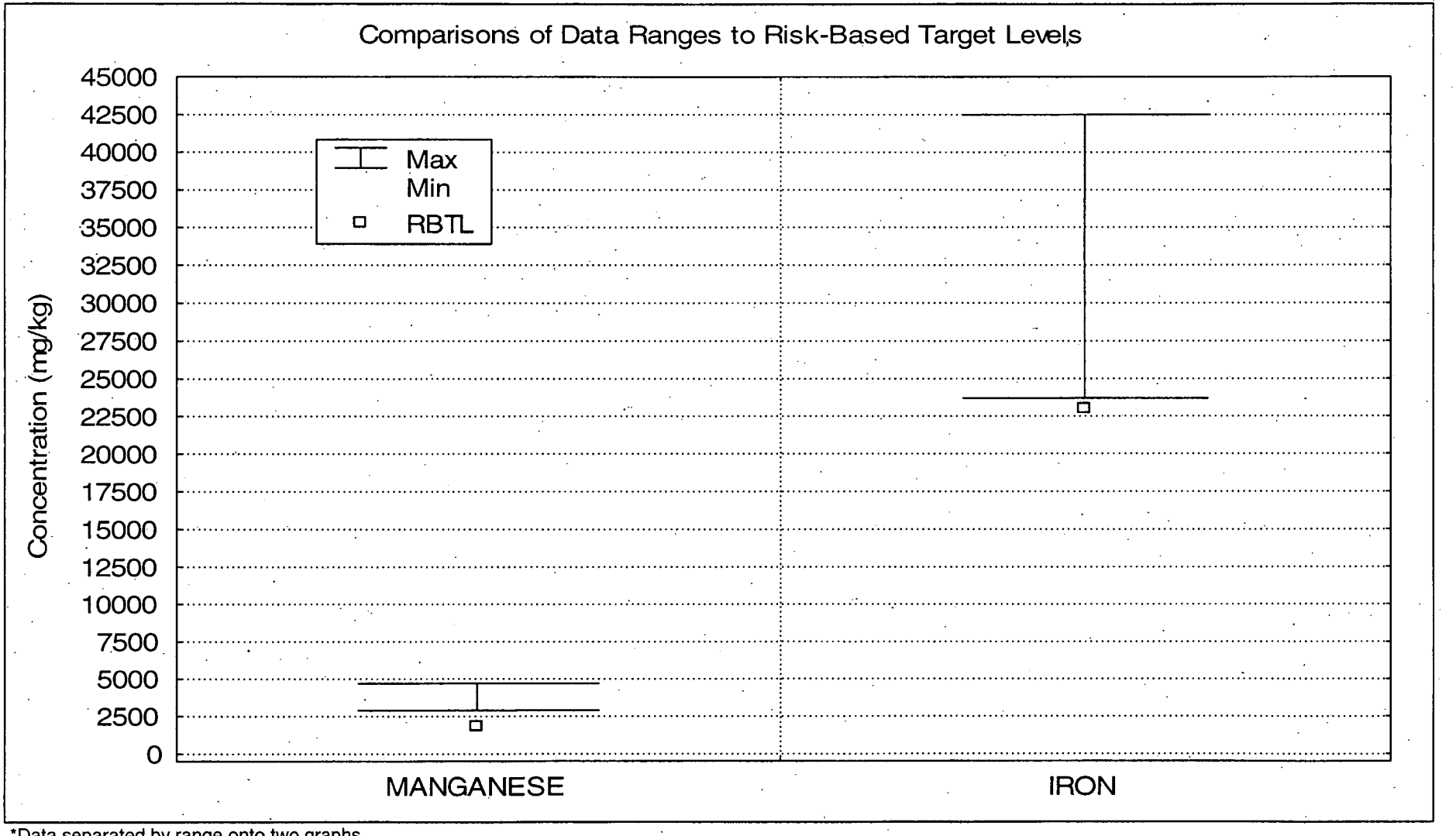
COMPARISONS OF DATA RANGES TO RISK-BASED TARGET LEVELS
SWMU 30 - LANDFARM
NAVAL SURFACE WARFARE CENTER
CRANE, INDIANA
PAGE 1 OF 2



*Data separated by range onto two graphs.

FIGU[illegible]-1

COMPARISONS OF DATA RANGES TO RISK-BASED TARGET LEVELS
SWMU 30 - LANDFARM
NAVAL SURFACE WARFARE CENTER
CRANE, INDIANA



*Data separated by range onto two graphs.

4.0 HUMAN HEALTH SCREENING EVALUATION

This section presents the results of the Human Health Risk Screening Evaluation (HHSE) of chemical concentrations detected in surface and subsurface soils collected at SWMU 30. Information on the selection of chemicals of potential concern, exposure assessment, characterization of estimated potential human health risks, and summary and conclusions for the risk screening are contained in Sections 4.1, 4.2, 4.3, and 4.4, respectively.

4.1 CHEMICALS OF POTENTIAL CONCERN SELECTION

Chemicals of potential concern (COPCs) are the target analytes detected in an environmental media that are selected for evaluation in a risk assessment. COPCs for this HHSE are identified below and are those chemicals detected in the SWMU 30 surface or subsurface soil samples at maximum concentrations exceeding the RBTLs previously defined in the Crane Landfarm Soil Sampling Work Plan Addendum for SWMU 30 (TtNUS, 2002) and the Base-specific background concentrations:

- Surface soil – antimony, arsenic, beryllium, cadmium, chromium, copper, iron, lead, mercury, silver, vanadium, and zinc.

- Subsurface soil - arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, iron, lead, manganese, nickel, selenium, silver, thallium, vanadium, and zinc.

This is a conservative approach for the HHSE because the RBTLs were derived based on both human health and ecological screening criteria and because the ecological screening criteria for metals are often lower than the risk-based screening criteria typically used for COPC selection in a human health risk assessment. For example, antimony, arsenic, chromium, iron, manganese, and vanadium were the only inorganics detected at concentrations exceeding risk-based human health screening levels typically recommended by EPA Region 5 for the selection of COPCs. EPA Region 5 recommends COPC screening levels based on the Region 9 Preliminary Remediation Goals (PRGs). The PRGs are chemical concentrations corresponding to fixed levels of risk (i.e., a Hazard Quotient (HQ) of 1 for non-carcinogenic chemicals or a lifetime cancer risk of 1E-06 for carcinogenic chemicals). The Region 5 COPC screening levels for carcinogenic and non-carcinogenic compounds are typically the Region 9 PRG and one-tenth the Region 9, respectively. One-tenth the Region 9 PRG is recommended for non-carcinogenic compounds to account for the potential cumulative effects of multiple compounds effecting the same target organ.

4.2 EXPOSURE ASSESSMENT

This section presents the exposure assessment for SWMU 30. SWMU 30 is a relatively flat area approximately 2.5 acres in size. The site is currently well vegetated. Surface water drainage from the area flows to the southwest. Depth to groundwater is approximately 25 feet below ground surface. Groundwater quality underlying the SWMU has not been impacted by site operations as described in the Draft Phase II Ground Water RFI Report (TtNUS, 2001).

Currently, SWMU 30 is not being used for any sludge application or other landfarming activities. In addition, the Base does not have any current plans to develop the site. Consequently, under current and anticipated future land use at SWMU 30, the following receptors are the most likely individuals to be exposed to COPCs in soils at the site.

- Base personnel engaged in site maintenance activities (cutting grass, etc.)
- Trespassers

These receptors may be exposed to COPCs in surface soils via direct contact (i.e., incidental ingestion, dermal contact) or via inhalation of airborne soil particulates from the site. Exposure to subsurface soil and groundwater is unlikely because these receptors are not expected to be engaged in ground-intrusive activities. However, for purposes of this risk screening, the exposure assessment will assume that a hypothetical future resident or typical industrial worker may be exposed to the COPCs in surface or subsurface soils. The exposure assessment assumptions (e.g., soil ingestion rates, etc) are those specified in the calculation of the Region 9 PRGs for the hypothetical future resident and the typical industrial worker. (The exposure assessment methodology for the Region 9 PRGs is presented in Appendix F, No. 1.) As detailed below, the maximum detected concentration is evaluated as the exposure point concentration (i.e., the COPC concentration to which a receptor is exposed).

4.3 RISK CHARACTERIZATION

Tables 4-1 through 4-8 present results of the risk characterization conducted for this HHSE. Cancer and non-cancer risk estimates were developed for the hypothetical future resident and typical industrial worker using the maximum detected COPC concentrations in surface and subsurface soils, and available Region 9 PRGs. As noted previously, the EPA Region 9 PRGs represent the 1E-06 cancer risk level for carcinogenic chemicals and a Hazard Index of 1 (i.e., the no adverse effect concentration) for non-carcinogens. Thus, risk estimates were developed using a simple ratio-ing technique:

$$\frac{\text{EPA Region 9 PRG}}{\text{EPC for COPC}} = \frac{\text{Hazard Index of 1 or Cancer Risk Estimate of 1E - 06}}{\text{?? Hazard Index or Cancer risk Estimate}}$$

Risk estimates for the hypothetical future resident and the typical industrial worker using maximum detected concentrations are summarized below:

	Surface Soil		Subsurface Soil	
	Grid	**Perimeter**	**Grid**	**Perimeter**
Hazard Index (Residential land use)	3.5	1.5	3.3	5
Cancer Risk Estimate (Residential land use)	5.8E-05	2.3E-05	3.3E-05	2.7E-05
Hazard Index (Industrial land use)	1.4E-01	6.3E-02	1.5E-01	2.4E-01
Cancer Risk Estimate (Industrial land use)	8.4E-06	3.3E-06	4.8E-06	4E-06

Cancer risk estimates presented above do not exceed the risk management range (1E-04 to 1E-06) often used by EPA to determine the need for environmental remediation or set standards and criteria. The total hazard indices calculated for the typical industrial worker are less than one indicating that adverse non-carcinogenic health effects are not anticipated under the conditions established for the exposure assessment. The total hazard indices calculated for the hypothetical future resident exposed to COPCs in surface or subsurface soils marginally exceed the EPA benchmark of 1 (i.e., they are between 1.5 and 5.) Arsenic, iron, and manganese are the primary contributors to the non-carcinogenic risk; the HIs developed for iron and/or manganese exceed 1 when maximum concentrations in perimeter subsurface soils, grid surface soils, or grid subsurface soils are evaluated. However, the following information should be considered when interpreting these results:

- The Region 9 PRG for iron in soil assuming a residential land use scenario (23,000 mg/kg) is based on a reference dose (i.e., the non-carcinogenic toxicity criteria) of 0.3 mg/kg/day and assumes that the receptor of concern is the resident child. However, based on guidance received courtesy EPA Region 3, this reference dose is based on a typical or recommended daily intake for an adult and not on the potential for adverse non-carcinogenic health effects (Appendix F, No.2). Additionally, the nutritional needs of children differ from adults and a more appropriate reference dose for children would be 1.1 mg/kg/day. A PRG for the resident child based on a reference dose of 1.1 mg/kg/day would be approximately 85,000 mg/kg. The maximum iron concentration in the soils at SWMU 30 does not exceed 42,500 mg/kg. The arithmetic mean concentrations in surface soils and subsurface soils are 20,500 and 29,500 mg/kg, respectively.

- The Region 9 PRG for manganese in soil assuming a residential land use scenario (1,800 mg/kg) is based on a reference dose (i.e., the non-carcinogenic toxicity criteria) of 0.024 mg/kg/day. However, based on guidance received courtesy EPA Region 1, a more appropriate risk-based concentration would be 5,173 mg/kg (Appendix F, No. 3). The maximum manganese concentration in soils (4,690 mg/kg) was detected in the perimeter subsurface soil samples. The maximum concentration detected in the grid surface soil samples was 1,550 mg/kg. Consequently, the pattern of contamination does not suggest that SWMU 30 is a significant source of manganese.

- The Region 9 PRG (noncarcinogenic effects) for arsenic in soil assuming a residential land use scenario is 22 mg/kg. Although the arsenic concentrations detected in the soils at SWMU 30 exceed Base-specific background concentrations, arsenic is a naturally occurring metal and may occur naturally in some locations (e.g., in the western United States) at concentrations exceeding 90 mg/kg. The HI for the maximum arsenic concentration in surface soils at SWMU 30 (22.4 mg/kg) is approximately 1. The HI associated with the 95 percent confidence limit on the arithmetic mean arsenic concentration (12.1 mg/kg) does not exceed 1.

In response to a comment the Navy received from EPA Region 5, risks were recalculated employing the 95% Upper Confidence Limit (UCL) of the mean concentrations of the COPCs (rather than the maximum detected COPC concentrations) to provide further rationale for why the iron, manganese, and arsenic screening level HIs may be regarded as overestimates. Tables 4-1A through 4-8A (which follow Table 4-8 at the end of this Section) present the recalculated results of the risk characterization conducted in the same manner as described above - except that cancer and non-cancer risk estimates were developed for the hypothetical future resident an typical industrial worker using the 95% UCL in surface and subsurface soils. These risk estimates are summarized below.

95% UCL of the Mean Concentration for COPCs	Surface Soil		Subsurface Soil	
	Grid	Perimeter	Grid	Perimeter
Hazard Index (Residential land use)	2.1	1.5	2.2	2.5
Cancer Risk Estimate (Residential land use)	3.1E-05	2.0E-05	2.5E-05	2.7E-05
Hazard Index (Industrial land use)	1.7E-01	1.1E-01	1.9E-01	2.4E-01
Cancer Risk Estimate (Industrial land use)	7.6E-06	5.0E-06	6.2E-06	6.6E-06

EPA Region 9 PRGs representing the 1E-06 cancer risk level for total chromium are calculated by EPA assuming that the ratio of the hexavalent chromium to trivalent chromium in soil is 1 to 6. Because all of the hexavalent chromium results were rejected except one (see Appendix D), these were the values used in risk characterization calculations.

4.4 SUMMARY AND CONCLUSIONS

Antimony, arsenic, chromium, iron, manganese, and vanadium were the only metals detected in soils at concentrations exceeding screening levels typically recommended by EPA Region 5 to select chemicals of potential concern for human health risk assessment. Two human receptors (the hypothetical future resident and typical industrial worker) were evaluated for health risks potentially resulting from exposure to these metals. Cancer risk estimates developed for these receptors do not exceed the risk management range (1E-04 to 1E-06) often used by EPA to determine the need for environmental remediation or to set environmental standards and criteria. Non-cancer risk estimates indicate a marginal exceedance of the EPA non-carcinogenic benchmark (a hazard index of 1) when the hypothetical future resident is evaluated; non-cancer risk estimates do not exceed the benchmark when the typical industrial worker is evaluated. The non-cancer risk estimates were developed in a very conservative manner (e.g., the evaluation assumed that a human receptor is exposed to the maximum detected concentration; very conservative toxicity benchmarks were used to evaluate iron and manganese). Consequently, the non-cancer risk results are likely to be over estimated.

TABLE 4-1

SUMMARY OF RESIDENTIAL HUMAN HEALTH RISKS AND HAZARDS FOR GRID SURFACE SOIL
LANDFARM
NSWC CRANE
CRANE, INDIANA

Parameter[7]	Incremental Lifetime Carcinogenic Risk (ILCR)			Estimated Non-Carcinogenic Hazard Quotient (HQ)			Maximum Background Concentration
	Maximum Concentration	PRG - Residential[1,3,5]	Estimated ILCR	Primary Target Organs[2]	PRG - Residential[1,4,6]	Estimated HQ	
Surface	(mg/kg)	(mg/kg)			(mg/kg)		(mg/kg)
ANTIMONY	6	NA	-	blood	3.1E+01	1.9E-01	ND
ARSENIC	22.4	3.9E-01	5.7E-05	CVS, skin	2.2E+01	1.0E+00	6.8
BERYLLIUM[8]	1.5	1.1E+03	1.4E-09	GI	1.5E+02	1.0E-02	0.74
CADMIUM[8]	1.6	1.4E+03	1.1E-09	kidney	3.7E+01	4.3E-02	ND
CHROMIUM[8]	39.3	2.1E+02	1.9E-07	respiratory	2.3E+02	1.7E-01	15.1
COPPER	38.7	NA	-		2.9E+03	1.3E-02	11.3
IRON	42500	NA	-		2.3E+04	1.8E+00	17400
LEAD	30.7	NA	-		NA	-	17.1
MERCURY	0.41	NA	-	neurological	2.3E+01	1.8E-02	0.06
SILVER	19.7	NA	-	skin	3.9E+02	5.1E-02	0.05
VANADIUM	60.9	NA	-		5.5E+02	1.1E-01	32.2
ZINC	115	NA	-	blood	2.3E+04	5.0E-03	49.6
	Total Carcinogenic Risk		5.8E-05		Total HI	3.5E+00	

Target Organ HIs

Total Blood HI =	2.0E-01
Total Cardiovascular HI =	1.0E+00
Total Skin HI =	1.1E+00
Total Kidney HI =	4.3E-02
Total Gastrointestinal HI =	1.0E-02
Total Respiratory HI =	1.7E-01
Total Neurological HI =	1.8E-02

Footnotes:
1 - Region IX - Preliminary Remediation Goals (PRGs) Tables, November 22, 2000.
2 - Primary Target Organs - Integrated Risk Information System (IRIS).
3 - Chromium value based on assumption of 1:6, Chromium VI : Chromium III ratio.
4 - Chromium value based on Chromium VI noncarcinogenic PRG.
5 - PRG is shaded if maximum detected concentration exceeds PRG.
6 - PRG is shaded if maximum detected concentration exceeds 1/10th PRG.
7 - Analyte name is shaded if maximum sample concentration is greater than the Region 9 carcinogenic PRG and/or 1/10th the Region 9 noncarcinogenic PRG.
8 - Carcinogenic PRG values are based on the inhalation cancer slope factor.

Abbreviations:
NA - Not available
ND - Nondetected
PRG - Preliminary Remediation Goal
ILCR - Incremental Lifetime Carcinogenic Risk
HQ - Hazard Quotient
HI - Hazard Index
CVS - Cardiovascular System
GI - Gastrointestinal

TABLE 4-2

SUMMARY OF INDUSTRIAL HUMAN HEALTH RISKS AND HAZARDS FOR GRID SURFACE SOIL
LANDFARM
NSWC CRANE
CRANE, INDIANA

Parameter[7]	Incremental Lifetime Carcinogenic Risk (ILCR)			Estimated Non-Carcinogenic Hazard Quotient (HQ)			Maximum Background Concentration
	Maximum Concentration	PRG - Industrial[1,3,5]	Estimated ILCR	Primary Target Organs[2]	PRG - Industrial[1,4,6]	Estimated HQ	
Surface	(mg/kg)	(mg/kg)			(mg/kg)		(mg/kg)
ANTIMONY	6	NA	-	blood	8.2E+02	7.3E-03	ND
ARSENIC	22.4	2.7E+00	8.3E-06	CVS, skin	4.4E+02	5.1E-02	6.8
BERYLLIUM[8]	1.5	2.2E+03	6.8E-10	GI	3.7E+03	4.1E-04	0.74
CADMIUM[8]	1.6	3.0E+03	5.3E-10	kidney	8.1E+02	2.0E-03	ND
CHROMIUM[8]	39.3	4.5E+02	8.7E-08	respiratory	6.1E+03	6.4E-03	15.1
COPPER	38.7	NA	-		7.6E+04	5.1E-04	11.3
IRON	42500	NA	-		6.1E+05	7.0E-02	17400
LEAD	30.7	NA	-		NA	-	17.1
MERCURY	0.41	NA	-	neurological	6.1E+02	6.7E-04	0.06
SILVER	19.7	NA	-	skin	1.0E+04	2.0E-03	0.05
VANADIUM	60.9	NA	-		1.4E+04	4.4E-03	32.2
ZINC	115	NA	-	blood	6.1E+05	1.9E-04	49.6
	Total Carcinogenic Risk		8.4E-06		Total HI	1.4E-01	

Total Blood HI =	7.5E-03
Total Cardiovascular HI =	5.1E-02
Total Skin HI =	5.3E-02
Total Kidney HI =	2.0E-03

Total Gastrointestinal HI =	4.1E-04
Total Respiratory HI =	6.4E-03
Total Neurological HI =	6.7E-04

Footnotes:
1 - Region IX - Preliminary Remediation Goals (PRGs) Tables, November 22, 2000.
2 - Primary Target Organs - Integrated Risk Information System (IRIS).
3 - Chromium value based on assumption of 1:6, Chromium VI : Chromium III ratio.
4 - Chromium value based on Chromium VI noncarcinogenic PRG.
5 - PRG is shaded if maximum detected concentration exceeds PRG.
6 - PRG is shaded if maximum detected concentration exceeds 1/10th PRG.
7 - Analyte name is shaded if maximum sample concentration is greater than the Region 9 carcinogenic PRG and/or 1/10th the Region 9 noncarcinogenic PRG.
8 - Carcinogenic PRG values are based on the inhalation cancer slope factor.

Abbreviations:
NA - Not available
ND - Nondetected
PRG - Preliminary Remediation Goal
ILCR - Incremental Lifetime Carcinogenic Risk
HQ - Hazard Quotient
HI - Hazard Index
CVS - Cardiovascular System
GI - Gastrointestinal

TABLE 4-3

SUMMARY OF RESIDENTIAL HUMAN HEALTH RISKS AND HAZARDS FOR GRID SUBSURFACE SOIL
LANDFARM
NSWC CRANE
CRANE, INDIANA

Parameter[7]	Incremental Lifetime Carcinogenic Risk (ILCR)			Estimated Non-Carcinogenic Hazard Quotient (HQ)			
	Maximum Concentration	PRG - Residential[1,3,5]	Estimated ILCR	Primary Target Organs[2]	PRG - Residential[1,4,6]	Estimated HQ	Maximum Background Concentration
Subsurface	(mg/kg)	(mg/kg)			(mg/kg)		(mg/kg)
ARSENIC	12.9	3.9E-01	3.3E-05	CVS, skin	2.2E+01	5.9E-01	6
BARIUM	161	NA	-	kidney	5.4E+03	3.0E-02	94.4
BERYLLIUM[8]	1.4	1.1E+03	1.3E-09	GI	1.5E+02	9.3E-03	0.69
CADMIUM[8]	0.72	1.4E+03	5.1E-10	kidney	3.7E+01	1.9E-02	ND
CHROMIUM[8]	27.8	2.1E+02	1.3E-07	respiratory	2.3E+02	1.2E-01	25.5
COBALT	13.1	NA	-		4.7E+03	2.8E-03	9.2
COPPER	20.3	NA	-		2.9E+03	7.0E-03	16.4
IRON	35300	NA	-		2.3E+04	1.5E+00	27700
LEAD	21	NA	-		NA	-	11.7
MANGANESE	1430	NA	-	neurological	1.8E+03	7.9E-01	376
NICKEL	17.7	NA	-	body weight	1.6E+03	1.1E-02	13.1
SELENIUM	0.51	NA	-		3.9E+02	1.3E-03	ND
SILVER	0.14	NA	-	skin	3.9E+02	3.6E-04	0.05
THALLIUM	0.34	NA	-		5.2E+00	6.5E-02	0.27
VANADIUM	50.6	NA	-		5.5E+02	9.2E-02	42.4
ZINC	64.8	NA	-	blood	2.3E+04	2.8E-03	35.3
	Total Carcinogenic Risk		3.3E-05		Total HI	3.3E+00	

Total Blood HI =	2.8E-03
Total Cardiovascular HI =	5.9E-01
Total Skin HI =	5.9E-01
Total Kidney HI =	4.9E-02

Total Gastrointestinal HI =	9.3E-03
Total Respiratory HI =	1.2E-01
Total Neurological HI =	7.9E-01
Total Body Weight HI =	1.1E-02

Footnotes:

1 - Region IX - Preliminary Remediation Goals (PRGs) Tables, November 22, 2000.
2 - Primary Target Organs - Integrated Risk Information System (IRIS).
3 - Chromium value based on assumption of 1:6, Chromium VI : Chromium III ratio.
4 - Chromium value based on Chromium VI noncarcinogenic PRG.
5 - PRG is shaded if maximum detected concentration exceeds PRG.
6 - PRG is shaded if maximum detected concentration exceeds 1/10th PRG.
7 - Analyte name is shaded if maximum sample concentration is greater than the Region 9 carcinogenic PRG and/or 1/10th the Region 9 noncarcinogenic PRG.
8 - Carcinogenic PRG values are based on the inhalation cancer slope factor.

Abbreviations:

NA - Not available
ND - Nondetected
PRG - Preliminary Remediation Goal
ILCR - Incremental Lifetime Carcinogenic Risk
HQ - Hazard Quotient
HI - Hazard Index
CVS - Cardiovascular System
GI - Gastrointestinal

TABLE 4-4

SUMMARY OF INDUSTRIAL HUMAN HEALTH RISKS AND HAZARDS FOR GRID SUBSURFACE SOIL
LANDFARM
NSWC CRANE
CRANE, INDIANA

Parameter[7]	Incremental Lifetime Carcinogenic Risk (ILCR)			Estimated Non-Carcinogenic Hazard Quotient (HQ)			
	Maximum Concentration	PRG - Industrial[1,3,5]	Estimated ILCR	Primary Target Organs[2]	PRG - Industrial[1,4,6]	Estimated HQ	Maximum Background Concentration
Subsurface	(mg/kg)	(mg/kg)			(mg/kg)		(mg/kg)
ARSENIC	12.9	2.7E+00	4.8E-06	CVS, skin	4.4E+02	2.9E-02	6
BARIUM	161	NA	-	kidney	1.2E+05	1.3E-03	94.4
BERYLLIUM[8]	1.4	2.2E+03	6.4E-10	GI	3.7E+03	3.8E-04	0.69
CADMIUM[8]	0.72	3.0E+03	2.4E-10	kidney	8.1E+02	8.9E-04	ND
CHROMIUM[8]	27.8	4.5E+02	6.2E-08	respiratory	6.1E+03	4.6E-03	25.5
COBALT	13.1	NA	-		1.2E+05	1.1E-04	9.2
COPPER	20.3	NA	-		7.6E+04	2.7E-04	16.4
IRON	35300	NA	-		6.1E+05	5.8E-02	27700
LEAD	21	NA	-		NA	-	11.7
MANGANESE	1430	NA	-	neurological	3.2E+04	4.5E-02	376
NICKEL	17.7	NA	-	body weight	4.1E+04	4.3E-04	13.1
SELENIUM	0.51	NA	-		1.0E+04	5.1E-05	ND
SILVER	0.14	NA	-	skin	1.0E+04	1.4E-05	0.05
THALLIUM	0.34	NA	-		1.3E+02	2.6E-03	0.27
VANADIUM	50.6	NA	-		1.4E+04	3.6E-03	42.4
ZINC	64.8	NA	-	blood	6.1E+05	1.1E-04	35.3
	Total Carcinogenic Risk		4.8E-06		Total HI	1.5E-01	

Total Blood HI =	1.1E-04
Total Cardiovascular HI =	2.9E-02
Total Skin HI =	2.9E-02
Total Kidney HI =	2.2E-03

Total Gastrointestinal HI =	3.8E-04
Total Respiratory HI =	4.6E-03
Total Neurological HI =	4.5E-02
Total Body Weight HI =	4.3E-04

Footnotes:
1 - Region IX - Preliminary Remediation Goals (PRGs) Tables, November 22, 2000.
2 - Primary Target Organs - Integrated Risk Information System (IRIS).
3 - Chromium value based on assumption of 1:6, Chromium VI : Chromium III ratio.
4 - Chromium value based on Chromium VI noncarcinogenic PRG.
5 - PRG is shaded if maximum detected concentration exceeds PRG.
6 - PRG is shaded if maximum detected concentration exceeds 1/10th PRG.
7 - Analyte name is shaded if maximum sample concentration is greater than the Region 9 carcinogenic PRG and/or 1/10th the Region 9 noncarcinogenic PRG.
8 - Carcinogenic PRG values are based on the inhalation cancer slope factor.

Abbreviations:
NA - Not available
ND - Nondetected
PRG - Preliminary Remediation Goal
ILCR - Incremental Lifetime Carcinogenic Risk
HQ - Hazard Quotient
HI - Hazard Index
CVS - Cardiovascular System
GI - Gastrointestinal

TABLE 4-5

SUMMARY OF RESIDENTIAL HUMAN HEALTH RISKS AND HAZARDS FOR PERIMETER SURFACE SOIL
LANDFARM
NSWC CRANE
CRANE, INDIANA

Parameter[7]	Incremental Lifetime Carcinogenic Risk (ILCR)			Estimated Non-Carcinogenic Hazard Quotient (HQ)			
	Maximum Concentration	PRG - Residential[1,3,5]	Estimated ILCR	Primary Target Organs[2]	PRG - Residential[1,4,6]	Estimated HQ	Maximum Background Concentration
Surface	(mg/kg)	(mg/kg)			(mg/kg)		(mg/kg)
ARSENIC	8.8	3.9E-01	2.3E-05	CVS, skin	2.2E+01	4.0E-01	6.8
BERYLLIUM[8]	1.1	1.1E+03	1.0E-09	GI	1.5E+02	7.3E-03	0.74
CADMIUM[8]	1	1.4E+03	7.1E-10	kidney	3.7E+01	2.7E-02	ND
CHROMIUM[8]	23	2.1E+02	1.1E-07	respiratory	2.3E+02	1.0E-01	15.1
COPPER	16.5	NA	-		2.9E+03	5.7E-03	11.3
IRON	20600	NA	-		2.3E+04	9.0E-01	17400
LEAD	21.1	NA	-		NA	-	17.1
MERCURY	0.054	NA	-	neurological	2.3E+01	2.3E-03	0.06
SILVER	5.8	NA	-	skin	3.9E+02	1.5E-02	0.05
VANADIUM	40.7	NA	-		5.5E+02	7.4E-02	32.2
ZINC	60.5	NA	-	blood	2.3E+04	2.6E-03	49.6
		Total Carcinogenic Risk	2.3E-05		Total HI	1.5E+00	

Target Organ HIs

Total Blood HI =	2.6E-03
Total Cardiovascular HI =	4.0E-01
Total Skin HI =	4.1E-01
Total Kidney HI =	2.7E-02
Total Gastrointestinal HI =	7.3E-03
Total Respiratory HI =	1.0E-01
Total Neurological HI =	2.3E-03

Footnotes:
1 - Region IX - Preliminary Remediation Goals (PRGs) Tables, November 22, 2000.
2 - Primary Target Organs - Integrated Risk Information System (IRIS).
3 - Chromium value based on assumption of 1:6, Chromium VI : Chromium III ratio.
4 - Chromium value based on Chromium VI noncarcinogenic PRG.
5 - PRG is shaded if maximum detected concentration exceeds PRG.
6 - PRG is shaded if maximum detected concentration exceeds 1/10th PRG.
7 - Analyte name is shaded if maximum sample concentration is greater than the Region 9 carcinogenic PRG and/or 1/10th the Region 9 noncarcinogenic PRG.
8 - Carcinogenic PRG values are based on the inhalation cancer slope factor.

Abbreviations:
NA - Not available
ND - Nondetected
PRG - Preliminary Remediation Goal
ILCR - Incremental Lifetime Carcinogenic Risk
HQ - Hazard Quotient
HI - Hazard Index
CVS - Cardiovascular System
GI - Gastrointestinal

TABLE 4-6

SUMMARY OF INDUSTRIAL HUMAN HEALTH RISKS AND HAZARDS FOR PERIMETER SURFACE SOIL
LANDFARM
NSWC CRANE
CRANE, INDIANA

Parameter[7]	Incremental Lifetime Carcinogenic Risk (ILCR)			Estimated Non-Carcinogenic Hazard Quotient (HQ)			
	Maximum Concentration	PRG - Industrial[1,3,5]	Estimated ILCR	Primary Target Organs[2]	PRG - Industrial[1,4,6]	Estimated HQ	Maximum Background Concentration
Surface	(mg/kg)	(mg/kg)			(mg/kg)		(mg/kg)
ARSENIC	8.8	2.7E+00	3.3E-06	CVS, skin	4.4E+02	2.0E-02	6.8
BERYLLIUM[8]	1.1	2.2E+03	5.0E-10	GI	3.7E+03	3.0E-04	0.74
CADMIUM[8]	1	3.0E+03	3.3E-10	kidney	8.1E+02	1.2E-03	ND
CHROMIUM[8]	23	4.5E+02	5.1E-08	respiratory	6.1E+03	3.8E-03	15.1
COPPER	16.5	NA	-		7.6E+04	2.2E-04	11.3
IRON	20600	NA	-		6.1E+05	3.4E-02	17400
LEAD	21.1	NA	-		NA	-	17.1
MERCURY	0.054	NA	-	neurological	6.1E+02	8.9E-05	0.06
SILVER	5.8	NA	-	skin	1.0E+04	5.8E-04	0.05
VANADIUM	40.7	NA	-		1.4E+04	2.9E-03	32.2
ZINC	60.5	NA	-	blood	6.1E+05	9.9E-05	49.6
	Total Carcinogenic Risk		3.3E-06		Total HI	6.3E-02	

Target Organ HIs

Total Blood HI =	9.9E-05	Total Gastrointestinal HI =	3.0E-04
Total Cardiovascular HI =	2.0E-02	Total Respiratory HI =	3.8E-03
Total Skin HI =	2.1E-02	Total Neurological HI =	8.9E-05
Total Kidney HI =	1.2E-03		

Footnotes:
1 - Region IX - Preliminary Remediation Goals (PRGs) Tables, November 22, 2000.
2 - Primary Target Organs - Integrated Risk Information System (IRIS).
3 - Chromium value based on assumption of 1:6, Chromium VI : Chromium III ratio.
4 - Chromium value based on Chromium VI noncarcinogenic PRG.
5 - PRG is shaded if maximum detected concentration exceeds PRG.
6 - PRG is shaded if maximum detected concentration exceeds 1/10th PRG.
7 - Analyte name is shaded if maximum sample concentration is greater than the Region 9 carcinogenic PRG and/or 1/10th the Region 9 noncarcinogenic PRG.
8 - Carcinogenic PRG values are based on the inhalation cancer slope factor.

Abbreviations:
NA - Not available
ND - Nondetected
PRG - Preliminary Remediation Goal
ILCR - Incremental Lifetime Carcinogenic Risk
HQ - Hazard Quotient
HI - Hazard Index
CVS - Cardiovascular System
GI - Gastrointestinal

TABLE 4-7

SUMMARY OF RESIDENTIAL HUMAN HEALTH RISKS AND HAZARDS FOR PERIMETER SUBSURFACE SOIL
LANDFARM
NSWC CRANE
CRANE, INDIANA

Parameter[7]	Incremental Lifetime Carcinogenic Risk (ILCR)			Estimated Non-Carcinogenic Hazard Quotient (HQ)			Maximum Background Concentration
	Maximum Concentration	PRG - Residential[1,3,5]	Estimated ILCR	Primary Target Organs[2]	PRG - Residential[1,4,6]	Estimated HQ	
Surface	(mg/kg)	(mg/kg)			(mg/kg)		(mg/kg)
ARSENIC	10.6	3.9E-01	2.7E-05	CVS, skin	2.2E+01	4.8E-01	6
BARIUM	118	NA	-	kidney	5.4E+03	2.2E-02	94.4
BERYLLIUM[8]	1.3	1.1E+03	1.2E-09	GI	1.5E+02	8.7E-03	0.69
CHROMIUM[8]	30.7	2.1E+02	1.5E-07	respiratory	2.3E+02	1.3E-01	25.5
COBALT	26.2	NA	-		4.7E+03	5.6E-03	9.2
COPPER	19.2	NA	-		2.9E+03	6.6E-03	16.4
IRON	35800	NA	-		2.3E+04	1.6E+00	27700
LEAD	35	NA	-		NA	-	11.7
MANGANESE	4690	NA	-	neurological	1.8E+03	2.6E+00	376
NICKEL	15.6	NA	-	body weight	1.6E+03	9.8E-03	13.1
SELENIUM	0.58	NA	-		3.9E+02	1.5E-03	ND
SILVER	0.11	NA	-	skin	3.9E+02	2.8E-04	0.05
THALLIUM	0.3	NA	-		5.2E+00	5.8E-02	0.27
VANADIUM	55.9	NA	-		5.5E+02	1.0E-01	42.4
ZINC	68.8	NA	-	blood	2.3E+04	3.0E-03	35.3
	Total Carcinogenic Risk		2.7E-05		Total HI	5.0E+00	

Target Organ HIs

Total Blood HI =	3.0E-03	Total Gastrointestinal HI =	8.7E-03
Total Cardiovascular HI =	4.8E-01	Total Respiratory HI =	1.3E-01
Total Skin HI =	4.8E-01	Total Neurological HI =	2.6E+00
Total Kidney HI =	2.2E-02	Total Body Weight HI =	9.8E-03

Footnotes:
1 - Region IX - Preliminary Remediation Goals (PRGs) Tables, November 22, 2000.
2 - Primary Target Organs - Integrated Risk Information System (IRIS).
3 - Chromium value based on assumption of 1:6, Chromium VI : Chromium III ratio.
4 - Chromium value based on Chromium VI noncarcinogenic PRG.
5 - PRG is shaded if maximum detected concentration exceeds PRG.
6 - PRG is shaded if maximum detected concentration exceeds 1/10th PRG.
7 - Analyte name is shaded if maximum sample concentration is greater than the Region 9 carcinogenic PRG and/or 1/10th the Region 9 noncarcinogenic PRG.
8 - Carcinogenic PRG values are based on the inhalation cancer slope factor.

Abbreviations:
NA - Not available
ND - Nondetected
PRG - Preliminary Remediation Goal
ILCR - Incremental Lifetime Carcinogenic Risk
HQ - Hazard Quotient
HI - Hazard Index
CVS - Cardiovascular System
GI - Gastrointestinal

TABLE 4-8

SUMMARY OF INDUSTRIAL HUMAN HEALTH RISKS AND HAZARDS FOR PERIMETER SUBSURFACE SOIL
LANDFARM
NSWC CRANE
CRANE, INDIANA

Parameter[7]	Incremental Lifetime Carcinogenic Risk (ILCR)			Estimated Non-Carcinogenic Hazard Quotient (HQ)			Maximum Background Concentration
	Maximum Concentration	PRG - Industrial[1,3,5]	Estimated ILCR	Primary Target Organs[2]	PRG - Industrial[1,4,6]	Estimated HQ	
Surface	(mg/kg)	(mg/kg)			(mg/kg)		(mg/kg)
ARSENIC	10.6	2.7E+00	3.9E-06	CVS, skin	4.4E+02	2.4E-02	6
BARIUM	118	NA	-	kidney	1.2E+05	9.8E-04	94.4
BERYLLIUM[8]	1.3	2.2E+03	5.9E-10	GI	3.7E+03	3.5E-04	0.69
CHROMIUM[8]	30.7	4.5E+02	6.8E-08	respiratory	6.1E+03	5.0E-03	25.5
COBALT	26.2	NA	-		1.2E+05	2.2E-04	9.2
COPPER	19.2	NA	-		7.6E+04	2.5E-04	16.4
IRON	35800	NA	-		6.1E+05	5.9E-02	27700
LEAD	35	NA	-		NA	-	11.7
MANGANESE	4690	NA	-	neurological	3.2E+04	1.5E-01	376
NICKEL	15.6	NA	-	body weight	4.1E+04	3.8E-04	13.1
SELENIUM	0.58	NA	-		1.0E+04	5.8E-05	ND
SILVER	0.11	NA	-	skin	1.0E+04	1.1E-05	0.05
THALLIUM	0.3	NA	-		1.3E+02	2.3E-03	0.27
VANADIUM	55.9	NA	-		1.4E+04	4.0E-03	42.4
ZINC	68.8	NA	-	blood	6.1E+05	1.1E-04	35.3
	Total Carcinogenic Risk		4.0E-06		Total HI	2.4E-01	

Target Organ HIs

Total Blood HI =	1.1E-04	Total Gastrointestinal HI =	3.5E-04
Total Cardiovascular HI =	2.4E-02	Total Respiratory HI =	5.0E-03
Total Skin HI =	2.4E-02	Total Neurological HI =	1.5E-01
Total Kidney HI =	9.8E-04	Total Body Weight HI =	3.8E-04

Footnotes:
1 - Region IX - Preliminary Remediation Goals (PRGs) Tables, November 22, 2000.
2 - Primary Target Organs - Integrated Risk Information System (IRIS).
3 - Chromium value based on assumption of 1:6, Chromium VI : Chromium III ratio.
4 - Chromium value based on Chromium VI noncarcinogenic PRG.
5 - PRG is shaded if maximum detected concentration exceeds PRG.
6 - PRG is shaded if maximum detected concentration exceeds 1/10th PRG.
7 - Analyte name is shaded if maximum sample concentration is greater than the Region 9 carcinogenic PRG and/or 1/10th the Region 9 noncarcinogenic PRG.
8 - Carcinogenic PRG values are based on the inhalation cancer slope factor.

Abbreviations:
NA - Not available
ND - Nondetected
PRG - Preliminary Remediation Goal
ILCR - Incremental Lifetime Carcinogenic Risk
HQ - Hazard Quotient
HI - Hazard Index
CVS - Cardiovascular System
GI - Gastrointestinal

TABLE 4-1A

SUMMARY OF RESIDENTIAL HUMAN HEALTH RISKS AND HAZARDS FOR GRID SURFACE SOIL- EPC = 95% UCL
LANDFARM
NSWC CRANE
CRANE, INDIANA

Parameter[7]	Incremental Lifetime Carcinogenic Risk (ILCR)			Estimated Non-Carcinogenic Hazard Quotient (HQ)			Maximum Background Concentration
	95% UCL	PRG - Residential[1,3,5]	Estimated ILCR	Primary Target Organs[2]	PRG - Residential[1,4,6]	Estimated HQ	
Surface	(mg/kg)	(mg/kg)			(mg/kg)		(mg/kg)
ANTIMONY	3.37	NA	-	blood	3.1E+01	1.1E-01	ND
ARSENIC	12.1	3.9E-01	3.1E-05	CVS, skin	2.2E+01	5.5E-01	6.8
BERYLLIUM[8]	0.979	1.1E+03	8.9E-10	GI	1.5E+02	6.5E-03	0.74
CADMIUM[8]	0.715	1.4E+03	5.1E-10	kidney	3.7E+01	1.9E-02	ND
CHROMIUM[8]	27.7	2.1E+02	1.3E-07	respiratory	2.2E+02	1.3E-01	15.1
COPPER	19.9	NA	-		3.1E+03	6.4E-03	11.3
IRON	26700	NA	-		2.3E+04	1.2E+00	17400
LEAD	23.1	NA	-		NA	-	17.1
MERCURY	0.213	NA	-	neurological	2.3E+01	9.3E-03	0.06
SILVER	19.7	NA	-	skin	3.9E+02	5.1E-02	0.05
VANADIUM	46.6	NA	-		5.5E+02	8.5E-02	32.2
ZINC	71.4	NA	-	blood	2.3E+04	3.1E-03	49.6
		Total Carcinogenic Risk	3.1E-05		Total HI	2.1E+00	

Target Organ HIs

Total Blood HI =	1.1E-01
Total Cardiovascular HI =	5.5E-01
Total Skin HI =	6.0E-01
Total Kidney HI =	1.9E-02
Total Gastrointestinal HI =	6.5E-03
Total Respiratory HI =	1.3E-01
Total Neurological HI =	9.3E-03

Footnotes:
1 - Region IX - Preliminary Remediation Goals (PRGs) Tables, October 1, 2002.
2 - Primary Target Organs - Integrated Risk Information System (IRIS).
3 - Chromium value based on assumption of 1:6, Chromium VI : Chromium III ratio.
4 - Chromium value based on Chromium VI noncarcinogenic PRG.
5 - PRG is shaded if 95% UCL exceeds PRG.
6 - PRG is shaded if 95% UCL exceeds 1/10th PRG.
7 - Analyte name is shaded if 95% UCL is greater than the Region 9 carcinogenic PRG and/or 1/10th the Region 9 noncarcinogenic PRG.
8 - Carcinogenic PRG values are based on the inhalation cancer slope factor.

Abbreviations:
NA - Not available
ND - Nondetected
PRG - Preliminary Remediation Goal
ILCR - Incremental Lifetime Carcinogenic Risk
HQ - Hazard Quotient
HI - Hazard Index
CVS - Cardiovascular System
GI - Gastrointestinal
EPC - Exposure Point Concentration

TABLE 4-2A

SUMMARY OF INDUSTRIAL HUMAN HEALTH RISKS AND HAZARDS FOR GRID SURFACE SOIL - EPC = 95% UCL
LANDFARM
NSWC CRANE
CRANE, INDIANA

Parameter[7]	Incremental Lifetime Carcinogenic Risk (ILCR)			Estimated Non-Carcinogenic Hazard Quotient (HQ)			Maximum Background Concentration
	95% UCL	PRG - Industrial[1,3,5]	Estimated ILCR	Primary Target Organs[2]	PRG - Industrial[1,4,6]	Estimated HQ	
Surface	(mg/kg)	(mg/kg)			(mg/kg)		(mg/kg)
ANTIMONY	3.37	NA	-	blood	4.1E+02	8.2E-03	ND
ARSENIC	12.1	1.6E+00	7.6E-06	CVS, skin	2.6E+02	4.7E-02	6.8
BERYLLIUM[8]	0.979	2.2E+03	4.5E-10	GI	1.9E+03	5.2E-04	0.74
CADMIUM[8]	0.715	3.0E+03	2.4E-10	kidney	4.5E+02	1.6E-03	ND
CHROMIUM[8]	27.7	4.5E+02	6.2E-08	respiratory	2.5E+03	1.1E-02	15.1
COPPER	19.9	NA	-		4.1E+04	4.9E-04	11.3
IRON	26700	NA	-		3.1E+05	8.6E-02	17400
LEAD	23.1	NA	-		NA	-	17.1
MERCURY	0.213	NA	-	neurological	3.1E+02	6.9E-04	0.06
SILVER	19.7	NA	-	skin	5.1E+03	3.9E-03	0.05
VANADIUM	46.6	NA	-		7.2E+03	6.5E-03	32.2
ZINC	71.4	NA	-	blood	3.1E+05	2.3E-04	49.6
		Total Carcinogenic Risk	7.6E-06		Total HI	1.7E-01	

Total Blood HI =	8.4E-03
Total Cardiovascular HI =	4.7E-02
Total Skin HI =	5.0E-02
Total Kidney HI =	1.6E-03

Total Gastrointestinal HI =	5.2E-04
Total Respiratory HI =	1.1E-02
Total Neurological HI =	6.9E-04

Footnotes:
1 - Region IX - Preliminary Remediation Goals (PRGs) Tables, October 1, 2002.
2 - Primary Target Organs - Integrated Risk Information System (IRIS).
3 - Chromium value based on assumption of 1:6, Chromium VI : Chromium III ratio.
4 - Chromium value based on Chromium VI noncarcinogenic PRG.
5 - PRG is shaded if 95% UCL exceeds PRG.
6 - PRG is shaded if 95% UCL exceeds 1/10th PRG.
7 - Analyte name is shaded if 95% UCL is greater than the Region 9 carcinogenic PRG and/or 1/10th the Region 9 noncarcinogenic PRG.
8 - Carcinogenic PRG values are based on the inhalation cancer slope factor.

Abbreviations:
NA - Not available
ND - Nondetected
PRG - Preliminary Remediation Goal
ILCR - Incremental Lifetime Carcinogenic Risk
HQ - Hazard Quotient
HI - Hazard Index
CVS - Cardiovascular System
GI - Gastrointestinal
EPC - Exposure Point Concentration

TABLE 4-3A

SUMMARY OF RESIDENTIAL HUMAN HEALTH RISKS AND HAZARDS FOR GRID SUBSURFACE SOIL - EPC = 95% UCL
LANDFARM
NSWC CRANE
CRANE, INDIANA

Parameter[7]	Incremental Lifetime Carcinogenic Risk (ILCR)			Estimated Non-Carcinogenic Hazard Quotient (HQ)			Maximum Background Concentration
	95% UCL	PRG - Residential[1,3,5]	Estimated ILCR	Primary Target Organs[2]	PRG - Residential[1,4,6]	Estimated HQ	
Subsurface	(mg/kg)	(mg/kg)			(mg/kg)		(mg/kg)
ARSENIC	9.88	3.9E-01	2.5E-05	CVS, skin	2.2E+01	4.5E-01	6
BARIUM	111	NA	-	kidney	5.4E+03	2.1E-02	94.4
BERYLLIUM[8]	0.958	1.1E+03	8.7E-10	GI	1.5E+02	6.4E-03	0.69
CADMIUM[8]	0.366	1.4E+03	2.6E-10	kidney	3.7E+01	9.9E-03	ND
CHROMIUM[8]	26.2	2.1E+02	1.2E-07	respiratory	2.2E+02	1.2E-01	25.5
COBALT[8]	7.94	9.0E+02	8.8E-09		1.4E+03	5.7E-03	9.2
COPPER	16.2	NA	-		3.1E+03	5.2E-03	16.4
IRON	31000	NA	-		2.3E+04	1.3E+00	27700
LEAD	16.9	NA	-		NA	-	11.7
MANGANESE	552	NA	-	neurological	5.2E+03	1.1E-01	376
NICKEL	15.5	NA	-	body weight	1.6E+03	9.7E-03	13.1
SELENIUM	0.29	NA	-		3.9E+02	7.4E-04	ND
SILVER	0.0758	NA	-	skin	3.9E+02	1.9E-04	0.05
THALLIUM	0.276	NA	-		5.2E+00	5.3E-02	0.27
VANADIUM	48.2	NA	-		5.5E+02	8.8E-02	42.4
ZINC	53.7	NA	-	blood	2.3E+04	2.3E-03	35.3
		Total Carcinogenic Risk	2.5E-05		Total HI	2.2E+00	

Total Blood HI =	2.3E-03
Total Cardiovascular HI =	4.5E-01
Total Skin HI =	4.5E-01
Total Kidney HI =	3.0E-02

Total Gastrointestinal HI =	6.4E-03
Total Respiratory HI =	1.2E-01
Total Neurological HI =	1.1E-01
Total Body Weight HI =	9.7E-03

Footnotes:
1 - Region IX - Preliminary Remediation Goals (PRGs) Tables, October 1, 2002.
2 - Primary Target Organs - Integrated Risk Information System (IRIS).
3 - Chromium value based on assumption of 1:6, Chromium VI : Chromium III ratio.
4 - Chromium value based on Chromium VI noncarcinogenic PRG.
5 - PRG is shaded if 95% UCL exceeds PRG.
6 - PRG is shaded if 95% UCL exceeds 1/10th PRG.
7 - Analyte name is shaded if 95% UCL is greater than the Region 9 carcinogenic PRG and/or 1/10th the Region 9 noncarcinogenic PRG.
8 - Carcinogenic PRG values are based on the inhalation cancer slope factor.

Abbreviations:
NA - Not available
ND - Nondetected
PRG - Preliminary Remediation Goal
ILCR - Incremental Lifetime Carcinogenic Risk
HQ - Hazard Quotient
HI - Hazard Index
CVS - Cardiovascular System
GI - Gastrointestinal
EPC - Exposure Point Concentration

TABLE 4-4A

SUMMARY OF INDUSTRIAL HUMAN HEALTH RISKS AND HAZARDS FOR GRID SUBSURFACE SOIL - EPC = 95% UCL
LANDFARM
NSWC CRANE
CRANE, INDIANA

Parameter[7]	Incremental Lifetime Carcinogenic Risk (ILCR)			Estimated Non-Carcinogenic Hazard Quotient (HQ)			Maximum Background Concentration
	95% UCL	PRG - Industrial[1,3,5]	Estimated ILCR	Primary Target Organs[2]	PRG - Industrial[1,4,6]	Estimated HQ	
Subsurface	(mg/kg)	(mg/kg)			(mg/kg)		(mg/kg)
ARSENIC	9.88	1.6E+00	6.2E-06	CVS, skin	2.6E+02	3.8E-02	6
BARIUM	111	NA	-	kidney	6.7E+04	1.7E-03	94.4
BERYLLIUM[8]	0.958	2.2E+03	4.4E-10	GI	1.9E+03	5.0E-04	0.69
CADMIUM[8]	0.366	3.0E+03	1.2E-10	kidney	4.5E+02	8.1E-04	ND
CHROMIUM[8]	26.2	4.5E+02	5.8E-08	respiratory	2.5E+03	1.0E-02	25.5
COBALT[8]	7.94	1.9E+03	4.2E-09		1.3E+04	6.1E-04	9.2
COPPER	16.2	NA	-		4.1E+04	4.0E-04	16.4
IRON	31000	NA	-		3.1E+05	1.0E-01	27700
LEAD	16.9	NA	-		NA	-	11.7
MANGANESE	552	NA	-	neurological	1.9E+04	2.9E-02	376
NICKEL	15.5	NA	-	body weight	2.0E+04	7.8E-04	13.1
SELENIUM	0.29	NA	-		5.1E+03	5.7E-05	ND
SILVER	0.0758	NA	-	skin	5.1E+03	1.5E-05	0.05
THALLIUM	0.276	NA	-		6.7E+01	4.1E-03	0.27
VANADIUM	48.2	NA	-		7.2E+03	6.7E-03	42.4
ZINC	53.7	NA	-	blood	3.1E+05	1.7E-04	35.3
	Total Carcinogenic Risk		6.2E-06		Total HI	1.9E-01	

Total Blood HI =	1.7E-04
Total Cardiovascular HI =	3.8E-02
Total Skin HI =	3.8E-02
Total Kidney HI =	2.5E-03

Total Gastrointestinal HI =	5.0E-04
Total Respiratory HI =	1.0E-02
Total Neurological HI =	2.9E-02
Total Body Weight HI =	7.8E-04

Footnotes:
1 - Region IX - Preliminary Remediation Goals (PRGs) Tables, October 1, 2002.
2 - Primary Target Organs - Integrated Risk Information System (IRIS).
3 - Chromium value based on assumption of 1:6, Chromium VI : Chromium III ratio.
4 - Chromium value based on Chromium VI noncarcinogenic PRG.
5 - PRG is shaded if 95% UCL exceeds PRG.
6 - PRG is shaded if 95% UCL exceeds 1/10th PRG.
7 - Analyte name is shaded if 95% UCL is greater than the Region 9 carcinogenic PRG and/or 1/10th the Region 9 noncarcinogenic PRG.
8 - Carcinogenic PRG values are based on the inhalation cancer slope factor.

Abbreviations:
NA - Not available
ND - Nondetected
PRG - Preliminary Remediation Goal
ILCR - Incremental Lifetime Carcinogenic Risk
HQ - Hazard Quotient
HI - Hazard Index
CVS - Cardiovascular System
GI - Gastrointestinal
EPC - Exposure Point Concentration

TABLE 4-5A

SUMMARY OF RESIDENTIAL HUMAN HEALTH RISKS AND HAZARDS FOR PERIMETER SURFACE SOIL - EPC = 95% UCL
LANDFARM
NSWC CRANE
CRANE, INDIANA

Parameter[7]	Incremental Lifetime Carcinogenic Risk (ILCR)			Estimated Non-Carcinogenic Hazard Quotient (HQ)			Maximum Background Concentration
	95% UCL	PRG - Residential[1,3,5]	Estimated ILCR	Primary Target Organs[2]	PRG - Residential[1,4,6]	Estimated HQ	
Surface	(mg/kg)	(mg/kg)			(mg/kg)		(mg/kg)
ARSENIC	7.85	3.9E-01	2.0E-05	CVS, skin	2.2E+01	3.6E-01	6.8
BERYLLIUM[8]	0.941	1.1E+03	8.6E-10	GI	1.5E+02	6.3E-03	0.74
CADMIUM[8]	0.493	1.4E+03	3.5E-10	kidney	3.7E+01	1.3E-02	ND
CHROMIUM[8]	21.6	2.1E+02	1.0E-07	respiratory	2.2E+02	9.8E-02	15.1
COPPER	16.2	NA	-		3.1E+03	5.2E-03	11.3
IRON	20600	NA	-		2.3E+04	9.0E-01	17400
LEAD	19.5	NA	-		NA	-	17.1
MERCURY	0.054	NA	-	neurological	2.3E+01	2.3E-03	0.06
SILVER	5.8	NA	-	skin	3.9E+02	1.5E-02	0.05
VANADIUM	39.4	NA	-		5.5E+02	7.2E-02	32.2
ZINC	59.1	NA	-	blood	2.3E+04	2.6E-03	49.6
		Total Carcinogenic Risk	2.0E-05		Total HI	1.5E+00	

Target Organ HIs

Total Blood HI =	2.6E-03
Total Cardiovascular HI =	3.6E-01
Total Skin HI =	3.7E-01
Total Kidney HI =	1.3E-02
Total Gastrointestinal HI =	6.3E-03
Total Respiratory HI =	9.8E-02
Total Neurological HI =	2.3E-03

Footnotes:
1 - Region IX - Preliminary Remediation Goals (PRGs) Tables, October 1, 2002.
2 - Primary Target Organs - Integrated Risk Information System (IRIS).
3 - Chromium value based on assumption of 1:6, Chromium VI : Chromium III ratio.
4 - Chromium value based on Chromium VI noncarcinogenic PRG.
5 - PRG is shaded if 95% UCL exceeds PRG.
6 - PRG is shaded if 95% UCL exceeds 1/10th PRG.
7 - Analyte name is shaded if 95% UCL is greater than the Region 9 carcinogenic PRG and/or 1/10th the Region 9 noncarcinogenic PRG.
8 - Carcinogenic PRG values are based on the inhalation cancer slope factor.

Abbreviations:
NA - Not available
ND - Nondetected
PRG - Preliminary Remediation Goal
ILCR - Incremental Lifetime Carcinogenic Risk
HQ - Hazard Quotient
HI - Hazard Index
CVS - Cardiovascular System
GI - Gastrointestinal
EPC - Exposure Point Concentration

TABLE 4-6A

SUMMARY OF INDUSTRIAL HUMAN HEALTH RISKS AND HAZARDS FOR PERIMETER SURFACE SOIL - EPC = 95% UCL
LANDFARM
NSWC CRANE
CRANE, INDIANA

Parameter[7]	Incremental Lifetime Carcinogenic Risk (ILCR)			Estimated Non-Carcinogenic Hazard Quotient (HQ)			Maximum Background Concentration
	95% UCL	PRG - Industrial[1,3,5]	Estimated ILCR	Primary Target Organs[2]	PRG - Industrial[1,4,6]	Estimated HQ	
Surface	(mg/kg)	(mg/kg)			(mg/kg)		(mg/kg)
ARSENIC	7.85	1.6E+00	4.9E-06	CVS, skin	2.6E+02	3.0E-02	6.8
BERYLLIUM[8]	0.941	2.2E+03	4.3E-10	GI	1.9E+03	5.0E-04	0.74
CADMIUM[8]	0.493	3.0E+03	1.6E-10	kidney	4.5E+02	1.1E-03	ND
CHROMIUM[8]	21.6	4.5E+02	4.8E-08	respiratory	2.5E+03	8.6E-03	15.1
COPPER	16.2	NA	-		4.1E+04	4.0E-04	11.3
IRON	20600	NA	-		3.1E+05	6.6E-02	17400
LEAD	19.5	NA	-		NA	-	17.1
MERCURY	0.054	NA	-	neurological	3.1E+02	1.7E-04	0.06
SILVER	5.8	NA	-	skin	5.1E+03	1.1E-03	0.05
VANADIUM	39.4	NA	-		7.2E+03	5.5E-03	32.2
ZINC	59.1	NA	-	blood	3.1E+05	1.9E-04	49.6
	Total Carcinogenic Risk		5.0E-06		Total HI	1.1E-01	

Target Organ HIs

Total Blood HI =	1.9E-04	Total Gastrointestinal HI =	5.0E-04
Total Cardiovascular HI =	3.0E-02	Total Respiratory HI =	8.6E-03
Total Skin HI =	3.1E-02	Total Neurological HI =	1.7E-04
Total Kidney HI =	1.1E-03		

Footnotes:
1 - Region IX - Preliminary Remediation Goals (PRGs) Tables, October 1, 2002.
2 - Primary Target Organs - Integrated Risk Information System (IRIS).
3 - Chromium value based on assumption of 1:6, Chromium VI : Chromium III ratio.
4 - Chromium value based on Chromium VI noncarcinogenic PRG.
5 - PRG is shaded if 95% UCL exceeds PRG.
6 - PRG is shaded if 95% UCL exceeds 1/10th PRG.
7 - Analyte name is shaded if 95% UCL is greater than the Region 9 carcinogenic PRG and/or 1/10th the Region 9 noncarcinogenic PRG.
8 - Carcinogenic PRG values are based on the inhalation cancer slope factor.

Abbreviations:
NA - Not available
ND - Nondetected
PRG - Preliminary Remediation Goal
ILCR - Incremental Lifetime Carcinogenic Risk
HQ - Hazard Quotient
HI - Hazard Index
CVS - Cardiovascular System
GI - Gastrointestinal
EPC - Exposure Point Concentration

TABLE 4-7A

SUMMARY OF RESIDENTIAL HUMAN HEALTH RISKS AND HAZARDS FOR PERIMETER SUBSURFACE SOIL - EPC = 95% UCL
LANDFARM
NSWC CRANE
CRANE, INDIANA

Parameter[7]	Incremental Lifetime Carcinogenic Risk (ILCR)			Estimated Non-Carcinogenic Hazard Quotient (HQ)			Maximum Background Concentration
	95% UCL	PRG - Residential[1,3,5]	Estimated ILCR	Primary Target Organs[2]	PRG - Residential[1,4,6]	Estimated HQ	
Surface	(mg/kg)	(mg/kg)			(mg/kg)		(mg/kg)
ARSENIC	10.4	3.9E-01	2.7E-05	CVS, skin	2.2E+01	4.7E-01	6
BARIUM	102	NA	-	kidney	5.4E+03	1.9E-02	94.4
BERYLLIUM[8]	1.16	1.1E+03	1.1E-09	GI	1.5E+02	7.7E-03	0.69
CHROMIUM[8]	27.9	2.1E+02	1.3E-07	respiratory	2.2E+02	1.3E-01	25.5
COBALT	10.2	9.0E+02	1.1E-08		1.4E+03	7.3E-03	9.2
COPPER	17.9	NA	-		3.1E+03	5.8E-03	16.4
IRON	34800	NA	-		2.3E+04	1.5E+00	27700
LEAD	27.7	NA	-		NA	-	11.7
MANGANESE	1148	NA	-	neurological	5.2E+03	2.2E-01	376
NICKEL	14.4	NA	-	body weight	1.6E+03	9.0E-03	13.1
SELENIUM	0.27	NA	-		3.9E+02	6.9E-04	ND
SILVER	0.0883	NA	-	skin	3.9E+02	2.3E-04	0.05
THALLIUM	0.294	NA	-		5.2E+00	5.7E-02	0.27
VANADIUM	46.7	NA	-		5.5E+02	8.5E-02	42.4
ZINC	63.1	NA	-	blood	2.3E+04	2.7E-03	35.3
	Total Carcinogenic Risk		2.7E-05		Total HI	2.5E+00	

Target Organ HIs

Total Blood HI =	2.7E-03	Total Gastrointestinal HI =	7.7E-03
Total Cardiovascular HI =	4.7E-01	Total Respiratory HI =	1.3E-01
Total Skin HI =	4.7E-01	Total Neurological HI =	2.2E-01
Total Kidney HI =	1.9E-02	Total Body Weight HI =	9.0E-03

Footnotes:
1 - Region IX - Preliminary Remediation Goals (PRGs) Tables, October 1, 2002.
2 - Primary Target Organs - Integrated Risk Information System (IRIS).
3 - Chromium value based on assumption of 1:6, Chromium VI : Chromium III ratio.
4 - Chromium value based on Chromium VI noncarcinogenic PRG.
5 - PRG is shaded if 95% UCL exceeds PRG.
6 - PRG is shaded if 95% UCL exceeds 1/10th PRG.
7 - Analyte name is shaded if 95% UCL is greater than the Region 9 carcinogenic PRG and/or 1/10th the Region 9 noncarcinogenic PRG.
8 - Carcinogenic PRG values are based on the inhalation cancer slope factor.

Abbreviations:
NA - Not available
ND - Nondetected
PRG - Preliminary Remediation Goal
ILCR - Incremental Lifetime Carcinogenic Risk
HQ - Hazard Quotient
HI - Hazard Index
CVS - Cardiovascular System
GI - Gastrointestinal
EPC - Exposure Point Concentration

TABLE 4-8A

SUMMARY OF INDUSTRIAL HUMAN HEALTH RISKS AND HAZARDS FOR PERIMETER SUBSURFACE SOIL - EPC = 95% UCL
LANDFARM
NSWC CRANE
CRANE, INDIANA

Parameter[7]	Incremental Lifetime Carcinogenic Risk (ILCR)			Estimated Non-Carcinogenic Hazard Quotient (HQ)			Maximum Background Concentration
	95% UCL	PRG - Industrial[1,3,5]	Estimated ILCR	Primary Target Organs[2]	PRG - Industrial[1,4,6]	Estimated HQ	
Surface	(mg/kg)	(mg/kg)			(mg/kg)		(mg/kg)
ARSENIC	10.4	1.6E+00	6.5E-06	CVS, skin	2.6E+02	4.0E-02	6
BARIUM	102	NA	-	kidney	6.7E+04	1.5E-03	94.4
BERYLLIUM[8]	1.16	2.2E+03	5.3E-10	GI	1.9E+03	6.1E-04	0.69
CHROMIUM[8]	27.9	4.5E+02	6.2E-08	respiratory	2.5E+03	1.1E-02	25.5
COBALT	10.2	1.9E+03	5.4E-09		1.3E+04	7.8E-04	9.2
COPPER	17.9	NA	-		4.1E+04	4.4E-04	16.4
IRON	34800	NA	-		3.1E+05	1.1E-01	27700
LEAD	27.7	NA	-		NA	-	11.7
MANGANESE	1148	NA	-	neurological	1.9E+04	6.0E-02	376
NICKEL	14.4	NA	-	body weight	2.0E+04	7.2E-04	13.1
SELENIUM	0.27	NA	-		5.1E+03	5.3E-05	ND
SILVER	0.0883	NA	-	skin	5.1E+03	1.7E-05	0.05
THALLIUM	0.294	NA	-		6.7E+01	4.4E-03	0.27
VANADIUM	46.7	NA	-		7.2E+03	6.5E-03	42.4
ZINC	63.1	NA	-	blood	3.1E+05	2.0E-04	35.3
	Total Carcinogenic Risk		6.6E-06		Total HI	2.4E-01	

Target Organ HIs

Total Blood HI =	2.0E-04	Total Gastrointestinal HI =	6.1E-04
Total Cardiovascular HI =	4.0E-02	Total Respiratory HI =	1.1E-02
Total Skin HI =	4.0E-02	Total Neurological HI =	6.0E-02
Total Kidney HI =	1.5E-03	Total Body Weight HI =	7.2E-04

Footnotes:
1 - Region IX - Preliminary Remediation Goals (PRGs) Tables, October 1, 2002.
2 - Primary Target Organs - Integrated Risk Information System (IRIS).
3 - Chromium value based on assumption of 1:6, Chromium VI : Chromium III ratio.
4 - Chromium value based on Chromium VI noncarcinogenic PRG.
5 - PRG is shaded if 95% UCL exceeds PRG.
6 - PRG is shaded if 95% UCL exceeds 1/10th PRG.
7 - Analyte name is shaded if 95% UCL is greater than the Region 9 carcinogenic PRG and/or 1/10th the Region 9 noncarcinogenic PRG.
8 - Carcinogenic PRG values are based on the inhalation cancer slope factor.

Abbreviations:
NA - Not available
ND - Nondetected
PRG - Preliminary Remediation Goal
ILCR - Incremental Lifetime Carcinogenic Risk
HQ - Hazard Quotient
HI - Hazard Index
CVS - Cardiovascular System
GI - Gastrointestinal
EPC - Exposure Point Concentration

5.0 ECOLOGICAL RISK SCREENING EVALUATION

This section presents the results of an ecological risk screening evaluation (ERSE) of metals concentrations detected in the surface soil samples within the Landfarm (i.e., the grid samples) and at the perimeter of (the Landfarm). This ERSE is limited to a comparison of maximum and arithmetic mean metals concentrations to ecological screening benchmarks typically used in ecological risk assessments prepared for regulatory review within EPA Region 5. It does not include a detailed discussion of habitats and ecological receptors, and also does not include food chain modeling calculations. The objective of this assessment is to determine if metals concentrations at the Landfarm are significant enough to warrant further evaluation (i.e., do chemicals of potential concern exist?). A brief site description and discussion of potential ecological receptors of concern and exposure pathways is presented in Sections 5.1 and 5.2, respectively. The analytical results for the soils samples collected at the Landfarm were presented in Section 3. The comparison of maximum and arithmetic mean metals concentrations to the aforementioned ecological screening benchmarks is presented in Section 5.3. Summary and conclusions are presented in Section 5.4.

5.1 SITE DESCRIPTION

As described in more detail in Section 1 of the Phase II Ground Water RFI SWMU 30 (Landfarm) (TtNUS, 2001), the Landfarm is located in the west central part of the NSWC Crane and is approximately 2.5 acres in area. The site is lightly vegetated and is bound on the north and south by forested areas. Above ground, high-voltage power lines cross the site from east to west. Topographically the site is relatively flat. Ground surface elevations for the Landfarm range from about 703 feet above mean sea level (ftMSL) at location 30-7 to 718 ftMSL at location 30-3. A hill is located north-northeast of the site which slopes gently toward the Landfarm.

5.2 POTENTIAL ECOLOGICAL RECEPTORS AND EXPOSURE PATHWAYS

Based on the description of the site found in Section 1, ecological receptors could be directly exposed to chemicals in the surface soils at the Landfarm (i.e., plants and soil invertebrates) or indirectly via the food chain (i.e., through the ingestion of plants and invertebrates). The primary ecological receptors of concern are:

- Soil invertebrates
- Soil vegetation

- Small invertebrate eating mammals and birds
- Small herbivorous eating mammals or birds

Large herbivorous mammals may visit and graze at the site; however, the Landfarm (2.5 acres) would comprise only a portion of the territory needed to maintain such animals or the larger omnivores or predatory animals and birds.

5.3 ECOLOGICAL SCREENING

The risk screening summarized in Tables 5-1 and 5-2 was performed by comparing maximum and arithmetic mean metals concentrations to the following ecological screening benchmarks for surface soil:

- EPA Region 5 Ecological Data Quality Levels (EDQLs) for Ecological Receptors – These levels were developed to protect soil invertebrates, plants, and terrestrial wildlife from exposure to chemical concentrations in the soil (U.S. EPA, 1999). The lower of the screening values to protect each of the above endpoints was selected as the EDQL.

- Soil Remediation Target Values (SRTV)/Soil Remediation Intervention Values (SRIV) - The Intervention Values and Target Values – Soil Quality Standards were developed by the Netherlands Ministry of Housing, Spatial Planning, and Environment, Department of Soil Protection and will be referred to as the Dutch Screening Values (MHSPE, 2000). The Dutch Screening Values for surface soil consist of Target Values and Intervention Values. The Target Values are the soil quality levels that are ultimately desired (MHSPE, 2000). The values for heavy metals, arsenic, and fluoride were derived from analysis of field data from relatively pollution-free rural areas. The Intervention Values indicate the "concentration levels of the contaminants in the soil above which the functionality of the soil for human, plant, or animal life is seriously impaired or threatened" (MHSPE, 2000).

- Canadian Soil Quality Guidelines (CSQG) - The Canadian Soil Quality Guidelines were developed by the Canadian Council of Ministers of the Environment (CCME, 1997). They are derived using toxicological data to determine the threshold level for key receptors (CCME, 1997). The values are calculated for four land uses: agricultural, residential/parkland, commercial, and industrial. Exposure from direct soil contact is used to derive guidelines for the residential/parkland, commercial, and industrial land uses (CCME, 1997). However, the soil guidelines for the agricultural land use incorporates direct soil contact as well as soil and food ingestion (CCME, 1997).

No screening levels are available for iron from these sources. However, as summarized in Tables 5-1 and 5-2, several metals were detected in the grid or perimeter surface soil samples at concentrations exceeding the EPA Region 5 EDQLs and basewide background soil concentrations (i.e., antimony, arsenic, beryllium, cadmium, chromium, copper, lead, mercury, silver, vanadium, and zinc). The EPA Region 5 EDQLs are the most conservative screening levels presented in these tables. An exceedance of an EPA Region 5 EDQL is not necessarily indicative of a potential for ecological risk at a site because:

- EDQLs represent the lowest screening levels found in the literature for any receptor, are not always applicable to site receptors and conditions, and
- EDQLs are often less than base-specific background concentrations.

The key is to determine the degree of the exceedance and compare the value to the potential ecological impact of the exceedance.

The following paragraphs discuss each of the metals exceeding the EPA Region 5 EDQLs, the alternative screening levels (i.e., SRTV, CSQG, and SRIV), and background concentrations.

Antimony was detected in one of the 12 grid samples and in none of the perimeter samples. The detection (6 mg/kg) did exceed the EPA Region 5 EDQL (0.1423 mg/kg) and the SRTV (3 mg/kg); but, not the SRIV (15 mg/kg). The average concentration in the grid soil samples (1.84 mg/kg) is less than the SRTV. Antimony is not recommended as a COPC for further evaluation because of the low frequency of detection.

Arsenic (C_{max} = 22.4 mg/kg) was detected in 10 of 12 grid and 5 of 6 perimeter surface soil samples at concentrations exceeding the Region 5 EDQL (5.7 mg/kg). However, none of the reported results exceed the alternative screening criteria. Additionally, with the exception of the maximum detected concentration, all results are similar to or within 2 times the maximum background concentration. For these reasons, arsenic is not recommended as a COPC. The maximum arsenic concentration is above the CSQG of 19.

Beryllium was detected in all 12 grid samples and all 6 perimeter samples. However, only the maximum detected concentrations in the grid (1.5 mg/kg) and perimeter (1.1 mg/kg) samples marginally exceed the EPA Region 5 EDQL (1.06 mg/kg) while the arithmetic mean concentrations do not. Beryllium is not recommended as a COPC for further evaluation because of the low frequency of concentrations that exceed the EPA Region 5 EDQL.

Cadmium was detected in five of 12 grid samples (C_{max} = 1.6 mg/kg) and 1 of 6 perimeter (C_{max} = 1 mg/kg) samples. The EDQL for this metal (0.00222 mg/kg) is less than all of the detections reported as well as background concentrations reported in the scientific literature. Consequently, a COPC selection decision is difficult based on this benchmark alone. All positive cadmium results also marginally exceed the SRTV (0.8 mg/kg); however, arithmetic mean concentration does not. None of the analytical results exceed the CSQG or the SRIV criteria. Cadmium is not recommended as a COPC for further evaluation because of the marginal exceedance of the more relevant alternative screening criteria and because, although it exceeds base-specific background concentrations, the detections reported are within the natural background concentration range reported in the literature.

Chromium (C_{max} = 39.3 mg/kg), copper (C_{max} = 38.7 mg/kg), lead (C_{max} = 30.7 mg/kg) and **zinc (C_{max} = 115 mg/kg)** were detected in all 18 surface soil samples (12 grid and 6 perimeter) at concentrations exceeding the EPA Region 5 EDQLs. However, as noted above, the EPA Region 5 EDQLs for all of these metals are less than base-specific background concentrations. The CSQG for chromium (0.4 mg/kg) is also less than base-specific background concentrations. Thus, a COPC selection is difficult based on these benchmarks alone. Chromium, copper, lead, and zinc were not detected at concentrations exceeding the SRTVs or the SRIVs. Chromium, lead, and zinc were not detected at concentrations exceeding the CSQG, while the maximum copper detection only slightly exceeded the CSQC of 36 mg/kg. These metals are not recommended as COPCs for further evaluation because the maximum detected concentrations do not exceed the more relevant alternative screening criteria.

Mercury (C_{max} = 0.41 mg/kg) was detected in 7 of 12 grid surface soil samples at concentrations exceeding the EPA Region 5 EDQL (0.073 mg/kg). Concentrations noted in the perimeter surface soil samples do not exceed the EDQL. However, the arithmetic mean concentration for the grid surface soil samples (0.114 mg/kg) only marginally exceeds the EDQL and only one mercury detection exceeded the SRTV. There were no exceedances of the CSQG or the SRIVs. Mercury is not recommended as a COPC for further evaluation because the maximum detected concentration only exceeds one of the more relevant alternative screening criteria (i.e., the SRTV) and because all detections are less than or within two times the maximum background concentration.

Silver (C_{max} = 19.7mg/kg) was detected in six of the12 grid surface soil samples and in two of the 6 perimeter samples at concentrations exceeding the Region 5 EDQL (2 mg/kg). The arithmetic mean concentration in the grid surface soil samples (7.07 mg/kg) also exceeds the EDQL. SRTL and CSQG values are not available for silver. Two of the silver detections [grid cell locations 4 (19.4 mg/kg) and 10 (19.7 mg/kg)] also exceed the SRIV (15 mg/kg). In contrast to most of the other metals detected in the grid surface soils, the mean silver concentration (7.07 mg/kg) is roughly two orders of magnitude greater

than the maximum silver concentration reported for base-wide background soil samples (0.05 mg/kg). This may be explained, in part, by the results of studies reported in the literature documenting that some soils have a great capacity for retaining silver from waste streams (Hazardous Waste Land Treatment, Edited by Brown et al, 1983, page 291). This same fact may limit the bioavailability of silver to ecological receptors as described below.

Although the silver concentrations are elevated in the soil samples, there are several articles/documents in the literature to indicate that silver in the soil is not expected to be bioavailable or toxic. In the Silver Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review (Eisler, 1996), it is reported that silver in soils is largely immobilized by precipitation to insoluble salts and by complexation or adsorption by organic matter, clays, and manganese oxides. It is also reported in Eisler (1996) that silver thiosulfate from photoprocessing is immobile and should not restrict the use of sludge for the enrichment of soils. A few studies also have evaluated the toxicity of silver in soils. Tests done with lettuce, oats, turnips, and soybeans grown in sewage sludge spiked with photographic silver waste at concentrations up to 155 mg/kg revealed no effect on emergence time and rate, however, there were some decreases in the weight of the plants (Hirsch, 1998). Also, in artificial soil spiked with silver, no effect to earthworms was observed at 62 mg/kg after 28 days, and no effects to earthworms were observed after the worms were exposed to soil containing 2,000 mg/kg for 14 days (Ratte, 1999). Finally, one study reported low biota accumulation factors (BAFs) for silver in plants (BAFs of 0.007 to 0.023) (Hirsch, 1998) and the media BAF for earthworms on a wet weight basis is 0.33 (Sample et al., 1998). Based on the above studies, it does not appear that silver in the soil will be available and/or toxic to plants and invertebrates. Also, the low BAFs would for silver make it unlikely that silver will impact terrestrial receptors feeding on plants growing in the soil. Note that there is some uncertainty in these conclusions because the form of the silver in the soil (i.e., silver thiosulfate, silver sulfide, etc.) is not known.

Vanadium (C_{max} = 60.9 mg/kg) was detected in all 18 surface soil samples at concentrations exceeding the Region 5 EDQL (1.59 mg/kg). However, the EDQL is less than the maximum background concentration (32.2 mg/kg). Vanadium concentrations detected at five grid cell locations also exceed the SRTL (42 mg/kg); the arithmetic mean concentration does not exceed the SRTL. None of the reported results exceed the CSQG (130 mg/kg) or the SRIV (250 mg/kg). Vanadium is not recommended as a COPC for further evaluation because the arithmetic mean concentration is less than all of the more relevant alternative screening criteria and because all detections are less than or within two times the maximum background concentration.

5.4 SUMMARY AND CONCLUSIONS

Silver is the only metal detected in the Landfarm surface soils at concentrations that may cause a risk to ecological receptors. Concentrations reported for many sample locations exceed the maximum background concentration by an order of magnitude or more, while samples in two grid cells had silver concentrations greater than the soil remediation intervention value, which is indicative of serious contamination. However, based on a review of the literature, it is unlikely that the silver in the soil will be available and thus toxic to ecological receptors, although there is some uncertainty in this conclusion. Therefore, the elevated detections of silver in the soil do not warrant further evaluation.

Finally, while several other metals were also detected at concentrations exceeding background and the EPA Region 5 EDQLs, there were few exceedances of alternative screening values referenced in this ecological risk screening evaluation. Also, in most cases the detected concentrations are within 2 or 3 times the maximum base-wide background concentration. Therefore, risks from these other metals are low and do not warrant further evaluation.

TABLE 5-1

EXCEEDANCES OF ECOLOGICAL CRITERIA FOR GRID SURFACE SOIL
CRANE LAND FARM
NSWC CRANE
CRANE, INDIANA

Parameter	Maximum Background Concentration	Mean	Minimum Detection	Maximum Detection	Location of Maximum Detection	Frequency of Detection	Surface Soil COPC Screening Level	# Exceed	Soil remediation target values	# Exceed	Canadian Soil Quality Guidelines	# Exceed	Soil remediation intervention values/indicative level serious contamination	# Exceed
Inorganics (mg/kg)														
ANTIMONY	ND	1.84	6	6	30CP080001	1/12	0.1423	1	3	1	---		15	
ARSENIC	6.8	9.22	5.1	22.4	30CP100001	12/12	5.7	10	29		19	0	55	
BERYLLIUM	0.74	0.840	0.52	1.5	30CP100001	12/12	1.06	1	1.1	1	---		30(1)	
CADMIUM	ND	0.680	0.81	1.6	30CP100001	5/12	0.00222	6	0.8	6	3.8		12	
CHROMIUM	15.1	24.4	16.6	39.3	30CP100001	12/12	0.4	12	100		0.4	12	380	
COPPER	11.3	19.3	13.4	38.7	30CP100001	12/12	2.96	12	36	1	63		190	
IRON	17400	21717	12900	42500	30CP100001	12/12	---		---		---		---	
LEAD	17.1	19.9	12	30.7	30CP100001	12/12	0.05373	12	85		70		530	
MERCURY	0.06	0.114	0.05	0.41	30CP100001	10/12	0.073	7	0.3	1	10		10	
SILVER	0.05	7.07	0.75	19.7	30CP100001	10/12	2	6	---		---		15(1)	2
VANADIUM	32.2	40.4	27.9	60.9	30CP100001	12/12	1.59	12	42	5	130		250(1)	
ZINC	49.6	69.9	55	115	30CP100001	12/12	6.62	12	140		200		720	

1 - Value based on Indicative Level Serious Contamination criteria so is not very reliable by itself.

TABLE 5-2

EXCEEDANCES OF ECOLOGICAL CRITERIA FOR PERIMETER SURFACE SOIL
CRANE LAND FARM
NSWC CRANE
CRANE, INDIANA

Parameter	Maximum Background Concentration	Mean	Minimum Detection	Maximum Detection	Location of Maximum Detection	Frequency of Detection	Surface Soil COPC Screening Level	# Exceed	Soil remediation target values	# Exceed	Canadian Soil Quality Guidelines	# Exceed	Soil remediation intervention values/indicative level serious contamination	# Exceed
Inorganics (mg/kg)														
ANTIMONY	ND	0.680	---	---	---	0/6	0.1423		3		---		15	
ARSENIC	6.8	6.77	4.8	8.8	30SS020001	6/6	5.7	5	29		19		55	
BERYLLIUM	0.74	0.750	0.48	1.1	30SS020001	6/6	1.06	1	1.1		---		30(1)	
CADMIUM	ND	0.464	1	1	30SS030001	1/6	0.00222	1	0.8	1	3.8		12	
CHROMIUM	15.1	19.7	17.9	23	30SS060001	6/6	0.4	6	100		0.4	6	380	
COPPER	11.3	11.9	7.4	16.5	30SS030001	6/6	2.96	6	36		63		190	
IRON	17400	18000	13300	20600	30SS050001	6/6	---		---		---		---	
LEAD	17.1	16.3	10.3	21.1	30SS020001	6/6	0.05373	6	85		70		530	
MERCURY	0.06	0.0406	0.031	0.054	30SS030001	5/6	0.073		0.3		10		10	
SILVER	0.05	1.44	0.22	5.8	30SS030001	3/6	2	2	---		---		15(1)	
VANADIUM	32.2	35.1	26.7	40.7	30SS060001	6/6	1.59	6	42		130		250(1)	
ZINC	49.6	49.9	38.9	60.5	30SS030001	6/6	6.62	6	140		200		720	

1 - Value based on Indicative Level Serious Contamination criteria so is not very reliable by itself.

6.0 CONCLUSIONS AND RECOMMENDATIONS

As discussed in Section 3, data evaluation resulted in eliminating aluminum, cyanide and the macronutrients from the risk screening process. Data sets to be used in the risk screening process were created in accordance with statistical findings and then compared to Base-Wide Background sample sets as well as each other to further investigate chemicals that could show potential concern at SWMU 30. Six analytes were found not to be statistically greater than background in the surface soils (barium, cobalt, manganese, nickel, selenium, and thallium), and only mercury was eliminated by the WRS test as not greater than background in subsurface samples. Antimony, arsenic, beryllium, cadmium, chromium, copper, iron, lead, mercury, silver, vanadium, and zinc were found to be statistically greater than background in grid surface soils. Surface soil samples were found to be different comparing grid samples to the perimeter samples for six analytes (antimony, chromium, copper, mercury, silver, and zinc) showing that the grid samples were elevated in surface soils compared to the perimeter. No evidence was found for any differences between the grid and perimeter samples in subsurface soil.

As part of the HHSE, antimony, arsenic, chromium, iron, manganese, and vanadium were the only metals detected in soils at concentrations exceeding screening levels typically recommended by EPA Region 5 for selection of COPCs for human health risk assessment. Cancer risk estimates developed for the hypothetical future resident and typical industrial worker do not exceed the risk management range (1E-04 to 1E-06) often used by EPA to determine the need for environmental remediation or to set environmental standards and criteria. Non-cancer risk estimates indicate a marginal exceedance of the EPA non-carcinogenic benchmark (a hazard index of 1) when the hypothetical future resident is evaluated. Non-cancer risk estimates do not exceed the benchmark when the typical industrial worker is evaluated. The non-cancer risk estimates were developed in a very conservative manner - assuming that a human receptor is exposed to the maximum detected concentration and very conservative toxicity benchmarks were used to evaluate iron and manganese. Consequently, the non-cancer risk results are likely to be over estimated.

° From an ecological perspective, silver is the only metal detected in the Landfarm surface soils at concentrations that may cause a risk to ecological receptors. Concentrations reported for many sample locations exceed the maximum background concentration by an order of magnitude or more, while samples in two grid cells had silver concentrations greater than the soil remediation intervention value, which is indicative of serious contamination. However, based on a review of the literature, it is unlikely that the silver in the soil will be available and thus toxic to ecological receptors, although there is some

uncertainty in this conclusion. Therefore, the elevated detections of silver in the soil do not warrant further evaluation.

While several other metals were also detected at concentrations exceeding background and the EPA Region 5 EDQLs, there were few exceedances of alternative screening values referenced in the ecological risk screening evaluation (Section 5). Also, in most cases the detected concentrations were within 2 or 3 times the maximum Base-Wide Background concentration. Therefore, risks from these other metals are low and do not warrant further evaluation.

Based upon the results of this soil investigation, the Navy believes that human health and ecological risks are within an acceptable range and do not warrant further investigation. The ground water data do not indicate that the soils have adversely impacted ground water quality (TtNUS, 2001) and there are no significant ground water quality problems in the vicinity of the site. Therefore, no remedial actions are warranted for ground water or soils at the site and a recommendation for No Further Action is requested by the Navy. This No Further Action request is for all media based on review of the operational history of the site, wastes that were disposed, the length of time they were disposed, and site data.

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APPENDIX A

FIELD LOGBOOK

TITLE NSWC CRANE
MONDAY 3.4.02

PROJECT NO. 4070
BOOK 2450

Work continued from Page WEATHER: 3/4 COLD, CLEAR
5-20°F
SUNDAY PM CLYDE SNYDER
TERRY RODAHN & KEITH SIMPSON
TRAVEL TO SITE. HOTEL ARRIVE @
2130 TRAVEL DAY ONLY.

0655 KS TR & CS @ CRANE
GATE PICK-UP PASSES TO
BLD 3245 UNLOAD EQ. PREP
FOR SAMPLING.
0800 DAVID MEIER & RICH JENKS
BT&R SURVEYORS ON SITE
0830 ALL 5 OF US TO POLE YARD
LAY-OUT CORNERS OF GEO PHY
GRID AND CHECK SAMPLE LOCATION
FOR EQ. POLES, TRANSFORMERS ETC
THAT MAY NEED MOVED. ONLY
ONE SB UNDER UTILITIES POLES
(LAYING IN RACKS)
1030 TR CS & KS TO LANDFARM
& START LAYOUT
1140 TO LUNCH - PICK-UP DIG PERMIT
FOR POLE YARD.
1200 JOE PARISH (GEO PHY) @ BLD 3245
CLYDE S. CONDUCTES H&S TRAINING

SCIENTIFIC BINDERY PRODUCTIONS CHICAGO 60605
Work continued to Page

SIGNATURE
WITNESS
DATE 3.4.02
DATE

TITLE NSWC CRANE
3.4.02

PROJECT NO. 4070
BOOK 2450

Work continued from Page
1320 CLYDE & JOE P. TO POLE YD
KS & TR TO LANDFARM FOR
LAY-OUT
1725 KS & TR BACK @ BLD 3245
UNLOAD TRUCK DECON STAINLESS
MIXING BOWLS PAPER WORK
2 1/2 LANDFARM IS LAYED-OUT
1800 CLYDE & JOE RETURN FROM
POLE YARD
1830 OFF SITE TO LOWE'S FOR
SUPPLIES

SCIENTIFIC BINDERY PRODUCTIONS CHICAGO 60605
Work continued to Page

SIGNATURE
WITNESS
DATE 3.4.02
DATE

TITLE NSWC CRANE PROJECT NO. 7393/4070

TUE 3.5.02 BOOK 2450

Work continued from Page WEATHER: WARMER 25-42°F
OVERCAST

0650 KS, CS, TR & JOE PARISH ON SITE @ BLD 3245
TALKED WITH TOM BRENT ABOUT HAVING PUBLIC WORKS MOVE POLES & TRANSFORMERS @ THE POLE YD. TOM WILL CALL PW THIS AM.

0725 CS & JP TO POLE YD
KS & TR TO LANDFARM, CONTINUE LAYOUT

0950 COMPLETE LAYOUT AT LANDFARM TO POLE YARD MET WITH TOM BRENT, STEVE ___ FROM PW & JOE PARISH. PW WILL MOVE ALL EQUIPMENT IN THE AREA OF GEO SURVEY ALSO TOM B. WILL CHECK WITH ENGINEERING BILL HUDSON @ BLD 3173 - THE FLOOR OF BLD 357 IS 727.54' FROM 1956 SURVEY

1050 RETURN TO BLD 3245 CALLED RALPH B. AND JUDY L FOR SOME SURVEY INFO. FOR POLE YD.

SCIENTIFIC BINDERY PRODUCTIONS CHICAGO 60605 Work continued to Page

SIGNATURE [signature] DATE 3.5.02
WITNESS DATE

TITLE NSWC CRANE PROJECT NO. 7393/4070

3.5.02 BOOK 2450

Work continued from Page

1130 RETURN TO POLE YD THEN LUNCH

1200 LAY OUT ORR THEN RETURN TO BLD 3245
CALLED MARK FRANCIS AND DISCUSSED ORR SAMPLE LOCATIONS. WE WILL HAVE SURVEYORS RELOCATE 07SB16 (WINTER 2001) NOW 07SB47.
ALSO ADD VALVE TO SURVEY
ORR 07SB16
1305631.933
302611.6.225
508.44 ELEV.

1530 CALLED JUDY LAMEY FIG 4-1 POLE YARD LOCATIONS WERE TAKEN FROM NSWC CRANE SUPPLIED DRAWINGS. IT WILL HELP IF THE SURVEYORS SHOOT A FEW BUILDING CORNERS (WE ADDED 8-10 TO THERE LIST).
AND SURVEYORS WILL SUPPLY DATA FOR ALL SITES (PER JUDY'S OK) IN NAD27/NAVD 88.

1620 TR & KS PREP FOR SBs @ ORR ON WED. AM

SCIENTIFIC BINDERY PRODUCTIONS CHICAGO 60605 Work continued to Page

SIGNATURE [signature] DATE 3.5.02
WITNESS DATE

TITLE NSWC CRANE 3-5-02 PROJECT NO. 7393/4070 BOOK 2450

Work continued from Page

1650 JOE PERISH OFF-SITE TO HOTEL
CLYDE S. @ BLD 3245
CLEAN-UP & STORE EQ.
1750 CS, TR & KS OFF SITE

SCIENTIFIC BINDERY PRODUCTIONS CHICAGO 60605

Work continued to Page

SIGNATURE WITNESS

DATE 3-5-02

DATE

TITLE NSWC CRANE WED 3-6-02 PROJECT NO. 7393/4070 3961 BOOK 2450

Work continued from Page WEATHER: WINDY OVERCAST 40-55°F

0645 KEITH S. & TERRY R. AT BLD
3245 LOAD TRUCK FOR SAMPLING
@ ORR
0715 JOE P. & CLYDE S. TO POLE
YARD
0715 TONY STRATI EFS @ BLD
3245 TERRY R. GOING OVER
H&S WITH TONY.
0755 KS, TR & TONY TO ORR
1130 COMPLETE SAMPLING @ ORR
7 SBs
LOAD EQUIPMENT TO LUNCH
1230 @ BLD 3245 - SURVEYORS ARE
DONE @ ORR & LANDFARM WILL
RETURN LATER IN THE WEEK TO
COMPLETE THE POLE YARD
1300 RESTOCK SUPPLIES TO LANDFARM
TO START SBs
CALLED SECURITY TO LET THEM
KNOW EFS TRAILER WILL BE LEFT
ON LF TONIGHT
1715 COMPLETED 3 CELLS & 2 BOUNDARY
SAMPLES LOAD TRUCKS TO BLD 3245
DECON PAPER WORK, PREP FOR SAMPLING
1830 ON 3.7.02 OFF SITE TO WAL-MART
1900 KS OFF SITE

SCIENTIFIC BINDERY PRODUCTIONS CHICAGO 60605

Work continued to Page CS/TR

SIGNATURE WITNESS

DATE 3-6-02

DATE

TITLE NSWC CRANE PROJECT NO.

THUR 3-7-02 BOOK 2450

Work continued from Page WEATHER: NICE, 45-65°F
CLEAR
0655 ON SITE @ BLD 3245 KEITH S.,
TERRY R., CLYDE S. (T+N&S)
TONY S. (EFS) JOE P. (EMI)
CLYDE & JOE TO POLE YARD
0720 KS & TR TO LANDFARM
1145 COMPLETE 4 CELLS 03, 04, 05 & 10 +
SB02 TO LUNCH
1215 @ BLD 3245 RESTOCK TRUCK, DECON
1240 BOWLS - RETURN TO LANDFARM
1700 COMPLETE 2 SB & 4 CELLS
ALL BUT 1 CELL DONE
TO BLD 3245. DECON, PACK
SAMPLES FOR FEDEX, PAPERWORK

SCIENTIFIC BINDERY PRODUCTIONS CHICAGO 60605 Work continued to Page

SIGNATURE [signature] DATE 3-7-02
WITNESS DATE

TITLE NSWC CRANE PROJECT NO.

FRIDAY 3-8-02 BOOK 2450

Work continued from Page WEATHER: WINDY, CLEAR
45-55°F
0650 KS, TR & CS ON SITE BLD 3245
CAL PID LOAD TRUCKS
0700 TONY S. (EFS) ON SITE
TO LANDFARM TO COMPLETE
LAST CELL (3 SAMPLES).
0850 COMPLETE LF SAMPLING
CLYDE & TONY TO PCB SITE 17
KS & TR TO BLD 3245 DECON
0935 & RESTOCK TRUCK THEN TO
PCB SITE. START SBs
1145 COMPLETED 6 SBs TO LUNCH
@ BLD 3245 FOR SUPPLIES
1225 TO SITE SB SAMPLING
1730 TO BLD 3245 20 SBs COMPLETE
TERRY R. WORK ON ECO.
STUDYS THE REST OF SHIFT
PAPER WORK, DECON, STOCK TRUCK
FOR SAMPLING
1850 DEPART SITE TO HOTEL: TR & CS
1910 KS TO HOTEL

SCIENTIFIC BINDERY PRODUCTIONS CHICAGO 60605 Work continued to Page

SIGNATURE [signature] DATE 3-8-02
WITNESS DATE

TITLE NSWC CRANE
SAT. 3.9.02

PROJECT NO. 4070
BOOK 2450

Work continued from Page WEATHER: RAIN STARTING @
0500 RAIN-ON/OFF 48-60° WINDY
0650 KS, TR & CS ON SITE @ BLD
3245 PREP FOR SB SAMPLING
@ POLE YD KS & CS
TR WORKING ON ECO. STUDYS
0720 TO POLE YD SAMPLING SBs
HEAVY RAIN 0950 → 1115
1540 COMPLETE DPT SAMPLING
RETURN TO BLD 3245 DECON,
RINSATE BLANK, PAPER WORK
1600 TONY OFF SITE
1740 KS, TR & CS OFF SITE

SCIENTIFIC BINDERY PRODUCTIONS CHICAGO 60605

Work continued to Page

SIGNATURE [signature]
WITNESS

DATE 3.9.02
DATE

TITLE NSWC CRANE
SUN. 3.10.02

PROJECT NO. 4070
BOOK 2450

Work continued from Page WEATHER: 14-40°F CLEAR
0650 KS, CS & TR ON SITE @
BLD 3245 CAL PID PREP
FOR SAMPLING @ POLE YARD
TR WORKING ON ECO. STUDIES.
0730 KS, CS & TONY S. TO POLE YD
0900 COMPLETE ALL DPT SBs 41
1000 TONY S. OFF SITE
KS & CS START 3 HAND AUGER
LOCATION.
1130 COMPLETE HAND AUGER LOCATION
RETURN TO BLD 3245 DECON,
PAPER WORK, PACK EQ FOR SHIPPING
1600 CLYDE CLEANING BLD 3245
TR & KS TO SWMU 5 TO WORK ON
ECO. STUDY
1830 OFF SITE TO HOTEL

SCIENTIFIC BINDERY PRODUCTIONS CHICAGO 60605

Work continued to Page

SIGNATURE [signature]
WITNESS

DATE 3.10.02
DATE

TITLE NSWC CRANE

PROJECT NO. ECO. STUDY

MONDAY 3-11-02

BOOK 2450

Work continued from Page WEATHER: CLEAR 33-44°F

0650 KS & TR @ BLD 3245, PAPER WORK
DEPART TO SWMU 5 FOR ECO.
STUDY.
WORKING ON ECO. STUDY ALL DAY

TRAVEL TO PGH 3-12-02

SEE ALSO LOG BOOK #
PL-006

END OF SHIFT

SCIENTIFIC BINDERY PRODUCTIONS CHICAGO 60605

Work continued to Page

SIGNATURE

DATE 3-11-02

WITNESS

DATE

TITLE

PROJECT NO.

BOOK

Work continued from Page

SCIENTIFIC BINDERY PRODUCTIONS CHICAGO 60605

Work continued to Page

SIGNATURE

DATE

WITNESS

DATE

APPENDIX B

SOIL SAMPLE LOG SHEETS AND BORING LOGS

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NSWC CRANE - Landfarm
PROJECT NUMBER: CTO 19 job # 7393
DRILLING COMPANY: Environmental Field Services
DRILLING RIG: GeoProbe 54 LT

BORING NUMBER: 30 SB01
DATE: 3-7-02
GEOLOGIST: K. Simpson & T. Rojahn
DRILLER: Tony Strati

Sample No. and Type or RQD	Depth (Ft.) or Run No.	Blows / 6" or RQD (%)	Sample Recovery / Sample Length	Lithology Change (Depth /Ft.) or Screened Interval	MATERIAL DESCRIPTION: Soil Density/ Consistency or Rock Hardness	Color	Material Classification	USCS *	Remarks	PID/FID Reading (ppm): Sample	Sampler BZ	Borehole**	Driller BZ**
28	1				SOFT	BRN	SILTY CLAY	CL	MOIST, TR ROOTS	0	0	0	0
	2				↓	↓	↓	↓	↓	↓	↓	↓	↓
	3				MED STIFF	↓	GRAY MOTTLING RUST COLOR NOD.	↓	↓	↓	↓	↓	↓
31	4		3.5/4		STIFF	↓	↓	↓	↓	↓	↓	↓	↓
	5												
	6												
	7												
	8												
	9												
	10												
							TD = 4'						

* When rock coring, enter rock brokeness.

** Include monitor reading in 6 foot intervals @ borehole. Increase reading frequency if elevated reponse read.

Remarks: BOUNDARY SAMPLE

Drilling Area Background (ppm): 0

Converted to Well: Yes ____ No X Well I.D. #: NA

SOIL SAMPLE LOG SHEET

Project Site Name: NSWC Crane, IN - Landfarm
Project No.: CTO 19 job # 7393 SWMU 30

Sample ID No.: 30 SB 01 0001
Sample Location: 30 SB 01
Sampled By: K. Simpson & T. Rojahn
C.O.C. No.:

[X] Surface Soil
[] Subsurface Soil
[] Sediment
[] Other:
[] QA Sample Type:

Type of Sample:
[X] Low Concentration
[] High Concentration

GRAB SAMPLE DATA:

	Depth	Color	Description (Sand, Silt, Clay, Moisture, etc.)
Date: 3.7.02 Time: 1330 Method: DPT Monitor Reading (ppm):	0-0.5	BRN	MOIST TR ROOTS SILTY CLAY

SAMPLE COLLECTION INFORMATION:

Analysis	Container Requirements	Collected	Other
Metals: Al, Ca, Fe, Mg, Mn, K, Na, As, Ba, Be, Cd, Cr-total, Co, Cu, Pb, Ni, Se, Ag, Tl, V, Zn, Hg, Sb Cr+6 and Cyanide, pH	(1) 8 oz. Glass	✓	Laucks

OBSERVATIONS / NOTES:

Sludge noted at this location (Y/N): N

MAP:

See Figure

BOUNDARY LOCATION

Circle if Applicable:

MS/MSD	Duplicate ID No.:
—	—

Signature(s): KJ SL

SOIL SAMPLE LOG SHEET

Project Site Name: NSWC Crane, IN - Landfarm
Project No.: CTO 19 job # 7393 SWMU 30

Sample ID No.: 30 SB 01 0002
Sample Location: 30 SB 01
Sampled By: K. Simpson & T. Rojahn
C.O.C. No.:

[X] Surface Soil
[] Subsurface Soil
[] Sediment
[] Other:
[] QA Sample Type:

Type of Sample:
[X] Low Concentration
[] High Concentration

GRAB SAMPLE DATA:

	Depth	Color	Description (Sand, Silt, Clay, Moisture, etc.)
Date: 8.7.02 Time: 1333 Method: DPT Monitor Reading (ppm): 0	0.5-2	BRN	MOIST, SILTY CLAY GRAY MOTTLING STARTING @ 1.8'

SAMPLE COLLECTION INFORMATION:

Analysis	Container Requirements	Collected	Other
Metals: Al, Ca, Fe, Mg, Mn, K, Na, As, Ba, Be, Cd, Cr-total, Co, Cu, Pb, Ni, Se, Ag, Tl, V, Zn, Hg, Sb Cr+6 and Cyanide, pH	(1) 8 oz. Glass	✓	Laucks

OBSERVATIONS / NOTES:

Sludge noted at this location (Y/N): N

MAP:

See Figure

BOUNDARY LOCATION

Circle if Applicable:

MS/MSD

Duplicate ID No.:

Signature(s):

K. T. Simpson

SOIL SAMPLE LOG SHEET

Project Site Name: NSWC Crane, IN - Landfarm
Project No.: CTO 19 job # 7393 SWMU 30

[] Surface Soil
[X] Subsurface Soil
[] Sediment
[] Other:
[] QA Sample Type:

Sample ID No.: 30 SB 01 0204
Sample Location: 30 SB 01
Sampled By: K. Simpson & T. Rojahn
C.O.C. No.:

Type of Sample:
[X] Low Concentration
[] High Concentration

GRAB SAMPLE DATA:

	Depth '	Color	Description (Sand, Silt, Clay, Moisture, etc.)
Date: 3·7·02 Time: 1335 Method: DPT Monitor Reading (ppm): 0	2-4	BRN	MOIST, SILTY CLAY GRAY MOTTLING, RUST COLOR NODULES

SAMPLE COLLECTION INFORMATION:

Analysis	Container Requirements	Collected	Other
Metals: Al, Ca, Fe, Mg, Mn, K, Na, As, Ba, Be, Cd, Cr-total, Co, Cu, Pb, Ni, Se, Ag, Tl, V, Zn, Hg, Sb Cr+6 and Cyanide, pH	(1) 8 oz. Glass	✓	Laucks

OBSERVATIONS / NOTES:

Sludge noted at this location (Y/N): N

MAP:

See Figure

BOUNDARY LOCATION

Circle if Applicable:

MS/MSD

Duplicate ID No.:

Signature(s):

KJ S Simpson

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NSWC CRANE - Landfarm
PROJECT NUMBER: CTO 19 job # 7393
DRILLING COMPANY: Environmental Field Services
DRILLING RIG: GeoProbe 54 LT
BORING NUMBER: 30 SB02
DATE: 3-7-02
GEOLOGIST: K. Simpson & T. Rojahn
DRILLER: Tony Strati

Sample No. and Type or RQD	Depth (Ft.) or Run No.	Blows / 6" or RQD (%)	Sample Recovery / Sample Length	Lithology Change (Depth /Ft.) or Screened Interval	MATERIAL DESCRIPTION: Soil Density/ Consistency or Rock Hardness	Color	Material Classification	USCS *	Remarks	PID/FID Reading (ppm): Sample	Sampler BZ	Borehole**	Driller BZ**
45													
	1				SOFT	BRN	SILTY CLAY	CL	MOIST, TR ROOTS	0	0	0	0
	2												
	3						GRAY MOTTLING TR RUST COLOR NODULES						
350	4		3.5/4		MED STIFF								
	5												
	6												
	7												
	8												
	9												
	10												
							TD = 4'						

* When rock coring, enter rock brokeness.

** Include monitor reading in 6 foot intervals @ borehole. Increase reading frequency if elevated reponse read.

Remarks: BOUNDARY LOCATION

Drilling Area Background (ppm): 0

Converted to Well: Yes ____ No X Well I.D. #: NA

SOIL SAMPLE LOG SHEET

Project Site Name: NSWC Crane, IN - Landfarm
Project No.: CTO 19 job # 7393 SWMU 30

Sample ID No.: 30 SB 02 0001
Sample Location: 30 SB 02
Sampled By: K. Simpson & T. Rojahn
C.O.C. No.:

[X] Surface Soil
[] Subsurface Soil
[] Sediment
[] Other:
[] QA Sample Type:

Type of Sample:
[X] Low Concentration
[] High Concentration

GRAB SAMPLE DATA:

	Depth	Color	Description (Sand, Silt, Clay, Moisture, etc.)
Date: 3-7-02 Time: 0845 Method: DPT Monitor Reading (ppm): 0	0 - 0.5	BRN	SILTY CLAY TR ROOTS MOIST

SAMPLE COLLECTION INFORMATION:

Analysis	Container Requirements	Collected	Other
Metals: Al, Ca, Fe, Mg, Mn, K, Na, As, Ba, Be, Cd, Cr-total, Co, Cu, Pb, Ni, Se, Ag, Tl, V, Zn, Hg, Sb Cr+6 and Cyanide, pH	(1) 8 oz. Glass	✓	Laucks

OBSERVATIONS / NOTES:

Sludge noted at this location (Y/N): N

MAP:

See Figure

BOUNDARY LOCATION

Circle if Applicable:

MS/MSD

Duplicate ID No.:

Signature(s):

K. S. Simpson

SOIL SAMPLE LOG SHEET

Project Site Name: NSWC Crane, IN - Landfarm
Project No.: CTO 19 job # 7393 SWMU 30

Sample ID No.: 30 SB 02 0002
Sample Location: 30 SB 02
Sampled By: K. Simpson & T. Rojahn
C.O.C. No.:

[X] Surface Soil
[] Subsurface Soil
[] Sediment
[] Other:
[] QA Sample Type:

Type of Sample:
[X] Low Concentration
[] High Concentration

GRAB SAMPLE DATA:

	Depth	Color	Description (Sand, Silt, Clay, Moisture, etc.)
Date: 3-7-02	0.5-2	BRN	SILTY ~~SA~~ CLAY MOIST
Time: 0847			
Method: DPT			
Monitor Reading (ppm): 0			

SAMPLE COLLECTION INFORMATION:

Analysis	Container Requirements	Collected	Other
Metals: Al, Ca, Fe, Mg, Mn, K, Na, As, Ba, Be, Cd, Cr-total, Co, Cu, Pb, Ni, Se, Ag, Tl, V, Zn, Hg, Sb Cr+6 and Cyanide, pH	(1) 8 oz. Glass	✓	Laucks

OBSERVATIONS / NOTES:

Sludge noted at this location (Y/N): N

MAP:

See Figure

BOUNDARY LOCATION

Circle if Applicable:

MS/MSD	Duplicate ID No.:
—	—

Signature(s):

K. S. Simpson

SOIL SAMPLE LOG SHEET

Project Site Name: NSWC Crane, IN - Landfarm
Project No.: CTO 19 job # 7393 SWMU 30

[] Surface Soil
[X] Subsurface Soil
[] Sediment
[] Other:
[] QA Sample Type:

Sample ID No.: 30 SB 02 0204
Sample Location: 30 SB 02
Sampled By: K. Simpson & T. Rojahn
C.O.C. No.:

Type of Sample:
[X] Low Concentration
[] High Concentration

GRAB SAMPLE DATA:

	Depth '	Color	Description (Sand, Silt, Clay, Moisture, etc.)
Date: 3-7-02 Time: 0850 Method: DPT Monitor Reading (ppm): 0	2-4	BRN	SILTY CLAY, MOISTS, GRAY MOTTLING TR RUST COLOR NODULES

SAMPLE COLLECTION INFORMATION:

Analysis	Container Requirements	Collected	Other
Metals: Al, Ca, Fe, Mg, Mn, K, Na, As, Ba, Be, Cd, Cr-total, Co, Cu, Pb, Ni, Se, Ag, Tl, V, Zn, Hg, Sb Cr+6 and Cyanide, pH	(1) 8 oz. Glass	✓	Laucks

OBSERVATIONS / NOTES:

Sludge noted at this location (Y/N): N

MAP:

See Figure

BOUNDARY LOCATION

Circle if Applicable:

MS/MSD

Duplicate ID No.:

Signature(s):

K. S. Simpson

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NSWC CRANE - Landfarm
PROJECT NUMBER: CTO 19 job # 7393
DRILLING COMPANY: Environmental Field Services
DRILLING RIG: GeoProbe 54 LT
BORING NUMBER: 30SB03
DATE: 3.6.02
GEOLOGIST: K. Simpson & T. Rojahn
DRILLER: Tony Strati

Sample No. and Type or RQD	Depth (Ft.) or Run No.	Blows / 6" or RQD (%)	Sample Recovery / Sample Length	Lithology Change (Depth /Ft.) or Screened Interval	MATERIAL DESCRIPTION: Soil Density/ Consistency or Rock Hardness	Color	Material Classification: GRASS AREA	USCS*	Remarks	PID/FID Reading (ppm): Sample	Sampler B.Z.	Borehole**	Driller B.Z.**
	1				SOFT	BRN	LIMESTONE GRAVEL CLAY/SILT	CL	MOIST, TR ROOTS	0	0	0	0
	2				↓	↓	↓ ↓	↓	↓				
	3				↓	↓	CLAY SOME SILT GRAY MOTTLING	↓	↓				
	4		4 / 4		↓	↓	SOME RUST NODULES	↓	↓				
	5												
	6												
	7												
	8												
	9												
	10												
							TD = 4'						

* When rock coring, enter rock brokeness.

** Include monitor reading in 6 foot intervals @ borehole. Increase reading frequency if elevated reponse read.

Remarks: BOUNDARY LOCATION EAST SIDE OF SITE

Drilling Area Background (ppm): 0

Converted to Well: Yes ____ No X Well I.D. #: NA

SOIL SAMPLE LOG SHEET

Project Site Name: NSWC Crane, IN - Landfarm
Project No.: CTO 19 job # 7393 SWMU 30

Sample ID No.: 30 SB 03 0001
Sample Location: 30 SB 03
Sampled By: K. Simpson & T. Rojahn
C.O.C. No.:

[X] Surface Soil
[] Subsurface Soil
[] Sediment
[] Other:
[] QA Sample Type:

Type of Sample:
[X] Low Concentration
[] High Concentration

GRAB SAMPLE DATA:

Date: 3·6·02	Depth	Color	Description (Sand, Silt, Clay, Moisture, etc.)
Time: ~~1040~~ 1340	0 - 0.5'	BRN	BRN, MOIST, TR ROOTS LIMESTONE GRAVEL TR CLAY / SILT
Method: DPT			
Monitor Reading (ppm): 0			

SAMPLE COLLECTION INFORMATION:

Analysis	Container Requirements	Collected	Other
Metals: Al, Ca, Fe, Mg, Mn, K, Na, As, Ba, Be, Cd, Cr-total, Co, Cu, Pb, Ni, Se, Ag, Tl, V, Zn, Hg, Sb Cr+6 and Cyanide, pH	(1) 8 oz. Glass	✓	Laucks

OBSERVATIONS / NOTES:

Sludge noted at this location (Y/N): N

MAP:

See Figure

BOUNDARY LOCATION

Circle if Applicable:

MS/MSD	Duplicate ID No.:
—	—

Signature(s):

SOIL SAMPLE LOG SHEET

Project Site Name: NSWC Crane, IN - Landfarm
Project No.: CTO 19 job # 7393 SWMU 30

[] Surface Soil
[X] Subsurface Soil
[] Sediment
[] Other:
[] QA Sample Type:

Sample ID No.: 30 SB 03 0002
Sample Location: 30 SB 03
Sampled By: K. Simpson & T. Rojahn
C.O.C. No.:

Type of Sample:
[X] Low Concentration
[] High Concentration

GRAB SAMPLE DATA:

	Depth	Color	Description (Sand, Silt, Clay, Moisture, etc.)
Date: 3-6-02 Time: KS ~~104~~ 1345 Method: DPT Monitor Reading (ppm): 0	0.5-2'	BRN	MOIST, CLAY/SILT

SAMPLE COLLECTION INFORMATION:

Analysis	Container Requirements	Collected	Other
Metals: Al, Ca, Fe, Mg, Mn, K, Na, As, Ba, Be, Cd, Cr-total, Co, Cu, Pb, Ni, Se, Ag, Tl, V, Zn, Hg, Sb Cr+6 and Cyanide, pH	(1) 8 oz. Glass	✓	Laucks

OBSERVATIONS / NOTES:

Sludge noted at this location (Y/N): N

MAP:

See Figure

BOUNDARY LOCATION

Circle if Applicable:

MS/MSD	Duplicate ID No.:
—	—

Signature(s):

SOIL SAMPLE LOG SHEET

Project Site Name: NSWC Crane, IN - Landfarm
Project No.: CTO 19 job # 7393 SWMU 30

[] Surface Soil
[X] Subsurface Soil
[] Sediment
[] Other:
[] QA Sample Type:

Sample ID No.: 30 SB 03 0204
Sample Location: 30 SB 03
Sampled By: K. Simpson & T. Rojahn
C.O.C. No.:

Type of Sample:
[X] Low Concentration
[] High Concentration

GRAB SAMPLE DATA:

	Depth	Color	Description (Sand, Silt, Clay, Moisture, etc.)
Date: 3·6·02 Time: 1350 Method: DPT Monitor Reading (ppm): 0	2-4'	BRN	CLAY SOME SILT GRAY MOTTLING SOME RUST NODULES

SAMPLE COLLECTION INFORMATION:

Analysis	Container Requirements	Collected	Other
Metals: Al, Ca, Fe, Mg, Mn, K, Na, As, Ba, Be, Cd, Cr-total, Co, Cu, Pb, Ni, Se, Ag, Tl, V, Zn, Hg, Sb Cr+6 and Cyanide, pH	(1) 8 oz. Glass	✓	Laucks

OBSERVATIONS / NOTES:

Sludge noted at this location (Y/N): NO

MAP:

See Figure

BOUNDARY LOCATION

Circle if Applicable:

MS/MSD

Duplicate ID No.:

Signature(s):

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NSWC CRANE - Landfarm
PROJECT NUMBER: CTO 19 job # 7393
DRILLING COMPANY: Environmental Field Services
DRILLING RIG: GeoProbe 54 LT

BORING NUMBER: 30 SB 04
DATE: 3-6-02
GEOLOGIST: K. Simpson & T. Rojahn
DRILLER: Tony Strati

Sample No. and Type or RQD	Depth (Ft.) or Run No.	Blows / 6" or RQD (%)	Sample Recovery / Sample Length	Lithology Change (Depth /Ft.) or Screened Interval	MATERIAL DESCRIPTION: Soil Density/ Consistency or Rock Hardness	Color	Material Classification	USCS *	Remarks	PID/FID Reading (ppm): Sample	Sampler BZ	Borehole**	Driller BZ**
30													
	1				SOFT	BRN	SILTY CLAY	CL	MOIST TR ROOTS	0	0	0	0
	2				MED								
	3				STIFF		SOME GRAY MOTTLING						
35	4		2.5/4										
	5												
	6												
	7												
	8												
	9												
	10												
							TD = 4'						

* When rock coring, enter rock brokeness.

Include monitor reading in 6 foot intervals @ borehole. Increase reading frequency if elevated reponse read.

Remarks: BOUNDARY LOCATION

Drilling Area Background (ppm): 0

Converted to Well: Yes _____ No X Well I.D. #: NA

SOIL SAMPLE LOG SHEET

Project Site Name: NSWC Crane, IN - Landfarm
Project No.: CTO 19 job # 7393 SWMU 30

Sample ID No.: 30 SB 04 0001
Sample Location: 30 SB 04
Sampled By: K. Simpson & T. Rojahn
C.O.C. No.:

[X] Surface Soil
[] Subsurface Soil
[] Sediment
[] Other:
[] QA Sample Type:

Type of Sample:
[X] Low Concentration
[] High Concentration

GRAB SAMPLE DATA:

	Depth	Color	Description (Sand, Silt, Clay, Moisture, etc.)
Date: 3.6.02 Time: 1631 Method: DPT Monitor Reading (ppm): 0	0-0.5'	BRN.	MOIST, TR ROOTS SILTY CLAY

SAMPLE COLLECTION INFORMATION:

Analysis	Container Requirements	Collected	Other
Metals: Al, Ca, Fe, Mg, Mn, K, Na, As, Ba, Be, Cd, Cr-total, Co, Cu, Pb, Ni, Se, Ag, Tl, V, Zn, Hg, Sb Cr+6 and Cyanide, pH	(1) 8 oz. Glass	✓	Laucks

OBSERVATIONS / NOTES:

Sludge noted at this location (Y/N): N

MAP:

See Figure

BOUNDARY LOCATION

Circle if Applicable:

MS/MSD	Duplicate ID No.:
—	—

Signature(s):

KJ SL

SOIL SAMPLE LOG SHEET

Project Site Name: NSWC Crane, IN - Landfarm
Project No.: CTO 19 job # 7393 SWMU 30

Sample ID No.: 30 SB 04 0002
Sample Location: 30 SB 04
Sampled By: K. Simpson & T. Rojahn
C.O.C. No.:

[X] Surface Soil
[] Subsurface Soil
[] Sediment
[] Other:
[] QA Sample Type:

Type of Sample:
[X] Low Concentration
[] High Concentration

GRAB SAMPLE DATA:

	Depth	Color	Description (Sand, Silt, Clay, Moisture, etc.)
Date: 3.6.02 Time: 1634 Method: DPT Monitor Reading (ppm): 0	0.5-2'	BRN	MOIST, SILTY CLAY

SAMPLE COLLECTION INFORMATION:

Analysis	Container Requirements	Collected	Other
Metals: Al, Ca, Fe, Mg, Mn, K, Na, As, Ba, Be, Cd, Cr-total, Co, Cu, Pb, Ni, Se, Ag, Tl, V, Zn, Hg, Sb Cr+6 and Cyanide, pH	(1) 8 oz. Glass	✓	Laucks

OBSERVATIONS / NOTES:

Sludge noted at this location (Y/N): N

MAP:

See Figure

BOUNDARY LOCATION

Circle if Applicable:

MS/MSD —

Duplicate ID No.: —

Signature(s):

SOIL SAMPLE LOG SHEET

Project Site Name: NSWC Crane, IN - Landfarm
Project No.: CTO 19 job # 7393 SWMU 30

[] Surface Soil
[X] Subsurface Soil
[] Sediment
[] Other:
[] QA Sample Type:

Sample ID No.: 30 SB 04 0204
Sample Location: 30 SB 04
Sampled By: K. Simpson & T. Rojahn
C.O.C. No.:

Type of Sample:
[X] Low Concentration
[] High Concentration

GRAB SAMPLE DATA:

Date: 3·6·02	Depth	Color	Description (Sand, Silt, Clay, Moisture, etc.)
Time: 1636	2-4'	BRN	SILTY CLAY, MOIST SOME GRAY MOTTLING
Method: DPT			
Monitor Reading (ppm): 0			

SAMPLE COLLECTION INFORMATION:

Analysis	Container Requirements	Collected	Other
Metals: Al, Ca, Fe, Mg, Mn, K, Na, As, Ba, Be, Cd, Cr-total, Co, Cu, Pb, Ni, Se, Ag, Tl, V, Zn, Hg, Sb Cr+6 and Cyanide, pH	(1) 8 oz. Glass	✓	Laucks

OBSERVATIONS / NOTES:

Sludge noted at this location (Y/N): N.

MAP:

See Figure

BOUNDARY LOCATION

Circle if Applicable:

MS/MSD

Duplicate ID No.: YES
FD 030602 03

→ FDs 01 & 02 COLLECTED AT ORR THIS AM

Signature(s): [illegible]

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NSWC CRANE - Landfarm
PROJECT NUMBER: CTO 19 job # 7393
DRILLING COMPANY: Environmental Field Services
DRILLING RIG: GeoProbe 54 LT

BORING NUMBER: 30 SB05
DATE: 3-7-02
GEOLOGIST: K. Simpson.& T. Rojahn
DRILLER: Tony Strati

Sample No. and Type or RQD	Depth (Ft.) or Run No.	Blows / 6" or RQD (%)	Sample Recovery / Sample Length	Lithology Change (Depth /Ft.) or Screened Interval	MATERIAL DESCRIPTION: Soil Density/ Consistency or Rock Hardness	Color	Material Classification	USCS *	Remarks	PID/FID Reading (ppm): Sample	Sampler BZ	Borehole**	Driller BZ**
20	1				SOFT	BRN	SILTY CLAY	CL	MOIST, TR ROOTS	0	0	0	0
	2				MED								
	3				STIFF		GRAY/RUST COLOR MOTTLING TR RUST COLOR NODULES						
25	4		3.5 / 4		STIFF								
	5												
	6												
	7												
	8												
	9												
	10												
							TD = 4'						

* When rock coring, enter rock brokeness.

** Include monitor reading in 6 foot intervals @ borehole. Increase reading frequency if elevated reponse read.

Drilling Area Background (ppm): 0

Remarks: BOUNDARY SAMPLE

Converted to Well: Yes ____ No X Well I.D. #: NA

SOIL SAMPLE LOG SHEET

Project Site Name: NSWC Crane, IN - Landfarm
Project No.: CTO 19 job # 7393 SWMU 30

Sample ID No.: 30 SB SS 05 0001
Sample Location: 30 SB 05
Sampled By: K. Simpson & T. Rojahn
C.O.C. No.:

[X] Surface Soil
[] Subsurface Soil
[] Sediment
[] Other:
[] QA Sample Type:

Type of Sample:
[X] Low Concentration
[] High Concentration

GRAB SAMPLE DATA:

	Depth	Color	Description (Sand, Silt, Clay, Moisture, etc.)
Date: 3-7-02	0-0.5	BRN	MOIST, TR ROOTS SILTY CLAY
Time: 1420			
Method: DPT			
Monitor Reading (ppm): 0			

SAMPLE COLLECTION INFORMATION:

Analysis	Container Requirements	Collected	Other
Metals: Al, Ca, Fe, Mg, Mn, K, Na, As, Ba, Be, Cd, Cr-total, Co, Cu, Pb, Ni, Se, Ag, Tl, V, Zn, Hg, Sb Cr+6 and Cyanide, pH	(1) 8 oz. Glass	✓	Laucks

OBSERVATIONS / NOTES:

Sludge noted at this location (Y/N): N

MAP:

See Figure

BOUNDARY LOCATION

Circle if Applicable:

MS/MSD	Duplicate ID No.:
—	—

Signature(s):

KS / EL

SOIL SAMPLE LOG SHEET

Project Site Name: NSWC Crane, IN - Landfarm
Project No.: CTO 19 job # 7393 SWMU 30

Sample ID No.: 30 SB 05 0002
Sample Location: 30 SB 05
Sampled By: K. Simpson & T. Rojahn
C.O.C. No.:

[X] Surface Soil
[] Subsurface Soil
[] Sediment
[] Other:
[] QA Sample Type:

Type of Sample:
[X] Low Concentration
[] High Concentration

GRAB SAMPLE DATA:

Date: 3-7-02	Depth	Color	Description (Sand, Silt, Clay, Moisture, etc.)
Time: 1422	0.5'-2	BRN	MOIST, SILTY CLAY
Method: DPT			
Monitor Reading (ppm): 0			

SAMPLE COLLECTION INFORMATION:

Analysis	Container Requirements	Collected	Other
Metals: Al, Ca, Fe, Mg, Mn, K, Na, As, Ba, Be, Cd, Cr-total, Co, Cu, Pb, Ni, Se, Ag, Tl, V, Zn, Hg, Sb Cr+6 and Cyanide, pH	(1) 8 oz. Glass	✓	Laucks

OBSERVATIONS / NOTES:

Sludge noted at this location (Y/N): N

MAP:

See Figure

BOUNDARY LOCATION

Circle if Applicable:

MS/MSD	Duplicate ID No.:
—	—

Signature(s):

SOIL SAMPLE LOG SHEET

Project Site Name: NSWC Crane, IN - Landfarm
Project No.: CTO 19 job # 7393 SWMU 30

[] Surface Soil
[X] Subsurface Soil
[] Sediment
[] Other:
[] QA Sample Type:

Sample ID No.: 30 SB 05 0204
Sample Location: 30 SB 05
Sampled By: K. Simpson & T. Rojahn
C.O.C. No.:

Type of Sample:
[X] Low Concentration
[] High Concentration

GRAB SAMPLE DATA:

	Depth '	Color	Description (Sand, Silt, Clay, Moisture, etc.)
Date: 3-7-02	2 - 4	BRN	MOIST, SILTY CLAY GRAY/RUST COLOR MOTTLING TR. RUST COLOR NODULES
Time: 1425			
Method: DPT			
Monitor Reading (ppm): 0			

SAMPLE COLLECTION INFORMATION:

Analysis	Container Requirements	Collected	Other
Metals: Al, Ca, Fe, Mg, Mn, K, Na, As, Ba, Be, Cd, Cr-total, Co, Cu, Pb, Ni, Se, Ag, Tl, V, Zn, Hg, Sb Cr+6 and Cyanide, pH	(1) 8 oz. Glass	✓	Laucks

OBSERVATIONS / NOTES:

Sludge noted at this location (Y/N): N

MAP:

See Figure

BOUNDARY LOCATION

Circle if Applicable:

MS/MSD	Duplicate ID No.:
—	—

Signature(s):

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NSWC CRANE - Landfarm
PROJECT NUMBER: CTO 19 job # 7393
DRILLING COMPANY: Environmental Field Services
DRILLING RIG: GeoProbe 54 LT

BORING NUMBER: 30 SB 06
DATE: 3-7-02
GEOLOGIST: K. Simpson & T. Rojahn
DRILLER: Tony Strati

Sample No. and Type or RQD	Depth (Ft.) or Run No.	Blows / 6" or RQD (%)	Sample Recovery / Sample Length	Lithology Change (Depth /Ft.) or Screened Interval	MATERIAL DESCRIPTION: Soil Density/ Consistency or Rock Hardness	Color	Material Classification	USCS *	Remarks	PID/FID Reading (ppm): Sample	Sampler BZ	Borehole**	Driller BZ**
	1				SOFT	BRN	SILTY CLAY	CL	MOIST, TR ROOTS	0	0	0	0
	2				STIFF		GRAY MOTTLING TR RUST COLOR NODULES						
	3												
	4		4/4		VERY STIFF								
	5												
	6												
	7												
	8												
	9												
	10												
							TD = 4'						

* When rock coring, enter rock brokeness.

** Include monitor reading in 6 foot intervals @ borehole. Increase reading frequency if elevated reponse read.

Remarks: BOUNDARY SAMPLE

Drilling Area Background (ppm): 0

Converted to Well: Yes ____ No X Well I.D. #: NA

SOIL SAMPLE LOG SHEET

Project Site Name: NSWC Crane, IN - Landfarm
Project No.: CTO 19 job # 7393 SWMU 30

Sample ID No.: 30 SB 06 0001
Sample Location: 30 SB 06
Sampled By: K. Simpson & T. Rojahn
C.O.C. No.:

[X] Surface Soil
[] Subsurface Soil
[] Sediment
[] Other:
[] QA Sample Type:

Type of Sample:
[X] Low Concentration
[] High Concentration

GRAB SAMPLE DATA:

	Depth	Color	Description (Sand, Silt, Clay, Moisture, etc.)
Date: 3-7-02	0-0.5	BRN	MOIST TR ROOTS SILTY CLAY
Time: 1633			
Method: DPT			
Monitor Reading (ppm): 0			

SAMPLE COLLECTION INFORMATION:

Analysis	Container Requirements	Collected	Other
Metals: Al, Ca, Fe, Mg, Mn, K, Na, As, Ba, Be, Cd, Cr-total, Co, Cu, Pb, Ni, Se, Ag, Tl, V, Zn, Hg, Sb Cr+6 and Cyanide, pH	(1) 8 oz. Glass	✓	Laucks

OBSERVATIONS / NOTES:

Sludge noted at this location (Y/N): N

MAP:

See Figure

BOUNDARY LOCATION

Circle if Applicable:

MS/MSD	Duplicate ID No.:

Signature(s): T. Rojahn / K. Simpson

SOIL SAMPLE LOG SHEET

Project Site Name: NSWC Crane, IN - Landfarm
Project No.: CTO 19 job # 7393 SWMU 30

Sample ID No.: 30 SB 06 0002
Sample Location: 30 SB 06
Sampled By: K. Simpson & T. Rojahn
C.O.C. No.:

[X] Surface Soil
[] Subsurface Soil
[] Sediment
[] Other:
[] QA Sample Type:

Type of Sample:
[X] Low Concentration
[] High Concentration

GRAB SAMPLE DATA:

Date: 3-7-02	Depth	Color	Description (Sand, Silt, Clay, Moisture, etc.)
Time: 1635	0.5-2	BRN	MOIST, SILTY CLAY
Method: DPT			
Monitor Reading (ppm): 0			

SAMPLE COLLECTION INFORMATION:

Analysis	Container Requirements	Collected	Other
Metals: Al, Ca, Fe, Mg, Mn, K, Na, As, Ba, Be, Cd, Cr-total, Co, Cu, Pb, Ni, Se, Ag, Tl, V, Zn, Hg, Sb Cr+6 and Cyanide, pH	(1) 8 oz. Glass	✓	Laucks

OBSERVATIONS / NOTES:

Sludge noted at this location (Y/N): N

MAP:

See Figure

BOUNDARY LOCATION

Circle if Applicable:

MS/MSD	Duplicate ID No.:
—	—

Signature(s): [illegible]

SOIL SAMPLE LOG SHEET

Project Site Name: NSWC Crane, IN - Landfarm
Project No.: CTO 19 job # 7393 SWMU 30

[] Surface Soil
[X] Subsurface Soil
[] Sediment
[] Other:
[] QA Sample Type:

Sample ID No.: 30 SB 06 0204
Sample Location: 30 SB06
Sampled By: K. Simpson & T. Rojahn
C.O.C. No.:

Type of Sample:
[X] Low Concentration
[] High Concentration

GRAB SAMPLE DATA:

Date: 3-7-02	Depth	Color	Description (Sand, Silt, Clay, Moisture, etc.)
Time: 1638	2 - 4	BRN	MOIST, SILTY CLAY; GRAY MOTTLING TR RUST COLOR NODULES
Method: DPT			
Monitor Reading (ppm): 0			

SAMPLE COLLECTION INFORMATION:

Analysis	Container Requirements	Collected	Other
Metals: Al, Ca, Fe, Mg, Mn, K, Na, As, Ba, Be, Cd, Cr-total, Co, Cu, Pb, Ni, Se, Ag, Tl, V, Zn, Hg, Sb Cr+6 and Cyanide, pH	(1) 8 oz. Glass	✓	Laucks

OBSERVATIONS / NOTES:

Sludge noted at this location (Y/N): N

MAP:

See Figure

BOUNDARY LOCATION

Circle if Applicable:

MS/MSD

Duplicate ID No.:

Signature(s):

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NSWC CRANE - Landfarm
PROJECT NUMBER: CTO 19 job # 7393
DRILLING COMPANY: Environmental Field Services
DRILLING RIG: GeoProbe 54 LT

BORING NUMBER: 30 CP 01 ABCDE
DATE: 3.7.02
GEOLOGIST: K. Simpson & T. Rojahn
DRILLER: Tony Strati

Sample No. and Type or RQD	Depth (Ft.) or Run No.	Blows / 6" or RQD (%)	Sample Recovery / Sample Length	Lithology Change (Depth /Ft.) or Screened Interval	MATERIAL DESCRIPTION: Soil Density/ Consistency or Rock Hardness	Color	Material Classification	USCS *	Remarks	PID/FID Reading (ppm): Sample	Sampler BZ	Borehole**	Driller BZ**
,00	1				SOFT	BRN	SILTY CLAY	CL	MOIST TR ROOTS	0	0	0	0
	2				MED								
	3				STIFF		– GRAY MOTTLING TR RUST COLOR NODULES –						
,22	4		4/4		STIFF								
	5												
	6												
	7												
	8												
	9												
	10												
							TD = 4'						

* When rock coring, enter rock brokeness.

** Include monitor reading in 6 foot intervals @ borehole. Increase reading frequency if elevated reponse read.

Drilling Area Background (ppm): 0

Remarks:

Converted to Well: Yes ____ No X Well I.D. #: NA

SOIL SAMPLE LOG SHEET

Project Site Name: NSWC Crane, IN - Landfarm
Project No.: CTO 19 job # 7393 SWMU.30

Sample ID No.: 30 CP01 SEE BELOW
Sample Location: 30 CP 01
Sampled By: K. Simpson & T. Rojahn
C.O.C. No.:

[X] Surface Soil
[X] Subsurface Soil
[] Sediment
[] Other:
[] QA Sample Type:

Type of Sample:
[X] Low Concentration
[] High Concentration

COMPOSITE SAMPLE DATA:

Date: 3.7.02
Method: DPT
Monitor Readings (Range in ppm): 0 – 1622

Time	Cell	SubCell	Depth (ft)	Color	Description (Sand, Silt, Clay, Moisture, etc.)
1600	1	A	0 - 4	BRN	MOIST, TR ROOTS
		B			SILTY CLAY
		C			GRAY MOTTLING + RUST
		D			COLOR MODULES BTM 2.5'
		E			

SAMPLE COLLECTION INFORMATION:

Analysis	Container Requirements	Collected	Other
Metals: Al, Ca, Fe, Mg, Mn, K, Na, As, Ba, Be, Cd, Cr-total, Co, Cu, Pb, Ni, Se, Ag, Tl, V, Zn, Hg, Sb Cr+6 and Cyanide, pH	(1) 8 oz. Glass	✓	Laucks

OBSERVATIONS / NOTES:

Sludge noted at this location (Y/N): N

— 3 SAMPLES —

ID	DEPTH'	TIME	
30CP01	0-0.5	1605	
30CP01	~~0-0.~~ 0.5-2	1615	
30CP01	2-4	1620	- DUP

MAP:

See figure & sampling grid

3 COMP SAMPLES
5 LOCATIONS

Circle if Applicable:

MS/MSD

Duplicate ID No.: FD03070205

→ 30CP01 0204

Signature(s): [signature]

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NSWC CRANE - Landfarm
PROJECT NUMBER: CTO 19 job # 7393
DRILLING COMPANY: Environmental Field Services
DRILLING RIG: GeoProbe 54 LT
BORING NUMBER: 30 CP02 (ABCDE)
DATE: 3-7-02
GEOLOGIST: K. Simpson & T. Rojahn
DRILLER: Tony Strati

Sample No. and Type or RQD	Depth (Ft.) or Run No.	Blows / 6" or RQD (%)	Sample Recovery / Sample Length	Lithology Change (Depth /Ft.) or Screened Interval	MATERIAL DESCRIPTION: Soil Density/ Consistency or Rock Hardness	Color	Material Classification	USCS *	Remarks	PID/FID Reading (ppm): Sample	Sampler BZ	Borehole**	Driller BZ**
10	1				SOFT	BRN	TR LIMESTONE GRAVEL SILTY CLAY	CL	MOIST, TR ROOTS	0	0	0	0
	2				MED		GRAY MOTTLING TR RUST COLOR NODULES						
10	3				STIFF								
	4		3.5/4		STIFF								
	5												
	6												
	7												
	8												
	9												
	10												
							TD = 4'						

* When rock coring, enter rock brokeness.

** Include monitor reading in 6 foot intervals @ borehole. Increase reading frequency if elevated reponse read.

Drilling Area Background (ppm): 0

Remarks:

Converted to Well: Yes ____ No X Well I.D. #: NA

SOIL SAMPLE LOG SHEET

Project Site Name: NSWC Crane, IN - Landfarm
Project No.: CTO 19 job # 7393 SWMU 30

Sample ID No.: 30 CP 02 SEE BELOW
Sample Location: 30 CP 02
Sampled By: K. Simpson & T. Rojahn
C.O.C. No.:

[X] Surface Soil
[X] Subsurface Soil
[] Sediment
[] Other:
[] QA Sample Type:

Type of Sample:
[X] Low Concentration
[] High Concentration

COMPOSITE SAMPLE DATA:

Date: 3.7.02	Time	Cell	SubCell	Depth (ft)	Color	Description (Sand, Silt, Clay, Moisture, etc.)
	1510	2	A	0-4	BRN	MOIST TR ROOT, TR LIMESTONE
Method: DPT	↓	↓	B	↓	↓	GRAVEL TOP 0.5'
			C			SILTY CLAY
Monitor Readings	↓	↓	D	↓	↓	GRAY MOTTLING START @ 1'
(Range in ppm) 0	1540	↓	E	↓	↓	+ RUST COLOR NODULES

SAMPLE COLLECTION INFORMATION:

Analysis	Container Requirements	Collected	Other
Metals: Al, Ca, Fe, Mg, Mn, K, Na, As, Ba, Be, Cd, Cr-total, Co, Cu, Pb, Ni, Se, Ag, Tl, V, Zn, Hg, Sb Cr+6 and Cyanide, pH	(1) 8 oz. Glass	✓	Laucks

OBSERVATIONS / NOTES:

Sludge noted at this location (Y/N): N

— 3 SAMPLES —

ID	DEPTH '	TIME
30CP02	0-0.5	1515 - DUP
30CP02	0.5-2	1525
30CP02	2-4	1535

MAP:

See figure & sampling grid

3 COMP. SAMPLES
5 LOCATIONS

Circle if Applicable:

MS/MSD

Duplicate ID No.: FD 030702 04 → 30CP020001

Signature(s): KJ Sh.

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NSWC CRANE - Landfarm
PROJECT NUMBER: CTO 19 job # 7393
DRILLING COMPANY: Environmental Field Services
DRILLING RIG: GeoProbe 54 LT

BORING NUMBER: 30 CP03 (ABCDE)
DATE: 3·7·02
GEOLOGIST: K. Simpson & T. Rojahn
DRILLER: Tony Strati

Sample No. and Type or RQD	Depth (Ft.) or Run No.	Blows / 6" or RQD (%)	Sample Recovery / Sample Length	Lithology Change (Depth /Ft.) or Screened Interval	MATERIAL DESCRIPTION: Soil Density/ Consistency or Rock Hardness	Color	Material Classification	USCS *	Remarks	PID/FID Reading (ppm): Sample	Sampler BZ	Borehole**	Driller BZ**
30	1				SOFT	BRN	TR LIMESTONE GRAVEL SILTY CLAY	CL	MOIST, TR ROOTS	0	0	0	0
	2				MED STIFF		GRAY MOTTLING RUST COLOR NODULES						
	3				STIFF								
105	4		4 / 4										
	5				VERY STIFF BTM 1'								
	6												
	7												
	8												
	9												
	10												
							TD = 4'						

* When rock coring, enter rock brokeness.

** Include monitor reading in 6 foot intervals @ borehole. Increase reading frequency if elevated reponse read.

Remarks:

Drilling Area Background (ppm): 0

Converted to Well: Yes ____ No X Well I.D. #: NA

SOIL SAMPLE LOG SHEET

Project Site Name: NSWC Crane, IN - Landfarm
Project No.: CTO 19 job # 7393 SWMU 30

Sample ID No.: 30 CP 03 SEE BELOW
Sample Location: 30 CP 03
Sampled By: K. Simpson & T. Rojahn
C.O.C. No.:

[X] Surface Soil
[X] Subsurface Soil
[] Sediment
[] Other:
[] QA Sample Type:

Type of Sample:
[X] Low Concentration
[] High Concentration

COMPOSITE SAMPLE DATA:

	Time	Cell	SubCell	Depth (ft)	Color	Description (Sand, Silt, Clay, Moisture, etc.)
Date: 3-7-02	1030	3	A	0-4	BRN	MOIST TR ROOTS, TR LIMESTONE
Method: DPT	↓	↓	B	↓	↓	GRAVEL TOP 0.5'
			C			SILTY CLAY
Monitor Readings	↓	↓	D	↓	↓	GRAY MOTTLING & RUST COLOR
(Range in ppm): 0	1105	↓	E	↓	↓	NODULES STARTING @ 1.2'

SAMPLE COLLECTION INFORMATION:

Analysis	Container Requirements	Collected	Other
Metals: Al, Ca, Fe, Mg, Mn, K, Na, As, Ba, Be, Cd, Cr-total, Co, Cu, Pb, Ni, Se, Ag, Tl, V, Zn, Hg, Sb Cr+6 and Cyanide, pH	(1) 8 oz. Glass	✓	Laucks

OBSERVATIONS / NOTES:

Sludge noted at this location (Y/N): N

— 3 SAMPLES —

ID	DEPTH'	TIME
30 CP03	0-0.5	1035
30 CP03	0.5-2	1045
30 CP03	2-4	1100

MAP:

See figure & sampling grid

PHOTO TAKEN

3 COMP. SAMPLES FROM 5 LOCATIONS

Circle if Applicable:

MS/MSD

Duplicate ID No.:

Signature(s): K. S. Simpson

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NSWC CRANE - Landfarm
PROJECT NUMBER: CTO 19 job # 7393
DRILLING COMPANY: Environmental Field Services
DRILLING RIG: GeoProbe 54 LT

BORING NUMBER: 30 CP04 ABCDE
DATE: 3-7-02
GEOLOGIST: K. Simpson & T. Rojahn
DRILLER: Tony Strati

Sample No. and Type or RQD	Depth (Ft.) or Run No.	Blows / 6" or RQD (%)	Sample Recovery / Sample Length	Lithology Change (Depth /Ft.) or Screened Interval	MATERIAL DESCRIPTION: Soil Density/ Consistency or Rock Hardness	Color	Material Classification	USCS *	Remarks	PID/FID Reading (ppm): Sample	Sampler BZ	Borehole**	Driller BZ**
55	1				SOFT	BRN	SILTY CLAY	CL	MOIST, TR ROOTS	0	0	0	0
	2				MED STIFF	↓	↓	↓	↓	↓	↓	↓	↓
	3				↓	LT BRN	GRAY MOTTLING w/ RUST COLOR NODULES	↓	↓	↓	↓	↓	↓
920	4		3.5/4		↓	↓	↓	↓	↓	↓	↓	↓	↓
	5												
	6												
	7												
	8												
	9												
	10												
							TD = 4'						

* When rock coring, enter rock brokeness.

** Include monitor reading in 6 foot intervals @ borehole. Increase reading frequency if elevated reponse read.

Drilling Area Background (ppm): 0

Remarks:

Converted to Well: Yes ____ No X Well I.D. #: NA

SOIL SAMPLE LOG SHEET

Project Site Name: NSWC Crane, IN - Landfarm
Project No.: CTO 19 job # 7393 SWMU 30

Sample ID No.: 30 CP 04 SEE BELOW
Sample Location: 30 CP 04
Sampled By: K. Simpson & T. Rojahn
C.O.C. No.:

[X] Surface Soil
[X] Subsurface Soil
[] Sediment
[] Other:
[] QA Sample Type:

Type of Sample:
[X] Low Concentration
[] High Concentration

COMPOSITE SAMPLE DATA:

Date: 3.7.02	Time	Cell	SubCell	Depth (ft)	Color	Description (Sand, Silt, Clay, Moisture, etc.)
	0855	4	A	0-4	BRN	MOIST TR ROOTS
Method: DPT	↓		B	↓	TO	SILTY CLAY
			C		LT	GRAY MOTTLING W/
Monitor Readings	↓		D		BRN	RUST COLOR NODULES
(Range in ppm): 0	0920		E	↓	↓	BTM 2'

SAMPLE COLLECTION INFORMATION:

Analysis	Container Requirements	Collected	Other
Metals: Al, Ca, Fe, Mg, Mn, K, Na, As, Ba, Be, Cd, Cr-total, Co, Cu, Pb, Ni, Se, Ag, Tl, V, Zn, Hg, Sb Cr+6 and Cyanide, pH	(1) 8 oz. Glass	✓	Laucks

OBSERVATIONS / NOTES:

Sludge noted at this location (Y/N): N

— 3 SAMPLES —

ID	DEPTH	TIME
30CP04	0-0.5	0900
30CP04	0.5-2	0905
30CP04	2-4	0915

MAP:

See figure & sampling grid

3 COMP SAMPLES FROM 5 LOCATIONS

Circle if Applicable:

MS/MSD

Duplicate ID No.:

Signature(s):

K. S. Simpson

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NSWC CRANE - Landfarm
PROJECT NUMBER: CTO 19 job # 7393
DRILLING COMPANY: Environmental Field Services
DRILLING RIG: GeoProbe 54 LT

BORING NUMBER: 30CP05 (ABCDE)
DATE: 3.7.02
GEOLOGIST: K. Simpson & T. Rojahn
DRILLER: Tony Strati

Sample No. and Type or RQD	Depth (Ft.) or Run No.	Blows / 6" or RQD (%)	Sample Recovery / Sample Length	Lithology Change (Depth /Ft.) or Screened Interval	MATERIAL DESCRIPTION: Soil Density/ Consistency or Rock Hardness	Color	Material Classification	USCS *	Remarks	PID/FID Reading (ppm): Sample	Sampler BZ	Borehole**	Driller BZ**
1/0	1				SOFT	BRN	TR LIMESTONE GRAVEL SILTY CLAY	CL	MOIST TR ROOTS	0	0	0	0
	2												
	3				MED		GRAY MOTTLING	TR RUST NODULES					
2/0	4		3.5/4		STIFF								
	5												
	6												
	7												
	8												
	9												
	10												
							TD = 4'						
							LIMESTONE GRAVEL ON SURFACE FROM GRAVEL RD. UNDER THE POWER LINES						

* When rock coring, enter rock brokeness.

** Include monitor reading in 6 foot intervals @ borehole. Increase reading frequency if elevated reponse read.

Remarks:

Drilling Area Background (ppm): 0

Converted to Well: Yes ____ No X Well I.D. #: NA

SOIL SAMPLE LOG SHEET

Project Site Name: NSWC Crane, IN - Landfarm
Project No.: CTO 19 job # 7393 SWMU 30

Sample ID No.: 30 CP 05 SEE BELOW
Sample Location: 30 CP 05
Sampled By: K. Simpson & T. Rojahn
C.O.C. No.:

[X] Surface Soil
[X] Subsurface Soil
[] Sediment
[] Other:
[] QA Sample Type:

Type of Sample:
[X] Low Concentration
[] High Concentration

COMPOSITE SAMPLE DATA:

Date: 3-6-02	Time	Cell	SubCell	Depth (ft)	Color	Description (Sand, Silt, Clay, Moisture, etc.)
	0810	5	A	0-4	BRN	TOP 0.5' LIMESTONE GRAVEL
Method:	↓	↓	B	↓	↓	SILTY CLAY, MOIST,
DPT			C			TR ROOTS, GRAY MOTTLING
Monitor Readings			D			BTM 2' + RUST COLOR
(Range in ppm): 0	0840	↓	E	↓	↓	NODULES

SAMPLE COLLECTION INFORMATION:

Analysis	Container Requirements	Collected	Other
Metals: Al, Ca, Fe, Mg, Mn, K, Na, As, Ba, Be, Cd, Cr-total, Co, Cu, Pb, Ni, Se, Ag, Tl, V, Zn, Hg, Sb Cr+6 and Cyanide, pH	(1) 8 oz. Glass	✓	Laucks
	X VOL FOR DUP		

OBSERVATIONS / NOTES:

Sludge noted at this location (Y/N): N

— 3 SAMPLES —

ID	DEPTH'	TIME
30CP 05	0-0.5	0815
30CP05	0.5-2	0820 + DUP
30CP05	2-4	0830

MAP:

See figure & sampling grid

3 COMP. SAMPLES FROM 5 LOCATIONS

Circle if Applicable:

MS/MSD —

Duplicate ID No.: FD 030702 01

→ @ 30CP050.5-2'

30CP050002-DUP

Signature(s):

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NSWC CRANE - Landfarm
PROJECT NUMBER: CTO 19 job # 7393
DRILLING COMPANY: Environmental Field Services
DRILLING RIG: GeoProbe 54 LT

BORING NUMBER: 30 ~~SB~~ CP 06 (ABCDE)
DATE: 3-6-02
GEOLOGIST: K. Simpson & T. Rojahn
DRILLER: Tony Strati

Sample No. and Type or RQD	Depth (Ft.) or Run No.	Blows / 6" or RQD (%)	Sample Recovery / Sample Length	Lithology Change (Depth /Ft.) or Screened Interval	MATERIAL DESCRIPTION: Soil Density/ Consistency or Rock Hardness	Color	Material Classification	USCS *	Remarks	PID/FID Reading (ppm): Sample	Sampler BZ	Borehole**	Driller BZ*
355	1				SOFT	BRN	SILT SOME CLAY SOME DK. BRN.	CL	MOIST TR ROOTS	0	0	0	0
	2				MED STIFF		SILTY CLAY GRAY/RUST MOTTLING		WET				
	3								MOIST				
30	4		4 / 4										
	5												
	6						TR. LIMESTONE GRAVEL TOP 0.3'						
	7												
	8												
	9												
	10												
							TD = 4'						

* When rock coring, enter rock brokeness.

** Include monitor reading in 6 foot intervals @ borehole. Increase reading frequency if elevated reponse read.

Remarks:

Drilling Area Background (ppm): 0

Converted to Well: Yes ____ No X Well I.D. #: NA

SOIL SAMPLE LOG SHEET

Project Site Name: NSWC Crane, IN - Landfarm
Project No.: CTO 19 job # 7393 SWMU 30

Sample ID No.: 30 CP 06
Sample Location: 30 CP 06
Sampled By: K. Simpson & T. Rojahn
C.O.C. No.:

[X] Surface Soil
[X] Subsurface Soil
[] Sediment
[] Other:
[] QA Sample Type:

Type of Sample:
[X] Low Concentration
[] High Concentration

COMPOSITE SAMPLE DATA:

Date: 3.6.02	Time	Cell	SubCell	Depth (ft)	Color	Description (Sand, Silt, Clay, Moisture, etc.)
	1355	6	A	0-4'		MOIST, TR ROOTS
Method: DPT	↓	↓	B	↓	BRN	SILT SOME CLAY
			C			WITH RUST/GRAY
Monitor Readings			D			MOTTLING BTM 1'
(Range in ppm): 0	1430	↓	E	↓		

SAMPLE COLLECTION INFORMATION:

Analysis	Container Requirements	Collected	Other
Metals: Al, Ca, Fe, Mg, Mn, K, Na, As, Ba, Be, Cd, Cr-total, Co, Cu, Pb, Ni, Se, Ag, Tl, V, Zn, Hg, Sb Cr+6 and Cyanide, pH	(1) 8 oz. Glass	✓	Laucks

OBSERVATIONS / NOTES:

Sludge noted at this location (Y/N): N

		SAMPLE TIME
3 SAMPLES; 0001	0-0.5'	1400
0002	0.5-2'	1410
0204	2-4'	1415

MAP:

See figure & sampling grid

GRID # 6
A, B, C, D & E

SAMPLE 3 DEPTHS

3 COMP. SAMPLES
FROM 5 LOCATIONS

Circle if Applicable:

MS/MSD	Duplicate ID No.:
—	—

Signature(s): K. Simpson

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NSWC CRANE - Landfarm
PROJECT NUMBER: CTO 19 job # 7393
DRILLING COMPANY: Environmental Field Services
DRILLING RIG: GeoProbe 54 LT
BORING NUMBER: 30CP07 ABCDE
DATE: 3.8.02
GEOLOGIST: K. Simpson & T. Rojahn
DRILLER: Tony Strati

Sample No. and Type or RQD	Depth (Ft.) or Run No.	Blows / 6" or RQD (%)	Sample Recovery / Sample Length	Lithology Change (Depth /Ft.) or Screened Interval	MATERIAL DESCRIPTION: Soil Density/ Consistency or Rock Hardness	Color	Material Classification	USCS *	Remarks	PID/FID Reading (ppm): Sample	Sampler BZ	Borehole**	Driller BZ**
305	1				SOFT	BRN	TR LIMESTONE GRAVEL SILTY CLAY	CL	MOIST, TR ROOTS	0	0	0	0
	2				MED STIFF		GRAY MOTTLING TR RUST COLOR NODULES						
	3												
830	4		4 / 4		STIFF								
	5												
	6												
	7												
	8												
	9												
	10												
							TD = 4'						

* When rock coring, enter rock brokeness.

** Include monitor reading in 6 foot intervals @ borehole. Increase reading frequency if elevated reponse read.

Remarks:

Drilling Area Background (ppm): 0

Converted to Well: Yes ____ No X Well I.D. #: NA

SOIL SAMPLE LOG SHEET

Project Site Name: NSWC Crane, IN - Landfarm
Project No.: CTO 19 job # 7393 SWMU 30

Sample ID No.: 30 CP 07 SEE Below
Sample Location: 30 CP 07
Sampled By: K. Simpson & T. Rojahn
C.O.C. No.:

[X] Surface Soil
[X] Subsurface Soil
[] Sediment
[] Other:
[] QA Sample Type:

Type of Sample:
[X] Low Concentration
[] High Concentration

COMPOSITE SAMPLE DATA:

Date: 3-8-02	Time	Cell	SubCell	Depth (ft)	Color	Description (Sand, Silt, Clay, Moisture, etc.)
	0805	7	A	0-4	BRN	MOIST, TR ROOTS,
Method: DPT			B			TR LIMESTONE GRAVEL TOP 0.5'
			C			GRAY MOTTLING + TR RUST
Monitor Readings			D			COLOR NODULES BTM 2'
(Range in ppm): 0	0830		E			

SAMPLE COLLECTION INFORMATION:

Analysis	Container Requirements	Collected	Other
Metals: Al, Ca, Fe, Mg, Mn, K, Na, As, Ba, Be, Cd, Cr-total, Co, Cu, Pb, Ni, Se, Ag, Tl, V, Zn, Hg, Sb Cr+6 and Cyanide, pH	(1) 8 oz. Glass	✓	Laucks

OBSERVATIONS / NOTES:

Sludge noted at this location (Y/N) :_____

— 3 SAMPLES —

ID	DEPTH	TIME
30CP07	0-0.5	0810
30CP07	0.5-2	0820
30CP07	2-4	0825

MAP:

See figure & sampling grid

3 COMP. SAMPLES
@ 5 LOCATIONS

Circle if Applicable:

MS/MSD

Duplicate ID No.:

Signature(s):

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NSWC CRANE - Landfarm
PROJECT NUMBER: CTO 19 job # 7393
DRILLING COMPANY: Environmental Field Services
DRILLING RIG: GeoProbe 54 LT

BORING NUMBER: 30 CP 08 A B C D E
DATE: 3-7-02
GEOLOGIST: K. Simpson & T. Rojahn
DRILLER: Tony Strati

Sample No. and Type or RQD	Depth (Ft.) or Run No.	Blows / 6" or RQD (%)	Sample Recovery / Sample Length	Lithology Change (Depth /Ft.) or Screened Interval	MATERIAL DESCRIPTION: Soil Density/ Consistency or Rock Hardness	Color	Material Classification	USCS *	Remarks	PID/FID Reading (ppm): Sample	Sampler BZ	Borehole**	Driller BZ**
	1				SOFT	BRN	LIMESTONE GRAVEL SILTY CLAY	CL	MOIST, TR ROOTS	0	0	0	0
	2				MED STIFF								
	3						GRAY MOTTLING TR RUST COLOR NODULES						
	4		3.5 / 4		VERY STIFF								
	5												
	6												
	7												
	8												
	9												
	10												
							TD = 4'						

* When rock coring, enter rock brokeness.

** Include monitor reading in 6 foot intervals @ borehole. Increase reading frequency if elevated reponse read.

Remarks:

Drilling Area Background (ppm): 0

Converted to Well: Yes ____ No X Well I.D. #: NA

SOIL SAMPLE LOG SHEET

Project Site Name: NSWC Crane, IN - Landfarm
Project No.: CTO 19 job # 7393 SWMU 30

[X] Surface Soil
[X] Subsurface Soil
[] Sediment
[] Other:
[] QA Sample Type:

Sample ID No.: 30 CP 08 SEE BELOW
Sample Location: 30 CP 08
Sampled By: K. Simpson & T. Rojahn
C.O.C. No.:

Type of Sample:
[X] Low Concentration
[] High Concentration

COMPOSITE SAMPLE DATA:

Date: 3.7.02	Time	Cell	SubCell	Depth (ft)	Color	Description (Sand, Silt, Clay, Moisture, etc.)
	1435	8	A	0-4	BRN	MOIST LIMESTONE GRAVEL TOP 0.5'
Method: DPT	↓	↓	B	↓	↓	TR ROOTS
			C			SILTY CLAY
Monitor Readings	↓	↓	D	↓	↓	GRAY MOTTLING &
(Range in ppm): 0	1500	↓	E	↓	↓	RUST COLOR NODULES BTM 2'

SAMPLE COLLECTION INFORMATION:

Analysis	Container Requirements	Collected	Other
Metals: Al, Ca, Fe, Mg, Mn, K, Na, As, Ba, Be, Cd, Cr-total, Co, Cu, Pb, Ni, Se, Ag, Tl, V, Zn, Hg, Sb Cr+6 and Cyanide, pH	(1) 8 oz. Glass	✓	Laucks

OBSERVATIONS / NOTES:

Sludge noted at this location (Y/N): N

— 3 SAMPLES —

ID	DEPTH	TIME
30CP08	0-0.5	1440 - DUP
30CP08	0.5-2	1445
30CP08	2-4	1500

MAP:

See figure & sampling grid

3 SAMPLES (COMPS)
5 LOCATIONS

Circle if Applicable:

MS/MSD

Duplicate ID No.: FD 030702 03
→ 30CP080001

Signature(s): [illegible]

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NSWC CRANE - Landfarm
PROJECT NUMBER: CTO 19 job # 7393
DRILLING COMPANY: Environmental Field Services
DRILLING RIG: GeoProbe 54 LT

BORING NUMBER: 30 CP09 ABCDE
DATE: 3.7.02
GEOLOGIST: K. Simpson & T. Rojahn
DRILLER: Tony Strati

Sample No. and Type or RQD	Depth (Ft.) or Run No.	Blows / 6" or RQD (%)	Sample Recovery / Sample Length	Lithology Change (Depth /Ft.) or Screened Interval	MATERIAL DESCRIPTION: Soil Density/ Consistency or Rock Hardness	Color	Material Classification	USCS *	Remarks	PID/FID Reading (ppm): Sample	Sampler BZ	Borehole**	Driller BZ**
AO	1				SOFT	BRN	LIMESTONE GRAVEL SILTY CLAY	SM CL	MOIST, TR ROOTS	0	0	0	0
	2				STIFF								
	3				VERY STIFF	REDISH BRN	GRAY MOTTLING RUST COLOR NODULES						
HO	4		3.5/4										
	5												
	6												
	7												
	8												
	9												
	10												
							TD = 4'						

* When rock coring, enter rock brokeness.

** Include monitor reading in 6 foot intervals @ borehole. Increase reading frequency if elevated reponse read.

Drilling Area Background (ppm): 0

Remarks:

Converted to Well: Yes ____ No X Well I.D. #: NA

SOIL SAMPLE LOG SHEET

Project Site Name: NSWC Crane, IN - Landfarm
Project No.: CTO 19 job # 7393 SWMU 30

Sample ID No.: 30 CP 09 SEE BELOW
Sample Location: 30 CP 09
Sampled By: K. Simpson & T. Rojahn
C.O.C. No.:

[X] Surface Soil
[X] Subsurface Soil
[] Sediment
[] Other:
[] QA Sample Type:

Type of Sample:
[X] Low Concentration
[] High Concentration

COMPOSITE SAMPLE DATA:

Date: 3.7.02	Time	Cell	SubCell	Depth (ft)	Color	Description (Sand, Silt, Clay, Moisture, etc.)
	1340	9	A	0-4	BRN	MOIST, TR. ROOTS,
Method:			B			LIMESTONE GRAVEL TOP 0.5'
DPT			C			SILTY CLAY
Monitor Readings			D			GRAY MOTTLING BTM 2'
(Range in ppm): 0	1410		E			REDISH BRN BTM 2'

SAMPLE COLLECTION INFORMATION:

Analysis	Container Requirements	Collected	Other
Metals: Al, Ca, Fe, Mg, Mn, K, Na, As, Ba, Be, Cd, Cr-total, Co, Cu, Pb, Ni, Se, Ag, Tl, V, Zn, Hg, Sb Cr+6 and Cyanide, pH	(1) 8 oz. Glass	✓	Laucks

OBSERVATIONS / NOTES:

Sludge noted at this location (Y/N): N

— 3 SAMPLES —

ID	DEPTH	TIME
30CP09	0-0.5'	1345
30CP09	0.5-2	1350 — MS/MSD
30CP09	2-4	1355

MAP:

See figure & sampling grid

3 COMP. SAMPLES FROM 5 LOCATIONS

Circle if Applicable:

MS/MSD: YES

Duplicate ID No.: —

Signature(s):

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NSWC CRANE - Landfarm
PROJECT NUMBER: CTO 19 job # 7393
DRILLING COMPANY: Environmental Field Services
DRILLING RIG: GeoProbe 54 LT

BORING NUMBER: 30 CP 10 ABCDE
DATE: 3-7-02
GEOLOGIST: K. Simpson & T. Rojahn
DRILLER: Tony Strati

Sample No. and Type or RQD	Depth (Ft.) or Run No.	Blows / 6" or RQD (%)	Sample Recovery / Sample Length	Lithology Change (Depth /Ft.) or Screened Interval	MATERIAL DESCRIPTION: Soil Density/ Consistency or Rock Hardness	Color	Material Classification	USCS *	Remarks	PID/FID Reading (ppm): Sample	Sampler BZ	Borehole**	Driller BZ**
30	1				SOFT	BRN	TR LIMESTONE GRAVEL SILTY CLAY	CL	MOIST TR ROOTS	0	0	0	0
	2				MED STIFF								
	3				STIFF		GRAY MOTTLING						
35	4		3.5/4										
	5												
	6												
	7												
	8												
	9												
	10												
							TD = 4'						

* When rock coring, enter rock brokeness.

** Include monitor reading in 6 foot intervals @ borehole. Increase reading frequency if elevated reponse read.

Remarks:

Drilling Area Background (ppm): 0

Converted to Well: Yes ____ No X Well I.D. #: NA

SOIL SAMPLE LOG SHEET

Project Site Name: NSWC Crane, IN - Landfarm
Project No.: CTO 19 job # 7393 SWMU 30

Sample ID No.: 30 CP 10 SEE BELOW
Sample Location: 30 CP 10
Sampled By: K. Simpson & T. Rojahn
C.O.C. No.:

[X] Surface Soil
[X] Subsurface Soil
[] Sediment
[] Other:
[] QA Sample Type:

Type of Sample:
[X] Low Concentration
[] High Concentration

COMPOSITE SAMPLE DATA:

Date: 3-7-02	Time	Cell	SubCell	Depth (ft)	Color	Description (Sand, Silt, Clay, Moisture, etc.)
	0930	10	A	0-4	BRN	MOIST, TR ROOTS, TR LIMESTONE GRAVEL
Method: DPT			B			SILTY CLAY
			C			GRAY MOTTLING BTM 2'
Monitor Readings			D			
(Range in ppm): 0	1005		E			

SAMPLE COLLECTION INFORMATION:

Analysis	Container Requirements	Collected	Other
Metals: Al, Ca, Fe, Mg, Mn, K, Na, As, Ba, Be, Cd, Cr-total, Co, Cu, Pb, Ni, Se, Ag, Tl, V, Zn, Hg, Sb Cr+6 and Cyanide, pH	(1) 8 oz. Glass	✓	Laucks
	X VOL DUP + MS/MSD		

OBSERVATIONS / NOTES:

Sludge noted at this location (Y/N): N

— 3 SAMPLES —

ID	DEPTH'	TIME	
30CP10	0-0.5	0935	- DUP
30CP10	0.5-2	0945	
30CP10	2-4	1000	- MS/MSD

MAP:

See figure & sampling grid

3 COMP SAMPLES FROM 5 LOCATIONS

Circle if Applicable:

MS/MSD: YES

Duplicate ID No.: FD 030702 02 → 30CP10 0001

Signature(s): K. S. Simpson

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NSWC CRANE - Landfarm
PROJECT NUMBER: CTO 19 job # 7393
DRILLING COMPANY: Environmental Field Services
DRILLING RIG: GeoProbe 54 LT
BORING NUMBER: 30 CP 11 ABCD & E
DATE: 3.6.02
GEOLOGIST: K. Simpson & T. Rojahn
DRILLER: Tony Strati

Sample No. and Type or RQD	Depth (Ft.) or Run No.	Blows / 6" or RQD (%)	Sample Recovery / Sample Length	Lithology Change (Depth /Ft.) or Screened Interval	MATERIAL DESCRIPTION: Soil Density/ Consistency or Rock Hardness	Color	Material Classification	USCS *	Remarks	PID/FID Reading (ppm): Sample	Sampler BZ	Borehole**	Driller BZ**
.14	1				MED STIFF	BRN	SILTY CLAY	CL	MOIST TR ROOTS	0	0	0	0
	2												
	3				STIFF		SOME GRAY MOTTLING						
.20	4		3.5/4										
	5						TR RUST COLOR NODULES BTM 1'						
	6												
	7												
	8												
	9												
	10												
							TD = 4'						

* When rock coring, enter rock brokeness.

** Include monitor reading in 6 foot intervals @ borehole. Increase reading frequency if elevated reponse read.

Remarks:

Drilling Area Background (ppm): 0

Converted to Well: Yes ____ No X Well I.D. #: NA

SOIL SAMPLE LOG SHEET

Project Site Name: NSWC Crane, IN - Landfarm
Project No.: CTO 19 job # 7393 SWMU 30

Sample ID No.: 30 CP 11 SEE BELOW
Sample Location: 30 CP 11
Sampled By: K. Simpson & T. Rojahn
C.O.C. No.:

[X] Surface Soil
[X] Subsurface Soil
[] Sediment
[] Other:
[] QA Sample Type:

Type of Sample:
[X] Low Concentration
[] High Concentration

COMPOSITE SAMPLE DATA:

Date: 3.6.02	Time	Cell	SubCell	Depth (ft)	Color	Description (Sand, Silt, Clay, Moisture, etc.)
	1514	11	A	0-4'	BRN	MOIST, TR ROOTS
Method: DPT	↓	↓	B	↓		SILTY CLAY
			C			SOME GRAY MOTTLING
Monitor Readings	↓		D			TR RUST COLOR NODULES
(Range in ppm): 0	1620	↓	E	↓		BTM 1'

SAMPLE COLLECTION INFORMATION:

Analysis	Container Requirements	Collected	Other
Metals: Al, Ca, Fe, Mg, Mn, K, Na, As, Ba, Be, Cd, Cr-total, Co, Cu, Pb, Ni, Se, Ag, Tl, V, Zn, Hg, Sb Cr+6 and Cyanide, pH	(1) 8 oz. Glass	✓	Laucks

OBSERVATIONS / NOTES:

Sludge noted at this location (Y/N): N

— 3 SAMPLES —

ID - DEPTH	DEPTH	TIME
30CP11 0001	0-0.5'	1610
30CP11 0002	0.5-2'	1615
30CP11 0204	2-4'	1620 → MS/MSD

MAP:

See figure & sampling grid

3 COMP SAMPLES FROM 5 LOCATIONS

Circle if Applicable:

MS/MSD	Duplicate ID No.:
YES	—

0204

Signature(s): KJS

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NSWC CRANE - Landfarm
PROJECT NUMBER: CTO 19 job # 7393
DRILLING COMPANY: Environmental Field Services
DRILLING RIG: GeoProbe 54 LT

BORING NUMBER: 30 CP 12 (A,B,C,D,E)
DATE: 3.6.02
GEOLOGIST: K. Simpson & T. Rojahn
DRILLER: Tony Strati

Sample No. and Type or RQD	Depth (Ft.) or Run No.	Blows / 6" or RQD (%)	Sample Recovery / Sample Length	Lithology Change (Depth /Ft.) or Screened Interval	MATERIAL DESCRIPTION: Soil Density/ Consistency or Rock Hardness	Color	Material Classification	USCS *	Remarks	PID/FID Reading (ppm): Sample	Sampler BZ	Borehole**	Driller BZ**
40	1				MED STIFF	BRN	SILTY CLAY	CL	MOIST TR ROOTS	0	0	0	0
	2				↓	↓							
	3				STIFF	GRAY	GRAY/BRN MOTTLING						
35	4		4 / 4				TR RUST NODULES						
	5												
	6												
	7												
	8												
	9												
	10												
							TD = 4'						

* When rock coring, enter rock brokeness.

** Include monitor reading in 6 foot intervals @ borehole. Increase reading frequency if elevated reponse read.

Remarks:

Drilling Area Background (ppm): 0

Converted to Well: Yes ____ No X Well I.D. #: NA

SOIL SAMPLE LOG SHEET

Project Site Name: NSWC Crane, IN - Landfarm
Project No.: CTO 19 job # 7393 SWMU 30

Sample ID No.: 30 CP 12 SEE BELOW
Sample Location: 30 CP 12
Sampled By: K. Simpson & T. Rojahn
C.O.C. No.:

[X] Surface Soil
[X] Subsurface Soil
[] Sediment
[] Other:
[] QA Sample Type:

Type of Sample:
[X] Low Concentration
[] High Concentration

COMPOSITE SAMPLE DATA:

Date: 3.6.02	Time	Cell	SubCell	Depth (ft)	Color	Description (Sand, Silt, Clay, Moisture, etc.)
	1440	12	A	0-4	BRN	MOIST TR ROOTS
Method: DPT	↓		B	↓	TO	SILTY CLAY
	↓		C	↓	GRAY	GRAY/BRN MOTTLING
Monitor Readings	↓		D	↓	↓	TR. RUST COLOR NODULES
(Range in ppm): 0			E	↓	↓	

SAMPLE COLLECTION INFORMATION:

Analysis	Container Requirements	Collected	Other
Metals: Al, Ca, Fe, Mg, Mn, K, Na, As, Ba, Be, Cd, Cr-total, Co, Cu, Pb, Ni, Se, Ag, Tl, V, Zn, Hg, Sb Cr+6 and Cyanide, pH	(1) 8 oz. Glass	✓	Laucks

OBSERVATIONS / NOTES:

Sludge noted at this location (Y/N): N

	ID	DEPTH	SAMPLE TIME
3 SAMPLES:	0001	0-0.5'	1445
	0002	0.5-2'	1450
	0204	2-4'	1455

MAP:

See figure & sampling grid

3 COMP. SAMPLES FROM 5 LOCATIONS

Circle if Applicable:

MS/MSD —

Duplicate ID No.: —

Signature(s): [illegible]

APPENDIX C

CHAIN OF CUSTODY FORMS

TETRA TECH NUS, INC. CHAIN OF CUSTODY | NUMBER | PAGE 1 OF 3

PROJECT NO.	SITE NAME	PROJECT MANAGER AND PHONE NUMBER	LABORATORY NAME AND CONTACT
CT019 # 7393	NSWC CRANE	ROGER CLARK 412 921 7090	LAUCKS - HUGH PRENTICE

SAMPLERS (SIGNATURE): [signature]

FIELD OPERATIONS LEADER AND PHONE NUMBER: KEITH SIMPSON 412 921 8131

ADDRESS:

CARRIER/WAYBILL NUMBER: FEDEX 8280 7402 8113

CITY, STATE: SEATTLE WA

STANDARD TAT ☒
RUSH TAT ☐
☐ 24 hr. ☐ 48 hr. ☐ 72 hr. ☐ 7 day ☐ 14 day

CONTAINER TYPE PLASTIC (P) or GLASS (G): G

PRESERVATIVE USED: 4°C

TYPE OF ANALYSIS: SELECT METALS, CR+6, CN, pH

DATE YEAR 2002	TIME	SAMPLE ID	MATRIX	GRAB (G) COMP (C)	No. OF CONTAINERS	SELECT METALS, CR+6, CN, pH								COMMENTS
3/6	1340	LANDFARM SWMU 30 30SS03 0001	S	G	1	1								CPs ARE
	1345	30SS03 0002	S	G	1	1	*							COMPOSIT SAMPLES
	1350	30SB03 0204	S	G	1	1								
	1400	30CP06 0001	S	G	1	1								
	1410	30CP06 0002	S	G	1	1	*							
	1415	30CP06 0204	S	G	1	1								
	1445	30CP12 0001	S	G	1	1								
	1450	30CP12 0002	S	G	1	1	*							
	1455	30CP12 0204	S	G	1	1								
	1610	30CP11 0001	S	G	1	1								
	1615	30CP11 0002	S	G	1	1	*							
	1620	30CP11 0204	S	G	1	1								RUN ALSO MS/MSD
	0000	FD 030602 03	S	G	1	1								30SB04 0204

	DATE	TIME		DATE	TIME
1. RELINQUISHED BY [signature]	3.7.02	1830	1. RECEIVED BY FEDEX		
2. RELINQUISHED BY			2. RECEIVED BY		
3. RELINQUISHED BY			3. RECEIVED BY		

COMMENTS: LAUCKS SEE ATTACHMENT 4 SPEC. FOR SELECT METALS LIST | * = SAMPLES TO BE HELD

DISTRIBUTION: WHITE (ACCOMPANIES SAMPLE) YELLOW (FIELD COPY) PINK (FILE COPY) DO NOT ANALYZE

3/99
FORM NO. TtNUS-001

TETRA TECH NUS, INC. CHAIN OF CUSTODY | NUMBER | PAGE 2 OF 5

PROJECT NO:	SITE NAME:	PROJECT MANAGER AND PHONE NUMBER	LABORATORY NAME AND CONTACT:
CTO19 # 7393	NSWC CRANE	ROGER CLARK 412 921 8415	LAUCKS - HUGH PRENTICE

SAMPLERS (SIGNATURE): K.J.S. Simpson

FIELD OPERATIONS LEADER AND PHONE NUMBER: KEITH SIMPSON 412 921 8131

ADDRESS:

CARRIER/WAYBILL NUMBER: FEDEX 8280 7402 8113

CITY, STATE: SEATTLE WA

STANDARD TAT ☒
RUSH TAT ☐
☐ 24 hr. ☐ 48 hr. ☐ 72 hr. ☐ 7 day ☐ 14 day

CONTAINER TYPE PLASTIC (P) or GLASS (G): G

PRESERVATIVE USED: 4°C

TYPE OF ANALYSIS: SELECT METALS, CR+6, CN, PH

DATE YEAR 2002	TIME	SAMPLE ID	MATRIX	GRAB (G) COMP (C)	No. OF CONTAINERS	TYPE OF ANALYSIS	COMMENTS
3/6	1631	30 SS 04 0001	S	G	1	1	
	1634	30 SS 04 0002	S	G	1	1	*
	1636	30 SB 04 0204	S	G	1	1	
3/7	0815	30 CP 05 0001	S	C	1	1	
	0820	30 CP 05 0002	S	C	1	1	*
	0830	30 CP 05 0204	S	C	1	1	
	0000	FD 030702 01	S	C	1	1	* 30CP05 0002
	0845	30 SS 02 0001	S	G	1	1	
	0847	30 SS 02 0002	S	G	1	1	*
	0850	30 SB 02 0204	S	G	1	1	
	0900	30CP 04 0001	S	C	1	1	
	0905	30 CP 04 0002	S	C	1	1	*
	0915	30 CP 04 0204	S	C	1	1	

	DATE	TIME		DATE	TIME
1. RELINQUISHED BY: K.J.S.	3.7.02	1830	1. RECEIVED BY: FEDEX		
2. RELINQUISHED BY			2. RECEIVED BY		
3. RELINQUISHED BY			3. RECEIVED BY		

COMMENTS: * = SAMPLES TO BE HELD

DISTRIBUTION: WHITE (ACCOMPANIES SAMPLE) YELLOW (COPY) PINK (FILE COPY)

3/99
FORM NO. TtNUS-001

TETRA TECH NUS, INC. CHAIN OF CUSTODY NUMBER PAGE 3 OF 3

PROJECT NO: CTO 19 # 7393	SITE NAME: NSWC CRANE	PROJECT MANAGER AND PHONE NUMBER: ROGER CLARK 412 921 8415	LABORATORY NAME AND CONTACT: CAUCKS - HUGH PRENTICE
SAMPLERS (SIGNATURE): K. S. Simpson		FIELD OPERATIONS LEADER AND PHONE NUMBER: KEITH SIMPSON 412 921 8131	ADDRESS:
		CARRIER/WAYBILL NUMBER: FEDEX 8280 7402 8113	CITY, STATE: SEATTLE WA

STANDARD TAT ☒
RUSH TAT ☐
☐ 24 hr. ☐ 48 hr. ☐ 72 hr. ☐ 7 day ☐ 14 day

CONTAINER TYPE PLASTIC (P) or GLASS (G): G
PRESERVATIVE USED: 4°C

DATE YEAR 2002	TIME	SAMPLE ID (LANDFARM SWMU 30)	MATRIX	GRAB (G) COMP (C)	No. OF CONTAINERS	TYPE OF ANALYSIS: SELECT METALS, CR+6, CN, PH								COMMENTS
3/7	0000	FD 030702 02	S	C	1	1								30CP10 0001
	0935	30CP10 0001	S	C	1	1								
	0945	30CP10 0002	S	C	1	1								*
	1000	30CP10 0204	S	C	1	1								RUN ALSO MS/MSD
	1035	30CP03 0001	S	C	1	1								
	1045	30CP03 0002	S	C	1	1								*
	1100	30CP03 0204	S	C	1	1								
	1330	30SS01 0001	S	G	1	1								
	1333	30SS01 0002	S	G	1	1								*
	1335	30SB01 0204	S	G	1	1								
	1345	30CP09 0001	S	C	1	1								
	1350	30CP09 0002	S	C	1	1								* RUN ALSO MS/MSD
	1355	30CP09 0204	S	C	1	1								

1. RELINQUISHED BY: K. S. Simpson	DATE: 3-7-02	TIME: 1830	1. RECEIVED BY: FEDEX	DATE	TIME
2. RELINQUISHED BY	DATE	TIME	2. RECEIVED BY	DATE	TIME
3. RELINQUISHED BY	DATE	TIME	3. RECEIVED BY	DATE	TIME

COMMENTS: * = SAMPLES TO BE HELD

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3/99
FORM NO. TtNUS-001

TETRA TECH NUS, INC. CHAIN OF CUSTODY | NUMBER | PAGE 4 OF 5

PROJECT NO: CT019# 7393	SITE NAME:	PROJECT MANAGER AND PHONE NUMBER: ROGER CLARK 412 921 8415	LABORATORY NAME AND CONTACT: LAUCKS - HUGH PRENTICE
SAMPLERS (SIGNATURE): [signature]		FIELD OPERATIONS LEADER AND PHONE NUMBER: KEITH SIMPSON 412 921 8131	ADDRESS:
		CARRIER/WAYBILL NUMBER: FEDEX 8280 7402 8113	CITY, STATE: SEATTLE WA

STANDARD TAT ☒
RUSH TAT ☐
☐ 24 hr. ☐ 48 hr. ☐ 72 hr. ☐ 7 day ☐ 14 day

CONTAINER TYPE PLASTIC (P) or GLASS (G): G P P P
PRESERVATIVE USED: 4°C HNO_3 NaOH 4°C

DATE YEAR 2002	TIME	SAMPLE ID	MATRIX	GRAB (G) COMP (C)	No. OF CONTAINERS	SELECT METALS, CR+6, CN, PH	METALS	CN	CR+6, PH					COMMENTS
		LANDFARM SWMU 30												
3/7	1420	30SS05 0001	S	G	1	1								
	1422	30SS05 0002	S	G	1	1								*
	1425	30SB05 0204	S	G	1	1								
	0000	FD030702 03	S	C	1	1								30CP08 0001
	1440	30CP08 0001	S	C	1	1								
	1445	30CP08 0002	S	C	1	1								*
	1500	30CP08 0204	S	C	1	1								
	1515	30CP02 0001	S	C	1	1								
	1525	30CP02 0002	S	C	1	1								*
	1535	30CP02 0204	S	C	1	1								
	0000	FD030702 04	S	C	1	1								30CP02 0001
	1700	RB030702 01	AQ	G	3	—	1	1	1					STAINLESS STEEL BOWL
	1710	RB030702 02	AQ	G	3	—	1	1	1					PLASTIC TUBE

	DATE	TIME		DATE	TIME
1. RELINQUISHED BY [signature]	3-7-02	1830	1. RECEIVED BY FEDEX		
2. RELINQUISHED BY			2. RECEIVED BY		
3. RELINQUISHED BY			3. RECEIVED BY		

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FORM NO. TtNUS-001

PETRA TECH NUS, INC. CHAIN OF CUSTODY NUMBER PAGE 5 OF 5

PROJECT NO: CTO 19 # 7393	SITE NAME: NSWC CRANE	PROJECT MANAGER AND PHONE NUMBER: ROGER CLARK 412 921 8415	LABORATORY NAME AND CONTACT: CAUCKS - HUGH PRENTICE
SAMPLERS (SIGNATURE): [signature]		FIELD OPERATIONS LEADER AND PHONE NUMBER: KEITH SIMPSON 412 921 8131	ADDRESS:
		CARRIER/WAYBILL NUMBER: FEDEX 8280 7402 8113	CITY, STATE: SEATTLE WA

STANDARD TAT ☒
RUSH TAT ☐
☐ 24 hr. ☐ 48 hr. ☐ 72 hr. ☐ 7 day ☐ 14 day

DATE YEAR 2002	TIME	SAMPLE ID (LANDFARM SWMU 30)	MATRIX	GRAB (G) COMP (C)	No. OF CONTAINERS	SELECT METALS, CR+6, CN, PH	METALS	CN	CR+6, PH	ENERGETICS	PCBs			COMMENTS
		CONTAINER TYPE PLASTIC (P) or GLASS (G)				G	P	P	P	G	G			
		PRESERVATIVE USED				4°C	HNO3	NaOH	4°C	4°C	4°C			
3/7	0000	FD 030702 05	S	C	1	1								30CP01 0204
	1605	30 CP 01 0001	S	C	1	1								
	1615	30 CP 01 0002	S	C	1	1								*
	1620	30 CP 01 0204	S	C	1	1								
	1633	30 SS 06 0001	S	G	1	1								
	1635	30 SS 06 0002	S	G	1	1								*
	1638	30 SB 06 0204	S	G	1	1								
	1730	RB 030702 03	AQ	G	7	—	1	1	1	2	2			PLASTIC DPT SLEEVE

	DATE	TIME		DATE	TIME
1. RELINQUISHED BY [signature]	3-7-02	1830	1. RECEIVED BY FEDEX		
2. RELINQUISHED BY			2. RECEIVED BY		
3. RELINQUISHED BY			3. RECEIVED BY		

COMMENTS * = SAMPLES TO BE HELD | RB WILL COVER SLEEVE FOR CTO19, 160 & 205

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FORM NO. TtNUS-001

TETRA TECH NUS, INC. CHAIN OF CUSTODY | NUMBER | PAGE 1 OF 1

PROJECT NO: CTO19 # 7393	SITE NAME: NSWC CRANE	PROJECT MANAGER AND PHONE NUMBER: ROGER CLARK 412921 7090	LABORATORY NAME AND CONTACT: LAUCKS - HUGH PRENTICE
SAMPLERS (SIGNATURE): [signature]		FIELD OPERATIONS LEADER AND PHONE NUMBER: KEITH SIMPSON 412921 8131	ADDRESS:
		CARRIER/WAYBILL NUMBER: FEDEX	CITY, STATE: SEATTLE WA

STANDARD TAT ☒
RUSH TAT ☐
☐ 24 hr. ☐ 48 hr. ☐ 72 hr. ☐ 7 day ☐ 14 day

CONTAINER TYPE PLASTIC (P) or GLASS (G):
PRESERVATIVE USED:

DATE YEAR 2002	TIME	SAMPLE ID: LANDFARM SWMU 30	MATRIX	GRAB (G) COMP (C)	No. OF CONTAINERS	TYPE OF ANALYSIS: SELECT METALS, CR+6, CN, PH								COMMENTS
3/8	0810	30 CP 07 0001	S	C	1	1								
↓	0820	30 CP 07 0002	S	C	1	1								*
↓	0825	30 CP 07 0204	S	C	1	1								

1. RELINQUISHED BY [signature]	DATE	TIME	1. RECEIVED BY FEDEX	DATE	TIME
2. RELINQUISHED BY	DATE	TIME	2. RECEIVED BY	DATE	TIME
3. RELINQUISHED BY	DATE	TIME	3. RECEIVED BY	DATE	TIME

COMMENTS * = SAMPLE TO BE HELD

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APPENDIX D

DATA VALIDATION LETTERS

Tetra Tech NUS **INTERNAL CORRESPONDENCE**

TO:	**R. CLARK**	**DATE:**	**AUGUST 2, 2002**
FROM:	**ETHAN G. LEE**	**COPIES:**	**DV FILE**

SUBJECT: **INORGANIC DATA VALIDATION – TAL METALS AND MISCELLANEOUS PARAMETERS**
NSWC CRANE – CTO 019
SAMPLE DELIVERY GROUP (SDG) – T1903

SAMPLES: 7/SOIL/

30CP010001 30CP010204 30CP070001 30CP070204
30SB060204 30SS060001 FD03070205

1/AQUEOUS/

RB03070203

Overview

The sample set for NSWC Crane, SDG T1903, consists of seven (7) soil environmental samples and one (1) aqueous rinsate blank. One (1) field duplicate pair (FD03070205 / 30CP010204) is included in this SDG.

The samples were analyzed for TAL metals and miscellaneous parameters. The samples were collected by Tetra Tech NUS March 7-8, 2002 and analyzed by Laucks Testing Laboratories. Aluminum, calcium, iron, magnesium, manganese, potassium, and sodium analyses were conducted using method SW846 6010B. Mercury analyses were conducted using method SW846 7471A. All other metals analyses were conducted using method SW846 6020. Hexavalent chromium analyses were conducted using method SW846 7196A. Cyanide analyses were conducted using method SW846 9012A. pH analyses were conducted using method SW846 9045C. Concentrations for antimony, barium, cadmium, copper, lead, selenium, silver, and thallium were diluted 10X. Concentrations for arsenic, beryllium, chromium, cobalt, nickel, vanadium, and zinc were diluted 20X.

Metals analyses except mercury were conducted using Inductively Coupled Plasma (ICP) methodologies. Aluminum, calcium, iron, magnesium, manganeses, potassium, and sodium analyses were performed via ICP-Trace and all other metals analyses except mercury were performed via ICP-MS. Mercury analyses were conducted using Manual Cold Vapor Atomic Absorption (CVAA) methodologies.

These data were evaluated based on the following parameters:

* • Data Completeness
* • Holding Times
  • Laboratory Blank Analyses
  • Calibration Recoveries
* • ICP Interference
  • Matrix Spike Results

* • Laboratory Duplicate Results
  • Field Duplicate Results
  • Laboratory Control Sample Results
  • ICP Serial Dilution Results
* • Sample Quantitation
* • Detection Limits

* - All quality control criteria were met for this parameter.

Laboratory Blank Analyses

The following contaminants were detected in the laboratory method/preparation blanks at the following maximum concentrations:

Analyte	Maximum Concentration	Action Level
Antimony[1]	0.111 mg/kg	0.56 mg/kg
Barium[1]	0.045 mg/kg	0.23 mg/kg
Calcium	31.7 ug/L	15.9 mg/kg
Chromium[1]	0.027 mg/kg	0.135 mg/kg
Iron	50.2 ug/L	25.1 mg/kg
Lead[1]	0.029 mg/kg	0.145 mg/kg
Magnesium	42.2 ug/L	21.1 mg/kg
Mercury	0.05 ug/L	0.05 mg/kg
Nickel[1]	0.016 mg/kg	0.08 mg/kg
Potassium	46.2 ug/L	23.1 mg/kg
Silver[1]	0.035 mg/kg	0.175 mg/kg
Sodium	235 ug/L	118 mg/kg
Zinc[1]	0.211 mg/kg	1.06 mg/kg

[1] Maximum concentration found in laboratory preparation blank.

An action level of 5X the maximum concentration was used to evaluate the sample data for blank contamination. Sample aliquot, percent solids, and dilution factors, if applicable, were taken into consideration when evaluating for blank contamination. Positive results < Action Level were qualified (U) for antimony, mercury, silver, and sodium. Positive results > Action Level were qualified as estimated (J).

Calibration Noncompliance

The calibration percent recovery (%R) for beryllium was above the control limit of 90-110%. Positive results (>IDL) were qualified as estimated (J).

Matrix Spike Analysis

The matrix spike %R for arsenic, calcium, magnesium, and sodium were less than the control limit of 75-125% and the sample results were <4X the spike added. Positive results were qualified as estimated (J). Nondetects were qualified as estimated (UJ).

The matrix spike %R for barium was greater than the control limit of 75-125% and the sample result was <4X the spike added. Positive results were qualified as estimated (J).

The matrix spike %R for hexavalent chromium was less than the control limit of 75-125% and the sample results were <4X the spike added. Nondetects were qualified as rejected (UR) because standard reference materials (SRM's) yielded poor %R's.

Field Duplicate Analysis

The Relative Percent Difference (RPD) for the field duplicate pair (FD03060203 / 30SB040204) for manganese was calculated to be >50%. Because both values were >5X CRDL, positive results for manganese were qualified as estimated (J) in all soil samples.

Laboratory Control Sample Analysis

The soil LCS %R for aluminum, magnesium, potassium, sodium, and zinc were less than the control limits set by the EPA. Positive results (>IDL) were qualified as estimated (J). Nondetected results (<IDL) were qualified as estimated (UJ).

The soil LCS %R for lead was greater than the control limits set by the EPA. Positive results (>IDL) were qualified as estimated (J).

The aqueous LCS %R for zinc was greater than the control limit of 80-120%. Positive results (>IDL) were qualified as estimated (J).

ICP Serial Dilution Analysis

The Percent Differences (%D's) for barium, magnesium, manganese, and potassium were >10% and the initial sample results were >50X IDL. Positive results (>IDL) were qualified as estimated (J) for all soil samples.

SRM / Laboratory Control Samples/Laboratory Performance

Hexavalent chromium analyses in all soil samples except one have been rejected due to poor recoveries of the quality control Standard Reference Material (SRM). The basis of the rejection is that the SRM is an independent certified standard (of known concentration) and is used to assess laboratory performance for a given analytical parameter. The recoveries of the SRM, associated with Crane data, as determined by Laucks ranged from 1.2% to 12.6%. The acceptable minimum recovery defined in the QAPP is 50%. All results except in one sample were reported as nondetected. The reporting limit provided by Laucks was approximately 2-3 mg/kg.

As a result of the poor recoveries, an investigation on the SRM was conducted to determine whether reduction of the hexavalent chromium ion to the trivalent chromium ion had occurred. In order to begin the investigation, Laucks Laboratory was contacted and provided the lot number of the SRM that was used for analysis. The manufacturer (ERA) of the SRM was also contacted and was asked to analyze the exact lot used by Laucks. ERA agreed to perform tests on the lot used by Laucks.

ERA performed tests on the SRM in triplicate. The recoveries reported by ERA are as follows: 37%, 44%, and 34 %. The average concentration of hexavalent chromium reported by ERA was 20.9 mg/kg. The certified concentration of the SRM was 54.5 mg/kg.

The variance of the average concentration from the certified concentration raises three possibilities: (1) some reduction of the SRM may have occurred over time thus accounting for the difference between the results; (2) the recovery is representative of the analytical procedure; or (3) some combination of points 1 & 2. However, despite the possibility of some hexavalent chromium reduction and deficiencies in the analytical procedure, it is evident that hexavalent chromium is still present in the SRM at a sufficiently high concentration.

In addition to the tests conducted by ERA, Laucks conducted their own re-testing (5 tests) of the SRM and reported an average recovery of 35%.

Finally, upon review of the ERA results, it is my conclusion that although some reduction of the SRM may have occurred, the recoveries reported by ERA indicate that the SRM contains a sufficiently high concentration of hexavalent chromium upon which to conduct analysis. The SRM recoveries associated with the Crane analytical data are indicative of poor performance of the analytical procedure and cannot be attributed to the reduction of hexavalent chromium in the SRM. This is supported by the fact that the average recovery improved to 35% when Laucks conducted their own re-testing. Therefore, because it has been proven that the SRM had not reduced to a level beyond detection (concentration of hexavalent chromium >10X the reporting limit) and that the recoveries of the SRM are poor, the data are not considered reliable and have been rejected (UR).

Notes

The hexavalent chromium holding time limit of 4 days from extraction to analysis was exceeded for all samples. No qualification action was required because all results were rejected due to matrix spike and poor SRM recoveries.

The ICS AB solution %R's for arsenic, chromium, nickel, vanadium, and zinc were below the control limit of 80-110%. No qualification action was necessary because there were no interfering analytes present at significant concentrations.

Executive Summary

Laboratory Performance: Several analytes were present in the laboratory method/preparation blanks. Beryllium was qualified due to calibration noncompliance. Several analytes were qualified due to matrix spike noncompliance. Several analytes were qualified due to laboratory control sample noncompliance. Hexavalent chromium was rejected due to poor SRM and matrix spike recoveries.

Other Factors Affecting Data Quality: Manganese was qualified due to field duplicate noncompliance. Several analytes were qualified due to ICP serial dilution noncompliance.

The data for these analyses were reviewed with reference to the "National Functional Guidelines for Inorganic Review", September 1993 and the NFESC document entitled "Navy IRCDQM" (September 1999).

The text of this report has been formulated to address only those problem areas affecting data quality.

"I attest that the data referenced herein were validated according to the agreed upon validation criteria as specified in the NFESC Guidelines and the Quality Assurance Project Plan (QAPP)."

Tetra Tech NUS
Ethan G. Lee
Environmental Scientist

Tetra Tech NUS
Joseph A. Samchuck
Quality Assurance Officer

Attachments:

1. Appendix A - Qualified Analytical Results
2. Appendix B - Results as reported by the Laboratory
3. Appendix C - Support Documentation

APPENDIX A
QUALIFIED ANALYTICAL RESULTS

Qualifier Codes:

A = Lab Blank Contamination
B = Field Blank Contamination
C = Calibration (i.e., % RSDs, %Ds, ICVs, CCVs, RPDs, RRFs, etc.) Noncompliance
D = MS/MSD Noncompliance
E = LCS/LCSD Noncompliance
F = Lab Duplicate Imprecision
G = Field Duplicate Imprecision
H = Holding Time Exceedance
I = ICP Serial Dilution Noncompliance
J = GFAA PDS - GFAA MSA's $r < 0.995$
K = ICP Interference - include ICSAB % R's
L = Instrument Calibration Range Exceedance
M = Sample Preservation
N = Internal Standard Noncompliance
N01 = Internal Standard Noncompliance Dioxins
N02 = Recovery Standard Noncompliance Dioxins
N03 = Clean-up Standard Noncompliance Dioxins
O = Poor Instrument Performance (i.e., base-time drifting)
P = Uncertainty near detection limit (< 2 x IDL for inorganics and <CRQL for organics)
Q = Other problems (can encompass a number of issues)
R = Surrogates Recovery Noncompliance
S = Pesticide/PCB Resolution
T = % Breakdown Noncompliance for DDT and Endrin
U = Pest/PCD% between columns for positive results
V = Non-linear calibrations, tuning $r < 0.995$ (correlation coefficient)
W = EMPC result
X = Signal to noise response drop
Y = Percent solids <30%
Z = Uncertainty at 2 sigma deviation is less than sample activity

PROJ_NO: 7393

SDG: T1903 MEDIA: SOIL DATA FRACTION: MISC

nsample	30CP010001
samp_date	3/7/2002
lab_id	0203160-02
qc_type	NM
Pct_Solids	73.7
DUP_OF:	

Parameter	units	Result	Val Qual	Qual Code
CYANIDE	MG/KG	0.7	U	
HEXAVALENT CHROMIUM	MG/KG	3	UR	DQ
PH	SU	6.2		

nsample	30CP010204
samp_date	3/7/2002
lab_id	0203160-03
qc_type	NM
Pct_Solids	81.3
DUP_OF:	

Parameter	units	Result	Val Qual	Qual Code
CYANIDE	MG/KG	0.6	U	
HEXAVALENT CHROMIUM	MG/KG	2	UR	DQ
PH	SU	5.0		

nsample	30CP010204-D
samp_date	3/7/2002
lab_id	0203160-01
qc_type	NM
Pct_Solids	80.8
DUP_OF:	30CP010204

Parameter	units	Result	Val Qual	Qual Code
CYANIDE	MG/KG	0.6	U	
HEXAVALENT CHROMIUM	MG/KG	2	UR	DQ
PH	SU	5.1		

PROJ_NO: 7393

SDG: T1903 MEDIA: SOIL DATA FRACTION: MISC

nsample	30CP070001
samp_date	3/8/2002
lab_id	0203218-01
qc_type	NM
Pct_Solids	74.9
DUP_OF:	

Parameter	units	Result	Val Qual	Qual Code
CYANIDE	MG/KG	0.7	U	
HEXAVALENT CHROMIUM	MG/KG	3	UR	DQ
PH	SU	7.6		

nsample	30CP070204
samp_date	3/8/2002
lab_id	0203218-02
qc_type	NM
Pct_Solids	82.4
DUP_OF:	

Parameter	units	Result	Val Qual	Qual Code
CYANIDE	MG/KG	0.6	U	
HEXAVALENT CHROMIUM	MG/KG	2	UR	DQ
PH	SU	7.2		

nsample	30SB060204
samp_date	3/7/2002
lab_id	0203160-05
qc_type	NM
Pct_Solids	84.4
DUP_OF:	

Parameter	units	Result	Val Qual	Qual Code
CYANIDE	MG/KG	0.5	U	
HEXAVALENT CHROMIUM	MG/KG	2	UR	DQ
PH	SU	7.6		

PROJ_NO: 7393

SDG: T1903 MEDIA: SOIL DATA FRACTION: MISC

nsample	30SS060001
samp_date	3/7/2002
lab_id	0203160-04
qc_type	NM
Pct_Solids	80.1
DUP_OF:	

Parameter	units	Result	Val Qual	Qual Code
CYANIDE	MG/KG	0.6	U	
HEXAVALENT CHROMIUM	MG/KG	2	UR	DQ
PH	SU	7.9		

PROJ_NO. 7393

SDG: T1903 MEDIA: SOIL DATA FRACTION: M

nsample	30CP010001
samp_date	3/7/02
lab_id	0203160-02
qc_type	NM
units	MG/KG
Pct_Solids	73.7
DUP_OF:	

Parameter	Result	ValQual	QualCode
ALUMINUM	12400	J	E
ANTIMONY	1.0	U	A
ARSENIC	11.2	J	D
BARIUM	110	J	ADI
BERYLLIUM	0.99	J	C
CADMIUM	0.81		
CALCIUM	1980	J	AD
CHROMIUM	27.9	J	A
COBALT	12.4		
COPPER	13.5		
IRON	25200	J	A
LEAD	25.8	J	AE
MAGNESIUM	1260	J	ADEI
MANGANESE	994	J	GI
MERCURY	0.054	U	A
NICKEL	14.6	J	A
POTASSIUM	980	J	AEI
SELENIUM	0.60		
SILVER	2.2	U	A
SODIUM	7.1	UJ	DE
THALLIUM	0.27		
VANADIUM	45.0		
ZINC	56.9	J	AE

nsample	30CP010204
samp_date	3/7/02
lab_id	0203160-03
qc_type	NM
units	MG/KG
Pct_Solids	81.3
DUP_OF:	

Parameter	Result	ValQual	QualCode
ALUMINUM	17300	J	E
ANTIMONY	3.0	U	A
ARSENIC	9.8	J	D
BARIUM	75.9	J	ADI
BERYLLIUM	0.65	J	C
CADMIUM	0.66	U	
CALCIUM	526	J	AD
CHROMIUM	24.5	J	A
COBALT	6.2		
COPPER	20.3		
IRON	26100	J	A
LEAD	17.7	J	AE
MAGNESIUM	2660	J	ADEI
MANGANESE	232	J	GI
MERCURY	0.023	U	A
NICKEL	13.9	J	A
POTASSIUM	1550	J	AEI
SELENIUM	0.38	U	
SILVER	0.09	U	
SODIUM	17.1	U	A
THALLIUM	0.30		
VANADIUM	45.5		
ZINC	53.2	J	AE

nsample	30CP070001
samp_date	3/8/02
lab_id	0203218-01
qc_type	NM
units	MG/KG
Pct_Solids	74.9
DUP_OF:	

Parameter	Result	ValQual	QualCode
ALUMINUM	18500	J	E
ANTIMONY	1.1	U	A
ARSENIC	13.2	J	D
BARIUM	86.4	J	ADI
BERYLLIUM	0.76	J	C
CADMIUM	0.78	U	
CALCIUM	2740	J	AD
CHROMIUM	29.0	J	A
COBALT	5.2		
COPPER	23.4		
IRON	26500	J	A
LEAD	18.7	J	AE
MAGNESIUM	2600	J	ADEI
MANGANESE	189	J	GI
MERCURY	0.055	U	A
NICKEL	14.8	J	A
POTASSIUM	1550	J	AEI
SELENIUM	0.57		
SILVER	0.38	U	A
SODIUM	8.0	UJ	DE
THALLIUM	0.37		
VANADIUM	54.7		
ZINC	67.5	J	AE

PROJ_NO: 7393

SDG: T1903 MEDIA: SOIL DATA FRACTION: M

nsample	30CP070204
samp_date	3/8/02
lab_id	0203218-02
qc_type	NM
units	MG/KG
Pct_Solids	82.4
DUP_OF:	

Parameter	Result	ValQual	QualCode
ALUMINUM	13500	J	E
ANTIMONY	0.75	U	A
ARSENIC	8.1	J	D
BARIUM	84.4	J	ADI
BERYLLIUM	0.83	J	C
CADMIUM	0.62	U	
CALCIUM	538	J	AD
CHROMIUM	27.7	J	A
COBALT	6.8		
COPPER	15.6		
IRON	33000	J	A
LEAD	18.2	J	AE
MAGNESIUM	2090	J	ADEI
MANGANESE	248	J	GI
MERCURY	0.010	U	
NICKEL	13.5	J	A
POTASSIUM	1040	J	AEI
SELENIUM	0.35	U	
SILVER	0.10	U	A
SODIUM	25.8	U	A
THALLIUM	0.22		
VANADIUM	45.7		
ZINC	44.4	J	AE

nsample	30SB060204
samp_date	3/7/02
lab_id	0203160-05
qc_type	NM
units	MG/KG
Pct_Solids	84.4
DUP_OF:	

Parameter	Result	ValQual	QualCode
ALUMINUM	13600	J	E
ANTIMONY	0.90	U	A
ARSENIC	5.3	J	D
BARIUM	73.0	J	ADI
BERYLLIUM	0.97	J	C
CADMIUM	0.61	U	
CALCIUM	1430	J	AD
CHROMIUM	26.9	J	A
COBALT	6.4		
COPPER	11.4		
IRON	28500	J	A
LEAD	17.9	J	AE
MAGNESIUM	1370	J	ADEI
MANGANESE	263	J	GI
MERCURY	0.010	U	A
NICKEL	11.4	J	A
POTASSIUM	982	J	AEI
SELENIUM	0.35	U	
SILVER	0.09	U	
SODIUM	8.0	U	A
THALLIUM	0.19		
VANADIUM	44.8		
ZINC	33.4	J	AE

nsample	30SS060001
samp_date	3/7/02
lab_id	0203160-04
qc_type	NM
units	MG/KG
Pct_Solids	80.1
DUP_OF:	

Parameter	Result	ValQual	QualCode
ALUMINUM	14600	J	E
ANTIMONY	1.4	U	A
ARSENIC	7.3	J	D
BARIUM	110	J	ADI
BERYLLIUM	0.75	J	C
CADMIUM	0.73	U	
CALCIUM	12500	J	AD
CHROMIUM	23.0	J	A
COBALT	7.4		
COPPER	15.1		
IRON	18500	J	A
LEAD	16.9	J	AE
MAGNESIUM	2490	J	ADEI
MANGANESE	628	J	GI
MERCURY	0.023	U	A
NICKEL	14.0	J	A
POTASSIUM	1300	J	AEI
SELENIUM	0.42	U	
SILVER	0.10	U	
SODIUM	25.4	U	A
THALLIUM	0.29		
VANADIUM	40.7		
ZINC	48.8	J	AE

PROJ_NO: 7393

SDG: T1903 MEDIA: SOIL DATA FRACTION: M

nsample	FD03070205
samp_date	3/7/02
lab_id	0203160-01
qc_type	NM
units	MG/KG
Pct_Solids	80.8
DUP_OF:	30CP010204

Parameter	Result	ValQual	QualCode
ALUMINUM	19900	J	E
ANTIMONY	0.75	U	A
ARSENIC	7.5	J	D
BARIUM	92.0	J	ADI
BERYLLIUM	0.63	J	C
CADMIUM	0.67	U	
CALCIUM	629	J	AD
CHROMIUM	27.2	J	A
COBALT	5.2		
COPPER	19.8		
IRON	23700	J	A
LEAD	13.6	J	AE
MAGNESIUM	2860	J	ADEI
MANGANESE	137	J	GI
MERCURY	0.031	U	A
NICKEL	14.0	J	A
POTASSIUM	1700	J	AEI
SELENIUM	0.38	U	
SILVER	0.29	U	A
SODIUM	27.1	U	A
THALLIUM	0.36		
VANADIUM	44.0		
ZINC	57.3	J	AE

PROJ_NO: 7393

SDG: T1903 MEDIA: WATER DATA FRACTION: M

nsample	RB03070203
samp_date	3/7/02
lab_id	0203160-06
qc_type	NM
units	UG/L
Pct_Solids	0
DUP_OF:	

Parameter	Result	ValQual	QualCode
ALUMINUM	4.1		
ANTIMONY	0.11		
ARSENIC	0.20	U	
BARIUM	0.36		
BERYLLIUM	0.10	U	
CADMIUM	0.70	U	
CALCIUM	24.0	U	
CHROMIUM	0.39		
COBALT	0.10	U	
COPPER	0.15		
IRON	40.0	U	
LEAD	0.10	U	
MAGNESIUM	12.4		
MANGANESE	2.1	U	
MERCURY	0.040	U	
NICKEL	0.12		
POTASSIUM	13.5		
SELENIUM	0.40	U	
SILVER	0.13		
SODIUM	35.7		
THALLIUM	0.10	U	
VANADIUM	0.10	U	
ZINC	2.2	J	E

PROJ_N[illegible] 7393

SDG: T1903 MEDIA: WATER DATA FRACTION: MISC

nsample	RB03070203
samp_date	3/7/2002
lab_id	0203160-06
qc_type	NM
units	MG/L
Pct_Solids	0
DUP_OF:	

Parameter	Result	ValQual	QualCode
CYANIDE	0.01	UJ	H
HEXAVALENT CHROMIUM	0.005	U	
PH	5.2		

Tetra Tech NUS **INTERNAL CORRESPONDENCE**

TO:	**R. CLARK**	**DATE:**	**AUGUST 2, 2002**
FROM:	**REBEKAH A. HAYNIE**	**COPIES:**	**DV FILE**

SUBJECT: **INORGANIC DATA VALIDATION – TAL METALS AND MISCELLANEOUS PARAMETERS**
CTO-019 NSWC CRANE
SAMPLE DELIVERY GROUP (SDG) – T1902

SAMPLES: 2/Aqueous/

RB03070201 RB03070202

17/Soil/

30CP020001	30CP020204	30CP030001
30CP030204	30CP080001	30CP080204
30CP090001	30CP090204	30CP100001
30CP100204	30SB010204	30SB050204
30SS010001	30SS050001	FD03070202
FD03070203	FD03070204	

Overview

The sample set for CTO 019, NSWC Crane, SDG T1902, consists of two (2) aqueous rinsate samples and seventeen (17) soil environmental samples. There are three (3) soil field duplicate pair (FD03070202 / 30CP100001, FD03070203 / 30CP080001, FD03070204 / 30CP020001) included within this SDG.

All samples were analyzed for cyanide, hexavalent chromium, pH, and target analyte list (TAL) metals. Aluminum, calcium, iron, magnesium, manganese, potassium and sodium analyses were conducted using SW-846 methods 6010B. Mercury analyses were conducted using SW-846 method 7471. All other metals analyses were conducted using SW-846 method 6020. Analyses for hexavalent chromium and cyanide were conducted using SW 846 methods 7196A and 9012A, respectively. Soil samples were analyzed for pH using SW 846 method 9045C, while aqueous samples were analyzed for pH by EPA method 150-1. The samples were collected by TetraTech NUS on March 7, 2002 and analyzed by Laucks Testing Laboratory under Naval Facilities Engineering Service Center (NFESC) Quality Assurance/Quality Control (QA/QC) criteria.

Mercury analyses were conducted using Cold Vapor Atomic Absorption (CVAA) methodologies. Aluminum, calcium, iron, magnesium, manganese, potassium, and sodium analyses were conducted using Inductively Coupled Plasma (ICP) methodolgies while all other metals analyses were conducted using ICP- Mass Spectrometry (ICP-MS) methodologies.

These data were evaluated based on the following parameters:

* • Data Completeness

* • Holding Times
• Calibration Recoveries
• Laboratory Blank Analyses
• Laboratory Control Sample Results
* • ICP Interference Check Sample Results
• Matrix Spike Recoveries
• Field Duplicate Results
• Laboratory Duplicate Results
• ICP Serial Dilution Results
* • Detection Limits

* - All quality control criteria were met for this parameter.

Laboratory Blank Analyses

The following contaminants were detected in the laboratory soil method/preparation blanks at the following maximum concentrations:

Analyte	Maximum Concentration	Action Level
Antimony(1)	0.116 mg/kg	0.58 mg/kg
Barium(1)	0.03 mg/kg	0.15 mg/kg
Calcium(1)	3.725 mg/kg	18.625 mg/kg
Chromium(1)	0.019 mg/kg	0.095 mg/kg
Iron(1)	11.582 mg/kg	57.91 mg/kg
Lead(1)	0.019 mg/kg	0.095 mg/kg
Magnesium	29.9 µg/L	14.95 mg/kg
Manganese(1)	0.311 mg/kg	1.555 mg/kg
Nickel(1)	0.011 mg/kg	0.055 mg/kg
Potassium	74.9 µg/L	37.45 mg/kg
Sodium	652.6 µg/L	326.3 mg/kg
Zinc(1)	0.361 mg/kg	1.805 mg/kg

(1) Maximum concentration found in a soil preparation blank.

An action level of 5X the maximum concentration was used to evaluate the sample data for blank contamination. Sample aliquot, percent solids and dilution factors were taken into consideration when evaluating for blank contamination. Positive results for antimony, calcium, magnesium, and potassium that are greater than the blank action levels and less than 5X CRDL were qualified as estimated, "J", due to blank contamination. Positive results for antimony and sodium that are less than the blank action levels were qualified, "U", due to blank contamination.

Calibration Recoveries

Continuing calibration verification (CCV) recovery non-compliance (%R > 110) was noted for beryllium. All positive sample results were qualified as estimated, "J".

Matrix Spike Recoveries

The Matrix Spike (MS) percent recovery (%R) for arsenic, magnesium, potassium, lead, sodium, and vanadium was <75% quality control limit, affecting the soil matrix. Positive results reported

for arsenic, lead, magnesium, potassium, and vanadium were estimated, "J".
The MS %R for hexavalent chromium was poor (0%), affecting the soil matrix. Because the standard reference material (SRM) %R was also poor (11%), hexavalent chromium results were rejected, "UR".

SRM/Laboratory Control Sampl Results

LCS recovery non-compliance (recovery > the upper control limit) was noted for cadmium, selenium, and zinc, affecting the soil matrix. Positive results were estimated, "J", while non-detected results reported for cadmium and selenium were estimated, "UJ".

LCS recovery non-compliance (%R > 120%) was noted for zinc, affecting the aqueous matrix. Positive results were estimated, "J".

Hexavalent chromium analyses in all soil samples except one have been rejected due to poor recoveries of the quality control Standard Reference Material (SRM). The basis of the rejection is that the SRM is an independent certified standard (of known concentration) and is used to assess laboratory performance for a given analytical parameter. The recoveries of the SRM, associated with Crane data, as determined by Laucks ranged from 1.2% to 12.6%. The acceptable minimum recovery defined in the QAPP is 50%. All results except in one sample were reported as nondetected. The reporting limit provided by Laucks was approximately 2-3 mg/kg.

As a result of the poor recoveries, an investigation on the SRM was conducted to determine whether reduction of the hexavalent chromium ion to the trivalent chromium ion had occurred. In order to begin the investigation, Laucks Laboratory was contacted and provided the lot number of the SRM that was used for analysis. The manufacturer (ERA) of the SRM was also contacted and was asked to analyze the exact lot used by Laucks. ERA agreed to perform tests on the lot used by Laucks.

ERA performed tests on the SRM in triplicate. The recoveries reported by ERA are as follows: 37%, 44%, and 34 %. The average concentration of hexavalent chromium reported by ERA was 20.9 mg/kg. The certified concentration of the SRM was 54.5 mg/kg.

The variance of the average concentration from the certified concentration raises three possibilities: (1) some reduction of the SRM may have occurred over time thus accounting for the difference between the results; (2) the recovery is representative of the analytical procedure; or (3) some combination of points 1 & 2. However, despite the possibility of some hexavalent chromium reduction and deficiencies in the analytical procedure, it is evident that hexavalent chromium is still present in the SRM at a sufficiently high concentration.

In addition to the tests conducted by ERA, Laucks conducted their own re-testing (5 tests) of the SRM and reported an average recovery of 35%.

Finally, upon review of the ERA results, it is my conclusion that although some reduction of the SRM may have occurred, the recoveries reported by ERA indicate that the SRM contains a sufficiently high concentration of hexavalent chromium upon which to conduct analysis. The SRM recoveries associated with the Crane analytical data are indicative of poor performance of the analytical procedure and cannot be attributed to the reduction of hexavalent chromium in the SRM. This is supported by the fact that the average recovery improved to 35% when Laucks conducted their own re-testing. Therefore, because it has been proven that the SRM had not reduced to a level beyond detection (concentration of hexavalent chromium >10X the reporting limit) and that the recoveries of the SRM are poor, the data are not considered reliable and have been rejected (UR).

ICP Serial Dilution Results

Serial dilution non-compliance (%D > 10%) was noted for magnesium, manganese, and potassium, affecting the soil matrix. Positive results were estimated, "J".

Laboratory Duplicate Results

Laboratory duplicate imprecision (% RPD > 35%) was noted for arsenic and iron, affecting the soil matrix. Positive results reported for arsenic and iron were estimated, "J".

Field Duplicate Results

Field duplicate imprecision (%RPD > 50%) was noted for antimony, arsenic, beryllium, cadmium, calcium, cobalt, iron, silver, and vanadium, affecting the soil matrix. Positive results were qualified as estimated, "J".

Notes

The Contract Required Detection Limit (CRDL) %Rs for arsenic and antimony were < 90% quality control limit. Additionally, %Rs for barium, beryllium, and zinc were > 110%. No validation action was required per regional guidance.

The interfering analytes aluminum, calcium, and iron were present in several soil samples at concentrations comparable to the levels in the interference check sample solution. However, when calculated (see attached sheet), interference affects did not exist and validation action was not necessary.

Sample results for antimony, barium, cadmium, copper, lead, selenium, silver, and thallium underwent 10 X dilutions.

Sample results for arsenic, beryllium, chromium, cobalt, nickel, vanadium, and zinc underwent 20 X dilutions.

Executive Summary

Laboratory Performance: Several analytes were present in the laboratory method blanks, affecting the soil matrix. Calibration recoveries required qualification of soil beryllium results. Laboratory duplicates non-compliance was noted for arsenic and iron affecting the soil matrix. Laboratory control sample recovery non-compliance was noted for several analytes, affecting both the aqueous and soil matrices.

Other Factors Affecting Data Quality: MS noncompliance was noted affecting the soil matrix. Serial dilution non-compliance was noted for magnesium, manganese, and potassium, affecting the soil matrix. Field duplicate RPD non-compliance was noted for several analytes, affecting the soil matrix.

The data for these analyses were reviewed with reference to the "National Functional Guidelines for Inorganic Review", February 1994, the "Region 5 SOP for validation of inorganic data", September 1993, and the NFESC document entitled "Navy IRCDQM", September 1999.

The text of this report has been formulated to address only those problem areas affecting data quality.

"I attest that the data referenced herein were validated according to the agreed upon validation criteria as specified in the NFESC Guidelines and the Quality Assurance Project Plan (QAPP)."

Tetra Tech NUS
Rebekah A. Haynie
Environmental Scientist

TetraTech NUS
Joseph A. Samchuck
Quality Assurance Officer

Attachments:

1. Appendix A - Qualified Analytical Results
2. Appendix B - Results as reported by the Laboratory
3. Appendix C - Support Documentation

APPENDIX A

QUALIFIED ANALYTICAL RESULTS

Qualifier Codes:

A = Lab Blank Contamination
B = Field Blank Contamination
C = Calibration (i.e., % RSDs, %Ds, ICVs, CCVs, RPDs, RRFs, etc.) Noncompliance
D = MS/MSD Noncompliance
E = LCS/LCSD Noncompliance
F = Lab Duplicate Imprecision
G = Field Duplicate Imprecision
H = Holding Time Exceedance
I = ICP Serial Dilution Noncompliance
J = GFAA PDS - GFAA MSA's $r < 0.995$
K = ICP Interference - include ICSAB % R's
L = Instrument Calibration Range Exceedance
M = Sample Preservation
N = Internal Standard Noncompliance
N01 = Internal Standard Noncompliance Dioxins
N02 = Recovery Standard Noncompliance Dioxins
N03 = Clean-up Standard Noncompliance Dioxins
O = Poor Instrument Performance (i.e., base-time drifting)
P = Uncertainty near detection limit (< 2 x IDL for inorganics and <CRQL for organics)
Q = Other problems (can encompass a number of issues)
R = Surrogates Recovery Noncompliance
S = Pesticide/PCB Resolution
T = % Breakdown Noncompliance for DDT and Endrin
U = Pest/PCD% between columns for positive results
V = Non-linear calibrations, tuning $r < 0.995$ (correlation coefficient)
W = EMPC result
X = Signal to noise response drop
Y = Percent solids <30%
Z = Uncertainty at 2 sigma deviation is less than sample activity

PROJ_NO: 7393

SDG: T1902 MEDIA: SOIL DATA FRACTION: M

nsample	30CP020001
samp_date	3/7/02
lab_id	0203159-15
qc_type	NM
units	MG/KG
Pct_Solids	74.4
DUP_OF:	

Parameter	Result	ValQual	QualCode
ALUMINUM	11300		
ANTIMONY	3.8	U	A
ARSENIC	5.9	J	DFG
BARIUM	114		
BERYLLIUM	0.86	J	CG
CADMIUM	0.71	UJ	EG
CALCIUM	5170	J	G
CHROMIUM	16.6		
COBALT	12.8	J	G
COPPER	14.2		
IRON	13700	J	FG
LEAD	19.2	J	D
MAGNESIUM	1180	J	ADI
MANGANESE	1190	J	I
MERCURY	0.11		
NICKEL	14.3		
POTASSIUM	816	J	ADI
SELENIUM	0.48	J	E
SILVER	4.4	J	G
SODIUM	71.7	U	A
THALLIUM	0.21		
VANADIUM	27.9	J	DG
ZINC	60.5	J	E

nsample	30CP020204
samp_date	3/7/02
lab_id	0203159-16
qc_type	NM
units	MG/KG
Pct_Solids	79.4
DUP_OF:	

Parameter	Result	ValQual	QualCode
ALUMINUM	19700		
ANTIMONY	0.58	U	A
ARSENIC	8.7	J	DFG
BARIUM	80.3		
BERYLLIUM	0.80	J	CG
CADMIUM	0.72	J	EG
CALCIUM	821	J	AG
CHROMIUM	27.2		
COBALT	6.2	J	G
COPPER	17.2		
IRON	28700	J	FG
LEAD	13.7	J	D
MAGNESIUM	2970	J	DI
MANGANESE	212	J	I
MERCURY	0.01	U	
NICKEL	15.2		
POTASSIUM	1710	J	ADI
SELENIUM	0.39	UJ	E
SILVER	0.10	J	G
SODIUM	186	U	A
THALLIUM	0.25		
VANADIUM	47.4	J	DG
ZINC	53.7	J	E

nsample	30CP030001
samp_date	3/7/02
lab_id	0203159-04
qc_type	NM
units	MG/KG
Pct_Solids	76.2
DUP_OF:	

Parameter	Result	ValQual	QualCode
ALUMINUM	20600		
ANTIMONY	3.8	U	A
ARSENIC	9.6	J	DFG
BARIUM	81.1		
BERYLLIUM	0.68	J	CG
CADMIUM	0.69	UJ	EG
CALCIUM	1910	J	AG
CHROMIUM	25.5		
COBALT	11.6	J	G
COPPER	14.9		
IRON	23800	J	FG
LEAD	14.3	J	D
MAGNESIUM	2390	J	ADI
MANGANESE	403	J	I
MERCURY	0.05		
NICKEL	16.1		
POTASSIUM	1720	J	ADI
SELENIUM	0.39	UJ	E
SILVER	0.75	J	G
SODIUM	98.9	U	A
THALLIUM	0.35		
VANADIUM	48.6	J	DG
ZINC	64.5	J	E

PROJ_[illegible]: 7393

SDG: T1902 MEDIA: SOIL DATA FRACTION: M

nsample	30CP030204
samp_date	3/7/02
lab_id	0203159-05
qc_type	NM
units	MG/KG
Pct_Solids	82.7
DUP_OF:	

Parameter	Result	ValQual	QualCode
ALUMINUM	18800		
ANTIMONY	1.4	U	A
ARSENIC	6.3	J	DFG
BARIUM	72.2		
BERYLLIUM	0.97	J	CG
CADMIUM	0.64	UJ	EG
CALCIUM	726	J	AG
CHROMIUM	27.8		
COBALT	6.8	J	G
COPPER	13.7		
IRON	28500	J	FG
LEAD	11.8	J	D
MAGNESIUM	2370	J	ADI
MANGANESE	202	J	I
MERCURY	0.01		
NICKEL	17.7		
POTASSIUM	1320	J	ADI
SELENIUM	0.37	UJ	E
SILVER	0.11	J	G
SODIUM	174	U	A
THALLIUM	0.22		
VANADIUM	41.8	J	DG
ZINC	47.3	J	E

nsample	30CP080001
samp_date	3/7/02
lab_id	0203159-13
qc_type	NM
units	MG/KG
Pct_Solids	77.5
DUP_OF:	

Parameter	Result	ValQual	QualCode
ALUMINUM	14700		
ANTIMONY	6.0	J	AG
ARSENIC	5.3	J	DFG
BARIUM	144		
BERYLLIUM	0.82	J	CG
CADMIUM	0.96	J	EG
CALCIUM	39700	J	G
CHROMIUM	19.3		
COBALT	13.9	J	G
COPPER	20.2		
IRON	12900	J	FG
LEAD	19.0	J	D
MAGNESIUM	2500	J	DI
MANGANESE	1350	J	I
MERCURY	0.26		
NICKEL	17.1		
POTASSIUM	1400	J	ADI
SELENIUM	0.47	J	E
SILVER	10.6	J	G
SODIUM	94.7	U	A
THALLIUM	0.23		
VANADIUM	30.0	J	DG
ZINC	73.0	J	E

nsample	30CP080204
samp_date	3/7/02
lab_id	0203159-14
qc_type	NM
units	MG/KG
Pct_Solids	77.5
DUP_OF:	

Parameter	Result	ValQual	QualCode
ALUMINUM	17900		
ANTIMONY	0.92	U	A
ARSENIC	7.4	J	DFG
BARIUM	90.3		
BERYLLIUM	0.76	J	CG
CADMIUM	0.66	UJ	EG
CALCIUM	1200	J	AG
CHROMIUM	25.9		
COBALT	6.9	J	G
COPPER	16.2		
IRON	26000	J	FG
LEAD	13.9	J	D
MAGNESIUM	2680	J	DI
MANGANESE	243	J	I
MERCURY	0.03		
NICKEL	15.7		
POTASSIUM	1460	J	ADI
SELENIUM	0.38	UJ	E
SILVER	0.09	UJ	G
SODIUM	108	U	A
THALLIUM	0.23		
VANADIUM	44.5	J	DG
ZINC	52.5	J	E

PROJ_NO: 7393

SDG: T1902 MEDIA: SOIL DATA FRACTION: M

nsample	30CP090001
samp_date	3/7/02
lab_id	0203159-08
qc_type	NM
units	MG/KG
Pct_Solids	75.4
DUP_OF:	

Parameter	Result	ValQual	QualCode
ALUMINUM	16200		
ANTIMONY	4.5	U	A
ARSENIC	5.4	J	DFG
BARIUM	78.3		
BERYLLIUM	0.52	J	CG
CADMIUM	0.69	UJ	EG
CALCIUM	30100	J	G
CHROMIUM	19.9		
COBALT	7.2	J	G
COPPER	13.4		
IRON	16000	J	FG
LEAD	12.0	J	D
MAGNESIUM	2270	J	ADI
MANGANESE	527	J	I
MERCURY	0.08		
NICKEL	13.2		
POTASSIUM	1530	J	ADI
SELENIUM	0.40	UJ	E
SILVER	3.9	J	G
SODIUM	94.0	U	A
THALLIUM	0.23		
VANADIUM	35.7	J	DG
ZINC	56.1	J	E

nsample	30CP090204
samp_date	3/7/02
lab_id	0203159-09
qc_type	NM
units	MG/KG
Pct_Solids	81.8
DUP_OF:	

Parameter	Result	ValQual	QualCode
ALUMINUM	18200		
ANTIMONY	0.89	U	A
ARSENIC	8.0	J	DFG
BARIUM	60.1		
BERYLLIUM	0.69	J	CG
CADMIUM	0.66	UJ	EG
CALCIUM	628	J	AG
CHROMIUM	25.5		
COBALT	7.0	J	G
COPPER	15.0		
IRON	29600	J	FG
LEAD	13.8	J	D
MAGNESIUM	2490	J	ADI
MANGANESE	310	J	I
MERCURY	0.01		
NICKEL	14.3		
POTASSIUM	1430	J	ADI
SELENIUM	0.38	UJ	E
SILVER	0.09	UJ	G
SODIUM	141	U	A
THALLIUM	0.24		
VANADIUM	44.8	J	DG
ZINC	53.0	J	E

nsample	30CP100001
samp_date	3/7/02
lab_id	0203159-02
qc_type	NM
units	MG/KG
Pct_Solids	63.4
DUP_OF:	

Parameter	Result	ValQual	QualCode
ALUMINUM	19500		
ANTIMONY	6.0	U	A
ARSENIC	22.4	J	DFG
BARIUM	180		
BERYLLIUM	1.5	J	CG
CADMIUM	1.6	J	EG
CALCIUM	34200	J	G
CHROMIUM	39.3		
COBALT	16.9	J	G
COPPER	38.7		
IRON	42500	J	FG
LEAD	30.7	J	D
MAGNESIUM	1830	J	ADI
MANGANESE	1550	J	I
MERCURY	0.41		
NICKEL	20.6		
POTASSIUM	1520	J	ADI
SELENIUM	0.85	J	E
SILVER	19.7	J	G
SODIUM	183	U	A
THALLIUM	0.24		
VANADIUM	60.9	J	DG
ZINC	115	J	E

PROJ_NO: 7393

SDG: T1902 MEDIA: SOIL DATA FRACTION: M

nsample	30CP100204
samp_date	3/7/02
lab_id	0203159-03
qc_type	NM
units	MG/KG
Pct_Solids	78.2
DUP_OF:	

Parameter	Result	ValQual	QualCode
ALUMINUM	19100		
ANTIMONY	0.53	U	A
ARSENIC	10.9	J	DFG
BARIUM	161		
BERYLLIUM	1.4	J	CG
CADMIUM	0.66	UJ	EG
CALCIUM	1290	J	AG
CHROMIUM	26.2		
COBALT	10.9	J	G
COPPER	11.4		
IRON	27600	J	FG
LEAD	17.3	J	D
MAGNESIUM	1650	J	ADI
MANGANESE	1350	J	I
MERCURY	0.04		
NICKEL	17.5		
POTASSIUM	1860	J	ADI
SELENIUM	0.46	J	E
SILVER	0.14	J	G
SODIUM	138	U	A
THALLIUM	0.29		
VANADIUM	50.6	J	DG
ZINC	53.3	J	E

nsample	30SB010204
samp_date	3/7/02
lab_id	0203159-07
qc_type	NM
units	MG/KG
Pct_Solids	79.9
DUP_OF:	

Parameter	Result	ValQual	QualCode
ALUMINUM	25300		
ANTIMONY	0.99	U	A
ARSENIC	10.6	J	DFG
BARIUM	81.8		
BERYLLIUM	0.84	J	CG
CADMIUM	0.71	UJ	EG
CALCIUM	775	J	AG
CHROMIUM	30.7		
COBALT	5.7	J	G
COPPER	19.2		
IRON	34600	J	FG
LEAD	11.2	J	D
MAGNESIUM	3520	J	DI
MANGANESE	143	J	I
MERCURY	0.01	U	
NICKEL	15.6		
POTASSIUM	2010	J	ADI
SELENIUM	0.41	UJ	E
SILVER	0.11	J	G
SODIUM	205	U	A
THALLIUM	0.30		
VANADIUM	55.9	J	DG
ZINC	68.8	J	E

nsample	30SB050204
samp_date	3/7/02
lab_id	0203159-11
qc_type	NM
units	MG/KG
Pct_Solids	81.1
DUP_OF:	

Parameter	Result	ValQual	QualCode
ALUMINUM	21200		
ANTIMONY	0.78	U	A
ARSENIC	6.6	J	DFG
BARIUM	64.1		
BERYLLIUM	0.64	J	CG
CADMIUM	0.67	UJ	EG
CALCIUM	542	J	AG
CHROMIUM	24.5		
COBALT	7.3	J	G
COPPER	16.8		
IRON	24800	J	FG
LEAD	13.4	J	D
MAGNESIUM	2790	J	DI
MANGANESE	343	J	I
MERCURY	0.01	U	
NICKEL	13.2		
POTASSIUM	1720	J	ADI
SELENIUM	0.39	UJ	E
SILVER	0.10	UJ	G
SODIUM	197	U	A
THALLIUM	0.27		
VANADIUM	43.8	J	DG
ZINC	62.1	J	E

PROJ_NO: 7393

SDG: T1902 MEDIA: SOIL DATA FRACTION: M

nsample	30SS010001
samp_date	3/7/02
lab_id	0203159-06
qc_type	NM
units	MG/KG
Pct_Solids	73.3
DUP_OF:	

Parameter	Result	ValQual	QualCode
ALUMINUM	13600		
ANTIMONY	1.8	U	A
ARSENIC	6.3	J	DFG
BARIUM	108		
BERYLLIUM	0.87	J	CG
CADMIUM	0.76	UJ	EG
CALCIUM	2210	J	AG
CHROMIUM	17.9		
COBALT	12.2	J	G
COPPER	12.0		
IRON	15000	J	FG
LEAD	19.1	J	D
MAGNESIUM	1360	J	ADI
MANGANESE	1120	J	I
MERCURY	0.05		
NICKEL	14.8		
POTASSIUM	1090	J	ADI
SELENIUM	0.43	UJ	E
SILVER	2.4	J	G
SODIUM	89.4	U	A
THALLIUM	0.24		
VANADIUM	33.3	J	DG
ZINC	59.2	J	E

nsample	30SS050001
samp_date	3/7/02
lab_id	0203159-10
qc_type	NM
units	MG/KG
Pct_Solids	79.6
DUP_OF:	

Parameter	Result	ValQual	QualCode
ALUMINUM	15600		
ANTIMONY	0.80	U	A
ARSENIC	7.0	J	DFG
BARIUM	59.3		
BERYLLIUM	0.48	J	CG
CADMIUM	0.70	UJ	EG
CALCIUM	1030	J	AG
CHROMIUM	20.7		
COBALT	6.0	J	G
COPPER	9.2		
IRON	20600	J	FG
LEAD	10.3	J	D
MAGNESIUM	1430	J	ADI
MANGANESE	312	J	I
MERCURY	0.05		
NICKEL	10.9		
POTASSIUM	1090	J	ADI
SELENIUM	0.40	UJ	E
SILVER	0.22	J	G
SODIUM	72.5	U	A
THALLIUM	0.21		
VANADIUM	40.2	J	DG
ZINC	41.8	J	E

nsample	FD03070202
samp_date	3/7/02
lab_id	0203159-01
qc_type	NM
units	MG/KG
Pct_Solids	63.6
DUP_OF:	30CP100001

Parameter	Result	ValQual	QualCode
ALUMINUM	18500		
ANTIMONY	9.0	J	AG
ARSENIC	5.5	J	DFG
BARIUM	199		
BERYLLIUM	0.75	J	CG
CADMIUM	2.9	J	EG
CALCIUM	22000	J	G
CHROMIUM	31.1		
COBALT	9.7	J	G
COPPER	61.0		
IRON	16800	J	FG
LEAD	32.2	J	D
MAGNESIUM	2420	J	ADI
MANGANESE	1180	J	I
MERCURY	0.30		
NICKEL	21.7		
POTASSIUM	1460	J	ADI
SELENIUM	0.65	J	E
SILVER	42.2	J	G
SODIUM	195	U	A
THALLIUM	0.22		
VANADIUM	32.9	J	DG
ZINC	161	J	E

PROJ_NO: 7393

SDG: T1902 MEDIA: SOIL DATA FRACTION: M

nsample	FD03070203
samp_date	3/7/02
lab_id	0203159-12
qc_type	NM
units	MG/KG
Pct_Solids	74.9
DUP_OF:	30CP080001

Parameter	Result	ValQual	QualCode
ALUMINUM	19900		
ANTIMONY	3.0	U	A
ARSENIC	7.6	J	DFG
BARIUM	110		
BERYLLIUM	0.73	J	CG
CADMIUM	0.70	UJ	EG
CALCIUM	3000	J	G
CHROMIUM	21.8		
COBALT	18.0	J	G
COPPER	13.5		
IRON	20800	J	FG
LEAD	15.9	J	D
MAGNESIUM	2070	J	ADI
MANGANESE	810	J	I
MERCURY	0.10		
NICKEL	16.8		
POTASSIUM	1580	J	ADI
SELENIUM	0.40	UJ	E
SILVER	1.3	J	G
SODIUM	125	U	A
THALLIUM	0.31		
VANADIUM	43.0	J	DG
ZINC	61.1	J	E

nsample	FD03070204
samp_date	3/7/02
lab_id	0203159-17
qc_type	NM
units	MG/KG
Pct_Solids	72.1
DUP_OF:	30CP020001

Parameter	Result	ValQual	QualCode
ALUMINUM	13700		
ANTIMONY	2.2	U	A
ARSENIC	5.9	J	DFG
BARIUM	131		
BERYLLIUM	0.81	J	CG
CADMIUM	0.99	J	EG
CALCIUM	10400	J	AG
CHROMIUM	20.5		
COBALT	13.3	J	G
COPPER	21.8		
IRON	13400	J	FG
LEAD	20.9	J	D
MAGNESIUM	1430	J	ADI
MANGANESE	1150	J	I
MERCURY	0.10		
NICKEL	16.3		
POTASSIUM	1160	J	ADI
SELENIUM	0.52	J	E
SILVER	12.4	J	G
SODIUM	45.4	U	A
THALLIUM	0.23		
VANADIUM	31.8	J	DG
ZINC	80.2	J	E

PROJ_NO: 7393

SDG: T1902 MEDIA: SOIL DATA FRACTION: MISC

nsample	30CP020001
samp_date	3/7/02
lab_id	0203159-15
qc_type	NM
units	MG/KG
Pct_Solids	74.4
DUP_OF:	

Parameter	Result	ValQual	QualCode
CYANIDE	0.7	U	
HEXAVALENT CHROMIUM	3	UR	DQ
PH	7.5		

nsample	30CP020204
samp_date	3/7/02
lab_id	0203159-16
qc_type	NM
units	MG/KG
Pct_Solids	79.4
DUP_OF:	

Parameter	Result	ValQual	QualCode
CYANIDE	0.6	U	
HEXAVALENT CHROMIUM	2	UR	DQ
PH	4.9		

nsample	30CP030001
samp_date	3/7/02
lab_id	0203159-04
qc_type	NM
units	MG/KG
Pct_Solids	76.2
DUP_OF:	

Parameter	Result	ValQual	QualCode
CYANIDE	0.7		
HEXAVALENT CHROMIUM	3	UR	DQ
PH	7.3		

PROJ_NO: 7393

SDG: T1902 MEDIA: SOIL DATA FRACTION: MISC

nsample	30CP030204
samp_date	3/7/02
lab_id	0203159-05
qc_type	NM
units	MG/KG
Pct_Solids	82.7
DUP_OF:	

Parameter	Result	ValQual	QualCode
CYANIDE	0.5	U	
HEXAVALENT CHROMIUM	2	UR	DQ
PH	5.1		

nsample	30CP080001
samp_date	3/7/02
lab_id	0203159-13
qc_type	NM
units	MG/KG
Pct_Solids	77.5
DUP_OF:	

Parameter	Result	ValQual	QualCode
CYANIDE	0.6	U	
HEXAVALENT CHROMIUM	2	UR	DQ
PH	7.4		

nsample	30CP080204
samp_date	3/7/02
lab_id	0203159-14
qc_type	NM
units	MG/KG
Pct_Solids	77.5
DUP_OF:	

Parameter	Result	ValQual	QualCode
CYANIDE	0.5	U	
HEXAVALENT CHROMIUM	2	UR	DQ
PH	5.5		

PROJ_NO: 7393

SDG: T1902 MEDIA: SOIL DATA FRACTION: MISC

nsample	30CP090001
samp_date	3/7/02
lab_id	0203159-08
qc_type	NM
units	MG/KG
Pct_Solids	75.4
DUP_OF:	

Parameter	Result	ValQual	QualCode
CYANIDE	0.6	U	
HEXAVALENT CHROMIUM	3	UR	DQ
PH	7.6		

nsample	30CP090204
samp_date	3/7/02
lab_id	0203159-09
qc_type	NM
units	MG/KG
Pct_Solids	81.8
DUP_OF:	

Parameter	Result	ValQual	QualCode
CYANIDE	0.6	U	
HEXAVALENT CHROMIUM	2	UR	DQ
PH	5.4		

nsample	30CP100001
samp_date	3/7/02
lab_id	0203159-02
qc_type	NM
units	MG/KG
Pct_Solids	63.4
DUP_OF:	

Parameter	Result	ValQual	QualCode
CYANIDE	0.7	U	
HEXAVALENT CHROMIUM	3	UR	DQ
PH	7.4		

PROJ_NO: 7393

SDG: T1902 MEDIA: SOIL DATA FRACTION: MISC

nsample	30CP100204
samp_date	3/7/02
lab_id	0203159-03
qc_type	NM
units	MG/KG
Pct_Solids	78.2
DUP_OF:	

Parameter	Result	ValQual	QualCode
CYANIDE	0.6	U	
HEXAVALENT CHROMIUM	2	UR	DQ
PH	6.1		

nsample	30SB010204
samp_date	3/7/02
lab_id	0203159-07
qc_type	NM
units	MG/KG
Pct_Solids	79.9
DUP_OF:	

Parameter	Result	ValQual	QualCode
CYANIDE	0.5	U	
HEXAVALENT CHROMIUM	2	UR	DQ
PH	5.1		

nsample	30SB050204
samp_date	3/7/02
lab_id	0203159-11
qc_type	NM
units	MG/KG
Pct_Solids	81.1
DUP_OF:	

Parameter	Result	ValQual	QualCode
CYANIDE	0.6	U	
HEXAVALENT CHROMIUM	2	UR	DQ
PH	5.5		

PROJ_NO: 7393

SDG: T1902 MEDIA: SOIL DATA FRACTION: MISC

nsample	30SS010001
samp_date	3/7/02
lab_id	0203159-06
qc_type	NM
units	MG/KG
Pct_Solids	73.3
DUP_OF:	

Parameter	Result	ValQual	QualCode
CYANIDE	0.6	U	
HEXAVALENT CHROMIUM	3	UR	DQ
PH	6.6		

nsample	30SS050001
samp_date	3/7/02
lab_id	0203159-10
qc_type	NM
units	MG/KG
Pct_Solids	79.6
DUP_OF:	

Parameter	Result	ValQual	QualCode
CYANIDE	0.5	U	
HEXAVALENT CHROMIUM	2	UR	DQ
PH	5.6		

nsample	FD03070202
samp_date	3/7/02
lab_id	0203159-01
qc_type	NM
units	MG/KG
Pct_Solids	63.6
DUP_OF:	30CP100001

Parameter	Result	ValQual	QualCode
CYANIDE	0.8	U	
HEXAVALENT CHROMIUM	3	UR	DQ
PH	7.6		

PROJ_NO: 7393

SDG: T1902 MEDIA: SOIL DATA FRACTION: MISC

nsample	FD03070203
samp_date	3/7/02
lab_id	0203159-12
qc_type	NM
units	MG/KG
Pct_Solids	74.9
DUP_OF:	30CP080001

Parameter	Result	ValQual	QualCode
CYANIDE	0.5	U	
HEXAVALENT CHROMIUM	3	UR	DQ
PH	7.5		

nsample	FD03070204
samp_date	3/7/02
lab_id	0203159-17
qc_type	NM
units	MG/KG
Pct_Solids	72.1
DUP_OF:	30CP020001

Parameter	Result	ValQual	QualCode
CYANIDE	0.6	U	
HEXAVALENT CHROMIUM	3	UR	DQ
PH	7.3		

PROJ_NO: 7393

SDG: T1902 MEDIA: WATER DATA FRACTION: MISC

nsample	RB03070201
samp_date	3/7/02
lab_id	0203159-18
qc_type	NM
units	MG/L
Pct_Solids	0
DUP_OF:	

Parameter	Result	ValQual	QualCode
CYANIDE	0.01	UJ	H
HEXAVALENT CHROMIUM	0.005	U	
PH	5.2		

nsample	RB03070202
samp_date	3/7/02
lab_id	0203159-19
qc_type	NM
units	MG/L
Pct_Solids	0
DUP_OF:	

Parameter	Result	ValQual	QualCode
CYANIDE	0.01	UJ	H
HEXAVALENT CHROMIUM	0.005	U	
PH	5.1		

Tetra Tech NUS **INTERNAL CORRESPONDENCE**

TO:	**R. CLARK**	**DATE:**	**AUGUST 2, 2002**
FROM:	**ETHAN G. LEE**	**COPIES:**	**DV FILE**

SUBJECT: **INORGANIC DATA VALIDATION – TAL METALS AND MISCELLANEOUS PARAMETERS**
NSWC CRANE – CTO 019
SAMPLE DELIVERY GROUP (SDG) – T1901

SAMPLES: 17/SOIL/

30CP040001	30CP040204	30CP050001	30CP050204
30CP060001	20CP060204	30CP110001	30CP110204
30CP120001	30CP120204	30SB020204	30SB030204
30SB040204	30SS020001	30SS030001	30SS040001
FD03060203			

Overview

The sample set for NSWC Crane, SDG T1901, consists of seventeen (17) soil environmental samples. One (1) field duplicate pair (FD03060203 / 30SB040204) is included in this SDG.

The samples were analyzed for TAL metals and miscellaneous parameters. The samples were collected by Tetra Tech NUS March 6-7, 2002 and analyzed by Laucks Testing Laboratories. Aluminum, calcium, iron, magnesium, manganese, potassium, and sodium analyses were conducted using method SW846 6010B. Mercury analyses were conducted using method SW846 7471A. All other metals analyses were conducted using method SW846 6020. Hexavalent chromium analyses were conducted using method SW846 7196A. Cyanide analyses were conducted using method SW846 9012B. pH analyses were conducted using method SW846 9045C. Concentrations of antimony, barium, cadmium, copper, lead, selenium, silver, thallium, and zinc were diluted 10X. Concentrations of arsenic, beryllium, chromium, cobalt, nickel, and vanadium were diluted 20X.

Metals analyses except mercury were conducted using Inductively Coupled Plasma (ICP) methodologies. Aluminum, calcium, iron, magnesium, manganeses, potassium, and sodium analyses were performed via ICP-Trace and all other metals analyses except mercury were performed via ICP-MS. Mercury analyses were conducted using Manual Cold Vapor Atomic Absorption (CVAA) methodologies.

These data were evaluated based on the following parameters:

- Data Completeness
- Holding Times
- Laboratory Blank Analyses
- Calibration Recoveries
- ICP Interference
- Matrix Spike Results
- Laboratory Duplicate Results
- Field Duplicate Results

- Laboratory Control Sample Results
- ICP Serial Dilution Results
- * Sample Quantitation
- * Detection Limits

* - All quality control criteria were met for this parameter.

Laboratory Blank Analyses

The following contaminants were detected in the laboratory method/preparation blanks at the following maximum concentrations:

Analyte	Maximum Concentration	Action Level
Antimony(1)	0.086 mg/kg	0.43 mg/kg
Barium(1)	0.049 mg/kg	0.245 mg/kg
Calcium	69.0 ug/L	34.5 mg/kg
Chromium(1)	0.027 mg/kg	0.135 mg/kg
Iron	46.1 ug/L	23.1 mg/kg
Lead(1)	0.033 mg/kg	0.165 mg/kg
Magnesium	29.9 ug/L	15.0 mg/kg
Nickel(1)	0.012 mg/kg	0.06 mg/kg
Potassium	74.9 ug/L	37.5 mg/kg
Silver(1)	0.018 mg/kg	0.09 mg/kg
Sodium	652.6 ug/L	327 mg/kg
Chromium^{6+}	0.019 mg/L	2.375 mg/kg

(1) Maximum concentration found in laboratory preparation blank.

An action level of 5X the maximum concentration was used to evaluate the sample data for blank contamination. Sample aliquot, percent solids, and dilution factors, if applicable, were taken into consideration when evaluating for blank contamination. Positive results < Action Level were qualified (U) for antimony, silver, sodium, and hexavalent chromium. Positive results > Action Level were qualified as estimated (J).

Holding Time Noncompliance

The holding time limit of 4 days from extraction to analysis for hexavalent chromium was exceeded for all samples. Positive results were qualified as estimated (J).

Calibration Noncompliance

The calibration percent recovery (%R) for beryllium was above the control limit of 90-110%. Positive results (>IDL) were qualified as estimated (J).

Matrix Spike Analysis

The matrix spike %R for arsenic, lead, and vanadium were less than the control limit of 75-125% and the sample result was <4X the spike added. Positive results for all analytes were qualified as estimated (J).

The matrix spike %R for hexavalent chromium was above the control limit of 75-125%. Positive results were qualified as estimated (J). Nondetects were qualified as rejected (UR) because standard reference material (SRM) yielded poor %R.

The matrix spike duplicate RPD for hexavalent chromium was above the control limit of 30%. Positive results were qualified as estimated (J).

Field Duplicate Analysis

The Relative Percent Difference (RPD) for the field duplicate pair (FD03060203 / 30SB040204) for manganese was calculated to be >50%. Becauses both values were >5X CRDL, positive results for manganese were qualified as estimated (J).

Laboratory Control Sample Analysis

The LCS %R for aluminum, cadmium, potassium, sodium, selenium, and zinc were below the control limits set by the EPA. Positive results (>IDL) were qualified as estimated (J). Nondetected results (<IDL) were qualified as estimated (UJ). Sodium was not qualified for LCS noncompliance because of blank contamination.

ICP Serial Dilution Analysis

The Percent Difference (%D) for magnesium and potassium was >10% and the initial sample result was >50X IDL. Positive results (>IDL) were qualified as estimated (J).

SRM / Laboratory Control Samples/Laboratory Performance

Hexavalent chromium analyses in all soil samples except one have been rejected due to poor recoveries of the quality control Standard Reference Material (SRM). The basis of the rejection is that the SRM is an independent certified standard (of known concentration) and is used to assess laboratory performance for a given analytical parameter. The recoveries of the SRM, associated with Crane data, as determined by Laucks ranged from 1.2% to 12.6%. The acceptable minimum recovery defined in the QAPP is 50%. All results except in one sample were reported as nondetected. The reporting limit provided by Laucks was approximately 2-3 mg/kg.

As a result of the poor recoveries, an investigation on the SRM was conducted to determine whether reduction of the hexavalent chromium ion to the trivalent chromium ion had occurred. In order to begin the investigation, Laucks Laboratory was contacted and provided the lot number of the SRM that was used for analysis. The manufacturer (ERA) of the SRM was also contacted and was asked to analyze the exact lot used by Laucks. ERA agreed to perform tests on the lot used by Laucks.

ERA performed tests on the SRM in triplicate. The recoveries reported by ERA are as follows: 37%, 44%, and 34 %. The average concentration of hexavalent chromium reported by ERA was 20.9 mg/kg. The certified concentration of the SRM was 54.5 mg/kg.

The variance of the average concentration from the certified concentration raises three possibilities: (1) some reduction of the SRM may have occurred over time thus accounting for the difference between the results; (2) the recovery is representative of the analytical procedure; or (3) some combination of points 1 & 2. However, despite the possibility of some hexavalent chromium reduction and deficiencies in the analytical procedure, it is evident that hexavalent chromium is still present in the SRM at a sufficiently high concentration.

In addition to the tests conducted by ERA, Laucks conducted their own re-testing (5 tests) of the SRM and reported an average recovery of 35%.

Finally, upon review of the ERA results, it is my conclusion that although some reduction of the SRM may have occurred, the recoveries reported by ERA indicate that the SRM contains a sufficiently high concentration of hexavalent chromium upon which to conduct analysis. The SRM

recoveries associated with the Crane analytical data are indicative of poor performance of the analytical procedure and cannot be attributed to the reduction of hexavalent chromium in the SRM. This is supported by the fact that the average recovery improved to 35% when Laucks conducted their own re-testing. Therefore, because it has been proven that the SRM had not reduced to a level beyond detection (concentration of hexavalent chromium >10X the reporting limit) and that the recoveries of the SRM are poor, the data are not considered reliable and have been rejected.

As a result of the poor SRM and matrix spike recoveries, the positive result was qualified as estimated (J) and nondetected results were rejected (UR).

Notes

The CRDL %R for antimony was below the control limit of 90-110%. No qualification action was required for this analysis.

The ICS AB solution %R's for arsenic, chromium, nickel, and vanadium were below the control limit of 80-110%. No qualification action was done because there were no interfering analytes present at significant concentrations.

The matrix spike %R's for aluminum, iron, and manganese were outside the control limit of 75-125%. No qualification action was required because the sample results were >4X the spike added.

Executive Summary

Laboratory Performance: Several analytes were present in the laboratory method/preparation blanks. Beryllium was qualified due to calibration noncompliance. Several analytes were qualified due to matrix spike noncompliance. Several analytes were qualified due to laboratory control sample noncompliance. Several analytes were qualified due to ICP serial dilution noncompliance. Hexavalent chromium was qualified due to holding time noncompliance. Hexavalent chromium was qualified due to poor SRM recovery.

Other Factors Affecting Data Quality: Manganese was qualified due to field duplicate noncompliance.

The data for these analyses were reviewed with reference to the "National Functional Guidelines for Inorganic Review", September 1993 and the NFESC document entitled "Navy IRCDQM" (September 1999).

The text of this report has been formulated to address only those problem areas affecting data quality.

"I attest that the data referenced herein were validated according to the agreed upon validation criteria as specified in the NFESC Guidelines and the Quality Assurance Project Plan (QAPP)."

Tetra Tech NUS
Ethan G. Lee
Environmental Scientist

Tetra Tech NUS
Joseph A. Samchuck
Quality Assurance Officer

Attachments:

1. Appendix A - Qualified Analytical Results
2. Appendix B - Results as reported by the Laboratory
3. Appendix C - Support Documentation

APPENDIX A
QUALIFIED ANALYTICAL RESULTS

Qualifier Codes:

A = Lab Blank Contamination
B = Field Blank Contamination
C = Calibration (i.e., % RSDs, %Ds, ICVs, CCVs, RPDs, RRFs, etc.) Noncompliance
D = MS/MSD Noncompliance
E = LCS/LCSD Noncompliance
F = Lab Duplicate Imprecision
G = Field Duplicate Imprecision
H = Holding Time Exceedance
I = ICP Serial Dilution Noncompliance
J = GFAA PDS - GFAA MSA's $r < 0.995$
K = ICP Interference - include ICSAB % R's
L = Instrument Calibration Range Exceedance
M = Sample Preservation
N = Internal Standard Noncompliance
N01 = Internal Standard Noncompliance Dioxins
N02 = Recovery Standard Noncompliance Dioxins
N03 = Clean-up Standard Noncompliance Dioxins
O = Poor Instrument Performance (i.e., base-time drifting)
P = Uncertainty near detection limit (< 2 x IDL for inorganics and <CRQL for organics)
Q = Other problems (can encompass a number of issues)
R = Surrogates Recovery Noncompliance
S = Pesticide/PCB Resolution
T = % Breakdown Noncompliance for DDT and Endrin
U = Pest/PCD% between columns for positive results
V = Non-linear calibrations, tuning $r < 0.995$ (correlation coefficient)
W = EMPC result
X = Signal to noise response drop
Y = Percent solids <30%
Z = Uncertainty at 2 sigma deviation is less than sample activity

PROJ_NO: 7393

SDG: T1901 MEDIA: SOIL DATA FRACTION: M

nsample	30CP040001
samp_date	3/7/02
lab_id	0203158-16
qc_type	NM
units	MG/KG
Pct_Solids	70.5
DUP_OF:	

Parameter	Result	ValQual	QualCode
ALUMINUM	12600	J	E
ANTIMONY	4.4	U	A
ARSENIC	5.1	J	D
BARIUM	159	J	A
BERYLLIUM	0.69	J	C
CADMIUM	1.2	J	E
CALCIUM	1600	J	A
CHROMIUM	20.9	J	A
COBALT	9.1		
COPPER	27.3		
IRON	14700	J	A
LEAD	24.5	J	AD
MAGNESIUM	1260	J	AI
MANGANESE	881	J	G
MERCURY	0.058		
NICKEL	12.4	J	A
POTASSIUM	909	J	AEI
SELENIUM	0.43	J	E
SILVER	19.4	J	A
SODIUM	20.8	U	A
THALLIUM	0.21		
VANADIUM	29.0	J	D
ZINC	87.7	J	E

nsample	30CP040204
samp_date	3/7/02
lab_id	0203158-17
qc_type	NM
units	MG/KG
Pct_Solids	76.5
DUP_OF:	

Parameter	Result	ValQual	QualCode
ALUMINUM	21700	J	E
ANTIMONY	1.9	U	A
ARSENIC	6.8	J	D
BARIUM	138	J	A
BERYLLIUM	0.92	J	C
CADMIUM	0.71	UJ	E
CALCIUM	767	J	A
CHROMIUM	23.4	J	A
COBALT	5.6		
COPPER	15.8		
IRON	28400	J	A
LEAD	13.2	J	AD
MAGNESIUM	2390	J	AI
MANGANESE	426	J	G
MERCURY	0.012		
NICKEL	15.2	J	A
POTASSIUM	1500	J	AEI
SELENIUM	0.41	UJ	E
SILVER	0.30	U	A
SODIUM	202	U	A
THALLIUM	0.34		
VANADIUM	40.0	J	D
ZINC	64.8	J	E

nsample	30CP050001
samp_date	3/7/02
lab_id	0203158-12
qc_type	NM
units	MG/KG
Pct_Solids	77.9
DUP_OF:	

Parameter	Result	ValQual	QualCode
ALUMINUM	14400	J	E
ANTIMONY	1.1	U	A
ARSENIC	9.5	J	D
BARIUM	147	J	A
BERYLLIUM	1.0	J	C
CADMIUM	0.69	UJ	E
CALCIUM	22500	J	A
CHROMIUM	24.3	J	A
COBALT	12.0		
COPPER	13.8		
IRON	26300	J	A
LEAD	19.0	J	AD
MAGNESIUM	1930	J	AI
MANGANESE	1200	J	G
MERCURY	0.051		
NICKEL	15.1	J	A
POTASSIUM	1440	J	AEI
SELENIUM	0.67	J	E
SILVER	2.8	J	A
SODIUM	112	U	A
THALLIUM	0.24		
VANADIUM	39.3	J	D
ZINC	55.0	J	E

PROJ_NO: 7393

SDG: T1901 MEDIA: SOIL DATA FRACTION: M

nsample	30CP050204
samp_date	3/7/02
lab_id	0203158-13
qc_type	NM
units	MG/KG
Pct_Solids	80.1
DUP_OF:	

Parameter	Result	ValQual	QualCode
ALUMINUM	14100	J	E
ANTIMONY	0.68	U	A
ARSENIC	12.9	J	D
BARIUM	113	J	A
BERYLLIUM	1.0	J	C
CADMIUM	0.63	UJ	E
CALCIUM	923	J	A
CHROMIUM	18.8	J	A
COBALT	13.1		
COPPER	11.8		
IRON	35300	J	A
LEAD	21.0	J	AD
MAGNESIUM	1310	J	AI
MANGANESE	1430	J	G
MERCURY	0.031		
NICKEL	14.0	J	A
POTASSIUM	1070	J	AEI
SELENIUM	0.47	J	E
SILVER	0.09	U	A
SODIUM	146	U	A
THALLIUM	0.23		
VANADIUM	40.5	J	D
ZINC	45.3	J	E

nsample	30CP060001
samp_date	3/6/02
lab_id	0203158-03
qc_type	NM
units	MG/KG
Pct_Solids	71.8
DUP_OF:	

Parameter	Result	ValQual	QualCode
ALUMINUM	14700	J	E
ANTIMONY	2.7	U	A
ARSENIC	7.5	J	D
BARIUM	143	J	A
BERYLLIUM	0.69	J	C
CADMIUM	1.1	J	E
CALCIUM	41000	J	A
CHROMIUM	25.1	J	A
COBALT	9.9		
COPPER	23.0		
IRON	17800	J	A
LEAD	21.8	J	AD
MAGNESIUM	3590	J	AI
MANGANESE	954	J	G
MERCURY	0.11		
NICKEL	16.8	J	A
POTASSIUM	1650	J	AEI
SELENIUM	0.50	J	E
SILVER	13.4	J	A
SODIUM	171	U	A
THALLIUM	0.21		
VANADIUM	33.1	J	D
ZINC	89.6	J	E

nsample	30CP060204
samp_date	3/6/02
lab_id	0203158-04
qc_type	NM
units	MG/KG
Pct_Solids	78.4
DUP_OF:	

Parameter	Result	ValQual	QualCode
ALUMINUM	15400	J	E
ANTIMONY	0.56	U	A
ARSENIC	9.0	J	D
BARIUM	93.7	J	A
BERYLLIUM	0.72	J	C
CADMIUM	0.64	UJ	E
CALCIUM	783	J	A
CHROMIUM	21.2	J	A
COBALT	11.1		
COPPER	10.2		
IRON	25500	J	A
LEAD	16.1	J	AD
MAGNESIUM	1530	J	AI
MANGANESE	955	J	G
MERCURY	0.016		
NICKEL	12.3	J	A
POTASSIUM	1120	J	AEI
SELENIUM	0.41	J	E
SILVER	0.09	U	
SODIUM	172	U	A
THALLIUM	0.25		
VANADIUM	41.5	J	D
ZINC	38.0	J	E

PROJ_NO: 7393

SDG: T1901 MEDIA: SOIL DATA FRACTION: M

nsample	30CP110001
samp_date	3/6/02
lab_id	0203158-07
qc_type	NM
units	MG/KG
Pct_Solids	77.3
DUP_OF:	

Parameter	Result	ValQual	QualCode
ALUMINUM	16200	J	E
ANTIMONY	1.6	U	A
ARSENIC	6.6	J	D
BARIUM	104	J	A
BERYLLIUM	0.70	J	C
CADMIUM	0.74	UJ	E
CALCIUM	1870	J	A
CHROMIUM	22.0	J	A
COBALT	8.5		
COPPER	14.9		
IRON	19300	J	A
LEAD	15.6	J	AD
MAGNESIUM	1420	J	AI
MANGANESE	745	J	G
MERCURY	0.089		
NICKEL	15.1	J	A
POTASSIUM	1200	J	AEI
SELENIUM	0.42	UJ	E
SILVER	5.8	J	A
SODIUM	147	U	A
THALLIUM	0.24		
VANADIUM	38.0	J	D
ZINC	56.9	J	E

nsample	30CP110204
samp_date	3/6/02
lab_id	0203158-08
qc_type	NM
units	MG/KG
Pct_Solids	81.9
DUP_OF:	

Parameter	Result	ValQual	QualCode
ALUMINUM	15500	J	E
ANTIMONY	0.77	U	A
ARSENIC	10.2	J	D
BARIUM	76.3	J	A
BERYLLIUM	0.75	J	C
CADMIUM	0.68	UJ	E
CALCIUM	542	J	A
CHROMIUM	26.2	J	A
COBALT	7.0		
COPPER	11.2		
IRON	34900	J	A
LEAD	17.1	J	AD
MAGNESIUM	1500	J	AI
MANGANESE	376	J	G
MERCURY	0.020		
NICKEL	10.7	J	A
POTASSIUM	1110	J	AEI
SELENIUM	0.51	J	E
SILVER	0.10	U	A
SODIUM	179	U	A
THALLIUM	0.23		
VANADIUM	44.2	J	D
ZINC	42.2	J	E

nsample	30CP120001
samp_date	3/6/02
lab_id	0203158-05
qc_type	NM
units	MG/KG
Pct_Solids	75
DUP_OF:	

Parameter	Result	ValQual	QualCode
ALUMINUM	16900	J	E
ANTIMONY	2.1	U	A
ARSENIC	8.9	J	D
BARIUM	127	J	A
BERYLLIUM	0.87	J	C
CADMIUM	0.67	UJ	E
CALCIUM	2700	J	A
CHROMIUM	23.1	J	A
COBALT	10.0		
COPPER	14.5		
IRON	21900	J	A
LEAD	18.2	J	AD
MAGNESIUM	1560	J	AI
MANGANESE	1280	J	G
MERCURY	0.096		
NICKEL	15.1	J	A
POTASSIUM	1380	J	AEI
SELENIUM	0.53	J	E
SILVER	2.8	J	A
SODIUM	187	U	A
THALLIUM	0.27		
VANADIUM	42.1	J	D
ZINC	55.8	J	E

PROJ_NO: 7393

SDG: T1901 MEDIA: SOIL DATA FRACTION: M

nsample	30CP120204
samp_date	3/6/02
lab_id	0203158-06
qc_type	NM
units	MG/KG
Pct_Solids	82.3
DUP_OF:	

Parameter	Result	ValQual	QualCode
ALUMINUM	18800	J	E
ANTIMONY	0.49	U	A
ARSENIC	6.3	J	D
BARIUM	88.6	J	A
BERYLLIUM	0.58	J	C
CADMIUM	0.60	UJ	E
CALCIUM	492	J	A
CHROMIUM	23.5	J	A
COBALT	5.3		
COPPER	14.4		
IRON	25100	J	A
LEAD	10.4	J	AD
MAGNESIUM	2460	J	AI
MANGANESE	190	J	G
MERCURY	0.009	U	
NICKEL	12.8	J	A
POTASSIUM	1530	J	AEI
SELENIUM	0.34	UJ	E
SILVER	0.09	U	
SODIUM	220	U	A
THALLIUM	0.27		
VANADIUM	38.7	J	D
ZINC	49.6	J	E

nsample	30SB020204
samp_date	3/7/02
lab_id	0203158-15
qc_type	NM
units	MG/KG
Pct_Solids	72.8
DUP_OF:	

Parameter	Result	ValQual	QualCode
ALUMINUM	14300	J	E
ANTIMONY	0.73	U	A
ARSENIC	10.3	J	D
BARIUM	118	J	A
BERYLLIUM	1.3	J	C
CADMIUM	0.80	UJ	E
CALCIUM	474	J	A
CHROMIUM	18.9	J	A
COBALT	26.2		
COPPER	10.1		
IRON	35800	J	A
LEAD	35.0	J	AD
MAGNESIUM	953	J	AI
MANGANESE	4690	J	G
MERCURY	0.048		
NICKEL	10.9	J	A
POTASSIUM	717	J	AEI
SELENIUM	0.58	J	E
SILVER	0.11	U	
SODIUM	56.4	U	A
THALLIUM	0.25		
VANADIUM	44.3	J	D
ZINC	36.6	J	E

nsample	30SB030204
samp_date	3/6/02
lab_id	0203158-02
qc_type	NM
units	MG/KG
Pct_Solids	80.1
DUP_OF:	

Parameter	Result	ValQual	QualCode
ALUMINUM	20300	J	E
ANTIMONY	0.63	U	A
ARSENIC	9.3	J	D
BARIUM	73.9	J	A
BERYLLIUM	0.53	J	C
CADMIUM	0.66	UJ	E
CALCIUM	768	J	A
CHROMIUM	24.4	J	A
COBALT	5.4		
COPPER	17.7		
IRON	26600	J	A
LEAD	12.5	J	AD
MAGNESIUM	3100	J	AI
MANGANESE	162	J	G
MERCURY	0.010	U	
NICKEL	13.7	J	A
POTASSIUM	1880	J	AEI
SELENIUM	0.38	UJ	E
SILVER	0.13	U	A
SODIUM	173	U	A
THALLIUM	0.30		
VANADIUM	45.6	J	D
ZINC	55.9	J	E

PROJ_NO: 7393

SDG: T1901 MEDIA: SOIL DATA FRACTION: M

nsample	30SB040204
samp_date	3/6/02
lab_id	0203158-11
qc_type	NM
units	MG/KG
Pct_Solids	79.4
DUP_OF:	

Parameter	Result	ValQual	QualCode
ALUMINUM	18200	J	E
ANTIMONY	0.88	U	A
ARSENIC	9.8	J	D
BARIUM	87.4	J	A
BERYLLIUM	0.63	J	C
CADMIUM	0.65	UJ	E
CALCIUM	559	J	A
CHROMIUM	22.2	J	A
COBALT	5.0		
COPPER	14.6		
IRON	32100	J	A
LEAD	13.8	J	AD
MAGNESIUM	2270	J	AI
MANGANESE	242	J	G
MERCURY	0.028		
NICKEL	11.6	J	A
POTASSIUM	1220	J	AEI
SELENIUM	0.37	UJ	E
SILVER	0.09	U	
SODIUM	183	U	A
THALLIUM	0.25		
VANADIUM	42.5	J	D
ZINC	52.6	J	E

nsample	30SS020001
samp_date	3/7/02
lab_id	0203158-14
qc_type	NM
units	MG/KG
Pct_Solids	72.3
DUP_OF:	

Parameter	Result	ValQual	QualCode
ALUMINUM	12300	J	E
ANTIMONY	0.76	U	A
ARSENIC	8.8	J	D
BARIUM	181	J	A
BERYLLIUM	1.1	J	C
CADMIUM	0.72	UJ	E
CALCIUM	1260	J	A
CHROMIUM	19.4	J	A
COBALT	12.1		
COPPER	11.1		
IRON	20500	J	A
LEAD	21.1	J	AD
MAGNESIUM	1040	J	AI
MANGANESE	2890	J	G
MERCURY	0.047		
NICKEL	14.0	J	A
POTASSIUM	937	J	AEI
SELENIUM	0.60	J	E
SILVER	0.25	U	A
SODIUM	29.8	U	A
THALLIUM	0.28		
VANADIUM	36.6	J	D
ZINC	50.4	J	E

nsample	30SS030001
samp_date	3/6/02
lab_id	0203158-01
qc_type	NM
units	MG/KG
Pct_Solids	86.5
DUP_OF:	

Parameter	Result	ValQual	QualCode
ALUMINUM	11500	J	E
ANTIMONY	2.3	U	A
ARSENIC	4.8	J	D
BARIUM	120	J	A
BERYLLIUM	0.51	J	C
CADMIUM	1.0	J	E
CALCIUM	124000	J	A
CHROMIUM	18.9	J	A
COBALT	6.2		
COPPER	16.5		
IRON	13300	J	A
LEAD	16.5	J	AD
MAGNESIUM	5840	J	AI
MANGANESE	384	J	G
MERCURY	0.054		
NICKEL	15.9	J	A
POTASSIUM	2230	J	AEI
SELENIUM	0.34	UJ	E
SILVER	5.8	J	A
SODIUM	176	U	A
THALLIUM	0.27		
VANADIUM	26.7	J	D
ZINC	60.5	J	E

PROJ_NO: 7393

SDG: T1901 MEDIA: SOIL DATA FRACTION: M

nsample	30SS040001
samp_date	3/6/02
lab_id	0203158-10
qc_type	NM
units	MG/KG
Pct_Solids	81.2
DUP_OF:	

Parameter	Result	ValQual	QualCode
ALUMINUM	11600	J	E
ANTIMONY	1.1	U	A
ARSENIC	6.4	J	D
BARIUM	114	J	A
BERYLLIUM	0.79	J	C
CADMIUM	0.66	UJ	E
CALCIUM	1250	J	A
CHROMIUM	18.3	J	A
COBALT	9.9		
COPPER	7.4		
IRON	20100	J	A
LEAD	14.0	J	AD
MAGNESIUM	1080	J	AI
MANGANESE	1460	J	G
MERCURY	0.031		
NICKEL	10.7	J	A
POTASSIUM	858	J	AEI
SELENIUM	0.38	UJ	E
SILVER	0.14	U	A
SODIUM	77.0	U	A
THALLIUM	0.22		
VANADIUM	32.8	J	D
ZINC	38.9	J	E

nsample	FD03060203
samp_date	3/6/02
lab_id	0203158-09
qc_type	NM
units	MG/KG
Pct_Solids	79.9
DUP_OF:	30SB040204

Parameter	Result	ValQual	QualCode
ALUMINUM	16100	J	E
ANTIMONY	3.2	U	A
ARSENIC	12.0	J	D
BARIUM	84.7	J	A
BERYLLIUM	0.72	J	C
CADMIUM	0.68	UJ	E
CALCIUM	571	J	A
CHROMIUM	22.6	J	A
COBALT	23.4		
COPPER	13.7		
IRON	34400	J	A
LEAD	46.3	J	AD
MAGNESIUM	1990	J	AI
MANGANESE	1030	J	G
MERCURY	0.039		
NICKEL	12.4	J	A
POTASSIUM	1430	J	AEI
SELENIUM	0.64	J	E
SILVER	0.29	U	A
SODIUM	150	U	A
THALLIUM	0.30		
VANADIUM	52.4	J	D
ZINC	48.3	J	E

PROJ_NO: 7393

SDG: T1901 MEDIA: SOIL DATA FRACTION: MISC

nsample	30CP040001
samp_date	3/7/02
lab_id	0203158-16
qc_type	NM
units	MG/KG
Pct_Solids	70.5
DUP_OF:	

Parameter	Result	ValQual	QualCode
CYANIDE	0.2	U	
HEXAVALENT CHROMIUM	3	UR	Q
PH	5.9		

nsample	30CP040204
samp_date	3/7/02
lab_id	0203158-17
qc_type	NM
units	MG/KG
Pct_Solids	76.5
DUP_OF:	

Parameter	Result	ValQual	QualCode
CYANIDE	0.2	U	
HEXAVALENT CHROMIUM	4	J	DQ
PH	7.5		

nsample	30CP050001
samp_date	3/7/02
lab_id	0203158-12
qc_type	NM
units	MG/KG
Pct_Solids	77.9
DUP_OF:	

Parameter	Result	ValQual	QualCode
CYANIDE	0.2	U	
HEXAVALENT CHROMIUM	3	UR	Q
PH	7.8		

PROJ_[illegible]: 7393

SDG: T1901 MEDIA: SOIL DATA FRACTION: MISC

nsample	30CP050204
samp_date	3/7/02
lab_id	0203158-13
qc_type	NM
units	MG/KG
Pct_Solids	80.1
DUP_OF:	

Parameter	Result	ValQual	QualCode
CYANIDE	0.2	U	
HEXAVALENT CHROMIUM	2	UR	Q
PH	5.1		

nsample	30CP060001
samp_date	3/6/02
lab_id	0203158-03
qc_type	NM
units	MG/KG
Pct_Solids	71.8
DUP_OF:	

Parameter	Result	ValQual	QualCode
CYANIDE	0.2	U	
HEXAVALENT CHROMIUM	3	UR	Q
PH	7.8		

nsample	30CP060204
samp_date	3/6/02
lab_id	0203158-04
qc_type	NM
units	MG/KG
Pct_Solids	78.4
DUP_OF:	

Parameter	Result	ValQual	QualCode
CYANIDE	0.2	U	
HEXAVALENT CHROMIUM	3	UR	Q
PH	7.6		

PROJ_NO: 7393

SDG: T1901 MEDIA: SOIL DATA FRACTION: MISC

nsample	30CP110001
samp_date	3/6/02
lab_id	0203158-07
qc_type	NM
units	MG/KG
Pct_Solids	77.3
DUP_OF:	

Parameter	Result	ValQual	QualCode
CYANIDE	0.2	U	
HEXAVALENT CHROMIUM	3	UR	Q
PH	6.8		

nsample	30CP110204
samp_date	3/6/02
lab_id	0203158-08
qc_type	NM
units	MG/KG
Pct_Solids	81.9
DUP_OF:	

Parameter	Result	ValQual	QualCode
CYANIDE	0.2	U	
HEXAVALENT CHROMIUM	2	UR	Q
PH	5.3		

nsample	30CP120001
samp_date	3/6/02
lab_id	0203158-05
qc_type	NM
units	MG/KG
Pct_Solids	75
DUP_OF:	

Parameter	Result	ValQual	QualCode
CYANIDE	0.2	U	
HEXAVALENT CHROMIUM	3	UR	Q
PH	7.6		

PROJ_NO: 7393

SDG: T1901 MEDIA: SOIL DATA FRACTION: MISC

nsample	30CP120204
samp_date	3/6/02
lab_id	0203158-06
qc_type	NM
units	MG/KG
Pct_Solids	82.3
DUP_OF:	

Parameter	Result	ValQual	QualCode
CYANIDE	0.2	U	
HEXAVALENT CHROMIUM	2	UR	Q
PH	5		

nsample	30SB020204
samp_date	3/7/02
lab_id	0203158-15
qc_type	NM
units	MG/KG
Pct_Solids	72.8
DUP_OF:	

Parameter	Result	ValQual	QualCode
CYANIDE	0.2	U	
HEXAVALENT CHROMIUM	3	UR	Q
PH	5.1		

nsample	30SB030204
samp_date	3/6/02
lab_id	0203158-02
qc_type	NM
units	MG/KG
Pct_Solids	80.1
DUP_OF:	

Parameter	Result	ValQual	QualCode
CYANIDE	0.2	U	
HEXAVALENT CHROMIUM	2	UR	Q
PH	5		

PROJ_NO: 7393

SDG: T1901 MEDIA: SOIL DATA FRACTION: MISC

nsample	30SB040204
samp_date	3/6/02
lab_id	0203158-11
qc_type	NM
units	MG/KG
Pct_Solids	79.4
DUP_OF:	

Parameter	Result	ValQual	QualCode
CYANIDE	0.2	U	
HEXAVALENT CHROMIUM	3	UR	Q
PH	5.2		

nsample	30SS020001
samp_date	3/6/02
lab_id	0203158-14
qc_type	NM
units	MG/KG
Pct_Solids	72.3
DUP_OF:	

Parameter	Result	ValQual	QualCode
CYANIDE	0.2		
HEXAVALENT CHROMIUM	3	UR	Q
PH	5.3		

nsample	30SS030001
samp_date	3/6/02
lab_id	0203158-01
qc_type	NM
units	MG/KG
Pct_Solids	86.5
DUP_OF:	

Parameter	Result	ValQual	QualCode
CYANIDE	0.2	U	
HEXAVALENT CHROMIUM	2	UR	Q
PH	8		

PROJ_NO. 7393

SDG: T1901 MEDIA: SOIL DATA FRACTION: MISC

nsample	30SS040001	nsample	FD03060203
samp_date	3/6/02	samp_date	3/6/02
lab_id	0203158-10	lab_id	0203158-09
qc_type	NM	qc_type	NM
units	MG/KG	units	MG/KG
Pct_Solids	81.2	Pct_Solids	79.9
DUP_OF:		DUP_OF:	30SB040204

Parameter	Result	ValQual	QualCode
CYANIDE	0.2	U	
HEXAVALENT CHROMIUM	2	UR	Q
PH	6.9		

Parameter	Result	ValQual	QualCode
CYANIDE	0.2	U	
HEXAVALENT CHROMIUM	3	UR	Q
PH	4.9		

APPENDIX E

STATISTICAL SAMPLE CALCULATION SHEETS

CLIENT: NSWC CRANE	JOB NUMBER: CTO 19
SUBJECT: SAMPLE CALCULATIONS OF STATISTICAL ANALYSIS	
BASED ON: GRID SS ARSENIC RESULTS -- LANDFARM	DRAWING NUMBER:
BY: JSK / CHECKED BY: BEL	APPROVED BY: MRF 8/1/02 / DATE: 7/30/02

THE DATA USED FOR THE FOLLOWING SAMPLE CALCULATIONS ARE THE ARSENIC RESULTS COLLECTED FROM GRID SURFACE SOIL AT THE LANDFARM.

NSAMPLE	PARAMETER	RESULT	QUALIFIER	VALUE	SITE	RISK
30CP010001	ARSENIC	11.2	J	11.2	GRID	SITE
30CP020001	ARSENIC	5.9	J	5.9	GRID	SITE
30CP030001	ARSENIC	9.6	J	9.6	GRID	SITE
30CP040001	ARSENIC	5.1	J	5.1	GRID	SITE
30CP050001	ARSENIC	9.5	J	9.5	GRID	SITE
30CP060001	ARSENIC	7.5	J	7.5	GRID	SITE
30CP070001	ARSENIC	13.2	J	13.2	GRID	SITE
30CP080001	ARSENIC	5.3	J	5.3	GRID	SITE
30CP090001	ARSENIC	5.4	J	5.4	GRID	SITE
30CP100001	ARSENIC	22.4	J	22.4	GRID	SITE
30CP110001	ARSENIC	6.6	J	6.6	GRID	SITE
30CP120001	ARSENIC	8.9	J	8.9	GRID	SITE

* VALUE = RESULT/2 FOR NON-DETECTS (NO NON-DETECTS IN THIS CASE)

① CALCULATE THE ARITHMETIC MEAN ($\bar{x}$):

$$\bar{x} = \frac{\sum_{i=1}^{n} x_i}{n}$$

$$\sum_{i=1}^{12} = 11.2 + 5.9 + 9.6 + 5.1 + 9.5 + 7.5 + 13.2 + 5.3 + 5.4 + 22.4 + 6.6 + 8.9$$

$$= 110.6 \qquad \bar{x} = \frac{110.6}{12} = 9.2167$$

② CALCULATE THE STANDARD DEVIATION (S_x):

$$S_x = \sqrt{\frac{\sum_{i=1}^{n} (x_i - \bar{x})^2}{n-1}}$$

CLIENT NSWC CRANE	JOB NUMBER CTO 19
SUBJECT Sample Calculation of Statistical Analysis	
BASED ON Grid SS Arsenic Results -- Landfarm	DRAWING NUMBER
BY TSK / CHECKED BY BGL	APPROVED BY MRF 8/1/02 / DATE 7/30/02

$$\sum_{i=1}^{12}(x_i-\bar{x})^2 = (11.2-9.2167)^2+(5.9-9.2167)^2+(9.6-9.2167)^2+(5.1-9.2167)^2+(9.5-9.2167)^2$$
$$+(7.5-9.2167)^2+(13.2-9.2167)^2+(5.3-9.2167)^2+(5.4-9.2167)^2+(22.4-9.2167)^2$$
$$+(6.6-9.2167)^2+(8.9-9.2167)^2$$

$$=(1.9833)^2+(-3.3167)^2+(0.3833)^2+(-4.1167)^2+(0.2833)^2$$
$$+(-1.7167)^2+(3.9833)^2+(-3.9167)^2+(-3.8167)^2+(13.1833)^2$$
$$+(-2.6167)^2+(-0.3167)^2$$

$$=(3.933)+(11.0005)+(0.1469)+(16.9472)+(0.08026)$$
$$+(2.9471)+(15.867)+(15.341)+(14.567)+(173.799)$$
$$+(6.8471)+(0.1003)$$

$$\sum_{i=1}^{12}(x_i-\bar{x})^2 = 261.57636$$

$$S_x=\sqrt{\frac{\sum_{i=1}^{n}(x_i-\bar{x})^2}{n-1}}=\sqrt{\frac{261.57636}{12-1}}=\sqrt{23.7797}=4.876$$

③ Calculate the Shapiro Wilk W Statistic (W_{CALC}):

$$W_{CALC}=\left(\frac{b}{S_x\sqrt{n-1}}\right)^2$$

Calculate b by creating the following table:

Column 1: Value ordered from smallest to largest (R_i)
Column 2: Value ordered from largest to smallest (R_{n-i+1})
Column 3: Column 2 − Column 1 ($R_{n-i+1}-R_i$)
Column 4: Coefficient a_i found in Table 1
Column 5: Column 3 × Column 4 = b_i = $(R_{n-i+1}-R_i)a_i$

$$b=\sum_{i=1}^{K}b_i=\sum_{i=1}^{6}b_i = \text{Sum Column 5}$$

* where K is the greatest integer less than or equal to $n/2$

$K \rightarrow n/2 = 12/2 = 6$

CLIENT NSWC CRANE	JOB NUMBER CTO 19
SUBJECT Sample Calculations of Statistical Analysis	
BASED ON Grid SS Arsenic Results -- Landfarm	DRAWING NUMBER
BY TSK / CHECKED BY BEL	APPROVED BY MRF 8/1/02 / DATE 7/30/02

1	2	3	4	5	6
R_i	R_{n-i+1}	$R_{n-i+1} - R_i$	a_i	b_i	i
5.1	22.4	17.3	0.5475	9.472	1
5.3	13.2	7.9	0.3325	2.627	2
5.4	11.2	5.8	0.2347	1.361	3
5.9	9.6	3.7	0.1586	0.587	4
6.6	9.5	2.9	0.0922	0.267	5
7.5	8.9	1.4	0.0303	0.042	6
8.9	7.5				7
9.5	6.6				8
9.6	5.9				9
11.2	5.4				10
13.2	5.3				11
22.4	5.1				12
				+	
				$b =$	14.356

$$W_{CALC} = \left(\frac{b}{S_x\sqrt{n-1}}\right)^2 = \left(\frac{14.356}{4.876\sqrt{11}}\right)^2 = \left(\frac{14.356}{16.172}\right)^2 = 0.7880$$

Determine W_{TEST} at a 5% level of significance from Table 2:

$$W_{TEST} = 0.859$$

Compare W_{CALC} to W_{TEST}

$$W_{CALC} = 0.7880 < 0.859 = W_{TEST}$$

Since $W_{CALC} < W_{TEST}$ we reject the null hypothesis that the data set has a Normal Distribution.

* After further investigation, running the Shapiro Wilk Test on log-transformed data, the data set is best represented as a Lognormal Distribution

$$W_{CALC\ LOG} = 0.9182 > 0.859 = W_{TEST}$$

CLIENT NSWC CRANE	JOB NUMBER CTO 19
SUBJECT Sample Calculation of Statistical Analysis	
BASED ON Grid SS Arsenic Results --Landfarm	DRAWING NUMBER
BY JSK / CHECKED BY BEL	APPROVED BY MRF 8/1/02 / DATE 7/30/02

The following data will be used for the Wilcoxon Rank Sum Test sample calculation. This data set is the background soil group #1 arsenic results from the Crane Basewide Background Study:

NSAMPLE	PARAMETER	RESULT	QUALIFIER	VALUE	RISK
BG1SBL0101	Arsenic	6.8	–	6.8	Back
BG1SBL0501	Arsenic	5.7	–	5.7	Back
BG2SBG0101	Arsenic	5.8	–	5.8	Back
BG2SBG0201	Arsenic	3.6	–	3.6	Back
BG2SBG0401-MAX	Arsenic	4.3	–	4.3	Back

* Value = Result/2 for non-detects (no non-detects in this case)

④ Perform the Wilcoxon Rank Sum Non-Parametric ANOVA:

a) Rank results from lowest to highest

* Rank adjusted for ties by using the median (middle) rank of the tied ranks for all tied values

VALUE	RISK	RANK	ADJUSTED RANK	VALUE	RISK	RANK	ADJUSTED RANK
3.6	Back	1	1	6.8	Back	10	10
4.3	Back	2	2	7.5	Site	11	11
5.1	Site	3	3	8.9	Site	12	12
5.3	Site	4	4	9.5	Site	13	13
5.4	Site	5	5	9.6	Site	14	14
5.7	Back	6	6	11.2	Site	15	15
5.8	Back	7	7	13.2	Site	16	16
5.9	Site	8	8	22.4	Site	17	17
6.6	Site	9	9				

* No ties in this case.

CLIENT: NSWC CRANE	JOB NUMBER: CTO 19
SUBJECT: SAMPLE CALCULATION OF STATISTICAL ANALYSIS	
BASED ON: GRID 55 ARSENIC RESULTS -- LANDFARM	DRAWING NUMBER:
BY: JSK / CHECKED BY: BCL	APPROVED BY: MRF 8/1/02 / DATE: 7/30/02

B] SUM THE ADJUSTED RANKS OF SITE AND BACKGROUND RESULTS:

$$WRS_{SITE} = \sum_{i=1}^{12} R_{(ADJ)\,SITE} = 3+4+5+8+9+11+12+13+14+15+16+17$$

$$WRS_{SITE} = 127$$

$$SUM_{BACK} = \sum_{i=1}^{5} R_{(ADJ)\,BACK} = 1+2+6+7+10$$

$$SUM_{BACK} = 26$$

✓ RANK SUMS $\quad WRS_{SITE} + SUM_{BACK} = \sum_{i=1}^{17} i = \frac{17}{2}(17+1)$

$$127 + 26 = 1+2+3+\ldots+16+17 = 8.5(18)$$

$$153 = 153 = 153$$

C] CALCULATE THE WRS_{SITE} Z-SCORE (Z_{RS}):

$$Z_{RS} = \frac{WRS_{SITE} - \frac{n_1(n+1)}{2}}{\sqrt{\frac{n_1(n_2)(n+1)}{12}}}$$

WHERE $n_1 = 12 = $ # OF SITE RESULTS

$n_2 = 5 = $ # OF BACK RESULTS

$n = 17 = $ # OF TOTAL RESULTS $= n_1 + n_2$

$$Z_{RS} = \frac{127 - \frac{12(18)}{2}}{\sqrt{\frac{12(5)(18)}{12}}} = \frac{127 - 108}{\sqrt{\frac{1080}{12}}} = \frac{19}{9.48683}$$

$$Z_{RS} = 2.00$$

CLIENT NSWC CRANE	JOB NUMBER CTO 19
SUBJECT Sample Calculation of Statistical Analysis	
BASED ON Grid SS Arsenic Results -- Landfarm	DRAWING NUMBER
BY TSK / CHECKED BY BEL	APPROVED BY MRF 8/1/02 / DATE 7/30/02

Determine Z_{TEST} from Table 3 as a two-sided test p-level = 0.10. This corresponds to a 0.05 p-level for a one-sided test.

$$Z_{TEST} = 1.645$$

Compare Z_{RS} to Z_{TEST}

$$Z_{RS} = 2.00 > 1.645 = Z_{TEST}$$

Since $Z_{RS} > Z_{TEST}$ we reject the null hypothesis that our site Arsenic concentrations are not statistically higher than our background Arsenic concentrations at a 95% confidence level.

(5) Calculate the 95% Upper Confidence Limit ($UCL_{0.95}$):

$$UCL_{0.95} = \bar{X} + t_{0.95,n-1}\left(\frac{S_x}{\sqrt{n}}\right)$$

* Determine $t_{0.95,n-1}$ from Table 4

$$t_{0.95,11} = 1.796$$

$$UCL_{0.95} = 9.2167 + 1.796\left(\frac{4.876}{\sqrt{12}}\right)$$

$$= 9.2167 + 1.796(1.408)$$

$$= 9.2167 + 2.528$$

$$UCL_{0.95} = 11.7447$$

CLIENT: NSWC CRANE	JOB NUMBER: CTO 19
SUBJECT: Sample Calculation of Statistical Analysis	
BASED ON: Grid SS Arsenic Results -- Landfarm	DRAWING NUMBER:
BY: TSK / CHECKED BY: BEL	APPROVED BY: MRF 8/1/02 / DATE: 7/30/02

(6) Calculate the 95% Upper Confidence Limit for Lognormal Values:

* First, find $\bar{y}$ & S_y using log-transformed values of the original data by the same procedures on pages 1 & 2 for $\bar{x}$ & S_x.

$$\bar{y} = 2.122 \qquad S_y = 0.4408$$

$$UCL_{0.95} = e^{\left[\bar{y} + 0.5(S_y)^2 + \frac{S_y (H_{.95,n})}{\sqrt{n-1}}\right]}$$

* Find $H_{0.95,n}$ from Table 5 by interpulation

$$y - y_1 = \frac{y_2 - y_1}{x_2 - x_1}(x - x_1)$$

where: $x = S_y$ for $n = 12$

$x_1 = S_y < 0.4408 = 0.40$ (Table 5)

$x_2 = S_y > 0.4408 = 0.50$ (Table 5)

y_1 = Respective $H_{0.95}$ value from Table 5 (at x_1)

y_2 = Respective $H_{0.95}$ value from Table 5 (at x_2)

$y = H_{0.95,n}$

$$y - 2.026 = \frac{2.141 - 2.026}{0.50 - 0.40}(0.4408 - 0.40)$$

$$= 1.15(0.0408) + 2.026$$

$$H_{0.95,12} = 2.0729$$

CLIENT: NSWC CRANE	JOB NUMBER: CTO 19
SUBJECT: Sample Calculation of Statistical Analysis	
BASED ON: Grid SS Arsenic Results -- Landfarm	DRAWING NUMBER:
BY: TSK / CHECKED BY: BEL	APPROVED BY: MRF 8/1/02 / DATE: 7/30/02

$$UCL_{0.95} = e^{\left[\bar{y} + 0.5(S_y)^2 + \frac{S_y (H_{0.95,n})}{\sqrt{n-1}}\right]}$$

$$= e^{\left[2.122 + 0.5(0.4408)^2 + \frac{0.4408\,(2.0729)}{\sqrt{11}}\right]}$$

$$= e^{\left[2.122 + 0.09715 + 0.2755\right]}$$

$$= e^{\left[2.49465\right]}$$

$$UCL_{0.95} = 12.1175$$

Sample Calculations Table 1
COEFFICIENTS A_i FOR W TEST OF NORMALITY FOR N=2 to 50

i/n	2	3	4	5	6	7	8	9	10
1	0.7071	0.7071	0.6872	0.6646	0.6431	0.6233	0.6052	0.5888	0.5739
2			0.1677	0.2413	0.2806	0.3031	0.3164	0.3244	0.3291
3					0.0875	0.1401	0.1743	0.1976	0.2141
4							0.0561	0.0947	0.1224
5									0.0399

i/n	11	12	13	14	15	16	17	18	19	20
1	0.5601	0.5475	0.5359	0.5251	0.5150	0.5056	0.4968	0.4886	0.4808	0.4734
2	0.3315	0.3325	0.3325	0.3318	0.3306	0.3290	0.3273	0.3253	0.3232	0.3211
3	0.2260	0.2347	0.2412	0.2460	0.2495	0.2521	0.2540	0.2553	0.2561	0.2565
4	0.1429	0.1586	0.1707	0.1802	0.1878	0.1939	0.1988	0.2027	0.2059	0.2085
5	0.0695	0.0922	0.1099	0.1240	0.1353	0.1447	0.1524	0.1587	0.1641	0.1686
6		0.0303	0.0539	0.0727	0.0880	0.1005	0.1109	0.1197	0.1271	0.1334
7				0.0240	0.0433	0.0593	0.0725	0.0837	0.0932	0.1013
8						0.0196	0.0359	0.0496	0.0612	0.0711
9								0.0163	0.0303	0.0422
10										0.0140

i/n	21	22	23	24	25	26	27	28	29	30
1	0.4643	0.4590	0.4542	0.4493	0.4450	0.4407	0.4366	0.4328	0.4291	0.4254
2	0.3185	0.3156	0.3126	0.3098	0.3069	0.3043	0.3018	0.2992	0.2968	0.2944
3	0.2578	0.2571	0.2563	0.2554	0.2543	0.2533	0.2522	0.2510	0.2499	0.2487
4	0.2119	0.2131	0.2139	0.2145	0.2148	0.2151	0.2152	0.2151	0.2150	0.2148
5	0.1736	0.1764	0.1787	0.1807	0.1822	0.1836	0.1848	0.1857	0.1864	0.1870
6	0.1399	0.1443	0.1480	0.1512	0.1539	0.1563	0.1584	0.1601	0.1616	0.1630
7	0.1092	0.1150	0.1201	0.1245	0.1283	0.1316	0.1346	0.1372	0.1395	0.1415
8	0.0804	0.0878	0.0941	0.0997	0.1046	0.1089	0.1128	0.1162	0.1192	0.1219
9	0.0530	0.0618	0.0696	0.0764	0.0823	0.0876	0.0923	0.0965	0.1002	0.1036
10	0.0263	0.0368	0.0459	0.0539	0.0610	0.0672	0.0728	0.0778	0.0822	0.0862
11		0.0122	0.0228	0.0321	0.0403	0.0476	0.0540	0.0598	0.0650	0.0697
12				0.0107	0.0200	0.0284	0.0358	0.0424	0.0483	0.0537
13						0.0094	0.0178	0.0253	0.0320	0.0381
14								0.0084	0.0159	0.0227
15										0.0076

i/n	31	32	33	34	35	36	37	38	39	40
1	0.4220	0.4188	0.4156	0.4127	0.4096	0.4068	0.4040	0.4015	0.9689	0.3964
2	0.2921	0.2898	0.2876	0.2854	0.2834	0.2813	0.2794	0.2774	0.2755	0.2737
3	0.2475	0.2463	0.2451	0.2439	0.2427	0.2415	0.2403	0.2391	0.2380	0.2368
4	0.2145	0.2141	0.2137	0.2132	0.2127	0.2121	0.2116	0.2110	0.2104	0.2098
5	0.1874	0.1878	0.1880	0.1882	0.1883	0.1883	0.1883	0.1881	0.1880	0.1878
6	0.1641	0.1651	0.1660	0.1667	0.1673	0.1678	0.1683	0.1686	0.1689	0.1691
7	0.1433	0.1449	0.1463	0.1475	0.1487	0.1496	0.1503	0.1513	0.1520	0.1526
8	0.1243	0.1265	0.1284	0.1301	0.1317	0.1331	0.1344	0.1356	0.1366	0.1376
9	0.1066	0.1093	0.1118	0.1140	0.1160	0.1179	0.1196	0.1211	0.1225	0.1237
10	0.0899	0.0931	0.0961	0.0988	0.1013	0.1036	0.1056	0.1075	0.1092	0.1108
11	0.0739	0.0777	0.0821	0.0844	0.0873	0.0900	0.0924	0.0947	0.0967	0.0986
12	0.0585	0.0629	0.0669	0.0706	0.0739	0.0770	0.0798	0.0824	0.0848	0.0870
13	0.0435	0.0485	0.0530	0.0572	0.0610	0.0645	0.0677	0.0706	0.0733	0.0759
14	0.0289	0.0344	0.0395	0.0441	0.0484	0.0523	0.0559	0.0592	0.0622	0.0651
15	0.0144	0.0206	0.0262	0.0314	0.0361	0.0404	0.0444	0.0481	0.0515	0.0546
16		0.0068	0.0131	0.0187	0.0239	0.0287	0.0331	0.0372	0.0409	0.0444
17				0.0062	0.0119	0.0172	0.0220	0.0264	0.0305	0.0343
18						0.0057	0.0110	0.0158	0.0203	0.0244
19								0.0053	0.0101	0.0146
20										0.0049

i/n	41	42	43	44	45	46	47	48	49	50
1	0.3940	0.3917	0.3894	0.3872	0.3850	0.3830	0.3808	0.3789	0.3770	0.3751
2	0.2719	0.2701	0.2684	0.2667	0.2651	0.2635	0.2620	0.2604	0.2589	0.2574
3	0.2357	0.2345	0.2334	0.2323	0.2313	0.2302	0.2291	0.2281	0.2271	0.2260
4	0.2091	0.2085	0.2078	0.2072	0.2065	0.2058	0.2052	0.2045	0.2038	0.2032
5	0.1876	0.1874	0.1871	0.1868	0.1865	0.1862	0.1859	0.1855	0.1851	0.1847
6	0.1693	0.1694	0.1695	0.1695	0.1695	0.1695	0.1695	0.1693	0.1692	0.1691
7	0.1531	0.1535	0.1539	0.1542	0.1545	0.1548	0.1550	0.1551	0.1553	0.1554
8	0.1384	0.1392	0.1398	0.1405	0.1410	0.1415	0.1420	0.1423	0.1427	0.1430
9	0.1249	0.1259	0.1269	0.1278	0.1286	0.1293	0.1300	0.1306	0.1312	0.1317
10	0.1123	0.1136	0.1149	0.1160	0.1170	0.1180	0.1189	0.1197	0.1205	0.1212
11	0.1004	0.1020	0.1035	0.1049	0.1062	0.1073	0.1085	0.1095	0.1105	0.1113
12	0.0891	0.0909	0.0927	0.0943	0.0959	0.0972	0.0986	0.0998	0.1010	0.1020
13	0.0782	0.0804	0.0824	0.0842	0.0860	0.0876	0.0892	0.0906	0.0919	0.0932
14	0.0677	0.0701	0.0724	0.0745	0.0775	0.0785	0.0801	0.0817	0.0832	0.0846
15	0.0575	0.0602	0.0628	0.0651	0.0673	0.0694	0.0713	0.0731	0.0748	0.0764
16	0.0476	0.0506	0.0534	0.0560	0.0584	0.0607	0.0628	0.0648	0.0667	0.0685
17	0.0379	0.0411	0.0442	0.0471	0.0497	0.0522	0.0546	0.0568	0.0588	0.0608
18	0.0283	0.0318	0.0352	0.0383	0.0412	0.0439	0.0465	0.0489	0.0511	0.0532
19	0.0188	0.0227	0.0263	0.0296	0.0328	0.0357	0.0385	0.0411	0.0436	0.0459
20	0.0094	0.0136	0.0175	0.0211	0.0245	0.0277	0.0307	0.0335	0.0361	0.0386
21		0.0045	0.0087	0.0126	0.0163	0.0197	0.0229	0.0259	0.0288	0.0314
22				0.0042	0.0081	0.0188	0.0153	0.0185	0.0215	0.0244
23						0.0039	0.0076	0.0111	0.0143	0.0174
24								0.0037	0.0071	0.0104
25										0.0350

TABLE 2
PERCENTAGE POINTS OF THE W TEST FOR N=3 to 50

n	0.01	0.05
3	0.753	0.767
4	0.687	0.748
5	0.686	0.762
6	0.713	0.788
7	0.730	0.803
8	0.749	0.818
9	0.764	0.829
10	0.781	0.842
11	0.792	0.850
12	0.805	0.859
13	0.814	0.866
14	0.825	0.874
15	0.835	0.881
16	0.844	0.887
17	0.851	0.892
18	0.858	0.897
19	0.863	0.901
20	0.868	0.905
21	0.873	0.908
22	0.878	0.911
23	0.881	0.914
24	0.884	0.916
25	0.888	0.918
26	0.891	0.920
27	0.894	0.923
28	0.896	0.924
29	0.898	0.926
30	0.900	0.927

n	0.01	0.05
31	0.902	0.929
32	0.904	0.930
33	0.906	0.931
34	0.908	0.933
35	0.910	0.934
36	0.912	0.935
37	0.914	0.936
38	0.916	0.938
39	0.917	0.939
40	0.919	0.940
41	0.920	0.941
42	0.922	0.942
43	0.923	0.943
44	0.924	0.944
45	0.926	0.945
46	0.927	0.945
47	0.928	0.946
48	0.929	0.947
49	0.929	0.947
50	0.930	0.947

Sample Calculat[illegible]ble 3
p Levels from Z Scores for 2 Sided Tests

Z	p	Z	p	Z	p	Z	p	Z	p	Z	p	Z	p	Z	p
0.00	1.0000	0.50	0.6171	1.00	0.3173	1.50	0.1336	2.00	0.0455	2.50	0.0124	3.00	0.0027	3.50	0.0005
0.01	0.9920	0.51	0.6101	1.01	0.3125	1.51	0.1310	2.01	0.0444	2.51	0.0121	3.01	0.0026	3.51	0.0004
0.02	0.9840	0.52	0.6031	1.02	0.3077	1.52	0.1285	2.02	0.0434	2.52	0.0117	3.02	0.0025	3.52	0.0004
0.03	0.9761	0.53	0.5961	1.03	0.3030	1.53	0.1260	2.03	0.0424	2.53	0.0114	3.03	0.0024	3.53	0.0004
0.04	0.9681	0.54	0.5892	1.04	0.2983	1.54	0.1236	2.04	0.0414	2.54	0.0111	3.04	0.0024	3.54	0.0004
0.05	0.9601	0.55	0.5823	1.05	0.2937	1.55	0.1211	2.05	0.0404	2.55	0.0108	3.05	0.0023	3.55	0.0004
0.06	0.9522	0.56	0.5755	1.06	0.2891	1.56	0.1188	2.06	0.0394	2.56	0.0105	3.06	0.0022	3.56	0.0004
0.07	0.9442	0.57	0.5687	1.07	0.2846	1.57	0.1164	2.07	0.0385	2.57	0.0102	3.07	0.0021	3.57	0.0004
0.08	0.9362	0.58	0.5619	1.08	0.2801	1.58	0.1141	2.08	0.0375	2.58	0.0099	3.08	0.0021	3.58	0.0003
0.09	0.9283	0.59	0.5552	1.09	0.2757	1.59	0.1118	2.09	0.0366	2.59	0.0096	3.09	0.0020	3.59	0.0003
0.10	0.9203	0.60	0.5485	1.10	0.2713	1.60	0.1096	2.10	0.0357	2.60	0.0093	3.10	0.0019	3.60	0.0003
0.11	0.9124	0.61	0.5419	1.11	0.2670	1.61	0.1074	2.11	0.0349	2.61	0.0091	3.11	0.0019	3.61	0.0003
0.12	0.9045	0.62	0.5353	1.12	0.2627	1.62	0.1052	2.12	0.0340	2.62	0.0088	3.12	0.0018	3.62	0.0003
0.13	0.8966	0.63	0.5287	1.13	0.2585	1.63	0.1031	2.13	0.0332	2.63	0.0085	3.13	0.0017	3.63	0.0003
0.14	0.8887	0.64	0.5222	1.14	0.2543	1.64	0.1010	2.14	0.0324	2.64	0.0083	3.14	0.0017	3.64	0.0003
0.15	0.8808	0.65	0.5157	1.15	0.2501	1.65	0.0989	2.15	0.0316	2.65	0.0080	3.15	0.0016	3.65	0.0003
0.16	0.8729	0.66	0.5093	1.16	0.2460	1.66	0.0969	2.16	0.0308	2.66	0.0078	3.16	0.0016	3.66	0.0003
0.17	0.8650	0.67	0.5029	1.17	0.2420	1.67	0.0949	2.17	0.0300	2.67	0.0076	3.17	0.0015	3.67	0.0002
0.18	0.8572	0.68	0.4965	1.18	0.2380	1.68	0.0930	2.18	0.0293	2.68	0.0074	3.18	0.0015	3.68	0.0002
0.19	0.8493	0.69	0.4902	1.19	0.2340	1.69	0.0910	2.19	0.0285	2.69	0.0071	3.19	0.0014	3.69	0.0002
0.20	0.8415	0.70	0.4839	1.20	0.2301	1.70	0.0891	2.20	0.0278	2.70	0.0069	3.20	0.0014	3.70	0.0002
0.21	0.8337	0.71	0.4777	1.21	0.2263	1.71	0.0873	2.21	0.0271	2.71	0.0067	3.21	0.0013	3.71	0.0002
0.22	0.8259	0.72	0.4715	1.22	0.2225	1.72	0.0854	2.22	0.0264	2.72	0.0065	3.22	0.0013	3.72	0.0002
0.23	0.8181	0.73	0.4654	1.23	0.2187	1.73	0.0836	2.23	0.0257	2.73	0.0063	3.23	0.0012	3.73	0.0002
0.24	0.8103	0.74	0.4593	1.24	0.2150	1.74	0.0819	2.24	0.0251	2.74	0.0061	3.24	0.0012	3.74	0.0002
0.25	0.8026	0.75	0.4533	1.25	0.2113	1.75	0.0801	2.25	0.0244	2.75	0.0060	3.25	0.0012	3.75	0.0002
0.26	0.7949	0.76	0.4473	1.26	0.2077	1.76	0.0784	2.26	0.0238	2.76	0.0058	3.26	0.0011	3.76	0.0002
0.27	0.7872	0.77	0.4413	1.27	0.2041	1.77	0.0767	2.27	0.0232	2.77	0.0056	3.27	0.0011	3.77	0.0002
0.28	0.7795	0.78	0.4354	1.28	0.2005	1.78	0.0751	2.28	0.0226	2.78	0.0054	3.28	0.0010	3.78	0.0002
0.29	0.7718	0.79	0.4295	1.29	0.1971	1.79	0.0735	2.29	0.0220	2.79	0.0053	3.29	0.0010	3.79	0.0002
0.30	0.7642	0.80	0.4237	1.30	0.1936	1.80	0.0719	2.30	0.0214	2.80	0.0051	3.30	0.0010	3.80	0.0001
0.31	0.7566	0.81	0.4179	1.31	0.1902	1.81	0.0703	2.31	0.0209	2.81	0.0050	3.31	0.0009	3.81	0.0001
0.32	0.7490	0.82	0.4122	1.32	0.1868	1.82	0.0688	2.32	0.0203	2.82	0.0048	3.32	0.0009	3.82	0.0001
0.33	0.7414	0.83	0.4065	1.33	0.1835	1.83	0.0672	2.33	0.0198	2.83	0.0047	3.33	0.0009	3.83	0.0001
0.34	0.7339	0.84	0.4009	1.34	0.1802	1.84	0.0658	2.34	0.0193	2.84	0.0045	3.34	0.0008	3.84	0.0001
0.35	0.7263	0.85	0.3953	1.35	0.1770	1.85	0.0643	2.35	0.0188	2.85	0.0044	3.35	0.0008	3.85	0.0001
0.36	0.7188	0.86	0.3898	1.36	0.1738	1.86	0.0629	2.36	0.0183	2.86	0.0042	3.36	0.0008	3.86	0.0001
0.37	0.7114	0.87	0.3843	1.37	0.1707	1.87	0.0615	2.37	0.0178	2.87	0.0041	3.37	0.0008	3.87	0.0001
0.38	0.7039	0.88	0.3789	1.38	0.1676	1.88	0.0601	2.38	0.0173	2.88	0.0040	3.38	0.0007	3.88	0.0001
0.39	0.6965	0.89	0.3735	1.39	0.1645	1.89	0.0588	2.39	0.0168	2.89	0.0039	3.39	0.0007	3.89	0.0001
0.40	0.6892	0.90	0.3681	1.40	0.1615	1.90	0.0574	2.40	0.0164	2.90	0.0037	3.40	0.0007	3.90	0.0001
0.41	0.6818	0.91	0.3628	1.41	0.1585	1.91	0.0561	2.41	0.0160	2.91	0.0036	3.41	0.0006	3.91	0.0001
0.42	0.6745	0.92	0.3576	1.42	0.1556	1.92	0.0549	2.42	0.0155	2.92	0.0035	3.42	0.0006	3.92	0.0001
0.43	0.6672	0.93	0.3524	1.43	0.1527	1.93	0.0536	2.43	0.0151	2.93	0.0034	3.43	0.0006	3.93	0.0001
0.44	0.6599	0.94	0.3472	1.44	0.1499	1.94	0.0524	2.44	0.0147	2.94	0.0033	3.44	0.0006	3.94	0.0001
0.45	0.6527	0.95	0.3421	1.45	0.1471	1.95	0.0512	2.45	0.0143	2.95	0.0032	3.45	0.0006	3.95	0.0001
0.46	0.6455	0.96	0.3371	1.46	0.1443	1.96	0.0500	2.46	0.0139	2.96	0.0031	3.46	0.0005	3.96	0.0001
0.47	0.6384	0.97	0.3320	1.47	0.1416	1.97	0.0488	2.47	0.0135	2.97	0.0030	3.47	0.0005	3.97	0.0001
0.48	0.6312	0.98	0.3271	1.48	0.1389	1.98	0.0477	2.48	0.0131	2.98	0.0029	3.48	0.0005	3.98	0.0001
0.49	0.6241	0.99	0.3222	1.49	0.1362	1.99	0.0466	2.49	0.0128	2.99	0.0028	3.49	0.0005	3.99	0.0001

Sample Calculations Table 4
PERCENTILES OF STUDENT's t-DISTRIBUTION WITH n DEGREES OF FREEDOM

n\F	0.60	0.75	0.90	0.95	0.975	0.99	0.995	0.9995
1	0.325	1.000	3.078	6.314	12.706	31.821	63.656	636.578
2	0.289	0.816	1.886	2.920	4.303	6.965	9.925	31.600
3	0.277	0.765	1.638	2.353	3.182	4.541	5.841	12.924
4	0.271	0.741	1.533	2.132	2.776	3.747	4.604	8.610
5	0.267	0.727	1.476	2.015	2.571	3.365	4.032	6.869
6	0.265	0.718	1.440	1.943	2.447	3.143	3.707	5.959
7	0.263	0.711	1.415	1.895	2.365	2.998	3.499	5.408
8	0.262	0.706	1.397	1.860	2.306	2.896	3.355	5.041
9	0.261	0.703	1.383	1.833	2.262	2.821	3.250	4.781
10	0.260	0.700	1.372	1.812	2.228	2.764	3.169	4.587
11	0.260	0.697	1.363	1.796	2.201	2.718	3.106	4.437
12	0.259	0.695	1.356	1.782	2.179	2.681	3.055	4.318
13	0.259	0.694	1.350	1.771	2.160	2.650	3.012	4.221
14	0.258	0.692	1.345	1.761	2.145	2.624	2.977	4.140
15	0.258	0.691	1.341	1.753	2.131	2.602	2.947	4.073
16	0.258	0.690	1.337	1.746	2.120	2.583	2.921	4.015
17	0.257	0.689	1.333	1.740	2.110	2.567	2.898	3.965
18	0.257	0.688	1.330	1.734	2.101	2.552	2.878	3.922
19	0.257	0.688	1.328	1.729	2.093	2.539	2.861	3.883
20	0.257	0.687	1.325	1.725	2.086	2.528	2.845	3.850
21	0.257	0.686	1.323	1.721	2.080	2.518	2.831	3.819
22	0.256	0.686	1.321	1.717	2.074	2.508	2.819	3.792
23	0.256	0.685	1.319	1.714	2.069	2.500	2.807	3.768
24	0.256	0.685	1.318	1.711	2.064	2.492	2.797	3.745
25	0.256	0.684	1.316	1.708	2.060	2.485	2.787	3.725
26	0.256	0.684	1.315	1.706	2.056	2.479	2.779	3.707
27	0.256	0.684	1.314	1.703	2.052	2.473	2.771	3.689
28	0.256	0.683	1.313	1.701	2.048	2.467	2.763	3.674
29	0.256	0.683	1.311	1.699	2.045	2.462	2.756	3.660
30	0.256	0.683	1.310	1.697	2.042	2.457	2.750	3.646
40	0.255	0.681	1.303	1.684	2.021	2.423	2.704	3.551
60	0.254	0.679	1.296	1.671	2.000	2.390	2.660	3.460
65	0.254	0.679	1.295	1.670	1.998	2.387	2.656	3.453
120	0.254	0.677	1.289	1.658	1.980	2.358	2.617	3.373
1,000,000	0.253	0.674	1.282	1.645	1.960	2.326	2.576	3.290

$F = 1 - \alpha$

Sample calcula[illegible] Table 5
VALUES OF $H_{0.95}$ FOR COMPUTING A ONE-SIDED UPPER 95% CONFIDENCE LIMIT ON A LOGNORMAL MEAN

Sy\n	3	5	7	10	12	15	21	31	51	101	201
0.10	2.750	2.035	1.886	1.802	1.775	1.749	1.722	1.701	1.684	1.670	1.652
0.20	3.295	2.198	1.992	1.881	1.843	1.809	1.771	1.742	1.718	1.697	1.676
0.30	4.109	2.402	2.125	1.977	1.927	1.882	1.833	1.793	1.761	1.733	1.705
0.40	5.220	2.651	2.282	2.089	2.026	1.968	1.905	1.856	1.813	1.777	1.727
0.50	6.495	2.947	2.465	2.220	2.141	2.068	1.989	1.928	1.876	1.830	1.784
0.60	7.807	3.287	2.673	2.368	2.271	2.181	2.085	2.010	1.946	1.891	1.836
0.70	9.120	3.662	2.904	2.532	2.414	2.306	2.191	2.102	2.025	1.960	1.895
0.80	10.43	4.062	3.155	2.710	2.570	2.443	2.307	2.202	2.112	2.035	1.958
0.90	11.74	4.478	3.420	2.902	2.738	2.589	2.432	2.310	2.206	2.117	2.028
1.00	13.05	4.905	3.698	3.103	2.915	2.744	2.564	2.423	2.306	2.205	2.104
1.25	16.33	6.001	4.426	3.639	3.389	3.163	2.923	2.737	2.580	2.447	2.314
1.50	19.6	7.120	5.184	4.207	3.896	3.612	3.311	3.077	2.881	2.713	2.545
1.75	22.87	8.250	5.960	4.795	4.422	4.081	3.719	3.437	3.200	2.997	2.794
2.00	26.14	9.387	6.747	5.396	4.962	4.564	4.141	3.812	3.533	3.295	3.057
2.50	32.69	11.67	8.339	6.621	6.067	5.557	5.013	4.588	4.228	3.92	3.612
3.00	39.23	13.97	9.945	7.864	7.191	6.57	5.907	5.388	4.947	4.569	4.191
3.50	45.77	16.27	11.56	9.118	8.326	7.596	6.815	6.201	5.681	5.233	4.758
4.00	52.31	18.58	13.18	10.38	9.469	8.63	7.731	7.024	6.424	5.908	5.392
4.50	58.85	20.88	14.8	11.64	10.62	9.669	8.652	7.854	7.174	6.59	6.006
5.00	65.39	23.19	16.43	12.91	11.77	10.71	9.579	8.688	7.929	7.277	6.625
6.00	78.47	27.81	19.68	15.45	14.08	12.81	11.44	10.36	9.449	8.661	7.873
7.00	91.55	32.43	22.94	18.00	16.39	14.9	13.31	12.05	10.98	10.05	9.12
8.00	104.6	37.06	26.2	20.55	18.71	17.01	15.18	13.74	12.51	11.45	10.39
9.00	117.7	41.68	29.46	23.1	21.03	19.11	17.05	15.43	14.05	12.85	11.65
10.00	130.8	46.31	32.73	25.66	23.35	21.22	18.93	17.13	15.59	14.26	12.93

Coefficients of Variation (CV) for Various Data Sets

parameter	Group 1 - All SS			Group 2 - All SB			Group 3 - Grid SS			Group 4 - Perimeter SS			Group 5 - Grid SB			Group 6 - Perimeter SB		
	Standard Deviation	Mean	CV*	Standard Deviation	Mean	CV*	Standard Deviation	Mean	CV*	Standard Deviation	Mean	CV*	Standard Deviation	Mean	CV*	Standard Deviation	Mean	CV*
ALUMINUM	2,767.93	14,844.44	0.19	3,161.56	17,938.89	0.18	2,888.33	15,666.67	0.18	1,681.67	13,200.00	0.13	2,432.36	17,500.00	0.14	4,425.12	18,816.67	0.24
ANTIMONY *	1.37	1.45	0.94	0.30	0.48	0.63	1.54	1.84	0.84	0.30	0.68	0.44	0.37	0.52	0.71	0.07	0.41	0.16
ARSENIC	4.16	8.40	0.50	1.99	8.68	0.23	4.88	9.22	0.53	1.32	6.77	0.19	1.99	8.70	0.23	2.18	8.65	0.25
BARIUM	33.83	120.34	0.28	26.21	90.67	0.29	32.59	122.82	0.27	38.88	115.38	0.34	29.19	94.48	0.31	18.90	83.03	0.23
BERYLLIUM	0.24	0.81	0.30	0.23	0.83	0.28	0.25	0.84	0.30	0.23	0.75	0.31	0.22	0.84	0.26	0.28	0.82	0.35
CADMIUM	0.40	0.61	0.65	0.09	0.35	0.27	0.44	0.68	0.65	0.26	0.46	0.57	0.11	0.36	0.32	0.03	0.34	0.10
CALCIUM	30,165.03	18,206.67	1.66	283.43	765.78	0.37	16,590.11	15,455.83	1.07	49,333.22	23,708.33	2.08	260.46	769.67	0.34	351.82	758.00	0.46
CHROMIUM	5.37	22.84	0.24	3.09	24.75	0.12	5.91	24.41	0.24	1.89	19.70	0.10	2.72	24.83	0.11	4.02	24.60	0.16
COBALT	3.09	10.18	0.30	4.99	8.27	0.60	3.15	10.79	0.29	2.83	8.97	0.32	2.50	7.74	0.32	8.30	9.33	0.89
COPPER	7.43	16.84	0.44	3.07	14.59	0.21	7.74	19.32	0.40	3.45	11.88	0.29	2.92	14.40	0.20	3.61	14.97	0.24
IRON	7,035.42	20,477.78	0.34	3,793.57	29,505.56	0.13	8,187.78	21,716.67	0.38	3,122.82	18,000.00	0.17	3,546.43	29,058.33	0.12	4,451.97	30,400.00	0.15
LEAD	4.96	18.71	0.27	5.52	16.00	0.35	5.18	19.90	0.26	3.81	16.32	0.23	3.04	15.35	0.20	8.96	17.30	0.52
MAGNESIUM	1,166.29	2,057.22	0.57	704.29	2,227.94	0.32	719.27	1,982.50	0.36	1,856.44	2,206.67	0.84	546.87	2,175.00	0.25	1,004.18	2,333.83	0.43
MANGANESE	627.22	1,003.17	0.63	1,078.13	667.61	1.61	410.48	938.58	0.44	967.91	1,132.33	0.85	459.06	514.50	0.89	1,821.98	973.83	1.87
MERCURY	0.10	0.09	1.08	0.01	0.02	0.84	0.11	0.11	0.98	0.02	0.04	0.40	0.01	0.02	0.72	0.02	0.02	1.14
NICKEL	2.27	14.75	0.15	2.06	13.84	0.15	2.10	15.43	0.14	2.12	13.38	0.16	2.03	14.40	0.14	1.78	12.73	0.14
POTASSIUM	365.92	1,311.11	0.28	355.42	1,401.61	0.25	298.15	1,341.25	0.22	503.14	1,250.83	0.40	264.26	1,391.67	0.19	524.55	1,421.50	0.37
SELENIUM	0.21	0.41	0.52	0.14	0.27	0.52	0.20	0.48	0.42	0.17	0.26	0.63	0.14	0.28	0.49	0.16	0.26	0.63
SILVER	6.40	5.19	1.23	0.04	0.07	0.52	7.02	7.07	0.99	2.32	1.44	1.61	0.04	0.07	0.56	0.02	0.06	0.40
SODIUM	30.38	46.26	0.66	34.32	70.31	0.49	32.36	49.80	0.65	27.25	39.18	0.70	32.05	71.20	0.45	41.70	68.53	0.61
THALLIUM	0.05	0.25	0.18	0.04	0.26	0.15	0.05	0.26	0.21	0.03	0.25	0.13	0.04	0.26	0.15	0.04	0.26	0.16
VANADIUM	9.22	38.59	0.24	3.99	44.56	0.09	10.41	40.36	0.26	5.27	35.05	0.15	3.41	43.77	0.08	4.89	46.15	0.11
ZINC	18.47	63.23	0.29	9.48	50.37	0.19	18.64	69.88	0.27	8.80	49.93	0.18	6.97	49.78	0.14	14.01	51.57	0.27
CYANIDE	0.16	0.25	0.63	0.09	0.20	0.47	0.18	0.27	0.68	0.09	0.21	0.44	0.10	0.21	0.47	0.09	0.18	0.51
PH	0.83	7.07	0.12	1.00	5.73	0.17	0.62	7.24	0.09	1.13	6.72	0.17	1.03	5.81	0.18	1.00	5.58	0.18
		Average CV	0.51		Average CV	0.38		Average CV	0.44		Average CV	0.47		Average CV	0.32		Average CV	0.42

* CV = (Standard Deviation)/(Mean). Standard Deviation and Mean sample calculations are provided in Appendix E - Sample Calculation Sheets.

APPENDIX F

RISK ASSESSMENT APPENDICES

1 REGION 9 PRG EXPOSURE ASSESSMENT METHODOLOGY
2 REGION 3 IRON GUIDANCE
3 REGION 1 MANGANESE GUIDANCE

EPA United States Environmental Protection Agency

Waste Programs

Region 9

PRGs: What's New in 2000

Subject: Region 9 PRGs Table 2000 Update

From: Stanford J. Smucker, Ph.D.
Regional Toxicologist (SFD-8-B)
Technical Support Group

To: PRG Table Users

The Region 9 PRGs Table has been updated. You can find it at the PRG home page on the Web at: http://www.epa.gov/region09/waste/sfund/prg/.

PRG Home | What's New
FAQ | Other Links

R9 PRG Tables:
A-Bu | Ca-De | Di-Fe | Fl-Mo | Na-Pu | Py-Zi
Soil Calculations:
A-Bu | Ca-De | Di-Fe | Fl-Mo | Na-Pu | Py-Zi
Air-Water Calculations:
A-Bu | Ca-De | Di-Fe | Fl-Mo | Na-Pu | Py-Zi
Toxicity Values:
A-Bu | Ca-De | Di-Fe | Fl-Mo | Na-Pu | Py-Zi
Phys-Chem Data:
A-Di | Ep-Tr

To minimize paper usage, the PRGs Table is now primarily available through the Internet. A PRG mailing list will no longer be maintained for sending out printed copies.

The risk-based concentrations ("PRGs") presented in the Table reflect state-of-the-science approaches in toxicology and exposure assessment. Chemicals for which new toxicity values have been added in the 2000 update include: **benzene, chlorine, cyclohexane, 4,4'-dichlorobenzophenone, 1,3-dichloropropene, diisononyl phthalate, n,n-diphenyl-1,4 benzenediamine (DPPD), dysprosium, ethylene glycol monobutyl ether, hexachlorobutadiene, monomethyl and dimethyl hydrazines, 1,1'-sulfonylbis(4-chlorobenzene), thallium, trimellitic anhydride (TMAN), triphenylphosphine oxide, tris(2-chloroethyl) phosphate, vinyl chloride and uranium.** In addition, **lead** in industrial soils has a new "screening" PRG based on the recommendations of the Technical Review Workgroup (TRW) for Lead. Finally, two new "Cal-Modified PRGs" have been added for **1,1-dichloroethane** and **MTBE** based on California EPA toxicity values. EXIT EPA

In this update, there are no changes to the exposure factors used to calculate PRGs. We are hopeful that the Dermal Guidance document entitled "Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Interim Guidance" will be officially released in the near future. The recommendations of the dermal workgroup that had previously been incorporated in the 1999 PRG Table for soil exposures have not changed.

Before relying on any number in the table, it is recommended that the user verify the numbers with an agency toxicologist or risk assessor because the toxicity / exposure information in the table may contain errors or default assumptions that need to be refined based on further evaluation. If you find an error please send me a note via email at smucker.stan@epa.gov .

Region 9 Waste Home | Region 9 Superfund Home | Region 9 PRG Home
Region 9 Home | EPA Home | Search | Comments/Questions

Region 9 Office: 75 Hawthorne St., San Francisco, Calif., 94105

Send PRG-related comments and questions to smucker.stan@epa.gov

Posted: November 3, 2000

URL: http://www.epa.gov/region09/waste/sfund/prg/whatsnew.htm

DISCLAIMER

Preliminary remediation goals (PRGs) focus on common exposure pathways and may not consider all exposure pathways encountered at CERCLA / RCRA sites (Exhibit 1-1). PRGs do not consider impact to groundwater or address ecological concerns. PRGs are specifically not intended as a (1) stand-alone decision-making tool, (2) as a substitute for EPA guidance for preparing baseline risk assessments, or (3) a rule to determine if a waste is hazardous under RCRA.

The guidance set out in this document is not final Agency action. It is not intended, nor can it be relied upon to create any rights enforceable by any party in litigation with the United States. EPA officials may decide to follow the guidance provided herein, or act at variance with the guidance, based on an analysis of specific circumstances. The Agency also reserves the right to change this guidance at any time without public notice.

1.0 INTRODUCTION

Region 9 Preliminary Remediation Goals (PRGs) are risk-based tools for evaluating and cleaning up contaminated sites. They are being used to streamline and standardize all stages of the risk decision-making process.

The Region 9 PRG table combines current EPA toxicity values with "standard" exposure factors to estimate contaminant concentrations in environmental media (soil, air, and water) that are considered protective of humans, including sensitive groups, over a lifetime. Chemical concentrations above these levels would not automatically designate a site as "dirty" or trigger a response action. However, exceeding a PRG suggests that further evaluation of the potential risks that may be posed by site contaminants is appropriate. Further evaluation may include additional sampling, consideration of ambient levels in the environment, or a reassessment of the assumptions contained in these screening-level estimates (e.g. appropriateness of route-to-route extrapolations, appropriateness of using chronic toxicity values to evaluate childhood exposures, appropriateness of generic exposure factors for a specific site etc.).

The PRG concentrations presented in the table can be used to screen pollutants in environmental media, trigger further investigation, and provide an initial cleanup goal if applicable. When considering PRGs as preliminary goals, residential concentrations should be used for maximum beneficial uses of a property. Industrial concentrations are included in the table as an alternative cleanup goal for soils. In general, it is not recommended that industrial PRGs be used for screening sites unless they are used in conjunction with residential values.

Before applying PRGs as screening tools or initial goals, the user of the table should consider whether the exposure pathways and exposure scenarios at the site are fully accounted for in the PRG calculation. Region 9 PRG concentrations are based on exposure pathways for which generally accepted methods, models, and assumptions have been developed (i.e. ingestion, dermal contact, and inhalation) for specific land-use conditions and do not consider impact to groundwater or ecological receptors (see Developing a Conceptual Site Model below).

EXHIBIT 1-1
TYPICAL EXPOSURE PATHWAYS BY MEDIUM
FOR RESIDENTIAL AND INDUSTRIAL LAND USES[a]

EXPOSURE PATHWAYS, ASSUMING:		
MEDIUM	RESIDENTIAL LAND USE	INDUSTRIAL LAND USE
Ground Water	***Ingestion from drinking***	Ingestion from drinking
	Inhalation of volatiles	Inhalation of volatiles
	Dermal absorption from bathing	Dermal absorption
Surface Water	***Ingestion from drinking***	Ingestion from drinking
	Inhalation of volatiles	Inhalation of volatiles
	Dermal absorption from bathing	Dermal absorption
	Ingestion during swimming	
	Ingestion of contaminated fish	
Soil	***Ingestion***	***Ingestion***
	Inhalation of particulates	***Inhalation of particulates***
	Inhalation of volatiles	***Inhalation of volatiles***
	Exposure to indoor air from soil gas	Exposure to indoor air from soil gas
	Exposure to ground water contaminated by soil leachate	Exposure to ground water contaminated by soil leachate
	Ingestion via plant, meat, or dairy products	Inhalation of particulates from trucks and heavy equipment
	Dermal absorption	***Dermal absorption***

Footnote:
[a]Exposure pathways considered in the PRG calculations are indicated in boldface italics.

2.0 READING THE PRG TABLE

2.1 General Considerations

With the exceptions described below, PRGs are chemical concentrations that correspond to fixed levels of risk (i.e. either a one-in-one million [10^{-6}] cancer risk or a noncarcinogenic hazard quotient of 1) in soil, air, and water. In most cases, where a substance causes both cancer and noncancer (systemic) effects, the 10^{-6} cancer risk will result in a more stringent criteria and consequently this value is presented in the hard copy of the table. PRG concentrations that equate to a 10^{-6} cancer risk are indicated by "ca". PRG concentrations that equate to a hazard quotient of 1 for noncarcinogenic concerns are indicated by "nc".

If the risk-based concentrations are to be used for site screening, it is recommended that both cancer and noncancer-based PRGs be used. Both carcinogenic and noncarcinogenic values may be obtained at the Region 9 PRG homepage at:

http://www.epa.gov/region09/waste/sfund/prg/

It has come to my attention that some users have been multiplying the cancer PRG concentrations by 10 or 100 to set "action levels" for triggering remediation or to set less stringent cleanup levels for a specific site after considering non-risk-based factors such as ambient levels, detection limits, or technological feasibility. This risk management practice recognizes that there may be a range of values that may be "acceptable" for carcinogenic risk (EPA's risk management range is one-in-a-million [10^{-6}] to one-in-ten thousand [10^{-4}]). However, this practice could lead one to overlook serious noncancer health threats and it is strongly recommended that the user consult with a toxicologist or regional risk assessor before doing this. For carcinogens, I have indicated by asterisk ("ca*") in the PRG table where the noncancer PRGs would be exceeded if the cancer value that is displayed is multiplied by 100. Two stars ("ca**") indicate that the noncancer values would be exceeded if the cancer PRG were multiplied by 10. There is no range of "acceptable" noncarcinogenic "risk" so that under no circumstances should noncancer PRGs be multiplied by 10 or 100, when setting final cleanup criteria.

In general, PRG concentrations in the table are risk-based but for soil there are two important exceptions: (1) for several volatile chemicals, PRGs are based on the soil saturation equation ("sat") and (2) for relatively less toxic inorganic and semivolatile contaminants, a non-risk based "ceiling limit" concentration is given as 10^{+5} mg/kg ("max").

Also included in the PRG table are soil screening levels (SSLs) for protection of groundwater (see Section 2.3); and, California EPA PRGs ("CAL-Modified PRGs") for specific chemicals where CAL-EPA screening values may be "significantly" more restrictive than the federal values (see Section 2.4).

2.2 Toxicity Values

Heirarchy of Toxicity Values

EPA toxicity values, known as noncarcinogenic reference doses (RfD) and carcinogenic slope factors (SF) were obtained from IRIS, NCEA (formerly ECAO) through September 2000, and HEAST. The priority among sources of toxicological constants of the table in order of preference is as follows: (1) IRIS (indicated by "i"), (2) NCEA ("n"), (3) HEAST ("h"), (4) withdrawn from IRIS or HEAST and under review ("x") or obtained from other EPA documents ("o").

Inhalation Conversion Factors

As of January 1991, IRIS and NCEA databases no longer present RfDs or SFs for the inhalation route. These criteria have been replaced with reference concentrations (RfC) for noncarcinogenic effects and unit risk factors (URF) for carcinogenic effects. However, for purposes of estimating risk and calculating risk-based concentrations, inhalation reference doses (RfDi) and inhalation slope factors (SFi) are preferred. This is not a problem for most chemicals because the inhalation toxicity criteria are easily converted. To calculate an RfDi from an RfC, the following equation and assumptions may be used for most chemicals:

$$\text{RfDi}\ \frac{\text{mg}}{(\text{kg-day})} = \text{RfC}(\text{mg}/\text{m}^3) \times \frac{20\text{m}^3}{\text{day}} \times \frac{1}{70\text{kg}}$$

Likewise, to calculate an SFi from an inhalation URF, the following equation and assumptions may be used:

$$\text{SFi}\ \frac{(\text{kg-day})}{(\text{mg})} = \text{URF}(\text{m}^3/\text{ug}) \times \frac{\text{day}}{20\text{m}^3} \times 70\text{kg} \times \frac{10^3\ \text{ug}}{\text{mg}}$$

Substances with New Toxicity Values

To help users rapidly identify substances with new toxicity values, these chemicals are printed in boldface type. This issue of the PRG table contains new or revised toxicity values for **benzene, chlorine, cyclohexane, 4,4'-dichlorobenzophenone, 1,3-dichloropropene, diisononyl phthalate, n,n-diphenyl-1,4 benzenediamine (DPPD), dysprosium, ethylene glycol monobutyl ether, hexachlorobutadiene, monomethyl and dimethyl hydrazines, 1,1'-sulfonylbis(4-chlorobenzene), thallium, trimellitic anhydride (TMAN), triphenylphosphine oxide, tris(2-chloroethyl) phosphate, vinyl chloride and uranium.** In addition, **lead** in industrial soils has a new PRG based on the recommendations of the Technical Review Workgroup (TRW) for Lead.

Route-to-Route Methods

Route-to-route extrapolations ("r") were frequently used when there were no toxicity values available for a given route of exposure. Oral cancer slope factors ("SFo") and reference doses ("RfDo") were used for both oral and inhaled exposures for organic compounds lacking inhalation values. Inhalation slope factors ("SFi") and inhalation reference doses ("RfDi") were used for both inhaled and oral exposures for organic compounds lacking oral values. Route extrapolations were not performed for inorganics due to portal of entry effects and known differences in absorption efficiency for the two routes of exposure.

An additional route extrapolation is the use of oral toxicity values for evaluating dermal exposures. For many chemicals, a scientifically defensible data base does not exist for making an adjustment of an oral slope factor/RfD to estimate a dermal toxicity value. Based on the current guidance (USEPA 2000a), the only chemical for which an adjustment is recommended is cadmium. An oral absorption efficiency of 5% is assumed for cadmium which leads to an estimated dermal reference dose (RfDd) of 2.5E-05. Please note that the PRG calculations for cadmium are based on this adjustment.

Although route-to-route methods are a useful screening procedure, the appropriateness of these default assumptions for specific contaminants should be verified by a toxicologist or regional risk assessor. Please note that whenever route-extrapolated values are used to calculate risk-based PRGs, additional uncertainties are introduced in the calculation.

2.3 Soil Screening Levels

Generic, soil screening levels (SSLs) for the protection of groundwater have been included in the PRG table for 100 of the most common contaminants at Superfund sites. Generic SSLs are derived using default values in standardized equations presented in *Soil Screening Guidance* (available from NTIS as document numbers PB96-963502 and PB96-963505 or EPA/540/R-95/128 and EPA/540/R-96/018).

The SSLs were developed using a default dilution-attenuation factor (DAF) of 20 to account for natural processes that reduce contaminant concentrations in the subsurface. Also included are generic SSLs that assume no dilution or attenuation between the source and the receptor well (i.e., a DAF of 1). These values can be used at sites where little or no dilution or attenuation of soil leachate concentrations is expected at a site (e.g., sites with shallow water tables, fractured media, karst topography, or source size greater than 30 acres).

In general, if an SSL is not exceeded for the migration to groundwater pathway, the user may eliminate this pathway from further investigation.

2.4 "Cal-Modified PRGs"

When EPA Region 9 first came out with a Draft of the PRG tables in 1992, there was concern expressed by California EPA's Department of Toxic Substances and Control (DTSC) that for some chemicals, the risk-based concentrations calculated using Cal-EPA toxicity

values were "significantly" more protective than the risk-based PRGs calculated by Region 9. At an interagency meeting comprised of mostly toxicologists, it was agreed that values that differed by a factor of four or more would be said to have "significant" difference in risk-based PRGs. Although four was a somewhat arbitrary cutoff point, it reflects a consideration that the numbers are not very precise and at best, are order-of-magnitude estimates of risk.

Cal-Modified PRGs are included for those chemicals where Cal-EPA values are "significantly" more protective. The original list of Cal-Modified PRGs (cadmium, chromium 6, nickel, PAHs benzo(a)pyrene and benzo(k)fluoranthene, tetrachloroethylene [PCE] and lead which has been withdrawn) were based on exposure factors and modeling assumptions presented in California EPA's Preliminary Endangerment Assessment Guidance Manual (PEA 1994). Please note that any Cal-Modified PRGs that have been added to this original list after 1995 have been calculated using Cal-EPA toxicity values and Region 9 exposure methodology. In this issue of the PRG table, Cal-Modified PRGs have been added for **1,1-dichloroethane** and **MTBE**. In the State of California, Cal-Modified PRGs should be used as screening levels because they are more stringent than the Federal numbers.

2.5 Miscellaneous

Volatile organic compounds (VOCs) are indicated by "1" in the VOC column of the table and in general, are defined as those chemicals having a Henry's Law constant greater than 10^{-5} (atm-m^3/mol) and a molecular weight less than 200 g/mole). Three borderline chemicals (dibromochloromethane, 1,2-dibromochloropropane, and pyrene) which do not strictly meet these criteria of volatility have also been included based upon discussions with other state and federal agencies and after a consideration of vapor pressure characteristics etc. Volatile organic chemicals are evaluated for potential volatilization from soil/water to air using volatilization factors (see Section 4.1).

Chemical-specific dermal absorption values for contaminants in soil and dust are presented for arsenic, cadmium, chlordane, 2,4-D, DDT, lindane, TCDD, PAHs, PCBs, and pentachlorophenols as recommended in the "Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Interim Guidance" (USEPA 2000). Otherwise, default skin absorption fractions are assumed to be 0.10 for nonvolatile organics. Please note that previous defaults of 0.01 and 0.10 for inorganics and VOCs respectively, have been withdrawn per new guidance.

3.0 USING THE PRG TABLE

The decision to use PRGs at a site will be driven by the potential benefits of having generic risk-based concentrations in the absence of site-specific risk assessments. The original intended use of PRGs was to provide initial cleanup goals for individual chemicals given specific medium and land-use combinations (see RAGS Part B, 1991), however risk-based concentrations have several applications. They can also be used for:

- Setting health-based detection limits for chemicals of potential concern
- Screening sites to determine whether further evaluation is appropriate
- Calculating cumulative risks associated with multiple contaminants

A few basic procedures are recommended for using PRGs properly. These are briefly described below. Potential problems with the use of PRGs are also identified.

3.1 Developing a Conceptual Site Model

The primary condition for use of PRGs is that exposure pathways of concern and conditions at the site match those taken into account by the PRG framework. Thus, it is always necessary to develop a conceptual site model (CSM) to identify likely contaminant source areas, exposure pathways, and potential receptors. This information can be used to determine the applicability of PRGs at the site and the need for additional information. For those pathways not covered by PRGs, a risk assessment specific to these additional pathways may be necessary. Nonetheless, the PRG lookup values will still be useful in such situations for focusing further investigative efforts on the exposure pathways not addressed.

To develop a site-specific CSM, perform an extensive records search and compile existing data (e.g. available site sampling data, historical records, aerial photographs, and hydrogeologic information). Once this information is obtained, CSM worksheets such as those provided in ASTM's *Standard Guide for Risk-Based Corrective Action Applied at Petroleum Release Sites* (1995) can be used to tailor the generic worksheet model to a site-specific CSM. The final CSM diagram represents linkages among contaminant sources, release mechanisms, exposure pathways and routes and receptors. It summarizes our understanding of the contamination problem.

As a final check, the CSM should answer the following questions:

- Are there potential ecological concerns?
- Is there potential for land use other than those covered by the PRGs (that is, residential and industrial)?
- Are there other likely human exposure pathways that were not considered in development of the PRGs (e.g. impact to groundwater, local fish consumption, raising beef, dairy, or other livestock)?
- Are there unusual site conditions (e.g. large areas of contamination, high fugitive dust levels, potential for indoor air contamination)?

If any of these four conditions exist, the PRG may need to be adjusted to reflect this new information. Suggested references for evaluating pathways not currently evaluated by Region 9 PRG's are presented in Exhibit 3-1.

EXHIBIT 3-1
SUGGESTED READINGS FOR EVALUATING EXPOSURE PATHWAYS NOT CURRENTLY ADDRESSED BY REGION 9 PRGs

EXPOSURE PATHWAY	REFERENCE
Migration of contaminants to an underlying potable aquifer	*Soil Screening Guidance* (USEPA 1996a,b), *Standard Guide for Risk-Based Corrective Action Applied at Petroleum Release Sites* (ASTM 1995)
Ingestion via plant uptake	*Soil Screening Guidance* (USEPA 1996a,b)
Ingestion via meat, dairy products, human milk	*Estimating Exposure to Dioxin-Like Compounds* (USEPA 1994a)
Inhalation of volatiles that have migrated into basements	*User's Guide for Johnson and Ettinger (1991) Model for Subsurface Vapor Intrusion into Buildings* (USEPA 1997a)
Ecological pathways	*Ecological Risk Assessment: Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments*, (USEPA 1997b), *Guidance for Ecological Risk Assessment at Hazardous Waste Sites and Permitted Facilities* (CAL-EPA 1996)

3.2 Background Levels Evaluation

A necessary step in determining the usefulness of Region 9 PRGs is the consideration of background contaminant concentrations. EPA may be concerned with two types of background at sites: naturally occurring and anthropogenic. Natural background is usually limited to metals whereas anthropogenic (i.e. human-made) "background" includes both organic and inorganic contaminants. Before embarking on an extensive sampling and analysis program to determine local background concentrations in the area, one should first compile existing data on the subject. Far too often there is pertinent information in the literature that gets ignored, resulting in needless expenditures of time and money.

Generally EPA does not clean up below natural background. In some cases, the predictive risk-based models generate PRG levels that lie within or even below typical background. If natural background concentrations are higher than the risk-based PRGs, an adjustment of the PRG is probably needed. Exhibit 3-2 presents summary statistics for selected elements in soils that have background levels that may exceed risk-based PRGs. An illustrative example of this is naturally occurring arsenic in soils which frequently is higher than the risk-based concentration set at a one-in-one-million cancer risk (the PRG for residential soils is 0.39 mg/kg). After considering

background concentrations in a local area, EPA Region 9 has at times used the non-cancer PRG (22 mg/kg) to evaluate sites recognizing that this value tends to be above background levels yet still falls within the range of soil concentrations (0.39-39 mg/kg) that equates to EPA's "acceptable" cancer risk range of 10E-6 to 10E-4.

Where anthropogenic "background" levels exceed PRGs and EPA has determined that a response action is necessary and feasible, EPA's goal will be to develop a comprehensive response to the widespread contamination. This will often require coordination with different authorities that have jurisdiction over the sources of contamination in the area.

EXHIBIT 3-2
BACKGROUND CONCENTRATIONS OF SELECTED ELEMENTS IN SOILS

TRACE	U.S. STUDY DATA[1]			CALIFORNIA DATA[2]		
ELEMENT	Range	GeoMean	ArMean	Range	GeoMean	ArMean
Arsenic	<.1-97	5.2 mg/kg	7.2 mg/kg	0.59-11	2.75 mg/kg	3.54 mg/kg
Beryllium	<1-15	0.63 "	0.92 "	0.10-2.7	1.14 "	1.28 "
Cadmium	<1-10	--	<1	0.05-1.7	0.26	0.36
Chromium	1-2000	37	54	23-1579	76.25	122.08
Nickel	<5-700	13	19	9.0-509	35.75	56.60

[1]Shacklette and Hansford, "Element Concentrations in Soils and Other Surficial Materials of the Conterminous United States",USGS Professional Paper 1270, 1984.

[2]Bradford et. al, "Background Concentrations of Trace and Major Elements in California Soils", Kearney Foundation Special Report, UC-Riverside and CAL-EPA DTSC, March 1996.

3.3 Screening Sites with Multiple Pollutants

A suggested stepwise approach for PRG-screening of sites with multiple pollutants is as follows:

- Perform an extensive records search and compile existing data.
- Identify site contaminants in the PRG table. Record the PRG concentrations for various media and note whether PRG is based on cancer risk (indicated by "ca") or noncancer hazard (indicated by "nc"). Segregate cancer PRGs from non-cancer PRGs and exclude (but don't eliminate) non-risk based PRGs ("sat" or "max").
- For cancer risk estimates, take the site-specific concentration (maximum or 95 UCL) and divide by the PRG concentrations that are designated for cancer evaluation ("ca"). Multiply this ratio by 10^{-6} to estimate chemical-specific risk for a reasonable maximum exposure (RME). For multiple pollutants, simply add the risk for each chemical:

$$Risk = [(\frac{conc_x}{PRG_x}) + (\frac{conc_y}{PRG_y}) + (\frac{conc_z}{PRG_z})] \times 10^{-6}$$

- For non-cancer hazard estimates. Divide the concentration term by its respective non-cancer PRG designated as "nc" and sum the ratios for multiple contaminants. The cumulative ratio represents a non-carcinogenic hazard index (HI). A hazard index of 1 or less is generally considered "safe". A ratio greater than 1 suggests further evaluation. **[Note that carcinogens may also have an associated non-cancer PRG that is not listed in the printed copy of the table sent to folks on the mailing list. To obtain these values, the user should view or download the PRG table at our website and display the appropriate sections.]**

$$Hazard\ Index = [(\frac{conc_x}{PRG_x}) + (\frac{conc_y}{PRG_y}) + (\frac{conc_z}{PRG_z})]$$

For more information on screening site risks, the reader should contact EPA Region 9's Technical Support Group.

3. 4 Potential Problems

As with any risk-based tool, the potential exists for misapplication. In most cases the root cause will be a lack of understanding of the intended use of Region 9 PRGs. In order to prevent misuse of PRGs, the following should be avoided:

- Applying PRGs to a site without adequately developing a conceptual site model that identifies relevant exposure pathways and exposure scenarios,
- Not considering background concentrations when choosing PRGs as cleanup goals,
- Use of PRGs as cleanup levels without the nine-criteria analysis specified in the National Contingency Plan (or, comparable analysis for programs outside of Superfund),
- Use of PRGs as cleanup levels without verifying numbers with a toxicologist or regional risk assessor,
- Use of antiquated PRG tables that have been superseded by more recent publications,
- Not considering the effects of additivity when screening multiple chemicals, and
- Adjusting PRGs upward by factors of 10 or 100 without consulting a toxicologist or regional risk assessor.

4.0 TECHNICAL SUPPORT DOCUMENTATION

Region 9 PRGs consider human exposure hazards to chemicals from contact with contaminated soils, air, and water. The emphasis of the PRG equations and technical discussion are aimed at developing screening criteria for soils, since this is an area where few standards exist. For air and water, additional reference concentrations or standards are available for many chemicals (e.g. MCLs, non-zero MCLGs, AWQC, and NAAQS) and consequently the discussion of these media are brief.

4.1 Soils - Direct Ingestion

Calculation of risk-based PRGs for direct ingestion of soil is based on methods presented in RAGS HHEM, Part B (USEPA 1991a) and *Soil Screening Guidance* (USEPA 1996a,b). Briefly, these methods backcalculate a soil concentration level from a target risk (for carcinogens) or hazard quotient (for noncarcinogens).

A number of studies have shown that inadvertent ingestion of soil is common among children 6 years old and younger (Calabrese et al. 1989, Davis et al. 1990, Van Wijnen et al. 1990). To take into account the higher soil intake rate for children, two different approaches are used to estimate PRGs, depending on whether the adverse health effect is cancer or some effect other than cancer.

For carcinogens, the method for calculating PRGs uses an age-adjusted soil ingestion factor that takes into account the difference in daily soil ingestion rates, body weights, and exposure duration for children from 1 to 6 years old and others from 7 to 31 years old. This health-protective approach is chosen to take into account the higher daily rates of soil ingestion in children as well as the longer duration of exposure that is anticipated for a long-term resident. For more on this method, see USEPA RAGs Part B (1991a).

For noncarcinogenic concerns, the more protective method of calculating a soil PRG is to evaluate childhood exposures separately from adult exposures. In other words, an age-adjustment factor is not applied as was done for carcinogens. This approach is considered conservative because it combines the higher 6-year exposure for children with chronic toxicity criteria. In their analysis of the method, the Science Advisory Board (SAB) indicated that, for most chemicals, the approach may be overly protective. However, they noted that there are specific instances when the chronic RfD may be based on endpoints of toxicity that are specific to children (e.g. fluoride and nitrates) or when the dose-response is steep (i.e., the dosage difference between the no-observed-adverse-effects level [NOAEL] and an adverse effects level is small). Thus, for the purposes of screening, EPA Region 9 has adopted this approach for calculating soil PRGs for noncarcinogenic health concerns.

4.2 Soils - Vapor and Particulate Inhalation

Agency toxicity criteria indicate that risks from exposure to some chemicals via inhalation far outweigh the risk via ingestion; therefore soil PRGs have been designed to address this pathway as well. The models used to calculate PRGs for inhalation of volatiles/particulates are updates of risk assessment methods presented in RAGS Part B (USEPA 1991a) and are identical to the *Soil Screening Guidance: User's Guide and Technical Background Document* (USEPA 1996a,b).

To address the soil-to-air pathways the PRG calculations incorporate volatilization factors (VF_s) for volatile contaminants and particulate emission factors (PEF) for nonvolatile contaminants. These factors relate soil contaminant concentrations to air contaminant concentrations that may be inhaled on-site. The VF_s and PEF equations can be broken into two separate models: an emission model to estimate emissions of the contaminant from the soil and a dispersion model to simulate the dispersion of the contaminant in the atmosphere.

It should be noted that the box model in RAGS Part B has been replaced with a dispersion term (Q/C) derived from a modeling exercise using meteorological data from 29 locations across the United States because the box model may not be applicable to a broad range of site types and meteorology and does not utilize state-of-the-art techniques developed for regulatory dispersion modeling. The dispersion model for both volatiles and particulates is the AREA-ST, an updated version of the Office of Air Quality Planning and Standards, Industrial Source Complex Model, ISC2. However, different Q/C terms are used in the VF and PEF equations. Los Angeles was selected as the 90th percentile data set for volatiles and Minneapolis was selected as the 90th percentile data set for fugitive dusts (USEPA 1996 a,b). A default source size of 0.5 acres was chosen for the PRG calculations. This is consistent with the default exposure area over which Region 9 typically averages contaminant concentrations in soils. If unusual site conditions exist such that the area source is substantially larger than the default source size assumed here, an alternative Q/C could be applied (see USEPA 1996a,b).

Volatilization Factor for Soils

Volatile chemicals, defined as those chemicals having a Henry's Law constant greater than 10^{-5} (atm-m^3/mol) and a molecular weight less than 200 g/mole, were screened for inhalation exposures using a volatilization factor for soils (VF_s). Please note that VF_s's are available at our website.

The emission terms used in the VF_s are chemical-specific and were calculated from physical-chemical information obtained from several sources. The priority of these sources were as follows: *Soil Screening Guidance* (USEPA 1996a,b), *Superfund Chemical Data Matrix* (USEPA 1996c), *Fate and Exposure Data* (Howard 1991), *Subsurface Contamination Reference Guide* (EPA 1990a), and *Superfund Exposure Assessment Manual* (SEAM, EPA 1988). In those cases where Diffusivity Coefficients (Di) were not provided in existing literature, Di's were calculated using Fuller's Method described in SEAM. A surrogate term was required for some chemicals that lacked physico-chemical information. In these cases, a proxy chemical of similar structure was used that may over- or under-estimate the PRG for soils.

Equation 4-9 forms the basis for deriving generic soil PRGs for the inhalation pathway. The following parameters in the standardized equation can be replaced with specific site data to develop a simple site-specific PRG

- Source area
- Average soil moisture content
- Average fraction organic carbon content
- Dry soil bulk density

The basic principle of the VF_s model (Henry's law) is applicable only if the soil contaminant concentration is at or below soil saturation "sat". Above the soil saturation limit, the model

cannot predict an accurate VF-based PRG. How these particular cases are handled, depends on whether the contaminant is liquid or solid at ambient soil temperatures (see Section 4.5).

Particulate Emission Factor for Soils

Inhalation of chemicals adsorbed to respirable particles (PM_{10}) were assessed using a default PEF equal to 1.316×10^9 m^3/kg that relates the contaminant concentration in soil with the concentration of respirable particles in the air due to fugitive dust emissions from contaminated soils. The generic PEF was derived using default values in Equation 4-11, which corresponds to a receptor point concentration of approximately 0.76 ug/m^3. The relationship is derived by Cowherd (1985) for a rapid assessment procedure applicable to a typical hazardous waste site where the surface contamination provides a relatively continuous and constant potential for emission over an extended period of time (e.g. years). This represents an annual average emission rate based on wind erosion that should be compared with chronic health criteria; it is not appropriate for evaluating the potential for more acute exposures.

The impact of the PEF on the resultant PRG concentration (that combines soil exposure pathways for ingestion, skin contact, and inhalation) can be assessed by accessing the Region 9 PRG website and viewing the pathway-specific soil concentrations. Equation 4-11 forms the basis for deriving a generic PEF for the inhalation pathway. For more details regarding specific parameters used in the PEF model, the reader is referred to *Soil Screening Guidance: Technical Background Document* (USEPA 1996a).

Note: the generic PEF evaluates windborne emissions and does not consider dust emissions from traffic or other forms of mechanical disturbance that could lead to greater emissions than assumed here.

4.3 Soils - Dermal Exposure

Dermal Contact Assumptions

Since the 1998 PRG table was issued, exposure factors for dermal contact with soil have changed in a few cases (USEPA 2000a). Recommended RME (reasonable maximum exposure) defaults for adult workers' skin surface areas (3300 cm^2/day) and soil adherence factors (0.2 mg/cm^2) now differ from the defaults recommended for adult residents (5700 cm^2/day, 0.07 mg/cm^2) as noted in Exhibit 4-1. This is due to differences in the range of activities experienced by workers versus residents.

Dermal Absorption

Chemical-specific skin absorption values recommended by the Superfund Dermal Workgroup were applied when available. Chemical-specific values are included for the following chemicals: arsenic, cadmium, chlordane, 2,4-D, DDT, lindane, TCDD, PAHs, PCBs, and pentachlorophenols.

The recently issued "Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Interim Guidance" (USEPA 2000a) recommends a default dermal absorption factor for semivolatile organic compounds of 10% as a screening method for the majority of SVOCs without dermal

absorption factors. Default dermal absorption values for other chemicals (VOCs and inorganics) are not recommended in the new guidance. Therefore, the assumption of 1% for inorganics and 10% for volatiles is no longer included in the Region 9 PRG table. This change has minimal impact on the final risk-based calculations because human exposure to VOCs and inorganics in soils is generally driven by other pathways of exposure.

4.4 Soils - Migration to Groundwater

The methodology for calculating SSLs for the migration to groundwater was developed to identify chemical concentrations in soil that have the potential to contaminate groundwater. Migration of contaminants from soil to groundwater can be envisioned as a two-stage process: (1) release of contaminant in soil leachate and (2) transport of the contaminant through the underlying soil and aquifer to a receptor well. The SSL methodology considers both of these fate and transport mechanisms.

SSLs are backcalculated from acceptable ground water concentrations (i.e. nonzero MCLGs, MCLs, or risk-based PRGs). First, the acceptable groundwater concentration is multiplied by a dilution factor to obtain a target leachate concentration. For example, if the dilution factor is 10 and the acceptable ground water concentration is 0.05 mg/L, the target soil leachate concentration would be 0.5 mg/L. The partition equation (presented in the *Soil Screening Guidance* document) is then used to calculate the total soil concentration (i.e. SSL) corresponding to this soil leachate concentration.

The SSL methodology was designed for use during the early stages of a site evaluation when information about subsurface conditions may be limited. Because of this constraint, the methodology is based on conservative, simplifying assumptions about the release and transport of contaminants in the subsurface. For more on SSLs, and how to calculate site-specific SSLs versus generic SSLs presented in the PRG table, the reader is referred to the *Soil Screening Guidance* document (USEPA 1996a,b).

4.5 Soil Saturation Limit

The soil saturation concentration "sat" corresponds to the contaminant concentration in soil at which the absorptive limits of the soil particles, the solubility limits of the soil pore water, and saturation of soil pore air have been reached. Above this concentration, the soil contaminant may be present in free phase, i.e., nonaqueous phase liquids (NAPLs) for contaminants that are liquid at ambient soil temperatures and pure solid phases for compounds that are solid at ambient soil temperatures.

Equation 4-10 is used to calculate "sat" for each volatile contaminant. As an update to RAGS HHEM, Part B (USEPA 1991a), this equation takes into account the amount of contaminant that is in the vapor phase in soil in addition to the amount dissolved in the soil's pore water and sorbed to soil particles.

Chemical-specific "sat" concentrations must be compared with each VF-based PRG because a basic principle of the PRG volatilization model is not applicable when free-phase contaminants are present. How these cases are handled depends on whether the contaminant is liquid or solid at ambient temperatures. Liquid contaminant that have a VF-based PRG that exceeds the "sat" concentration are set equal to "sat" whereas for solids (e.g., PAHs), soil screening decisions are

based on the appropriate PRGs for other pathways of concern at the site (e.g., ingestion).

4.6 Ground Water/Surface Water - Ingestion and Inhalation

Calculation of PRGs for ingestion and inhalation of contaminants in domestic water is based on the methodology presented in RAGS HHEM, Part B (USEPA 1991a). Ingestion of drinking water is an appropriate pathway for all chemicals. For the purposes of this guidance, however, inhalation of volatile chemicals from water is considered routinely only for chemicals with a Henry's Law constant of 1×10^{-5} atm-m^3/mole or greater <u>and</u> with a molecular weight of less than 200 g/mole.

For volatile chemicals, an upperbound volatilization constant (VF_w) is used that is based on all uses of household water (e.g showering, laundering, and dish washing). Certain assumptions were made. For example, it is assumed that the volume of water used in a residence for a family of four is 720 L/day, the volume of the dwelling is 150,000 L and the air exchange rate is 0.25 air changes/hour (Andelman in RAGS Part B). Furthermore, it is assumed that the average transfer efficiency weighted by water use is 50 percent (i.e. half of the concentration of each chemical in water will be transferred into air by all water uses). Note: the range of transfer efficiencies extends from 30% for toilets to 90% for dishwashers.

4.7 Default Exposure Factors

Default exposure factors were obtained primarily from RAGS Supplemental Guidance Standard Default *Exposure Factors* (OSWER Directive, 9285.6-03) dated March 25, 1991 and more recent information from U.S. EPA's Office of Solid Waste and Emergency Response, U.S. EPA's Office of Research and Development, and California EPA's Department of Toxic Substances Control (see Exhibit 4-1).

Because contact rates may be different for children and adults, carcinogenic risks during the first 30 years of life were calculated using age-adjusted factors ("adj"). Use of age-adjusted factors are especially important for soil ingestion exposures, which are higher during childhood and decrease with age. However, for purposes of combining exposures across pathways, additional age-adjusted factors are used for inhalation and dermal exposures. These factors approximate the integrated exposure from birth until age 30 combining contact rates, body weights, and exposure durations for two age groups - small children and adults. Age-adjusted factors were obtained from RAGS PART B or developed by analogy (see derivations next page).

For soils only, noncarcinogenic contaminants are evaluated in children separately from adults. No age-adjustment factor is used in this case. The focus on children is considered protective of the higher daily intake rates of soil by children and their lower body weight. For maintaining consistency when evaluating soils, dermal and inhalation exposures are also based on childhood contact rates.

(1) ingestion([mg-yr]/[kg-d]:

$$IFS_{adj} = \frac{ED_c \times IRS_c}{BW_c} + \frac{(ED_r - ED_c) \times IRS_a}{BW_a}$$

(2) skin contact([mg-yr]/[kg-d]:

$$SFS_{adj} = \frac{ED_c \times AF \times SA_c}{BW_c} + \frac{(ED_r - ED_c) \times AF \times SA_a}{BW_a}$$

(3) inhalation ([m^3-yr]/[kg-d]):

$$InhF_{adj} = \frac{ED_c \times IRA_c}{BW_c} + \frac{(ED_r - ED_c) \times IRA_a}{BW_a}$$

EXHIBIT 4-1
STANDARD DEFAULT FACTORS

Symbol	Definition (units)	Default	Reference
CSFo	Cancer slope factor oral (mg/kg-d)-1	–	IRIS, HEAST, or NCEA
CSFi	Cancer slope factor inhaled (mg/kg-d)-1	–	IRIS, HEAST, or NCEA
RfDo	Reference dose oral (mg/kg-d)	–	IRIS, HEAST, or NCEA
RfDi	Reference dose inhaled (mg/kg-d)	–	IRIS, HEAST, or NCEA
TR	Target cancer risk	10^{-6}	–
THQ	Target hazard quotient	1	–
BWa	Body weight, adult (kg)	70	RAGS (Part A), EPA 1989 (EPA/540/1-89/002)
BWc	Body weight, child (kg)	15	Exposure Factors, EPA 1991 (OSWER No. 9285.6-03)
ATc	Averaging time - carcinogens (days)	25550	RAGS(Part A), EPA 1989 (EPA/540/1-89/002)
ATn	Averaging time - noncarcinogens (days)	ED*365	
SAa	Exposed surface area for soil/dust (cm^2/day)		Dermal Assessment, EPA 2000 (EPA/540/R-99/005)
	– adult resident	5700	
	– adult worker	3300	
SAc	Exposed surface area, child in soil (cm^2/day)	2800	Dermal Assessment, EPA 2000 (EPA/540/R-99/005)
AFa	Adherence factor, soils (mg/cm^2)		Dermal Assessment, EPA 2000 (EPA/540/R-99/005)
	– adult resident	0.07	
	– adult worker	0.2	
AFc	Adherence factor, child (mg/cm^2)	0.2	Dermal Assessment, EPA 2000 (EPA/540/R-99/005)
ABS	Skin absorption defaults (unitless):		
	– semi-volatile organics	0.1	Dermal Assessment, EPA 2000 (EPA/540/R-99/005)
	– volatile organics	–	Dermal Assessment, EPA 2000 (EPA/540/R-99/005)
	– inorganics	–	Dermal Assessment, EPA 2000 (EPA/540/R-99/005)
IRAa	Inhalation rate - adult (m^3/day)	20	Exposure Factors, EPA 1991 (OSWER No. 9285.6-03)
IRAc	Inhalation rate - child (m^3/day)	10	Exposure Factors, EPA 1997 (EPA/600/P-95/002Fa)
IRWa	Drinking water ingestion - adult (L/day	2	RAGS(Part A), EPA 1989 (EPA/540/1-89/002)
IRWc	Drinking water ingestion - child (L/day)	1	PEA, Cal-EPA (DTSC, 1994)
IRSa	Soil ingestion - adult (mg/day)	100	Exposure Factors, EPA 1991 (OSWER No. 9285.6-03)
IRSc	Soil ingestion - child (mg/day),	200	Exposure Factors, EPA 1991 (OSWER No. 9285.6-03)
IRSo	Soil ingestion - occupational (mg/day)	50	Exposure Factors, EPA 1991 (OSWER No. 9285.6-03)
EFr	Exposure frequency - residential (d/y)	350	Exposure Factors, EPA 1991 (OSWER No. 9285.6-03)
EFo	Exposure frequency - occupational (d/y)	250	Exposure Factors, EPA 1991 (OSWER No. 9285.6-03)
EDr	Exposure duration - residential (years)	30*	Exposure Factors, EPA 1991 (OSWER No. 9285.6-03)
EDc	Exposure duration - child (years)	6	Exposure Factors, EPA 1991 (OSWER No. 9285.6-03)
EDo	Exposure duration - occupational (years)	25	Exposure Factors, EPA 1991 (OSWER No. 9285.6-03)
	Age-adjusted factors for carcinogens:		
IFSadj	Ingestion factor, soils ([mg-yr]/[kg-d])	114	RAGS(Part B), EPA 1991 (OSWER No. 9285.7-01B)
SFSadj	Dermal factor, soils ([mg-yr]/[kg-d])	361	By analogy to RAGS (Part B)
InhFadj	Inhalation factor, air ([m^3-yr]/[kg-d])	11	By analogy to RAGS (Part B)
IFWadj	Ingestion factor, water ([L-yr]/[kg-d])	1.1	By analogy to RAGS (Part B)
VFw	Volatilization factor for water (L/m^3)	0.5	RAGS(Part B), EPA 1991 (OSWER No. 9285.7-01B)
PEF	Particulate emission factor (m^3/kg)	See below	Soil Screening Guidance (EPA 1996a,b)
VFs	Volatilization factor for soil (m^3/kg)	See below	Soil Screening Guidance (EPA 1996a,b)
sat	Soil saturation concentration (mg/kg)	See below	Soil Screening Guidance (EPA 1996a,b)

Footnote:
*Exposure duration for lifetime residents is assumed to be 30 years total. For carcinogens, exposures are combined for children (6 years) and adults (24 years).

4.8 Standardized Equations

The equations used to calculate the PRGs for carcinogenic and noncarcinogenic contaminants are presented in Equations 4-1 through 4-8. The PRG equations update RAGS Part B equations. The methodology backcalculates a soil, air, or water concentration level from a target risk (for carcinogens) or hazard quotient (for noncarcinogens). For completeness, the soil equations combine risks from ingestion, skin contact, and inhalation simultaneously. Note: the electronic version of the table also includes pathway-specific PRGs, should the user decide against combining specific exposure pathways; or, the user wants to identify the relative contribution of each pathway to exposure.

To calculate PRGs for volatile chemicals in soil, a chemical-specific volatilization factor is calculated per Equation 4-9. Because of its reliance on Henry's law, the VF_s model is applicable only when the contaminant concentration in soil is at or below saturation (i.e. there is no free-phase contaminant present). Soil saturation ("sat") corresponds to the contaminant concentration in soil at which the adsorptive limits of the soil particles and the solubility limits of the available soil moisture have been reached. Above this point, pure liquid-phase contaminant is expected in the soil. If the PRG calculated using VF_s was greater than the calculated sat, the PRG was set equal to sat, in accordance with *Soil Screening Guidance* (USEPA 1996 a,b). The equation for deriving sat is presented in Equation 4-10.

PRG EQUATIONS

Soil Equations: For soils, equations were based on three exposure routes (ingestion, skin contact, and inhalation).

Equation 4-1: Combined Exposures to Carcinogenic Contaminants in Residential Soil

$$C(mg/kg) = \frac{TR \times AT_c}{EF_r \left[\left(\frac{IFS_{adj} \times CSF_o}{10^6 mg/kg} \right) + \left(\frac{SFS_{adj} \times ABS \times CSF_o}{10^6 mg/kg} \right) + \left(\frac{InhF_{adj} \times CSF_i}{VF_s^a} \right) \right]}$$

Equation 4-2: Combined Exposures to Noncarcinogenic Contaminants in Residential Soil

$$C(mg/kg) = \frac{THQ \times BW_c \times AT_n}{EF_r \times ED_c \left[\left(\frac{1}{RfD_o} \times \frac{IRS_c}{10^6 mg/kg} \right) + \left(\frac{1}{RfD_o} \times \frac{SA_c \times AF \times ABS}{10^6 mg/kg} \right) + \left(\frac{1}{RfD_i} \times \frac{IRA_c}{VF_s^a} \right) \right]}$$

Equation 4-3: Combined Exposures to Carcinogenic Contaminants in Industrial Soil

$$C(mg/kg) = \frac{TR \times BW_a \times AT_c}{EF_o \times ED_o \left[\left(\frac{IRS_o \times CSF_o}{10^6 mg/kg} \right) + \left(\frac{SA_a \times AF \times ABS \times CSF_o}{10^6 mg/kg} \right) + \left(\frac{IRA_a \times CSF_i}{VF_s^a} \right) \right]}$$

Footnote:
[a]Use VF_s for volatile chemicals (defined as having a Henry's Law Constant [atm-m^3/mol] greater than 10^{-5} and a molecular weight less than 200 grams/mol) or PEF for non-volatile chemicals.

SOIL SATURATION CONCENTRATION (sat)

Equation 4-10: Derivation of the Soil Saturation Limit

$$sat = \frac{S}{\rho_b} (K_d \rho_b + \Theta_w + H' \Theta_a)$$

Parameter	Definition (units)	Default
sat	Soil saturation concentration (mg/kg)	--
S	Solubility in water (mg/L-water)	Chemical-specific
ρ_b	Dry soil bulk density (kg/L)	1.5
n	Total soil porosity (L_{pore}/L_{soil})	0.43 or 1 - (ρ_b/ρ_s)
ρ_s	Soil particle density (kg/L)	2.65
K_d	Soil-water partition coefficient (L/kg)	K_{oc} x f_{oc} (chemical-specific)
k_{oc}	Soil organic carbon/water partition coefficient (L/kg)	Chemical-specific
f_{oc}	Fraction organic carbon content of soil (g/g)	0.006 or site-specific
Θ_w	Water-filled soil porosity (L_{water}/L_{soil})	0.15
Θ_a	Air filled soil porosity (L_{air}/L_{soil})	0.28 or n-Θ_w
w	Average soil moisture content (kg_{water}/kg_{soil} or L_{water}/kg_{soil})	0.1
H	Henry's Law constant (atm-m^3/mol)	Chemical-specific
H'	Dimensionless Henry's Law constant	H x 41, where 41 is a units conversion factor

$$C(mg/kg) = \frac{THQ \times BW_a \times AT_n}{EF_o \times ED_o[(\frac{1}{RfD_o} \times \frac{IRS_o}{10^6 mg/kg}) + (\frac{1}{RfD_o} \times \frac{SA_a \times AF \times ABS}{10^6 mg/kg}) + (\frac{1}{RfD_i} \times \frac{IRA_a}{VF_s^a})]}$$

Equation 4-4: Combined Exposures to Noncarcinogenic Contaminants in Industrial Soil

Tap Water Equations:

Equation 4-5: Ingestion and Inhalation Exposures to Carcinogenic Contaminants in Water

$$C(ug/L) = \frac{TR \times AT_c \times 1000 ug/mg}{EF_r\ [(IFW_{adj} \times CSF_o) + (VF_w \times InhF_{adj} \times CSF_i)]}$$

Equation 4-6: Ingestion and Inhalation Exposures to Noncarcinogenic Contaminants in Water

$$C(ug/L) = \frac{THQ \times BW_a \times AT_n \times 1000 ug/mg}{EF_r \times ED_r\ [(\frac{IRW_a}{RfD_o}) + (\frac{VF_w \times IRA_a}{RfD_i})]}$$

Air Equations:

Equation 4-7: Inhalation Exposures to Carcinogenic Contaminants in Air

$$C(ug/m^3) = \frac{TR \times AT_c \times 1000 ug/mg}{EF_r \times InhF_{adj} \times CSF_i}$$

Equation 4-8: Inhalation Exposures to Noncarcinogenic Contaminants in Air

$$C(ug/m^3) = \frac{THQ \times RfD_i \times BW_a \times AT_n \times 1000 ug/mg}{EF_r \times ED_r \times IRA_a}$$

Footnote:

[a]Use VF_s for volatile chemicals (defined as having a Henry's Law Constant [atm-m^3/mol] greater than 10^{-5} and a molecular weight less than 200 grams/mol) or PEF for non-volatile chemicals.

SOIL-TO-AIR VOLATILIZATION FACTOR (VF_s)

Equation 4-9: Derivation of the Volatilization Factor

$$VF_s\,(m^3/kg) = (Q/C) \times \frac{(3.14 \times D_A \times T)^{1/2}}{(2 \times \rho_b \times D_A)} \times 10^{-4}\,(m^2/cm^2)$$

where:

$$D_A = \frac{[\,(\Theta_a^{10/3} D_i H' + \Theta_w^{10/3} D_w)\,/\,n^2\,]}{\rho_B K_d + \Theta_w + \Theta_a H'}$$

Parameter	Definition (units)	Default
VF_s	Volatilization factor (m^3/kg)	--
D_A	Apparent diffusivity (cm^2/s)	--
Q/C	Inverse of the mean conc. at the center of a 0.5-acre square source (g/m^2-s per kg/m^3)	68.81
T	Exposure interval (s)	9.5×10^8
ρ_b	Dry soil bulk density (g/cm^3)	1.5
Θ_a	Air filled soil porosity (L_{air}/L_{soil})	0.28 or n-Θ_w
n	Total soil porosity (L_{pore}/L_{soil})	0.43 or 1 - (ρ_b/ρ_s)
Θ_w	Water-filled soil porosity (L_{water}/L_{soil})	0.15
ρ_s	Soil particle density (g/cm^3)	2.65
Di	Diffusivity in air (cm^2/s)	Chemical-specific
H	Henry's Law constant (atm-m^3/mol)	Chemical-specific
H'	Dimensionless Henry's Law constant	Calculated from H by multiplying by 41 (USEPA 1991a)
D_w	Diffusivity in water (cm^2/s)	Chemical-specific
K_d	Soil-water partition coefficient (cm^3/g) = $K_{oc}f_{oc}$	Chemical-specific
K_{oc}	Soil organic carbon-water partition coefficient (cm^3/g)	Chemical-specific
f_{oc}	Fraction organic carbon in soil (g/g)	0.006 (0.6%)

SOIL-TO-AIR PARTICULATE EMISSION FACTOR (PEF)

Equation 4-11: Derivation of the Particulate Emission Factor

$$PEF(m^3/kg) = Q/C \times \frac{3600 s/h}{0.036 \times (1-V) \times (U_m/U_t)^3 \times F(x)}$$

Parameter	Definition (units)	Default
PEF	Particulate emission factor (m^3/kg)	1.316×10^9
Q/C	Inverse of the mean concentration at the center of a 0.5-acre-square source (g/m^2-s per kg/m^3)	90.80
V	Fraction of vegetative cover (unitless)	0.5
U_m	Mean annual windspeed (m/s)	4.69
U_t	Equivalent threshold value of windspeed at 7 m (m/s)	11.32
F(x)	Function dependent on U_m/U_t derived using Cowherd (1985) (unitless)	0.194

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Iron

-1-

DATE: March 16, 2000

TO: Chem/Tox

From: Bob Jupin

Subject: RfD for Iron

The RfD used to evaluate exposures to iron is based on the recommended dietary allowance (RDA) for adults. Alvaro Alvarado, toxicologist for EPA Region III, has advised us that since children and adolescents require more iron in their diets than adults do, exposures to iron by children should be evaluated using a RfD based on the RDA for children. The recommend RfD for children exposed to iron is 1.1 mg/kg/day. Attached is a copy of the National Center for Environmental Assessment's (NCEA) Risk Assessment Issue Paper for iron, which provides the basis for the RfD.

CONFIRMED -2
1/5/99

Attachment 1

(07/23/96)

Risk Assessment Issue Paper for:
Derivation of a Provisional RfD for Iron (CASRN 7439-89-6)

INTRODUCTION

Review documents available for iron and compounds include a Health Effects Assessment (U.S. EPA, 1984) and reviews by Jacobs (1977), Bothwell et al. (1979), and Lauffer (1991). The following computer searches, performed in April, 1993, were screened to identify additional pertinent studies not discussed in review documents: TOXLINE (oral and inhalation toxicity and cancer from 1983-April, 1993), CANCERLINE (1990 - April, 1993), MEDLINE (1991 - April, 1993), TSCATS, RTECS, and HSDB.

Iron is not listed on IRIS (U.S. EPA, 1995a), the RfD/RfC Work Group Status Report (U.S. EPA, 1995b), or Drinking Water Regulations and Health Advisories (U.S. EPA, 1994a). The HEAST (U.S. EPA, 1995c) reported that data regarding iron were inadequate for quantitative risk assessment. Iron was not listed on the NTP Chemical Status Report (NTP, 1993a). An NTP Results Report (NTP, 1993b) indicates a gavage study has been completed on iron and compounds, but the study does not meet minimum standards (as per telephone conversation with NTP, April, 1993).

Iron is an essential element, and deriving a risk assessment value for such chemicals poses a special problem in that the dose adversity curve is "U-shaped". Thus, the risk value must be protective against deficiency as well as toxicity. The NAS (1989) has determined that the Recommended Dietary Allowance (RDA) for iron is 10 mg/day (0.13 mg/kg-day) for adult men and 15 mg/day (0.24-0.33 mg/kg-day) for females aged 11-50 years. The RDA is 6 mg/day (1 mg/kg-day) for non-breastfed infants aged 0-6 months; 10 mg/day (0.36-1.11 mg/kg-day) for children aged 6 months to 10 years; and 12 mg/day (0.18-0.27 mg/kg-day) for males aged 11-14 years. Note that breastfed infants typically receive only 0.15 to 0.3 mg Fe/day, about 20- to 40-fold lower than the RDA. The RDA is 30 mg/day (0.443 mg/kg-day) for pregnant women and 15 mg/day (0.25 mg/kg-day) for women who are lactating.

In humans and other animals, levels in the body are regulated primarily through changes in the amount of iron absorbed by the gastrointestinal mucosa. The absorption of dietary iron is influenced by body stores, by the amount and chemical nature of iron in ingested food, and by a variety of dietary factors that increase or decrease the availability of iron for absorption. However, excessive accumulation of iron in the body resulting from chronic ingestion of high levels of iron cannot be prevented by intestinal regulation of absorption, nor do humans have a mechanism to increase excretion of absorbed iron in response to elevated body levels (NAS, 1989). Below are summaries of selected epidemiological and medical studies, and of available toxicity studies in animals exposed

to iron and inorganic compounds.

REVIEW OF PERTINENT LITERATURE

While chronic iron toxicity occurs in people with genetic metabolic disorders resulting in excessive iron absorption, with abnormal hemoglobin synthesis, or who receive frequent blood transfusions (Jacobs, 1977; Bothwell et al., 1979), there is a long-standing controversy as to whether a chronic overload due to oral intake is possible in individuals with a normal ability to control iron absorption (Hillman and Finch, 1985). Nevertheless, "the cumulative experience in human subjects suffering from iron overload of various etiologies strongly suggests that iron is noxious to tissues [when]...present in parenchymal cells...for a sufficiently long period of time" (Bothwell et al., 1979).

Looker et al. (1988) made comparisons of dietary iron intake and biochemical indices of iron status based on values taken from the second National Health and Nutrition Examination Survey (NHANES II) data base. NHANES II was a probability sample of the noninstitutionalized U.S. population aged 6 months to 74 years, conducted between 1976 and 1980 by the National Center for Health Statistics. These data suggest that normal intake of iron by men 16-74 years old exceeds the RDAs, and that iron intake is somewhat lower than the RDA for women younger than 51 years. Concomitant with the study of dietary intake, the NHANES II measured the iron status of these populations. The serum ferritin levels, which index total body iron stores, ranged from 23.8 µg/L, for premenopausal women not using iron supplements, to 105.6 µg/L for 45- to 64-year-old supplement users. These values are well within the normal range of 12-300 µg/L (Cook, 1991). (From Taber's Medical Dictionary, ferritin is the form in which iron is stored in the tissues, principally in the reticuloendothelial cells of the liver, spleen, and bone marrow. [It is] an iron-phosphorus-protein complex containing about 23% iron.) The percent serum transferrin saturation, a measure of the residual capacity of the iron transport system to process potential variations in iron from dietary intake or catabolized body stores, ranged from 23.9% saturation for pre- and post-menopausal women not using iron supplements, to 28.9% saturation for male supplement users in the 25- to 44- and 65- to 75-year-old groups. These values are also within the normal range (20-40%), establishing that the intake levels of 0.15-0.27 mg/kg-day consumed by these groups are both sufficient to protect against iron deficiency and insufficient to cause the toxic effects of iron overload (Elinder, 1986; Cook, 1991; Hillman and Finch, 1985). Therefore, 0.15-0.27 mg/kg-day represents a NOEL for chronic dietary iron intake.

Hemosiderosis (or siderosis) and iron overload are increases in tissue iron or a general increase in iron stores without associated tissue damage (Bothwell et al., 1979; Jacobs, 1977). Hemochromatosis describes massive iron overload (15 g of body iron stores or greater) together with cirrhosis and/or other tissue damage attributable to iron. Although focal deposits of iron may occur in any part of the body where red cells are extravasated, the clinical syndrome of hemochromatosis typically involves damage to the hepatic parenchyma (particularly fibrosis), heart (cardiac dysfunction including failure) and endocrine glands (particularly hypogonadism). Pancreatic iron deposition is common, and

massive deposits may be associated with fibrosis and diabetes. A number of studies involving chronic oral administration of iron to animals have been designed in an attempt to identify an animal model for hemochromatosis. Most of these studies have been negative (Bothwell et al., 1979; NRC, 1979). Animal studies involving parenteral administration of iron have been generally negative as well, even though parenteral routes bypass the mechanisms that regulate absorption of iron from the gastrointestinal tract.

Chronic iron toxicity has been observed in people with idiopathic hemochromatosis (a genetic metabolic disorder resulting in excessive iron absorption), abnormalities of hemoglobin synthesis (e.g., thalassemia) or various anemic states (e.g., sideroblastic anemia), frequent blood transfusions or a combination of these conditions (Jacobs, 1977; Bothwell et al., 1979). Chronic hemochromatosis has also occurred among the South African Bantu population from an excessive intake of absorbable iron in an alcoholic beverage.

Habitual excessive intake of iron by the Bantus is attributed to consumption of home-brewed Kaffir beer, which was contaminated by iron vessels during brewing (Bothwell and Bradlow, 1960; Bothwell et al., 1964). The beer's high acidity (pH 3-3.5) enhanced iron leaching from the vessels. The iron in the beer is readily assimilable (i.e., ionizable) due to the acidity and presence of iron-complexing ligands such as fructose, and is absorbed to approximately the same degree as ferric chloride. The alcohol content of the beer is also believed to contribute to the bioavailability of the iron (Jacobs, 1977; Finch and Monsen, 1972). Based primarily on drinking habits and analyses of beer samples, the estimated average dietary iron intake of the Bantu men ranged from 50-100 mg/day from beer alone (Bothwell et al., 1964). Using a reference body weight of 70 kg (U.S. EPA, 1987), this range corresponds to 0.7-1.4 mg/kg-day. Histological examinations of the liver of 147 Bantus (129 male, 18 female), ranging in age from 11-70 years (most were between 20 and 50 years old) that died from acute traumatic causes, were performed (Bothwell and Bradlow, 1960). Varying degrees of hepatic siderosis were observed in 89% of the cases; the degree tended to increase with age 40-50 years or less. The siderosis was mild in 59%, and severe in 19% of the cases, respectively. There was a close correlation between hepatic iron concentration and portal fibrosis and cirrhosis. Although the overall prevalence was low (15.6% fibrosis and 1.4% cirrhosis), all 11 subjects with the highest iron concentrations (>2.0% dry weight of liver) showed either fibrosis or cirrhosis. Histological examination of the spleen (50 subjects) also showed siderosis and unspecified histological changes. Malnutrition and alcoholism could have played a role in the etiology of the hepatic and splenic siderosis in the Bantus.

Hemosiderosis of the skin and liver with cirrhotic changes, accompanied by a serum iron level of 246 µg/100 mL and 100% saturation of transferrin, also developed in a 60-year-old female patient who ingested approximately 12,000 g of elemental iron (as 12 g ferrous carbonate/day or 2 g ferrous gluconate/day) for 27 years (Turnberg, 1965). Assuming a mean body weight of 64 kg for a woman 33-60 years old, 12 kg iron 365 days/year for 27 years averages to approximately 19 mg/kg-day. Using an estimated intake of 0.17 mg iron/kg-day for dietary iron, the total intake of iron was approximately

19.2 mg/kg-day. The author noted that the patient was not anemic during the treatment period, was absorbing iron at a normal rate, had no history of hepatitis (a potential complication in people with iron overload following repeated transfusion) and did not consume alcohol. It was concluded that the prolonged high iron intake was the sole origin of the clinical picture of hemochromatosis.

Ethiopia reportedly has the highest per capita iron intake in the world, with an average daily intake of 471 mg iron/day (range 98-1418 mg/day; 1.4-20.3 mg iron/kg-day assuming 70 kg body weight) (Roe, 1966; Hofvander, 1968). Increased stored iron in the liver and adverse health effects have not been observed due to low bioavailability of the iron in Ethiopian food.

A recent study in Eastern Finnish men suggests that high serum ferritin concentration and high dietary iron intake are risk factors for myocardial infarction (Salonen et al., 1992). Of the 1,931 randomly selected men aged 42-60 years who had no history of coronary heart disease upon entry to the study, 51 experienced an acute myocardial infarction during the average 3-year follow-up. After adjusting via Cox proportional hazards model for age and examination year, cigarette-pack years, ischemic ECG in exercise test, oxygen uptake, systolic blood pressure, blood glucose, serum copper, blood leukocyte count, and concentrations of serum high density lipoprotein cholesterol, apolipoprotein B, and triglyceride, those having serum ferritin at levels $\geq$ 200 µg/L (median value for healthy adult men is 69-140 µg/L) showed increased risk ($p<0.01$) of myocardial infarction compared to those with lower serum ferritin. Use of the same model and covariates indicated dietary iron intake was also significantly ($p<0.05$) associated with disease risk; consumption of red meat had the strongest correlation of all foods with serum ferritin concentration ($r=0.059$). High serum low density lipoprotein (LDL) cholesterol concentrations ($\geq$5.0 mml/L) associated with elevated serum ferritin was also a strong risk factor for acute myocardial infarction; this lends support to the theory that iron overload elevates risk of acute myocardial infarction by promoting oxidation of LDL (Lauffer, 1991; Sullivan, 1992).

The effects of acute oral exposure to iron in humans are well characterized. Acute iron toxicity has most often been observed in small children who accidentally ingested iron supplements, usually in the form of ferrous sulfate, but also as ferrous gluconate, ferrous chloride, ferric chloride or ferric ammonium citrate (Bothwell et al., 1979). The pathogenesis of acute oral iron toxicity consists primarily of gastrointestinal, cardiovascular, metabolic, neurological and hepatic alterations caused by direct corrosive action or the presence of unbound iron in the circulation (Bothwell et al., 1979; Banner and Tong, 1986; Engle et al., 1987; Mann et al., 1989). Gastrointestinal toxicity is due to the direct caustic effect of iron on the mucosa, particularly in the stomach and small intestine, and is characterized initially by vomiting, diarrhea and abdominal pain. These symptoms can progress to gastric and intestinal hemorrhage and/or necrosis and, rarely, 4-6 weeks after ingestion, scarring that may result in stenosis in the stomach outlet and small intestine. Cardiovascular toxicity of iron results from severe hemodynamic alterations characterized by loss of vascular integrity, decreased circulating plasma

volume, decreased cardiac output and acidosis, leading to shock and cardiac failure. Neurological effects ranging from lethargy and mild obtundation to coma may occur. Hepatic damage, which can range from cloudy swelling of hepatocytes to necrosis, is a rare complication after ingestion of large quantities of iron in acute overexposure.

Determinations of serum iron concentration and total iron binding capacity (TIBC) in blood 2-4 hours after ingestion may provide reliable laboratory indices of the bioavailability of iron resulting from an acute ingestion (Mann et al., 1989), but are impractical for assessments of environmental exposures because they may be difficult to obtain rapidly. Since iron is rapidly cleared from the plasma and taken up by hepatocytes, samples drawn 4-6 hours after exposure may be low and not indicative of the quantity of iron bioaccumulated following ingestion. Clinically serious acute iron toxicity generally occurs when free unbound iron circulates (i.e., when serum iron exceeds the TIBC of transferrin and the serum transferrin is 100% saturated). Serum levels of iron are normally in the range of 65-165 μg/100 mL; concentrations of 150-350 μg/100 mL may be associated with mild symptoms, and concentrations >350 μg/dL are generally considered toxic if the TIBC or the percent saturation of serum transferrin is not available (Engle et al., 1987; Mann et al., 1989). Except for the case reported by Turnberg (1965), in which a chronically exposed patient suffering iron overload had 246 μg/100 mL iron in her serum with 100% saturation of her serum transferrin, data on serum levels of iron following repeated exposures were not located.

Information on acute oral toxic doses of iron in humans is available from numerous case reports of ingestions by children, but values vary because it is difficult to obtain accurate estimates of the amount taken in most overdose situations. It may be unclear whether amounts of elemental iron or iron compound are reported, and serum iron levels may peak at different times depending upon the type of product ingested (Engle et al., 1987). Reviews of these case reports indicate that doses in the range of 200-300 mg iron/kg are generally considered lethal (Arena, 1970; Krenzelok and Hoff, 1979; NRC, 1979; Engle et al., 1987; Mann et al., 1989; Klein-Schwartz et al., 1990), although doses as low as 40-60 mg iron/kg have been regarded as potentially fatal (NRC, 1979; Krenzelok and Hoff, 1979).

Minimum acute toxic doses of iron in humans are poorly defined because most of the cases of poisoning were overdose situations that relied on clinical histories (information from the patient or parent) for determination of dose. Additionally, toxicity mitigation procedures may complicate determining actual severity of effects. Management of acute iron poisoning typically includes gastrointestinal decontamination (e.g., emesis with syrup of ipecac, gastric lavage) and/or chelation therapy with deferoxamine performed at varying times after ingestion (Mann et al., 1989). Based on reviews of case reports and consensus opinions, treatment protocols generally consider ingestions of <20 mg iron/kg minimally toxic and ingestions of >40 mg iron/kg potentially serious (Engle et al., 1987; Mann et al., 1989; Elinder 1986). Klein-Schwartz et al. (1990) analyzed 339 iron ingestion cases to validate the treatment protocol of a regional poison control center. According to the protocol of this center, ingestions of 20-40 mg iron/kg required only

home treatment if there were no symptoms other than mild gastrointestinal symptoms, and ingestions 40 mg iron/kg or higher required hospital referral. The median age of the subjects was 3 years (range, 9 months to 33 years). The amount of iron ingestion was known in 199 subjects, ranging from 20-301 mg/kg (mean, 39.5 mg/kg). Of the 199 subjects, 144 ingested 20-40 mg/kg, 31 ingested 40-60 mg/kg, and 24 ingested 60 mg/kg and higher. There was no statistically significant difference in the mean dose ingested by patients with symptoms (abdominal pain, vomiting and/or diarrhea), compared with asymptomatic patients [42.2 mg/kg versus 38.5 mg/kg ($p=0.33$)]. The overall prevalence of the gastrointestinal symptoms was higher in the 40-60 mg/kg and 60 mg/kg or higher groups (41.9 and 33.3%, respectively), than in the 20-40 mg/kg group (22.2%), but the differences among the three groups were not statistically significant ($p=0.058$). Also, there was no statistically significant difference ($p>0.05$) in the development of any of the specific symptoms in any of the groups. The prevalence of symptoms generally increased with increasing serum iron levels, but only 20 of the patients had serum iron levels higher than the concentration of 350 µg/dL, generally considered toxic. Symptoms more serious than gastrointestinal ones (e.g., metabolic, cardiovascular, central nervous system or hepatic effects) did not develop in any of the patients. The results of this study suggest that acute iron ingestions in the range of 20-60 mg/kg are unlikely to be serious in children. Based on this study, the poison center protocol was changed to home management (i.e., ipecac syrup), for iron ingestions of 20-60 mg/kg unless significant symptoms developed, and hospital referral for ingestions 60 mg/kg or greater.

Effects of iron therapy on the upper gastrointestinal tract were evaluated in 14 healthy volunteers [13 women, 1 man; mean age 29 years (range, 24-48 years)] who were instructed to ingest 325 mg tablets of ferrous sulfate (65 mg iron) 3 times/day (before meals) for 2 weeks (Laine et al., 1988). This study was performed to ascertain whether there is a basis for implications that iron therapy may cause false-positive fecal occult blood testing. Evaluation consisted of gastrointestinal symptom survey, qualitative (Hemoccult) and quantitative (HemoQuant; mg mercury/g stool) testing for fecal blood loss, endoscopy of the upper gastrointestinal tract and histological examination of pinch biopsies of the gastric body, antrum and duodenum. In a separate portion of the study, Hemoccult testing was performed on 13 other subjects [12 men, 1 woman; mean age 33 years (range 23-50 years)] who were similarly treated with ferrous sulfate for 1 week. All subjects served as their own controls and ingested no other substances that could potentially damage the upper gastrointestinal tract during their participation in the study. Based on actual average ingestion of 2.5 tablets/day (2-week study) and 2.6 tablets/day (1-week study) and a reference human body weight of 70 kg (U.S. EPA, 1987), the estimated doses consumed by the subjects were 2.3 and 2.4 mg iron/kg-day, respectively, in addition to dietary iron. All subjects had significantly increased ($p<0.05$) dark brown-black stools and symptoms of nausea and vomiting during the treatment period, but not abdominal pain, compared to the 2 weeks prior to treatment. The stool samples of all 27 subjects were Hemoccult-negative prior to iron treatment. Only 1 of 27 stool samples was questionably trace positive after treatment. Hemoglobin levels in stool did not change significantly after iron treatment. Endoscopic examination showed a significant ($p=0.003$) increase in abnormalities in the stomach, but not duodenum, after therapy. These changes

consisted of erythema, small areas of subepithelial hemorrhage and solitary antral erosions in nine, six and two subjects, respectively, and were considered only minimally abnormal. Linear regression analysis showed that there was a significant correlation between endoscopy scores and abdominal pain scores ($r=0.64$, $p=0.01$), but not with vomiting ($r=0.5$, $p=0.07$), diarrhea ($r=0.46$, $p=0.1$) or nausea ($r=0.4$, $p=0.16$). No treatment-related histological changes were observed and there was no correlation between the endoscopic and histologic findings, although the investigators noted that the correlation between endoscopic findings and histologic changes in small mucosal pinch biopsies is "notoriously" poor. Although it was speculated that the changes in the stomach could represent a mild form of iron poisoning, the investigators concluded that the treatment caused mild endoscopic abnormalities of uncertain clinical significance in the stomach. Evidence for iron overload (tissue biopsies or hematologic iron status indices) was not examined.

Adverse developmental effects in humans have not been associated with the ingestion of supplemental iron during pregnancy. As indicated above, NAS (1989) recommended that pregnant women supplement their diets with 30 mg iron/day (0.43 mg/kg-day). McElhatton et al. (1991) reported on 49 women who took an overdose of a simple iron preparation (53%) or iron with folate preparation (47%). For 48 of the women, the amount of iron ingested was known; 28 took > 1.2 g and the remainder took ≤ 1.2 g. Twenty-five of the women received chelation treatment with desferrioxamine (DFO) and 12 received an emetic. Maternal toxicity, consisting of nausea, vomiting, hematoemesis, abdominal pain and diarrhea, was observed in 35 of the women. Two spontaneous abortions occurred and there were 3 premature deliveries. One of the spontaneous abortions and the premature deliveries were not related to the iron overdose. It is not known if the other spontaneous abortion occurring at 22 weeks (3 weeks after the overdose) was caused by the iron overdose. A LOAEL for maternal toxicity or NOAEL for developmental toxicity could not be identified due to inexact exposure data, variation in type of mitigation used, and time elapsed prior to its administration.

Animal studies have shown that rats administered 2.7 mg iron/kg-day as ferric chloride on gestation days 6-15 (Nolen et al., 1972) or rats and mice administered 24-76 mg iron/kg-day as ferrous sulfate for 6 days (gestation days unspecified) (Tadokoro et al., 1979) had no treatment-related teratogenic or embryotoxic effects. Some (numbers and species not reported) embryonic mortality occurred in the latter study at 240 mg iron/kg-day.

DERIVATION OF THE PROVISIONAL CHRONIC ORAL RfD

Most of the quantitative chronic oral toxicity data for iron have been obtained from studies of the Bantu population of South Africa. These data indicate that intakes in the range of 0.7-1.4 mg iron/kg-day in home-brewed beer are associated with hemosiderosis and liver cirrhosis (Bothwell and Bradlow, 1960; Bothwell et al., 1964). However, confounding factors such as malnutrition and unusually high iron bioavailability,

due to the high acidity and ethanol in the beer, preclude use of these data for risk assessment. Much higher dietary intakes (average 6.7 mg/kg-day) of less soluble forms of iron are tolerated in nonwestern diets as indicated by studies of populations in Ethiopia. Therapeutic oral doses of 2.3 mg iron/kg-day as ferrous sulfate for 2 weeks were minimally toxic to the gastrointestinal tract, causing nausea, vomiting and endoscopic abnormalities in the stomach (e.g., erythema and small areas of hemorrhage), but no gastric histological changes were found, and evidence for iron overload (tissue biopsies or hematologic iron status indices) was not examined (Laine et al., 1988). One case of hemochromatosis was reported in a woman who ingested 19.2 mg/kg-day of iron for 27 years; treatment was not accompanied by alcohol- or transfusion-induced hepatitis, anemia, malnutrition or abnormal intestinal absorption (Turnberg, 1965). Thus, although toxicity associated with iron overload due to chronic oral intake can be demonstrated qualitatively or even semiquantitatively, assignment of a precise LOAEL for normal individuals consuming western diets is compromised by studies containing confounding factors, inadequate endpoint assessment, too short a duration of exposure or too few subjects.

Nonetheless, it is possible to establish a NOEL for chronic iron overload using the values for dietary intake and iron status indices taken from the second National Health and Nutrition Examination Survey (NHANES II) data base. Looker et al. (1988) made comparisons of dietary iron intake and biochemical indices of iron status using data from NHANES II. The average intakes of iron ranged from 0.15 to 0.27 mg/kg-day. The serum ferritin levels and percent serum transferrin saturation were within the normal range. Thus, intake levels of 0.15-0.27 mg/kg-day consumed are both sufficient to protect against iron deficiency and insufficient to cause the toxic effects of iron overload.

Using the NOAEL of 0.27 (representing the upperbound value in the range of mean dietary iron intakes, dietary plus supplemental, taken from the NHANES II data base) and dividing by an uncertainty factor of 1 yields the provisional chronic oral RfD of 0.3 mg/kg-day. An uncertainty factor of 1 is supported by the fact that iron is an essential element. In addition, the information used to derive the oral RfD for iron was derived from intake data from over 20,000 individuals aged 6 months to 74 years and humans exert an efficient homeostatic control over iron such that body burdens are kept constant with variations in diet.

Confidence in the critical study is high; the NHANES II data are derived from a very large sampling of the U.S. population ranging in age from 6 months to 74 years. Overall confidence in the data base is medium; there are insufficient data to determine what chronic dose level is associated with adverse effects in healthy individuals. While a point estimate has been derived in this risk assessment, individual variations in diet, nutritional status, physiology, etc. suggest that a range of values may be more appropriate. Reflecting the high confidence in the critical study and medium confidence in the data base, confidence in the RfD is medium.

NOTE: This RfD supplies adequate levels of iron to meet the nutritional requirements of adults and adolescents over a lifetime. It does not supply the recommended dietary

allowance (RDA) to those members of the population that have greater requirements for a short, less-than-lifetime duration such as infants, pre-adolescent children, and pregnant women. For shorter term requirements for these subpopulations, refer to the RDAs (NAS, 1989). Further, this RfD may not be protective of people with inherited disorders of iron metabolism and could be conservative if applied to exposure scenarios involving forms of iron with low bioavailability.

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Manganese — SEE PAGE 8 - LEFT HAND COLUMN

EPA Region 1, New England

RISK UPDATES

Number 4 November 1996

RISK UPDATES is a periodic bulletin prepared by EPA - Region I, New England risk assessors to provide information on new regional guidance. Risk Updates is distributed to contractors supporting Superfund and RCRA, regulators, and interested parties. Risk assessment questions may be directed to the following EPA scientists (area code 617):

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EPA Region I, New England receives additional ecological technical support from Ken Finkelstein (223-5537) of the National Oceanic Atmospheric Administration (NOAA), and US Fish & Wildlife (Steve Mierzykowski 207/827-5938, Ken Munney 603/225-1411, and Tim Prior 401/364-9124).

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EPA Ecological Risk Assessment Guidance Update

The EPA is in the process of finalizing two major ecological guidance documents. The first, *Guidelines for Ecological Risk Assessment*, is under development by the EPA Risk Assessment Forum (The Forum). The Forum was established to promote consensus on risk assessment issues, as defined in the 1983 *Report of the National Research Council*, and to ensure that this consensus be incorporated into Agency risk assessment guidance. The Forum consists of risk assessment experts from throughout the Agency, including Region I. The final version of this document will expand upon the work presented in the *Framework for Ecological Risk Assessment*. The Guidelines will provide more direction for the various programs in EPA to follow when conducting ecological risk assessment and promise to be a particularly valuable tool in understanding the role of ecological risk assessment in the Superfund process. The *Notice of Availability and Opportunity to Comment on Proposed Guidelines* was published in the Monday, September 9, 1996 Federal Register (Vol. 61, No.175, page 47552). A copy can be obtained from the National Technical Information Service (703/487-4650) for $47, or from the EPA home page: http://www.epa.gov/ord/webpubs/ fedreg.

The second document which is being developed by the EPA Environmental Response Team is entitled *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments*. This document provides a "hands-on" approach for conducting an ecological risk assessment and gathering the data to support such an assessment. This guidance loosely follows the Risk Assessment Forum approach.

Both of the documents described above are supplements to existing ecological guidance and do not replace existing guidance. EPA New England will issue regional guidance explaining how these two guidance documents should be used in the Superfund program. This is tentatively scheduled for fall of 1996, depending upon the progress with the national guidance.

Two new *Eco Updates* were recently released by the EPA Office of Emergency and Remedial Response and can be found on the EPA home page:

- *Ecotox Thresholds* (EPA 540/f-95/038)
- *Ecological Significance and Selection of Candidate Assessment Endpoints* (EPA 540/f-95/037).

The *Ecotox Thresholds* bulletin provides an overview of the development and use of ecotox benchmark values in Superfund ecological risk assessments. The "*Endpoints*" bulletin provides guidance to risk assessors and managers in the selection of appropriate assessment endpoints for ecological study. Currently under development are *Eco Update* bulletins describing the screening process and how to use ecotox benchmarks correctly, and bioaccumulation of contaminants.

written by Susan Svirsky

Superfund Risk Assessment Reform Initiatives

Specific areas of the Superfund risk assessment process were identified by the Superfund Administrative Reforms Initiative announced in 1995. Two EPA workgroups are currently addressing the risk assessment reform requirement to ensure reasonable and consistent risk assessments. The respective goals of these workgroups are:

- To establish national criteria to plan, report, and review risk assessments; and
- To revise *Risk Assessment Guidance for Superfund* (RAGS).

The first work group is tasked with establishing national criteria for the review, approval, and reporting of Superfund risk assessments. The products of this work group will also address the four core values of EPA Administrator Carol Browner's *Risk Characterization Policy and Guidance Memorandum* of *transparency, clarity, consistency, and reasonableness* (refer to *Risk Characterization Update* on the next page). To date, the work group has drafted a standard statement of work for risk assessments, standard risk assessment reporting tables, and a risk assessment data quality assurance checklist. The EPA work group has also solicited and received stakeholder input on these draft documents.

The RAGS Reform Work Group has developed a list of key technical focus areas where the Superfund program would most benefit with respect to improving risk assessment and its application to Superfund, and also responds to critics of the program. The focus areas are toxicity assessment, exposure assessment, and risk communication. Two stakeholder dialogue meetings have been planned for late October and early November with representatives of the community, public, and private sector stakeholder groups. The goal of these meetings is to receive stakeholder input on which issues EPA should focus resources when revising and updating RAGS.

In Region I, preliminary stakeholder advisory opinions were obtained earlier this year at an EPA Federal Facilities Risk Assessment meeting at which the Air Force, Army, Navy, contractors, and States were present. The following technical issues were ranked highest among the participants: background determination, use of the reasonable maximum exposure method in decision making, uncertainty/probabilistic analysis, and land and groundwater use. The upcoming stakeholder dialogue meetings will provide formal input into the RAGS Reform Initiative.

For more information on the Superfund Administrative Reforms Initiatives, please contact Ann-Marie Burke or Jayne Michaud.

written by Jayne Michaud

Risk Characterization Update

In response to criticism that the EPA's risk assessments are often difficult to understand and communicate, EPA Administrator Carol Browner issued a memorandum on Risk Characterization on March 21, 1995. This memorandum presents policies and guidance to serve as "building blocks" for development of program specific and region specific policies and procedures for improving risk characterizations. This policy will provide a basis for greater clarity, transparency, reasonableness and consistency in risk assessments across Agency programs. To achieve **clarity**, risk assessments must clearly identify the purpose and scope of the assessment, and present its uncertainties, strengths and weaknesses, and assumptions. To achieve **transparency**, the decision-making process must clearly separate scientific or technically-based conclusions from those based on policy. To achieve **reasonableness**, the components of the risk assessment must be based on sound scientific information and reasonable judgement and be integrated into an overall conclusion. The implementation of this policy will improve overall **consistency** of risk assessments.

Region I has developed a plan for implementing this policy in the *Risk Characterization Implementation Plan for Region I*. The plan describes risk assessments conducted by or for Region I and outlines the criteria that should be used to determine whether the four fundamental values presented above have been addressed. The *Risk Characterization Implementation Plan for Region I* was signed by John DeVillars, Regional Administrator, on October 24, 1996. Copies of the Administrator's March 21, 1995 memorandum and Region I's Implementation Plan are available from Jerri Weiss or Margaret McDonough.

written by Margaret McDonough

Mercury Update

Combustion facilities or incinerators are potentially a large source of environmental mercury contamination. To reduce emissions of mercury and other hazardous air pollutants, the revised MACT standards proposed for hazardous waste combustion facilities were signed by EPA Administrator Carol Browner on March 20, 1996 under the joint authority of the Clean Air Act (CAA) and the Resource Conservation and Recovery Act (RCRA). The rules were proposed on April 19, 1996 (61 FR 17358) and are scheduled to be finalized by March, 1998.

The proposed MACT standards for mercury are 50 ug/dscm (micrograms per dry weight standard cubic meter) for hazardous waste incinerators and hazardous waste-burning cement kilns, and 72 ug/dscm for hazardous waste-burning light weight aggregate kilns. Under this proposal, continuous emission monitors (CEMs) would be required for particulate matter and mercury.

The CAA 112(n)(1)(B) requires EPA to submit a study on the atmospheric mercury emissions to Congress (*the Mercury Report*). The release of this report to Congress has been delayed. EPA released the report to the Science Advisory Board (SAB) in the beginning of July. The SAB was asked to review the issues related to effects of methyl mercury on child development and to develop a process for evaluating new data that is forthcoming from two large epidemiological studies. This report will also address mercury speciation, atmospheric deposition, bioconcentration factors, and toxicity data which are important for meaningful quantitative risk assessments.

The EPA has made the *Mercury Study SAB Review Draft Report to Congress* (document number EPA-452/R-96-001) available through the National Technical Information Service (703/487-4650).

written by Jui-Yu Hsieh

EPA Finalizes Soil Screening Guidance

EPA finalized the Soil Screening Guidance in April, 1996. This guidance provides methods for calculating site-specific soil screening levels (SSLs) which can

be used to identify areas of a hazardous waste site which do not warrant further federal attention. The SSL guidance is expected to help standardize and accelerate the evaluation and cleanup of contaminated soils at sites with a future residential land use.

SSLs are not national standards and alone do not trigger the need for response actions nor do they define "unacceptable" levels of contaminants in soils. The SSL Guidance contains 110 general soil values as well as a methodology for derivation of site-specific concentrations. If soil screening levels are exceeded, further assessment but not necessarily cleanup is generally warranted. The generic soil values and methodology are designed to protect against exposures resulting from soil ingestion, inhalation of particulates and ingestion of contaminated groundwater resulting from soil leachate.

Soil screening levels are limited in their application by the fact that 1) they do not address ecological threats and 2) they are only developed for a residential exposure scenario. EPA has issued the guidance in two parts:

1. **Soil Screening Guidance: User's Guide** (OSWER Directive 9355.4-23, PB96-963505). The User's Guide is designed for the EPA site manager or Regional Manager seeking to understand the basic concepts, approaches, and assumptions in the soil screening decision framework.

2. **Soil Screening Guidance: Technical Background Document (TBD)** (OSWER Directive 9355.4-17A, PB96-963502). *The Technical Background Document* provides a comprehensive analysis of the technical and policy issues and choices.

In addition, an overview is provided in the **Soil Screening Guidance: Fact Sheet** (OSWER Directive 9533.1-14FSA, PB96-963501). An overview of the EPA's response to comments received during the public comment period is also available in the **Soil Screening Guidance: Response to Comments** (OSWER Directive 9355.4-22, PB96-963506). These can be purchased from the National Technical Information Service (703/ 487-4650).

written by Stephanie Carr

EPA's Proposed Cancer Guidance and Implementation Plan

EPA released the *Proposed Guidelines for Carcinogen Risk Assessment* in April, 1996 for a 120-day public review and comment period. The proposed revisions to the guidelines are a result of extensive EPA and other federal and independent scientific reviews, as well as recommendations from the National Academy of Sciences 1994 report, *Science and Judgement in Risk Assessment*. The Proposed Guidelines are a revision of EPA's 1986 *Guidelines for Carcinogen Risk Assessment* (51FR 33992), and when final will replace the 1986 guidelines.

The Proposed Guidelines will allow scientists to provide more relevant and up-to-date information in cancer evaluations on dose-response, route of exposure, and chemical structure of regulated chemicals. The major changes in the Proposed Guidelines are summarized below:

- **Mode of Action**: Perhaps the most important aspect of the proposal is the emphasis on mode of action, which considers how a substance causes cancer. More emphasis on the mode of action is expected to reduce the uncertainty in describing likelihood of harm and in determining dose-response approaches.

- **Three descriptors for classifying human carcinogenic potential:** 1) "known/likely", 2) cannot be determined, and 3) not likely replace the six alphanumeric categories (A, B1, B2, C, D, E) in the 1986 guidelines. In addition, a weight of evidence narrative, targeted at the risk manager, is added. This narrative summarizes the key evidence for the classification and presents significant strengths, weaknesses and uncertainties of the contributing evidence.

- **Biologically-based extrapolation model is the preferred approach** for quantifying risk.

- **Three default approaches - Linear, Nonlinear, or Both are provided.** Curve fitting in the observed range would be used to determine the effective dose corresponding to the lower 95% limit on a dose associated with a 10% response (LED_{10}). The LED_{10} would then be used as a point of departure for extrapolation to the origin as the linear default or for a margin of exposure discussion as the nonlinear default.

- **Hazard characterization is added** to integrate the Data Analysis of all relevant studies into one weight of evidence conclusion of hazard.

- **Risk characterization is more fully developed** by providing direction on how the overall conclusion and confidence of risk is presented to the risk manager. Descriptions of major default assumptions and criteria for departing from them are described.

Until the guidelines are final, EPA will continue to rely on existing assessments. Once they are final, EPA will assess existing cancer values considering new risk assessment methods, principles and data. Reevaluating all existing cancer values on EPA's Integrated Risk Information System (IRIS) database would be time and resource prohibitive; therefore, EPA has developed a prioritization process to ensure that agents which warrant reevaluation are given the highest priority.

A five-step process will be used for determining which chemicals should be reevaluated. 1. EPA publishes an annual Federal Register notice requesting candidates for reevaluation. 2. Candidates are submitted. 3. EPA reviews and prioritizes candidates. 4. Candidates that EPA selects are published in a Federal Register notice. 5. Reassessment takes place in the following fiscal year during which time chemicals are peer reviewed and placed on IRIS.

It should be noted that pending finalization of the Proposed Guidelines, the principles and approaches of the Proposed Guidelines may be applied in part or in whole, on a case-by-case basis. The proposed process for using the new guidelines can be found in the Federal Register (61 FR 32799).

The Proposed Guidelines are available in the Federal Register (61 FR 17960). An electronic version is also available through EPA's Office of Research and Development home page on the Internet at http://www.epa.gov /ORD. To obtain a 3.5" disc in WordPerfect 5.1 format, contact: ORD Publications Technology Transfer and Support Division, National Risk Management Laboratory, USEPA, 26 W. Martin Luther King Drive, Cincinnati, OH 43268 Telephone: 513/560-7562; Fax: 513/569-7566.

Please provide your name, mailing address, document title and the following EPA number (EPA/600/P-921003(a)).

written by Ann-Marie Burke

Ground Water Use and Value Guidance

EPA-Region I recently finalized a new guidance document entitled the *Ground Water Use and Value Determination Guidance*. This guidance combines the goals of two major regional initiatives, the Superfund Beneficial Reuse Initiative and the Comprehensive Ground Water Protection Strategy. As part of the Superfund Beneficial Reuse Initiative, this guidance is intended to result in more informed and focused decision-making and more common-sense, cost-effective ground water cleanups which will facilitate the beneficial reuse of contaminated parcels. To accomplish these objectives, this guidance incorporates the resource-based considerations used in EPA's Comprehensive Ground Water Protection Strategy. Specifically, this guidance document establishes an approach for determining the relative "use" and "value" of site ground water resources and explains how this determination affects EPA-Region I ground water remedial decision making process.

The guidance is a good example of how EPA intends to provide more flexibility to the states. The six New England States have provided comments on this guidance and support the process and concepts it contains.

Overview

The new Approach to Superfund ground water decision making will be as follows:

- The Approach will be implemented in States with EPA-endorsed Comprehensive State Ground Water Protection Programs or CSGWPPs, but only where such States have entered into a Memorandum of Agreement (MOA) with EPA- Region I concerning the implementation of the Approach;

- In states that have entered into an MOA for the implementation of this guidance, EPA-New England will no longer rely on the 1986 Draft EPA Guidelines for Ground Water Classification in setting goals for ground water remediation and in making decisions on the level of cleanup necessary;

- Instead, a site specific determination will be made on the relative "use" and "value" of the ground water. States will play a pivotal role in determining the relative "use" and "value" of site ground water and will seek input from local officials and the public, as appropriate;

- EPA-New England will utilize the Use and Value Determinations performed by the States, in establishing remedial action objectives and making ground water remedial action decisions.

Application of This Guidance

The Approach provided in this guidance will be considered at current and future sites in the pre-remedial or RI/FS stages, to the extent possible. This guidance is for use by EPA-Region I and State Remedial Project Managers in scoping Remedial Investigations, conducting Risk Assessments, developing Remedial Action Objectives and identifying Remedial Alternatives. EPA-Region I does not intend to re-open remedy selection decisions based on this guidance. This guidance is for internal Agency use and contains no right, substantive or procedural, for any party.

Relationship To Risk Assessment

In performing the Human Health Risk Assessment for the site, exposure scenarios will generally be based on the generally allowed uses under the state ground water classification system. Risk assessors should not vary their existing risk assessment procedures as a result of this policy, other than to consider exposures based on the state classification rather than the 1986 draft federal guidelines.

The Use and Value Determination prepared by the States may be discussed as part of the exposure assessment section of the Risk Assessment. In other words, the Use and Value Determination may be used to place the exposure scenarios in perspective.

If you have any questions on how this guidance should be applied or would like to receive a copy of the guidance document, please contact any one of the following staff: Lynne Jennings, (617) 573-9634; Margery Adams, (617) 565-3746; Audrey Zucker, (617) 565-3444.

written by Lynne Jennings

Lead Risk at CERCLA Sites and RCRA Correction Action Facilities

EPA takes a multimedia approach to estimating the risk from exposure to inorganic lead at a hazardous waste sites. Risks to children exposed to lead are estimated by predicting blood lead levels using a pharmacokinetic model. Risks to adults are estimated through use of a slope-factor approach. These methods for estimating risks are described below.

Lead Risks for Children in a Residential Setting

For sites with a current or future potential residential land use, the sensitive receptor should be a child. EPA's Integrated Exposure Uptake and Biokinetic (IEUBK) model estimates the risk to a child resident. It is not appropriate to use this model for the adult resident, an older child (i.e., ages 9-18), or the adult worker. For future residential exposure scenarios, only a child's exposure to lead need be evaluated since this is the most sensitive receptor.

The IEUBK is a software package designed to combine exposures from lead in air, water, soil, dust, diet, paint, and

other sources with a pharmacokinetic model. The output is a predicted distribution of blood lead levels in a child or a population of children from 6 months to 7 years of age. From this distribution, the model calculates the probability that blood lead concentration of a child or population of children will exceed a selected level of concern (the default value is a blood lead level of 10 micrograms lead per deciliter of blood). The user can then explore an array of possible changes in exposure media that would reduce the probability of unacceptable risk to those populations.

The model allows the user to input site-specific values other than the concentration of lead in soil; i.e., the concentration of lead in household dust, air, or drinking water, or the bioavailability of lead. The model can also be used to develop cleanup goals for lead at a hazardous waste site. In cases where site-specific data are not available, the standard default exposure assumptions built into the model should be used. This will result in a cleanup goal of 400 mg/kg (ppm) for residential soils. The model's default values are the basis for the risk screening value of 400 mg/kg recommended in the "Revised Interim Soil Lead Guidance for CERCLA Sites and RCRA Corrective Action Facilities" (OSWER Directive #9355.4-12) and the EPA Soil Screening Guidance (Publication number 9355.4-23).

When presenting the IEUBK model results to EPA, the user should include: 1) the age of the child targeted; 2) site-specific parameter values; 3) standard defaults; and, 4) the percentage of children predicted to have blood leads above the EPA cutoff of 10 micrograms/deciliter. In the IEUBK computer model, the user should choose the graph for the probability density function and enter the appropriate parameters.

Both the IEUBK computer model (Pub. No. 9285.7-15-2; PB93-963511) and the guidance manual (Pub. No. 9285.7-15-1; PB93-963510) are available to the public through the National Technical Information Service (703/487-4650) or the EPA Region I Library (617/565-3300).

Lead Risks for Commercial or Industrial Workers and Youth Trespassers

The EPA Technical Review Workgroup for Lead (TRW) is conducting additional research on a biokinetic mode for adult exposures. The TRW consists of risk assessors, scientists, policy analysts, statisticians, and project managers including Region I representatives Margaret McDonough and Mary Ballew. As an interim approach, the TRW has recommended a simplified slope factor approach. The slope factor approach is conceptually similar to that proposed by Bowers et al. (1994) which was adapted for use at the California Gulch NPL site in Region 8 (Weston, 1995).

On October 26, 1995, the TRW published a report, *Review of a Methodology for Establishing Risk-Based Soil Remediation Goals for Commercial Areas of the California Gulch Site*. The TRW has endorsed the slope factor approach presented in this report, as an interim method for evaluating the risks to adults exposed to lead. This fall, the TRW expects to release a more generic guidance document that will contain a clear method for calculating a preliminary remediation goal for an industrial or commercial exposure scenario and the rationale for each parameter used in this new approach. The TRW has emphasized the importance of collecting data to support site-specific parameter estimates, however, default parameter guidance will also be provided.

Preliminary calculations by the TRW suggest that the slope factor approach could be adapted for use in a trespasser scenario. Parameters should be adjusted to account for any age-related differences. It is appropriate to use the slope factor approach when trespassing frequency is equal to or greater than once per week over the course of a minimum duration of ninety days.

The 1995 California Gulch review report is available from the Region I library. The TRW report *Methodology for Assessing Risks Associated with Adult Exposures to Lead in Soil* will be available by the end of 1996. A copy will be available at the Region I library 617/565-3300 or Toll Free at 800-EPA-LIBR.

written by Mary Ballew and Margaret McDonough

References

Bowers et al. 1994: Bowers, TS, Beck BD, Karam HS.1994. Assessing the relationship

between environmental lead concentrations and adult blood lead levels. Risk Analysis 14:183-89.

Weston 1995: Roy F. Weston, Inc. 1995. Baseline human health risk assessment for the California Gulch Superfund site. February. Prepared for USEPA Region 8, Denver CO.

Revised Manganese Reference Dose

The manganese reference dose (RfD) in the IRIS data base was revised in November, 1995. This revision results in a lower risk (and thus, higher cleanup level) for drinking water compared to the previous RfD. The IRIS RfD of 1.4E-1 mg/kg/day is for the total oral intake of manganese. As stated in the IRIS file, it is recommended that a modifying factor of 3 be applied to the RfD for non-dietary exposures.

Background

Prior to November, 1995 the IRIS data base provided two references doses for manganese, one for food and one for water. The food RfD was based on dietary intake of manganese. The water RfD was based on a study of humans who had ingested drinking water containing elevated levels of manganese as well as on assumptions regarding differences in absorption of manganese in food as opposed to water.

The drinking water RfD was withdrawn from IRIS in November, 1995 because of concerns about the validity of the human exposure study and because new information indicated that the disparity between absorption of manganese from food as opposed to water was overestimated.

New Approach

The revised RfD for manganese is for the total oral intake of manganese. This value is 0.14 mg/kg/day and is derived as follows:

- 10 mg/day of manganese may be consumed without adverse effects (the "critical dose"). This value comes from several dietary studies.
- average adult body weight = 70 kg

Therefore, the RfD =

$$\frac{10\ \text{mg/day}}{70\ \text{kg}} = 0.14\ \text{mg/kg/day}$$

A modifying factor of 3 is recommended in IRIS when assessing exposure from drinking water.

Drinking Water Exposures

The average dietary manganese content of the U.S. population, 5 mg/day, is subtracted from the "critical dose" of 10 mg/day:

10 mg/day - 5mg/day = 5 mg/day

Apply modifying factor of 3 per IRIS recommendation:

$$\frac{5\ \text{mg/day}}{3} = 1.67\ \text{mg/day}$$

Compute RfD:

$$\frac{1.67\ \text{mg/day}}{70\ \text{kg}} = .024\ \text{mg/kg day}$$

The Hazard Index (HI) for drinking water is calculated as follows (using a simplified equation):

$$\frac{\text{Concentration(mg/L)} * \text{2liters/day}}{0.024\ \text{mg/kg/day} * 70\ \text{kg}}$$

A HI of 1 corresponds to a concentration of 840 ug/L.

Soil Exposure

A modifying factor of 3 may be appropriate for assessing risks via exposure to soils if neonates (a child 12 months or younger) are a potentially exposed population. For most RCRA and Superfund risk assessments neonates are unlikely to be exposed to significant amounts of soils. Therefore, a modifying factor of 1 is appropriate. Assuming exposure to a young child under a residential scenario, a hazard index of 1 for manganese in soil would correspond to a soil concentration of 5,500 mg/kg.

written by Margaret McDonough

New Cancer Slope Factors for PCBs

EPA recently reassessed the scientific evidence for the carcinogenicity of polychlorinated biphenyls (PCBs). A range of new cancer slope factors for PCB mixtures were posted on the IRIS chemical information

data base on October 1, 1996. The new slope factors reflect the current knowledge of EPA scientists and national experts concerning:

- the influence on toxicity of PCBs by chemical transformation in the environment;
- the tendency of PCBs to partition into various media; and
- the potential for PCBs to biomagnify through the food chain.

To fully understand the scientific basis for the slope factors and to correctly apply them in a risk assessment, carefully read EPA's supporting technical document, *PCBs: Cancer Dose-response Assessment and Application to Environmental Mixtures*, which explains in greater detail the basis for the PCB reassessment.

The PCB reassessment results in different cancer slope factors for PCB mixtures based on a consideration of several different factors. First, the reassessment recognizes that environmental processes may significantly change the toxicity of Aroclor mixtures released into the environment. Thus, new slope factors are determined by the environmental pathway of exposure rather than by reference to a toxicity study for the particular Aroclor. Second, toxicity studies which formed the basis of the previous slope factor for PCBs were reanalyzed using new criteria and nomenclature for rat liver tumors, which resulted in a reduced number of tumors reported for Aroclor mixtures. Third, new PCB toxicity studies, sponsored by the General Electric Company, were considered in the derivation of the new cancer slope factors. Fourth, a revised cross-species scaling factor as recommended in EPA's *Proposed Guidelines for Carcinogen Risk Assessment, 61FR 17960,* was incorporated into the derivation of the new slope factors. Lastly, a new method for extrapolating risk to low doses from experimental data as recommended in EPA's New Cancer Guidelines was utilized in deriving the new slope factors.

The reassessment recommends a tiered approach for determining central tendency and high end cancer slope factors for use in risk assessment. When congener information is limited, the exposure pathway is used to indicate whether environmental processes have increased or decreased a PCB mixture's potency. When congener information is available, further refinement of the potency estimate can occur. Three categories of slope factors are developed based on the exposure pathway or, if more information is available, the PCB congener makeup of the mixture. A "high-risk" category is used for exposure pathways associated with environmental processes that tend to increase risk: a "low-risk" category for those that tend to decrease risk; and a "lowest risk" category for cases where congener or isomer analyses verifies the absence of congeners with more than 4 chlorines (establishing sufficient similarity of an environmental mixture to the least potent PCB Aroclor tested).

Additional highlights of the reassessment include the following:

- Changes in the types of environmental data collected for PCBs are recommended. At present, data are collected for the commercially available mixtures of PCBs (Aroclors) and the total amount of PCBs. The reassessment recommends collecting data on either the total amount of PCBs or on congeners (which represent up to 209 different arrangements of the chlorine atoms on the PCB molecule).
- Analysis of dioxin-like PCBs is recommended, if they are thought to be present. For samples containing dioxin-like PCBs, the risk of the dioxin-like PCBs is added to the risks calculated using the cancer slope factors for nondioxin-like PCBs presented in this reassessment. Only a congener-specific analysis can determine whether dioxin-like PCBs are present. The risks from dioxin-like PCBs are evaluated using a toxicity equivalence factor (TEF) approach. (See the PCB reassessment and March 1989 *Interim Procedures For Estimating Risks Associated With Exposures to Mixtures of Chlorinated Dibenzo-p-dioxins and -Dibenzofurans (CDDs and CDFs) and 1989*

Update (EPA/625/3-89/016) for more details.)

New highly exposed and highly sensitive populations who merit specific evaluation are identified. "Highly exposed populations include some nursing infants and consumers of game fish and game animals contaminated through the food chain. Highly sensitive populations include people with decreased liver function and infants."

The reassessment may produce changes in the way we investigate hazardous waste sites and estimate risks for PCBs. Lower estimates of risk from PCBs could result for several exposure pathways. When assessing the risks from PCB mixtures, please contact Region I risk assessor.

The PCB reassessment is available on the Office of Research and Development home page on the Internet at http://www.epa.gov/ORD. A copy is also available at the Region I EPA library and it may be copied onto a disk if you bring your own. The library has a new toll free number for calls within New England: 888-EPA-LIBR.

written by Mary Ballew & Ann-Marie Burke

To be included on future mailing list, please send your address including Internet address to: Jayne Michaud or Stephanie Carr at:
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Manganese — SEE PAGE 8 — LEFT HAND COLUMN

EPA Region 1, New England

RISK UPDATES

Number 4 November 1996

RISK UPDATES is a periodic bulletin prepared by EPA - Region I, New England risk assessors to provide information on new regional guidance. Risk Updates is distributed to contractors supporting Superfund and RCRA, regulators, and interested parties. Risk assessment questions may be directed to the following EPA scientists (area code 617):

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Editors
Stephanie Carr and Jayne Michaud
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EPA Ecological Risk Assessment Guidance Update

The EPA is in the process of finalizing two major ecological guidance documents. The first, *Guidelines for Ecological Risk Assessment*, is under development by the EPA Risk Assessment Forum (The Forum). The Forum was established to promote consensus on risk assessment issues, as defined in the 1983 *Report of the National Research Council*, and to ensure that this consensus be incorporated into Agency risk assessment guidance. The Forum consists of risk assessment experts from throughout the Agency, including Region I. The final version of this document will expand upon the work presented in the *Framework for Ecological Risk Assessment*. The Guidelines will provide more direction for the various programs in EPA to follow when conducting ecological risk assessment and promise to be a particularly valuable tool in understanding the role of ecological risk assessment in the Superfund process. The *Notice of Availability and Opportunity to Comment on Proposed Guidelines* was published in the Monday, September 9, 1996 Federal Register (Vol. 61, No.175, page 47552). A copy can be obtained from the National Technical Information Service (703/487-4650) for $47, or from the EPA home page: http://www.epa.gov/ord/webpubs/fedreg.

The second document which is being developed by the EPA Environmental Response Team is entitled *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments*. This document provides a "hands-on" approach for conducting an ecological risk assessment and gathering the data to support such an assessment. This guidance loosely follows the Risk Assessment Forum approach.

Both of the documents described above are supplements to existing ecological guidance and do not replace existing guidance. EPA New England will issue regional guidance explaining how these two guidance documents should be used in the Superfund program. This is tentatively scheduled for fall of 1996, depending upon the progress with the national guidance.

Two new *Eco Updates* were recently released by the EPA Office of Emergency and Remedial Response and can be found on the EPA home page.

- *Ecotox Thresholds* (EPA 540/f-95/038)
- *Ecological Significance and Selection of Candidate Assessment Endpoints* (EPA 540/f-95/037).

The *Ecotox Thresholds* bulletin provides an overview of the development and use of ecotox benchmark values in Superfund ecological risk assessments. The *"Endpoints"* bulletin provides guidance to risk assessors and managers in the selection of appropriate assessment endpoints for ecological study. Currently under development are *Eco Update* bulletins describing the screening process and how to use ecotox benchmarks correctly, and bioaccumulation of contaminants.

written by Susan Svirsky

Superfund Risk Assessment Reform Initiatives

Specific areas of the Superfund risk assessment process were identified by the Superfund Administrative Reforms Initiative announced in 1995. Two EPA workgroups are currently addressing the risk assessment reform requirement to ensure reasonable and consistent risk assessments. The respective goals of these workgroups are:

- To establish national criteria to plan, report, and review risk assessments; and
- To revise *Risk Assessment Guidance for Superfund* (RAGS).

The first work group is tasked with establishing national criteria for the review, approval, and reporting of Superfund risk assessments. The products of this work group will also address the four core values of EPA Administrator Carol Browner's *Risk Characterization Policy and Guidance Memorandum* of *transparency, clarity, consistency, and reasonableness* (refer to *Risk Characterization Update* on the next page). To date, the work group has drafted a standard statement of work for risk assessments, standard risk assessment reporting tables, and a risk assessment data quality assurance checklist. The EPA work group has also solicited and received stakeholder input on these draft documents.

The RAGS Reform Work Group has developed a list of key technical focus areas where the Superfund program would most benefit with respect to improving risk assessment and its application to Superfund, and also responds to critics of the program. The focus areas are toxicity assessment, exposure assessment, and risk communication. Two stakeholder dialogue meetings have been planned for late October and early November with representatives of the community, public, and private sector stakeholder groups. The goal of these meetings is to receive stakeholder input on which issues EPA should focus resources when revising and updating RAGS.

In Region I, preliminary stakeholder advisory opinions were obtained earlier this year at an EPA Federal Facilities Risk Assessment meeting at which the Air Force, Army, Navy, contractors, and States were present. The following technical issues were ranked highest among the participants: background determination, use of the reasonable maximum exposure method in decision making, uncertainty/probabilistic analysis, and land and groundwater use. The upcoming stakeholder dialogue meetings will provide formal input into the RAGS Reform Initiative.

For more information on the Superfund Administrative Reforms Initiatives, please contact Ann-Marie Burke or Jayne Michaud.

written by Jayne Michaud

Risk Characterization Update

In response to criticism that the EPA's risk assessments are often difficult to understand and communicate, EPA Administrator Carol Browner issued a memorandum on Risk Characterization on March 21, 1995. This memorandum presents policies and guidance to serve as "building blocks" for development of program specific and region specific policies and procedures for improving risk characterizations. This policy will provide a basis for greater clarity, transparency, reasonableness and consistency in risk assessments across Agency programs. To achieve **clarity**, risk assessments must clearly identify the purpose and scope of the assessment, and present its uncertainties, strengths and weaknesses, and assumptions. To achieve **transparency**, the decision-making process must clearly separate scientific or technically-based conclusions from those based on policy. To achieve **reasonableness**, the components of the risk assessment must be based on sound scientific information and reasonable judgement and be integrated into an overall conclusion. The implementation of this policy will improve overall **consistency** of risk assessments.

Region I has developed a plan for implementing this policy in the *Risk Characterization Implementation Plan for Region I.* The plan describes risk assessments conducted by or for Region I and outlines the criteria that should be used to determine whether the four fundamental values presented above have been addressed. The *Risk Characterization Implementation Plan for Region I* was signed by John DeVillars, Regional Administrator, on October 24, 1996. Copies of the Administrator's March 21, 1995 memorandum and Region I's Implementation Plan are available from Jerri Weiss or Margaret McDonough.

written by Margaret McDonough

Mercury Update

Combustion facilities or incinerators are potentially a large source of environmental mercury contamination. To reduce emissions of mercury and other hazardous air pollutants, the revised MACT standards proposed for hazardous waste combustion facilities were signed by EPA Administrator Carol Browner on March 20, 1996 under the joint authority of the Clean Air Act (CAA) and the Resource Conservation and Recovery Act (RCRA). The rules were proposed on April 19, 1996 (61 FR 17358) and are scheduled to be finalized by March, 1998.

The proposed MACT standards for mercury are 50 ug/dscm (micrograms per dry weight standard cubic meter) for hazardous waste incinerators and hazardous waste-burning cement kilns, and 72 ug/dscm for hazardous waste-burning light weight aggregate kilns. Under this proposal, continuous emission monitors (CEMs) would be required for particulate matter and mercury.

The CAA 112(n)(1)(B) requires EPA to submit a study on the atmospheric mercury emissions to Congress (*the Mercury Report*). The release of this report to Congress has been delayed. EPA released the report to the Science Advisory Board (SAB) in the beginning of July. The SAB was asked to review the issues related to effects of methyl mercury on child development and to develop a process for evaluating new data that is forthcoming from two large epidemiological studies. This report will also address mercury speciation, atmospheric deposition, bioconcentration factors, and toxicity data which are important for meaningful quantitative risk assessments.

The EPA has made the *Mercury Study SAB Review Draft Report to Congress* (document number EPA-452/R-96-001) available through the National Technical Information Service (703/487-4650).

written by Jui-Yu Hsieh

EPA Finalizes Soil Screening Guidance

EPA finalized the Soil Screening Guidance in April, 1996. This guidance provides methods for calculating site-specific soil screening levels (SSLs) which can

be used to identify areas of a hazardous waste site which do not warrant further federal attention. The SSL guidance is expected to help standardize and accelerate the evaluation and cleanup of contaminated soils at sites with a future residential land use.

SSLs are not national standards and alone do not trigger the need for response actions nor do they define "unacceptable" levels of contaminants in soils. The SSL Guidance contains 110 general soil values as well as a methodology for derivation of site-specific concentrations. If soil screening levels are exceeded, further assessment but not necessarily cleanup is generally warranted. The generic soil values and methodology are designed to protect against exposures resulting from soil ingestion, inhalation of particulates and ingestion of contaminated groundwater resulting from soil leachate.

Soil screening levels are limited in their application by the fact that 1) they do not address ecological threats and 2) they are only developed for a residential exposure scenario. EPA has issued the guidance in two parts:

1. **Soil Screening Guidance: User's Guide** (OSWER Directive 9355.4-23, PB96-963505). The User's Guide is designed for the EPA site manager or Regional Manager seeking to understand the basic concepts, approaches, and assumptions in the soil screening decision framework.

2. **Soil Screening Guidance: Technical Background Document (TBD)** (OSWER Directive 9355.4-17A, PB96-963502). *The Technical Background Document* provides a comprehensive analysis of the technical and policy issues and choices.

In addition, an overview is provided in the **Soil Screening Guidance: Fact Sheet** (OSWER Directive 9533.1-14FSA, PB96-963501). An overview of the EPA's response to comments received during the public comment period is also available in the **Soil Screening Guidance: Response to Comments** (OSWER Directive 9355.4-22, PB96-963506). These can be purchased from the National Technical Information Service (703/ 487-4650).

written by Stephanie Carr

EPA's Proposed Cancer Guidance and Implementation Plan

EPA released the *Proposed Guidelines for Carcinogen Risk Assessment* in April, 1996 for a 120-day public review and comment period. The proposed revisions to the guidelines are a result of extensive EPA and other federal and independent scientific reviews, as well as recommendations from the National Academy of Sciences 1994 report, *Science and Judgement in Risk Assessment*. The Proposed Guidelines are a revision of EPA's 1986 *Guidelines for Carcinogen Risk Assessment* (51FR 33992), and when final will replace the 1986 guidelines.

The Proposed Guidelines will allow scientists to provide more relevant and up-to-date information in cancer evaluations on dose-response, route of exposure, and chemical structure of regulated chemicals. The major changes in the Proposed Guidelines are summarized below:

- **Mode of Action**: Perhaps the most important aspect of the proposal is the emphasis on mode of action, which considers how a substance causes cancer. More emphasis on the mode of action is expected to reduce the uncertainty in describing likelihood of harm and in determining dose-response approaches.

- **Three descriptors for classifying human carcinogenic potential: 1)** "known/likely", **2)** cannot be determined, and **3)** not likely replace the six alphanumeric categories (A, B1, B2, C, D, E) in the 1986 guidelines. In addition, a weight of evidence narrative, targeted at the risk manager, is added. This narrative summarizes the key evidence for the classification and presents significant strengths, weaknesses and uncertainties of the contributing evidence.

- **Biologically-based extrapolation model is the preferred approach** for quantifying risk.

- **Three default approaches - Linear, Nonlinear, or Both are provided.** Curve fitting in the observed range would be used to determine the effective dose corresponding to the lower 95% limit on a dose associated with a 10% response (LED_{10}). The LED_{10} would then be used as a point of departure for extrapolation to the origin as the linear default or for a margin of exposure discussion as the nonlinear default.

- **Hazard characterization is added** to integrate the Data Analysis of all relevant studies into one weight of evidence conclusion of hazard.

- **Risk characterization is more fully developed** by providing direction on how the overall conclusion and confidence of risk is presented to the risk manager. Descriptions of major default assumptions and criteria for departing from them are described.

Until the guidelines are final, EPA will continue to rely on existing assessments. Once they are final, EPA will assess existing cancer values considering new risk assessment methods, principles and data. Reevaluating all existing cancer values on EPA's Integrated Risk Information System (IRIS) database would be time and resource prohibitive; therefore, EPA has developed a prioritization process to ensure that agents which warrant reevaluation are given the highest priority.

A five-step process will be used for determining which chemicals should be reevaluated. **1.** EPA publishes an annual Federal Register notice requesting candidates for reevaluation. **2.** Candidates are submitted. **3.** EPA reviews and prioritizes candidates. **4.** Candidates that EPA selects are published in a Federal Register notice. **5.** Reassessment takes place in the following fiscal year during which time chemicals are peer reviewed and placed on IRIS.

It should be noted that pending finalization of the Proposed Guidelines, the principles and approaches of the Proposed Guidelines may be applied in part or in whole, on a case-by-case basis. The proposed process for using the new guidelines can be found in the Federal Register (61 FR 32799).

The Proposed Guidelines are available in the Federal Register (61 FR 17960). An electronic version is also available through EPA's Office of Research and Development home page on the Internet at http://www.epa.gov /ORD. To obtain a 3.5" disc in WordPerfect 5.1 format, contact: ORD Publications Technology Transfer and Support Division, National Risk Management Laboratory, USEPA, 26 W. Martin Luther King Drive, Cincinnati, OH 43268 Telephone: 513/560-7562; Fax: 513/569-7566.

Please provide your name, mailing address, document title and the following EPA number (EPA/600/P-921003(a)).

written by Ann-Marie Burke

Ground Water Use and Value Guidance

EPA-Region I recently finalized a new guidance document entitled the *Ground Water Use and Value Determination Guidance*. This guidance combines the goals of two major regional initiatives, the Superfund Beneficial Reuse Initiative and the Comprehensive Ground Water Protection Strategy. As part of the Superfund Beneficial Reuse Initiative, this guidance is intended to result in more informed and focused decision-making and more common-sense, cost-effective ground water cleanups which will facilitate the beneficial reuse of contaminated parcels. To accomplish these objectives, this guidance incorporates the resource-based considerations used in EPA's Comprehensive Ground Water Protection Strategy. Specifically, this guidance document establishes an approach for determining the relative "use" and "value" of site ground water resources and explains how this determination affects EPA-Region I ground water remedial decision making process.

The guidance is a good example of how EPA intends to provide more flexibility to the states. The six New England States have provided comments on this guidance and support the process and concepts it contains.

Overview

The new Approach to Superfund ground water decision making will be as follows:

- The Approach will be implemented in States with EPA-endorsed Comprehensive State Ground Water Protection Programs or CSGWPPs, but only where such States have entered into a Memorandum of Agreement (MOA) with EPA- Region I concerning the implementation of the Approach;

- In states that have entered into an MOA for the implementation of this guidance, EPA-New England will no longer rely on the 1986 Draft EPA Guidelines for Ground Water Classification in setting goals for ground water remediation and in making decisions on the level of cleanup necessary;

- Instead, a site specific determination will be made on the relative "use" and "value" of the ground water. States will play a pivotal role in determining the relative "use" and "value" of site ground water and will seek input from local officials and the public, as appropriate;

- EPA-New England will utilize the Use and Value Determinations performed by the States, in establishing remedial action objectives and making ground water remedial action decisions.

Application of This Guidance

The Approach provided in this guidance will be considered at current and future sites in the pre-remedial or RI/FS stages, to the extent possible. This guidance is for use by EPA-Region I and State Remedial Project Managers in scoping Remedial Investigations, conducting Risk Assessments, developing Remedial Action Objectives and identifying Remedial Alternatives. EPA-Region I does not intend to re-open remedy selection decisions based on this guidance. This guidance is for internal Agency use and contains no right, substantive or procedural, for any party.

Relationship To Risk Assessment

In performing the Human Health Risk Assessment for the site, exposure scenarios will generally be based on the generally allowed uses under the state ground water classification system. Risk assessors should not vary their existing risk assessment procedures as a result of this policy, other than to consider exposures based on the state classification rather than the 1986 draft federal guidelines.

The Use and Value Determination prepared by the States may be discussed as part of the exposure assessment section of the Risk Assessment. In other words, the Use and Value Determination may be used to place the exposure scenarios in perspective.

If you have any questions on how this guidance should be applied or would like to receive a copy of the guidance document, please contact any one of the following staff: Lynne Jennings, (617) 573-9634; Margery Adams, (617) 565-3746; Audrey Zucker, (617) 565-3444.

written by Lynne Jennings

Lead Risk at CERCLA Sites and RCRA Correction Action Facilities

EPA takes a multimedia approach to estimating the risk from exposure to inorganic lead at a hazardous waste sites. Risks to children exposed to lead are estimated by predicting blood lead levels using a pharmacokinetic model. Risks to adults are estimated through use of a slope-factor approach. These methods for estimating risks are described below.

Lead Risks for Children in a Residential Setting

For sites with a current or future potential residential land use, the sensitive receptor should be a child. EPA's Integrated Exposure Uptake and Biokinetic (IEUBK) model estimates the risk to a child resident. It is not appropriate to use this model for the adult resident, an older child (i.e., ages 9-18), or the adult worker. For future residential exposure scenarios, only a child's exposure to lead need be evaluated since this is the most sensitive receptor.

The IEUBK is a software package designed to combine exposures from lead in air, water, soil, dust, diet, paint, and

other sources with a pharmacokinetic model. The output is a predicted distribution of blood lead levels in a child or a population of children from 6 months to 7 years of age. From this distribution, the model calculates the probability that blood lead concentration of a child or population of children will exceed a selected level of concern (the default value is a blood lead level of 10 micrograms lead per deciliter of blood). The user can then explore an array of possible changes in exposure media that would reduce the probability of unacceptable risk to those populations.

The model allows the user to input site-specific values other than the concentration of lead in soil; i.e., the concentration of lead in household dust, air, or drinking water, or the bioavailability of lead. The model can also be used to develop cleanup goals for lead at a hazardous waste site. In cases where site-specific data are not available, the standard default exposure assumptions built into the model should be used. This will result in a cleanup goal of 400 mg/kg (ppm) for residential soils. The model's default values are the basis for the risk screening value of 400 mg/kg recommended in the "Revised Interim Soil Lead Guidance for CERCLA Sites and RCRA Corrective Action Facilities" (OSWER Directive #9355.4-12) and the EPA Soil Screening Guidance (Publication number 9355.4-23).

When presenting the IEUBK model results to EPA, the user should include: 1) the age of the child targeted; 2) site-specific parameter values; 3) standard defaults; and, 4) the percentage of children predicted to have blood leads above the EPA cutoff of 10 micrograms/deciliter. In the IEUBK computer model, the user should choose the graph for the probability density function and enter the appropriate parameters.

Both the IEUBK computer model (Pub. No. 9285.7-15-2; PB93-963511) and the guidance manual (Pub. No. 9285.7-15-1; PB93-963510) are available to the public through the National Technical Information Service (703/487-4650) or the EPA Region I Library (617/565-3300).

Lead Risks for Commercial or Industrial Workers and Youth Trespassers

The EPA Technical Review Workgroup for Lead (TRW) is conducting additional research on a biokinetic mode for adult exposures. The TRW consists of risk assessors, scientists, policy analysts, statisticians, and project managers including Region I representatives Margaret McDonough and Mary Ballew. As an interim approach, the TRW has recommended a simplified slope factor approach. The slope factor approach is conceptually similar to that proposed by Bowers et al. (1994) which was adapted for use at the California Gulch NPL site in Region 8 (Weston, 1995).

On October 26, 1995, the TRW published a report, *Review of a Methodology for Establishing Risk-Based Soil Remediation Goals for Commercial Areas of the California Gulch Site*. The TRW has endorsed the slope factor approach presented in this report, as an interim method for evaluating the risks to adults exposed to lead. This fall, the TRW expects to release a more generic guidance document that will contain a clear method for calculating a preliminary remediation goal for an industrial or commercial exposure scenario and the rationale for each parameter used in this new approach. The TRW has emphasized the importance of collecting data to support site-specific parameter estimates, however, default parameter guidance will also be provided.

Preliminary calculations by the TRW suggest that the slope factor approach could be adapted for use in a trespasser scenario. Parameters should be adjusted to account for any age-related differences. It is appropriate to use the slope factor approach when trespassing frequency is equal to or greater than once per week over the course of a minimum duration of ninety days.

The 1995 California Gulch review report is available from the Region I library. The TRW report *Methodology for Assessing Risks Associated with Adult Exposures to Lead in Soil* will be available by the end of 1996. A copy will be available at the Region I library 617/565-3300 or Toll Free at 800-EPA-LIBR.

written by Mary Ballew and Margaret McDonough

References

Bowers et al. 1994: Bowers, TS, Beck BD, Karam HS.1994. Assessing the relationship

between environmental lead concentrations and adult blood lead levels. Risk Analysis 14:183-89.

Weston 1995: Roy F. Weston, Inc. 1995. Baseline human health risk assessment for the California Gulch Superfund site. February. Prepared for USEPA Region 8, Denver CO.

Revised Manganese Reference Dose

The manganese reference dose (RfD) in the IRIS data base was revised in November, 1995. This revision results in a lower risk (and thus, higher cleanup level) for drinking water compared to the previous RfD. The IRIS RfD of 1.4E-1 mg/kg/day is for the total oral intake of manganese. As stated in the IRIS file, it is recommended that a modifying factor of 3 be applied to the RfD for non-dietary exposures.

Background

Prior to November, 1995 the IRIS data base provided two references doses for manganese, one for food and one for water. The food RfD was based on dietary intake of manganese. The water RfD was based on a study of humans who had ingested drinking water containing elevated levels of manganese as well as on assumptions regarding differences in absorption of manganese in food as opposed to water.

The drinking water RfD was withdrawn from IRIS in November, 1995 because of concerns about the validity of the human exposure study and because new information indicated that the disparity between absorption of manganese from food as opposed to water was overestimated.

New Approach

The revised RfD for manganese is for the total oral intake of manganese. This value is 0.14 mg/kg/day and is derived as follows:

- 10 mg/day of manganese may be consumed without adverse effects (the "critical dose"). This value comes from several dietary studies.
- average adult body weight = 70 kg

Therefore, the RfD =

$$\frac{10\ \text{mg/day}}{70\ \text{kg}} = 0.14\ \text{mg/kg/day}$$

A modifying factor of 3 is recommended in IRIS when assessing exposure from drinking water.

Drinking Water Exposures

The average dietary manganese content of the U.S. population, 5 mg/day, is subtracted from the "critical dose" of 10 mg/day:

10 mg/day - 5mg/day = 5 mg/day

Apply modifying factor of 3 per IRIS recommendation:

$$\frac{5\ \text{mg/day}}{3} = 1.67\ \text{mg/day}$$

Compute RfD:

$$\frac{1.67\ \text{mg/day}}{70\ \text{kg}} = .024\ \text{mg/kg day}$$

The Hazard Index (HI) for drinking water is calculated as follows (using a simplified equation):

$$\frac{\text{Concentration(mg/L)} * \text{2liters/day}}{0.024\ \text{mg/kg/day} * 70\ \text{kg}}$$

A HI of 1 corresponds to a concentration of 840 ug/L.

Soil Exposure

A modifying factor of 3 may be appropriate for assessing risks via exposure to soils if neonates (a child 12 months or younger) are a potentially exposed population. For most RCRA and Superfund risk assessments neonates are unlikely to be exposed to significant amounts of soils. Therefore, a modifying factor of 1 is appropriate. Assuming exposure to a young child under a residential scenario, a hazard index of 1 for manganese in soil would correspond to a soil concentration of 5,500 mg/kg.

written by Margaret McDonough

New Cancer Slope Factors for PCBs

EPA recently reassessed the scientific evidence for the carcinogenicity of polychlorinated biphenyls (PCBs). A range of new cancer slope factors for PCB mixtures were posted on the IRIS chemical information

data base on October 1, 1996. The new slope factors reflect the current knowledge of EPA scientists and national experts concerning:

- the influence on toxicity of PCBs by chemical transformation in the environment;
- the tendency of PCBs to partition into various media; and
- the potential for PCBs to biomagnify through the food chain.

To fully understand the scientific basis for the slope factors and to correctly apply them in a risk assessment, carefully read EPA's supporting technical document, *PCBs: Cancer Dose-response Assessment and Application to Environmental Mixtures*, which explains in greater detail the basis for the PCB reassessment.

The PCB reassessment results in different cancer slope factors for PCB mixtures based on a consideration of several different factors. First, the reassessment recognizes that environmental processes may significantly change the toxicity of Aroclor mixtures released into the environment. Thus, new slope factors are determined by the environmental pathway of exposure rather than by reference to a toxicity study for the particular Aroclor. Second, toxicity studies which formed the basis of the previous slope factor for PCBs were reanalyzed using new criteria and nomenclature for rat liver tumors, which resulted in a reduced number of tumors reported for Aroclor mixtures. Third, new PCB toxicity studies, sponsored by the General Electric Company, were considered in the derivation of the new cancer slope factors. Fourth, a revised cross-species scaling factor as recommended in EPA's *Proposed Guidelines for Carcinogen Risk Assessment, 61FR 17960,* was incorporated into the derivation of the new slope factors. Lastly, a new method for extrapolating risk to low doses from experimental data as recommended in EPA's New Cancer Guidelines was utilized in deriving the new slope factors.

The reassessment recommends a tiered approach for determining central tendency and high end cancer slope factors for use in risk assessment. When congener information is limited, the exposure pathway is used to indicate whether environmental processes have increased or decreased a PCB mixture's potency. When congener information is available, further refinement of the potency estimate can occur. Three categories of slope factors are developed based on the exposure pathway or, if more information is available, the PCB congener makeup of the mixture. A "high-risk" category is used for exposure pathways associated with environmental processes that tend to increase risk: a "low-risk" category for those that tend to decrease risk; and a "lowest risk" category for cases where congener or isomer analyses verifies the absence of congeners with more than 4 chlorines (establishing sufficient similarity of an environmental mixture to the least potent PCB Aroclor tested).

Additional highlights of the reassessment include the following:

- Changes in the types of environmental data collected for PCBs are recommended. At present, data are collected for the commercially available mixtures of PCBs (Aroclors) and the total amount of PCBs. The reassessment recommends collecting data on either the total amount of PCBs or on congeners (which represent up to 209 different arrangements of the chlorine atoms on the PCB molecule).
- Analysis of dioxin-like PCBs is recommended, if they are thought to be present. For samples containing dioxin-like PCBs, the risk of the dioxin-like PCBs is added to the risks calculated using the cancer slope factors for nondioxin-like PCBs presented in this reassessment. Only a congener-specific analysis can determine whether dioxin-like PCBs are present. The risks from dioxin-like PCBs are evaluated using a toxicity equivalence factor (TEF) approach, (See the PCB reassessment and March 1989 *Interim Procedures For Estimating Risks Associated With Exposures to Mixtures of Chlorinated Dibenzo-p-dioxins and -Dibenzofurans (CDDs and CDFs) and 1989*

Update (EPA/625/3-89/016) for more details.)

- New highly exposed and highly sensitive populations who merit specific evaluation are identified. "Highly exposed populations include some nursing infants and consumers of game fish and game animals contaminated through the food chain. Highly sensitive populations include people with decreased liver function and infants."

The reassessment may produce changes in the way we investigate hazardous waste sites and estimate risks for PCBs. Lower estimates of risk from PCBs could result for several exposure pathways. When assessing the risks from PCB mixtures, please contact a Region I risk assessor.

The PCB reassessment is available on the Office of Research and Development home page on the Internet at http://www.epa.gov/ORD. A copy is also available at the Region I EPA library and it may be copied onto a disk if you bring your own. The library has a new toll free number for calls within New England: 888-EPA-LIBR.

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