Basewide Background Soil Investigation Report

Naval Surface Warfare Center Crane

Crane, Indiana

Southern Division Naval Facilities Engineering Command

Contract Number N62467-94-D-0888

Contract Task Order 0083

January 2001

DEPARTMENT OF THE NAVY

CRANE DIVISION
NAVAL SURFACE WARFARE CENTER
300 HIGHWAY 361
CRANE, INDIANA 47522-5000

IN REPLY REFER TO:

5090
Ser 095/1020

29 JAN 2001

U.S. Environmental Protection Agency, Region V
Waste, Pesticides, & Toxics Division
Waste Management Branch
Illinois, Indiana, and Michigan Section
ATTN: Mr. Peter Ramanauskas (DW-8J)
77 West Jackson Blvd.
Chicago, IL 60604

Dear Mr. Ramanauskas:

Crane Division, Naval Surface Warfare Center (NAVSURFWARCENDIV Crane) submits two copies of the Basewide Background Soil Investigation ~~Draft~~ Final Report as enclosure (1). This report is complete in that it includes results from the November 1999 and October 2000 sampling efforts. The permit required Certification Statement is provided as enclosure (2).

NAVSURFWARCENDIV Crane point of contact is Mr. Thomas J. Brent, Code 09510, telephone 812-854-6160.

Sincerely,

James M. Hunsicker
Director, Environmental
Protection Department
By direction of the Commander

Encl:
(1) Basewide Background Soil Investigation ~~Draft~~ Final Report
(2) Certification Statement

Copy to:
ADMINISTRATIVE RECORD
SOUTHNAVFACENGCOM (Code 1864) (w/o encl)
IDEM (Doug Griffin)
TTNUS (Keith Henn) (w/o encl)

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PITT-01-1-047

January 15, 2001

Project Number 0087

Department of the Navy
SOUTHNAVFACENGCOM
ATTN: William H. Gates (Code 1864)
Southern Division, Naval Facilities Engineering Command
2155 Eagle Drive, P.O. Box 190010
North Charleston, South Carolina 29419-9010

Reference: CLEAN Contract Number N62467-94-D-0888
Contract Task Order 0083

Subject: Final Basewide Background Soil Investigation Report
Naval Surface Warfare Center Crane
Crane, Indiana

Dear Mr. Gates,

Enclosed is one copy of the Final Basewide Background Soil Investigation Report (Revision 1) prepared for the Naval Surface Warfare Center Crane at Crane Indiana. We have incorporated agency comments on the draft report (Revision 0) and the results from the October 2000 supplemental sampling event in this report.

As you requested during our phone conversation on January 12, 2001, I have also sent Tom Brent five copies of the Final Report. Per your request, Mr. Brent will distribute copies of this report to the appropriate agency representatives at the U.S. Environmental Protection Agency and Indiana Department of Environmental Management.

If you have any questions, feel free to call me at (412) 921-8146 or e-mail me at hennk@ttnus.com.

Sincerely,

Keith W. Henn. P.G.
Task Order Manager

KWH/sic
Enclosure

c: Tom Brent, NSWC Crane (5 copies)
Debbie Wroblewski (cover letter only)
Mark Perry/file (1 copy)
Tom Johnston (1 copy)
TtNUS NSWC Crane Library (1 copy)

Basewide Background Soil Investigation Report

Naval Surface Warfare Center Crane

Crane, Indiana

Southern Division
Naval Facilities Engineering Command

Contract Number N62467-94-D-0888

Contract Task Order 0083

January 2001

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BASEWIDE BACKGROUND SOIL INVESTIGATION REPORT

NAVAL SURFACE WARFARE CENTER CRANE
CRANE, INDIANA

COMPREHENSIVE LONG-TERM
ENVIRONMENTAL ACTION NAVY (CLEAN) CONTRACT

Submitted to:
Southern Division
Naval Facilities Engineering Command
2155 Eagle Drive
North Charleston, South Carolina 29406

Submitted by:
Tetra Tech NUS, Inc.
661 Andersen Drive
Foster Plaza 7
Pittsburgh, Pennsylvania 15220

CONTRACT NUMBER N62467-94-D-0888
CONTRACT TASK ORDER 0083

JANUARY 2001

PREPARED UNDER THE SUPERVISION OF:

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ACRONYMS

ABC	Alluvial subsurface clay soil
ABG	Ammunition Burning Grounds
ABL	Alluvial subsurface silt soil
ABS	Alluvial subsurface sand soil
ANOVA	Analysis of Variance
ARARs	Applicable, Relevant, or Appropriate Requirements
Army	U.S. Department of the Army
AS	Alluvial surface soil
ASTM	American Society for Testing of Materials
B&R Environmental	Brown and Root Environmental
B146	Building 146
BA1	Background Area 1
BA2	Background Area 2
BA3	Background Area 3
bgs	below ground surface
CAAA	Crane Army Ammunition Activity
CI	confidence interval
CFR	Code of Federal Regulations
CLEAN	Comprehensive Long-term Environmental Action Navy
CTO	Contract Task Order
DE	depositional environment
DQO	data quality objectives
DR	Demolition Range
EMR	Environmental Monitoring Report
EPA	United States Environmental Protection Agency
FSP	Field Sampling Plan
ft	foot; feet
GIS	geographic information systems
GPS	global positioning system
GRITS/STAT	Ground Water Information Tracking System/Statistics
HASP	Health and Safety Plan
IA	Installation Assessment
IAC	Indiana Administrative Code

IAS	Initial Assessment Study
IDEM	Indiana Department of Environmental Management
IDL	instrument detection limit
LBC	Loess/glacial subsurface claysoil
LBL	Loess/glacial subsurface Loess soil
LBS	Loess/glacial subsurface sand soil
LS	Loess/glacial surface soil
MBC	Mississippian residual subsurface clay soil
MBL	Mississippian residual subsurface silt soil
MBS	Mississippian residual subsurface sand soil
MS	Mississippian residual surface sand soil
MSL	mean sea level
NAVFAC	Naval Facilities Engineering Command
Navy	U.S. Department of the Navy
NGVD	National Geodetic Vertical Datum
NOAA	National Oceanographic and Atmospheric Administration
NSWC	Naval Surface Warfare Center
OB	Open Burning
OBP	Old Burn Pit
OD	Open Detonation
ORR	Old Rifle Range
PBC	Pennsylvanian residual subsurface clay soil
PBL	Pennsylvanian residual subsurface silt soil
PBS	Pennsylvanian residual subsurface sand soil
PID	Photo Iinization detector
PS	Pennsylvanian residual surface soil
PTA	Pyrotechnic Test Areas
QA/QC	quality assurance/quality control
QAPP	Quality Assurance Project Plan
RCRA	Resource Conservation and Recovery Act
RFI	RCRA facility investigation
RPD	Relative Percent Difference
SDG	Sample Deliver Group
SOP	Standard Operating Procedure
SOUTHNAVFACENGCOM	Southern Division, Naval Facilities Engineering Command
SQL	sample quantitation limit

SRBTL	soil risk-based target levels
SVOC	semivolatile organic compound
SWMA	Solid Waste Management Area
SWMU	Solid Waste Management Unit
TtNUS	TetraTech, NUS Inc.
USACE	United States Army Corps of Engineers
USCS	Unified Soil Classification System
USDA/SCS	United States Department of Agriculture/Soil Conservation Service
VOC	volatile organic compounds
WES	Waterways Experiment Station

EXECUTIVE SUMMARY

Tetra Tech NUS, Inc. (TtNUS) was tasked with performing a Basewide Background Soil Investigation for Naval Surface Warfare Center Crane (NSWC Crane), Crane, Indiana by the U.S. Navy (Navy) Southern Division, Naval Facilities Engineering Command (NAVFAC). NSWC Crane is located in the southern portion of Indiana. This investigation establishes a background database for soil for the entire NSWC Crane facility.

The results of this report are intended to support applicable Resource Conservation and Recovery Act (RCRA) Corrective Action requirements and other related environmental investigations conducted at NSWC Crane. One step typically taken when evaluating the risk of inorganic chemicals is a comparison of the chemical concentrations measured in the soil under investigation to their background concentrations. This comparison is made because many inorganic chemicals occur naturally in the environment. Background concentrations are those concentrations that would be observed in the absence of impact from facility operations. Thus, the background data contained herein can be used to differentiate site-related environmental contamination [from known or suspected Solid Waste Management Units (SWMUs), Areas of Concern (AOCs), or other sites at NSWC Crane] from naturally occurring and anthropogenic concentrations prior to U.S. Navy site operations.

The planning for this project conducted in early 1999 was followed by environmental sampling performed in November 1999 and October 2000. Background samples were collected from three background areas representing four different soil depositional environments (DEs). Each of these areas and specific sampling locations within these areas met numerous criteria to ensure that background soil samples represent "true background" areas or areas that have not been affected by past or present NSWC Crane operations. Based upon a sampling strategy, 67 soil samples were collected and analyzed for 27 inorganic (metal) concentrations.

The following conclusions can be drawn from the background investigation field effort, data set, and statistical analyses performed on the background data set:

- The data collected are of sufficient quality to be used for background comparisons of 27 metals in risk assessments, RCRA Facility Investigations, and other environmental investigations conducted at NSWC Crane. The background database should be valid for future comparisons for most soil encountered on the NSWC Crane facility. If exceptions arise, they should be handled on a case-by-case basis.

- Sixteen distinct soil types were represented in the background data set. A sufficient number of samples was collected to characterize background soil for 15 of the 16 soil types. The goal of attaining at least 3 samples was achieved for each of these 15 soil types. This goal was not achieved for the one remaining soil type.

- Statistical analyses supported by geological principles allowed the 16 soil types to be classified into 9 different soil groups. All soil types within each soil group have statistically similar metal concentrations. The goal of attaining at least 5 samples for statistical analysis for each of these soil groups was achieved, except for two soil groups. The goal of supporting a minimum detectable difference between site data and background data was also achieved for all but the same two soil groups. However, one of these two soil groups only marginally fails to meet the two-sigma project objective.

- The background concentrations for several metals exceeded human health and ecological risk-based target levels (SRBTLs) used during planning for this project.

- Because of varying soil types at any given site at NSWC Crane, two to three background (soil group) data sets will be needed for comparisons with site investigation data to determine whether site concentrations exceed background concentrations.

- In the initial sampling effort, insufficient background data were obtained for two of nine soil groups. A supplemental sampling effort seeking additional samples provided enough data to achieve project objectives for one of those two soil groups. For the remaining soil group (Pennsylvania Subsurface Sand, PBS), the background data set is still insufficient to support the intended statistical comparisons with site investigation data. However, it was shown that additional data collection is not warranted, given the infrequency with which that soil group was encountered during sampling.

The following items should be considered when using this data for comparisons with site investigation data:

- This report outlines procedures to be followed when comparing site investigation data to the background data sets (soil groups) presented in this report. Two types of comparisons may be performed. One historic approach used, involves a direct comparison between the site data and the background data's descriptive statistics (minimum, maximum, and average values in a data set as well as the upper tolerance limit [UTL] values). The information for this type of comparison is included in Tables 4-1 through 4-10. A second approach involves a more direct comparison of background and site data distributions using a statistical comparison. The complete data sets used in this type of comparison is held in a database currently managed by Tetra Tech NUS, Inc. See Section 5 for more details on data comparisons.

- Because some metals exceed human health and ecological risk-based target levels and these target levels are updated on a periodic basis, it is important that when the site investigation data are evaluated with respect to background data the current target levels are also considered.

- There may be circumstances where it might be beneficial for SWMU specific background data to be collected to supplement the basewide background soil database. These circumstances may include SWMUs which are affected by contamination from other SWMUs, SWMUs which are believed to be affected by small scale variations in local geology, where a SWMU's metals of potential concern differs from the background data sets, or when the PBS soil type is encountered and a comparison is needed.

1.0 INTRODUCTION

This report presents the results and conclusions of the Basewide Background Soil investigation at the Naval Surface Warfare Center Crane (NSWC Crane), Crane, Indiana. This report has been prepared for the U.S. Department of the Navy (Navy) by Tetra Tech NUS, Inc. (TtNUS) under the Southern Division, Naval Facilities Engineering Command (NAVFAC) contract, Contract Number N62467-94-D-0888, Contract Task Order (CTO) 0083. A copy of this report is maintained at the NSWC Crane Environmental Division office.

This investigation supports applicable Resource Conservation and Recovery Act (RCRA) Corrective Action requirements, including the need for RCRA Facility Investigations (RFIs) and other related environmental investigations to be conducted at the NSWC Crane. The Work Plan (TtNUS, 1999a, TtNUS, 2000b) for this investigation outlines the rationale and procedures for sample collection while the Quality Assurance Project Plan (TtNUS, 1999b) outlines the procedures for collection, analysis, and characterization of background data.

Based on the results of Solid Waste Management Unit (SWMU) investigations, decisions are made concerning risks to humans and ecological receptors that could be exposed to potential contaminants. The risk assessment decision process is performed in a step wise manner. The first step when evaluating the risk of inorganic chemicals often is a comparison of the chemical concentrations measured in site soil to their background concentrations. This comparison is made because many inorganic chemicals occur naturally in the environment. Background concentrations are those concentrations that would be observed in the absence of impact from site operations. In accordance with RCRA (EPA, 1989a) and risk assessment guidance (EPA, 1989b), if the measured site concentrations are not significantly greater than the background concentrations, it may be inferred that an operationally related release of those contaminants has not occurred, and the site investigation is often terminated at that point. If measured concentrations exceed background concentrations, additional assessment may be warranted.

Before comparisons to background concentrations can be performed, a suitable set of background data must be available. The background data must be representative of the background chemical concentrations. This means that samples collected for a background data set must be collected from areas that have not been affected by chemical releases associated with site activities. The background samples must also have similar geologic, chemical, and physical characteristics to those collected at the area(s) of investigation (i.e., SWMU) so that a meaningful comparison can be made (EPA, 1995). Soil having these similar characteristics are referred to as soil types.

This report consists of six sections. Section 1.0 is this introduction. Section 2.0 provides a description of the site characteristics and a brief summary of the SWMUs at the facility. Section 3.0 discusses the methodology followed for this investigation. It includes a summary of the data quality objectives, sample network design and rationale, and sampling procedures. Section 4.0 provides an evaluation of the background data collected. Section 5.0 provides a proposed methodology for using the findings of this report for data comparisons in future site investigations. Finally, Section 6.0 discusses the summary, conclusions and recommendations of this report. It is noted that Section 5.0 and 6.0 should be reviewed, at a minimum, when using the findings of this report for data comparisons.

1.1 PURPOSE OF THE BASEWIDE BACKGROUND SOIL INVESTIGATION

Background data sets presented in this report are intended to be the benchmarks to which current and future NSWC Crane SWMU and non-SWMU investigation soil data will be compared. The purpose of these comparisons is to differentiate site-related environmental contamination from naturally occurring and anthropogenic (i.e., prior to U.S. Navy operations) background concentrations of inorganic (i.e., metals) constituents. Consequently, comparability of the soil metals background data to data from these SWMU and non-SWMU investigations is crucial to the success of future projects. The background analytes of interest, the soil types, analytical methods, future land use, risk-based cleanup levels likely to be used in future investigations, methods of comparing data distributions, sampling schemes, and other pertinent considerations have been examined in this investigation. Soil has been classified into soil types with respect to physical characteristics that facilitate comparability among data sets. This critical aspect of the Data Quality Objective (DQO) planning, with rationales for selecting particular soil types, is summarized in Section 3.3.

In a meeting with the EPA Region 5, the Navy, based on input from TtNUS, recommended analyzing background samples for polycyclic aromatic hydrocarbons and pesticides, and possibly volatile organic compounds and polychlorinated biphenyls, to use as verification that samples were collected from background populations. EPA Region 5 recommended, instead, that samples be analyzed for metals only. Accordingly, analyses for the EPA Contract Laboratory Program (CLP) Target Analytic List (TAL) metals, lithium, strontium, thorium, and tin were conducted in accordance with the standard EPA analytical methods.

1.2 OBJECTIVES OF THE BASEWIDE BACKGROUND SOIL INVESTIGATION

The primary objective of this investigation was to collect a sufficient number of soil samples to adequately characterize, according to soil type, the background soil concentrations of a select number of metals at NSWC Crane. The samples should be adequate to enable the detection of a two-sigma concentration difference between data sets (see Section 3.3.3). The soil types for this investigation are derived by various combinations of soil from different depositional environments (DE), grain size, and depth below the ground surface. The following paragraph briefly describes how each of the soil types are derived from the DEs, grain size, and depth while Sections 2.0 and 3.0 describe this in greater detail.

The parent material or the origin of the soil and the manner in which it was deposited largely determines the chemical and mineralogical composition of that soil. The mechanism (e.g., water, wind, glaciers, weathering) from which the soil was formed is referred to herein as the depositional environment (DE) of the soil. Because the soil in each DE is derived from various types of parent material the resulting chemical composition is believed to vary significantly between the soil in each DE. NSWC Crane has been subdivided into four DE classifications: (1) alluvium (stream derived sediments); (2) loess (wind-blown sediment)/glacial outwash (glacially derived sediments); (3) residual soil derived from Pennsylvanian bedrock/colluvium; and (4) residual soils derived from Mississippian bedrock/colluvium. Within each DE, surface soil and subsurface soil were targeted, because the surface soil's chemical composition is believed to differ significantly from subsurface soil's chemical composition. This physical classification is believed to affect the chemical composition of soil because the parent material of the surface soil is believed, at least in part, to differ from the parent material from the subsurface material. It is also believed that the soil grain size (e.g., clay, silt, and sand) also significantly affects the concentration of inorganics in soil, providing another potential discriminating factor that is not necessarily well correlated to depth. Therefore, grouping of soil grain sizes into gross grain size classifications (e.g., clay, silt, and sand) was necessary to test this expectation. Collectively, all of these physical classifications of soil (i.e. DE, grain size, and depth) have been evaluated in this investigation to determine appropriate soil types for meaningful comparison with site investigation data.

The secondary objective of this investigation was to prepare the background data so that an actual minimum detectable concentration difference between SWMU and background data sets can be computed. The minimum detectable difference was established for various conditions such as different parametric data distributions, and was tailored to the actual data. Assumptions were made (e.g., the number of samples which would be collected) concerning site investigation data sets to permit the preparation of the data for computation of the minimum detectable difference. The comparison between SWMU and background data sets will be completed in each site investigation.

All reported metal concentrations are "total metal" concentrations (EPA, 1986b). The total metal concentration is herein defined as the sum total of a specific metal that can be dissolved from the native soil matrix by digesting the sample with a hot mineral acid in accordance with SW-836 Method 3050B. Method 3050B is not actually a total digestion technique for most samples in that it will not result in complete dissolution of the soil. Rather, it is a very strong acid digestion that will dissolve most chemical elements that could become environmentally available (EPA, 1986b). Chemical elements bound in silicate structures are not normally dissolved by this method because the acid used will not dissolved silicates. This is acceptable because silicates are not usually mobile in the environment.

This investigation is designed for quantification of metal concentrations in background soils only. The number of samples that might be collected in future investigations for comparison to background data sets is unknown. This lack of information limited the ability to project the minimum number of samples required for this investigation because data set comparisons are influenced by the number of samples in each data set. Consequently, best professional judgment was used in establishing criteria for determining whether enough data of the appropriate type and quality have been collected. Section 3.3 summarizes the rationale for selecting the number of samples for this background investigation.

The decision statement for this investigation is:

> Determine if enough data points of adequate quality for each analyte in each soil type have been collected. If enough data of adequate quality have been collected, no more data will be collected; otherwise the need to collect additional data will be considered. If no additional data will be collected, the smallest detectable difference between normally distributed data sets of equal variance will be computed.

2.0 BACKGROUND INFORMATION

This section provides a discussion of the background information and general site characteristics at the NSWC Crane facility. It includes such topics as site location, physiography, topography, land use classification, climatology/meteorology, hydrology, geology, hydrogeology, and site history.

2.1 SITE LOCATION AND DESCRIPTION

NSWC Crane is located in the southern portion of Indiana, approximately 75 miles southwest of Indianapolis, 60 miles northwest of Louisville, Kentucky and immediately east of Burns City and Crane Village, Indiana. NSWC Crane encompasses approximately 62,463 acres or approximately 98 square miles of the northern portion of Martin County and smaller portions of Greene, Daviess, and Lawrence Counties. A location map of the NSWC Crane facility is shown on Figure 2-1.

2.2 PHYSIOGRAPHY AND TOPOGRAPHY

NSWC Crane is in the unglaciated area of the Crawford Uplands Physiographic Province. This province is a rugged, highly vegetated, dissected plateau bounded by the Mitchell Plain Physiographic Province to the east and the Wabash Lowland Physiographic Province to the west (Murphy and Wade, 1995). The Mitchell Plain is a low dissected limestone plateau characterized by sinkholes and karst topographic features. The boundary between the Crawford Upland and the Mitchell Plain is marked by the highly irregular, eastern facing Chester Escarpment. Springs, caverns, caves, and other solution weathering features can be found along this escarpment which runs along the eastern edge of the NSWC Crane facility. The boundary between the Crawford Upland and the Wabash Lowland near the western boundary of NSWC Crane is gradual (Murphy and Wade, 1995).

The overall terrain at the facility is predominantly rolling with moderately incised stream valleys. Few topographically flat areas are found at NSWC Crane. Most of the region is covered by deciduous trees and shrubs. The elevations across Crane range from about 500 feet above mean sea level (AMSL) to about 850 feet AMSL. Man-made Lake Greenwood extends west to east across the northern part of the facility. Topographic relief in the Crawford Upland ranges from 100 to 350 feet. Greater relief exists in the eastern part of NSWC Crane near the Chester Escarpment (Murphy and Wade, 1995). A topographic and surficial geology map of the entire facility has been compiled by Kvale (1992) and Blunck (1995) after U.S. Geological Survey 7.5 minute quadrangle maps (Indian Springs, Scotland, Koleen, Owensburg, Odon, Williams, Loogootee, and Shoals). Portions of this topographic and surficial geology map of the facility can be found on Figures 3-2, 3-3, and 3-4.

2.3 LAND USE CLASSIFICATION

NSWC Crane is situated in a rural area of south-central Indiana. The surrounding communities are in transition from an economic base of agriculture, mining, and quarrying to an economy built on manufacturing and service industries. The patterns of settlement, population statistics, and median income are similar throughout the region (B&R Environmental, 1997). Because most of the region is covered by vegetation, the area is classified as rural (B&R Environmental, 1997).

There is no state or local land use planning in the vicinity of NSWC Crane. The only zoning and land use regulations are in the municipalities in the region. None of the municipalities are close enough to have an impact on NSWC Crane. None of the areas adjacent to NSWC Crane are zoned, and zoning is not anticipated in the near future. There are no known land use or community actions under consideration or proposed at this time (B&R Environmental, 1997).

2.4 ECOLOGICAL COMMUNITIES AND HABITAT

A biological characterization of NSWC Crane, including a list of plants and animals found at the facility, is presented in the Installation Assessment (IA; Army, 1978) and the Initial Assessment Study (IAS; NEESA, 1983) and is summarized in the Environmental Monitoring Reports (EMR; Halliburton NUS, 1992a and 1992b). A list of species which may inhabit NSWC Crane and are protected under the U.S. Endangered Species Act, Indiana Department of Natural Resources Heritage Data Center, or the U.S. Fish and Wildlife Service is summarized in the RCRA Facility Permits (EPA, 1995). Other information on the subject is available from the Indiana Department of Natural Resources (1987, 1988).

2.5 CLIMATOLOGY AND METEOROLOGY

NSWC Crane is located in a warm temperate climatic zone. In general, the summers are warm and humid, and winters are mild with occasional short cold periods. The temperature ranges from an average maximum July temperature of 89^{o}F to an average minimum January temperature of 26^{o}F. Precipitation is fairly evenly distributed throughout the year, with the maximum precipitation occurring during the spring and early summer. The average annual precipitation at the facility is 44 inches, consisting of 42 inches of rain and 15 inches of snow. The average humidity ranges from 40 to 90 percent in summer and 60 to 90 percent in winter.

Although the NSWC Crane Open Burning (OB) and Open Detonation (OD) treatment units (e.g., Ammunition Burning Grounds and Demolition Range) have onsite meteorological monitoring stations, data are collected for wind speed and wind direction only prior to and during treatment events. Therefore, insufficient data are available at the site to generate a climatological summary for the area. As a result, climatological data collected at the Indianapolis International Airport, approximately 65 miles northeast of Crane, were selected to describe the general climatology of the area occupied by the NSWC Crane. Indianapolis was chosen because it is the closest and most representative National Weather Service reporting station (B&R Environmental, 1997a). The wind direction is summarized below, if additional information is needed please refer to the RCRA Air Quality Assessment (B&R Environmental, 1997a).

Long-term climatological records (NOAA, 1988) for the area indicate that the monthly prevailing wind direction is from the southwest quadrant (meaning it predominantly blows to the northeast) from April through December, then shifts to the northwest during January through March. The annual prevailing wind direction for the region is from the southwest quadrant. The annual average wind speed for the area is about 9.6 miles per hour. Figure 2-2 is a wind rose illustrating the wind direction and mean wind speed distribution for the Indianapolis International Airport over the 5-year period, 1985-1989. The least predominant wind directions are from the northeastern and southeastern quadrants. More specifically, Figure 2-2 shows that the wind blew from the southwest quadrant (from due west to due south) approximately 43%, from the northwest quadrant (due north to due west) approximately 31.5%, from the northeast quadrant (due north to due east) approximately 23.5%, from the southeast quadrant (due south to due east) approximately 27%, and was calm approximately 3.5% during this 5 year period. It is noted that the total flow percentage is greater than 100% because the N, S, E, and W "pole" directions each fit into two quadrants.

2.6 HYDROLOGY

The surface drainage at NSWC Crane has formed a dense, dendritic pattern that flows throughout the installation in a general southward or southwestward direction. Seven primary creeks in five drainage basins carry surface water off the installation which eventually drains into the East Fork of the White River and then to the Wabash River to the southwest. Figure 2-3 shows the basins and drainages of NSWC Crane.

Drainage Basin IV consists of Boggs and Turkey Creeks, which are the primary drainageways for the installation and drain the majority of the area. The northern and northwestern sections (Basin I) are drained by Furst Creek, the eastern portion (Basin III) is drained by the Sulphur Creek complex, the extreme eastern portion (Basin II) is drained by Indiana Creek (not shown on Figure 2-3), and the southwestern section (Basin V) is drained by Seed Tick Creek. Also located within the installation are several small ponds and Lake Greenwood, an 800-acre lake in the northwestern portion of the installation.

2.7 GEOLOGY

2.7.1 General Geology and Stratigraphy

The geology at NSWC Crane is generally characterized by thin overburden deposits overlying bedrock. The overburden deposits generally range in depth from the surface down to 65 feet (Nohrstedt, et al., 1998a) below ground surface. These deposits generally consist of two types: Quaternary-age unconsolidated deposits and unconsolidated residual soil derived from the underlying bedrock. Bedrock underlying the Crane facility consists of sedimentary rocks from the Lower Pennsylvanian-age Raccoon Creek Group and the Upper Mississippian-age Stephensport and West Baden Groups. The following subsections describe the unconsolidated deposits and bedrock at NSWC Crane in greater detail.

2.7.2 Unconsolidated Deposits

The Quaternary-age unconsolidated deposits consist of alluvial (stream-derived sediments), colluvial (sediments at the foot of a slope via gravity), and glacial outwash deposits (derived from glaciers) consisting of clay, silt, sand, and gravel; lacustrine deposits (derived from lakes) consisting of clay, silt, and sand; and loess (wind blown deposits) deposits consisting of clay and silt.

Unconsolidated residual soil at NSWC Crane were derived from the underlying sedimentary rocks of the Lower Pennsylvanian Raccoon Creek Group and the Upper Mississippian Stephensport and West Baden Groups. These soils consist of clay, silt, sand, and fragmented and/or partially weathered bedrock. The residual soil derived from Pennsylvanian bedrock/colluvium is referred to hereafter as Pennsylvanian soil. The residual soil derived from Mississipian bedrock/colluvium is referred to hereafter as Mississippian soil.

Using the United States Department of Agriculture (USDA)/ Soil Conservation Service (SCS) soil classification system (McElrath, 1988), the soil at NSWC Crane has been classified into 23 soil series. More specifically, the soil at the 33 Solid Waste Management Units (SWMUs) at the facility has been classified into 15 soil series. Each of these soil series are defined by various soil characteristics (e.g., grain size, erosion, slope, drainage, parent material or depositional source, etc.) specific to the series. Within these soil series various sub-classes or soil map units have been defined. Table 2-1 lists the soil series and map units present throughout the facility and indicates the number of facility SWMUs where these soil series are present. USDA/SCS soil maps for NSWC Crane have been included in Appendix D of the Work Plan (TtNUS, October 1999a).

For the purposes of this study, the USDA/SCS soil classifications at NSWC Crane have been categorized according to their DE. The DE refers to the mechanism and parent material from which a soil was formed. Thus, the DE (more specifically the parent material) determines the chemical and mineralogical composition of the soil (McElrath, 1988). Other factors such as grain size also affect the chemical and mineralogical make-up of a particular soil. The soil at the facility has been subdivided into four DE classifications: (1) alluvium; (2) loess/glacial outwash; (3) residual soils derived from Pennsylvanian bedrock/colluvium; and (4) residual soils derived from Mississippian bedrock/colluvium. The following sections describe each of these DEs and the USDA soil series which are classified within each DE. Table 2-1 illustrates this soil classification.

2.7.2.1 Alluvial Deposits

Alluvial deposits (or alluvium) are defined as material that has been deposited by streams or running water. The Quaternary sequences of alluvium generally correspond to the Bartle, Birds, Bonnie, Burnside, Haymond, Pekin, Wakeland, and Wilbur USDA soil series (McElrath, 1988). Alluvium was mapped by Kvale (1992) where it was found greater than 7 feet thick. These deposits generally were found in major river valleys in the area. Kvale's (1992) classification of alluvium generally corresponds to the Haymond or Wakeland silt loam soil series.

Based upon the background samples collected in alluvial deposits from the investigation, this soil is predominantly silt and sand with some gravel and traces of clay. Most borings encountered refusal before 6 feet indicating that gravel may be more predominant at depth or bedrock may be very shallow in these areas. In one boring (BG3SBA05; see Appendix B), naturally occurring red staining (likely from iron nodules) was evident in the soil samples.

2.7.2.2 Loess/Glacial Deposits

The glacial outwash in Martin County is typically composed of stratified gravel, sand, and silt formed by running water from melting glaciers during the Illinoian Period (McElrath, 1988). The glacial deposits have been classified by McElrath (1988) as Negley, Parke, and Pike USDA soil series. Kvale (1992) however eliminated some Negley soils as glacial deposits. Glacial outwash deposits are found locally only in the northwest corner of the Crane facility.

As the Illinoian glacial ice receded, temporary glacial lakes formed. The fine-grained material deposited in these glacial lakes was carried by wind out of the White River valley and deposited in the adjacent uplands. These thin, uniform silt deposits are referred to as loess deposits. During the late Wisconsinan time, a thin mantle of these loess deposits (ranging from a few inches to several feet thick) were deposited throughout Martin County (McElrath, 1988) and the NSWC Crane facility. Loess deposits are typically fine-grained material, dominated by silt-sized particles. Hosmer soil are examples of relatively thick loess deposits primarily found on ridgetops (Kvale, 1992), where as Zanesville soil are examples where only a thin layer of loess has formed on the surface (McElrath, 1988).

Based upon the background samples collected in this investigation, the loess deposits at NSWC Crane are predominantly clay and silt with traces of fine sand. All borings were able to penetrate to the specified depth of 6 feet below ground surface indicating that bedrock is greater than 6 feet in depth in these areas. In one boring (BG1SBL03; Appendix B) naturally occurring red iron nodules were evident in the soil samples. Incidentally, in this same boring the highest photoionization detector (PID) readings (i.e., 551 ppm) were detected. The cause of these anomously high readings is unknown, although these PID readings could be the result of decomposing organic matter.

As is typical of most glacially derived sediment, glacial deposits at NSWC Crane consist of a wide range of grain sizes (e.g., clay, silt, sand, and gravel). These sorted and unsorted, glacially derived sediments are commonly referred to as glacial outwash and till, respectively, and are found in the northwestern portion of the facility. Most of the borings penetrated to the specified depth of 6 feet bgs. Those that hit refusal at less than 6 feet were likely a result of gravel or boulders.

2.7.2.3 Residual Soil from Bedrock/Colluvium

Most of the soil in Martin County was developed from bedrock residuum (McElrath, 1988). As mentioned in Section 2.7.2 these residual soils developed from the underlying sedimentary rocks of the Lower Pennsylvanian and Upper Mississippian formations. Because the make-up and characteristics of these two bedrock types are significantly different, the residual soils developed are expected to be different. As discussed in Section 2.7.3, the Pennsylvanian bedrock contains black shales, carbonaceous shales, and coal which are expected to have a higher metals content than the “cleaner” shale and limestone encountered in the Mississippian bedrock (Rupp, 1999). Colluvial deposits, which are soil and bedrock fragments that have been moved by gravity and deposited at the base of steep slopes, have been classified with the residual soil because they are expected to have similar characteristics. For the purposes of this investigation, the Pennsylvanian and Mississippian residual soil DEs were not differentiated to their stratigraphic map units (i.e., formations). For example, the Raccoon Creek Formation and the undifferentiated portion of the lower Pennsylvanian were not addressed separately and formations in the Mississippian DE were not addressed separately when evaluating a DE. However, Mississippian formations were considered in sample selection from the Mississippian residual soil DE (see Section 3.0).

Based upon the background samples collected residual soil predominantly consisted of silty clay and silt with traces of sand. Most borings were able to penetrate to the specified depth of 6 feet bgs indicating that bedrock is deeper than 6 feet in most areas. However in some areas bedrock was encountered with 3 feet of ground surface. One boring in the Pennsylvanian (BG1SBP01) and four borings in the Mississippian residual soil (BG3SBM01, 02, 03, 05; Appendix B) encountered what appeared to be naturally occurring red iron nodules and iron staining.

2.7.3 Bedrock

Bedrock underlying the Crane facility consists of sedimentary rocks from the Lower Pennsylvanian-age and the Upper Mississippian-age bedrock. The Lower Pennsylvanian bedrock (Raccoon Creek Group) at the facility primarily consists of interbedded sandstone, siltstone, shale, and coal with a total thickness varying from 0 to more than 300 feet (Fisher, 1996). The underlying Missisippian-age bedrock consists of limestone, shale and sandstone (Murphy and Wade, 1995 and Palmer, 1969). An unconformity separates the Pennsylvanian from the Mississippian rock units at Crane. The relief of the unconformity between the Pennsylvanian and Mississippian bedrock has been measured to be as much as 100 feet (Kvale, 1992).

Pennsylvanian bedrock are absent in the deepest present day drainage channels (e.g., Sulphur Creek, Turkey Creek) primarily due to erosion. In these locations the Mississippian-age bedrock is exposed. A large number of SWMUs are located on ridges or other topographically high areas, primarily on top of Pennsylvanian bedrock. One exception to this generalization is the Ammunition Burning Ground (ABG) which is located over Mississippian bedrock (Fisher, 1996). The surficial geology of the mappable geologic units at NSWC Crane is shown on Figure 2-4. An outline of the of SWMUs is included as an illustration of the type of surface bedrock material underlying these SWMUs.

The following paragraphs provide a brief description of the geologic formations as described by Palmer (1969), Murphy and Wade (1998) and Kvale (1992). They are presented from youngest (first) to the oldest units. These geologic units are also illustrated on the stratigraphic column illustrated on Figure 2-5.

a. Mansfield Formation and Undifferentiated Lower Pennsylvanian (Pennsylvanian Raccoon Creek Group). This unit consists of alternating beds of shales (e.g., black shale and carbonaceous shale), sandstone, mudstone, siltstone, and thin discontinuous coal units.

b. Glen Dean Limestone, Hardinsburg Formation, Golconda/Haney Limestone, Indian Springs Member, undifferentiated (Mississippian Stephensport Group). This unit consists of limestone (Glen Dean Formation), soft shale and cross-bedded sandstone (Hardinsburg Formation), shaley limestone and limey shales (Golconda/Haney Formation), and dark gray shale (Indian Springs Formation). Thickness of the unit ranges from 60-70 feet. This group is referred to as M6 (Kvale, 1992).

c. Big Clifty Sandstone member, Big Clifty Formation (Mississippian Stephensport Group). The Big Clifty sandstone is a tan to green-gray, massive to thick-bedded, rippled, fine- to very fine-grained, well sorted, rounded, friable sandstone with occasional shaly partings. Thickness of this unit ranges from 30 to 40 feet. This group is referred to as M5 (Kvale, 1992).

d. Beech Creek Limestone Formation (Mississippian Stephensport Group). The Beech Creek Limestone consisted of fossiliferous, hard limestone. Joints in the limestone were sparse to numerous in cores recovered from the 18 well borings penetrating the Beech Creek Formation. The Beech Creek formation displayed moderate to extensive solution-enlarged jointing at another site within NSWC Crane (Hunt, 1988). Thickness of this unit ranges from 20 to 25 feet. This group is referred to as M4 (Kvale, 1992).

e. Elwren Formation, Reelsville Limestone, Upper Sample Formation, undifferentiated (Mississippian West Baden Group). This unit consists of fine-grained interbedded sandstone and mudstone (Elwren Formation), a thin discontinuous limestone (Reelsville Limestone), and fine-grained sandstone (Upper Sample Formation). Thickness of this unit ranges from 65 to 75 feet. This group is referred to as M3 (Kvale, 1992).

e. Lower Sample Formation, Beaver Bend Limestone, Bethel Formation, undifferentiated (Mississippian West Baden Group). This unit consists of dark greenish gray shale (Lower Sample Formation), fossiliferous limestone (Beaver Bend Limestone), and a calcareous sandstone and shale (Bethel Formation). Thickness of this unit ranges from 50 to 60 feet. This group is referred to as M2 (Kvale, 1992).

f. Paoli Limestone, Ste. Genevieve, undifferentiated (Mississippian Blue River). This unit consists of oolitic limestone and undifferentiated limestone. Thickness of this unit is at least 35 feet (based upon exposure in Boone Hollow, northeastern corner of the facility). This group is referred to as M1 (Kvale, 1992).

Structurally, NSWC Crane is located on the eastern edge of the Illinois Structural Basin, where the Pennsylvanian and Mississippian age bedrock dips to the west-southwest and southwest at approximately 30 to 35 feet per mile (Dunbar, 1982, p. 10 and Kvale, 1992). Locally, however the dip of the Mississippian bedrock can range from 0 to 15 feet per mile to as much as 100 feet per mile (Sulphur Creek; Kvale, 1992).

2.8 HYDROGEOLOGY

In general, groundwater in the unglaciated portion of southwestern Indiana is present in surficial unconsolidated aquifer(s) and underlying bedrock aquifers consisting of primarily sandstone and limestone. Bedrock aquifers are generally isolated from one another vertically by less permeable shale units. Groundwater enters the aquifers through outcrops and infiltration, and flows by gravity down the dip of the strata or locally in directions controlled by the potentiometric gradient.

Regionally, groundwater flow is expected to conform to the southwestward-dipping bedrock with a gradient approaching the dip. Locally, water-level measurements from wells generally show that groundwater flow direction agreed with local surface drainage. Seasonal fluctuations in the water table are expected to be slight because precipitation is well distributed throughout the year (Murphy, 1994; Murphy and Wade, 1995).

2.9 FACILITY HISTORY

This section contains a brief summary of the general history of NSWC Crane and the Solid Waste Management Units (SWMUs) present at the facility.

2.9.1 General History

The facility was commissioned in 1941 as the Naval Ammunition Depot (NAD) Burns City, to serve as an inland munitions production and storage center for the US Navy. The name of the facility was changed in 1943 to NAD Crane, in 1975 to the Naval Weapons Support Center, and in 1992 to NSWC Crane. The facility was constructed on land publicly acquired under the White River Land Utilization Project (35,000 acres) and land purchased from private ownership (26,830 acres) beginning in 1934. Prior to its acquisition by the Navy, the land was largely used for timber and agriculture (Poynter, 1999). The Department of Defense (DOD) ammunition procurement responsibility was transferred to the Army in 1977. The Army assumed ordnance production, storage, and related responsibilities under the single service management directive. All environmental activities on the installation remain the responsibility of the Navy.

2.9.2 Past Data Collection Activities

This section includes a brief description of the historic data collection activities conducted at NSWC Crane. The following summary has been generated using reports and supporting documents (submitted by other contractors) provided by NSWC Crane.

The first investigations performed at the NSWC Crane were the IA (Army, 1978) and the IAS (NEESA, 1983). Performed in 1977, the IA consisted of an extensive records search and interviews with former and present employees at NSWC Crane. The purpose of the IA was to investigate potential contaminant releases to the environment from past operations and to determine the potential of these releases to migrate beyond the facility boundaries. The IAS began in April 1981 in response to the Navy Assessment and Control of Installation Pollutants (NACIP) Program and was completed in May 1983 by the Naval Energy and Environmental Support Agency (NEESA) with assistance from the Ordnance Environmental Support Agency and the United States Army Corps of Engineers (USACE) Waterways Experiment Station (WES). The intent of the IAS was to identify and assess sites posing a potential threat to human health and the environment from past hazardous materials operations. Although none of the sites investigated were determined to represent immediate human health or environmental threats, 14 sites were recommended for further study to evaluate potential long-term impacts.

Based on these investigations and others (submitted by other contractors), 33 SWMUs have been identified at NSWC Crane (EPA, 1995). Table 2-2 lists each SWMU and briefly summarizes the Solid Waste Management Area (SWMA) classification, processes, and presumed metals (only) of potential concern at each of these SWMUs. Figure 2-4 illustrates the location and identification of each of these SWMUs.

2.9.2.1 Air Quality Assessment

Based on the predominant wind direction at NSWC Crane (Section 2.5) the southwest quadrant of the facility is less likely to have received fallout from airborne contaminant releases from the OB/OD (e.g., Ammunition Burning Grounds, Old Rifle Range, and Demolition Range) operations. Based on the predominant wind direction this area also is less likely to experience any potential contaminants from the Field Testing Ranges (Pyrotechnic Test Area, Annex, and Rocket Range [SWMU 19/00]) which are located to the east.

The RCRA Air Quality Assessment Report (B&R Environmental, 1997a) assessed the effects of airborne particulates from OB/OD (e.g., Ammunition Burning Grounds, Old Rifle Range, and Demolition Range) activities on the surrounding areas. This report however did not determine the maximum distance of impact on the surrounding areas from particulates released from OB/OD activities. Areas at the greatest distance downgradient (downwind) from these areas are least likely to be affected by any airborne releases.

The Old Open Burn Pit (SWMU 05/03) may have released particulates during the daily open burning of refuse. Activities at this site were discontinued in 1972. Based on the prevailing wind direction (Section 2.5), areas to the west of the Old Burn Pit are less likely to have been affected by airborne particulates released from this area than are areas to the east.

The Crane Army Ammunition Activity (CAAA) QA/QC Test Area (SWMU 20/00), which is located in the center of the NSWC Facility (see Figure 2-4) also may be a source for airborne particulates. At this site, flare testing was conducted which produced a lot of smoke (there are even signs in the area of operation which warn that the visibility on the road may be obscured by smoke; Brent, 1999). Although no longer in operation, the Building 146 incinerator (SWMU 16/16) was also a source for airborne emissions. This site is located in the north-central portion of the NSWC facility (Figure 2-4).

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TABLE 2-1

USDA/SCS SOIL CLASSIFICATIONS PRESENT AT NSWC CRANE[1]
NAVAL SURFACE WARFARE CENTER
CRANE, INDIANA
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Depositional Environment	Soil Series	Soil Type	Present at # of SWMUs	Soil Classification[2]		Soil Classification[3]		Description	Location	Type of Deposition (McElrath, 1988)
				Surface Soil[4]	Subsurface Soil[5]	Surface Soil[4]	Subsurface Soil[5]			
Alluvium	Bartle	Ba	0	silt loam	silt loam to silty clay loam	CL, CL- ML	CL, CL- ML	0 to 2 percent slopes, gently sloping, deep, poorly drained	lowlands	Lake plains & stream terraces
	Birds	Bk	2	silt loam	silt loam	CL	CL	frequently flooded, nearly level, deep, poorly drained; on broad bottom land.	lowlands	Alluvium derived from loess uplands
	Bonnie	Bo	0	silt loam	silt loam	CL	CL	0 to 2 percent slopes, gently sloping, deep, poorly drained	lowlands	Alluvium derived from loess uplands
	Burnside	Bu	4	loam	loam to channery loam	ML, CL, ML-CL	ML-CL, SC, GC, SM, GM	occassionally flooded, nearly level, deep, well drained; on flood plains	flood plains	Alluvium derived from sandstone, siltstone, and shale
	Haymond	Hd	3	silt loam	silt loam	ML	ML, SM	frequently flooded, nearly level, deep, well drained; on bottom land	lowlands	Silty alluvium
	Pekin	PeB	0	silt loam	silt loam to silty clay loam	CL-ML	CL-ML	2 to 6 percent slopes, deep, well drained	outwash terraces	Loess and underlying alluvium
	Wakeland	Wa	4	silt loam	silt loam	ML	ML	frequently flooded, nearly level, deep, somewhat poorly drained	flood plains	Silty alluvium derived from loess uplands
	Wilbur	Wr	0	silt loam	silt loam	ML, CL-ML	ML, CL-ML	0 to 2 percent slopes, deep, poorly drained	lowlands	Alluvium derived from loess uplands
	Hosmer	HoB	2	silt loam	silt loam to silty clay loam	ML, ML-CL, CL	ML, ML-CL, CL	2 to 6 degree slopes, gently sloping, deep, well drained	uplands & ridgetops and on loess-capped lake plains.	Loess
Loess/ Glacial Outwash	Camden	CaB	0	silt loam	silt loam,clay loam, sandy loam	CL, ML-CL	ML, CL, SM, SC	1 to 5 percent slopes, deep, well drained	stream terraces	Loess and underlying outwash material
	Negley	NeE	2	silt loam to loam	loam, clay loam, gravely loam	ML, ML-CL, CL	SM, ML	8 to 35 percent slopes, moderately steep to steep, deep, well drained	loess and outwash	Loess capped and underlying outwash material
	Parke	PaC2	1	silt loam	silty clay loam to sandy clay loam	CL-ML	SC, CL	6 to 18 percent slopes	uplands & sideslopes	Loess capped and underlying outwash material
	Pike	Pk	0	silt loam	silt loam to silty clay loam	CL	CL, SC	2 to 6 percent slopes, deep, well drained	outwash terraces	Loess capped and underlying outwash material
Residual Soil from Bedrock (both Pennsylvanian & Mississippian)/ Colluvium	Johnsburg	Jo	0	silt loam	silty clay loam, silt loam, to sandy loam	CL, ML-CL	ML, CL, SM, SC	0 to 2 percent slopes, deep, poorly drained	uplands	Loess and material weathered from SS, siltstone, shale.
	Udorthents	UhD	1	shaly silty clay loam	shaly silty clay loam	CL-ML, CL, ML	CL-ML, CL, ML	6 to 14 percent slopes, moderately steep to steep, moderately deep to deep, well drained	uplands	Excavated areas formerly used as landfills
	Udorthents-Pits complex	Up	1	gravelly sand	gravel	GM	GM	NA	uplands	Material left from sandstone quarries and sand pits
	Wellston	WeB	1	silt loam	silt loam, silty clay loam, to channery loam	ML	CL-ML, CL, SC, SM-SC	2 to 6 percent slopes, gently sloping, deep, well drained	ridgetops	Loess and material weathered from SS, siltstone, shale.
		WeC2	5	silt loam	silt loam, silty clay loam, to channery loam	ML	CL-ML, CL, SC, SM-SC	6 to 12 percent slopes, eroded, moderately sloping, deep, well drained	ridgetops and sideslopes in uplands	Loess and material weathered from SS, siltstone, shale.

TABLE 2-1

USDA/SCS SOIL CLASSIFICATIONS PRESENT AT NSWC CRANE[1]
NAVAL SURFACE WARFARE CENTER
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Depositional Environment	Soil Series	Soil Type	Present at # of SWMUs	Soil Classification[2] Surface Soil[4]	Soil Classification[2] Subsurface Soil[5]	Soil Classification[3] Surface Soil[4]	Soil Classification[3] Subsurface Soil[5]	Description	Location	Type of Deposition (McElrath, 1988)
Residual Soil from Bedrock (both Pennsylvanian & Mississippian)/ Colluvium		WeD2	8	silt loam	silt loam, silty clay loam, to channery loam	ML	CL-ML, CL, SC, SM-SC	12 to 18 percent slopes, eroded, steeply sloping, deep, well drained	sideslopes in uplands	Loess and material weathered from SS, siltstone, shale.
		WeD3	3	silt loam	silt loam, silty clay loam, to channery loam	ML	CL-ML, CL, SC, SM-SC	12 to 18 percent slopes, severly eroded, steeply sloping, deep, well drained	sideslopes in uplands	Loess and material weathered from SS, siltstone, shale.
	Wellston-Ebal	WID	0	silt loam	silt loam, silty clay loam, to channery loam	ML	CL-ML, CL, SC, SM-SC, CH, GC	10 to 18 percent slopes, deep, well drained	sideslopes in uplands	Loess, colluvium, and material weathered from SS, siltstone, shale.
	Wellston-Berks-Gilpin complex	WgG	5	silt loam to channery silt loam	silt loam, silty clay loam, to channery loam	ML, CL, CL-ML, SC, GM, GC	CL-ML, CL, SC, SM-SC	18 to 70 percent slopes, moderately to very steep, deep, well drained	sideslopes in uplands	Loess and material weathered from SS, siltstone, shale.
	Wellston-Gilpin complex	WnE	16	silt loam to channery silt loam	silt loam, silty clay loam, to channery loam	ML, CL, CL-ML, SC, GM, GC	CL-ML, CL, SC, SM-SC	12 to 30 percent slopes, strongly sloping to steep, moderately deep	sideslopes in uplands	Loess and material weathered from SS, siltstone, shale.
	Wellston-Udorthents complex	WpD[6]	8	silt loam to silty clay loam	silt clay loam to channery loam	ML, CL, CL-ML	CL-ML, CL, SC, SM-SC	12 to 18 percent slopes, strongly sloping, very shallow to deep	sideslopes in uplands	Loess and material weathered from SS, siltstone, shale.
	Zanesville	ZaB	6	silt loam to silty clay loam	silty loam, to sandy clay loam	CL-ML, CL, ML	CL-ML, CL, ML, SC, SM, GM	2 to 6 percent slopes, gently sloping, deep, moderately to well drained	ridgetops in uplands	Loess and material weathered from SS, siltstone, shale.
		ZaC2	7	silt loam to silty clay loam	silty loam, to sandy clay loam	CL-ML, CL, ML	CL-ML, CL, ML, SC, SM, GM	6 to 12 percent slopes, eroded, moderately sloping, deep, moderately to well drained	ridgetops and sideslopes in uplands	Loess and material weathered from SS, siltstone, shale.
		ZaC3	2	silt loam to silty clay loam	silty loam, to sandy clay loam	CL-ML, CL, ML	CL-ML, CL, ML, SC, SM, GM	6 to 12 percent slopes, severally eroded, moderately sloping, deep, moderately to well drained	ridgetops and sideslopes in uplands	Loess and material weathered from SS, siltstone, shale.
	Zanesville-Udorthents complex	ZnB[6]	13	silt loam to silty clay loam	silt loam, silty clay loam to loam	CL-ML, CL, ML	CL-ML, CL, ML, SC, SM, GM	2 to 6 percent slopes, gently sloping, moderately to well drained	ridgetops in uplands	Loess and material weathered from SS, siltstone, shale.
		ZnC[6]	17	silt loam to silty clay loam	silt loam, silty clay loam to loam	CL-ML, CL, ML	CL-ML, CL, ML, SC, SM, GM	6 to 12 percent slopes, gently sloping, moderately to well drained	ridgetops in uplands	Loess and material weathered from SS, siltstone, shale.

Notes:
USDA United States Department of Agriculture; SS - Sandstone; SWMU - solid waste management units
SCS Soil Conservation Service; NA - Not available

1. Information taken from McElrath (1988).
2. United States Department of Agriculture (USDA) classification system
3. Unified Soil Classification System (USCS), abbreviations are as follows
   - CL - Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays
   - ML - Inorganic silts and very fine sands, rock flour, silty or clayey fine sands with slight plasticity
   - SC - Clayey sands, poorly graded sand-clay mixtures
   - SM - Silty sands, poorly graded sand-silt mixtures
   - GM - Silty gravels , poorly graded gravel-sand-silt mixtures
   - GC - Clayey gravels, poorly graded gravel-sand-clay mixtures.
4. Surface soil is from 0 to 12 inches below ground surface (bgs) based upon classification by McElrath (1988).
5. Subsurface soil is between 12 to 70 inches bgs or to the top of bedrock based upon classification by McElrath (1988).
6. Soil at areas at the NSWC where a significant amount of construction and earth moving has removed most of the original soil, which has been deposited as fill on building sites.

TABLE 2-2

**SUMMARY SOLID WASTE MANAGEMENT UNITS
NAVAL SURFACE WARFARE CENTER
CRANE, INDIANA
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SWMU No.	SWMU Name	Abbreviated Name	Solid Waste Management Area (SWMA) Classification[1]	Process	Presumed Contaminants of Potential Concern[(4)] (metals only)	Source
01/12	Mustard Gas Burial Grounds	MGBG	Burial Area	burial of mustard agent, pyrotechnic mixtures containing radioactive thorium	Strontium and Thorium	Army, 1978 TtNUS, 2000a
02/11	Dye Burial Grounds	DBG	Burial Area	disposal of military smoke dyes (open and closed containers) in trenches	NA[2]	Army, 1978
03/10	Ammunition Burning Grounds/Old Jeep Trail	ABG/OJT	Explosive Type Waste (open burning/open detonation)	destruction of unwanted materials contaminated with explosives, bare explosives, rocket motors, candles, flares, solvents, detonators, and fuse materials.	aluminum, barium, lead, manganese, copper, silver, zinc	B&R Environmental, 1997a, 1997b
04/02	McComish Gorge	McCG	Solid Waste/Debris Landfill Unit	undefined garbage and trash burial (consisting of wood, paper, construction material, plaster filled warheads, metal shavings and industrial wastes).	antimony, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, iron, lead, selenium, thallium, and zinc	Nohrstedt, J.S., et. al, 1998a[3]
05/03	Old Burn Pit	OBP	Solid Waste/Debris Landfill Unit	open burning of solid and liquid wastes; ash/material from burning pushed into gully north of pit	antimony, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, iron, lead, mercury, nickel, selenium, silver, thallium, and zinc	Albertson et. al, 1998[3]
06/09	Demolition Range	DEMO	Explosive Type Waste	open burning/open detonation	arsenic, aluminum, beryllium, copper, lead, manganese, nickel, vanadium, zinc	B&R Environmental, 1997a, 1997b
07/09	Old Rifle Range	ORR	Explosive Type Waste/Contamination	open burning/flashing of explosives, thermal destruction of explosive waste	arsenic, aluminum, barium, beryllium, manganese, lead, and zinc	B&R Environmental, 1997b
08/17	Load & Fill Area, Bldg 106 Pond	106P	Unique Explosive, Dye Type Waste/Contamination	unlined surface impoundment from wastewater generated from Buildings 106 and 107	mercury, chromium, zinc, lead, cadium,	Halliburton NUS, 1992
09/03	Pesticide Control Area/ R-150-Tank	PCA	Organic Type Waste/Contamination	pesticide rinsing and container storage; solvents underground storage tanks	arsenic, barium, cadmium, chromium, lead, mercury, nickel, selenium, and zinc	Nohrstedt, J.S., et. al, 1998b[3]
10/15	Rockeye	RKT	Explosive Type Waste/Contamination	press-loading operation for projectiles and case-filling operation to produce cluster bombs	antimony, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, iron, lead, nickel, tin, and zinc.	USACE, 1992[3]
11/00	Old Storage, B-255	B225	Unique Explosive, Dye Type Waste/Contamination	NA	NA	NA
12/14	Mine Fill A	MFA	Explosive Type Waste/Contamination	manufactured mines, depth charges, rocket heads, aerial bombs, and projectiles	aluminum	Halliburton NUS, 1992
13/14	Mine Fill B	MFB	Explosive Type Waste/Contamination	manufactured mines, depth charges, rocket heads, aerial bombs, and projectiles - currently the site is used for renovation and rework of munition items	none	Halliburton NUS, 1992

TABLE 2-2

SUMMARY SOLID WASTE MANAGEMENT UNITS
NAVAL SURFACE WARFARE CENTER
CRANE, INDIANA
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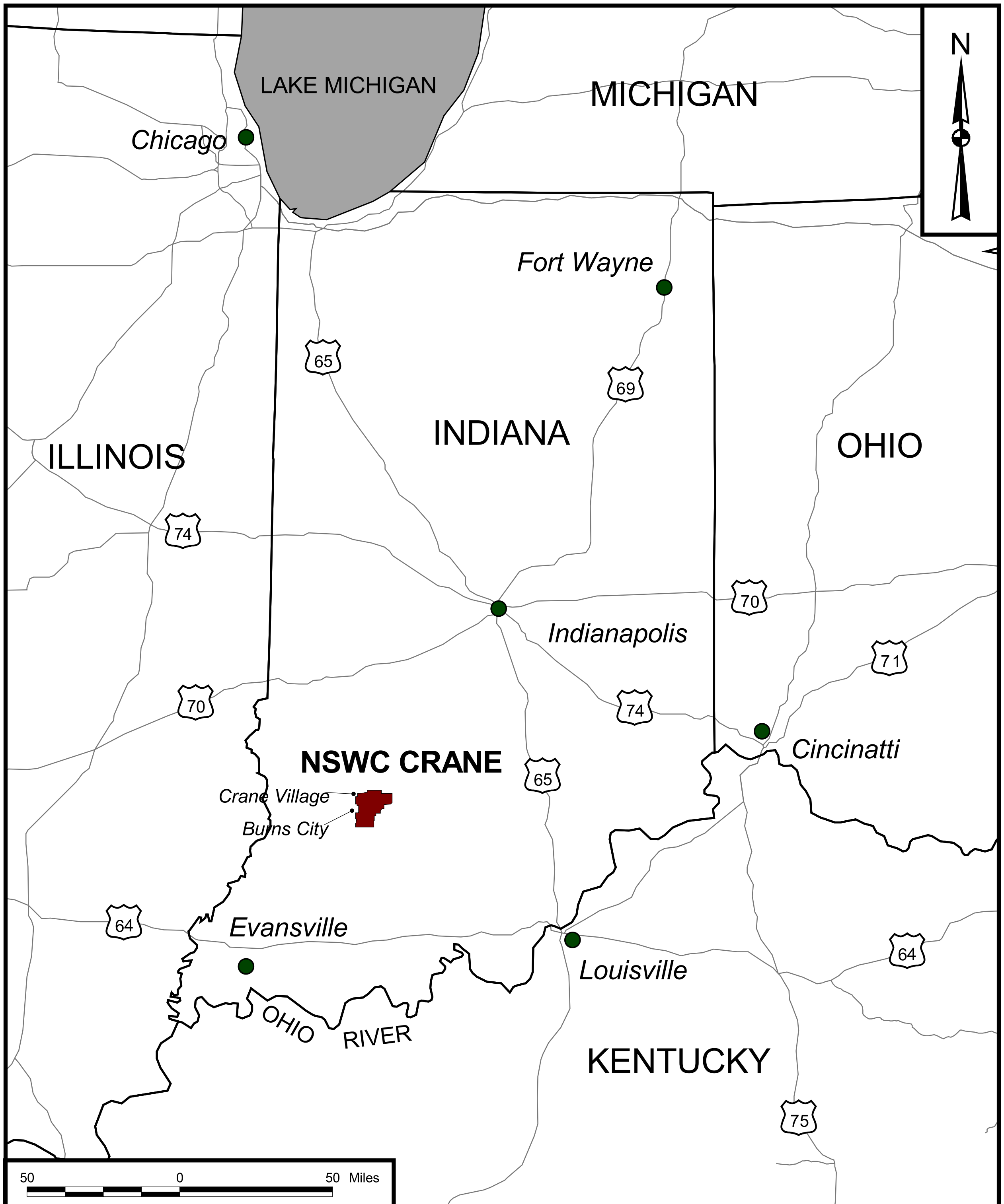
SWMU No.	SWMU Name	Abbreviated Name	Solid Waste Management Area (SWMA) Classification[1]	Process	Presumed Contaminants of Potential Concern[(4)] (metals only)	Source
14/00	Sanitary Landfill/Lithium Battery	SLF&LB	Burial Area	receives trash and garbage from production operations and residential and food preparation areas; also the burial of neutralized lithium batteries	barium, magnesium, lithium	Halliburton NUS, 1992
15/06	Roads and Grounds Area	R&GA	Solid Waste/Debris Landfill Unit	asphalt production, steam generation, and inert storage	barium, chromium, lead, arsenic, barium, cadium, mercury, selenium, silver	Halliburton NUS, 1992
16/16	Cast High Explosive Fill/ Incinerator Bldg 146	B146	Explosive Type Waste/Contamination	oil-fed rotary kiln incinerators; currently used for renovation and breakdown of munitions	barium, cadmium, chromium, lead, mercury	Halliburton NUS, 1992
17/04	PCB Burial/Pole Yard	PCB	Burial Area	NA	NA	NA
18/13	Load & Fill Area Buildings	L&FAB	Unique Explosive, Dye Type Waste/Contamination	loading of ammunition, storage of paints, solvents, dyes, inks, wood perservatives,	mercury, chromium, cadmium	Army, 1978; NEESA 1983
19/00	Pyrotechnic Test Area/ Annex/ Rocket Range/ Impact Area	PTA	Explosive Type Waste/Contamination	functional tests on flares, signals, other marking devices, and Rockeye bomblets	lead, aluminum, magnesium, *manganese, barium*, chromium, copper, iron, zinc	Halliburton NUS, 1992
20/00	CAAA QA/QC Test Area	CAAA	Explosive Type Waste/Contamination	Flare Testing	chromium and Lead	Army 1978
21/00	DRMO Storage Lot	DRMO	Heavy Metal Type Waste/Contamination	NA	NA	NA
22/00	Lead Azide	PbA	Heavy Metal Type Waste/Contamination	NA	lead	NEESA, 1983
23/00	Battery Shop	BS	Solid Waste/Debris Landfill Unit	NA	arsenic, beryllium, cobalt and lead	Morrison Knudsen, 1996
24/00	Sludge Drying Beds A	SDBA	Heavy Metal Type Waste/Contamination	NA	NA	NA
24/00	Sludge Drying Beds B	SDBB	Heavy Metal Type Waste/Contamination	NA	NA	NA
25/07 D	Highway 58 Dump Site A	H58DSA	Solid Waste/Debris Landfill Unit	NA	arsenic, beryllium, cobalt	Morrison Knudsen, 1999
26/08 D	Highway 58 Dump Site B	H58DSB	Solid Waste/Debris Landfill Unit	NA	arsenic, barium, beryllium, cobalt, and lead	Morrison Knudsen, 1997
27/00	Illuminant Building	IB	Heavy Metal Type Waste/Contamination	NA	NA	NA
28/00	Maintenance Shop, B-1820	MS	Organic Type Waste/Contamination	NA	NA	NA
29/07	PCP Dip Tank	PCP	Organic Type Waste/Contamination	NA	NA	NA
30/00	Landfarm (Sludge Application Area)	LF	Heavy Metal Type Waste/Contamination	sludge application from waste water treatment plant	*barium, cadmium, chromium*	USACE, 1995
31/00	Compressed Gas Cylinder Site	CGC	Removal of Materials Completed	No Further Action Required[1]	--	USEPA, 1995
32/00	Tank Farm	TF	Organic Type Waste/Contamination	NA	NA	NA
33/00	Composting Unit (Bioremediation Facility)	COMP	Explosive Type Waste/Contamination	remediation facility	NA	NA

Notes:
-- *Not applicable*
NA Not Available
1 RCRA Permit, USEPA, July, 1995
2 Soil analyses not conducted at site. RCRA cap prevents exposure to contaminated soil.
3 Contaminants of potential concern identified based on comparison of historical data to human health and ecological risk-based criteria.
4 Metals listed are based upon analytical data; also see note 3 where applicable.



DRAWN BY J. LAMEY	DATE 3/9/00	Tetra Tech NUS, Inc.	CONTRACT NUMBER 0087	OWNER NO. CTO 83	
CHECKED BY	DATE	GENERAL LOCATION MAP NAVAL SURFACE WARFARE CENTER CRANE, INDIANA	APPROVED BY K. HENN	DATE 3/9/00	
COST/SCHEDULE-AREA			APPROVED BY	DATE	
SCALE AS NOTED			DRAWING NO. FIGURE 2-1		REV 1

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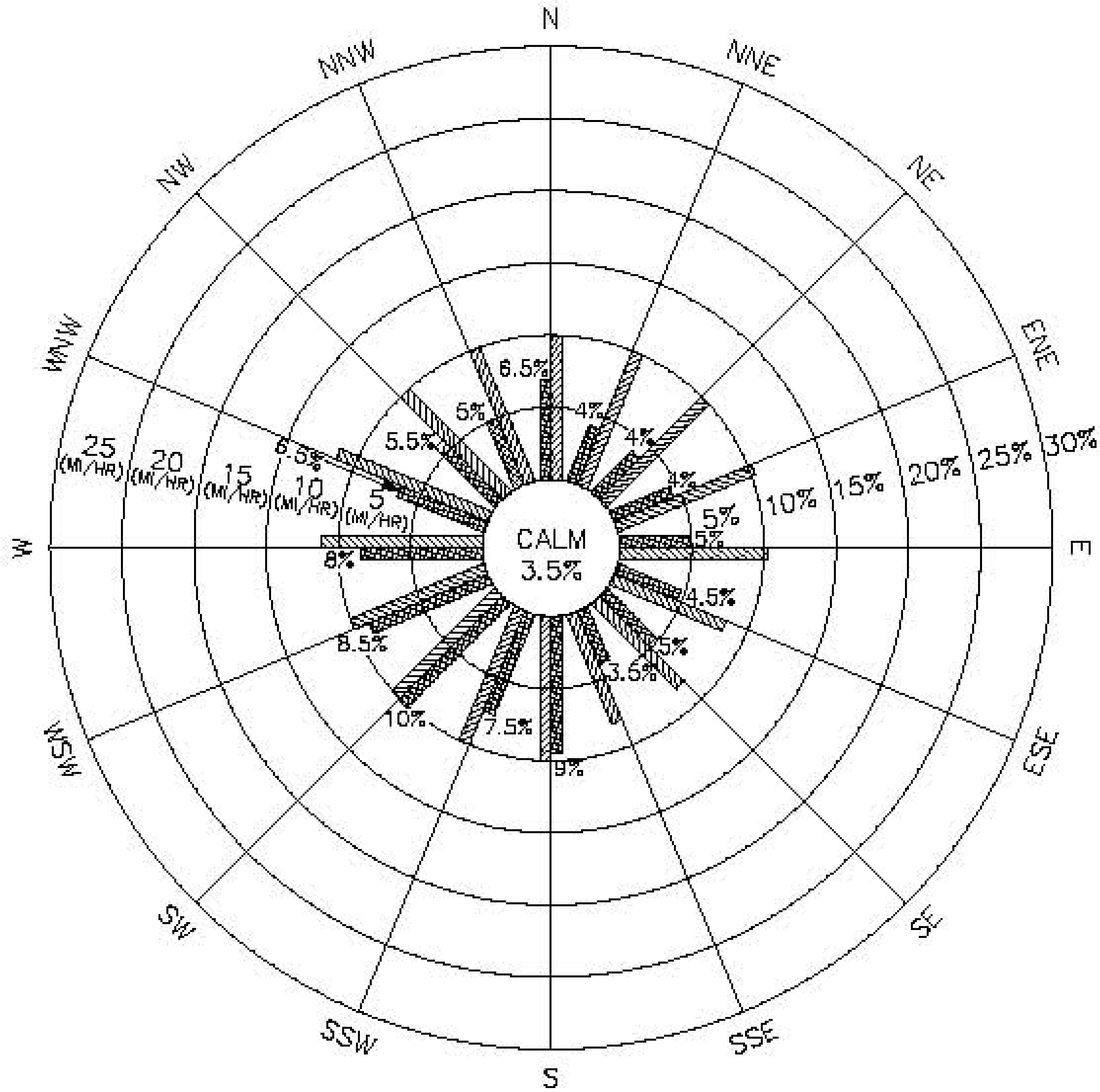
ACAD: 0087km02.dwg 04/26/01 HJP



LEGEND

9% WIND DIRECTION FREQUENCY (APPROXIMATE PERCENT) (DIRECTION FROM WHICH THE WIND IS BLOWING)

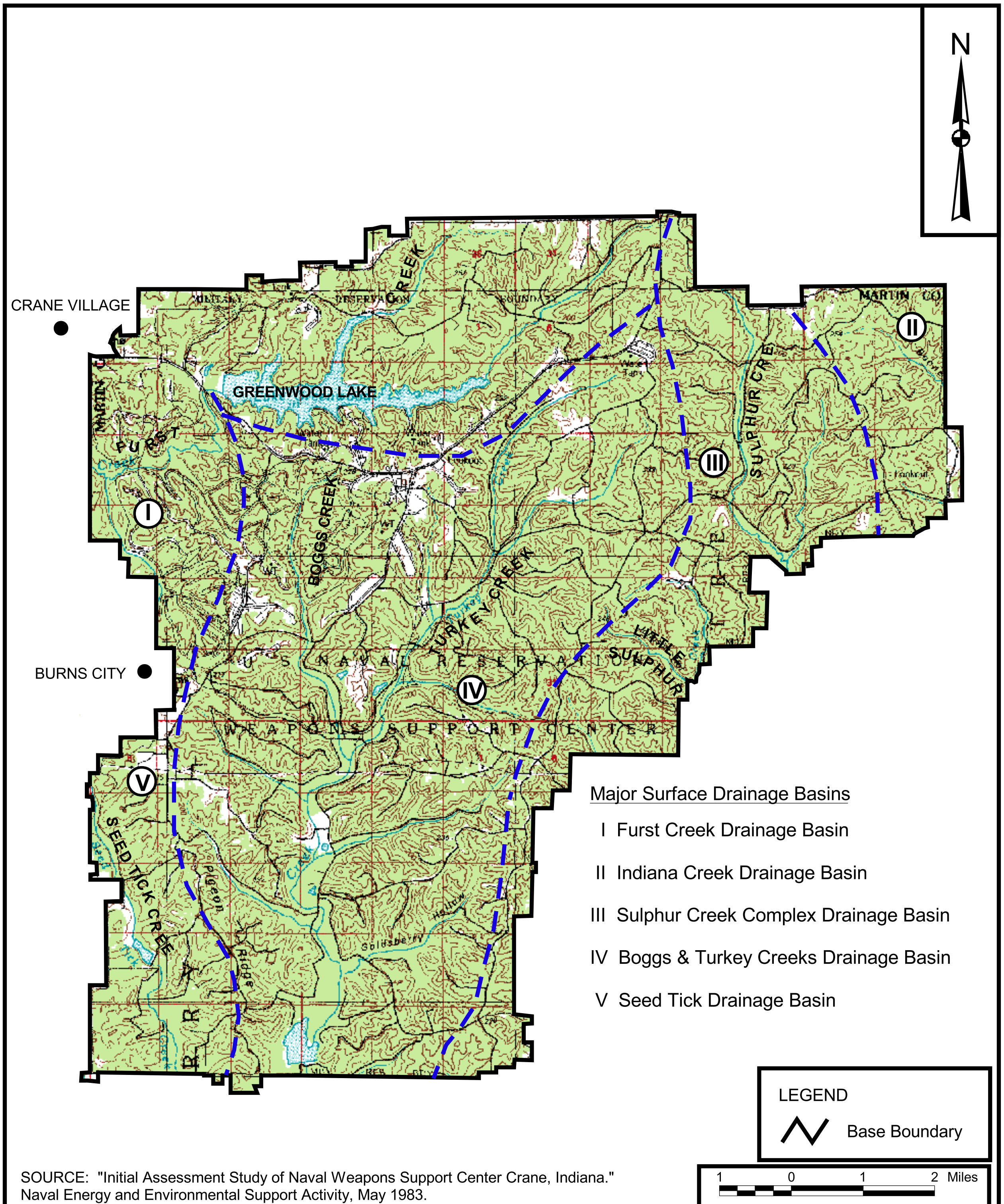
MEAN WIND SPEED (MI/HR)

DATA SOURCE: INDIANAPOLIS, INDIANA AIRPORT

PERIOD OF RECORD: 1985–1989
43,824 OBSERVATIONS

DRAWN BY HJP	DATE 7/6/00	FIVE-YEAR WINDROSE SUMMARY FOR INDIANAPOLIS, INDIANA NAVAL SURFACE WARFARE CENTER CRANE, INDIANA	CONTRACT NO. 0087
CHECKED BY	DATE		APPROVED BY K. HENN DATE 7/6/00
COST/SCHED-AREA			APPROVED BY DATE
SCALE NOT TO SCALE			DRAWING NO. FIGURE 2-2 REV. 3

FORM CADD NO. SDIV_AV.DWG – REV 0 – 1/20/98



SOURCE: "Initial Assessment Study of Naval Weapons Support Center Crane, Indiana." Naval Energy and Environmental Support Activity, May 1983.

DRAWN BY J. LAMEY	DATE 4/19/99	Tetra Tech NUS, Inc.	CONTRACT NUMBER 0087	OWNER NO. CTO 83
CHECKED BY K. HENN	DATE 7/6/00	SURFACE DRAINAGE AT THE NAVAL SURFACE WARFARE CENTER CRANE ,INDIANA	APPROVED BY K. HENN	DATE 7/6/00
COST/SCHEDULE-AREA			APPROVED BY —	DATE —
SCALE AS NOTED			DRAWING NO. FIGURE 2-3	REV 1

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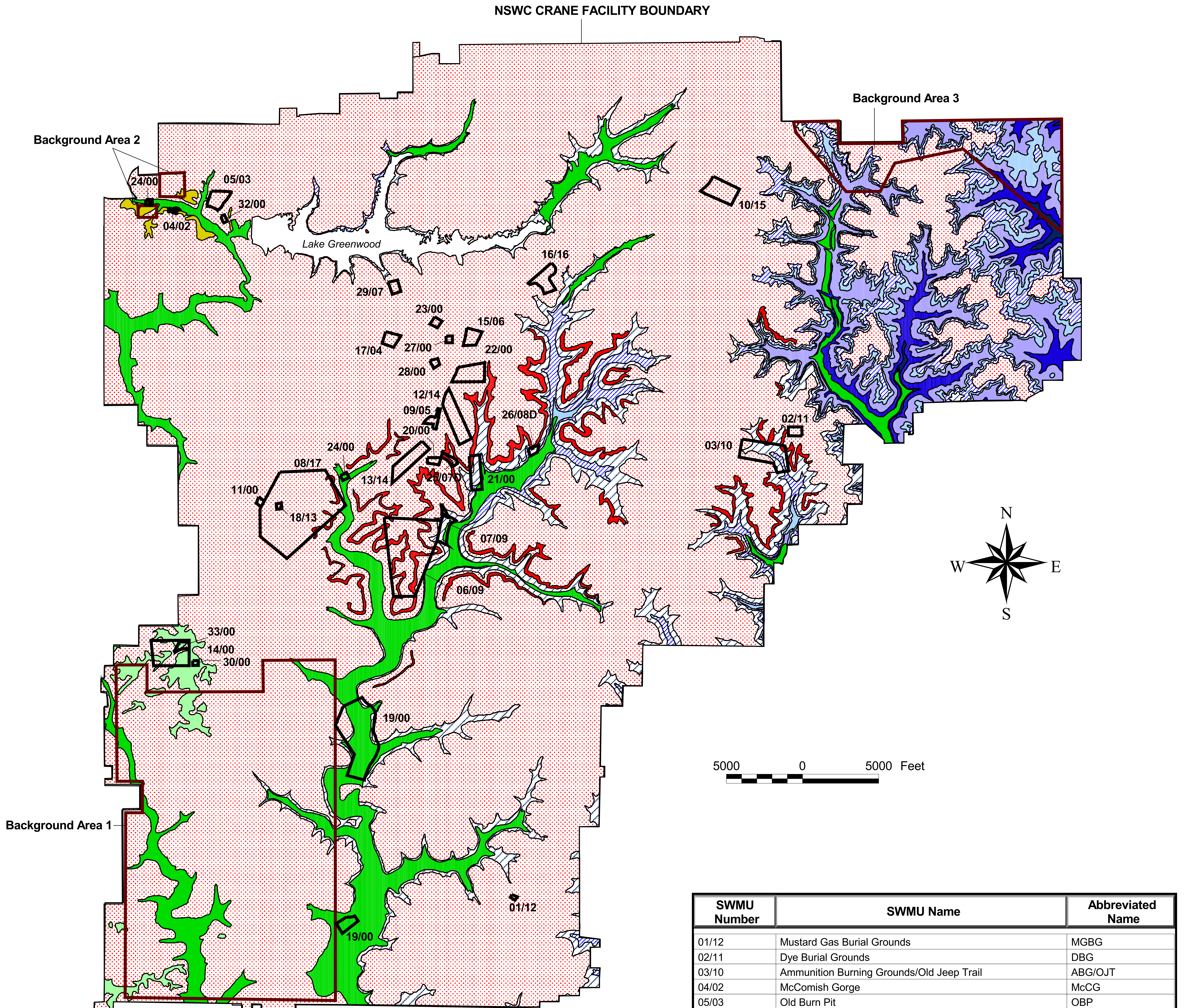

Inferred Depositional Environment	Explanation of Geology	
Alluvium	Qal	*Alluvium*
Loess/Glacial Outwash	Ql	*Loess*
	Qo	*Glacial Outwash*
Residual Soil derived from Pennsylvanian bedrock/colluvium	P	*Raccoon Creek Group and undifferentiated*
	Ps	*Sandstone-dominated horizon of Lower Pennsylvanian*
Residual soil derived from Mississippian bedrock/colluvium	M6	*Glenn Dean Ls, Hardinsburg Fm, Haney Ls, Indian Springs Shale Mbr, and undifferentiated*
	M5	*Sandstone member of the Big Clifty Fm*
	M4	*Beech Creek Ls*
	M3	*Elwren Fm, Reelsville Ls, upper Sample Fm, and undifferentiated*
	M2	*Lower part of Sample Fm, Beaver Bend Ls, Bethel Fm, and undifferentiated*
	M1	*Paoli Ls, Ste Genevieve Ls, and undifferentiated*

Select Solid Waste Management Units (SWMUs; Refer to Table 2-2 for a description of each SWMU)

Outline of Background Areas

SWMU Number	SWMU Name	Abbreviated Name
01/12	Mustard Gas Burial Grounds	MGBG
02/11	Dye Burial Grounds	DBG
03/10	Ammunition Burning Grounds/Old Jeep Trail	ABG/OJT
04/02	McComish Gorge	McCG
05/03	Old Burn Pit	OBP
06/09	Demolition Range	DEMO
07/09	Old Rifle Range	ORR
08/17	Load & Fill Area, Bldg 106 Pond	106P
09/03	Pesticide Control Area/ R-150-Tank	PCA
10/15	Rockeye	RKT
11/00	Old Storage, B-255	B225
12/14	Mine Fill A	MFA
13/14	Mine Fill B	MFB
14/00	Sanitary Landfill/Lithium Battery	SLF&LB
15/06	Roads and Grounds Area	R&GA
16/16	Cast High Explosive Fill/ Incinerator Bldg 146	B146
17/04	PCB Burial/Pole Yard	PCB
18/13	Load & Fill Area Buildings	L&FAB
19/00	Pyrotechnic Test Area/ Annex/ Rocket Range/ Impact Area	PTA
20/00	CAAA QA/QC Test Area	CAAA
21/00	DRMO Storage Lot	DRMO
22/00	Lead Azide	PbA
23/00	Battery Shop	BS
24/00	Sludge Drying Beds A	SDBA
24/00	Sludge Drying Beds B	SDBB
25/07 D	Highway 58 Dump Site A	H58DSA
26/06 D	Highway 58 Dump Site B	H58DSB
27/00	Illuminant Building	IB
28/00	Maintenance Shop, B-1820	MS
29/07	PCP Dip Tank	PCP
30/00	Landfarm	LF
31/00	Compressed Gas Cylinder Site	CGC
32/00	Tank Farm	TF
33/00	Composting Unit (Bioremediation Facility)	COMP

DRAWN BY J. LAMEY DATE 6/16/00 CHECKED BY ___ DATE ___ COST/SCHEDULE-AREA SCALE AS NOTED	Tetra Tech NUS, Inc.	SURFICIAL GEOLOGY, DEPOSITIONAL ENVIRONMENTS, AND SOLID WASTE MANAGEMENT UNIT LOCATION MAP NAVAL SURFACE WARFARE CENTER CRANE, INDIANA	CONTRACT NO. 0087 APPROVED BY K. HENN APPROVED BY ___ DRAWING NO. FIGURE 2-4	OWNER NO. 0083 DATE 6/16/00 DATE ___ REV. 2

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PERIOD	EPOCH	THICKNESS (FEET)	LITHOLOGY	FORMATION	GROUP
PENNSYLVANIAN	POTTSVILLE	150-300		MANSFIELD FM.	"RACCOON CREEK"
MISSISSIPPIAN	CHESTER	20-30		GLEN DEAN LS	STEPHENSPORT
		30-40		HARDINSBURG SS.	
		40-50		GOLCONDA LS.	
		25-40		BIG CLIFTY FM.	
		15-25		BEECH CREEK LS.	
		20-40		ELWREN FM.	WEST BADEN
		0-5		REELSVILLE LS.	
		20-40		SAMPLE FM.	
		10-20		BEAVER BEND LS.	
		12-30		BETHEL FM.	
	MERAMEC	15-20		PAOLI LS.	BLUE RIVER
		100-120		STE. GENEVIEVE LS.	
		100-120		ST. LOUIS LS.	
		90-100		SALEM LS.	SANDERS
		50-80		HARRODSBURG LS.	
	OSAGE	600-800		MULDRAUGH FM.	BORDEN

Source: Palmer, 1969; Cited in Draft Report, RCRA Facility Investigation Phase II Groundwater Release Assessment, SWMU 06/09 Demolition Area and Phase III Release Characterization SWMU 07/09 Old Rifle Range November 1995- Figure 13 by William L. Murphy and Roy Wade

DRAWN BY: J. LAMEY — DATE: 4/19/99	Tetra Tech NUS, Inc.	CONTRACT NUMBER: 0087	OWNER NO.: 0083
CHECKED BY: — DATE: —	STRATIGRAPHIC COLUMN FOR ROCK UNITS ENCOUNTERED AT THE NAVAL SURFACE WARFARE CENTER NAVAL SURFACE WARFARE CENTER CRANE, INDIANA	APPROVED BY: [signature] — DATE: 3-10-00	
COST/SCHEDULE-AREA		APPROVED BY: — DATE: —	
SCALE: AS NOTED		DRAWING NO.: FIGURE 2-5	REV: 0

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3.0 METHODOLOGY

3.1 INTRODUCTION

This section presents a discussion of the historical background sample evaluation, the sampling network rationale, sampling operations, and methods used in the statistical evaluation of the collected background data. All activities were conducted to meet the requirements of the Work Plan and Field Sampling Plan (TtNUS, 1999a) and the Quality Assurance Project Plan (TtNUS, 1999b).

3.2 SUMMARY OF HISTORICAL BACKGROUND EVALUATION

The purpose of this section is to summarize background soil samples collected in previous investigations at the NSWC Crane and establish their value for use in determining basewide background concentrations for metals. A qualitative evaluation of this data was performed in the Work Plan (TtNUS, 1999a). Table 3-1 provides a list of these SWMUs and summarizes details and results of the background evaluation.

None of the historical background data were judged to be useful in the basewide background database. This judgement is based primarily on rejection of some of the data by the EPA (1997), uncertainties regarding data quality, and the concern that some data may have been impacted by site operations, thereby affecting their value to the basewide background database. Although these data are not being used in the basewide database, at a minimum, these data may provide some value as a point of reference at each of the respective SWMU investigations.

3.3 SAMPLE NETWORK DESIGN AND RATIONALE

The sample network design and rationale is briefly summarized in the following section. The EPA DQO (EPA, 1994) process was followed to establish the sample network design. For a detailed discussion of the planning process, refer to Section 4.0 of the Work Plan (TtNUS, 1999a), Work Plan and Field Sampling Plan Addendum (TtNUS, 2000b), and Sections 1.1.1 and 1.4 of the QAPP (TtNUS, 1999b).

3.3.1 Determination of Background Areas

The background areas and specific sampling locations for background sample collection were selected to meet five criteria. Close adherence to these criteria was essential to ensure that the data collected represents “true background” information. The criteria, followed by a brief description are listed below:

1. Background areas must be within the NSWC Crane property boundary.

2. The background areas and the specific sampling locations within a background area must have a soil composition similar to the soil encountered in the presently defined SWMUs and across the entire NSWC Crane facility. The soil composition in the background areas must have similar geological, chemical, and physical characteristics as the soil encountered in the SWMUs and across the facility to ensure a high degree of data comparability. To achieve this the background areas and specific background sample locations were determined using the classification of soil according to their depositional environment (DE), grain size, and depth. Classification of soil according to its depositional environment was defined in Section 2.7.2. Classification of soil according to its depth and grain size is presented below.

   Soil depth was classified as surface or subsurface soil, with surface soil ranging from 0 to 1 foot and subsurface soil ranging from 2 to 6 feet in depth. A surface soil interval of 0 to 1 foot was determined as a compromise between several risk-based conventions that range from 0 to 0.5 feet and 0 to 2 feet bgs. However, it was assumed that background samples from 0 to 1 foot collected in this study will be used when comparing SWMU data within the 0 to 2 foot interval.

   Because the location of soil of a specified grain size was not known in advance of sampling, a specific sampling strategy was developed to aid in characterizing grain size in background soil. It was assumed that the surface soils do not differ significantly according to grain size. This assumption was based upon the findings of McElrath (1988) who stated that a thin mantle of loess has been deposited throughout the NSWC Crane facility. Furthermore, the surface soil at the site is predominantly a silt loam (McElrath, 1988). Thus, surface soil samples were not collected according to grain size. The grain size of subsurface soil, however, was collected according to three gross soil grain size classifications: clay, silt, or sand, based upon visual classification in the field by a field geologist using the Unified Soil Classification System (USCS).

3. Background areas must be known or have evidence to suggest that they are unaffected by past or present Navy site activities. To determine this, background areas and specific sample locations were identified using facility operation maps (NAVFAC, 1993 and Explosive Safety Officer, 1997), historic aerial photographs, and interviews with site personnel (Brent, 1999 and Poynter, 1999). These historic aerial photographs were compiled from 1935, 1953, 1958, 1966, 1984, 1998 (Natural Resources Office, 1999) and from 1975-1976 (McElrath, 1988).

   To locate specific sampling areas within a given background area an attempt was made to stay:

- Approximately 400 feet from any primary or secondary roads to minimize effects from vehicle emissions.

- Approximately 400 feet from any developed areas related to Navy operations (e.g., buildings, storage facilities), past or present, to minimize impact from Navy operations. Because the potential impact from these areas is unknown, a distance of 400 feet was selected to allow a "buffer zone" between the background sample location and these features.

4. Background areas must be upwind from any sites releasing airborne emissions to minimize impact from airborne contamination. The predominant upgradient wind direction was determined from the monthly prevailing wind directions determined for the facility according to the RCRA Air Quality Assessment (B&R Environmental, 1997a) as discussed in Sections 2.5 and 2.9.2.1. Areas with known or suspected contamination from airborne emissions include the Ammunition Burning Grounds (ABG), Old Rifle Range (ORR), Demolition Range (DEMO), Pyrotechnic Test Areas (PTA), Old Burn Pit (OBP) CAAA QA/QC Test Area, and Building 146 (B146) Incinerator.

5. Background sample locations must not be downslope from any SWMUs to eliminate contamination from surface runoff. To determine if each background area and specific sampling locations met this criteria, surface drainage patterns were analyzed using regional and local surface water maps and a topographic map of the facility (Kvale, 1992 and Blunck, 1995).

3.3.2 <u>Description of Background Areas</u>

Three general areas were identified that meet the criteria discussed above. Each of these areas is described in the following sections. Figure 3-1 illustrates the location and the extent of these potential background areas. More detailed maps of each area can be found on Figures 3-2, 3-3, and 3-4.

3.3.2.1 Background Area 1

Background Area 1 (BA1) is in the southwest quadrant of the NSWC Crane facility (Figures 3-1 and 3-2). The north boundary of BA1 is to the south of the Sanitary Waste Landfill (SWMU 14/00) and the Landfarm (LF; SWMU 30/00). The western and southern boundaries of BA1 are the western and southern NSWC Crane boundaries, respectively. The eastern boundary of BA1 is an arbitrary north-south line to the west of the Pyrotechnic Test Area, Annex, and Rocket Range (PTA; SWMU 19/00). The eastern boundary was located to minimize any airborne contamination from the PTA.

The soil DEs in this background area are classified as loess, alluvium, and residual soil derived from Pennsylvanian bedrock/colluvium. Additional information regarding the soil characterized from this background area can be found in Section 2.7.

3.3.2.2 Background Area 2

Background Area 2 (BA2) is in the northwest corner of the NSWC Crane facility. It has soil from the glacial outwash DE which is localized in the northwest corner of the facility. BA2 is very localized and is limited to non-impacted areas in this portion of the NSWC Crane facility. The extent of BA2 is defined by the boundaries of the glacial deposits as mapped by McElrath (1988) and Kvale (1992) and the proximity of two SWMUs. Due to the historic and on-going activities in the vicinity of BA2 and the interpretations of the spatial distribution of glacial outwash deposits in this area (McElrath, 1988 and Kvale, 1992), BA2 is divided into two subsections, BA2a and BA2b.

Background Area 2a

BA2a is south of Highway 5 on the elevated area to the southwest of the Sludge Drying Beds B (SWMU 24/00) and Culpepper Branch (Figures 3-1 and 3-3). Culpepper Branch separates SWMU 24/00 from BA2a. The boundaries of BA2a (Figure 3-3) are defined by the boundaries of the glacial outwash deposits as mapped by McElrath (1988; Parke Soil Series) and Kvale (1992). Refer to Section 2.7.2.2 for a more thorough description of the glacial outwash at NSWC Crane. BA2a does not include the soil deposits outside of the specified boundary shown on Figure 3-3 because of potential impacts identified by hummocky terrain and evidence of logging noted during site reconnaissance.

Background Area 2b

BA2b is in the glacial deposits north of Highway 5 and west of the NSWC Crane security fence (Figures 3-1 and 3-3). Although a portion of BA2b is outside the security fence (Figure 3-3) this area is still on Navy property. The boundaries of BA2b are defined by the boundaries of the Negley Soil Series as mapped by McElrath (1988). It is noted that the spatial distribution of glacial outwash as mapped by McElrath (1988) is not shown on Figure 3-3. Refer to Section 2.7.2.2 for a more thorough description of the glacial outwash at NSWC Crane. The southern boundary of BA2b is approximately 200 feet north of Highway 5 and the western boundary is the unnamed stream channel along the western edge of the Negley soil unit. The northern and eastern boundaries are the NSWC Crane security fence.

3.3.2.3 Background Area 3

Background Area 3 (BA3) is in the northeast corner of the NSWC Crane facility (Figures 3-1 and 3-4). This background area has the soil in the alluvium DE and residual soil derived from Pennsylvanian and Mississippian bedrock/colluvium DEs. This area was selected to characterize these soil types (particularly the residual soil from Mississippian bedrock) because, within the facility boundaries, it is the area least likely to receive airborne emissions from the open burning/open detonation areas (OB/OD; e.g., ABG). Sections 2.5 and 2.9.2.1 provide greater detail on the predominant wind direction and airborne releases at the NSWC Crane facility.

The extent of BA3 is defined by the boundaries of the Mississippian bedrock in this area as mapped by Kvale (1992), the facility boundaries, and the area least likely affected by airborne emissions as described above. The southern boundary of BA3 is to the south of Highway 162 (on the western portion), and approximately north of Highway 169 (in the central portion), and of the northwest-southeast trending Boone Hollow (on the eastern portion). This boundary is between 3.5 and 4.25 miles north and northwest of the ABG. The northern and eastern extent is NSWC Crane's northern and eastern boundaries, respectively. The western boundary is defined by the surface exposure of Mississippian bedrock (Kvale, 1992). Rockeye (SWMU 10/15) is located approximately 1.2 miles to the west of the BA3 western boundary. However, Rockeye has no known airborne releases of metals.

3.3.3 <u>Determination of Minimum Number of Background Samples</u>

This section summarizes the statistical considerations incorporated into calculating the required number of samples collected for this background investigation. A more thorough explanation of this subject is available in the Work Plan (TtNUS, 1999a).

Data sets appearing most like background would exhibit statistical population characteristics similar to the background data. Normally distributed data sets (not necessarily a reality) would exhibit similar means and standard deviations. rMore disparate data sets would exhibit more disparate means and/or standard deviations. Increased disparity in data set means would translate to easier discrimination between data set means, all else being equal.

The desired minimum detectable difference between sample means for background and site data was set equal to two standard deviations. Some assumptions were made: (1) normally distributed data sets, (2) equal variances for the data sets being compared, (3) a 5% chance of thinking that site data do not exceed background concentrations when in fact they do exceed background concentrations, (4) a 30%

chance that site data exceed background concentrations when in fact they do not. Evaluation of background data distributions and statistical assumptions are available in Section 4.0.

The two decision error tolerances (assumptions 3 and 4 above) were accounted for in a single computation to yield the number of samples required to achieve the desired level of decision performance:

$$m = n = \frac{\left(z_{1-\alpha} + z_{1-\beta}\right)^2}{2} + \frac{z^2_{1-\alpha}}{4}$$

where *m* and *n* are the numbers of samples in the two data sets being compared, and the *z*'s represent statistical *z*-scores.

With $\propto$ = 5%, it was calculated that collecting three to five samples from each population would limit the tolerance for the more egregious decision error (assumption 3, above) to 5%. The chance of committing the less egregious error (assumption 4 above) would range from 10% (5 samples) to 30% (3 samples) under the same conditions. To protect against loss of samples and the potential of having invalid assumptions, a target of five samples for each soil type would be collected for chemical analysis. With five background samples, five SWMU investigation samples would yield a discriminatory power of 1.18*s* if the assumptions were valid. This would be well within the original goal of detecting a 2*s* difference.

3.3.4 Field Events and Specific Background Sample Locations

Two field events were conducted to complete this scope of work. The majority of the sample collection took place during the first field event in November 1999. A supplemental field event in October 2000 was performed to collect additional data for soil types that were encountered infrequently during the first field event. The following two sections (3.3.4.1 and 3.3.4.2) outline the samples collected during each event.

The criteria listed in Section 3.3.1 and below were used to select specific background sample locations in both events. Ideally, samples would have been collected at randomly selected locations but consideration was given to the reality that not all future sampling schemes are likely to follow a simple random sampling design and that irregular topography and operation areas could prevent the implementation of such a sampling design. Sampling locations were selected to provide good spatial coverage of each DE while considering access to the sampling locations. No attempts were made to bias sampling locations for any reason. When selecting the background sampling locations within each DE, an attempt was made to select a representative number of soil classifications as defined by the

USDA/SCS (see Table 2-1) and at various topographic locations (i.e., lowlands, valleys, sideslopes, and ridgetops).

An attempt was made for the sampling locations to be within a 30 foot radius of the designated location in the Work Plan (TtNUS, 1999a, 2000b; see Section 3.4.1 for additional details). This range is reasonable considering the extent of the USDA soil series according to soil maps of the site (McElrath, 1988).

3.3.4.1 First Field Event

According to the Work Plan (TtNUS, 1999a) samples were taken from ten boreholes within each DE in the first field event. At each of these sample locations surface and subsurface soil samples were taken. Because the alluvium and the loess/glacial outwash DE span two background areas (BG1 and BG3, and BG1 and BG2, respectively) the number of sample locations in each background area was as follows:

- BG Area 1: 20 sampling locations (Figure 3-2, Table 3-2)
- BG Area 2: 5 sampling locations (Figure 3-3, Table 3-3)
- BG Area 3: 15 sampling locations (Figure 3-4, Table 3-4)

3.3.4.2 Supplemental Field Event

Based on evaluations of samples collected during the first field event, it was determined that an insufficient number of samples was collected of two soil types (Pennsylvanian Subsurface Sand, PBS and Alluvial Subsurface Clay, ABC; see Section 4.0). An attempt was made in the supplemental field event to obtain at least four more PBS samples and at least two more ABC samples to meet project goals.

The infrequent occurrence of these soil types in the first event indicated that there was a low probability of finding more of these soil types. Thus, a plan was outlined (TtNUS, 2000b) that ensured that a reasonable minimum effort was expended before concluding that additional sampling was no longer cost effective. The plan was designed such that boreholes were installed the cost of collecting four more PBS or ABC soil samples was periodically re-evaluated by updating the probabilities of finding the desired samples. Thus, sample collection would be terminated when the appropriate number of samples was collected or when collecting the desired number of samples projected was cost prohibitive. The details of how this approach was implemented are described in Appendix D. Please refer to the Work Plan Addendum (TtNUS, 2000) for details on the sampling strategy and rationale. Section 4 discusses the results of the data collected during the supplemental field event.

In summary, a total of three boring sets (PS1, PS2, and PS3) and one boring set (AB1) was completed for the PBS and ABC soil types, respectively in the supplemental field event. Note that there are 5 borings in each boring set so a total of 20 borings were completed for this event. Borings were located in two background areas (BG1 and BG3) as listed below:

- BG Area 1: 16 sampling locations (Figure 3-2, Table 3-2)
- BG Area 3: 4 sampling locations (Figure 3-4, Table 3-4)

3.3.5 Selection of Background Samples for Chemical Analysis

A total of 67 total samples were collected for analytical analysis between the two field events. The following section describes the sample collection procedure.

Tables 3-5, 3-6, and 3-7 tabulate the samples selected for chemical analysis from the BG1, BG2, and BG3, respectively. Table 3-8 tabulates a summary of the total number of samples selected for a given soil type. Table C-1 (Appendix C-1) summarizes all of the samples collected in the field for this background soil investigation. This table presents the depth at which each sample was collected, the gross grain size classification of each sample, and whether the sample was selected for chemical analysis. A review of this table illustrates that the procedures performed in the field followed exactly as discussed above and as outlined in the Work Plan (TtNUS, 1999a).

3.3.5.1 First Field Event

Theoretically, the total number of samples collected in the first field event would have been 200. That is, 1 surface soil sample and 4 subsurface soil samples at a total of 40 soil boring locations. From this pool of samples a maximum of 80 samples could have been sent for chemical analysis. This selection process for chemical analysis can be explained using a schematic diagram (Figure 3-5). The circle represents a given DE from which samples will be collected. Within the DE, five surface samples were collected (regardless of soil grain size), as represented by the top rectangle. Within the same DE, as many as five samples were collected for each gross soil grain size classification (e.g., clay, silt, and sand) from the subsurface, represented by the remaining rectangles. This leads to a possible maximum of 20 samples within each DE, assuming that all grain sizes are encountered in the subsurface in each of the 10 boreholes in a DE. In order to eliminate biasing the number of samples for a given grain size at a specific location, only one subsurface soil sample per grain size per sample location was selected.

Because of the field conditions encountered (boring, refusal, etc.), only 154 samples were collected. From this pool of 154 samples, 65 soil samples (not including quality control/quality assurance samples) were submitted for chemical analysis. The fact that fewer than 200 samples were collected is attributed to two primary factors: (1) In some cases fewer than four subsurface samples of a given grain size were encountered in a given DE, thus fewer than five samples of that grain size were collected. (2) Advancement refusal was met in some boreholes, thus limiting the number of samples collected. These two factors are discussed further in Section 3.4.2.1.

3.3.5.2 Supplemental Field Event

Ideally, at least four more PBS samples and at least two more ABC samples were to be collected in the supplemental field event. However, the infrequent occurrence of these soil types in the field event resulted in the collection of only 2 soil samples representing the ABC soil type and no PBS samples.

As a result, both field events yielded the collection of a minimum of three samples for each soil type with the exception of the PBS. For the PBS soil type only one sample was collected. As a result, the target number of samples (three) was not achieved for the PBS soil type. An evaluation of the impact of this on attaining project objectives is presented in Section 4.0. In summary, the target number of samples was achieved for 15 of 16 soil types.

3.4 SOIL SAMPLING, ANALYSIS AND FIELD OPERATIONS

The planning and rationale for this project was conducted from January through October 1999. The field effort involving background sample collection was performed from November 1 through November 9, 1999. The following section describes the field activities which took place during this field effort.

3.4.1 Background Sampling Locations

The general locations of each of the three background areas are shown on Figure 3-1. Figures 3-2, 3-3, and 3-4 illustrate the location of the sampling points for BG1, BG2, and BG3, respectively. Because of the remote nature of the sampling locations a hand held global positioning system (GPS) was used to navigate to the proposed sampling point locations. The proposed northing and easting coordinates listed in the Work Plan (TtNUS, 1999a, 2000b) were used as a basis for navigation. The actual sampling points in the field were selected within a 30-foot radius of the proposed location. The sample location(s) were moved within this range at the discretion of the TtNUS Field Operations Leader (FOL) if undesirable features were encountered at the proposed sampling point (e.g., bedrock exposed on the surface, surface drainage patterns, etc.). Only two sampling locations (BG2SBG05 and BG3SBM03) were moved beyond the 30-foot radius of the proposed locations. Both locations were moved approximately 300 feet north from the originally proposed sampling point as a result of GPS navigation.

3.4.2 <u>Sampling and Analysis Procedures</u>

This section discusses the soil sampling methodology used for the basewide background investigation at NSWC Crane.

3.4.2.1 Borehole Advancement

Soil borings were advanced using a hand auger. The hand auger consists of a stainless steel auger bucket and steel rods (each typically 3 feet in length). Commonly referred to as an Iwan sampler, the auger is advanced by turning a "T" handle in a clockwise motion. Samples were taken continuously from the ground surface to a maximum depth of 6 feet below ground surface or until one of the following conditions were met:

1. saturated zone was encountered;
2. bedrock or weathered bedrock was encountered; or,
3. advancement refusal was met by the hand auger.

Condition 1 was not met in any of the boreholes advanced for this project. It is important to note that it was difficult to determine if condition 2 was encountered using the hand auger. If bedrock was encountered advancement refusal usually results. As expected, condition 3 was encountered in many boreholes (see Appendix B). In this circumstance as many as four additional attempts were made at a nearby location at the discretion of the FOL. Samples were extracted from the auger bucket using a disposable polyethelyene trowel and a stainless-steel mixing bowl. Once the borings were advanced to the desired depth and sufficient sample volume was collected, the boreholes were abandoned by backfilling the hole with remaining soil cuttings. Standard operating procedure (SOP) CTO83-1 (TtNUS, Work Plan, 1999a, Appendix B) was followed for the borehole advancement and sample collection process.

3.4.2.2 Surface Sampling

Surface soil samples were collected from the ground surface to a maximum depth of 2 feet (i.e., 0 to 2 feet) during advancement of soil borings. Upon retrieval, all samples obtained were monitored for volatile organic compounds (VOCs) with a photo-ionization detector (PID) and then collected for visual lithologic classification. The 0 to 1 foot depth interval was collected and placed in sample bottles as defined on Tables 3-5, 3-6, and 3-7. Soil from the 1 to 2 foot depth interval was discarded after visual lithologic classification. All samples were placed in a cooler of ice immediately after collection. SOPs CTO83-2 and CTO83-3 (TtNUS, Work Plan, Appendix B, 1999a) were followed for the proper sample selection and soil handling procedures, respectively. All pertinent field data were recorded in the field logbook and on the soil sample log sheet (included in Appendix A).

3.4.2.3 Subsurface Sampling

Subsurface soil samples were collected in one foot intervals from a depth of 2 feet to a maximum depth of 6 feet below ground surface (e.g., 2-3, 3-4, 4-5, and 5-6). Upon retrieval, all samples were monitored for VOCs with a PID and then collected for visual classification of the lithology. Sample intervals are defined in Tables 3-5, 3-6, and 3-7. All samples were placed in a cooler of ice immediately after collection. SOPs CTO83-2 and CTO83-3 (TtNUS, Work Plan, Appendix B, 1999a) were followed for the proper sample selection and soil handling procedures, respectively. All pertinent field data were recorded in the field logbook and on the soil sample log sheet (included in Appendix A).

3.4.3 Borehole and 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 CTO83-4 (TtNUS, 1999a, Appendix B). The pertinent field information and data were recorded on the boring log form, the soil sample logsheet and, where applicable, the field logbook. These completed forms are included in Appendices A and B.

3.4.4 Sample Identification System

This section contains a brief summary of the sample identification system as designated in the Work Plan (TtNUS, 1999a). Refer to the Work Plan for additional details.

Each sample collected was assigned a unique four-segment, alpha-numeric sample tracking number. An example of a soil identification number for a soil sample collected from 0 to 1 foot at sampling location P04 in background area 1 was designated as BG1SBP0401; or a soil sample collected from the 4 to 5 foot interval at sampling location M10 in background area 3 was designated as BG3SBM1005.

Field quality assurance/ quality control (QA/QC) samples were designated with a different coding system. The QC code consists of a two-segment, alpha-numeric code that identifies the sample medium (for duplicates only), QC type, and date. An example for a field duplicate duplicate is as follows: a duplicate of sample BG1SBL0401 obtained on October 3, 1999 would be designated as: BGFD-100399. This allowed duplicates to be submitted as "blind" samples to the analytical laboratory. Chain of custody forms, not received by the analytical laboratory, were used to document duplicate sample locations.

Matrix spike and laboratory duplicate samples were designated on the field documentation forms and sample labels.

3.4.5 Sample Preservation, Shipping, and Handling

Soil samples are subject to physical and chemical changes during storage and therefore require preservation to prevent changes in either the concentration or the physical condition of the constituent(s) requiring analysis. Sample handling includes the field-related considerations connected with the selection of sample containers, preservatives, allowable holding times, and analyses requested. SOP CTO83-3 (TtNUS, 1999a, Appendix B), provides a detailed description of sample handling, packaging, and shipping procedures and requirements required for this sampling plan. This SOP and the procedures in the Work Plan (TtNUS, 1999a) were followed for this investigation.

3.4.6 Chain-of-Custody/Documentation

Sample custody procedures are designed to provide documentation of preparation, handling, storage, and shipping of all samples collected. Integrity of the samples collected during the investigation was the responsibility of identified persons from the time they were collected until they, or their derived data, were incorporated into the final report. Stringent chain-of-custody (COC) procedures described in the Work Plan and SOP CTO83-5 (TtNUS, 1999a, Appendix B) were followed to document sample possession. The completed chain of custody and other field documents have been included in Appendices A and B).

3.4.6.1 Calibration Procedures and Frequency

The PID was the only instrument used in the field. It was calibrated each day before use according to the procedures described in the applicable SOPs. Calibration was documented on an Equipment Calibration Log (Appendix A). During calibration, an appropriate maintenance check was performed on the PID. No damaged or defective parts were identified during the maintenance checks and the PID worked properly throughout the field effort.

3.4.7 Decontamination of Field Sampling Equipment

All nondedicated reusable sampling equipment used for collecting samples was decontaminated both prior to field sampling and between samples. This equipment included stainless-steel hand augers and mixing bowls. The following decontamination steps taken in accordance to SOP CTO83-6 (TtNUS, 1999a, Appendix B) were as follows:

- Potable water rinse
- Liquinox detergent wash
- Potable water rinse
- Deionized water rinse
- Air dry
- Wrap in aluminum foil (if not to be used immediately)

3.4.8 Investigation-Derived Waste Management

Two types of investigation-derived wastes (IDW) were generated during the field investigation: personal protective equipment (PPE) and decontamination water. Excess soil cuttings were returned to the borehole and/or scattered near the borehole. Based on the fact that this is a background investigation and rigorous investigation took place to ensure that these are “clean” areas none of these residues are expected to represent a significant risk to human health or the environment if properly managed. Management of each of these residues is provided below:

PPE - All PPE was contained in single plastic garbage bags and then placed in trash receptacles at the facility.

Decontamination Water – Because the background areas were not expected to have any contamination and were not located near any SWMUs the containerized decontamination fluids were discharged directly to a sanitary sewer at NSWC Crane.

3.5 QUALITY ASSURANCE/QUALITY CONTROL SAMPLES AND DETECTION LIMITS

The purpose of this section is to address the DQOs of field quality, quality assurance/control (QA/QC) samples such as field blanks, field duplicates, rinsate blanks, trip blanks, ambient blanks, and matrix spikes and laboratory duplicates. The QA/QC samples taken are listed on the COC forms and the field logbook (Appendix A) for this investigation. The following sections summarize the purpose and a description of each of the quality control samples selected. Section 8.0 of the QAPP (TtNUS, 1999b) provides additional information regarding QA/QC samples and analyses.

3.5.1 Source Water Blanks

One source water blank was obtained by sampling the analyte-free water used for decontaminating sampling equipment. Source water blanks were used to determine whether the analyte-free water used for sampling equipment decontamination procedures could have contributed to sample contamination.

3.5.2 Field Duplicates

Soil field duplicates were collected by splitting single samples into two portions collected in the same order as the procedure outlined in SOP CTO83-1 (TtNUS, 1999a). Field duplicates were obtained during a single act of sampling and were used to assess the overall precision of the sampling and analysis methods employed. Both samples of a duplicate pair were collected at a minimum frequency of 1 per every 10 samples. Field duplicates were analyzed for the same parameters in the laboratory and were labeled in order to make the identity of the duplicate sample unknown to the laboratory.

3.5.3 Rinsate Blanks

Equipment rinsate blanks were obtained under representative field conditions by running analyte-free water through sample collection equipment (e.g., hand auger, etc.) after decontamination and then placing it in the appropriate sample containers for analysis. Equipment rinsate blanks were used to assess the effectiveness of decontamination procedures. Equipment rinsate blanks were collected at a frequency of 1 per every 10 samples, with a minimum of 1 per day of sampling, per sampling device/instrument. For pre-cleaned, dedicated, and/or disposable equipment (i.e., disposable plastic trowels, etc.), one rinsate blank was collected and analyzed at a frequency of one per lot or “batch blank” for a specific equipment type. In this case, equipment rinsate blanks were used to assess the cleanliness of pre-cleaned, dedicated, and/or disposable equipment.

3.5.4 Trip Blanks

Trip blanks are organic free water blanks used to detect cross-contamination of samples by VOCs during sample shipment/storage. Because only inorganics (i.e., no VOCs) were analyzed in this investigation, the collection of trip blanks was not performed.

3.5.5 Ambient Condition Blanks

Ambient condition blank samples, consisting of deionized water, are collected in the field to provide a means to assess the quality of the data resulting from field conditions. Ambient blanks are analyzed to check for interfering contaminants that potentially could be present in ambient air at the sampling site (e.g., particulates). Ambient condition blanks were not collected because site conditions did not appear to have any effect on the integrity of the samples collected for this investigation.

3.5.6 Matrix Spikes/Laboratory Duplicates

Matrix spikes (MS) are investigative samples analyzed to provide information about the effect of the sample matrix on the digestion and measurement methodology. Laboratory duplicates are two portions of a sample that are removed from the same sample bottle after mixing the sample. These samples provide information on the analyte concentration variability attributable to the combined effects of sample heterogeneity after mixing, preparation of the sample for analysis, sample storage, and the actual sample analysis. Matrix spike and duplicate samples were collected at a frequency of 1 per 20 samples. No additional sample volume was required for analysis of the matrix spike/lab duplicate.

3.6 SURVEYING

The horizontal locations of all background samples locations were surveyed. A Solo (by Tripod Data Systems, Inc.) global positioning system (GPS) unit was used to identify horizontal locations of each of the background samples. The horizontal locations were surveyed to the Indiana State Plane Coordinates (Indiana West) and referenced to the 1983 North American Datum (NAD83). The Work Plan (TtNUS, 1999a) stated that the sample locations would be surveyed to within the nearest 0.10 foot. Based upon the accuracy limitation of the surveying equipment used, the sample locations were surveyed within ±1 meter (3.28 feet). Surveying the vertical locations of the background samples was not performed.

3.7 DATA QUALITY AND VALIDATION

All background analytical data were subjected to data validation and an evaluation for data bias and precision. Data validation is an objective systematic process in which analytical data are reviewed to ascertain the validity of the reported results and to identify for the data user some possible limitations of these results. This section summarizes the data validation process and a summary of the bias and precision of the analytical process.

3.7.1 General Data Validation Procedures

Validation of data generated for samples collected at NSWC Crane in support of the background investigation was completed in accordance with the procedures for data validation as outlined in Navy guidance (Navy Installation Restoration Laboratory Quality Assurance Guide, NFESC February 1996). Data validation was performed for all samples analyzed via SW-846 Methods 6010B and 6020. Such data were validated in accordance with the EPA's CLP Functional Guidelines for Inorganic Data Review, as amended for use in EPA Region 5 (EPA, 1993a, 1993b).

The validation process included consideration of the following: compliance to procedural methods, data completeness, holding time compliance, calibrations, field QC and laboratory-generated blanks, blank spikes, matrix spikes, field duplicate precision, lab duplicate precision, ICP serial dilution results, chemical interferences, analyte quantitation, detection limits, and system performance.

Evaluation of laboratory blank analyses aided in the elimination of false positive results that were identified as laboratory artifacts. The overall determination of data utility or reliability was based upon laboratory compliance with specified methods and adherence to QC requirements. According to the validation protocol, significant noncompliances observed during the validation process resulted in a qualification of analytical data. Qualifier flags, which are letters indicating the potential effect of quality control noncompliances on data usability, alert the data user to potentially imprecise or inaccurate results. If noncompliances are serious enough, data are qualified as rejected ("UR" qualifier). No identified qualifications were serious enough to result in rejection of any of these data. However, some noncompliances were identified that resulted in the qualification of some data as estimated ("J" qualifier flag). Qualifier flags are described in more detail in the next section.

The net results of the validation process were summarized in sample delivery group-specific technical reports consisting of a memorandum, a section of qualified analytical results, results as reported by the laboratory, and a supporting documentation section that provided the rationale for changes to and/or qualification of the data. These memoranda provided a detailed explanation of the results of the data validation review. All data validation documentation is currently retained on file by TtNUS.

3.7.2 Data Validation Qualifiers

The qualification of analytical data used during the validation process (i.e., application of U, J, UJ, and UR qualifiers) was conducted as required by the EPA CLP Functional Guidelines. The attachment of the data qualifiers to analytical results signifies the occurrence of QC noncompliances that have been noted during the course of data validation for this project. The various data qualifiers are defined as follows:

U - Indicates that the chemical was not detected at the numerical detection limit noted. Nondetected results from the laboratory are reported in this manner. This qualifier is added to a positive result if the detected concentration is determined to be attributable to contamination introduced during field sampling or laboratory analysis.

UJ - Indicates that the chemical was not detected. However, the detection limit is considered estimated based on problems encountered during laboratory analysis. The associated numerical detection limit is regarded as inaccurate or imprecise.

J - Indicates that the chemical was detected. However, the associated numerical result is not a precise representation of the amount that is actually present in the sample. The reported quantity is considered to be an estimate. This qualifier is added in place of the laboratory "B" qualifier as a matter of routine to all results between the soil-adjusted IDL and the laboratory reporting limit. This qualifier is added to lithium, strontium, and thorium results that were analyzed a few days after the 180 day holding times expired (see Section 3.7.3 for additional details).

UR - Indicates that the chemical may or may not be present. The nondetected analytical result reported by the laboratory is considered to be unreliable and unusable. This qualifier is applied in cases of gross technical deficiencies (i.e., holding times missed by a factor of two times the specified time limit, or severe calibration noncompliance, and/or extremely low QC recoveries).

The preceding data qualifiers may be categorized as indicative of major problems and minor problems. Major problems are defined as issues that result in the rejection of data, qualified with UR data validation qualifiers. These data are considered invalid and are not used for risk assessment or other decision making. Minor problems are defined as issues resulting in the estimation of data, qualified with the U, J, and UJ data validation qualifiers. A "U" qualifier flag can also mean that no quality control deficiencies have been noted but the analyte concentrations are less than the detection limit. Non-detected analytical results ("U" qualifier flag) and estimated analytical results ("J" qualifier flag) are considered to be suitable for risk assessment and decision making purposes.

3.7.3 Bias (Accuracy) Evaluation

Each of five soil matrix spike samples was analyzed for 21 metals, yielding 105 metal recovery values. The six macronutrient metals are not spiked. Acceptance limits for the spike recoveries are 75% to 125%. Of the 105 analyte recovery values, each of the following percent recoveries was outside of acceptance limits one time (please refer to Appendix C-2 for a description of the sample delivery groups [SDGs]):

- Soil SDG C8301: Cadmium (36%),
- Soil SDG C8308: Lithium (68.5%)
- Soil SDG C8301: Manganese (62.9%),
- Soil SDG C8303: Zinc (74.1%),
- Soil SDG C8304: Vanadium (74.5%)

Manganese and chromium spike values fell outside the recovery limits two times each. The deviant Soil Manganese recoveries were 62.9% (SDG C8301) and 73.1% (SDG C8311). The deviant chromium recoveries were 67.5% chromium (SDG C8305), and 135.2% (SDG C8311). Significant recovery deficit was limited to cadmium (36% recovery in SDG C8301). The other soil matrix spike samples exhibited cadmium recoveries of 92.1% (SDG C8303), 94.1% (SDG C8304), 82.3% (SDG C8305) and 96.6% (SDG C8311). The cadmium concentrations in the SDG C8301 soil samples do not appear to be biased low relative to the cadmium concentrations in the other soil samples. Instead, the poor recovery in this one matrix spike appears to be an artifact of two factors. One factor is the imprecision observed for cadmium (average RPD = 21%, maximum RPD = 40%). The other factor is the spiking level relative to the native analyte concentration. The spiking level only increased the analyte concentration in the soil matrix by a factor of two. The opportunity for obtaining a poor recovery as a result of random fluctuations in the measured chemical concentration under these conditions is significant. On this basis, no corrective action is warranted for the observed 36% cadmium recovery.

Only 21 of the 105 soil matrix spike metal recoveries exceeded 100.0%. This indicates a general negative bias in metal recoveries in the soil analyses. A similar effect was observed for soil laboratory control samples for which only 36 of 105 metal recoveries exhibited a value greater than 100.0%. The apparent bias is within normal bounds (75% to 125%) and does not indicate any problems with the data. The mean matrix spike recovery across all soil sample metals is 89.6% with a standard deviation of 14% (after eliminating a single value of –11.8% for sample BG1SBL0504S). The –11.8% recovery (for manganese in SDG C8305) was eliminated from these computations because the manganese spike increased the native manganese concentration in the sample by less than 25% in that sample. Thus, the spike amount was overwhelmed by normal analytical uncertainty and invalidates the manganese spike as a control parameter in that sample.

Two aqueous spiked samples were analyzed to yield 54 metal spike recoveries. The recoveries ranged from 94.8% to 111.4% and are well within the 80% to 120% acceptance range. The average percent recovery across all metals is 109%. All but four of the metal recoveries were greater than 100%, indicating a potential overall slight positive bias. A similar effect was observed for the aqueous laboratory control sample. The recoveries across metals for that sample ranged from 88.5% to 117% with an average recovery of 106% and only 4 of 54 metals exhibiting a recovery less than 100%. Cadmium recovery, which was poor (36%) in one soil sample, was 106.1% and 93.8% in the two water sample matrix spikes and was 108% and 102.5% in the aqueous LCSs.

Results for lithium, strontium, and thorium are qualified as estimated in all but the three samples collected most recently because the samples were analyzed for those metals less than 5 days after the holding time had expired. This qualification is required by the data validation rules. However, the qualification is more of a formality to let the data user know that the holding time was expired rather than an indicator of a technical deficiency in the data. One reason for this is that the holding time exceedance (a few days) is small relative to the holding time itself (180 days). Furthermore, chemical and physical properties such as low vapor pressures at sample storage temperatures and a lack of biodegradability indicate that none of the three affected metals would be expected to change concentration, even after decades of storage.

Overall, the percent recovery data for matrix spikes and laboratory control samples was acceptable and well within performance criteria. Furthermore, holding time exceedances (lithium, strontium and thorium only) are not expected to result in any biases.

3.7.4 <u>Precision Evaluation</u>

Precision was measured in terms of relative percent difference (RPD) for field and laboratory duplicate soil samples. The observed RPDs are summarized in Table 3-9. Despite the natural heterogeneity of soil, the observed RPDs are relatively small with a few exceptions. The RPDs for field duplicates range from 0.67% to 80.00% and for laboratory duplicates the RPDs range from 0.0% to 161.28%

A single field duplicate pair for cadmium had a RPD equal to 80.0%. Another duplicate pair, for silver, had a RPD equal to 66.7%. Both of these high RPD values are associated with results near detection limits. The next highest RPD for field duplicates was 36.4%. Most (82%) of field duplicates had RPD values less than 15% across all duplicate samples and all metals, indicating good sampling precision.

A single laboratory duplicate pair for cadmium had a RPD equal to 161%. Another laboratory duplicate pair, for manganese, had a RPD equal to 70.0%The next highest laboratory RPD was 45.8% (arsenic) and a seven other RPD values ranged from 31% to 38% for various metals. The 161% RPD values is associated with a duplicate pair for which the results are near the cadmium detection limit. Eight of these 10 RPD results are associated with the same duplicate sample, indicating either that the selected sample was relatively heterogeneous or that the analytical performance was slightly worse for that sample than other duplicate samples. However, 26 of the 27 metal RPD values are within the 50% acceptance window for that sample. Moreover, most (74%) of the laboratory RPD values across all duplicate samples and all metals are less than 15%. That the RPD values are this small is evidence of good analytical measurement precision.

The overall high degree of precision might be an indication that the soil samples were nearly completely dissolved during sample preparation. This is consistent with relatively high calcium carbonate content that is expected to be found in limestone, the parent material encountered in the residual soil from the Mississippian bedrock/colluvium depositional environment at NSWC Crane.

Soil RPD values for field duplicates and laboratory duplicates were compared by computing the ratios of their respective RPD values. RPD can only be computed if both samples in a duplicate pair yield detectable concentrations of analyte. Therefore, only duplicate sample pairs were compared for which both samples from each pair yielded detectable concentrations. The RPD ratios are summarized in Table 3-9.

The RPD values for field duplicates generally fall within a factor of two of laboratory duplicate RPD values, indicating comparable precision. This is supported in the data for this project in that most of the average Laboratory Duplicate/Field Duplicate ratios are between 0.5 and 2.0 in Table 3-9. For one metal, silver, the average laboratory RPD value is zero, which causes the laboratory to field duplicate ratio to be equal to zero. This is a chance occurrence and does not indicate poor agreement between field and laboratory duplicate precision. Precision values across all metals and all soil samples are generally within expectations and compared well between laboratory and field duplicates. When outside of expectations, individual RPD values can be attributed either to metal concentrations approximating detection limits (where increased measurement uncertainty is normal), or they appear to be spurious results that occur no more frequently than might be expected, given the number of data points.

3.7.5 Attainment of Detection Limits

For each of the following 19 metals, all soil sample results were classified as “detects,” with reported concentration values exceeding the detection limits. This includes 67 soil sample results for all metals except lithium, strontium and thorium. Sample BG1SBA0101 was lost at the analytical laboratory before the analyses were completed for the three latter metals, so only 66 soil sample results are available for each of those metals.

- Aluminum
- Arsenic
- Barium
- Calcium
- Chromium
- Cobalt
- Copper
- Iron
- Lead
- Lithium
- Magnesium
- Manganese
- Nickel
- Potassium
- Strontium
- Thallium
- Thorium
- Vanadium
- Zinc

The other eight metals (shown in Table 3-10) each exhibited at least one “non-detect.”

For most metals in most soil samples, the planned detection limits (Table 1-1 of the QAPP; TtNUS, 1999b) were achieved. Exceptions are identified in Table 3-10 with an asterisk in the “MINIMUM REPORTED DETECTION LIMIT” column. To achieve the planned limits, some samples originally analyzed using the ICP/AES technique were re-analyzed using the more sensitive ICP/MS technique. This was done according to the plan outlined in the QAPP (TtNUS, 1999b).

For the metals in Table 3-10, the detection limit values are compared for the 67 original samples with the exception of lithium, strontium and thorium in sample BG1SBA0101. Duplicate samples were not included in this tally. Table 3-10 depicts a range of detection limits for each of the eight metals. Most of the minimum reported detection limits approximate the planned detection limits, indicating a good effort by Laucks Laboratory to meet the unusually low limits requested. Several maximum and average detection limits (for antimony, beryllium, selenium, silver, sodium and tin) are significantly greater than the requested limits. As a result, several samples had elevated detection limits for each of those metals. The cause of the elevated detection limits is generally attributed to low levels of laboratory contamination, which was detected in analytical method blanks or calibration blanks. This is not necessarily a surprise, given that the planned limits are less than what are usually reported by the laboratory. Because this is a background investigation, the lower limits were requested in an effort to obtain measurable values for as many metals as reasonably achievable. This indicates that the planned limits have stretched the capabilities of Laucks Laboratory and may not be consistently achievable on a routine basis for the affected metals. This is not viewed as a laboratory deficiency, but as a natural limitation of current analytical technology.

Elevated detection limits for sodium are not viewed as problematic because sodium is not typically a metal of concern in environmental investigations. With the exception of the two soil samples in SDG C8311, silver detection limits in some samples barely exceeded the requested 0.05 mg/kg limit, so those values are also not viewed as problematic. In SDG C8311, the silver detection limits were reported as 0.23 mg/kg, and 0.22 mg/kg and the two soil results were “non-detects.” Qualifying the affected silver results as “non-detects” is consistent with data validation guidelines and with the silver concentrations observed across all samples in this project. Elevated detection limits for antimony, beryllium, selenium, and tin are more of an issue because those metals are common target parameters of environmental concern. However, given the apparent technological limitations associated with achieving the planned detection limits for antimony, beryllium, selenium, and tin, there is no plan for attempting to achieve lower detection limits for those metals.

3.7.6 Field Blank Evaluations

In Section 3.7.5, elevated concentrations of metals in method blanks and calibration blanks were discussed. Some source water blanks and equipment rinsate blanks also exhibited detectable concentrations of several metals. The observed concentrations were on the order of the analytical detection limits. The equipment rinsate blanks generally exhibited concentrations similar to the source water blanks, indicating that the equipment decontamination process was not deficient. Those levels of contamination present in source water and equipment rinsate blanks are orders of magnitude less than any levels that could be responsible for detectable levels of contamination in the soil samples. The potential for cross-contaminating samples is thus negligible at the observed blank concentrations and is not addressed further here. The data validation summaries (Appendix C-2) provide additional detail on this matter, including the observed blank concentrations.

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TABLE 3-1

SUMMARY OF HISTORICAL SOIL BACKGROUND DATA FOR METALS
NAVAL SURFACE WARFARE CENTER
CRANE, INDIANA

SWMU No.	SWMU Name	Abbreviated Name	Soil Background Data Available	Background Sample Identifiers	Validity of Background Samples[A]	Source	Remarks
01/12	Mustard Gas Burial Grounds	MGBG	no			1	no data/reports
02/11	Dye Burial Grounds	DBG	no			5	
03/10	Ammunition Burning Grounds/Old Jeep Trail	ABG/OJT	yes		invalid for RA	4, 12	Data rejected by USEPA, 1997
04/02	McCormish Gorge	McCG	no		invalid for RA	6	no valid samples for McComish G.; bgnd samples from OBP used at both sites
05/03	Old Burn Pit	OBP	yes	05/03-01-90, 05/03-02-90, 05/03-03-90	invalid for RA	7	3 samples are located very close to each other; treat as one datum. Data rejected by USEPA, 1997.
06/09	Demolition Range	DEMO	yes	CR95-06SS-A01-01; CR95-06SS-A01-01-AVG; CR95-06SS-A01-01-D; CR95-06SS-A02-01; CR95-06SS-A03-01;	invalid for the basewide background investigation	4	Data questionable due to proximity to nearby road. 1990 and 1993 data rejected by USEPA, 1997. 1995 data is suspect because soil may have been impacted by deposition from DR, and ORR
07/09	Old Rifle Range	ORR	yes	CR95-07SS-A01-01; CR95-07SS-A02-01; CR95-07SS-A03-01;	invalid for the basewide background investigation	4	1990 and 1993 data rejected by USEPA, 1997. 1995 data questionable due to historical land use (Pistol Range) and possibility that soil had been impacted by deposition from the DR, and ORR
08/17	Load & Fill Area, Bldg 106 Pond	106P	no			2	source is most recent available for site
09/03	Pesticide Control Area/ R-150-Tank	PCA	yes		invalid for RA	8, 9	samples analyzed using an ASTM method (not an EPA method SW-846). Data rejected by USEPA, 1997
10/15	Rockeye	RKT	yes	BN#1(90), BN#2(90), and BN#3 (90)	invalid for RA	10	no accurate sample location; only BN#2 analyzed for metals. Data rejected by USEPA, 1997.
11/00	Old Storage, B-255	B225	no			1	no data/reports
12/14	Mine Fill A	MFA	no			2	no data
13/14	Mine Fill B	MFB	no			2	no data
14/00	Sanitary Landfill/Lithium Battery	SLF&LB	yes	NSWC-14/00-002	questionable due to uncertainty in data quality	3	validation status uncertain; incomplete target analyte list

TABLE 3-1

SUMMARY OF HISTORICAL SOIL BACKGROUND DATA FOR METALS
NAVAL SURFACE WARFARE CENTER
CRANE, INDIANA

SWMU No.	SWMU Name	Abbreviated Name	Soil Background Data Available	Background Sample Identifiers	Validity of Background Samples[A]	Source	Remarks
15/06	Roads and Grounds Area	R&GA	no			3	source is most recent available for site
16/16	Cast High Explosive Fill/ Incinerator Bldg 146	B146	yes	B-146-BG1a-03140 thru B-146-BG1d-03140; B-146-BG2a-03140 thru B-146-BG2d-03140; B-146-BG3a-03140 thru B-146-BG4d-03140; B-146-BG4a-03140 thru B-146-BG4d-03140;	questionable due to reporting	3	uncertain if dry or wet weight analysis was reported; uncertainty in data quality
17/04	PCB Burial/Pole Yard	PCB	no			1	no data/reports
18/13	Load & Fill Area Buildings	L&FAB	no			1	no data/reports
19/00	Pyrotechnic Test Area/ Annex/ Rocket Range/ Impact Area	OTA or PTA	no			2	source is most recent available for site
20/00	CAAA QA/QC Test Area	CAAA	no			1	no data/reports
21/00	DRMO Storage Lot	DRMO	no			1	no data/reports
22/00	Lead Aside	PbA	no			1	no data/reports
23/00	Battery Shop	BS	no			1	no data/reports
24/00	Sludge Drying Beds A	SDBA	no			1	no data/reports
24/00	Sludge Drying Beds B	SDBB	no			1	no data/reports
25/07 D	Highway 58 Dump Site A	H58DSA	no			1	no data/reports
26/06 D	Highway 58 Dump Site B	H58DSB	no			1	no data/reports
27/00	Illuminant Building	IB	no			1	no data/reports
28/00	Maintenance Shop	MS	no			1	no data/reports
29/07	PCP Dip Tank	PCP	no			1	no data/reports
30/00	Landfarm	LF	no			1	groundwater issue only
31/00	Compressed Gas Cylinder Site	CGC	no			1	no data/reports
32/00	Tank Farm	TF	no			1	no data/reports
33/00	Compositing Unit (Bioremediation Facility)	COMP	yes	BIOF001 through BIOF014	questionable due to possible site contamination	1	Samples were not intended as background and may have been impacted by previous site activities
	Borrow Pit	BP	yes	BP/BF-001 through BP/BF-004, 02/11BP1 and 02/11BP2	questionable due to poor data quality		Several locations; Uncertainty in quality of data; analytical problems; possibility of impact due to site activities

TABLE 3-1

SUMMARY OF HISTORICAL SOIL BACKGROUND DATA FOR METALS
NAVAL SURFACE WARFARE CENTER
CRANE, INDIANA

SWMU No.	SWMU Name	Abbreviated Name	Soil Background Data Available	Background Sample Identifiers	Validity of Background Samples[A]	Source	Remarks

Notes:
A - Although this data is not used in the base-wide database, at a minimum, this data may provide some value as a point of reference at each of the respective SWMU investigations.

Sources:
1 Tom Brent, personal communication, December, 1998
2 HNUS, August 1992, RFI Phase I, Environmental Montoring Report, SWMUs 19/00, 08/17. 12/14, 13/14, NorthDiv, CTO 15
3 HNUS, November 1992, RFI Phase I, Environmental Montoring Report, SWMUs 15/06, 14/10, 16/16, NorthDiv, CTO 15
4 TtNUS 1999, Final Current Contamination Conditions Risk Assessment, SWMUs 03/10, 07/09, 06/09
5 Murphy and Wade, 1998, RCRA FI Phase III Groundwater Release Char., SWMU 02/11, Dye Burial Grounds, NSWC Crane, Final Report, USACE Waterways Experimental Station.
6 Nohrstedt, J.S., et al., 1998, RCRA Facility Investigation Phase II Soils Release Characterization, SWMU 04/02, McCormish Gorge, NSWC Crane, Final Report, USACE WES.
7 Albertson et al., September 1998, RCRA Facility Investigation Phase II Soils, SWMU 05/03, Old Burn Pit, NSWC Crane, Final Report, USACE Waterways Experimental Station
8 USACE Waterways Experimental Station, Feburary 1992, RCRA Facility Investigation Phase II and Phase III Soils, SWMU 09/05, Pest Control Area/ R150 Tank Site, NSWC Crane
9 Analytical Data, SWMU 09/05, Pest Control Area/ R150 Tank Site, NSWC Crane
10 Nohrstedt, J.S., et al., September 1998c, RCRA Facility Investigation Plahse II Soil Release Characterizatin, NSWC Crane
11 Nohrstedt, J.S., et al., September 1998, RCRA Facility Investigation Phase II Soils Release Characterization, SWMU 10/15, Rockeye Munitions Facility, Final Report, USACE WES
12 Rust E&I, July 1997, Environmental Data Assessment Memorandum, SWMUs 03/10, 06/09, and 07/09, NSWC Crane, Draft Report.

TABLE 3-2

BACKGROUND SOIL SAMPLE LOCATIONS
BACKGROUND AREA 1
NAVAL SURFACE WARFARE CENTER
CRANE, INDIANA
PAGE 1 OF 2

Depositional Environment	Sample Tracking Number	Source of Deposition[1]	Topographic Location	General Location	Crane Develop-ment Map #	Soil Survey of Martin County[2] Map #	Soil Series[1,3]	Soil Map Units[1,3]	Present at # of SWMU	Soil Classification[1,3] Surface Soil[4]	Soil Classification[1,3] Subsurface Soil[5]
FIRST FIELD EVENT											
Loess/ Glacial Outwash	BG1SBL01	Loess deposits	uplands & ridgetops	west-southwest of Landfill	28	12	Hosmer	HoB	2	silt loam	silt loam to silty clay loam
	BG1SBL02	Loess deposits	uplands & ridgetops	south of Landfill	28	12	Hosmer	HoB	2	silt loam	silt loam to silty clay loam
	BG1SBL03	Loess deposits	uplands & ridgetops	southwest corner of base	28	20	Hosmer	HoB	2	silt loam	silt loam to silty clay loam
	BG1SBL04	Loess deposits	uplands & ridgetops	southwest corner of base	12	20	Hosmer	HoB	2	silt loam	silt loam to silty clay loam
	BG1SBL05	Loess deposits	uplands & ridgetops	south of Landfarm	28	12	Hosmer	HoB	2	silt loam	silt loam to silty clay loam
Alluvium	BG1SBA01	Alluvium	lowlands	southwest of Pyrotechnic Test Areal	34	17	Haymond	Hd	3	silt loam	silt loam
	BG1SBA02	Alluvium	floodplains & lowlands	southwest of Pyrotechnic Test Areal	34	17	Wilbur	Wr	0	silt loam	silt loam
	BG1SBA03	Alluvium derived from sandstone, siltstone, and shale	floodplains & lowlands	south of Landfill	33	16	Burnside	Bu	4	loam	loam to channery loam
	BG1SBA04	Silty alluvium derived from loess uplands	floodplains & lowlands	south of Landfill	37	16	Wakeland	Wa	4	silt loam	silt loam
	BG1SBA05	Alluvium	lowlands	West of Rocket Range	34	17	Wakeland	Wa	4	silt loam	silt loam
Residual Soil from Pennsylvanian Bedrock/ Colluvium	BG1SBP01	material weathered from SS, siltstone, shale.	sideslopes	south of Landfill	28	12	Wellston-Gilpin complex	WnE	16	silt loam to channery silt loam	silt loam, silty clay loam, to channery loam
	BG1SBP02	Loess and material weathered from SS, siltstone, shale.	ridgetop in uplands	East of Landfill	29	13	Zanesville	ZaB	6	silt loam to silty clay loam	silty loam, to sandy clay loam
	BG1SBP03	material weathered from SSs, siltstone, shale.	toe of slope	east of Landfill	29	13	Wellston	WeD2	8	silt loam	silt loam, silty clay loam, to channery loam
	BG1SBP04	Loess and material weathered from SS, siltstone, shale.	sideslope in uplands	southeast of Landfill	29	13	Wellston	WeD2	8	silt loam	silt loam, silty clay loam, to channery loam
	BG1SBP05	Loess and material weathered from SS, siltstone, shale.	ridgetop in uplands	southeast of Landfill	33	17	Zanesville	ZaB	6	silt loam to silty clay loam	silty loam, to sandy clay loam
	BG1SBP06	Loess and material weathered from SS, siltstone, shale.	ridgetop in uplands	south of Landfill	33	16	Zanesville-Udorthents complex	ZnC	17	silt loam to silty clay loam	silt loam, silty clay loam to loam
	BG1SBP07	material weathered from SS, siltstone, shale.	sideslope	southwest of Annex	34	17	Wellston-Gilpin complex	WnE	16	silt loam to channery silt loam	silt loam, silty clay loam, to channery loam
	BG1SBP08	material weathered from SS, siltstone, shale.	sideslope near ridgetop	Northwest of Rocket Range	34	16	Wellston	WeC2	5	silt loam	silt loam, silty clay loam, to channery loam
	BG1SBP09	material weathered from SS, siltstone, shale.	toe of slope	West of Rocket Range	37	20	Wellston-Gilpin complex	WnE	16	silt loam to channery silt loam	silt loam, silty clay loam, to channery loam
	BG1SBP10	material weathered from SS, siltstone, shale.	toe of slope	West of Rocket Range	37	20	Zanesville	ZaC2	7	silt loam to silty clay loam	silty loam, to sandy clay loam

TABLE 3-2

BACKGROUND SOIL SAMPLE LOCATIONS
BACKGROUND AREA 1
NAVAL SURFACE WARFARE CENTER
CRANE, INDIANA
PAGE 2 OF 2

Depositional Environment	Sample Tracking Number	Source of Deposition[1]	Topographic Location	General Location	Crane Develop-ment Map #	Soil Survey of Martin County[2] Map #	Soil Series[1,3]	Soil Map Units[1,3]	Present at # of SWMU	Soil Classification[1,3] Surface Soil[4]	Soil Classification[1,3] Subsurface Soil[5]
SUPPLEMENTAL FIELD EVENT											
Alluvium	BG1SBA25[6]	Silty alluvium derived from loess uplands	floodplains & lowlands	App. 2500 feet southeast of storage bunker 1360	37	20	Wakeland	Wa	4	silt loam	silt loam
	BG1SBA28[6]	Loess and underlying alluvium	outwash terraces	App. 2500 feet southeast of the Rocket Range	38	21	Pekin	PeB	NP	silt loam	silt loam to silty clay loam
	BG1SBA29[6]	Alluvium derived from loess uplands	floodplains & lowlands	App. 1000 feet north of storage bunker 1289	34	17	Wilbur	Wr	NP	silt loam	silt loam
	BG1SBA38[6]	Alluvium derived from loess uplands	floodplains & lowlands	App. 5500 feet north of the Rocket Range	34	17	Wilbur	Wr	NP	silt loam	silt loam
Residual Soil from Pennsylvanian Bedrock/ Colluvium	BG1SBP11[8]	material weathered from ss, siltstone, shale.	top of slope	West of Pyrotechnic Area	28	13	Wellston	WeD2	8	silt loam	silt loam, silty clay loam, to channery loam
	BG1SBP13[9]	material weathered from ss, siltstone, shale.	sideslope	Northwest of Pyrotechnic Area	29	13	Wellston	WeD2	8	silt loam	silt loam, silty clay loam, to channery loam
	BG1SBP16[9]	material weathered from ss, siltstone, shale.	sideslope	Northwest of Rocket Range	34	17	Wellston-Gilpin complex	WnE	16	silt loam to channery silt loam	silt loam, silty clay loam, to channery loam
	BG1SBP22[8]	loess and material weathered from ss, siltstone, shale.	sideslope of ridge	West of Rocket Range	37	16	Zanesville	ZaB	6	silt loam to silty clay loam	silty loam, to sandy clay loam
	BG1SBP37[9]	material weathered from ss, siltstone, shale.	ridgetop	Northwest of Rocket Range	34	17	Wellston	WeC2	5	silt loam	silt loam, silty clay loam, to channery loam
	BG1SBP39[7]	material weathered from ss, siltstone, shale.	sideslope near ridgetop	Northwest of Rocket Range	33	16	Wellston-Gilpin complex	WnE	16	silt loam to channery silt loam	silt loam, silty clay loam, to channery loam
	BG1SBP40[9]	material weathered from ss, siltstone, shale.	sideslope near ridgetop	South of Landfill	28	12	Wellston-Gilpin complex	WnE	16	silt loam to channery silt loam	silt loam, silty clay loam, to channery loam
	BG1SBP42[7]	material weathered from ss, siltstone, shale.	sideslope	West of Pyrotechnic Area	29	13	Zanesville	ZaC2	7	silt loam to silty clay loam	silty loam, to sandy clay loam
	BG1SBP43[8]	material weathered from ss, siltstone, shale.	ridgetop	Southeast of Landfill	34	13	Wellston	WeD2	8	silt loam	silt loam, silty clay loam, to channery loam
	BG1SBP44[8]	material weathered from ss, siltstone, shale.	ridgetop	Southwest of Pyrotechnic Area	34	13	Wellston	WeC2	5	silt loam	silt loam, silty clay loam, to channery loam
	BG1SBP45[7]	material weathered from ss, siltstone, shale.	ridgetop	Northwest of Pyrotechnic Area	29	13	Wellston	WeC2	5	silt loam	silt loam, silty clay loam, to channery loam
	BG1SBP50[9]	loess and material weathered from ss, siltstone, shale.	sideslope of ridge	Northwest of Pyrotechnic Area	29	13	Zanesville	ZaB	6	silt loam to silty clay loam	silty loam, to sandy clay loam

Notes:
SS - sandstone
1 Information taken from McElrath (1988).
2 No depth specified for surface soil samples
3 United States Department of Agriculture (USDA) classification system
4 Surface soil is from 0 to 12 inches below ground surface (bgs) based upon classification by McElrath (1988).
5 Subsurface soil is between 12 to 70 inches bgs or to the top of bedrock McElrath (1988).
6 Boring Set AB1 (see TtNUS, 2000b for more details).
7 Boring Set PS1 (see TtNUS, 2000b for more details).
8 Boring Set PS2 (see TtNUS, 2000b for more details).
9 Boring Set PS3 (see TtNUS, 2000b for more details).

TABLE 3-3

**BACKGROUND SOIL SAMPLE LOCATIONS
BACKGROUND AREA 2
NAVAL SURFACE WARFARE CENTER
CRANE, INDIANA**

										Soil Classification[1,3]	
Depositional Environment	Sample Tracking Number	Source of Deposition[1]	Topo-graphic Location	General Location	Crane Development Map #	Soil Survey of Martin County[2] Map #	Soil Series[1,3]	Soil Map Units[1,3]	Present at # of SWMUs	Surface Soil[4]	Subsurface Soil[5]
Background Area 2a											
Loess/ Glacial Outwash	BG2SBG1	Glacial outwash deposits	sideslopes	south of Hwy 5, West Gate	8	4	Parke	PaC2	1	silt loam	silty clay loam to sandy clay loam
	BG2SBG2	Glacial outwash deposits	sideslopes	south of Hwy 5, West Gate	8	4	Parke	PaC2	2	silt loam	silty clay loam to sandy clay loam
	BG2SBG3	Glacial outwash deposits	sideslopes	south of Hwy 5, West Gate	8	4	Parke	PaC2	3	silt loam	silty clay loam to sandy clay loam
Background Area 2b											
Loess/ Glacial Outwash	BG2SBG4	Glacial outwash deposits	sideslopes	north of Hwy 5, West Gate	8	4	Negley	NeE	2	silt loam to loam	loam, clay loam, gravely loam
	BG2SBG5	Glacial outwash deposits	sideslopes	north of Hwy 5, West Gate	8	4	Negley	NeE	2	silt loam to loam	loam, clay loam, gravely loam

Notes:
1 Information taken from McElrath (1988).
2 No depth specified for surface soil samples
3 United States Department of Agriculture (USDA) classification system
4 Surface soil is from 0 to 12 inches below ground surface (bgs) based upon classification by McElrath (1988).
5 Subsurface soil is between 12 to 70 inches bgs or to the top of bedrock based upon classification by McElrath (1988).

TABLE 3-4

BACKGROUND SOIL SAMPLE LOCATIONS
BACKGROUND AREA 3
NAVAL SURFACE WARFARE CENTER
CRANE, INDIANA
PAGE 1 OF 2

Depositional Environment	Sample Tracking Number	Source of Deposition[1]	Topo-graphic Location	General Location	Crane Develop-ment Map #	Soil Survey of Martin County[2] Map #	Soil Series[1,3]	Soil Map Units[4,5]	Present at # of SWMU	Soil Classification[1,3] Surface Soil[4]	Soil Classification[1,3] Subsurface Soil[5]
FIRST FIELD EVENT											
Alluvium	BG3SBA01	Alluvium derived from SS, siltstone, and shale	floodplain & lowlands	Upper Sulphur Creek; northwest of intersection btwn JT-9 & H-162	12	3	Burnside	Bu	4	loam	loam to channery loam
	BG3SBA02	Alluvium derived from SS, siltstone, and shale	floodplain & lowlands	Upper Sulphur Creek; northwest of intersection btwn JT-9 & H-163	12	3	Burnside	Bu	4	loam	loam to channery loam
	BG3SBA03	Alluvium derived from SS, siltstone, and shale	floodplain & lowlands	southwest of PT-9	6	3	Burnside	Bu	4	loam	loam to channery loam
	BG3SBA04	Alluvium derived from SS, siltstone, and shale	floodplain & lowlands	Boone Hollow; west of PT-10A	14	3	Burnside	Bu	4	loam	loam to channery loam
	BG3SBA05	Alluvium derived from SS, siltstone, and shale	floodplain & lowlands	Boone Hollow; west of PT-10A	14	3	Burnside	Bu	4	loam	loam to channery loam
Residual Soil from Mississippian Bedrock/ Colluvium	BG3SBM01	material weathered from (M6) SS, siltstone, shale.	sideslope	East of Roberts Cemetary, along PT-8	5	3	Wellston-Ebal	WID	NP	silt loam	silt loam, silty clay loam, to channery loam
	BG3SBM02	material weathered from (M6) SS, siltstone, shale.	sideslope	East of Roberts Cemetary, along PT-8	5	3	Zanesville	ZaC3	2	silt loam to silty clay loam	silty loam, to sandy clay loam
	BG3SBM03	material weathered from (M5) SS, siltstone, shale.	sideslope	West of JT-9; Northeast of Bunker #1583	13	3	Wellston-Berks-Gilpin complex	WgG	6	silt loam to channery silt loam	silt loam, silty clay loam, to channery loam
	BG3SBM04	material weathered from (M5) SS, siltstone, shale.	sideslope	N.east of JT-10 & JT-10A intersection	6	3	Zanesville	ZaC2	7	silt loam to silty clay loam	silty loam, to sandy clay loam
	BG3SBM05	material weathered from (M5) SS, siltstone, shale.	ridgetop	North of JT-10A	14	3	Johnsburg	Jo	NP	silt loam	silty clay loam, silt loam, to sandy loam
	BG3SBM06	material weathered from (M4) SS, siltstone, shale.	sideslope/lowland	East of JT-9; north of intersection btwn JT-9 & H-162	13	3	Wellston-Berks-Gilpin complex	WgG	5	silt loam to channery silt loam	silt loam, silty clay loam, to channery loam
	BG3SBM07	material weathered from (M5) SS, siltstone, shale.	ridgetop	South of JT-10A	14	3	Zanesville	ZaB	6	silt loam to silty clay loam	silty loam, to sandy clay loam
	BG3SBM08	material weathered from (M3) SS, siltstone, shale.	sideslope/lowland	400 feet south of PT-9	6	3	Wellston-Ebal	WID	NP	silt loam	silt loam, silty clay loam, to channery loam
	BG3SBM09	material weathered from (M3) SS, siltstone, shale.	sideslope	800 feet South of JT-10A	13	3	Wellston-Berks-Gilpin complex	WgG	5	silt loam to channery silt loam	silt loam, silty clay loam, to channery loam
	BG3SBM10	material weathered from (M2) SS, siltstone, shale.	sideslope/lowland	400 feet West of PT-10A	14	3	Wellston-Berks-Gilpin complex	WgG	5	silt loam to channery silt loam	silt loam, silty clay loam, to channery loam

TABLE 3-4

BACKGROUND SOIL SAMPLE LOCATIONS
BACKGROUND AREA 3
NAVAL SURFACE WARFARE CENTER
CRANE, INDIANA

Depositional Environment	Sample Tracking Number	Source of Deposition[1]	Topo-graphic Location	General Location	Crane Develop-ment Map #	Soil Survey of Martin County[2] Map #	Soil Series[1,3]	Soil Map Units[4,5]	Present at # of SWMU	Soil Classification[1,3] Surface Soil[4]	Soil Classification[1,3] Subsurface Soil[5]
SUPPLEMENTAL FIELD EVENT											
Alluvium	BG3SBA07[6]	Alluviuim derived from sandstone, siltstone, and shale	fllodplain and lowlands	Upper Suilfur Creek: northwest intersection btwn JT-9 & H-162	12	3	Burnside	Bu	4	loam	loam to channery loam
Residual Soil from Pennsylvanian Bedrock/ Colluvium	BG3SBP01[7]	Loess and material weathered from ss, siltstone, shale	ridgetop	East of JT-10 and JT-10A intersection	6	3	Zanesville	ZaC2	7	silt loam to silty clay loam	silty loam to sandy clay loam
	BG3SBP08[8]	Loess and material weathered from ss, siltstone, shale	sideslope	App. 1600 feet southest of JT-9 and PT-8 intersection	13	3	Wellston-Berks-Gilpin Complex	WgG	5	silt loam to channery silt loam	silt loam,silty clay loam to channery loam
	BG3SBP09[7]	Loess, colluvium, and material weathered from ss, siltstone, shale	sideslope	App. 1600 feet west of JT-9 and PT-8 intersection	5	3	Wellston-Ebal	WID	NP	silt loam	silt loam,silty clay loam to channery loam

Notes:
SS - sandstone
1 Information taken from McElrath (1988).
2 No depth specified for surface soil samples
3 United States Department of Agriculture (USDA) classification system
4 Surface soil is from 0 to 12 inches below ground surface (bgs) based upon classification by McElrath (1988).
5 Subsurface soil is between 12 to 70 inches bgs or to the top of bedrock McElrath (1988).
6 Boring Set AB1 (see TtNUS, 2000b for more details).
7 Boring Set PS1 (see TtNUS, 2000b for more details).
8 Boring Set PS2 (see TtNUS, 2000b for more details).
9 Boring Set PS3 (see TtNUS, 2000b for more details).

TABLE 3-5

**SAMPLING SUMMARY FOR CHEMICAL ANALYSIS
BACKGROUND AREA 1
NAVAL SURFACE WARFARE CENTER
CRANE, INDIANA**

Depositional Environment	Background Sample Location	Background Sample Name	Depth (feet-bgs)	Analysis of TAL metals + Tin, Lithium, Strontium, and Thorium [1]
First Field Event				
Loess/ Glacial Outwash	BG1SBL01	BG1SBL0101	0-1	X
		BG1SBL0103	2-3	X
		BG1SBL0105	4-5	X
	BG1SBL03	BG1SBL0305	4-5	X
	BG1SBL04	BG1SBL0403	2-3	X
		BG1SBL0405	4-5	X
	BG1SBL05	BG1SBL0501	0-1	X
		BG1SBL0504	3-4	X
		BG1SBL0506	5-6	X
Alluvium	BG1SBA01	BG1SBA0101	0-1	X
		BG1SBA0104	3-4	X
	BG1SBA03	BG1SBA0306	5-6	X
	BG1SBA04	BG1SBA0401	0-1	X
		BG1SBA0405	4-5	X
	BG1SBA05	BG1SBA0503	2-3	X
		BG1SBA0504	3-4	X
Residual Soil from Pennsylvanian Bedrock/ Colluvium	BG1SBP01	BG1SBP0103	2-3	X
	BG1SBP02	BG1SBP0204	3-4	X
		BG1SBP0206	5-6	X
	BG1SBP03	BG1SBP0305	4-5	X
	BG1SBP04	BG1SBP0401	0-1	X
		BG1SBP0406	5-6	X
	BG1SBP05	BG1SBP0505	4-5	X
	BG1SBP06	BG1SBP0601	0-1	X
		BG1SBP0603	2-3	X
	BG1SBP07	BG1SBP0701	0-1	X
	BG1SBP08	BG1SBP0801	0-1	X
		BG1SBP0804	3-4	X
		BG1SBP0806	5-6	X
	BG1SBP09	BG1SBP0901	0-1	X
	BG1SBP10	BG1SBP1004	3-4	X
Supplement Field Event				
Alluvium	BG1SBA25	BG1SBA250203	2-3	X
	BG1SBA28	BG1SBA280304	3-4	X

Notes:
1 See Section 3.3.5 for a description of the process of selecting samples for chemical analysis.

TABLE 3-6

SAMPLING SUMMARY FOR CHEMICAL ANALYSIS
BACKGROUND AREA 2
NAVAL SURFACE WARFARE CENTER
CRANE, INDIANA

Depositional Environment	Background Sample Location	Background Sample Name	Depth (feet-bgs)	Analysis of TAL metals + Tin, Lithium, Strontium, and Thorium (1)
Loess/ Glacial Outwash	BG2SBG01	BG2SBG0101	0-1	**X**
		BG2SBG0104	3-4	**X**
	BG2SBG02	BG2SBG0201	0-1	**X**
		BG2SBG0203	2-3	**X**
		BG2SBG0206	5-6	**X**
	BG2SBG03	BG2SBG0303	2-3	**X**
	BG2SBG04	BG2SBG0401	0-1	**X**
		BG2SBG0404	3-4	**X**
	BG2SBG0503	BG2SBG0503	2-3	**X**

Notes:
1 See Section 3.3.5 for a description of the process of selecting samples for chemical analysis.

TABLE 3-7

SAMPLING SUMMARY FOR CHEMICAL ANALYSIS
BACKGROUND AREA 3
NAVAL SURFACE WARFARE CENTER
CRANE, INDIANA

Depositional Environment	Background Sample Location	Background Sample Name	Depth (feet-bgs)	Analysis of TAL metals + Tin, Lithium, Strontium, and Thorium [(1)]
First Field Event				
Alluvium	BG3SBA01	BG3SBA0101	0-1	X
	BG3SBA02	BG3SBA0203	2-3	X
	BG3SBA03	BG3SBA0301	0-1	X
	BG3SBA04	BG3SBA0403	2-3	X
		BG3SBA0404	3-4	X
	BG3SBA05	BG3SBA0501	0-1	X
		BG3SBA0504	3-4	X
		BG3SBA0506	5-6	X
Residual Soil from Mississippian Bedrock/ Colluvium	BG3SBM02	BG3SBM0201	0-1	X
		BG3SBM0203	2-3	X
		BG3SBM0206	5-6	X
	BG3SBM03	BG3SBM0305	4-5	X
	BG3SBM04	BG3SBM0401	0-1	X
		BG3SBM0404	3-4	X
		BG3SBM0406	5-6	X
	BG3SBM05	BG3SBM0504	3-4	X
	BG3SBM06	BG3SBM0601	0-1	X
		BG3SBM0604	3-4	X
	BG3SBM07	BG3SBM0701	0-1	X
		BG3SBM0704	3-4	X
		BG3SBM0706	5-6	X
	BG3SBM08	BG3SBM0801	0-1	X
		BG3SBM0803	2-3	X
	BG3SBM09	BG3SBM0904	3-4	X
	BG3SBM10	BG3SBM1003	2-3	X
Supplement Field Event				
No samples were collected				

Notes:
1 See Section 3.3.5 for a description of the process of selecting samples for chemical analysis.

TABLE 3-8

SUMMARY OF SOIL SAMPLES COLLECTED FOR CHEMICAL ANALYSIS
NAVAL SURFACE WARFARE CENTER
CRANE, INDIANA

Depositional Environment	Surface or Subsurface Soil	Gross Grain Size Classification	Number of Samples Sent for Chemical Analysis
ALLUVIUM	SS		5
ALLUVIUM	SB	CLAY	3
ALLUVIUM	SB	SAND	4
ALLUVIUM	SB	SILT	5
LOESS/GLACIAL	SS		5
LOESS/GLACIAL	SB	CLAY	5
LOESS/GLACIAL	SB	SAND	3
LOESS/GLACIAL	SB	SILT	5
MISSISSIPPIAN	SS		5
MISSISSIPPIAN	SB	CLAY	4
MISSISSIPPIAN	SB	SAND	3
MISSISSIPPIAN	SB	SILT	5
PENNSYLVANIAN	SS		5
PENNSYLVANIAN	SB	CLAY	4
PENNSYLVANIAN	SB	SAND	1
PENNSYLVANIAN	SB	SILT	5
Total Number of Samples Sent for Chemical Analysis			67

Notes:
SS - surface soil
SB - subsurface soil

TABLE 3-9

COMPARISON OF FIELD AND LABORATORY DUPLICATE SAMPLE CONCENTRATIONS
BASEWIDE BACKGROUND INVESTIGATION REPORT
NAVAL SURFACE WARFARE CENTER
CRANE, INDIANA

Metal (units of mg/kg)	Laboratory Duplicate AVG%RPD	Laboratory Duplicate MAX%RPD	Number of Laboratory Duplicate Pairs with 2 Detects	Field Duplicate AVG%RPD	Field Duplicate MAX%RPD	Number of Field Duplicate Pairs with 2 Detects	Ratio (Lab Duplicate AVG%RPD) / (Field Duplicate AVG%RPD)
ALUMINUM	7.84	20.2	4	7.27	17.22	8	1.08
ANTIMONY	NA	NA	0	NA	NA	0	NA
ARSENIC	13.48	45.84	4	13.32	24.00	8	1.01
BARIUM	11.28	22.36	4	6.82	21.28	8	1.65
BERYLLIUM	3.16	3.16	1	5.81	10.26	2	0.54
CADMIUM	85.60	161.28	2	43.53	80.00	2	1.97
CALCIUM	7.00	9.80	4	7.44	14.24	8	0.94
CHROMIUM	16.08	36.36	4	11.98	22.03	8	1.34
COBALT	18.04	31.04	4	9.38	20.59	8	1.92
COPPER	6.16	11.68	4	7.73	18.02	8	0.80
IRON	16.92	35.48	4	9.38	27.57	8	1.80
LEAD	14.08	38.44	4	8.60	21.80	8	1.64
MAGNESIUM	3.60	7.00	4	5.72	11.29	8	0.63
MANGANESE	30.56	70.60	4	15.28	36.37	8	2.00
MERCURY	NA	NA	0	9.09	4.55	2	NA
NICKEL	7.88	14.20	4	6.07	15.38	8	1.30
POTASSIUM	7.92	26.28	4	8.74	17.25	8	0.91
SELENIUM	21.64	26.88	2	NA	NA	0	NA
SILVER	0.00	0.00	1	33.33	66.67	2	0.00
SODIUM	0.84	0.80	1	5.64	7.07	3	0.15
THALLIUM	15.36	35.28	4	10.42	21.28	8	1.47

TABLE 3-9

COMPARISON OF FIELD AND LABORATORY DUPLICATE SAMPLE CONCENTRATIONS
BASEWIDE BACKGROUND INVESTIGATION REPORT
NAVAL SURFACE WARFARE CENTER
CRANE, INDIANA

Metal (units of mg/kg)	Laboratory Duplicate AVG%RPD	Laboratory Duplicate MAX%RPD	Number of Laboratory Duplicate Pairs with 2 Detects	Field Duplicate AVG%RPD	Field Duplicate MAX%RPD	Number of Field Duplicate Pairs with 2 Detects	Ratio (Lab Duplicate AVG%RPD) / (Field Duplicate AVG%RPD)
TIN	NA	NA	0	NA	NA	0	NA
VANADIUM	11.00	34.40	4	5.88	11.11	8	1.87
ZINC	6.64	12.28	4	5.78	16.04	7	1.15
Average RPD (all metals)	**14.52**			**10.79**			**1.35**

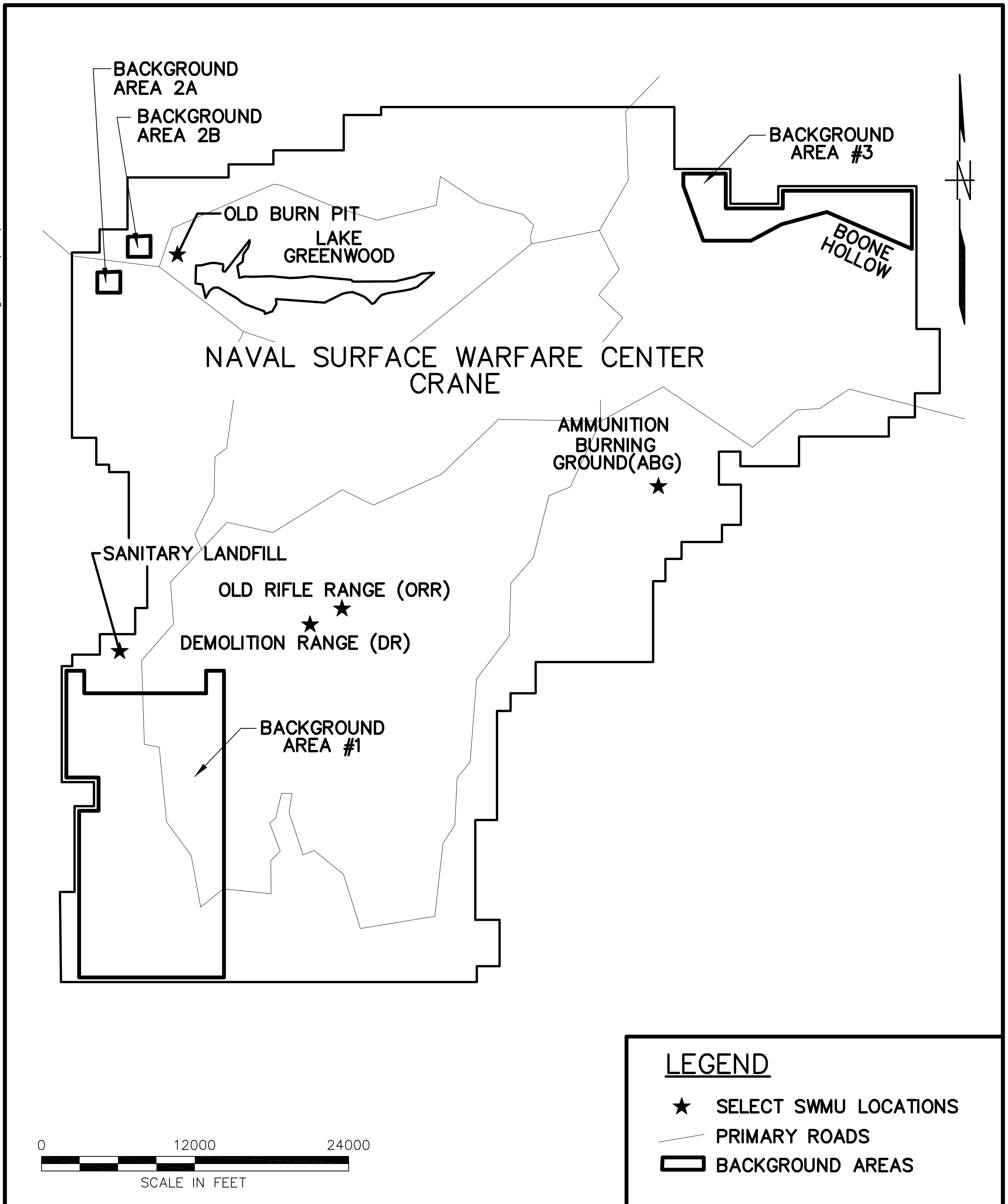
Notes:
AVG - average
RPd - relative percent difference
MAX - maximum
NA - Not available

TABLE 3-10

TABULATION OF REPORTED AND REQUESTED DETECTION LIMITS AND NUMBERS OF NON-DETECTS BASEWIDE BACKGROUND INVESTIGATION REPORT NAVAL SURFACE WARFARE CENTER CRANE, INDIANA

Metal	Minimum Reported Detection Limit (mg/kg)	Maximum Reported Detection Limit (mg/kg)	Average Reported Detection Limit (mg/kg)	Number of Non-Detects	Planned Detection Limit (mg/kg)
ANTIMONY	0.20*	5.5	0.77	59	0.15
BERYLLIUM	0.18*	1.4	0.64	53	0.15
CADMIUM	0.04	0.33	0.14	33	0.5
MERCURY	0.04	0.05	0.05	50	0.07
SELENIUM	0.23*	1.3	0.54	52	0.15
SILVER	0.04	0.23	0.07	19	0.05
SODIUM	2	125	3.3	35	2.6
TIN	0.38*	1.3	0.64	67	0.10

Notes:
* - Reported minimum detection limit exceeds the requested detection limit.



ACAD: 0087GM02.dwg 04/26/01 HJP

DRAWN BY DATE MF 2/23/99		LOCATION OF NAVAL SURFACE WARFARE CENTER CRANE AND BACKGROUND AREAS NAVAL SURFACE WAREFARE CENTER CRANE, INDIANA	CONTRACT NO. 0087
CHECKED BY DATE			APPROVED BY DATE K. HENN 3/9/00
COST/SCHED-AREA			APPROVED BY DATE
SCALE AS NOTED			DRAWING NO. FIGURE 3-1 — REV. 1

FORM CADD NO. SDIV_AV.DWG - REV 0 - 1/20/98

NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES	NO.	RELEASED FOR	BY	DATE

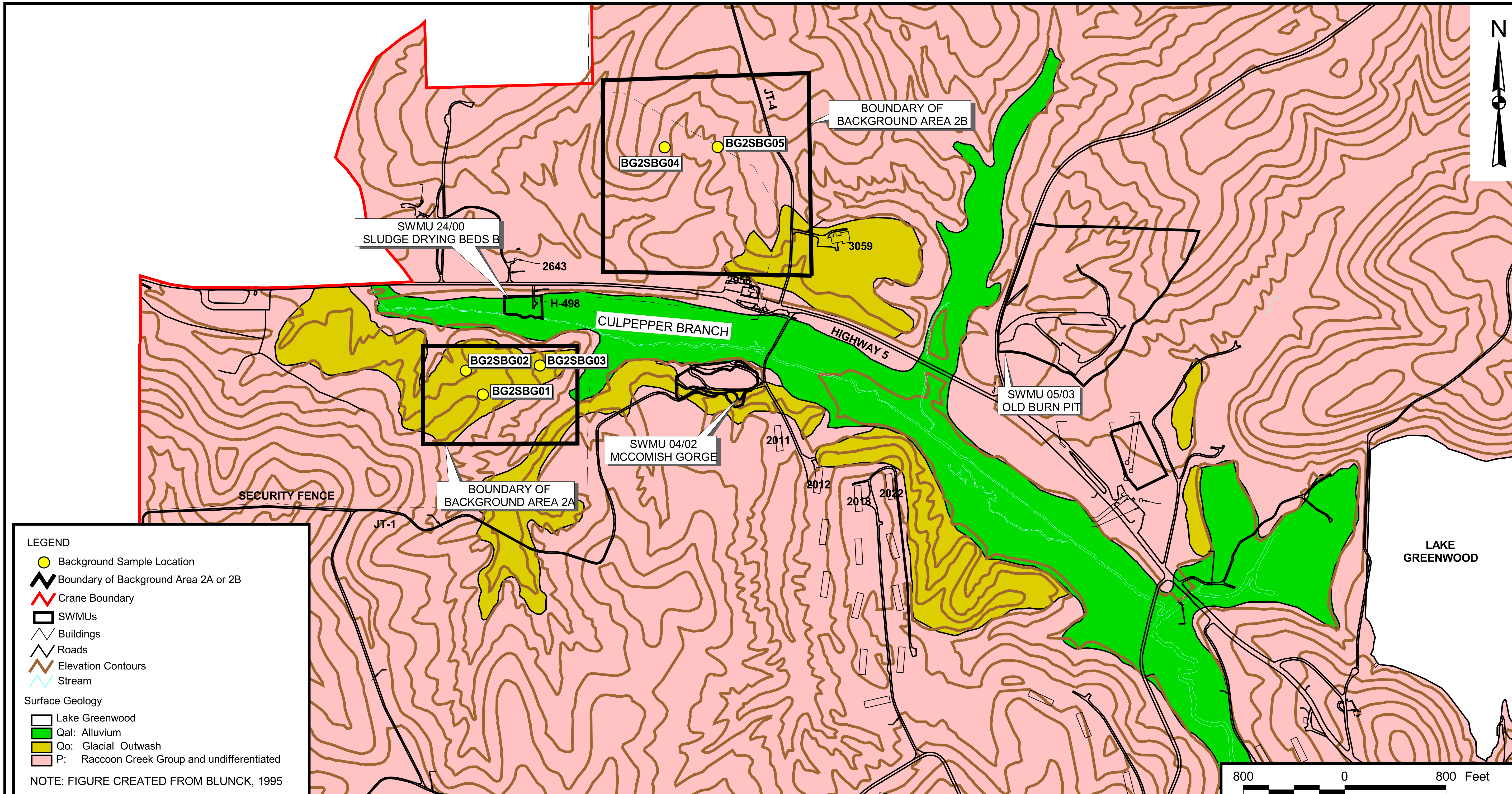
DRAWN BY: J. LAMEY — DATE: 2/25/00
CHECKED BY: K. HENN — DATE: 1/11/01
COST/SCHEDULE-AREA
SCALE: AS NOTED

Tetra Tech NUS, Inc.

SAMPLING LOCATION MAP
BACKGROUND AREA 1
WORK PLAN/FIELD SAMPLING PLAN ADDENDUM
NAVAL SURFACE WARFARE CENTER CRANE
CRANE, INDIANA

CONTRACT NO. 0087 — OWNER NO. 0083
APPROVED BY: K. HENN — DATE: 1/11/01
APPROVED BY: ___ — DATE: ___
DRAWING NO.: FIGURE 3-2 — REV.: 1

P:\GIS\NSWC_CRANE\0087.APR 7/6/00 JAL NORTHWEST BH LAYOUT



NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES

DRAWN BY: J. LAMEY — DATE: 2/25/00

CHECKED BY: K. HENN — DATE: 7/6/00

COST/SCHEDULE-AREA

SCALE: AS NOTED

Tetra Tech NUS, Inc.

BACKGROUND SAMPLE LOCATION MAP
BACKGROUND AREA 2
NAVAL SURFACE WARFARE CENTER CRANE
CRANE, INDIANA

CONTRACT NUMBER: 0087

OWNER NUMBER: 0083

APPROVED BY: K. HENN — DATE: 7/6/00

APPROVED BY: — DATE: —

DRAWING NO.: FIGURE 3-3

REV: 0

LEGEND

- Background Sample Location (November 1999)
- Background Sample Location (October 2000; No Samples Collected For Chemical Analysis)
- Crane Boundary
- Boundary of Background Area 3
- Buildings
- Roads
- Elevation Contours (20 Foot Contour Interval)

Surface Geology
- Qal: Alluvium
- P: Raccoon Creek Group and undifferentiated
- M6: Glenn Dean Ls, Hardinsburg Fm, Haney Ls, Indian Springs Shale Mbr, and undifferentiated
- M5: Sandstone Mbr of the Big Clifty Fm
- M4: Beech Creek Ls
- M3: Elwren Fm, Reelsville Ls, upper Sample Fm, and undifferentiated
- M2: Lower part of Sample Fm, Beaver Bend Ls, Bethel Fm, and undifferentiated
- M1: Paoli Ls, Ste Genevieve, and undifferentiated

NOTE: FIGURE CREATED FROM BLUNCK, 1995

600 0 600 Feet

P:\GIS\NSWC_CRANE\0087.APR 1/11/01 JAL
NORTHEAST CORNER LAYOUT

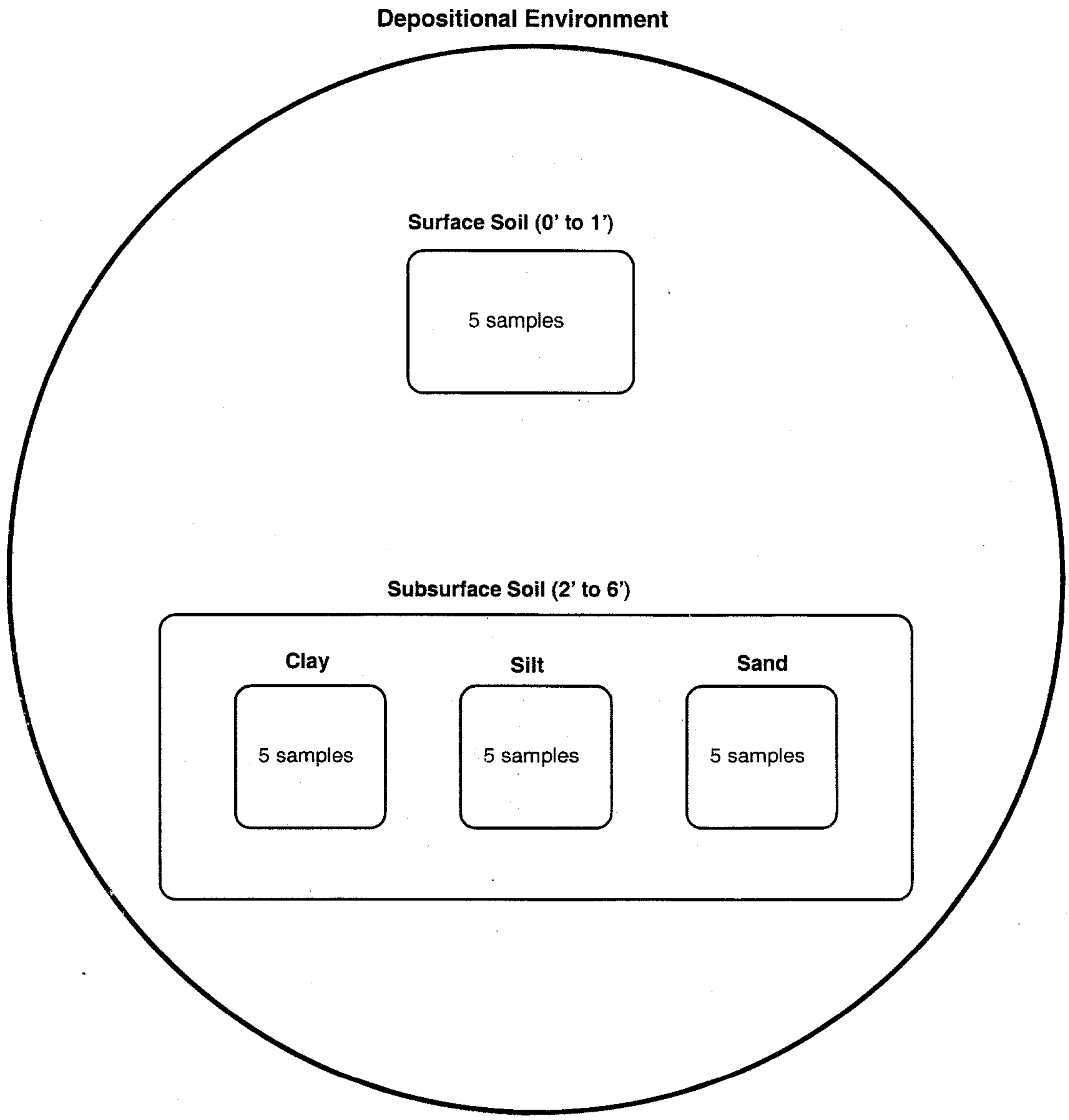
NO.	DATE	REVISIONS	BY	CHKD	APPD	REFERENCES	NO.	RELEASED FOR	BY	DATE

DRAWN BY	DATE
J. LAMEY	2/25/00
CHECKED BY	DATE
K. HENN	1/11/01
COST/SCHEDULE-AREA	
SCALE AS NOTED	

Tetra Tech NUS, Inc.

SAMPLE LOCATION MAP
BACKGROUND AREA 3
WORK PLAN/FIELD SAMPLING PLAN ADDENDUM
NAVAL SURFACE WARFARE CENTER CRANE
CRANE, INDIANA

CONTRACT NO.	OWNER NO.
0087	0083
APPROVED BY K. HENN	DATE 1/11/01
APPROVED BY ___	DATE ___
DRAWING NO. FIGURE 3-4	REV. 1



Note: This schematic diagram illustrates the maximum number of samples to be submitted for chemical analysis within a depositional environment, depth, and grain size.

DRAWN BY / DATE		CONTRACT NUMBER	OWNER NO.
J. LAMEY 3/9/00	Tetra Tech NUS, Inc.	0087	0083
CHECKED BY — DATE —	SELECTION OF SAMPLES FOR CHEMICAL ANALYSIS NAVAL SURFACE WARFARE CENTER CRANE, INDIANA	APPROVED BY [signature]	DATE 3-10-00
COST/SCHEDULE-AREA		APPROVED BY —	DATE —
SCALE AS NOTED		DRAWING NO. FIGURE 3-5	REV 0

P:\GIS\NSWC_CRANE\0087.APR 3/9/00 JAL SELECTION OF SAMPLES FOR CHEMICAL ANALYSIS

4.0 EVALUATION OF BACKGROUND ANALYTICAL DATA

A total of 16 soil types were anticipated to potentially exist within the background areas based upon various combinations of DE, depth, and grain size. The rationale for the development and description of each of these soil types has been presented in Sections 1, 2, and 3. Each of these 16 soil types are listed below:

1. Mississippian surface soil (MS)
2. Pennsylvanian surface soil (PS)
3. Alluvium surface soil (AS)
4. Loess/Glacial surface soil (LS)
5. Mississippian sand subsurface soil (MBS)
6. Mississippian silt subsurface soil (MBL)
7. Mississippian clay subsurface soil (MBC)
8. Pennsylvanian sand subsurface soil (PBS)
9. Pennsylvanian silt subsurface soil (PBL)
10. Pennsylvanian clay subsurface soil (PBC)
11. Alluvium sand subsurface soil (ABS)
12. Alluvium silt subsurface soil (ABL)
13. Alluvium clay subsurface soil (ABC)
14. Loess/Glacial sand subsurface soil (LBS)
15. Loess/Glacial silt subsurface soil (LBS)
16. Loess/Glacial clay subsurface soil (LBC)

All of the soil types were encountered in the NSWC Crane background areas. However, as noted in Section 3.3.5 two soil types were encountered less frequently than expected. Statistical analysis of the data is explained in the following sections and a discussion of the impact of detecting a small number of samples in certain soil type is also discussed.

4.1 DATA SET PREPARATION

Field logs were inspected to verify that the correct samples had been collected and that the samples had been correctly identified according to the procedures outlined in the Work Plan (TtNUS, 1999a). This QA/QC check on the field procedures and on sample collection and identification represents a verification of having attained the project goals, as presented in Section 1.0 and in the Work Plan and QAPP (TtNUS, 1999a, 1999b).

The data were validated according to the QAPP (TtNUS, 1999b) to determine whether the laboratory analytical process functioned as intended. A summary of overall data quality was then compiled to indicate whether biases or unexpectedly large imprecision had been observed. Detection limits were also reviewed to determine whether detection limit goals had been achieved. These summaries are presented in Section 3.7

4.2 SOIL TYPE CHARACTERIZATION AND CONSOLIDATION

Following the data validation and overall data quality evaluation, statistical analyses were undertaken to characterize the data sets and to test for differences among soil types. The methodology for statistical analyses is discussed in Appendix D-1. Statistical results from this analysis including plots and tables have been included in Appendix D-2. The statistical analyses began by generating a summary of analytical results (Table 4-1) which presents an overview of all of the analytical data and descriptive statistics. This table indicates the number of times each analyte was detected, the range of detected values, average value, and location of maximum detection. Also included in Table 4-1 are upper tolerance limits (UTLs) that may be used as points of reference representing the upper ends of the data sets, and soil risk-based target levels (SRBTLs) that provide perspective on the computed UTLs. The methodology for computing the UTLs is presented in Section 5.0 and Appendix D-1. The SRBTLs have been included as a point of reference to the background concentrations. The frequency or number of background samples detected that exceed the SRBTLs was also included in these tables. The SRBTLs are based on human health and ecological risk-based criteria as presented in Appendix E, Table E-1. These risk-based criteria were current as of the date of the approved QAPP (1999b). It is important to note that this information is updated by the appropriate regulatory agencies on a periodic basis.

Histograms were constructed and Shapiro-Wilk Tests of Normality (methodology outlined in Appendix D-1) were performed on each of the 27 metals in each of the 16 soil types. Both the data and the log transformed data were used to determine whether their underlying distributions were best categorized as normal or lognormal. Probability plots were then generated for each metal in each soil type. An example of a probability plot with its corresponding histograms is presented in Appendix D-2. The log transformed data were used for lognormal distributions and the untransformed data were used for normal distributions. A 95% confidence ellipse was delineated on each plot to distinguish statistical outliers. Statistical outliers were defined as results which fell outside the 95% confidence ellipse. The intent was to inspect statistical outliers to determine whether a physical cause could be assigned for their “outlier” status. However, no outliers were identified at the 5% significance level in any data set. This could be due, in part, to the small sizes of the data sets. However, because geological similarities were considered when establishing the soil types the data were expected to cluster well.

The statistical data set comparisons were conducted in three phases. The first phase followed the initial round of sampling and incorporated data for all metals except lithium, strontium and thorium (24 metals in all). The reason for this is that the latter three metals were not part of the originally planned analyte list (i.e., these three metals were analyzed at a later time). The second statistical analysis was a repeat of the first analysis, but included lithium, strontium, and thorium for a total of 27 metals. The lithium, strontium and thorium analyses were conducted on the originally acquired soil samples (from round one). A second round of sampling was later conducted in an effort to acquire at least two more samples of each of the PBS and ABC soil types. Only two more ABC samples were acquired. After the second round of sampling to collect two more ABC samples, 54 additional metal results from analysis of the two ABC samples were incorporated into the data sets. Each of the ABC samples collected during the second sampling round were analyzed for all 27 metals in the same analysis effort. The data analyses are described in detail in Appendix D-3. A summary of these analyses is described below.

The initial data analysis (24 metals) yielded nine distinct soil groups as depicted in Figure 4-1. Each soil group comprises soil types of similar metal concentrations. Similar soil types were collected into soil groups where there were two or less statistically significant differences in concentrations. That is, soil groups were differentiated by having at least three metals with statistically significant differences in concentration. Soil types ABC and PBS were not combined with any other soil type because only one sample was available for each of those soil types. Due to lack of sufficient data the data set comparisons conducted on the other data sets could not be performed on these two single-sample data sets. The infrequency of encountering the ABC and PBS soil types during the field investigation (tabulated in Table C-1, Appendix C-1) explains why each soil type was represented by only one sample. Unable to conduct the usual statistical comparisons, confidence interval tests (see Appendix D-3) were performed to test whether these soil types are unique. The tests indicated that they are unique relative to the other soil groups. Statistical summary data for the individual soil groups are presented in Tables 4-2 through 4-10 (inclusion of lithium, strontium and thorium is explained below).

A review of geological considerations generally supported the identified soil groupings with some minor surprises (see Appendix D-3). For example, all surface soils from the four DEs were expected to group together, yet the alluvium surface soil appears to be chemically different from the other three surface soil types. The statistical differences were significant enough for the alluvial surface soil not to be combined with the other surface soil types into a single group even though the geology was not entirely expected to have been different. Another example is that all of the subsurface residual soil from Mississippian bedrock was expected to be statistically similar, however the differences were significant enough to warrant the separation of silt from the clay and sand soil types in the Mississippian DE.

The primary goal of this investigation was to establish soil groups that would permit site investigators to detect a difference of two standard deviations (two-*sigma*) or less between site data and background data. This criterion was necessarily established without knowing how large would be the value of *sigma*. The minimum detectable differences between site and background data sets have been computed for each combination of the nine soil groups and the 27 metals (the inclusion of lithium, strontium and thorium is explained below). Table 4-11 presents the minimum detectable differences in units of mg/kg and Table 4-12 presents the equivalent data in units of standard deviation. Minimum detectable differences between data sets and applicable assumptions are discussed in detail in Section 4.3.

After adding lithium, strontium and thorium to the data sets, the statistical analyses were repeated. The analyses yielded only seven distinct soil groups (Table 4-13) instead of the original nine groups (Figure 4-1). The three additional metals themselves did not cause the regroupings. Instead, a change in the criterion used to differentiate among soil groups caused the regroupings. That is, the 5% significance level was also used when the number of metals was increased to 27 (from 24). With 27 metals the number of allowable differences among metals of similar soil types changed from 2 to 3 (see Appendix D-3). This change in criterion was judged not to be as significant a differentiating factor in the soil groupings as differences among DEs. That is, the seven soil groupings could not be explained geologically (see Appendix D-3) whereas the nine soil groupings appears to be more reasonable. Consequently, the newly generated seven soil groups were rejected in favor of the original nine soil groupings. Lithium, strontium and thorium were thus included in Tables 4-2 through 4-12. Figure 4-1 represents the nine soil groupings that are designated as the NSWC Crane background soil groups for use in site investigations.

The final statistical analysis conducted to incorporate the additional two ABC soil samples confirmed the results of the initial statistical analysis and geologic interpretations. That is, the ABC soil group is unique relative to the other soil groups and the originally selected nine soil groups adequately represent all soils likely to be encountered at NSWC Crane.

Figure 4-1 represents some practical factors that must be considered when planning to use the background data for site data comparisons. Within a DE a maximum of three soil groups exists. Thus, for any SWMU that lies entirely within a single DE, no more than three background data sets will be needed for comparisons with site data. For each DE two of the soil groups exist solely because of differences between surface and subsurface soil. Encountering soil from the ABC and PBS happened infrequently during this investigation so it is relatively unlikely that site investigation samples will belong to those soil groups. Consequently, only two background data sets will likely be needed for background comparisons in the alluvial and Pennsylvanian DEs.

4.3 MINIMUM DETECTABLE CONCENTRATION DIFFERENCES BETWEEN SITE AND BACKGROUND DATA

The minimum detectable concentration differences between site and background data for each metal in each background soil group (except PBS) are presented in Table 4-11. When computing these differences, actual data values were used for the background data set. Because the investigative data sets have not been collected some assumptions were made about these future investigative data sets. Those assumptions, with pertinent conditions associated with the background data sets, are:

- five samples exist in the investigative data set;
- investigative concentration variance equal to twice the background concentration variance;
- false positive error rate, α, equal to 5%; and
- a number of samples in the background data set equal to those presented in Figure 4-1.

The first two assumptions may be conservative assumptions but they provided a useful perspective. The α value of 5% was established in the Work Plan (1999a).

With α values and variances established, it was possible to compute minimum detectable concentration differences without specifying false negative error rates, β. Establishing β is not straightforward under these circumstances. It requires an iterative computational approach that was not deemed beneficial because the computed values already were based on some assumptions. Neglecting β is consistent with the approach taken in the EPA guidance for data quality assessment (Section 3.3.1.2 of EPA, 1998). Furthermore, Section 4.2.3 of the Work Plan shows that the planned number of samples to be collected (i.e., 3 to 5) corresponds to the β values ranging from 10% to 30% under the planning assumptions of this project. Given the actual computed minimum detectable differences the actual β values are probably less than 10% in most cases.

The minimum detectable concentration differences presented in Table 4-11 were translated into standard deviation, *sigma*, by dividing the values in Table 4-11 by the corresponding background set standard deviation. If the data for a given soil group were lognormally distributed (refer to Tables 4-2 through 4-10) a lognormal transformation was used in these calculations. The translated values are presented in Table

4-12. This translation allows a direct comparison of the data distributions to the project goal of attaining a two-sigma difference or less between background and investigative data sets for each metal. All but one (ABC) of the entries in Table 4-12 are less than or equal to 1.20 *sigma*. The ABC soil group has a value of 2.15 *sigma*. This indicates that it should be possible to detect a difference between investigative and background data sets that is less than or equal to 1.20 *sigma*, except ABC soil group, if the assumptions described above are valid.

If the investigative data set has a variance that is greater than the assumed variance, discrimination between background and investigative data sets will be more difficult. Conversely, data set discrimination will be facilitated by a lesser variance. Changing the alpha specification will also alter the ability to discriminate between data sets. A larger alpha value will facilitate discrimination, but at a lesser confidence level; while a lesser alpha value will make discrimination more difficult, but at a greater confidence level.

It must be understood that assumptions concerning investigative data set distributions were made here in order to generate the values in Tables 4-11 and 4-12. If these assumptions are different from actual values observed in future investigations, the actual values should be used to compute minimum detectable differences applicable to the investigation.

4.4 NEED AND COLLECTION OF ADDITIONAL SAMPLES

As noted in Section 4.3, soil from the ABC and PBS soil types were encountered infrequently during this investigation. Tables 4-14 and 4-15 present completeness tabulations for soil samples categorized by soil type and soil group, respectively. Although several soil types are not represented by at least five samples, the consolidation of soil types into soil groups generally mitigated this problem. However, only three samples were obtained for the ABC soil group and only one sample was obtained for the PBS soil group, even after a second round of sampling. This poses a potential problem in that statistical comparisons of background and site data cannot be performed for the PBS soil group. In addition, as discussed in Section 4.3, the PBS soil group minimum detectable difference in units of standard deviations is 2.15 *sigma*. This is a marginal deviation from the project objective of two-*sigma* or less and is a consequence of the relative unavailability of the ABC soil type. It is recommended that six or more samples be collected of the ABC soil type during site investigations, if feasible. Professional judgment should be used when conducting PBC background soil comparisons. Alternative, if a localized area rich in PBS soil is encountered at a SWMU, it might be worthwhile to collect background soil samples nearby for comparison.

TABLE 4-1
STATISTICAL SUMMARY OF ANALYTICAL RESULTS
COMPLETE BACKGROUND SOIL SAMPLE DATA SET
BASEWIDE BACKGROUND INVESTIGATION REPORT
NAVAL SURFACE WARFARE CENTER
CRANE, INDIANA

Metal (mg/kg)	Frequency of Detection	Frequency of Exceedance (2)	Minimum Detection	Maximum Detection	Average of All Results	Average of Positive Detections	Location of Maximum	Distribution of Data	95% Upper Tolerance Limit	Soil Risk Based Target Level (1)
ALUMINUM	67/67	0/67	5,020	17,400	11,290	11,100	BG1SBP0801	NORMAL	17,400	75,000
ANTIMONY	8/67	8/67	**0.49**	**11.3**	**0.86**	**4.36**	BG1SBP0505	LOGNORMAL	2.88	0.1423
ARSENIC	67/67	67/67	**1.1**	**10.2**	**5.28**	**5.20**	BG3SBM0701	NORMAL	9.60	0.38
BARIUM	67/67	67/67	**24.8**	**155**	**69.7**	**68.8**	BG1SBL0101	LOGNORMAL	147	1.04
BERYLLIUM	14/67	14/67	**0.3**	**0.82**	**0.36**	**0.47**	BG2SBG0401-MAX	LOGNORMAL	0.85	0.10
CADMIUM	34/67	28/67	0.05	**3.6**	**0.36**	**0.62**	BG3SBM0201	LOGNORMAL	2.05	0.18095
CALCIUM	66/67	0/67	53.6	35,300	997	1,010	BG3SBM0601	LOGNORMAL	3,350	NA
CHROMIUM	67/67	67/67	**7.7**	**30.6**	**16.4**	**16.1**	BG3SBM0604	LOGNORMAL	29.1	0.4
COBALT	67/67	67/67	**1.8**	**27.1**	**8.70**	**8.62**	BG3SBM0701	LOGNORMAL	21.7	0.14033
COPPER	67/67	67/67	**3.5**	**23.8**	**10.2**	**10.0**	BG1SBP0305	LOGNORMAL	21.4	0.3132
IRON	67/67	17/67	7,140	**40,800**	18,100	17,800	BG1SBP0305	LOGNORMAL	34,500	22,000
LEAD	67/67	67/67	**6.4**	**21.5**	**11.9**	**11.7**	BG1SBA0101	LOGNORMAL	19.7	0.45053
LITHIUM	66/66	0/66	7.8	46.6	16.1	15.7	BG1SBP0305	LOGNORMAL	29.4	1,500
MAGNESIUM	67/67	0/67	496	2,870	1,410	1,390	BG1SBP0204	LOGNORMAL	3,060	NA
MANGANESE	67/67	0/67	23.2	3,040	599	590	BG3SBM0701	LOGNORMAL	3,270	3,100
MERCURY	17/67	17/67	**0.04**	**0.14**	**0.033**	**0.062**	BG1SBP0103	LOGNORMAL	0.072	0.0079
NICKEL	67/67	63/67	4.6	**23.7**	**11.9**	**11.7**	BG1SBP0305	NORMAL	18.7	7
POTASSIUM	67/67	0/67	280	1,650	856	833	BG1SBA280304	NORMAL	1,370	NA
SELENIUM	15/67	15/67	**0.28**	**0.88**	**0.33**	**0.53**	BG1SBP0206	LOGNORMAL	0.83	0.02765
SILVER	48/67	0/67	0.04	0.11	0.049	0.055	BG1SBP0401	LOGNORMAL	0.10	2
SODIUM	32/67	0/67	3.7	205	33.0	56.2	BG1SBP0406-MAX	LOGNORMAL	232	NA
STRONTIUM	66/66	0/67	4.2	63.2	12.3	12.1	BG3SBM0601	LOGNORMAL	25.3	45,000
THALLIUM	66/67	66/67	**0.05**	**0.31**	**0.18**	**0.18**	BG1SBL0101	NORMAL	0.29	0.04
TIN	0/67	0/67	NA	NA	0.32 (3)	NA	NA	NA	NA	7.62
THORIUM	66/66	0/66	4.1	11.7	7.24	7.11	BG1SBP0305	LOGNORMAL	10.9	NA
VANADIUM	67/67	67/67	**14.1**	**48.5**	**26.5**	**26.2**	BG1SBP0206	LOGNORMAL	45.8	1.59
ZINC	50/67	50/67	**9.4**	**60.2**	**28.1**	**32.0**	BG3SBM0701	NORMAL	54.0	6.62

Notes:
NA - Not available
Concentrations which exceed soil risk-based target levels are bolded.
1 - Value is based on human health and ecological risk-based criteria as presented in Appendix E, Table E-1. This risked-based criteria was current as of the QAPP (1999b). It is important to note that this information is updated by the appropriate regulatory agencies on a periodic basis.
2 - Exceedances are defined as detected values above the SRBTL.
3 - This value is the average of all detected and non-detected values. Non-detected values were represented by using one half the detection limit. This value was used for statistical analysis when no detections were encountered.

TABLE 4-2
STATISTICAL SUMMARY OF ANALYTICAL RESULTS
SOIL GROUP 1 - LOESS/GLACIAL SURFACE SOIL
BASEWIDE BACKGROUND INVESTIGATION REPORT
NAVAL SURFACE WARFARE CENTER
CRANE, INDIANA

Metal (mg/kg)	Frequency of Detection	Frequency of Exceedance (2)	Minimum Detection	Maximum Detection	Average of All Results	Average of Positive Detections	Location of Maximum	Distribution of Data	95% Upper Tolerance Limit	Soil Risk Based Target Level (1)
ALUMINUM	5/5	0/5	7,940	14,300	11,900	11,900	BG2SBG0101	NORMAL	22,800	75,000
ANTIMONY	0/5	0/5	NA	NA	**0.23 (3)**	NA	NA	NA	NA	0.1423
ARSENIC	5/5	5/5	**3.6**	**6.8**	**5.24**	**5.24**	BG1SBL0101	NORMAL	10.61	0.38
BARIUM	5/5	5/5	**90.8**	**155**	**119**	**119**	BG1SBL0101	LOGNORMAL	262	1.04
BERYLLIUM	4/5	4/5	**0.48**	**0.74**	**0.61**	**0.62**	BG2SBG0401-MAX	NORMAL	1.03	0.10
CADMIUM	0/5	0/5	NA	NA	0.05 (3)	NA	NA	NA	NA	0.18095
CALCIUM	5/5	0/5	345	1,040	574	574	BG2SBG0401-MAX	LOGNORMAL	3,070	NA
CHROMIUM	5/5	5/5	**9.8**	**15.1**	**13.3**	**13.3**	BG2SBG0101	NORMAL	22.2	0.4
COBALT	5/5	5/5	**9.3**	**17.1**	**14.1**	**14.1**	BG1SBL0101	NORMAL	27.4	0.14033
COPPER	5/5	5/5	**6.5**	**11.3**	**9.00**	**9.00**	BG2SBG0101	NORMAL	17.7	0.3132
IRON	5/5	0/5	10,100	17,400	14,200	14,200	BG2SBG0101	NORMAL	27,100	22,000
LEAD	5/5	5/5	**12**	**17.1**	**14.6**	**14.6**	BG1SBL0101	NORMAL	23.0	0.45053
LITHIUM	5/5	0/5	10	14.5	12.8	12.8	BG1SBL0501	NORMAL	19.9	1,500
MAGNESIUM	5/5	0/5	1,030	1,810	1,350	1,350	BG2SBG0101	LOGNORMAL	3,120	NA
MANGANESE	5/5	0/5	936	1,960	1,440	1,440	BG1SBL0101	LOGNORMAL	5,450	3,100
MERCURY	2/5	2/5	**0.05**	**0.06**	**0.037**	**0.055**	BG2SBG0401-MAX	NORMAL	0.108	0.0079
NICKEL	5/5	5/5	**11**	**17.4**	**15.0**	**15.0**	BG1SBL0101	NORMAL	26.2	7
POTASSIUM	5/5	0/5	525	1,250	896	896	BG2SBG0101	NORMAL	2,000	NA
SELENIUM	0/5	0/5	NA	NA	0.33 (3)	NA	NA	NA	NA	0.02765
SILVER	1/5	0/5	0.05	0.05	0.031	0.050	BG1SBL0101	LOGNORMAL	0.11	2
SODIUM	2/5	0/5	7.2	17.8	11.1	12.5	BG1SBL0501	LOGNORMAL	56	NA
STRONTIUM	5/5	0/5	9.7	17.3	12.9	12.9	BG2SBG0401-MAX	LOGNORMAL	32.7	45,000
THALLIUM	5/5	5/5	**0.22**	**0.31**	**0.27**	**0.27**	BG1SBL0101	NORMAL	0.41	0.04
TIN	0/5	0/5	NA	NA	0.28 (3)	NA	NA	NA	NA	7.62
THORIUM	5/5	0/5	6.4	8.7	7.42	7.42	BG1SBL0501	LOGNORMAL	12.2	NA
VANADIUM	5/5	5/5	**19**	**32.2**	**26.8**	**26.8**	BG2SBG0101	NORMAL	49.7	1.59
ZINC	3/5	3/5	**29.7**	**49.6**	**32.3**	**39.2**	BG2SBG0101	LOGNORMAL	135.2	6.62

Notes:
NA - Not available
Concentrations which exceed soil risk-based target levels are bolded.
1 - Value is based on human health and ecological risk-based criteria as presented in Appendix E, Table E-1. This risked-based criteria was current as of the QAPP (1999b). It is important to note that this information is updated by the appropriate regulatory agencies on a periodic basis.
2 - Exceedances are defined as detected values above the SRBTL.
3 - This value is the average of all detected and non-detected values. Non-detected values were represented by using one half the detection limit. This value was used for statistical analysis when no detections were encountered.

TABLE 4-3
STATISTICAL SUMMARY OF ANALYTICAL RESULTS
SOIL GROUP 2 - LOESS/GLACIAL SUBSURFACE SOIL
BASEWIDE BACKGROUND INVESTIGATION REPORT
NAVAL SURFACE WARFARE CENTER
CRANE, INDIANA

Metal (mg/kg)	Frequency of Detection	Frequency of Exceedance (2)	Minimum Detection	Maximum Detection	Average of All Results	Average of Positive Detections	Location of Maximum	Distribution of Data	95% Upper Tolerance Limit	Soil Risk Based Target Level (1)
ALUMINUM	13/13	0/13	7,570	16,600	12,900	12,900	BG1SBL0506	NORMAL	19,700	75,000
ANTIMONY	1/13	1/13	**10.8**	**10.8**	**1.18**	**10.8**	BG1SBL0506	LOGNORMAL	10.1	0.1423
ARSENIC	13/13	13/13	**1.1**	**6**	**4.15**	**4.15**	BG2SBG0503	NORMAL	8.57	0.38
BARIUM	13/13	13/13	**41.7**	**94.4**	**60.8**	**60.8**	BG1SBL0305	LOGNORMAL	126	1.04
BERYLLIUM	7/13	7/13	**0.3**	**0.69**	**0.29**	**0.41**	BG1SBL0506	LOGNORMAL	1.32	0.10
CADMIUM	0/13	0/13	NA	NA	0.05 (3)	NA	NA	NA	NA	0.18095
CALCIUM	13/13	0/13	122	710	404	404	BG1SBL0305	NORMAL	884	NA
CHROMIUM	13/13	13/13	**9.2**	**25.5**	**18.0**	**18.0**	BG1SBL0506	NORMAL	32.3	0.4
COBALT	13/13	13/13	**1.8**	**9.2**	**4.98**	**4.98**	BG2SBG0404	LOGNORMAL	14.7	0.14033
COPPER	13/13	13/13	**4.3**	**16.4**	**10.3**	**10.3**	BG1SBL0103	NORMAL	21.0	0.3132
IRON	13/13	3/13	7,140	**27,700**	18,100	18,100	BG1SBL0506	NORMAL	33,500	22,000
LEAD	13/13	13/13	**6.9**	**11.7**	**9.60**	**9.60**	BG1SBL0506, BG1SBL0504-MAX	NORMAL	13.6	0.45053
LITHIUM	13/13	0/13	9.2	28.1	14.6	14.6	BG1SBL0506	LOGNORMAL	31.2	1,500
MAGNESIUM	13/13	0/13	760	2,350	1,550	1,550	BG1SBL0103	NORMAL	2,890	NA
MANGANESE	13/13	0/13	23.2	376	165	165	BG2SBG0104	LOGNORMAL	1,100	3,100
MERCURY	2/13	2/13	**0.05**	**0.07**	**0.028**	**0.060**	BG1SBL0403	LOGNORMAL	0.073	0.0079
NICKEL	13/13	11/13	4.9	**13.1**	**9.80**	**9.80**	BG2SBG0104	NORMAL	16.5	7
POTASSIUM	13/13	0/13	425	1,240	745	745	BG1SBL0103	LOGNORMAL	1,640	NA
SELENIUM	0/13	0/13	NA	NA	**0.16 (3)**	NA	NA	NA	NA	0.02765
SILVER	3/13	0/13	0.04	0.05	0.028	0.043	BG1SBL0105	LOGNORMAL	0.059	2
SODIUM	7/13	0/13	54.1	153	63.5	106	BG1SBL0506	NORMAL	208	NA
STRONTIUM	13/13	0/13	8	17	11.8	11.8	BG1SBL0305, BG1SBL0506	LOGNORMAL	23.2	45,000
THALLIUM	13/13	13/13	**0.13**	**0.27**	**0.18**	**0.18**	BG2SBG0206	LOGNORMAL	0.32	0.04
TIN	0/13	0/13	NA	NA	0.32 (3)	NA	NA	NA	NA	7.62
THORIUM	13/13	0/13	5.2	9.1	7.24	7.24	BG1SBL0506	NORMAL	10.7	NA
VANADIUM	13/13	13/13	**17.1**	**42.4**	**28.5**	**28.5**	BG1SBL0506	NORMAL	47.3	1.59
ZINC	6/13	6/13	**13.6**	**35.3**	**18.9**	**24.0**	BG2SBG0503	LOGNORMAL	54.9	6.62

Notes:
NA - Not available
Concentrations which exceed soil risk-based target levels are bolded.
1 - Value is based on human health and ecological risk-based criteria as presented in Appendix E, Table E-1. This risked-based criteria was current as of the QAPP (1999b). It is important to note that this information is updated by the appropriate regulatory agencies on a periodic basis.
2 - Exceedances are defined as detected values above the SRBTL.
3 - This value is the average of all detected and non-detected values. Non-detected values were represented by using one half the detection limit. This value was used for statistical analysis when no detections were encountered.

TABLE 4-4
STATISTICAL SUMMARY OF ANALYTICAL RESULTS
SOIL GROUP 3 - ALLUVIAL, MISSISSIPPIAN, AND PENNSYLVANIAN SURFACE SOIL
BASEWIDE BACKGROUND INVESTIGATION REPORT
NAVAL SURFACE WARFARE CENTER
CRANE, INDIANA

Metal (mg/kg)	Frequency of Detection	Frequency of Exceedance (2)	Minimum Detection	Maximum Detection	Average of All Results	Average of Positive Detections	Location of Maximum	Distribution of Data	95% Upper Tolerance Limit	Soil Risk Based Target Level (1)
ALUMINUM	15/15	0/15	6,770	17,400	10,238	10,238	BG1SBP0801	LOGNORMAL	19,900	75,000
ANTIMONY	2/15	2/15	**1.4**	**5.6**	**0.83**	**3.50**	BG3SBM0401	LOGNORMAL	6.9	0.1423
ARSENIC	15/15	15/15	**2.4**	**10.2**	**6.11**	**6.11**	BG3SBM0701	NORMAL	11.83	0.38
BARIUM	15/15	15/15	**46.1**	**153**	**89.0**	**89.0**	BG3SBM0601	LOGNORMAL	211	1.04
BERYLLIUM	1/15	1/15	**0.49**	**0.49**	**0.40**	**0.49**	BG3SBA0101-MAX	LOGNORMAL	0.93	0.10
CADMIUM	10/15	9/15	0.1	**3.6**	**0.63**	**0.88**	BG3SBM0201	LOGNORMAL	6.05	0.18095
CALCIUM	14/15	0/15	115	35,300	2,730	2,920	BG3SBM0601	LOGNORMAL	55,200	NA
CHROMIUM	15/15	15/15	**8.5**	**21.7**	**14.6**	**14.6**	BG1SBA0101	LOGNORMAL	28.7	0.4
COBALT	15/15	15/15	**6**	**27.1**	**12.9**	**12.9**	BG3SBM0701	LOGNORMAL	32.4	0.14033
COPPER	15/15	15/15	**5.4**	**17.1**	**8.85**	**8.85**	BG1SBP0801	LOGNORMAL	17.6	0.3132
IRON	15/15	2/15	10,700	**36,200**	16,800	16,800	BG1SBA0101	LOGNORMAL	37,400	22,000
LEAD	15/15	15/15	**9.4**	**21.5**	**15.0**	**15.0**	BG1SBA0101	LOGNORMAL	27.0	0.45053
LITHIUM	14/14	0/14	9.1	29.9	14.8	14.8	BG1SBP0901	LOGNORMAL	30.0	1,500
MAGNESIUM	15/15	0/15	620	2,250	1,200	1,200	BG1SBP0801	LOGNORMAL	2,800	NA
MANGANESE	15/15	0/15	268	3,040	1,140	1,140	BG3SBM0701	LOGNORMAL	5,700	3,100
MERCURY	7/15	7/15	**0.04**	**0.07**	**0.037**	**0.051**	BG1SBP0601-MAX	NORMAL	0.077	0.0079
NICKEL	15/15	15/15	**9.2**	**20**	**13.4**	**13.4**	BG1SBA0101	LOGNORMAL	22.1	7
POTASSIUM	15/15	0/15	418	1,490	847	847	BG1SBP0801	LOGNORMAL	1,970	NA
SELENIUM	5/15	5/15	**0.51**	**0.64**	**0.48**	**0.58**	BG1SBP0901	NORMAL	0.81	0.02765
SILVER	15/15	0/15	0.05	0.11	0.065	0.065	BG1SBP0401	LOGNORMAL	0.130	2
SODIUM	6/15	0/15	9.4	23.7	8.11	15.6	BG3SBM0601	NORMAL	28	NA
STRONTIUM	14/14	0/14	7.4	63.2	14.3	14.3	BG3SBM0601	LOGNORMAL	46.4	45,000
THALLIUM	15/15	15/15	**0.1**	**0.27**	**0.19**	**0.19**	BG1SBP0601-MAX	NORMAL	0.31	0.04
TIN	0/15	0/15	NA	NA	0.36 (3)	NA	NA	NA	NA	7.62
THORIUM	14/14	0/14	5.3	8.5	6.86	6.86	BG1SBP0801	LOGNORMAL	10.2	NA
VANADIUM	15/15	15/15	**17.1**	**40**	**25.4**	**25.4**	BG1SBP0801	LOGNORMAL	51.2	1.59
ZINC	14/15	14/15	**24.4**	**60.2**	**37.0**	**38.6**	BG3SBM0701	NORMAL	65.6	6.62

Notes:
NA - Not available
Concentrations which exceed soil risk-based target levels are bolded.
1 - Value is based on human health and ecological risk-based criteria as presented in Appendix E, Table E-1. This risked-based criteria was current as of the QAPP (1999b). It is important to note that this information is updated by the appropriate regulatory agencies on a periodic basis.
2 - Exceedances are defined as detected values above the SRBTL.
3 - This value is the average of all detected and non-detected values. Non-detected values were represented by using one half the detection limit. This value was used for statistical analysis when no detections were encountered.

TABLE 4-5
STATISTICAL SUMMARY OF ANALYTICAL RESULTS
SOIL GROUP 4 - ALLUVIAL SUBSURFACE SILT AND SAND
BASEWIDE BACKGROUND INVESTIGATION REPORT
NAVAL SURFACE WARFARE CENTER
CRANE, INDIANA

Metal (mg/kg)	Frequency of Detection	Frequency of Exceedance (2)	Maximum Detection	Average of All Results	Average of Positive Detections	Location of Maximum	Distribution of Data	95% Upper Tolerance Limit	Soil Risk Based Target Level (1)
ALUMINUM	9/9	0/9	12,200	8,550	8,550	BG3SBA0404	LOGNORMAL	15,100	75,000
ANTIMONY	0/9	0/9	NA	**0.34 (3)**	NA	NA	NA	NA	0.1423
ARSENIC	9/9	9/9	**10**	**5.27**	**5.27**	BG1SBA0504	LOGNORMAL	16.58	0.38
BARIUM	9/9	9/9	**83.4**	**56.1**	**56.1**	BG3SBA0203	LOGNORMAL	94	1.04
BERYLLIUM	0/9	0/9	NA	**0.33 (3)**	NA	NA	NA	NA	0.10
CADMIUM	0/9	0/9	NA	0.09 (3)	NA	NA	NA	NA	0.18095
CALCIUM	9/9	0/9	817	426	426	BG3SBA0404	NORMAL	991	NA
CHROMIUM	9/9	9/9	**19.6**	**13.2**	**13.2**	BG1SBA0504	LOGNORMAL	26.1	0.4
COBALT	9/9	9/9	**18**	**9.10**	**9.10**	BG1SBA0504	LOGNORMAL	21.8	0.14033
COPPER	9/9	9/9	**9.9**	**7.31**	**7.31**	BG1SBA0504	LOGNORMAL	10.5	0.3132
IRON	9/9	1/9	**29,400**	16,100	16,100	BG1SBA0504	LOGNORMAL	36,200	22,000
LEAD	9/9	9/9	**14.5**	**10.2**	**10.2**	BG1SBA0504	LOGNORMAL	16.2	0.45053
LITHIUM	9/9	0/9	17.1	13.1	13.1	BG1SBA0503	LOGNORMAL	24.3	1,500
MAGNESIUM	9/9	0/9	1,230	848	848	BG3SBA0404	LOGNORMAL	1,870	NA
MANGANESE	9/9	0/9	1,090	638	638	BG1SBA0504	NORMAL	1,300	3,100
MERCURY	1/9	1/9	**0.11**	**0.033**	**0.11**	BG1SBA0104	LOGNORMAL	0.114	0.0079
NICKEL	9/9	9/9	**13.1**	**10.1**	**10.1**	BG1SBA0504	LOGNORMAL	14.6	7
POTASSIUM	9/9	0/9	1,020	682	682	BG3SBA0404	LOGNORMAL	1,220	NA
SELENIUM	0/9	0/9	NA	**0.25 (3)**	NA	NA	NA	NA	0.02765
SILVER	9/9	0/9	0.05	0.048	0.048	7 LOCATIONS	LOGNORMAL	0.062	2
SODIUM	3/9	0/9	5.2	2.40	4.40	BG3SBA0203	LOGNORMAL	12	NA
STRONTIUM	9/9	0/9	10.6	7.94	7.94	BG3SBA0504	NORMAL	12.4	45,000
THALLIUM	9/9	9/9	**0.19**	**0.14**	**0.14**	BG3SBA0504	LOGNORMAL	0.22	0.04
TIN	0/9	0/9	NA	0.26	NA	NA	NA	NA	7.62
THORIUM	9/9	0/9	6.3	5.69	5.69	BG1SBA0503, BG1SBA0504	NORMAL	8.08	NA
VANADIUM	9/9	9/9	**26.9**	**20.8**	**20.8**	BG3SBA0404	LOGNORMAL	31.7	1.59
ZINC	2/9	2/9	**26.5**	**15.2**	**24.4**	BG3SBA0203	LOGNORMAL	33.0	6.62

Notes:
NA - Not available
Concentrations which exceed soil risk-based target levels are bolded.
1 - Value is based on human health and ecological risk-based criteria as presented in Appendix E, Table E-1. This risked-based criteria was current as of the QAPP (1999b). It is important to note that this information is updated by the appropriate regulatory agencies on a periodic basis.
2 - Exceedances are defined as detected values above the SRBTL.
3 - This value is the average of all detected and non-detected values. Non-detected values were represented by using one half the detection limit. This value was used for statistical analysis when no detections were encountered.

TABLE 4-6
STATISTICAL SUMMARY OF ANALYTICAL RESULTS
SOIL GROUP 5 - ALLUVIAL SUBSURFACE CLAY
BASEWIDE BACKGROUND INVESTIGATION REPORT
NAVAL SURFACE WARFARE CENTER
CRANE, INDIANA

Metal (mg/kg)	Frequency of Detection	Frequency of Exceedance (2)	Minimum Detection	Maximum Detection	Average of All Results	Average of Positive Detections	Location of Maximum	Distribution of Data	95% Upper Tolerance Limit	Soil Risk Based Target Level (1)
ALUMINUM	3/3	0/3	7,870	16,700	12,190	12,190	BG1SBA250203-MAX	NORMAL	46,000	75,000
ANTIMONY	1/3	1/3	**0.49**	**0.49**	**0.30**	**0.49**	BG1SBA250203-MAX	LOGNORMAL	14.8	0.1423
ARSENIC	3/3	3/3	**2.8**	**5.9**	**4.77**	**4.77**	BG1SBA250203-MAX	NORMAL	17.9	0.38
BARIUM	3/3	3/3	**36.9**	**80.4**	**65.3**	**65.3**	BG1SBA250203-MAX	NORMAL	253	1.04
BERYLLIUM	2/3	3/3	**0.54**	**0.82**	**0.56**	**0.68**	BG1SBA250203-MAX	LOGNORMAL	18.2	0.10
CADMIUM	3/3	2/3	0.15	**0.44**	**0.31**	**0.31**	BG1SBA250203-MAX	NORMAL	1.43	0.18095
CALCIUM	3/3	0/3	108	406	276	276	BG1SBA0405	NORMAL	1,440	NA
CHROMIUM	3/3	3/3	**10.5**	**20.9**	**16.2**	**16.2**	BG1SBA280304	NORMAL	56.7	0.4
COBALT	3/3	3/3	**2.2**	**7.5**	**4.97**	**4.97**	BG1SBA250203-MAX	NORMAL	25.3	0.14033
COPPER	3/3	3/3	**6.5**	**10.3**	**8.93**	**8.93**	BG1SBA250203-MAX	NORMAL	25.1	0.3132
IRON	3/3	2/3	9,680	**28,900**	20,427	20,427	BG1SBA280304	NORMAL	95,500	22,000
LEAD	3/3	3/3	**7.8**	**13.1**	**10.3**	**10.3**	BG1SBA250203-MAX	LOGNORMAL	73.5	0.45053
LITHIUM	3/3	0/3	17.4	27.9	22.0	22.0	BG1SBA280304	LOGNORMAL	134	1,500
MAGNESIUM	3/3	0/3	755	1,470	1,043	1,043	BG1SBA250203-MAX	LOGNORMAL	14,000	NA
MANGANESE	3/3	0/3	86.4	1030	540	540	BG1SBA250203-MAX	NORMAL	4,160	3,100
MERCURY	1/3	3/3	**0.04**	**0.04**	**0.030**	**0.04**	BG1SBA250203-MAX	LOGNORMAL	0.23	0.0079
NICKEL	3/3	3/3	**9.5**	**13**	**11.6**	**11.6**	BG1SBA250203-MAX	NORMAL	26.0	7
POTASSIUM	3/3	0/3	640	1650	1,243	1,243	BG1SBA280304	NORMAL	5,320	NA
SELENIUM	1/3	3/3	**0.75**	**0.75**	**0.40**	**0.75**	BG1SBA0405	LOGNORMAL	69.0	0.02765
SILVER	1/3	0/3	0.05	0.05	0.092	0.050	BG1SBA0405	NORMAL	0.37	2
SODIUM	2/3	0/3	80.3	97.8	63.48	89.05	BG1SBA280304	NORMAL	409	NA
STRONTIUM	3/3	0/3	11.6	12.8	12.20	12.20	BG1SBA250203-MAX	NORMAL	16.8	45,000
THALLIUM	2/3	3/3	**0.15**	**0.27**	**0.18**	**0.21**	BG1SBA250203-MAX	LOGNORMAL	5.40	0.04
TIN	0/3	0/3	NA	NA	0.22 (3)	NA	NA	NA	NA	7.62
THORIUM	3/3	0/3	6.9	9	8.20	8.20	BG1SBA280304	NORMAL	16.9	NA
VANADIUM	3/3	3/3	**16.7**	**26.3**	**21.0**	**21.0**	BG1SBA250203-MAX	LOGNORMAL	119	1.59
ZINC	3/3	3/3	**25.4**	**42.9**	**32.5**	**32.5**	BG1SBA250203-MAX	LOGNORMAL	254	6.62

Notes:
NA - Not available
Concentrations which exceed soil risk-based target levels are bolded.
1 - Value is based on human health and ecological risk-based criteria as presented in Appendix E, Table E-1. This risked-based criteria was current as of the QAPP (1999b). It is important to note that this information is updated by the appropriate regulatory agencies on a periodic basis.
2 - Exceedances are defined as detected values above the SRBTL.
3 - This value is the average of all detected and non-detected values. Non-detected values were represented by using one half the detection limit. This value was used for statistical analysis when no detections were encountered.

TABLE 4-7
STATISTICAL SUMMARY OF ANALYTICAL RESULTS
SOIL GROUP 6 - MISSISSIPPIAN SUBSURFACE CLAY AND SAND
BASEWIDE BACKGROUND INVESTIGATION REPORT
NAVAL SURFACE WARFARE CENTER
CRANE, INDIANA

Metal (mg/kg)	Frequency of Detection	Frequency of Exceedance (2)	Minimum Detection	Maximum Detection	Average of All Results	Average of Positive Detections	Location of Maximum	Distribution of Data	95% Upper Tolerance Limit	Soil Risk Based Target Level (1)
ALUMINUM	7/7	0/7	5,020	17,000	10,600	10,600	BG3SBM0206	NORMAL	24,000	75,000
ANTIMONY	3/7	3/7	**1.2**	**2.9**	**0.88**	**1.77**	BG3SBM0404	LOGNORMAL	27.6	0.1423
ARSENIC	7/7	7/7	**2**	**6.3**	**4.21**	**4.21**	BG3SBM1003	NORMAL	10.5	0.38
BARIUM	7/7	7/7	**27**	**87.9**	**53.2**	**53.2**	BG3SBM0206	NORMAL	123	1.04
BERYLLIUM	0/7	0/7	NA	NA	**0.24 (3)**	NA	NA	NA	NA	0.10
CADMIUM	7/7	6/7	0.06	**2.8**	**0.65**	**0.65**	BG3SBM0803-MAX	LOGNORMAL	17.5	0.18095
CALCIUM	7/7	0/7	92.6	1260	404	404	BG3SBM0206	LOGNORMAL	5,270	NA
CHROMIUM	7/7	7/7	**10.9**	**25.1**	**16.4**	**16.4**	BG3SBM0206	LOGNORMAL	39.4	0.4
COBALT	7/7	7/7	**3.3**	**8.2**	**5.10**	**5.10**	BG3SBM0206	LOGNORMAL	13.6	0.14033
COPPER	7/7	7/7	**3.5**	**12.9**	**9.06**	**9.06**	BG3SBM0504, BG3SBM1003	LOGNORMAL	49.6	0.3132
IRON	7/7	1/7	8,850	**26,400**	15,900	15,900	BG3SBM0206	LOGNORMAL	57,200	22,000
LEAD	7/7	7/7	**6.4**	**12.1**	**9.04**	**9.04**	BG3SBM1003	LOGNORMAL	19.0	0.45053
LITHIUM	7/7	0/7	7.8	30.6	15.9	15.9	BG3SBM0206	LOGNORMAL	64.2	1,500
MAGNESIUM	7/7	0/7	496	2,070	1,520	1,520	BG3SBM0206	NORMAL	3,500	NA
MANGANESE	7/7	0/7	35.3	266	150	150	BG3SBM0406, BG3SBM1003	LOGNORMAL	1,420	3,100
MERCURY	0/7	0/7	NA	NA	**0.023 (3)**	NA	NA	NA	NA	0.0079
NICKEL	7/7	6/7	4.6	**14.7**	**10.5**	**10.5**	BG3SBM0206	NORMAL	21.1	7
POTASSIUM	7/7	0/7	280	1270	862	862	BG3SBM0206	NORMAL	1,900	NA
SELENIUM	0/7	0/7	NA	NA	**0.27 (3)**	NA	NA	NA	NA	0.02765
SILVER	5/7	0/7	0.05	0.05	0.044	0.050	5 LOCATIONS	LOGNORMAL	0.12	2
SODIUM	3/7	0/7	7.8	182	47.7	103	BG3SBM0206	LOGNORMAL	5,460	NA
STRONTIUM	7/7	0/7	4.2	25.7	12.4	12.4	BG3SBM0206	LOGNORMAL	86.6	45,000
THALLIUM	7/7	7/7	**0.05**	**0.21**	**0.13**	**0.13**	BG3SBM1003	NORMAL	0.34	0.04
TIN	0/7	0/7	NA	NA	0.34 (3)	NA	NA	NA	NA	7.62
THORIUM	7/7	0/7	4.1	10	6.79	6.79	BG3SBM0206	LOGNORMAL	17.7	NA
VANADIUM	7/7	7/7	**14.1**	**33**	**24.2**	**24.2**	BG3SBM0206	NORMAL	50.3	1.59
ZINC	7/7	7/7	**9.4**	**36.2**	**21.4**	**21.4**	BG3SBM1003	LOGNORMAL	105	6.62

Notes:
NA - Not available
Concentrations which exceed soil risk-based target levels are bolded.
1 - Value is based on human health and ecological risk-based criteria as presented in Appendix E, Table E-1. This risked-based criteria was current as of the QAPP (1999b). It is important to note that this information is updated by the appropriate regulatory agencies on a periodic basis.
2 - Exceedances are defined as detected values above the SRBTL.
3 - This value is the average of all detected and non-detected values. Non-detected values were represented by using one half the detection limit. This value was used for statistical analysis when no detections were encountered.

TABLE 4-8
STATISTICAL SUMMARY OF ANALYTICAL RESULTS
SOIL GROUP 7 - MISSISSIPPIAN SUBSURFACE SILT
BASEWIDE BACKGROUND INVESTIGATION REPORT
NAVAL SURFACE WARFARE CENTER
CRANE, INDIANA

Metal (mg/kg)	Frequency of Detection	Frequency of Exceedance (2)	Minimum Detection	Maximum Detection	Average of All Results	Average of Positive Detections	Location of Maximum	Distribution of Data	95% Upper Tolerance Limit	Soil Risk Based Target Level (1)
ALUMINUM	5/5	0/5	10,100	15,600	12,700	12,700	BG3SBM0203	LOGNORMAL	26,200	75,000
ANTIMONY	0/5	0/5	NA	NA	**0.34 (3)**	NA	NA	NA	NA	0.1423
ARSENIC	5/5	5/5	**6.5**	**9**	**7.72**	**7.72**	BG3SBM0203	NORMAL	12.4	0.38
BARIUM	5/5	5/5	**41.8**	**116**	**67.3**	**67.3**	BG3SBM0604	LOGNORMAL	303	1.04
BERYLLIUM	0/5	0/5	NA	NA	**0.31 (3)**	NA	NA	NA	NA	0.10
CADMIUM	5/5	5/5	**0.25**	**2.1**	**0.97**	**0.97**	BG3SBM0704	LOGNORMAL	19.6	0.18095
CALCIUM	5/5	0/5	131	5320	1,240	1,240	BG3SBM0604	LOGNORMAL	222,000	NA
CHROMIUM	5/5	5/5	**17.2**	**30.6**	**21.7**	**21.7**	BG3SBM0604	LOGNORMAL	54.9	0.4
COBALT	5/5	5/5	**6.4**	**11.8**	**7.66**	**7.66**	BG3SBM0604	LOGNORMAL	22.2	0.14033
COPPER	5/5	5/5	**7.5**	**19.7**	**14.3**	**14.3**	BG3SBM0904	NORMAL	35.7	0.3132
IRON	5/5	3/5	20,100	**25,400**	**22,200**	**22,200**	BG3SBM0203	LOGNORMAL	32,100	22,000
LEAD	5/5	5/5	**10.9**	**15.4**	**13.5**	**13.5**	BG3SBM0604	NORMAL	21.0	0.45053
LITHIUM	5/5	0/5	14.8	20.8	17.9	17.9	BG3SBM0203	LOGNORMAL	34.5	1,500
MAGNESIUM	5/5	0/5	1,210	2,590	1,950	1,950	BG3SBM0203	LOGNORMAL	7,770	NA
MANGANESE	5/5	0/5	192	1410	500	500	BG3SBM0604	LOGNORMAL	9,500	3,100
MERCURY	3/5	3/5	**0.05**	**0.06**	**0.043**	**0.057**	BG3SBM0203, BG3SBM0305	NORMAL	0.12	0.0079
NICKEL	5/5	5/5	**9.8**	**17.3**	**13.5**	**13.5**	BG3SBM0604	NORMAL	25.4	7
POTASSIUM	5/5	0/5	851	1330	1,100	1,100	BG3SBM0604	NORMAL	1,880	NA
SELENIUM	0/5	0/5	NA	NA	**0.25 (3)**	NA	NA	NA	NA	0.02765
SILVER	5/5	0/5	0.05	0.05	0.050	0.050	5 LOCATIONS	LOGNORMAL	0.05	2
SODIUM	3/5	0/5	9.1	22.9	17.4	18.0	BG3SBM0305	NORMAL	53	NA
STRONTIUM	5/5	0/5	8.5	16.3	14.3	14.3	BG3SBM0203	NORMAL	28.2	45,000
THALLIUM	5/5	5/5	**0.1**	**0.21**	**0.18**	**0.18**	BG3SBM0203, BG3SBM0704, BG3SBM0904	NORMAL	0.39	0.04
TIN	0/5	0/5	NA	NA	0.34 (3)	NA	NA	NA	NA	7.62
THORIUM	5/5	0/5	6.9	9.4	8.28	8.28	BG3SBM0203	NORMAL	12.4	NA
VANADIUM	5/5	5/5	**26.1**	**37.7**	**31.8**	**31.8**	BG3SBM0203	NORMAL	50.7	1.59
ZINC	5/5	5/5	**28.5**	**47.7**	**38.0**	**38.0**	BG3SBM0203	LOGNORMAL	98	6.62

Notes:
NA - Not available
Concentrations which exceed soil risk-based target levels are bolded.
1 - Value is based on human health and ecological risk-based criteria as presented in Appendix E, Table E-1. This risked-based criteria was current as of the QAPP (1999b). It is important to note that this information is updated by the appropriate regulatory agencies on a periodic basis.
2 - Exceedances are defined as detected values above the SRBTL.
3 - This value is the average of all detected and non-detected values. Non-detected values were represented by using one half the detection limit. This value was used for statistical analysis when no detections were encountered.

TABLE 4-9

STATISTICAL SUMMARY OF ANALYTICAL RESULTS
SOIL GROUP 8 - PENNSYLVANIAN SUBSURFACE CLAY AND SILT
BASEWIDE BACKGROUND INVESTIGATION REPORT
NAVAL SURFACE WARFARE CENTER
CRANE, INDIANA

Metal (mg/kg)	Frequency of Detection	Frequency of Exceedance (2)	Minimum Detection	Maximum Detection	Average of All Results	Average of Positive Detections	Location of Maximum	Distribution of Data	95% Upper Tolerance Limit	Soil Risk Based Target Level (1)
ALUMINUM	9/9	0/9	9,070	16,200	13,019	13,019	BG1SBP0206	NORMAL	20,600	75,000
ANTIMONY	1/9	1/9	**11.3**	**11.3**	**1.83**	**11.30**	BG1SBP0505	LOGNORMAL	40.3	0.1423
ARSENIC	9/9	9/9	**1.4**	**8.5**	**5.51**	**5.51**	BG1SBP0204	NORMAL	12.5	0.38
BARIUM	9/9	9/9	**25.1**	**83.4**	**57.0**	**57.0**	BG1SBP0505	NORMAL	115	1.04
BERYLLIUM	0/9	0/9	NA	NA	**0.36 (3)**	NA	NA	NA	NA	0.10
CADMIUM	8/9	6/9	0.05	**0.64**	**0.26**	**0.28**	BG1SBP0206	NORMAL	0.8	0.18095
CALCIUM	9/9	0/9	85.2	970	470	470	BG1SBP0505	LOGNORMAL	4,640	NA
CHROMIUM	9/9	9/9	**14.2**	**27.1**	**19.9**	**19.9**	BG1SBP0206	NORMAL	33.0	0.4
COBALT	9/9	9/9	**5.2**	**12.5**	**8.32**	**8.32**	BG1SBP0206	LOGNORMAL	21.2	0.14033
COPPER	9/9	9/9	**11**	**23.8**	**15.3**	**15.3**	BG1SBP0305	LOGNORMAL	33.3	0.3132
IRON	9/9	5/9	14,800	**40,800**	**24,422**	**24,422**	BG1SBP0305	LOGNORMAL	60,200	22,000
LEAD	9/9	9/9	**8.6**	**15.2**	**11.8**	**11.8**	BG1SBP0603	NORMAL	19.6	0.45053
LITHIUM	9/9	0/9	13.7	46.6	23.2	23.2	BG1SBP0305	LOGNORMAL	80.0	1,500
MAGNESIUM	9/9	0/9	1,100	2,870	1,958	1,958	BG1SBP0204	NORMAL	3,410	NA
MANGANESE	9/9	0/9	29	457	263	263	BG1SBP0804	NORMAL	704	3,100
MERCURY	1/9	1/9	**0.14**	**0.14**	**0.037**	**0.140**	BG1SBP0103	LOGNORMAL	0.18	0.0079
NICKEL	9/9	9/9	**10**	**23.7**	**13.6**	**13.6**	BG1SBP0305	LOGNORMAL	29.6	7
POTASSIUM	9/9	0/9	718	1290	974	974	BG1SBP0204, BG1SBP0305	LOGNORMAL	1,890	NA
SELENIUM	8/9	8/9	**0.37**	**0.88**	**0.47**	**0.51**	BG1SBP0206	NORMAL	1.07	0.02765
SILVER	8/9	0/9	0.05	0.1	0.053	0.056	BG1SBP0206	LOGNORMAL	0.14	2
SODIUM	6/9	0/9	10	205	64.0	79.1	BG1SBP0406-MAX	LOGNORMAL	1,070	NA
STRONTIUM	9/9	0/9	10	20.3	13.8	13.8	BG1SBP0406-MAX	LOGNORMAL	30.9	45,000
THALLIUM	9/9	0/9	**0.14**	**0.25**	**0.20**	**0.20**	BG1SBP0204, BG1SBP0206	LOGNORMAL	0.33	0.04
TIN	0/9	0/9	NA	NA	0.35 (3)	NA	NA	NA	NA	7.62
THORIUM	9/9	9/9	7.1	11.7	9.02	9.02	BG1SBP0305	NORMAL	14.9	NA
VANADIUM	9/9	9/9	**20.9**	**48.5**	**33.2**	**33.2**	BG1SBP0206	LOGNORMAL	69.1	1.59
ZINC	9/9	9/9	**24.3**	**58.2**	**37.1**	**37.1**	BG1SBP0305	LOGNORMAL	83.3	6.62

Notes:
NA - Not available
Concentrations which exceed soil risk-based target levels are bolded.
1 - Value is based on human health and ecological risk-based criteria as presented in Appendix E, Table E-1. This risked-based criteria was current as of the QAPP (1999b). It is important to note that this information is updated by the appropriate regulatory agencies on a periodic basis.
2 - Exceedances are defined as detected values above the SRBTL.
3 - This value is the average of all detected and non-detected values. Non-detected values were represented by using one half the detection limit. This value was used for statistical analysis when no detections were encountered.

TABLE 4-10
STATISTICAL SUMMARY OF ANALYTICAL RESULTS
SOIL GROUP 9 - PENNSYLVANIAN SUBSURFACE SAND
BASEWIDE BACKGROUND INVESTIGATION REPORT
NAVAL SURFACE WARFARE CENTER
CRANE, INDIANA

Metal (mg/kg)	Frequency of Detection	Frequency of Exceedance (2)	Minimum Detection	Maximum Detection	Average of All Results	Average of Positive Detections	Location of Maximum	Distribution of Data	95% Upper Tolerance Limit	Soil Risk Based Target Level (1)
ALUMINUM	1/1	0/1	5,430	5,430	5,430	5,430	BG1SBP0806	NA	NA	75,000
ANTIMONY	0/1	0/1	NA	NA	**0.38 (3)**	NA	NA	NA	NA	0.1423
ARSENIC	1/1	1/1	**2.9**	**2.9**	**2.90**	**2.90**	BG1SBP0806	NA	NA	0.38
BARIUM	1/1	1/1	**24.8**	**24.8**	**24.8**	**24.8**	BG1SBP0806	NA	NA	1.04
BERYLLIUM	0/1	0/1	NA	NA	**0.14 (3)**	NA	NA	NA	NA	0.10
CADMIUM	1/1	0/1	0.14	0.14	0.14	0.14	BG1SBP0806	NA	NA	0.18095
CALCIUM	1/1	0/1	53.6	53.6	54	54	BG1SBP0806	NA	NA	NA
CHROMIUM	1/1	1/1	**7.7**	**7.7**	**7.7**	**7.7**	BG1SBP0806	NA	NA	0.4
COBALT	1/1	1/1	**8.8**	**8.8**	**8.80**	**8.80**	BG1SBP0806	NA	NA	0.14033
COPPER	1/1	1/1	**5.6**	**5.6**	**5.6**	**5.6**	BG1SBP0806	NA	NA	0.3132
IRON	1/1	0/1	11,300	11,300	11,300	11,300	BG1SBP0806	NA	NA	22,000
LEAD	1/1	1/1	**11.7**	**11.7**	**11.7**	**11.7**	BG1SBP0806	NA	NA	0.45053
LITHIUM	1/1	0/1	8.6	8.6	8.6	8.6	BG1SBP0806	NA	NA	1,500
MAGNESIUM	1/1	0/1	654	654	654	654	BG1SBP0806	NA	NA	NA
MANGANESE	1/1	0/1	327	327	327	327	BG1SBP0806	NA	NA	3,100
MERCURY	0/1	0/1	NA	NA	**0.02 (3)**	NA	NA	NA	NA	0.0079
NICKEL	1/1	0/1	4.6	4.6	4.6	4.6	BG1SBP0806	NA	NA	7
POTASSIUM	1/1	0/1	353	353	353	353	BG1SBP0806	NA	NA	NA
SELENIUM	1/1	1/1	**0.28**	**0.28**	**0.28**	**0.28**	BG1SBP0806	NA	NA	0.02765
SILVER	1/1	0/1	0.05	0.05	0.050	0.050	BG1SBP0806	NA	NA	2
SODIUM	0/1	0/1	NA	NA	1.15 (3)	NA	NA	NA	NA	NA
STRONTIUM	1/1	0/1	5.4	5.4	5.4	5.4	BG1SBP0806	NA	NA	45,000
THALLIUM	1/1	1/1	**0.09**	**0.09**	**0.09**	**0.09**	BG1SBP0806	NA	NA	0.04
TIN	0/1	0/1	NA	NA	0.22	NA	NA	NA	NA	7.62
THORIUM	1/1	0/1	4.9	4.9	4.90	4.90	BG1SBP0806	NA	NA	NA
VANADIUM	1/1	1/1	**14.1**	**14.1**	**14.1**	**14.1**	BG1SBP0806	NA	NA	1.59
ZINC	1/1	1/1	**11.4**	**11.4**	**11.4**	**11.4**	BG1SBP0806	NA	NA	6.62

Notes:
NA - Not available
Concentrations which exceed soil risk-based target levels are bolded.
1 - Value is based on human health and ecological risk-based criteria as presented in Appendix E, Table E-1. This risked-based criteria was current as of the QAPP (1999b). It is important to note that this information is updated by the appropriate regulatory agencies on a periodic basis.
2 - Exceedances are defined as detected values above the SRBTL.
3 - This value is the average of all detected and non-detected values. Non-detected values were represented by using one half the detection limit. This value was used for statistical analysis when no detections were encountered.

TABLE 4-11

MINIMUM DETECTABLE DIFFERENCE, IN mg/kg, BETWEEN SITE AND BACKGROUND DATA
BASEWIDE BACKGROUND REPORT
NAVAL SURFACE WARFARE CENTER
CRANE, INDIANA

SOIL GROUP (1) SOIL TYPES(2)	Soil Group 1 LS	Soil Group 2 LBC/LBL/LBS	Soil Group 3 AS/MS/PS	Soil Group 4 ABL/ABS	Soil Group 5 ABC	Soil Group 6 MBC/MBS	Soil Group 7 MBL	Soil Group 8 PBC/PBL
METAL (mg/kg)								
ALUMINUM	3,054	2,967	3,490	1,996	9,477	4,302	2,633	2,589
ANTIMONY	0.03	3.37	1.68	0.25	0.36	1.10	0.10	3.78
ARSENIC	1.50	1.91	2.57	2.65	3.67	2.00	1.32	2.39
BARIUM	27.2	20.9	38.7	12.7	52.7	22.3	33.4	20.0
BERYLLIUM	0.12	0.20	0.16	0.09	0.53	0.16	0.19	0.14
CADMIUM	0.05	0.05	1.07	0.05	0.31	1.05	0.81	0.20
CALCIUM	321	207	10,814	220	327	434	2,683	347
CHROMIUM	2.48	6.14	4.54	3.96	11.33	5.00	6.26	4.47
COBALT	3.74	2.33	6.13	3.92	5.70	1.80	2.73	2.86
COPPER	2.42	4.60	3.35	1.16	4.53	4.44	5.99	4.57
IRON	3,593	6,662	7,779	6,122	21,043	6,724	2,360	8,316
LEAD	2.33	1.74	4.15	2.04	5.70	2.20	2.11	2.67
LITHIUM	1.98	5.96	6.02	2.87	11.52	8.03	3.30	11.51
MAGNESIUM	336	575	512	276	810	634	734	497
MANGANESE	536	130	896	258	1,014	98	601	151
MERCURY	0.02	0.02	0.02	0.03	0.02	0.003	0.02	0.04
NICKEL	3.11	2.88	3.18	1.58	4.02	3.40	3.33	4.39
POTASSIUM	308	261	352	165	1,143	331	218	233
SELENIUM	0.12	0.05	0.15	0.07	0.65	0.12	0.09	0.21
SILVER	0.01	0.01	0.02	0.005	0.078	0.01	7.7E-10	0.02
SODIUM	5.40	62.49	8.97	1.69	96.8	79.0	9.98	71.2
STRONTIUM	3.50	3.73	17.07	1.54	1.29	7.77	3.89	4.19
THALLIUM	0.04	0.05	0.05	0.03	0.18	0.07	0.06	0.05
THORIUM	1.06	1.47	1.27	0.82	0.00	2.10	1.16	1.61
TIN	0.03	0.07	0.13	0.04	2.44	0.16	0.06	0.07
VANADIUM	6.41	8.11	8.83	3.49	10.49	8.36	5.30	8.58
ZINC	13.8	9.91	12.8	5.64	19.8	11.1	10.3	11.3

Notes:
1 - No statistical analysis was done for soil groups 5 and 9 because only one sample is in this data set.
2 - Collective soil types within a soil group (see Figure 4-1 for additional information)

TABLE 4-12

MINIMUM DETECTABLE DIFFERENCES EXPRESSED IN NUMBER OF STANDARD DEVIATIONS
BASEWIDE BACKGROUND INVESTIGATION REPORT
NAVAL SURFACE WARFARE CENTER
CRANE, INDIANA

SOIL GROUP (1) SOIL TYPES(2)	Soil Group 1 LS	Soil Group 2 LBC/LBL/LBS	Soil Group 3 AS/MS/PS	Soil Group 4 ABL/ABS	Soil Group 5 ABC	Soil Group 6 MBC/MBS	Soil Group 7 MBL	Soil Group 8 PBC/PBL
METAL (mg/kg)								
ALUMINUM	1.18	1.15	1.20	1.04	**2.15**	1.09	1.18	1.04
ANTIMONY	1.18	1.15	1.20	1.04	**2.15**	1.09	1.18	1.04
ARSENIC	1.18	1.15	1.20	1.04	**2.15**	1.09	1.18	1.04
BARIUM	1.18	1.15	1.20	1.04	**2.15**	1.09	1.18	1.04
BERYLLIUM	1.18	1.15	1.20	1.04	**2.15**	1.09	1.18	1.04
CADMIUM	1.18	1.15	1.20	1.04	**2.15**	1.09	1.18	1.04
CALCIUM	1.18	1.15	1.20	1.04	**2.15**	1.09	1.18	1.04
CHROMIUM	1.18	1.15	1.20	1.04	**2.15**	1.09	1.18	1.04
COBALT	1.18	1.15	1.20	1.04	**2.15**	1.09	1.18	1.04
COPPER	1.18	1.15	1.20	1.04	**2.15**	1.09	1.18	1.04
IRON	1.18	1.15	1.20	1.04	**2.15**	1.09	1.18	1.04
LEAD	1.18	1.15	1.20	1.04	**2.15**	1.09	1.18	1.04
LITHIUM	1.18	1.15	1.20	1.04	**2.15**	1.09	1.18	1.04
MAGNESIUM	1.18	1.15	1.20	1.04	**2.15**	1.09	1.18	1.04
MANGANESE	1.18	1.15	1.20	1.04	**2.15**	1.09	1.18	1.04
MERCURY	1.18	1.15	1.20	1.04	**2.15**	1.09	1.18	1.04
NICKEL	1.18	1.15	1.20	1.04	**2.15**	1.09	1.18	1.04
POTASSIUM	1.18	1.15	1.20	1.04	**2.15**	1.09	1.18	1.04
SELENIUM	1.18	1.15	1.20	1.04	**2.15**	1.09	1.18	1.04
SILVER	1.18	1.15	1.20	1.04	**2.15**	1.09	1.18	1.04
SODIUM	1.18	1.15	1.20	1.04	**2.15**	1.09	1.18	1.04
STRONTIUM	1.18	1.15	1.20	1.04	**2.15**	1.09	1.18	1.04
THALLIUM	1.18	1.15	1.20	1.04	**2.15**	1.09	1.18	1.04
THORIUM	1.18	1.15	1.20	1.04	**2.15**	1.09	1.18	1.04
TIN	1.18	1.15	1.20	1.04	**2.15**	1.09	1.18	1.04
VANADIUM	1.18	1.15	1.20	1.04	**2.15**	1.09	1.18	1.04
ZINC	1.18	1.15	1.20	1.04	**2.15**	1.09	1.18	1.04

Notes:

BOLD indicates above goal level of 2 standard deviations

1 - No statistical analysis was done for soil group 9 because only one sample is in this data set.

2 - Collective soil types within a soil group (see Figure 4-1 for additional information)

TABLE 4-13

STATISTICAL DIFFERENTIATION OF SOIL TYPES INTO SOIL GROUPS[1]
BASEWIDE BACKGROUND SOIL INVESTIGATION REPORT
NAVAL SURFACE WARFARE CENTER
CRANE, INDIANA

	DEPOSITIONAL ENVIRONMENT			
	LOESS/GLACIAL Soil	Residual soil from MISSISSIPPIAN Bedrock	Residual Soil from PENNSYLVANIAN Bedrock	ALLUVIAL Soil
SURFACE	LS	MS	PS	AS
SUBSURFACE CLAY	LBC	MBC	PBC	ABC
SUBSURFACE SILT	LBL	MBL	PBL	ABL
SUBSURFACE SAND	LBS	MBS	PBS	ABS

Notes:
1. Soil groups determined based upon statistical analysis alone. See Figure 4-1 for an illustration of final soil groups based upon a complete analysis.

[ ] = soil group determined based upon statitical analysis alone.

Letters are interpreted as follows:

First Letter:
- A - Alluvial Soil
- L - Loess/Glacial (Loess/Glacial outwash deposits)
- M - Mississippian Soil (residual soil from Mississippian bedrock/colluvium)
- P - Pennsylvanian Soil (residual soil from Pennsylvanian bedrock/colluvium)

Second Letter:
- B - Subsurface Soil
- S - Surface Soil

Third Letter:
- C - Clay
- S - Sand
- L - Silt

TABLE 4-14

COMPLETENESS BY SOIL TYPE*
BASEWIDE BACKGROUND INVESTIGATION REPORT
NAVAL SURFACE WARFARE CENTER
CRANE, INDIANA

	SOIL TYPE																
METAL	**ABC**	**ABL**	**ABS**	**AS**	**LBC**	**LBL**	**LBS**	**LS**	**MBC**	**MBL**	**MBS**	**MS**	**PBC**	**PBL**	**PBS**	**PS**	**ABC**
ALUMINUM	60	100	80	100	100	100	60	100	80	100	60	100	80	100	20	100	100
ANTIMONY	60	100	80	100	100	100	60	100	80	100	60	100	80	100	20	100	100
ARSENIC	60	100	80	100	100	100	60	100	80	100	60	100	80	100	20	100	100
BARIUM	60	100	80	100	100	100	60	100	80	100	60	100	80	100	20	100	100
BERYLLIUM	60	100	80	100	100	100	60	100	80	100	60	100	80	100	20	100	100
CADMIUM	60	100	80	100	100	100	60	100	80	100	60	100	80	100	20	100	100
CALCIUM	60	100	80	100	100	100	60	100	80	100	60	100	80	100	20	100	100
CHROMIUM	60	100	80	100	100	100	60	100	80	100	60	100	80	100	20	100	100
COBALT	60	100	80	100	100	100	60	100	80	100	60	100	80	100	20	100	100
COPPER	60	100	80	100	100	100	60	100	80	100	60	100	80	100	20	100	100
IRON	60	100	80	100	100	100	60	100	80	100	60	100	80	100	20	100	100
LEAD	60	100	80	100	100	100	60	100	80	100	60	100	80	100	20	100	100
LITHIUM	60	100	80	80	100	100	60	100	80	100	60	100	80	100	20	100	100
MAGNESIUM	60	100	80	100	100	100	60	100	80	100	60	100	80	100	20	100	100
MANGANESE	60	100	80	100	100	100	60	100	80	100	60	100	80	100	20	100	100
MERCURY	60	100	80	100	100	100	60	100	80	100	60	100	80	100	20	100	100
NICKEL	60	100	80	100	100	100	60	100	80	100	60	100	80	100	20	100	100
POTASSIUM	60	100	80	100	100	100	60	100	80	100	60	100	80	100	20	100	100
SELENIUM	60	100	80	100	100	100	60	100	80	100	60	100	80	100	20	100	100
SILVER	60	100	80	100	100	100	60	100	80	100	60	100	80	100	20	100	100
STRONTIUM	60	100	80	100	100	100	60	100	80	100	60	100	80	100	20	100	100
SODIUM	60	100	80	80	100	100	60	100	80	100	60	100	80	100	20	100	100
THALLIUM	60	100	80	100	100	100	60	100	80	100	60	100	80	100	20	100	100
THORIUM	60	100	80	80	100	100	60	100	80	100	60	100	80	100	20	100	100
TIN	60	100	80	100	100	100	60	100	80	100	60	100	80	100	20	100	100
VANADIUM	60	100	80	100	100	100	60	100	80	100	60	100	80	100	20	100	100
ZINC	60	100	80	100	100	100	60	100	80	100	60	100	80	100	20	100	100

Notes:

* Completeness = (No. data points collected)/(No. data points desired)

Combining soil types into soil groups mitigates the failure to acquire 5 samles of each soil type

** Cost benefit analysis showed that the limited availability of these soil types rendered continued search cost-prohibitive.

TABLE 4-15

COMPLETENESS BY SOIL GROUP*
BASEWIDE BACKGROUND INVESTIGATION REPORT
NAVAL SURFACE WARFARE CENTER
CRANE, INDIANA

	SOIL GROUP								
	1	2	3	4	5	6	7	8	9
METAL	**LS**	**LBC/LBL/LBS**	**AS/MS/PS**	**ABL/ABS**	**ABC****	**MBC/MBS**	**MBL**	**PBC/PBL**	**PBS****
ALUMINUM	100	260	300	180	60	140	100	180	20
ANTIMONY	100	260	300	180	60	140	100	180	20
ARSENIC	100	260	300	180	60	140	100	180	20
BARIUM	100	260	300	180	60	140	100	180	20
BERYLLIUM	100	260	300	180	60	140	100	180	20
CADMIUM	100	260	300	180	60	140	100	180	20
CALCIUM	100	260	300	180	60	140	100	180	20
CHROMIUM	100	260	300	180	60	140	100	180	20
COBALT	100	260	300	180	60	140	100	180	20
COPPER	100	260	300	180	60	140	100	180	20
IRON	100	260	300	180	60	140	100	180	20
LEAD	100	260	300	180	60	140	100	180	20
LITHIUM	100	260	280	180	60	140	100	180	20
MAGNESIUM	100	260	300	180	60	140	100	180	20
MANGANESE	100	260	300	180	60	140	100	180	20
MERCURY	100	260	300	180	60	140	100	180	20
NICKEL	100	260	300	180	60	140	100	180	20
POTASSIUM	100	260	300	180	60	140	100	180	20
SELENIUM	100	260	300	180	60	140	100	180	20
SILVER	100	260	300	180	60	140	100	180	20
STRONTIUM	100	260	300	180	60	140	100	180	20
SODIUM	100	260	280	180	60	140	100	180	20
THALLIUM	100	260	300	180	60	140	100	180	20
THORIUM	100	260	280	180	60	140	100	180	20
TIN	100	260	300	180	60	140	100	180	20
VANADIUM	100	260	300	180	60	140	100	180	20
ZINC	100	260	300	180	60	140	100	180	20

* Completeness = (No. data points collected)/(No. data points desired) = (No. data points collected)/5

** Cost benefit analysis showed that the limited availability of these soil types rendered continued search for them prohibitive

Additional background samples or more than 5 site samples may be collected for ech site investigation to offset this condition

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	DEPOSITIONAL ENVIRONMENT			
	LOESS/GLACIAL Soil	ALLUVIAL Soil	Residual soil from MISSISSIPPIAN Bedrock	Residual Soil from PENNSYLVANIAN Bedrock
SURFACE	LS	AS	MS	PS
SUBSURFACE CLAY	LBC	ABC	MBC	PBC
SUBSURFACE SILT	LBL	ABL	MBL	PBL
SUBSURFACE SAND	LBS	ABS	MBS	PBS

Soil Group Number	Soil Types within Soil Group & Representative Color	Soil Group Description	Total Number of Samples Collected & Analyzed in Soil Group
1	LS	Loess/Glacial Surface Soil	5
2	LBC/LBL/LBS	Loess/Glacial Subsurface Soil	13
3	AS/MS/PS	All Surface Soil (except Loess/Glacial)	15
4	ABL/ABS	Alluvial Silt and Sand Subsurface Soil (except Clay)	9
5	ABC	Alluvial Subsurface Clay	3
6	MBC/MBS	Mississippian Subsurface Soil (except Silt)	7
7	MBL	Mississippian Subsurface Silt	5
8	PBC/PBL	Pennsylvanian Clay and Silt Subsurface soil (except Sand)	9
9	PBS	Pennsylvanian Subsurface Sand	1

Notes: Abbreviations are as follows:

First Letter:	A - Alluvial Soil L - Loess/Glacial (deposits)	M - Mississippian Soil (residual soil from Mississippian bedrock/colluvium) P - Pennsylvanian Soil (residual soil from Pennsylvanian bedrock/colluvium)	
Second Letter:	B - Subsurface Soil	S - Surface Soil	
Third Letter:	C - Clay	S - Sand	L - Silt

DRAWN BY: K. HENN DATE: 7/6/00	Tetra Tech NUS, Inc.	CONTRACT NUMBER: 0087	OWNER NO.: 0083
CHECKED BY: — DATE: —	FINAL DIFFERENTIATION OF SOIL TYPES INTO SOIL GROUPS NAVAL SURFACE WARFARE CENTER (NSWC) CRANE DIVISION	APPROVED BY: K. HENN	DATE: 7/6/00
COST/SCHEDULE-AREA		APPROVED BY: —	DATE: —
SCALE: AS NOTED		DRAWING NO.: FIGURE 4-1	REV: 0

5.0 PROCEDURE FOR USE OF THIS REPORT FOR DATA COMPARISONS

This section provides a proposed methodology for using the background data contained herein for data comparisons in future site investigations. Two types of data comparisons may be performed. One approach, used historically, involves a direct comparison between the site data and the background data's descriptive statistics (i.e., minimum, maximum, average, 95% upper tolerance limit or 95% UTL values). The information for this type of comparison is included in Tables 4-1 through 4-10. The 95% UTL indicates that the background samples concentrations are below limits 95 percent of the time. Exceedances of this value suggest that the concentration is not from the same distribution as the background concentration. Therefore, the exceedance would be statistically significant (see Appendix D-1 for additional details on the calculation of the 95% UTL). It is noted that the 95% UTL calculated for a data set may exceed the maximum reported concentration. It is sometimes assumed that if a data set contains less than five data points, the maximum detected concentration is used in place of a 95% UTL.

A second approach involves a more rigorous statistical comparison as directed by project specific guidelines. The information for this type of comparison is in a database currently managed by Tetra Tech NUS, Inc.

Section 5.1 contains simplified steps which should be followed to select the appropriate background soil group data sets for comparisons with site investigation data. Section 5.2 illustrates the steps necessary to retrieve a background data set from the TtNUS database to be used in the second data comparison approach listed above.

5.1 SIMPLIFIED STEPS FOR BACKGROUND COMPARISONS

The following steps should be followed to select the appropriate background soil group data sets for data comparisons:

1. Collect site investigation data.

2. Identify the DE(s) present at the SWMU or other area of investigation. To identify the DE(s) refer to Figure 2-4 which illustrates the surface geology and DEs present at the NSWC Crane facility and Section 2.7.2. Other interpretations of the soil encountered at NSWC Crane may also be found in the USDA/SCS report by McElrath (1998).

3. Determine what soil groups are present at the SWMU based upon the selected DE(s) and the field data (i.e., soil sample depth and grain size by field interpretation) collected at the site. The soil groups for the NSWC Crane facility are defined in Section 4.0 of this report.

4. Consult with a qualified geologist to confirm that steps 2 and 3 have been performed correctly.

5. Identify the appropriate data set for the soil groups present at the SWMU from the background database (see Section 5.2 for this procedure). Begin comparison(s) of SWMU investigation data with background soil group data sets based upon project specific requirements.

6. Determine appropriate (current) risk-based screening levels for the site under investigation.

7. Take appropriate action(s) based upon site to background data comparisons and the appropriate screening levels.

5.2 DATABASE QUERY FOR RETRIEVAL OF BACKGROUND DATA SETS

The procedure listed below provides the steps necessary to retrieve a background data set from the database for site investigation and background data comparisons. The database is currently managed and maintained by TtNUS using Microsoft FoxPro® software.

This FoxPro® SQL example query illustrates the selection of background data for the Loess/Glacial surface soil data set from the NSWC Crane master database. Note that FoxPro® commands are case sensitive when performing data searches:

1. SET DEFAULT TO P:\SDIV\7141_010\

2. SELECT * FROM SAMPLE_DATA WHERE ALLTRIM(SOIL_TYPE) == "LS" AND ALLTRIM(QC_TYPE) == "NM" AND ALLTRIM(SACODE) <> "DUP" INTO TABLE LS_SAM ORDER BY LOCATION, NSAMPLE

3. SELECT * FROM ANALYTIC_RESULTS WHERE NSAMPLE IN (SELECT NSAMPLE FROM LS_SAM) INTO TABLE AS_RES ORDER BY NSAMPLE, PARAMETER

As a result of this query, table "LS_SAM" should contain 5 samples or records as shown below. Each of the 5 samples in table "LS_SAM" should contain 24 metals resulting in a total of 120 records (i.e., 24 metals x 5 samples):

- BG1SBL0101
- BG1SBL0501
- BG2SBG0101
- BG2SBG0201
- BG2SBG0401-MAX

4. The background soil group data set is now ready for comparisons with site investigation data based upon project specific requirements.

Note: To retrieve the data sets for other soil groups, the soil group "codes" illustrated on Figure 4-1 should be input in place of the "LS" soil group "code" in the example shown above.

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 SUMMARY AND CONCLUSIONS

The Basewide Background Investigation achieved the objective of establishing an inorganics (i.e., metals) basewide background database for the NSWC Crane facility. The background database includes analytical data for surface soil and subsurface soil for the entire facility. The background database will be used in current and future environmental investigations to differentiate site-related environmental contamination from naturally occurring and anthropogenic (i.e., prior to U.S. Navy site operations) concentrations.

Following are summaries and major conclusions of this report:

- Background sample collection was distributed across three background areas. Each of these areas and sampling locations inside these areas met numerous criteria established to ensure that background soil samples represent “true background” areas or areas that have not been affected by past or present NSWC Crane operations.

- The data collected are of sufficient quality to be used for background comparisons in risk assessments, RCRA Facility Investigations, and other environmental investigations conducted at NSWC Crane. The background database is valid for future comparisons to suspected SWMUs anywhere on the NSWC Crane facility. All background sample data have been validated in accordance with EPA Region V guidelines.

- A total of 16 soil types were represented by various combinations of soil from different DEs, grain sizes, and depths below the ground surface.

- A sufficient number of samples were collected to characterize background soil for 15 of the 16 soil types. The goal of attaining a minimum of 3 samples for each of these 15 soil types was achieved. This goal was not achieved for only one soil type (residual soil derived from Pennsylvanian bedrock/colluvium, PBS).

- Statistical analyses supported by geological principles allowed the 16 soil types to be classified into 9 different soil groups. All soil types within a given soil group have similar inorganic concentrations. The goal of attaining a minimum of 5 samples for statistical analysis for each of these soil groups was achieved, except for soil group 5 (alluvial subsurface clay soil) and soil group 9 (residual soil derived from Pennsylvanian bedrock/colluvium). Only 3 samples were collected for soil group 5 and only one sample was collected for soil group 9.

- In general, the background soil concentrations between the surface and subsurface soil, and between subsurface soil across different DEs are not the same. However, concentrations in surface soil across multiple DEs and the subsurface soil within a given DE are similar.

- The background concentrations for several metals exceeded human health and ecological risk-based target levels (i.e., risk-based screening levels) used during planning for this project.

- The overall project goal of achieving a minimum detectable difference of two-*sigma* or less between background and investigative data sets has been achieved, assuming that the assumptions used in planning this project (see Section 4.3) are valid. Even if the assumptions are not completely valid, most of the minimum detectable differences were significantly less than the two-*sigma* limit, thus differences between data sets should be detectable within a comfortable level of confidence.

- Within a DE, a maximum of three soil groups exists. Thus, for any SWMU that lies entirely within a single DE, no more than three background data sets will be needed for comparisons with site investigation data to determine whether site metal concentrations exceed background concentrations. Within each DE two of the soil groups exist solely because of differences between surface and subsurface soil.

- Because only one sample was encountered for the residual soil derived from Pennsylvanian bedrock/colluvium soil type, and the analytical results from this soil sample were not similar to the other soil types, there is no background data set for this soil type/group. Based upon the decision rule in the Work Plan (TtNUS, 2000b), sampling for this soil type was terminated at the end of the supplemental field event because additional sampling was shown to have been cost-prohibitive based upon a probability-cost analysis. Based upon infrequency of encountering this soil type there is a low probability of encountering it during site environmental investigations

6.2 RECOMMENDATIONS

The following recommendations are provided for additional consideration:

- The procedures outlined in Section 5 of this report should be followed when comparing site investigation data to the background data sets presented in this report.

- Because some metals exceed human health and ecological risk-based target levels and these target levels are updated on a periodic basis, it is important that when the site investigation data are evaluated with respected to background data the current target levels are also considered.

- There may be circumstances where it is beneficial for SWMU specific background data to be collected to supplement the basewide background soil database. The following are possible circumstances for which this may be valuable:

  - SMWUs that have open burning/open detonation operations on site or are affected by adjacent site operations may benefit from SWMU specific background concentrations, as these values will provide a localized point of reference. This item specifically refers to SWMUs which are downwind from other SWMUs which may have released airborne contaminants. An example where this may apply is at the DRMO Storage Lot (SWMU 21/00) which is downwind of the Demolition Range (06/09). In this case it is recommended that SWMU specific background is collected at SWMU 21/00 as a frame of reference to determine whether contaminants encountered at SWMU 21/00 are a SWMU specific issue or a result of contamination released from SWMU 06/09.

  - A SMWU located in an area where the local geology may affect the local background concentrations. For example, the Lower Pennsylvanian bedrock (and likely residual soil) which consists locally of thin black shale, carbonaceous shale and coal beds. These localized beds may contain elevated concentrations of naturally occurring inorganics (e.g., chromium, arsenic). As a result, residual soil in this localized geological environment may have abnormally high inorganic background concentrations where collection of SWMU specific background concentrations may provide some added value. If the site investigation data collected is significantly outside the bounds of the data in this report, then additional background data may need to be collected, based upon the consulting geologist's opinion, to determine if locally weathering bedrock affected the results.

  - For SWMUs where the analyte list of metal contaminants of potential concern differs from the analyte list used in this background investigation additional background data may need to be collected.

- For SWMUs where the PBS soil type/soil group is encountered during site investigations and a background data set is needed for comparison.

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APPENDIX A

FIELD FORMS

A-1 MULTIPLE SAMPLE LOG SHEETS

A-2 CHAIN-OF-CUSTODY RECORDS

A-3 FIELD LOG BOOK

A-4 EQUIPMENT CALIBRATION LOG

A-5 SURVEY RESULTS

A-1 MULTIPLE SAMPLE LOG SHEETS

FIRST FIELD EVENT

Tetra Tech NUS, Inc.

MULTIPLE SAMPLE LOG SHEET

[x] SURFACE SOIL [] SEDIMENT
[x] SUBSURFACE SOIL [] LAGOON / POND
[] OTHER ______

SIGNATURE(S): [signature]

PROJECT NAME: NSWC Crane
PROTECT NUMBER: 0087 CTO 83

LOCATION: BG1SBL01

SAMPLE No.	SAMPLE METHOD	DEPTH (Ft.)	DATE	TIME	SAMPLED BY	CONCENTRATION (L)LOW (H)HIGH	(G) GRAB (C) COMPOSITE	TOTAL No. OF CONTAINERS	ANALYSES: TAL Metals + Tin					SOIL DESCRIPTION
BG1SBL0101	HA	0-1	11/8 /99	1305	SN	L	G	1	x					SILT SOME CLAY
BG1SBL0103	HA	2-3	11/8 /99	1314	SN	L	G	1	x					BL CLAY SOME SILT TR VF OR SAND OR MOT.
BG1SBL0104	HA	3-4	11/8 /99	1320	SN	L	G	1	x					SILT W/SOME BL CLAY TR VF-C SAND OR MOT.
BG1SBL0105	HA	4-5	11/8 /99	1327	SN	L	G	1	x					↓
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											

REMARKS: Only 4 samples taken due to auger refusal @ 5 FT.

HA - Hand Auger

LABORATORY: Laucks Laboratory Seattle, Washington

COC No.:

Tetra Tech NUS, Inc.

MULTIPLE SAMPLE LOG SHEET

PAGE 1 OF 1

[] SURFACE SOIL
[] SUBSURFACE SOIL
[] OTHER ________________
[] SEDIMENT
[] LAGOON / POND

SIGNATURE(S): [signature]

PROJECT NAME: NSWC Crane
PROTECT NUMBER: 0087 CTO 83

LOCATION: BGISBL02

SAMPLE No.	SAMPLE METHOD	DEPTH (Ft.)	DATE	TIME	SAMPLED BY	CONCENTRATION (L)LOW (H)HIGH	(G) GRAB (C) COMPOSITE	TOTAL No. OF CONTAINERS	ANALYSES: TAL Metals + Tin					SOIL DESCRIPTION
BGISBL0201	HA	0-1	11/8/99	1410	SN	L	G	1	X					SILT TR CLAY TR VFGR SAND TR OR/GRAY MOT.
BGISBL0203	HA	2-3	11/8/99	1415	SN	L	G	1	X					BL CLAY SOME SILT TR VFGR SAND
BGISBL0204	HA	3-4	11/8/99	1422	SN	L	G	1	X					↓
BGISBL0205	HA	4-5	11/8/99	1430	SN	L	G	1	X					SILT SOME BL CLAY SOME FGR SAND
BGISBL0206	HA	5-6	11/8/99	1436	SN	L	G	1	X					↓
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											

REMARKS:

HA - Hand A

LABORATORY: Laucks Laboratory, Seattle, Washington

COC No.:

Tetra Tech NUS, Inc.

MULTIPLE SAMPLE LOG SHEET

PAGE 1 OF 1

[x] SURFACE SOIL
[x] SUBSURFACE SOIL
[] OTHER ________
[] SEDIMENT
[] LAGOON / POND

SIGNATURE(S): Scott L. Reid

PROJECT NAME: NSWC Crane
PROTECT NUMBER: 0087 CTO 83

LOCATION: BGISBL03

SAMPLE No.	SAMPLE METHOD	DEPTH (Ft.)	DATE	TIME	SAMPLED BY	CONCENTRATION (L)LOW (H)HIGH	(G) GRAB (C) COMPOSITE	TOTAL No. OF CONTAINERS	ANALYSES: TAL Metals + Tin					SOIL DESCRIPTION
BGISBL0301	HA	0-1	11/8/99	0905	SN	L	G	1	X					SILT TR CLAY
BGISBL0303	HA	2-3	11/8/99	0912	↓	↓	↓	↓	↓					SILTY BL CLAY TR FGR SAND
BGISBL0304	HA	3-4	11/8/99	0917	↓	↓	↓	↓	↓					↓
BGISBL0305	HA	4-5	11/8/99	0925	↓	↓	↓	↓	↓					↓
BGISBL0306	HA	5-6	11/8/99	0932	↓	↓	↓	↓	↓					BL CLAY SOME SILT
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											

REMARKS:

HA - Hand Auger

LABORATORY:
Laucks Laboratory
Seattle, Washington

COC No.:

Tetra Tech NUS, Inc.

MULTIPLE SAMPLE LOG SHEET

[x] SURFACE SOIL [] SEDIMENT
[x] SUBSURFACE SOIL [] LAGOON / POND
[] OTHER ____

SIGNATURE(S): Scott [signature]

PROJECT NAME: NSWC Crane
PROTECT NUMBER: 0087 CTO 83

LOCATION: BGISBL04

SAMPLE No.	SAMPLE METHOD	DEPTH (Ft.)	DATE	TIME	SAMPLED BY	CONCENTRATION (L)LOW (H)HIGH	(G) GRAB (C) COMPOSITE	TOTAL No. OF CONTAINERS	ANALYSES: TAL Metals + Tin					SOIL DESCRIPTION
BGISBL0401	HA	0-1	11/8/99	1000	SN	L	G	1	X					SILT TR CLAY
BGISBL0403	HA	2-3	11/8/99	1006	SN	L	G	1	X					SILTY BL CLAY OR MOT. TR FGR SAND
BGISBL0404	HA	3-4	11/8/99	1014	SN	L	G	1	X					↓
BGISBL0405	HA	4-5	11/8/99	1018	SN	L	G	1	X					CLAYEY SILT OR MOT TR FGR SAND
BGISBL0406	HA	5-6	11/8/99	1025	SN	L	G	1	X					BL CLAY SOME SILT ↓ ↓
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											

REMARKS:

HA - Hand A[uger]

LABORATORY: Laucks Laboratory, Seattle, Washington

COC No.:

Tetra Tech NUS, Inc.

MULTIPLE SAMPLE LOG SHEET

[x] SURFACE SOIL [] SEDIMENT
[x] SUBSURFACE SOIL [] LAGOON / POND
[] OTHER ________

SIGNATURE(S): Scott [illegible]

PROJECT NAME: NSWC Crane
PROTECT NUMBER: 0087 CTO 83
LOCATION: BGISBL05

SAMPLE No.	SAMPLE METHOD	DEPTH (Ft.)	DATE	TIME	SAMPLED BY	CONCENTRATION (L)LOW (H)HIGH	(G) GRAB (C) COMPOSITE	TOTAL No. OF CONTAINERS	ANALYSES: TAL Metals + Tin					SOIL DESCRIPTION
BGISBL0501	HA	0-1	11/8/99	0800	SN	L	G	1	X					SILT TR CLAY
BGISBL0503	HA	2-3	11/8/99	0810	SN	L	G	1	X					CLAYEY SILT TR VFGR SAND
BGISBL0504 (Dup + MS/MSD)	HA	3-4	11/8/99	0818	SN	L	G	3	X					↓ ↓
BGISBL0505	HA	4-5	11/8/99	0830	SN	L	G	1	X					
BGISBL0506	HA	5-6	11/8/99	0838	SN	L	G	1	X					OR MOT BL CLAY SOME SILT
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											

REMARKS: BGISBL0504 has an associated duplicate and MS/MSD. Duplicate # BGFD11089901.

HA - Hand Auger

LABORATORY: Laucks Laboratory, Seattle, Washington

COC No.:

Tetra Tech NUS, Inc.

MULTIPLE SAMPLE LOG SHEET

[x] SURFACE SOIL
[x] SUBSURFACE SOIL
[ ] OTHER ________
[ ] SEDIMENT
[ ] LAGOON / POND

SIGNATURE(S): Scott W. [illegible]

PROJECT NAME: NSWC Crane

PROTECT NUMBER: 0087 CTO 83

LOCATION: BG1SBA01

SAMPLE No.	SAMPLE METHOD	DEPTH (Ft.)	DATE	TIME	SAMPLED BY	CONCENTRATION (L)LOW (H)HIGH	(G) GRAB (C) COMPOSITE	TOTAL No. OF CONTAINERS	ANALYSES: TAL Metals + Tin	ANALYSES	ANALYSES	ANALYSES	ANALYSES	SOIL DESCRIPTION
BG1SBA0101	HA	0-1	11/4/99	1425	SN	L	G	1	X					SILT TR VFGR SAND GRAVEL / ROCK FRAGS
BG1SBA0103	HA	2-3	11/4/99	1434	SN	L	G	1	X					SILT SOME CLAY TR FGR SAND
BG1SBA0104	HA	3-3.5	11/4/99	1450	SN	L	G	1	X					
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											

REMARKS: Only 3 samples taken due to refusal.
0-1 + 2-3 FT samples taken from original borehole; 3-4 FT. SAMPLE TAKEN from third borehole.

HA - Hand Auger

LABORATORY:
Laucks Laboratory
Seattle, Washington

COC No.:

Tetra Tech NUS, Inc.

MULTIPLE SAMPLE LOG SHEET

[x] SURFACE SOIL
[] SUBSURFACE SOIL
[] OTHER ______
[] SEDIMENT
[] LAGOON / POND

SIGNATURE(S): [signature]

PROJECT NAME: NSWC Crane
PROTECT NUMBER: 0087 CTO 83

LOCATION: BG1SBA0~~1~~2 (SN)

SAMPLE No.	SAMPLE METHOD	DEPTH (Ft.)	DATE	TIME	SAMPLED BY	CONCENTRATION (L)LOW (H)HIGH	(G) GRAB (C) COMPOSITE	TOTAL No. OF CONTAINERS	ANALYSES: TAL Metals + Tin					SOIL DESCRIPTION
~~BG1SBA0101~~ BG1SBA0201 (SN)	HA	0 - 1	11/ 4/99	1545	SN	L	G	1	X					Some gravel / rock frags. Clayey silt TR VFGR sand
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											

REMARKS: Only surface sample taken due to refusal.
★ This point was <u>not</u> logged into the GPS.
Samples taken ≈ 15 ft. from dry, rocky stream bed.

HA - Hand Auger

LABORATORY: Laucks Laboratory, Seattle, Washington

COC No.:

Tetra Tech NUS, Inc.

MULTIPLE SAMPLE LOG SHEET

PAGE 1 OF 1

[x] SURFACE SOIL [] SEDIMENT
[x] SUBSURFACE SOIL [] LAGOON / POND
[] OTHER ______

SIGNATURE(S): [signature]

PROJECT NAME: NSWC Crane
PROTECT NUMBER: 0087 CTO 83

LOCATION: BGISBA03

SAMPLE No.	SAMPLE METHOD	DEPTH (Ft.)	DATE	TIME	SAMPLED BY	CONCENTRATION (L)LOW (H)HIGH	(G) GRAB (C) COMPOSITE	TOTAL No. OF CONTAINERS	ANALYSES: TAL Metals + Tin					SOIL DESCRIPTION
BGISBA0301	HA	0-1	11/5/99	1440	SN	L	G	1	X					VFGR SAND SOME SILT
BGISBA0303	HA	2-3	11/5/99	1448	SN	L	G	1	X					SILT SOME VFGR SAND
BGISBA0304	HA	3-4	11/5/99	1454	SN	L	G	1	X					↓
BGISBA0305	HA	4-5	11/5/99	1459	SN	L	G	1	X					Some Or Stain
BGISBA0306 (MS/MSD)	HA	5-6	11/5/99	1505	SN	L	G	2	X					↓ ↓
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											

REMARKS: Sample location ≈ 5 ft from dry stream bed
Sample BGISBA0306 collected for MS/MSD.

HA - Hand Auger

LABORATORY: Laucks Laboratory, Seattle, Washington

COC No.:

Tetra Tech NUS, Inc.

MULTIPLE SAMPLE LOG SHEET

PAGE 1 OF 1

[x] SURFACE SOIL [] SEDIMENT
[x] SUBSURFACE SOIL [] LAGOON / POND
[] OTHER ______

SIGNATURE(S): Scott Neil

PROJECT NAME: NSWC Crane
PROTECT NUMBER: 0087 CTO 83

LOCATION: BGISBA04

SAMPLE No.	SAMPLE METHOD	DEPTH (Ft.)	DATE	TIME	SAMPLED BY	CONCENTRATION (L)LOW (H)HIGH	(G) GRAB (C) COMPOSITE	TOTAL No. OF CONTAINERS	ANALYSES: TAL Metals + Tin					SOIL DESCRIPTION
BGISBA0401	HA	0-1	11/5/99	0825	SN	L	G	1	X					SILTY CLAY TR VF6R SAND
BGISBA0403	HA	2-3	11/5/99	0835	SN	L	G	1	X					↓
BGISBA0404	HA	3-4	11/5/99	0840	SN	L	G	1	X					Orange MOTTLING CLAY SOME SILT TR VFGR SAND
BGISBA0405	HA	45	11/5/99	0847	SN	L	G	1	X					↓
BGISBA0406	HA	5-6	11/5/99	0854	SN	L	G	1	X					↓
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											

REMARKS: Sample location is ≈ 5 FT. from dry stream bed.

HA - Hand Auger

LABORATORY: Laucks Laboratory, Seattle, Washington

COC No.:

Tetra Tech NUS, Inc.

MULTIPLE SAMPLE LOG SHEET

[x] SURFACE SOIL
[x] SUBSURFACE SOIL
[ ] SEDIMENT
[ ] LAGOON / POND
[ ] OTHER ________

SIGNATURE(S): Scott ... [signature]

PROJECT NAME: NSWC Crane
PROTECT NUMBER: 0087 CTO 83

LOCATION: BGISBA05

SAMPLE No.	SAMPLE METHOD	DEPTH (Ft.)	DATE	TIME	SAMPLED BY	CONCENTRATION (L)LOW (H)HIGH	(G) GRAB (C) COMPOSITE	TOTAL No. OF CONTAINERS	ANALYSES: TAL Metals + Tin	ANALYSES	ANALYSES	ANALYSES	ANALYSES	SOIL DESCRIPTION
BGISBA0501	HA	0-1	11/ 4/99	1640	SN	L	G	1	x					SILTY VFGR SAND
BGISBA0503	HA	2-3	11/ 4/99	1649	SN	L	G	1	x					SILT W/ TR VFGR SAND
BGISBA0504	HA	3-4	11/ 4/99	1655	SN	L	G	1	X					FGR SAND TR SILT SOME GRAVEL SOME ROCK FRAGS
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											

REMARKS: Only 3 samples taken due to refusal. Sample location ≈ 15 ft. from dry stream bed (very rocky).

HA - Hand Auger

LABORATORY:
Laucks Laboratory
Seattle, Washington

COC No.:

Tetra Tech NUS, Inc.

MULTIPLE SAMPLE LOG SHEET

■ SURFACE SOIL
■ SUBSURFACE SOIL
[] OTHER ______
[] SEDIMENT
[] LAGOON / POND

SIGNATURE(S): [signature]

PROJECT NAME: NSWC Crane
PROTECT NUMBER: 0087 CTO 83

LOCATION: BGISBP01

SAMPLE No.	SAMPLE METHOD	DEPTH (Ft.)	DATE	TIME	SAMPLED BY	CONCENTRATION (L)LOW (H)HIGH	(G) GRAB (C) COMPOSITE	TOTAL No. OF CONTAINERS	ANALYSES: TAL Metals + Tin					SOIL DESCRIPTION
BGISBP0101	HA	0-1	11/6/99	1005	SN	L	G	1	x					SILT SOME CLAY
BGISBP0103	HA	2-3	11/6/99	1012	SN	L	G	1	x					SILT w/ BLOCKY Clay RED STAIN FE NODS.
BGISBP0104	HA	3-4	11/6/99	1018	SN	L	G	1	x					SILT w/ BLOCKY CLAY TR FCR SAND ROCK FRAGS RED STAIN.
BGISBP0105	HA	4-4.5	11/6/99	1025	SN	L	G	1	x					SILT w/ BLOCKY CLAY TR V FCR SAND
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											

REMARKS: Only 4 samples taken due to auger refusal.

HA - Hand Auger

LABORATORY: Laucks Laboratory Seattle, Washington

COC No.:

Tetra Tech NUS, Inc.

MULTIPLE SAMPLE LOG SHEET

- [x] SURFACE SOIL
- [x] SUBSURFACE SOIL
- [ ] SEDIMENT
- [ ] LAGOON / POND
- [ ] OTHER ____

SIGNATURE(S): Scott [illegible]

PROJECT NAME: NSWC Crane

PROTECT NUMBER: 0087 CTO 83

LOCATION: BG1SBP02

SAMPLE No.	SAMPLE METHOD	DEPTH (Ft.)	DATE	TIME	SAMPLED BY	CONCENTRATION (L)LOW (H)HIGH	(G) GRAB (C) COMPOSITE	TOTAL No. OF CONTAINERS	ANALYSES: TAL Metals + Tin					SOIL DESCRIPTION
BG1SBP0201	HA	0-1	11/6/99	1055	SN	L	G	1	X					SILT SOME CLAY
BG1SBP0203	HA	2-3	11/6/99	1105	SN	L	G	1	X					BL CLAY SOME SILT OR MOT.
BG1SBP0204	HA	3-4	11/6/99	1112	SN	L	G	1	X					SILT SOME BL CLAY OR MOT.
BG1SBP0205	HA	4-5	11/6/99	1118	SN	L	G	1	X					ROCK FRAGS ↓ TR VFGR SAND
BG1SBP0206	HA	5-6	11/6/99	1125	SN	L	G	1	X					
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											

REMARKS:

HA - Hand Auger

LABORATORY: Laucks Laboratory, Seattle, Washington

COC No.:

MULTIPLE SAMPLE LOG SHEET

Tetra Tech NUS, Inc.

PAGE 1 OF 1

■ SURFACE SOIL [] SEDIMENT
■ SUBSURFACE SOIL [] LAGOON / POND
[] OTHER ______

SIGNATURE(S): Scott ...

PROJECT NAME: NSWC Crane
PROTECT NUMBER: 0087 CTO 83

LOCATION: BGISBP03

SAMPLE No.	SAMPLE METHOD	DEPTH (Ft.)	DATE	TIME	SAMPLED BY	CONCENTRATION (L)LOW (H)HIGH	(G) GRAB (C) COMPOSITE	TOTAL No. OF CONTAINERS	ANALYSES: TAL Metals + Tin					SOIL DESCRIPTION
BGISBP0301	HA	0-1	11/6/99	1425	SN	L	G	1	X					SILT VFGRSAND TR CLAY
BGISBP0303	HA	2-3	11/6/99	1438	SN	L	G	1	X					OR MOT. TR VFGR SAND BL CLAY SOME SILT TR ROCK FRAGS
BGISBP0304	HA	3-4	11/6/99	1446	SN	L	G	1	X					BL CLAY ~~X~~ (SN) TR SILT OR MOTTLING
(SN) ~~6~~ BGISBP0305	HA	4-5	11/6/99	1453	SN	L	G	1	X					↓
BGISBP0306	HA	5-6	11/6/99	1500	SN	L	G	1	X					↓
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											

REMARKS: BGISBP0301 taken from original boring. All other samples taken from last boring.

HA - Hand Auger

LABORATORY: Laucks Laboratory, Seattle, Washington

COC No.:

Tetra Tech NUS, Inc.

MULTIPLE SAMPLE LOG SHEET

■ SURFACE SOIL
■ SUBSURFACE SOIL
[] OTHER ________
[] SEDIMENT
[] LAGOON / POND

SIGNATURE(S): Scott C. Ne[illegible]

PROJECT NAME: NSWC Crane
PROTECT NUMBER: 0087 CTO 83

LOCATION: BG1SBP04

SAMPLE No.	SAMPLE METHOD	DEPTH (Ft.)	DATE	TIME	SAMPLED BY	CONCENTRATION (L)LOW (H)HIGH	(G) GRAB (C) COMPOSITE	TOTAL No. OF CONTAINERS	ANALYSES: TAL Metals + Tin					SOIL DESCRIPTION
BG1SBP0401	HA	0-1	11/6/99	1315	SN	L	G	1	X					SILT SOME BL CLAY
BG1SBP0403	HA	2-3	11/6/99	1323	SN	L	G	1	X					SILT SOME BL CLAY
BG1SBP0404	HA	3-4	11/6/99	1327	SN	L	G	1	X					SILT SOME BL CLAY TR FGR SAND
BG1SBP0405	HA	4-5	11/6/99	1333	SN	L	G	1	X					BL CLAY SOME SILT TR FGR SAND
BG1SBP0406 (DUP)	HA	5-6	11/6/99	1340	SN	L	G	1	X					↓
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											

REMARKS:

HA - Hand Auger

LABORATORY:
Laucks Laboratory
Seattle, Washington

COC No.:

Tetra Tech NUS, Inc.

MULTIPLE SAMPLE LOG SHEET

[x] SURFACE SOIL [] SEDIMENT
[x] SUBSURFACE SOIL [] LAGOON / POND
[] OTHER ______

SIGNATURE(S): [signature]

PROJECT NAME: NSWC Crane
PROTECT NUMBER: 0087 CTO 83

LOCATION: BG1SBP05

SAMPLE No.	SAMPLE METHOD	DEPTH (Ft.)	DATE	TIME	SAMPLED BY	CONCENTRATION (L)LOW (H)HIGH	(G) GRAB (C) COMPOSITE	TOTAL No. OF CONTAINERS	ANALYSES: TAL Metals + Tin					SOIL DESCRIPTION
BG1SBP0501	HA	0-1	11/5/99	1614	SN	L	G	1	X					SILT SOME CLAY
BG1SBP0503	HA	2-3	11/5/99	1622	SN	L	G	1	X					BLOCKY CLAY Some or MOTTLING SOME SILT
BG1SBP0504	HA	3-4	11/5/99	1629	SN	L	G	1	X					
BG1SBP0505	HA	4-5	11/5/99	1637	SN	L	G	1	X					TR FGR SAND SOME ROCK FRAGS
BG1SBP0506	HA	5-6	11/5/99	1642	SN	L	G	1	X					
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											

REMARKS:

HA - Hand Auger

LABORATORY:
Laucks Laboratory
Seattle, Washington

COC No.:

Tetra Tech NUS, Inc.

MULTIPLE SAMPLE LOG SHEET

■ SURFACE SOIL [] SEDIMENT
■ SUBSURFACE SOIL [] LAGOON / POND
[] OTHER ________

SIGNATURE(S): [illegible]

PROJECT NAME: NSWC Crane

PROTECT NUMBER: 0087 CTO 83

LOCATION: BGISBP06

SAMPLE No.	SAMPLE METHOD	DEPTH (Ft.)	DATE	TIME	SAMPLED BY	CONCENTRATION (L)LOW (H)HIGH	(G) GRAB (C) COMPOSITE	TOTAL No. OF CONTAINERS	ANALYSES: TAL Metals + Tin					SOIL DESCRIPTION
BGISBP0601 (DUP)	HA	0-1	11/5/99	1324	SN	L	G	2	x					SILTY CLAY TR VFGR SAND WEATHERED BEDROCK FRAGS.
BGISBP0603	HA	2-3	11/5/99	1335	SN	L	G	1	x					SILT SOME CLAY TR VFGR SAND
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											

REMARKS: Only 2 samples taken due to auger refusal. Surface sample BGISBP0601 has a duplicate associated with it. Duplicate ID BGFD11059901.

HA - Hand Auger

LABORATORY: Laucks Laboratory Seattle, Washington

COC No.:

Tetra Tech NUS, Inc.

MULTIPLE SAMPLE LOG SHEET

PAGE 1 OF ___

[x] SURFACE SOIL [] SEDIMENT
[] SUBSURFACE SOIL [] LAGOON / POND
[] OTHER ________

SIGNATURE(S): Scott [illegible]

PROJECT NAME: NSWC Crane
PROTECT NUMBER: 0087 CTO 83

LOCATION: BG15BP07

SAMPLE No.	SAMPLE METHOD	DEPTH (Ft.)	DATE	TIME	SAMPLED BY	CONCENTRATION (L)LOW (H)HIGH	(G) GRAB (C) COMPOSITE	TOTAL No. OF CONTAINERS	ANALYSES: TAL Metals + Tin					SOIL DESCRIPTION
BG15BP0101	HA	0-1	11/5/99	1056	SN	L	G	1	x					VFGR SAND SOME SILT; ROCK FRAGS.
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											

REMARKS: Only surface sample taken at this location due to auger refusal. Steep ravine into a drainage swale at this location.

HA - Hand Auger

LABORATORY: Laucks Laboratory, Seattle, Washington

COC No.:

Tetra Tech NUS, Inc.

MULTIPLE SAMPLE LOG SHEET

PAGE 1 OF 1

[x] SURFACE SOIL
[x] SUBSURFACE SOIL
[] OTHER ______
[] SEDIMENT
[] LAGOON / POND

SIGNATURE(S): Scott McO

PROJECT NAME: NSWC Crane
PROTECT NUMBER: 0087 CTO 83

LOCATION: BGISBP08

SAMPLE No.	SAMPLE METHOD	DEPTH (Ft.)	DATE	TIME	SAMPLED BY	CONCENTRATION (L)LOW (H)HIGH	(G) GRAB (C) COMPOSITE	TOTAL No. OF CONTAINERS	ANALYSES: TAL Metals + Tin					SOIL DESCRIPTION
BGISBP0801	HA	0-1	11/6/99	0905	SN	L	G	1	X					SILT SOME CLAY TR VFGR SAND
BGISBP0803	HA	2-3	11/6/99	0912	SN	L	G	1	X					↓
BGISBP0804	HA	3-4	11/6/99	0916	SN	L	G	1	X					↓ TR FGR SAND
BGISBP0805	HA	4-5	11/6/99	0922	SN	L	G	1	X					FGR SAND SOME SILT SOME ROCK FRAGS
BGISBP0806	HA	5-5.5	11/6/99	0930	SN	L	G	1	X					↓ MORE ROCK FRAGS
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											

REMARKS:

HA - Hand Auger

LABORATORY: Laucks Laboratory, Seattle, Washington

COC No.:

Tetra Tech NUS, Inc.

MULTIPLE SAMPLE LOG SHEET

■ SURFACE SOIL [] SEDIMENT
[] SUBSURFACE SOIL [] LAGOON / POND
[] OTHER ______

SIGNATURE(S): [signature]

PROJECT NAME: NSWC Crane
PROTECT NUMBER: 0087 CTO 83

LOCATION: BG1SBP09

SAMPLE No.	SAMPLE METHOD	DEPTH (Ft.)	DATE	TIME	SAMPLED BY	CONCENTRATION (L)LOW (H)HIGH	(G) GRAB (C) COMPOSITE	TOTAL No. OF CONTAINERS	ANALYSES: TAL Metals + Tin					SOIL DESCRIPTION
BG1SBP0901	HA	0-1	11/6/99	0807	SN	L	G	1	X					Clayey silt some rock frags some vfgr sand
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											

REMARKS: Only one sample taken due to auger refusal - 3 borings attempted - sample taken from original boring. Rock exposed at surface in several areas.

HA - Hand Auger

LABORATORY: Laucks Laboratory, Seattle, Washington

COC No.:

Tetra Tech NUS, Inc.

MULTIPLE SAMPLE LOG SHEET

- [x] SURFACE SOIL
- [x] SUBSURFACE SOIL
- [] OTHER ____________
- [] SEDIMENT
- [] LAGOON / POND

SIGNATURE(S): Scott Neal

PROJECT NAME: NSWC Crane

PROTECT NUMBER: 0087 CTO 83

LOCATION: BGISBP10

SAMPLE No.	SAMPLE METHOD	DEPTH (Ft.)	DATE	TIME	SAMPLED BY	CONCENTRATION (L)LOW (H)HIGH	(G) GRAB (C) COMPOSITE	TOTAL No. OF CONTAINERS	ANALYSES: TAL Metals + Tin					SOIL DESCRIPTION
BGISBP1001	HA	0-1	11/5/99	0917	SN	L	G	1	X					SILTY CLAY VFGR SAND
BGISBP1003	HA	2-3	11/5/99	0935	SN	L	G	1	X					SILT SOME CLAY SOME (SN) VFGR SAND ROCK FRAGS
BGISBP1004	HA	3-4	11/5/99	0943	SN	L	G	1	X					SILT SOME CLAY SOME FGR SAND ROCK FRAGS
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											

REMARKS: Only 3 samples taken due to auger refusal. Three borings attempted with BGISBP1001 and BGISBP1003 coming from the original boring, and BGISBP1004 coming from the third boring.

HA - Hand A[illegible]r

LABORATORY: Laucks Laboratory, Seattle, Washington

COC No.:

Tetra Tech NUS, Inc.

MULTIPLE SAMPLE LOG SHEET

[x] SURFACE SOIL [] SEDIMENT
[x] SUBSURFACE SOIL [] LAGOON / POND
[] OTHER ______

SIGNATURE(S): [signature]

PROJECT NAME: NSWC Crane
PROTECT NUMBER: 0087 CTO 83

LOCATION: BG2SBG01

SAMPLE No.	SAMPLE METHOD	DEPTH (Ft.)	DATE	TIME	SAMPLED BY	CONCENTRATION (L)LOW (H)HIGH	(G) GRAB (C) COMPOSITE	TOTAL No. OF CONTAINERS	ANALYSES: TAL Metals + Tin					SOIL DESCRIPTION
BG2SBG0101	HA	0-1	11/7/99	0900	SN	L	G	1	X					SILTY CLAY (BL) TR VFGR SAND.
BG2SBG0103	HA	2-3	11/7/99	0908	SN	L	G	1	X					↓
BG2SBG0104	HA	3-4	11/7/99	0914	SN	L	G	1	X					↓
BG2SBG0105	HA	4-5	11/7/99	0919	SN	L	G	1	X					FGR SAND SOME CLAY + SILT
BG2SBG0106	HA	5-6	11/7/99	0925	SN	L	G	1	X					↓ TR SILT TR CLAY
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											

REMARKS:

HA - Hand Auger

LABORATORY:
Laucks Laboratory
Seattle, Washington

COC No.:

Tetra Tech NUS, Inc.

MULTIPLE SAMPLE LOG SHEET

[x] SURFACE SOIL [ ] SEDIMENT
[x] SUBSURFACE SOIL [ ] LAGOON / POND
[ ] OTHER ____

SIGNATURE(S): [signature]

PROJECT NAME: NSWC Crane
PROTECT NUMBER: 0087 CTO 83

LOCATION: BG2SBG02

SAMPLE No.	SAMPLE METHOD	DEPTH (Ft.)	DATE	TIME	SAMPLED BY	CONCENTRATION (L)LOW (H)HIGH	(G) GRAB (C) COMPOSITE	TOTAL No. OF CONTAINERS	ANALYSES: TAL Metals + Tin					SOIL DESCRIPTION
BG2SBG0201	HA	0-1	11/7/99	0943	SN	L	G	1	X					SILT TR V FGR SAND
BG2SBG0203	HA	2-3	11/7/99	0946	SN	L	G	1	X					OR MOT
BG2SBG0204	HA	3-4	11/7/99	0954	SN	L	G	1	X					Mn NODS.
BG2SBG0205	HA	4-5	11/7/99	1000	SN	L	G	1	X					SILT SOME GRAY BL CLAY SOME V FGR SAND
BG2SBG0206	HA	5-6	11/7/99	1007	SN	L	G	1	X					BL CLAY OR MOT. TR SILT TR V FGR SAND
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											

REMARKS:

HA - Hand A[illegible]

LABORATORY: Laucks Laboratory, Seattle, Washington

COC No.:

Tetra Tech NUS, Inc.

MULTIPLE SAMPLE LOG SHEET

PAGE 1 OF 1

■ SURFACE SOIL [] SEDIMENT
■ SUBSURFACE SOIL [] LAGOON / POND
[] OTHER ____

SIGNATURE(S): Scott ... (signature)

PROJECT NAME: NSWC Crane
PROTECT NUMBER: 0087 CTO 83

LOCATION: BG2SBG03

SAMPLE No.	SAMPLE METHOD	DEPTH (Ft.)	DATE	TIME	SAMPLED BY	CONCENTRATION (L)LOW (H)HIGH	(G) GRAB (C) COMPOSITE	TOTAL No. OF CONTAINERS	ANALYSES: TAL Metals + Tin					SOIL DESCRIPTION
BG2SBG0301	HA	0-1	11/7/99	0805	SN	L	G	1	X					FGR SANDY SILT TR CLAY
BG2SBG0303 (DUP)	HA	2-3	11/7/99	0815	SN	L	G	2	X					FGR SAND TR ROCK FRAGS SOME SILT
BG2SBG0304	HA	3-4	11/7/99	0820	SN	L	G	1	X					↓ TR OR STAIN
BG2SBG0305	HA	4-5	11/7/99	0827	SN	L	G	1	X					FGR SAND TR SILT TR ROCK FRAGS
BG2SBG0306	HA	5-6	11/7/99	0833	SN	L	G	1	X					↓
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											

REMARKS: BG2SBG0303 has a duplicate associated with it – duplicate # BGFD11079901.

HA - Hand Auger

LABORATORY: Laucks Laboratory, Seattle, Washington

COC No.:

Tetra Tech NUS, Inc.

MULTIPLE SAMPLE LOG SHEET

[x] SURFACE SOIL [] SEDIMENT
[x] SUBSURFACE SOIL [] LAGOON / POND
[] OTHER

SIGNATURE(S): Scott [signature]

PROJECT NAME: NSWC Crane

PROTECT NUMBER: 0087 CTO 83

LOCATION: BG2SBG04

SAMPLE No.	SAMPLE METHOD	DEPTH (Ft.)	DATE	TIME	SAMPLED BY	CONCENTRATION (L)LOW (H)HIGH	(G) GRAB (C) COMPOSITE	TOTAL No. OF CONTAINERS	ANALYSES: TAL Metals + Tin					SOIL DESCRIPTION
BG2SBG0401 (DUP)	HA	0-1	11/7/99	1417	SN	L	G	2	x					Clayey silt Fe NODS. ROCK FRAGS
BG2SBG0403	HA	2-3	11/7/99	1427	SN	L	G	1	x					SILT SOME CLAY SOME FGM SAND
BG2SBG0404	HA	3-3.4	11/7/99	1445	SN	L	G	1	x					↓
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											

REMARKS: BG2SBG0401 has a duplicate associated with it - duplicate sample # BGFD11079902.
Only 3 samples taken due to auger refusal. The 0-1 and 2-3 Ft samples were taken from the original boring, while the 3-4 Ft sample was taken from the 3rd boring.

HA - Hand Au...

LABORATORY: Laucks Laboratory, Seattle, Washington

COC No.:

Tetra Tech NUS, Inc.

MULTIPLE SAMPLE LOG SHEET

[x] SURFACE SOIL [] SEDIMENT
[x] SUBSURFACE SOIL [] LAGOON / POND
[] OTHER

SIGNATURE(S): Scott N. Neal

PROJECT NAME: NSWC Crane
PROTECT NUMBER: 0087 CTO 83

LOCATION: BG2SBG05

SAMPLE No.	SAMPLE METHOD	DEPTH (Ft.)	DATE	TIME	SAMPLED BY	CONCENTRATION (L)LOW (H)HIGH	(G) GRAB (C) COMPOSITE	TOTAL No. OF CONTAINERS	ANALYSES: TAL Metals + Tin					SOIL DESCRIPTION
BG2SBG0501	HA	0-1	11/7/99	1305	SN	L	G	1	X					SILTY CLAY
BG2SBG0503	HA	2-3	11/7/99	1315	SN	L	G	1	X					FGR SAND SOME SILT OR TINT ROCK FRAGS
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											

REMARKS: Only 2 samples taken due to auger refusal. Both samples were taken from original boring - Sample location was in very close proximity to fence line with creosote posts - evidence of grading for fence installation.

HA - Hand Auger

LABORATORY: Laucks Laboratory Seattle, Washington

COC No.:

Tetra Tech NUS, Inc.

MULTIPLE SAMPLE LOG SHEET

[x] SURFACE SOIL [] SEDIMENT SIGNATURE(S): Scott Neo

[x] SUBSURFACE SOIL [] LAGOON / POND

[] OTHER ______

PROJECT NAME: NSWC Crane

PROTECT NUMBER: 0087 CTO 83

LOCATION: BG3SBA01

SAMPLE No.	SAMPLE METHOD	DEPTH (Ft.)	DATE	TIME	SAMPLED BY	CONCENTRATION (L)LOW (H)HIGH	(G) GRAB (C) COMPOSITE	TOTAL No. OF CONTAINERS	ANALYSES: TAL Metals + Tin	ANALYSES	ANALYSES	ANALYSES	ANALYSES	SOIL DESCRIPTION
BG3SBA0101	HA	0-1	11/2/99	1530	KS	L	G	1	X					Silt w fgr sand
BG3SBA0103	HA	2-3	11/2/99	1540	SN	L	G	1	X					Silt w fgr sand - rock frags.
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											

REMARKS: Duplicate sample taken of BG3SBA0101 - Duplicate number BGFD-110299-01, Tag # QC0001.

HA - Hand A[uger]

LABORATORY: Laucks Laboratory, Seattle, Washington

COC No.:

Tetra Tech NUS, Inc.

MULTIPLE SAMPLE LOG SHEET

[x] SURFACE SOIL
[x] SUBSURFACE SOIL
[] OTHER ______
[] SEDIMENT
[] LAGOON / POND

SIGNATURE(S): Scott [signature]

PROJECT NAME: NSWC Crane
PROTECT NUMBER: 0087 CTO 83

LOCATION: BG3SBA02

SAMPLE No.	SAMPLE METHOD	DEPTH (Ft.)	DATE	TIME	SAMPLED BY	CONCENTRATION (L)LOW (H)HIGH	(G) GRAB (C) COMPOSITE	TOTAL No. OF CONTAINERS	ANALYSES: TAL Metals + Tin					SOIL DESCRIPTION
BG3SBA0201	HA	0-1	11/2/99	1415	KS	L	G	1	x					Silt trace sand
BG3SBA0203	HA	2-3	11/2/99	1423	KS	L	G	1	x					Vfgr sand some silt; rock frags
BG3SBA0204	HA	3-4	11/2/99	1430	KS	L	G	1	x					Vfgr sand rock frags
BG3SBA0205	HA	4-4.5	11/2/99	1500	KS	L	G	1	x					↓
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											

REMARKS: Only four samples taken due to refusal at 4.5 Ft.

HA - Hand Auger

LABORATORY: Laucks Laboratory, Seattle, Washington

COC No.:

Tetra Tech NUS, Inc.

MULTIPLE SAMPLE LOG SHEET

[X] SURFACE SOIL
[] SUBSURFACE SOIL
[] SEDIMENT
[] LAGOON / POND
[] OTHER ________

SIGNATURE(S): Scott Neal

PROJECT NAME: NSWC Crane
PROTECT NUMBER: 0087 CTO 83

LOCATION: BG35BA05

SAMPLE No.	SAMPLE METHOD	DEPTH (Ft.)	DATE	TIME	SAMPLED BY	CONCENTRATION (L)LOW (H)HIGH	(G) GRAB (C) COMPOSITE	TOTAL No. OF CONTAINERS	ANALYSES: TAL Metals + Tin					SOIL DESCRIPTION
BG35BA0501	HA	0-1	11/3/99	0815	KS	L	G	1	x					Org. silt w/ tr fgr sand
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											

REMARKS: Only one (1) sample taken ~~due~~ SN due to refusal.

HA - Hand A

LABORATORY: Laucks Laboratory, Seattle, Washington

COC No.:

MULTIPLE SAMPLE LOG SHEET

Tetra Tech NUS, Inc.

PAGE 1 OF 1

[x] SURFACE SOIL
[x] SUBSURFACE SOIL
[] OTHER
[] SEDIMENT
[] LAGOON / POND

SIGNATURE(S): Scott Neo

PROJECT NAME: NSWC Crane
PROTECT NUMBER: 0087 CTO 83

LOCATION: BG3SBA04

SAMPLE No.	SAMPLE METHOD	DEPTH (Ft.)	DATE	TIME	SAMPLED BY	CONCENTRATION (L)LOW (H)HIGH	(G) GRAB (C) COMPOSITE	TOTAL No. OF CONTAINERS	ANALYSES: TAL Metals + Tin					SOIL DESCRIPTION
BG3SBA0401	HA	0-1	11/4/99	0830	SN	L	G	1	X					SILT SOME CLAY TR VFGR SAND
BG3SBA0402	HA	2-3	11/4/99	0840	SN	L	G	1	X					FGR SANDY SILT TR CLAY
BG3SBA0404	HA	3-4	11/4/99	0844	SN	L	G	1	X					FGR SAND TR SILT
BG3SBA0405	HA	4-5	11/4/99	0848	SN	L	G	1	X					FGR SAND
BG3SBA0406	HA	5-5.5	11/4/99	0852	SN	L	G	1	X					FGR SAND
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											

REMARKS:

HA - Hand Auger

LABORATORY:
Laucks Laboratory
Seattle, Washington

COC No.:

Tetra Tech NUS, Inc.

MULTIPLE SAMPLE LOG SHEET

PAGE 1 OF 1

[] SURFACE SOIL
[] SUBSURFACE SOIL
[] OTHER ______
[] SEDIMENT
[] LAGOON / POND

SIGNATURE(S): Scott a. [signature]

PROJECT NAME: NSWC Crane
PROTECT NUMBER: 0087 CTO 83

LOCATION: BG3SBA05

SAMPLE No.	SAMPLE METHOD	DEPTH (Ft.)	DATE	TIME	SAMPLED BY	CONCENTRATION (L)LOW (H)HIGH	(G) GRAB (C) COMPOSITE	TOTAL No. OF CONTAINERS	ANALYSES: TAL Metals + Tin					SOIL DESCRIPTION
BG3SBA0501	HA	0-1	11/4/99	0910	SN	L	G	1	X					FGR SANDY SILT
BG3SBA0503	HA	2-3	11/4/99	0916	SN	L	G	1	X					FGR SANDY SILT TR CLAY
BG3SBA0504	HA	3-4	11/4/99	0920	SN	L	G	1	X					SILT TR CLAY TR FGR SAND
BG3SBA0505	HA	4-5	11/4/99	0926	SN	L	G	1	X					FGR SAND SOME SILT
BG3SBA0506	HA	5-5.5	11/4/99	0934	SN	L	G	1	X					FGR SAND TR SILT TR ROCK FRAGS.
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											

REMARKS:

HA - Hand Auger

LABORATORY:
Laucks Laboratory
Seattle, Washington

COC No.:

Tetra Tech NUS, Inc.

MULTIPLE SAMPLE LOG SHEET

[x] SURFACE SOIL [] SEDIMENT
[x] SUBSURFACE SOIL [] LAGOON / POND
[] OTHER

SIGNATURE(S): Scott Sneid

PROJECT NAME: NSWC Crane
PROTECT NUMBER: 0087 CTO 83

LOCATION: BG3SBM01

SAMPLE No.	SAMPLE METHOD	DEPTH (Ft.)	DATE	TIME	SAMPLED BY	CONCENTRATION (L)LOW (H)HIGH	(G) GRAB (C) COMPOSITE	TOTAL No. OF CONTAINERS	ANALYSES: TAL Metals + Tin					SOIL DESCRIPTION
BG3SBM0101	HA	0-1	11/ 2/99	0730	KS	L	G	1	X					Clayey silt
BG3SBM0103	HA	2-3	11/ 2/99	0745	SN	L	G	1	X					Blocky clay w/ Fe nods.
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											

REMARKS: Only 2 samples taken due to refusal @ 3 feet.

HA - Hand Auger

LABORATORY: Laucks Laboratory, Seattle, Washington

COC No.:

Tetra Tech NUS, Inc.

MULTIPLE SAMPLE LOG SHEET

PAGE 1 OF 1

[x] SURFACE SOIL [x] SUBSURFACE SOIL [] OTHER ______

[] SEDIMENT [] LAGOON / POND

SIGNATURE(S): Scott Neal

PROJECT NAME: NSWC Crane

PROTECT NUMBER: 0087 CTO 83

LOCATION: BG3SBM02

SAMPLE No.	SAMPLE METHOD	DEPTH (Ft.)	DATE	TIME	SAMPLED BY	CONCENTRATION (L)LOW (H)HIGH	(G) GRAB (C) COMPOSITE	TOTAL No. OF CONTAINERS	ANALYSES: TAL Metals + Tin					SOIL DESCRIPTION
BG3SBM0201	HA	0-1	11/2/99	0830	KS	L	G	1	X					Clayey silt
BG3SBM0203	HA	2-3	11/2/99	0840	↓	↓	↓	↓	X					Clayey silt
BG3SBM0204	HA	3-4	11/2/99	0848	↓	↓	↓	↓	X					Clayey silt; Trace sand
BG3SBM0205	HA	4-5	11/2/99	0900	↓	↓	↓	↓	X					Clayey silt; Iron Nails
BG3SBM0206	HA	5-6	11/2/99	0908	↓	↓	↓	↓	X					Blocky Clay - Red mottling
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											

REMARKS:

HA - Hand Auger

LABORATORY: Laucks Laboratory, Seattle, Washington

COC No.:

Tetra Tech NUS, Inc.

MULTIPLE SAMPLE LOG SHEET

[x] SURFACE SOIL [] SEDIMENT
[x] SUBSURFACE SOIL [] LAGOON / POND
[] OTHER ______

SIGNATURE(S): Scott Neil

PROJECT NAME: NSWC Crane
PROTECT NUMBER: 0087 CTO 83

LOCATION: BG3SBM03

SAMPLE No.	SAMPLE METHOD	DEPTH (Ft.)	DATE	TIME	SAMPLED BY	CONCENTRATION (L)LOW (H)HIGH	(G) GRAB (C) COMPOSITE	TOTAL No. OF CONTAINERS	ANALYSES: TAL Metals + Tin					SOIL DESCRIPTION
BG3SBM0301	HA	0-1	11/2/99	1020	KS	L	G	1	X					Silt w/some clay
BG3SBM0303	HA	2-3	11/2/99	1033	↓	↓	↓	↓	X					Clayey silt
BG3SBM0304	HA	3-4	11/2/99	1039	↓	↓	↓	↓	X					Clayey silt w/orange staining
BG3SBM0305	HA	4-5	11/2/99	1048	↓	↓	↓	↓	X					Clayey silt; Fe Nods.
BG3SBM0306	HA	5-6	11/2/99	1055	↓	↓	↓	↓	X					Clayey silt trace sand
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											

REMARKS:

HA - Hand Auger

LABORATORY: Laucks Laboratory, Seattle, Washington

COC No.:

Tetra Tech NUS, Inc.

MULTIPLE SAMPLE LOG SHEET

PAGE 1 OF 1

[x] SURFACE SOIL [] SEDIMENT
[x] SUBSURFACE SOIL [] LAGOON / POND
[] OTHER ______

SIGNATURE(S): Scott Neil

PROJECT NAME: NSWC Crane
PROTECT NUMBER: 0087 CTO 83

LOCATION: BG3SBM04

SAMPLE No.	SAMPLE METHOD	DEPTH (Ft.)	DATE	TIME	SAMPLED BY	CONCENTRATION (L)LOW (H)HIGH	(G) GRAB (C) COMPOSITE	TOTAL No. OF CONTAINERS	ANALYSES: TAL Metals + Tin					SOIL DESCRIPTION
BG3SBM0401	HA		11/ 3 /99	1025	SN	L	G	1	X					Silt trace fgr sand
BG3SBM0403	HA		11/ 3 /99	1032	SN	L	G	1	X					Blocky clay some silt trace fgr sand
BG3SBM0404	HA		11/ 3 /99	1040	SN	L	G	1	X					↓
BG3SBM04 05	HA		11/ 3 /99	1050	SN	L	G	1	X					Vfgr sand trace silt Fe nods
BG3SBM0406	HA		11/ 3 /99	1055	SN	L	G	1	X					↓
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											

REMARKS:

HA - Hand Auger

LABORATORY: Laucks Laboratory Seattle, Washington

COC No.:

Tetra Tech NUS, Inc.

MULTIPLE SAMPLE LOG SHEET

■ SURFACE SOIL
■ SUBSURFACE SOIL
[] OTHER ______
[] SEDIMENT
[] LAGOON / POND

SIGNATURE(S): [signature]

PROJECT NAME: NSWC Crane
PROTECT NUMBER: 0087 CTO 83
LOCATION: BG3SBM05

SAMPLE No.	SAMPLE METHOD	DEPTH (Ft.)	DATE	TIME	SAMPLED BY	CONCENTRATION (L)LOW (H)HIGH	(G) GRAB (C) COMPOSITE	TOTAL No. OF CONTAINERS	ANALYSES: TAL Metals + Tin					SOIL DESCRIPTION
BG3SBM0501	HA	0-1	11/ 3/99	1355	SN	L	G	1	X					Clayey silt.
BG3SBM0502	HA	2-3	11/ 3/99	1407	SN	L	G	1	X					Blocky clay w/ vfgr sand.
BG3SB M05 04	HA	3-4	11/ 3/99	1415	SN	L	G	1	X					FGR SAND; SOME SILT; TR CLAY
BG3SBM0505	HA	4-5	11/ 3/99	1421	SN	L	G	1	X					FGR SAND; TR SILT; ROCK FRAGS
BG3SBM0506	HA	5-6	11/ 3/99	1428	SN	L	G	1	X					↓ OR STAIN.
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											

REMARKS:

HA - Hand Auger

LABORATORY:
Laucks Laboratory
Seattle, Washington

COC No.:

Tetra Tech NUS, Inc.

MULTIPLE SAMPLE LOG SHEET

PAGE 1 OF 1

[x] SURFACE SOIL [x] SUBSURFACE SOIL [] OTHER ______ [] SEDIMENT [] LAGOON / POND

SIGNATURE(S): Scott Neo

PROJECT NAME: NSWC Crane

PROTECT NUMBER: 0087 CTO 83

LOCATION: BG3SBM06

SAMPLE No.	SAMPLE METHOD	DEPTH (Ft.)	DATE	TIME	SAMPLED BY	CONCENTRATION (L)LOW (H)HIGH	(G) GRAB (C) COMPOSITE	TOTAL No. OF CONTAINERS	ANALYSES: TAL Metals + Tin					SOIL DESCRIPTION
BG3SBM0601	HA	0-1	11/2/99	0935	KS	L	G	1	x					Organic silt
BG3SBM0603	HA	2-3	11/2/99	0946	↓	↓	↓	↓	x					Clayey silt
BG3SBM0604	HA	3-3.5	11/2/99	1005	↓	↓	↓	↓	x					Silty sand; rock frags.
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											

REMARKS:

HA - Hand Auger

LABORATORY: Laucks Laboratory, Seattle, Washington

COC No.:

Tetra Tech NUS, Inc.

MULTIPLE SAMPLE LOG SHEET

■ SURFACE SOIL [] SEDIMENT
■ SUBSURFACE SOIL [] LAGOON / POND
[] OTHER ______

SIGNATURE(S): Scott Neil

PROJECT NAME: NSWC Crane
PROTECT NUMBER: 0087 CTO 83

LOCATION: BG3SBM07

SAMPLE No.	SAMPLE METHOD	DEPTH (Ft.)	DATE	TIME	SAMPLED BY	CONCENTRATION (L)LOW (H)HIGH	(G) GRAB (C) COMPOSITE	TOTAL No. OF CONTAINERS	ANALYSES: TAL Metals + Tin					SOIL DESCRIPTION
BG3SBM0701	HA	0-1	11/3/99	1610	SN	L	G	1	x					SILT w/ SOME CLAY
BG3SBM0703	HA	2-3	11/3/99	1620	SN	L	G	1	x					SILT w/ SOME CLAY TR VFGR SAND
BG3SBM0704	HA	3-4	11/3/99	1626	SN	L	G	1	x					↓
BG3SBM0705	HA	4-5	11/3/99	1634	SN	L	G	1	x					BLOCKY CLAY w/ SOME SILT TR VFGR SAND
BG3SBM0706	HA	5-6	11/3/99	1642	SN	L	G	1	x					↓
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											

REMARKS:

HA - Hand Auger

LABORATORY: Laucks Laboratory, Seattle, Washington

COC No.:

MULTIPLE SAMPLE LOG SHEET

Tetra Tech NUS, Inc.

[■] SURFACE SOIL [] SEDIMENT SIGNATURE(S): Scott Neil
[■] SUBSURFACE SOIL [] LAGOON / POND
[] OTHER ________

PROJECT NAME: NSWC Crane
PROTECT NUMBER: 0087 CTO 83

LOCATION: BG35BM08

SAMPLE No.	SAMPLE METHOD	DEPTH (Ft.)	DATE	TIME	SAMPLED BY	CONCENTRATION (L)LOW (H)HIGH	(G) GRAB (C) COMPOSITE	TOTAL No. OF CONTAINERS	ANALYSES: TAL Metals + Tin					SOIL DESCRIPTION
BG35BM0801	HA	0-1	11/3/99	0915	KS	L	G	1	x					vfgr sandy silt trce clay
BG35BM080/3 (SD)	HA	2-3	11/3/99	0940	KH	L	G	3	x					fgr sand some silt rock frags
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											

REMARKS: Duplicate + MS/MSD on BG35BM0803. Only 2 samples collected due to refusal. Duplicate ID # BGFD11034901.

HA - Hand Auger

LABORATORY: Laucks Laboratory, Seattle, Washington

COC No.:

Tetra Tech NUS, Inc.

MULTIPLE SAMPLE LOG SHEET

■ SURFACE SOIL
■ SUBSURFACE SOIL
[] OTHER ____________
[] SEDIMENT
[] LAGOON / POND

SIGNATURE(S): Scott [illegible]

PROJECT NAME: NSWC Crane
PROTECT NUMBER: 0087 CTO 83

LOCATION: BG35BM09

SAMPLE No.	SAMPLE METHOD	DEPTH (Ft.)	DATE	TIME	SAMPLED BY	CONCENTRATION (L)LOW (H)HIGH	(G) GRAB (C) COMPOSITE	TOTAL No. OF CONTAINERS	ANALYSES: TAL Metals + Tin					SOIL DESCRIPTION
BG35BM0901	HA	0-1	11/ 3/99	1505	KS	L	G	1	X					SILT W/SOME CLAY TR VFGR SAND
BG35BM0903	HA	2-3	11/ 3/99	1512	KS	L	G	1	X					CLAYEY SILT TR VFGR SAND
BG35BM0904	HA	3-4	11/ 3/99	1520	KS	L	G	1	X					CLAYEY SILT SOME FGR SAND ROCK FRAGS
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											

REMARKS: Only 3 samples taken due to refusal/bedrock @ 4 FT.

HA - Hand Auger

LABORATORY: Laucks Laboratory Seattle, Washington

COC No.:

Tetra Tech NUS, Inc.

MULTIPLE SAMPLE LOG SHEET

[] SURFACE SOIL
[] SUBSURFACE SOIL
[] OTHER ________
[] SEDIMENT
[] LAGOON / POND

SIGNATURE(S): [signature]

PROJECT NAME: NSWC Crane
PROTECT NUMBER: 0087 CTO 83

LOCATION: BG3SBM10

SAMPLE No.	SAMPLE METHOD	DEPTH (Ft.)	DATE	TIME	SAMPLED BY	CONCENTRATION (L)LOW (H)HIGH	(G) GRAB (C) COMPOSITE	TOTAL No. OF CONTAINERS	ANALYSES: TAL Metals + Tin					SOIL DESCRIPTION
BG3SBM1001	HA	0-1	11/4/99	1000	SN	L	G	1	X					SILTY CLAY
BG3SBM1003	HA	2-3	11/4/99	1009	SN	L	G	1	X					SILTY CLAY TR FGR SAND SOME ROCK FRAGS
BG3SBM1004	HA	3-4	11/4/99	1020	SN	L	G	1	X					SILT SOME CLAY SOME FGR SAND
BG3SBM1005	HA	4-4.5	11/4/99	1038	SN	L	G	1	X					SILT SOME FGR SAND ROCK FRAGS
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											
	HA		11/ /99											

REMARKS: Only four of five samples taken due to refusal.

HA - Hand Auger

LABORATORY:
Laucks Laboratory
Seattle, Washington

COC No.:

SUPPLEMENTAL FIELD EVENT

Tetra Tech NUS, Inc.

MULTIPLE SAMPLE LOG SHEET

[X] SURFACE SOIL [] SEDIMENT
[] SUBSURFACE SOIL [] LAGOON / POND
[] OTHER ____________

SIGNATURE(S): [signature]

PROJECT NAME: NSWC Crane
PROTECT NUMBER: 0087 CTO 83

LOCATION: CRANE, IN

SAMPLE No.	SAMPLE METHOD	DEPTH (Ft.)	DATE	TIME	SAMPLED BY	CONCENTRATION (L)LOW (H)HIGH	(G) GRAB (C) COMPOSITE	TOTAL No. OF CONTAINERS	ANALYSES: TAL Metals + Tin	ANALYSES: + LITH., STRON., THORIUM				SOIL DESCRIPTION
BG-1 SB A28 0304	HA	3-4	10.6	1635	KS	L	G	1	1					SILTY CLAY, TR F. SAND
BG-1 SBA 25 0203	HA	2-3	10.7	0815	KS	L	G	2	2					CLAY, SOME SILT, BRN
	HA													
	HA													
	HA													
	HA													
	HA													
	HA													
	HA													
	HA													
	HA													
	HA													
	HA													
	HA													

REMARKS: "ROUND" 2 SAMPLING, OCTOBER 2000

HA - Hand Auger

LABORATORY: Laucks Laboratory, Seattle, Washington

COC No.: 0100

A-2 CHAIN-OF-CUSTODY RECORDS

FIRST FIELD EVENT

TETRA TECH NUS, INC.
661 Andersen Drive • Pittsburgh, PA 15220

NSWC CRANE, INDIANA

CHAIN OF CUSTODY RECORD

PROJECT NO.: CTO 83
JOB # 0087
SAMPLERS (SIGNATURE): [signatures]

DATE 1999	TIME	SAMPLE ID	NO. OF CONTAINERS	VOLATILES	DISSOLVED GASES	SULFIDE	TOX	SEMIVOLATILES	EXPLOSIVES	METALS TAL +TIN	CYANIDE	PESTICIDES/PCBS	HERBICIDES	DIOXINS/FURANS	TOC	SULFATE	AMMONIA	CHLORIDE	PHOSPHORUS	SOIL	AQ	TAG NO.	REMARKS
11.2	1740	BGRB110299 01	1							1											✓	QC 002	AUGER BUCKET
↓	1745	BGSW110299 01	1							1											✓	QC 003	SOURCE BLANK
↓	0000	BGFD 11029901	1							1										✓		QC001	DUP of BG3SBA0101
11/3	0000	BGFD11039901	1							1										✓		QC004	DUP OF BG3SBM0803
↓	1750	BGRB11039901	1							1											✓	QC006	S.S. BOWL
11/4	1140	BGRB11049901	1							1											✓	QC007	PE TROWEL
11/2	0830	BG3SBM0201	1							1										✓		RM006	
	0840	BG3SBM0203	1							1										✓		RM007	
	0908	BG3SBM0206	1							1										✓		RM010	
	0935	BG3SBM0601	1							1										✓		RM027	
	1005	BG3SBM0604	1							1										✓		RM 029	
↓	1048	BG3SBM0305	1							1										✓		RM014	
11/3	0915	BG3SBM0801	1							1										✓		RM 037	
	0940	BG3SBM0803	2							2										✓		RM 038	RUN ALSO MS/MSD
	1025	BG3SBM0401	1							1										✓		RM016	
	1040	BG3SBM0404	1							1										✓		RM018	
	1055	BG3SBM0406	1							1										✓		RM020	
↓	1415	BG3SBM0504	1							1										✓		RM024	

RELINQUISHED BY (SIGNATURE):	DATE/TIME	RECEIVED BY (SIGNATURE):	RELINQUISHED BY (SIGNATURE):	DATE/TIME
[signature]	11.4.99 1640	FED EX		

RECEIVED BY (SIGNATURE):	RELINQUISHED BY (SIGNATURE):	DATE/TIME	RECEIVED FOR LAB BY (SIGNATURE):	DATE/TIME

AIR BILL NO.: 8117 3683 5381
TEMP. BLANK: AT SHIPMENT 4 °C AT LAB ____ °C
COOLER CUSTODY SEAL NOS: 01, 02
REMARKS:
SHIPPED TO LAUCKS LAB

TETRA TECH NUS, INC.
661 Andersen Drive • Pittsburgh, PA 15220

CHAIN OF CUSTODY RECORD

NSWC CRANE, INDIANA

PROJECT NO.: CTO 83
JOB# 0087
SAMPLERS (SIGNATURE): [illegible] [illegible]

DATE 1999	TIME	SAMPLE ID	NO. OF CONTAINERS	VOLATILES	DISSOLVED GASES	SULFIDE	TOX	SEMIVOLATILES	EXPLOSIVES	METALS TAL + TIN	CYANIDE	PESTICIDES/PCBS	HERBICIDES	DIOXINS/FURANS	TOC	SULFATE	AMMONIA	CHLORIDE	PHOSPHORUS	SOIL	AQ	TAG NO.	REMARKS
11.3	1520	BG3SBM0904	1							1										✓		RM044	
↓	1610	BG3SBM0701	1							1										✓		RM032	
	1626	BG3SBM0704	1							1										✓		RM034	
↓	1642	BG3SBM0706	1							1										✓		RM036	
11.4	1009	BG3SBM1003	1							1										✓		RM048	

RELINQUISHED BY (SIGNATURE):	DATE/TIME		RECEIVED BY (SIGNATURE):	RELINQUISHED BY (SIGNATURE):	DATE/TIME
[illegible]	11.4.99	1640	FEDEX		
RECEIVED BY (SIGNATURE):	**RELINQUISHED BY (SIGNATURE):**	**DATE/TIME**		**RECEIVED FOR LAB BY (SIGNATURE):**	**DATE/TIME**

AIR BILL NO.: 8117 3683 5381
TEMP. BLANK: AT SHIPMENT 4 °C AT LAB ____ °C
COOLER CUSTODY SEAL NOS: 01, 02
REMARKS:
SHIPPED TO LAUCKS LABS

TETRA TECH NUS, INC.
661 Andersen Drive • Pittsburgh, PA 15220

NSWC CRANE, INDIANA

CHAIN OF CUSTODY RECORD

PROJECT NO.: CTO 83
JOB# 0087

SAMPLERS (SIGNATURE): [signatures]

	DATE 1999	TIME	SAMPLE ID	NO. OF CONTAINERS	VOLATILES	DISSOLVED GASES	SULFIDE	TOX	SEMIVOLATILES	EXPLOSIVES	METALS TAL + TIN	CYANIDE	PESTICIDES/PCBS	HERBICIDES	DIOXINS/FURANS	TOC	SULFATE	AMMONIA	CHLORIDE	PHOSPHORUS	SOIL	AQ	TAG NO.	REMARKS
+	11/5	1725	BGRB11059901	1							X											X	QC009	Aueta Buckett
–	11/5	0000	BGFD11059901	1							X										X		QC008	DUPLICATE OF BG1SBP0601
WN 0097	11/5	1505	BG1SBA0306	2							X										X		A0015	RUN MS/MSD
+	11/6	1550	BGRB11069901	1							X											X	QC012	S.S. BOWL
–	11/6	0000	BGFD11069901	1							X										X		QC011	DUP OF BG1P0406
	11/2	1423	BG3SBA0203	1							X										X		A0032	
	↓	1530	BG3SBA0101	1							X										X		A0026	
	11/3	0825	BG3SBA0301	1							X										X		A0036	
	11/4	0840	BG3SBA0403	1							X										X		A0042	
	↓	0844	BG3SBA0404	1							X										X		A0043	
		0910	BG3SBA0501	1							X										X		A0046	
		0920	BG3SBA0504	1							X										X		A0048	
		0934	BG3SBA0506	1							X										X		A0050	
		1425	BG1SBA0101	1							X										X		A0001	
		1435	BG1SBA0104	1							X										X		A0003	
		1649	BG1SBA0503	1							X										X		A0022	
	↓	1655	BG1SBA0504	1							X										X		A0023	
	11/5	0825	BG1SBA0401	1							X										X		A0016	

RELINQUISHED BY (SIGNATURE):	DATE/TIME		RECEIVED BY (SIGNATURE):	RELINQUISHED BY (SIGNATURE):	DATE/TIME	
[signature]	11-8-99	1840	FED EX			

RECEIVED BY (SIGNATURE):	RELINQUISHED BY (SIGNATURE):	DATE/TIME		RECEIVED FOR LAB BY (SIGNATURE):	DATE/TIME	

AIR BILL NO.: 8161 4958 9231

TEMP. BLANK: AT SHIPMENT 4 °C AT LAB ____ °C

COOLER CUSTODY SEAL NOS: 03,04

REMARKS:
SHIPPED TO LAUCKS TESTING LAB

TETRA TECH NUS, INC.
661 Andersen Drive • Pittsburgh, PA 15220

0097

NSWC CRANE, INDIANA

CHAIN OF CUSTODY RECORD

PROJECT NO.: CTO 83
JOB # 0087

SAMPLERS (SIGNATURE): [signature] [signature]

DATE 1999	TIME	SAMPLE ID	NO. OF CONTAINERS	VOLATILES	DISSOLVED GASES	SULFIDE	TOX	SEMIVOLATILES	EXPLOSIVES	METALS TAL + TIN	CYANIDE	PESTICIDES/PCBS	HERBICIDES	DIOXINS/FURANS	TOC	SULFATE	AMMONIA	CHLORIDE	PHOSPHORUS	SOIL	AQ	TAG NO.	REMARKS
11/5	0847	BG1SBA0405	1							X										X		A0019	
	1505	BG1SBA0306	2							X										X		A0015	RUN ALSO MS/MSD
	0943	BG1SBP1004	1							X										X		RP049	
	1056	BG1SBP0701	1							X										X		RP032	
	1324	BG1SBP0601	1							X										X		RP027	
	1335	BG1SBP0603	1							X										X		RP028	
	1637	BG1SBP0505	1							X										X		RP025	
11/6	0807	BG1SBP0901	1							X										X		RP042	
	0905	BG1SBP0801	1							X										X		RP037	
	0916	BG1SBP0804	1							X										X		RP039	
	0930	BG1SBP0806	1							X										X		RP041	
	1012	BG1SBP0103	1							X										X		RP002	
	1112	BG1SBP0204	1							X										X		RP008	
	1125	BG1SBP0206	1							X										X		RP010	
	1315	BG1SBP0401	1							X										X		RP016	
	1340	BG1SBP0406	1							X										X		RP020	
	1453	BG1SBP0305	1							X										X		RP014	
11/7	1550	BGRB11079901	1							X											X	QC015	AUGER BUCKET

RELINQUISHED BY (SIGNATURE):	DATE/TIME		RECEIVED BY (SIGNATURE):	RELINQUISHED BY (SIGNATURE):	DATE/TIME	
[signature]	11-8-99	1840	FEDEX			

RECEIVED BY (SIGNATURE):	RELINQUISHED BY (SIGNATURE):	DATE/TIME		RECEIVED FOR LAB BY (SIGNATURE):	DATE/TIME	

AIR BILL NO.: 8161 4958 9231

TEMP. BLANK: AT SHIPMENT 4 °C AT LAB ____ °C

COOLER CUSTODY SEAL NOS: 05, 06

REMARKS:

SHIPPED TO CHUCKS TESTING LAB

TETRA TECH NUS, INC.
661 Andersen Drive • Pittsburgh, PA 15220

NSWC CRANE, INDIANA

CHAIN OF CUSTODY RECORD

PROJECT NO.: CTO 83
JOB# 0087

SAMPLERS (SIGNATURE): K. S. Simpson

DATE	TIME	SAMPLE ID	NO. OF CONTAINERS	VOLATILES	DISSOLVED GASES	SULFIDE	TOX	SEMIVOLATILES	EXPLOSIVES	METALS TAL + TIN	CYANIDE	PESTICIDES/PCBS	HERBICIDES	DIOXINS/FURANS	TOC	SULFATE	AMMONIA	CHLORIDE	PHOSPHORUS	SOIL	AQ	TAG NO.	REMARKS
11/8	1545	BGRB11089901	1							X											X	QC019	S.S. BOWL
11/7	0000	BGFD11079901	1							X										X		QC013	DUP OF BG2SBG0303
11/7	0000	BGFD11079902	1							X										X		QC014	DUP OF BG2SBG0401
11/8	0000	BGFD11089901	1							X										X		QC018	DUP OF BG1SBL0504
11/7	0815	BG2SBG0303	1							X										X		L0037	
↓	0900	BG2SBG0101	1							X										X		L0026	
	0914	BG2SBG0104	1							X										X		L0028	
	0943	BG2SBG0201	1							X										X		L0031	
	0946	BG2SBG0203	1							X										X		L0032	
	1007	BG2SBG0206	1							X										X		L0035	
	1315	BG2SBG0503	1							X										X		L0047	
	1417	BG2SBG0401	1							X										X		L0041	
↓	1445	BG2SBG0404	1							X										X		L0043	
11/8	0800	BG1SBL0501	1							X										X		L0021	
↓	0818	BG1SBL0504	2							X										X		L0023	RUN ALSO MS/MSD
	0838	BG1SBL0506	1							X										X		L0025	
	0925	BG1SBL0305	1							X										X		L0014	
↓	1006	BG1SBL0403	1							X										X		L0017	

RELINQUISHED BY (SIGNATURE):	DATE/TIME		RECEIVED BY (SIGNATURE):	RELINQUISHED BY (SIGNATURE):	DATE/TIME
K. S. Simpson	11-8-99	1840	FEDEX		

RECEIVED BY (SIGNATURE):	RELINQUISHED BY (SIGNATURE):	DATE/TIME	RECEIVED FOR LAB BY (SIGNATURE):	DATE/TIME

AIR BILL NO.: 8161 4958 9231
TEMP. BLANK: AT SHIPMENT 4 °C AT LAB ____ °C
COOLER CUSTODY SEAL NOS: 03, 04
REMARKS: SHIPPED TO LAUCKS TESTING LAB

TETRA TECH NUS, INC.
661 Andersen Drive • Pittsburgh, PA 15220

CHAIN OF CUSTODY RECORD

NSWC CRANE, INDIANA

PROJECT NO.: CTO 83
JOB # 0087

SAMPLERS (SIGNATURE): [signatures]

DATE	TIME	SAMPLE ID	NO. OF CONTAINERS	VOLATILES	DISSOLVED GASES	SULFIDE	TOX	SEMIVOLATILES	EXPLOSIVES	METALS TAL + TIN	CYANIDE	PESTICIDES/PCBS	HERBICIDES	DIOXINS/FURANS	TOC	SULFATE	AMMONIA	CHLORIDE	PHOSPHORUS	SOIL	AQ	TAG NO.	REMARKS
11/8	1018	BGISBL0405	1							X										X		L0019	
↓	1305	BGISBL0101	1							X										X		L0001	
↓	1314	BGISBL0103	1							X										X		L0002	
↓	1327	BGISBL0105	1							X										X		L0004	

RELINQUISHED BY (SIGNATURE):	DATE/TIME		RECEIVED BY (SIGNATURE):	RELINQUISHED BY (SIGNATURE):	DATE/TIME	
[signature]	11-8-99	1840	FEDEX			

RECEIVED BY (SIGNATURE):	RELINQUISHED BY (SIGNATURE):	DATE/TIME		RECEIVED FOR LAB BY (SIGNATURE):	DATE/TIME	

AIR BILL NO.: 8161 4958 9231

TEMP. BLANK: AT SHIPMENT 4 °C AT LAB ____ °C

COOLER CUSTODY SEAL NOS: 05, 06

REMARKS:

SHIPPED TO LAUCKS TESTING LAB

SUPPLEMENTAL FIELD EVENT

TETRA TECH NUS, INC.
661 Andersen Drive • Pittsburgh, PA 15220

NSWC CRANE, INDIANA

CHAIN OF COSTODY RECORD

[illegible] NO.: CT093 JOB# 0087

SAMPLERS (SIGNATURE): [signature]

DATE	TIME	SAMPLE ID	NO. OF CONTAINERS	VOLATILES	DISSOLVED GASES	SULFIDE	TOX	SEMIVOLATILES	EXPLOSIVES	TAL METALS + Li, STRON, THORI, TIN	CYANIDE	PESTICIDES/PCBS	HERBICIDES	DIOXINS/FURANS	TOC	SULFATE	AMMONIA	CHLORIDE	PHOSPHORUS			TAG NO.	REMARKS
10-6-00	1745	BG-RB10060001	1							1												QC 100	RINSATE BLANK AUGER
10-6-00	1635	BG1SBA280304	1							1												A101	
10-7-00	0000	BGFD10070001	1							1												QC 102	BG1SBA250203
10-7-00	0815	BG1SBA250203	2							2												A100, A102	RUN ALSO MS/MSD
10-7-00	1610	BGRB10070001	1							1												QC 101	RINSATE BLANK AUGER

RELINQUISHED BY (SIGNATURE): [signature] DATE/TIME: 10-9-00 0900

RECEIVED BY (SIGNATURE): FED EX

RELINQUISHED BY (SIGNATURE):

DATE/TIME:

RECEIVED BY (SIGNATURE):

RELINQUISHED BY (SIGNATURE):

DATE/TIME:

RECEIVED FOR LAB BY (SIGNATURE):

DATE/TIME:

AIR BILL NO.: 8216 5043 7455

TEMP. BLANK: AT SHIPMENT NA °C AT LAB NA °C

COOLER CUSTODY SEAL NOS: A100

REMARKS:

A-3 FIELD LOG BOOK

FIRST FIELD EVENT

TITLE NSWC CRANE **PROJECT NO.** 0087

BOOK 2446

MONDAY 11·1·99

Work continued from Page WEATHER: CRANE, OVERCAST 70°F

KEITH HENN, SCOTT NEIL & KEITH SIMPSON FROM PGH TO CRANE

1350 ARRIVE @ BLD 3260 CHECK-IN WITH TOM BRENT, TO BLD 41 & PICKED UP SUPPLIES THAT WERE FEDEX IN TO TRAILER PREP FOR FIELD WORK.

TO AB6 & WELL WES3 C2686 TO CHECK GPS AT A KNOWN POINT (SURVEYED IN)

NEED CONUS.LAS FILE WILL CHECK @ TRAILER & GPS MANUEL

UNABLE TO PREFORM GEODETIC TRANS-FORMATIONS - CHECK ZONE SETTINGS

RETURN TO TRAILER, LOAD SUV FOR TUE. SAMPLING.

1740 DEPART BASE FOR WAL-MART & HOTEL

SCIENTIFIC BINDERY PRODUCTIONS CHICAGO 60605

Work continued to Page

SIGNATURE [signature] DATE 11·1·99

WITNESS DATE

TITLE NSWC CRANE **PROJECT** NO. 0087

BOOK 2446

TUES 11·2·99

Work continued from Page WEATHER: OVERCAST BREEZY 50-26°F

0620 KS, SN & KH DEPART HOLIDAY INN TO SITE START SAMPLING @ BG-3, BACKGROUND SITE 3, COMPLETE 4 LOCATIONS SBM 01, 02, 03 & 06

GPS UNIT IS NOT BEING USED AT THIS TIME KH IS WORKING WITH TDS.

1100 RETURN TO TRAILER, SAMPLES TO FRIDGE DECON HAND AUGER & BOWLS

1135 TO LUNCH, RETURN TO TRAILER KH & SN WORKING ON GPS, KS PAPER WORK AND LOAD SUV FOR SAMPLING

1300 TO BLD 3260 PICK-UP SAMPLE BOTTLES

1330 RETURN TO BG-3 COMPLETED SBA01 & SBA02

1645 KH TO TRAILER WORKING ON GPS KS & SN BG3SBA3 COULD NOT FIND

1725 LOCATION RETURNED TO TRAILER CHARGE PID SAMPLES TO FRIDGE DECON & RB COLLECTED. ALSO COLLECTED A SOURCE WATER BLANK.

BG-RB-110299-01 @ 1740

BG-SW-110299-01 @ 1745

USED RICCA CHEM. CO. DI, 5 GAL CUBE, LOT # 1907078 EXP JUN 00

SCIENTIFIC BINDERY PRODUCTIONS CHICAGO 60605

Work continued to Page

SIGNATURE [signature] DATE 11·2·99

WITNESS DATE

TITLE NSWC CRANE **PROJECT NO.** 0087

11.2.99 **BOOK** 2446

Work continued from Page

1820 DEPART SITE FOR HOTEL

— DAILY SUMMARY —

ON SITE: TtNUS, K. SIMPSON, KEITH HENN & SCOTT NEIL

6 LOCATIONS SAMPLED
1 RINSATE TAKEN
1 SOURCE BLANK TAKEN
COLLECTED 1 DUP

SEE ALSO BORING LOGS, SAMPLE SHEETS & COC

Work continued to Page

SIGNATURE [signature] DATE 11.2.99

WITNESS DATE

TITLE NSWC CRANE **PROJECT NO.** 0001

WED 11.3.99 **BOOK** 2446

Work continued from Page WEATHER: 28 – 47°F SUNNY

0620 KS, KH & SN DEPART HOTEL KH TO SITE & GPS IN POINTS KS, SN TO TRAILER PICK-UP EQUIPMENT TO

0735 SITE START SAMPLING
SAMPLED 3 BG LOCATIONS
BG3SBA03, M08 & M04
BG3SBA0303 DUP + MS/MSD TAKEN

1130 RETURN TO TRAILER STORE SAMPLES IN FRIDGE DECON GO-OVER SOP 2 SAMPLE SELECTION WITH KH BEFORE HE DEPARTS SITE FOR INDA.

1225 TO LUNCH, TO BLD 3260 MET BILL GATES & TOM BRENT ALSO CHRIS F. & JAMES MAY.
DISSCUSSED SOIL SAMPLING BRIEFLY TOM MAY COME OUT TO SAMPLE POINTS THUR OR FRIDAY

1320 KS & SN TO BG3 KH DEPARTS SITE FOR ~~INDA~~ INDIANAPOLIS
KS & SN SAMPLE 3 LOCATIONS
BG3SBM05, M09 & M07

1715 RETURN TO TRAILER CHARGE EQUIPMENT, DECON, SAMPLES TO FRIDGE, CLEAN SUV & COLLECT RB.
BGRB 110301

Work continued to Page

SIGNATURE [signature] DATE 11.3.99

WITNESS DATE

TITLE NSWC CRANE PROJECT NO. 0087
11·3·99 BOOK 2446

Work continued from Page

COMPLETE PAPER WORK
1812 DEPART SITE TO HOTEL

— DAILY SUMMARY —
ON SITE: TTNUS: K. SIMPSON, S. NEIL & K. HENN
K.H. DEPARTS @ 1330
SAMPLED 6 BG-3 LOCATIONS
COLLECTED 1 DUP & 1 MS/MSD
@ BG3SBM0803
1 RINSATE TAKEN

SEE ALSO: SB LOGS, SAMPLE SHEETS & COC

SCIENTIFIC BINDERY PRODUCTIONS CHICAGO 60605

Work continued to Page

SIGNATURE [signature] DATE 11·3·99
WITNESS DATE

TITLE NSWC CRANE PROJECT NO. 0087
THUR. 11·4·99 BOOK 2446

Work continued from Page WEATHER: SUNNY 38-65°F

0620 KS & SN DEPART HOTEL TO BLD 3260
MAKE A FEW MORE COPIES OF FIELD
0710 FORMS, TO TRAILER CAL. PID LOAD
0730 SUV TO BG3 COLLECTED 3
LOCATIONS BG3SBA04, A05 & M10
1120 RETURN TO TRAILER TO SORT/PACK
SAMPLES. TOOK RINSATE BLANK
BGRB110499·01 FROM PLASTIC
DISPOSABLE TROWEL (BATCH).
1200 LUNCH, RETURN TO TRAILER SELECT
SAMPLES FOR SHIPPMENT TO LAB,
BOX REMAINING AND STORE IN
TRAILER.
1315 TO BG1 SAMPLED 3 LOCATIONS
BG1SBA01, 02 & 05
1720 RETURN TO TRAILER CHARGE EQ,
DECON, PACK SAMPLES FOR FEDEX
SHIPPED 1 COOLER ~~to~~ FEDEX TO
LAUCKS TESTING LAB.
1820 DEPART BASE FOR FEDEX / HOTEL

SCIENTIFIC BINDERY PRODUCTIONS CHICAGO 60605

Work continued to Page

SIGNATURE [signature] DATE 11·4·99
WITNESS DATE

TITLE NSWC CRANE **PROJECT NO.** 0087
FRIDAY 11·5·99 **BOOK** 2446

Work continued from Page — WEATHER: WARM 52-68°F SUNNY

0620 KS & SN CHECK OUT OF HOLIDAY INN TO BASE CAL. PID LOAD EQ. INTO SUV DEPART TRAILER FOR BG-1
KS & SN SAMPLED 3 BG1 LOCATIONS BG1SBA04, P07 & P10

1130 RETURN TO TRAILER SAMPLES TO FRIDGE, RESTOCK SUV

1150 TO LUNCH, GAS, ICE & BATTERIES CHECK INTO THE BCQ

1245 RETURN TO TRAILER, LOAD SUV

1255 RETURN TO BG1 FOR SAMPLING SAMPLED 3 LOCATIONS, BG1SBA03, P05 & P06

1700 RETURN TO TRAILER, SAMPLES TO FRIDGE CHARGE EQUIPMENT, PAPER WORK.
RINSATE BLANK - BGRB 11059901 OF AUGER BUCKET

1810 DEPART TRAILER FOR WAL-MART & SUPPLIES FOR JOB.

SCIENTIFIC BINDERY PRODUCTIONS CHICAGO 60605

Work continued to Page

SIGNATURE [signature] DATE 11·5·99
WITNESS DATE

TITLE NSWC CRANE **PROJECT NO.** 0087
SAT. 11·6·99 **BOOK** 2446

Work continued from Page — WEATHER: SUNNY 55-68°F

0650 SN & KS @ TRAILER CAL PID LOAD EQUIPMENT.

0715 TO BG-1, SAMPLED 4 LOCATIONS BG1SBP01, 02, 08 & 09

1140 RETURNED TO TRAILER RECAL PID, SAMPLES TO FRIDGE & RESTOCK SUV

1245 RETURN TO BG-1 COMPLETE 2 BORINGS BG1SBP03 & 04 THIS COMPLETES PENNSYLVANIAN SOILS.

1520 RETURN TO TRAILER, UNLOAD SUV DECON, BGRB110699-01 ON STAINLESS STEEL BOWL. SORT SAMPLES FOR SHIPMENT ALLUVIUM & PENNSYLVANIAN (A's & P's) STORE LAB SAMPLES IN FRIDGE OTHER ARE STORED IN BOX @ THE TRAILER.

1835 DEPART TRAILER TO BCQ

SCIENTIFIC BINDERY PRODUCTIONS CHICAGO 60605

Work continued to Page

SIGNATURE [signature] DATE 11·6·99
WITNESS DATE

TITLE NSWC CRANE — PROJECT NO. 0081
SUNDAY 11·7·99 — BOOK 2446

Work continued from Page WEATHER: SUNNY 50-68°F

0650 KS & SN @ TRAILER CAL. PID RESTOCK SUV (BOTTLES/AUGERS/BOWL ETC.)
0720 DEPART FOR BG2, COMPLETE 3 SB'S
1035 RETURN TO TRAILER
BG2SBG01, 02 & 03 COMPLETE
SAMPLES TO FRIDGE, PAPER WORK, RESTOCK TRUCK, LUNCH
1215 RETURN TO BG2 COMPLETE 2 SB'S: BG2SBG04 & 05
1505 RETURN TO TRAILER UNLOAD SUV DECON, RINSATE BLANK, STORE SAMPLES IN FRIDGE
1615 CLEANED TRAILER
1720 DEPART FOR BQ

SCIENTIFIC BINDERY PRODUCTIONS CHICAGO 60605

Work continued to Page

SIGNATURE [signature] — DATE 11·7·99
WITNESS — DATE

TITLE NSWC CRANE — PROJECT NO. 0081
MONDAY 11·8·99 — BOOK 2446

Work continued from Page WEATHER: SUNNY 55-70°F

0650 SN TO BLD 3260 TO COPY FIELD FORMS KS @ TRAILER CAL. EQUIPMENT
0705 SN @ TRAILER, LOAD SUV FOR SAMPLING. CALLED USAIR MOVED FLT. TO TUE (11·9·99) 1346
0725 TO BG1 FOR SB/SAMPLING
SAMPLED 3 SB LOCATIONS BG1SBL03, 04 & 05, RETURN TO
1045 TRAILER SAMPLES TO FRIDGE PAPER WORK RESTOCK SUV
1145 TO LUNCH
1205 TO BG1 FOR SAMPLING
COMPLETED SAMPLING BG1SBL01 & 02
ALL SB 40 COMPLETE
1515 RETURN TO TRAILER SORT & PACK SAMPLES FOR FEDEX
SHIPPED 2 COOLERS TO LUCKS LABS
DECON, BGRB11089901 S.S. BOWL COLLECTED. ALL SAMPLES NOT SHIPPED TO THE LAB ARE STORED IN THE TRAILER 8 BOXES + 2 BOTTLES (NOT ALL BOXES ARE FULL)
CLEAN LOAD COOLER + 9 ~~ANT~~ LBS
EMPTY COOLERS RETURNED TO LUCKS

SCIENTIFIC BINDERY PRODUCTIONS CHICAGO 60605

Work continued to Page

SIGNATURE [signature] — DATE 11·8·99
WITNESS — DATE

TITLE NSWC CRANE **PROJECT NO.** 0087

MONDAY 11-8-99 **BOOK** 2446

Work continued from Page

~~NSWC CRANE~~ KS

9 COOLERS WERE SENT FED EX SUPER SAVER ON A SEPERATE AIRBILL

1710 DUMP ALL DECON WATER INTO MANHOLE 327 AS PER FSP.

CLEAN TRAILER DEPART FOR

1750 FED EX & WAL-MART

SCIENTIFIC BINDERY PRODUCTIONS CHICAGO 60605

Work continued to Page

SIGNATURE [signature] DATE 11-8-99

WITNESS DATE

TITLE NSWC CRANE **PROJECT NO.** 0087

TUESDAY 11-9-99 **BOOK** 2446

Work continued from Page WEATHER: WARM 60-78°F SUNNY

0650 KS & SN CHECK OUT OF BCQ TO TRAILER. PACKING RENTED EQUIPMENT FOR RETURN. UPDATE/PROOF FIELD NOTES

0800 KS CALLED BASE WATER & SEWAGE TREATMENT PLANT @ 812 854 1239 & TALKED WITH _ _ _ BRADFIELD, HE CONFIRMED THAT OUR TRAILER IS HOOKED-UP TO THE BASE SEWAGE SYSTEM (NOT A SEPTIC SYSTEM) AND WE CAN DUMP WE CAN DUMP PURGE/DECON WATER THAT IS APPROVED FOR THE BASE WWTP DOWN THE DRAIN AT THE TRAILER AND THERE IS NO NEED TO HAUL THE WATER TO MANHOLE 327.

COMPLETE PACKING, CLEAN & INVENTORY TRAILER.

1100 DEPART BASE FOR AIRPORT/HOME

END OF SHIFT

SCIENTIFIC BINDERY PRODUCTIONS CHICAGO 60605

Work continued to Page

SIGNATURE [signature] DATE 11-9-99

WITNESS DATE

SUPPLEMENTAL FIELD EVENT

TITLE NS C CRANE PROJECT NO. 0087

MONDAY 10.2.00 BOOK 2446

Work continued from Page

1930 KEITH SIMPSON, PGH OFFICE &
KEVIN MARGETTS MEET @ PGH
AIRPORT.
TO CRANE CHECK-IN TO BCQ
1400 TO BLD 3245 CHECK WITH
TOM BRENT THEN STARTED
TO UNPACK EQ. & CAL./LEARN
TO USE TRIMBLE GPS UNIT.
TRIMBLE MODEL TSC1
SN 0220167399 - RENTED
FROM US ENVIRONMENTAL
NO LUCK WITH GPS UNIT
CAN NOT SET UNIT UP. WILL
TRY TUES AM.
PREP. AUGERS, BOTTLES TO
1700 BCQ

Work continued to Page

SIGNATURE [signature] DATE 10.2.00

WITNESS DATE

TITLE NSWC CRANE PROJECT NO. 0087

TUES 10.3.00 BOOK 2446

Work continued from Page WEATHER: SUNNY 55-70° NICE

0655 KS & KM TO BLD 3245
KS WORK ON GPS UNIT SET-UP
KEVIN TO BD. 45 & CHECK ON
DI BEING SHIPPED IN, NOT IN YET
0800 KEVIN TO WAL-MART FOR
SUPPLIES FOR FIELD OFFICE.
1150 LUNCH
LOAD SUV FOR SAMPLING
1250 TO 1ST SB NO LUCK WITH
THE TRIMBLE GPS UNIT
IT IS WORKING BUT THE LEAF
COVER THIS TIME OF YEAR KNOCKS
THE SATELLITE NUMBERS TO 3 OR
4 AND WE CAN NOT NAVIGATE
WITH THAT FEW SATELLITES
CLEANED WORK ROOM IN
BLD 3245
1800 TO BOQ

Work continued to Page

SIGNATURE [signature] DATE 10.3.00

WITNESS DATE

TITLE NSWC CRANE PROJECT NO. 0087

WED 10.4.00 BOOK 2446

Work continued from Page WEATHER: 62-70°F RAIN @ 1730

0655 KS & KM @ BLD 3245 CLEANING EQ. & WORK SPACE.
DISCUSSED JOB PROGRESS WITH KEITH HENN. WAITING ON TDS GPS UNIT (FEDEX) AT THAT POINT WE WILL TRY BOTH UNITS AND SEE IF WE CAN NAVIGATE IN THE WOODS, WITH THE LEAF COVER. THE TRIMBLE WILL NOT NAVIGATE IN THE WOOD ON 3 TO 4 SATTLITES ARE ON LINE. MADE SOME CHANGES TO THE GPS SET-UP AND GOT IT WORKING.

COMPLETE 5 BORINGS:

PS1 BG1SBP39
↓ 42
45
BG3SBP01
↓ 09

1700 RETURN TO BUILDING 3245: DECON, CLEAN SUV OUT, PAPERWORK

1800 TO BCQ

Work continued to Page

SIGNATURE [signature] DATE 10.4.00

WITNESS DATE

TITLE NSWC CRANE PROJECT NO. 0087

10.4.00 BOOK 2446

Work continued from Page

— GPS UNIT —
TRIMBLE
SER.# 0220167399
TSCI DATA COLLECTOR
ASSET SURVEYOR
V 4.03
RENTED FROM US ENVIRONMENTAL

NORTHING / EASTING IN FEET
NAD 1927
IN. WEST

Work continued to Page

SIGNATURE [signature] DATE 10.4.00

WITNESS DATE

TITLE NSWC CRANE PROJECT NO. 0087

THUR 10.5.00 BOOK 2446

Work continued from Page WEATHER: RAIN ~~WENNITE~~ 58-68°F

0645 DEPART BOQ TO 1st BORING OF THE DAY BGISBP22
NEXT / BGISBP11
NEXT BGISBP43
1140 TO LUNCH
KEVIN IS NOT FEELING WELL
1230 I TOOK HIM TO THE BOQ
KS TO BLD 3245 PAPER WORK & DECON AUGERS
1400 KES TO BG3SBP08
RETURN TO BLD 3245 PAPER WORK AND CLEAN EQUIPMENT
1740 TO BOQ

RAIN ON/OFF ALL DAY

4 SBs COMPLETED TODAY

TOTAL 9 @ THIS POINT

SCIENTIFIC BINDERY PRODUCTIONS CHICAGO 60605

Work continued to Page

SIGNATURE [signature] DATE 10.5.00

WITNESS DATE

TITLE NSWC CRANE PROJECT .0087

FRI 10.6.00 BOOK 2446

Work continued from Page WEATHER:

0655 KS & KM @ BG1SBP44
COMPLETED BG1SBP16
" BG1SBP13
3 COMPLETE
TO BLD 3245 CHANGE BATTERIES DECON
1135 TO LUNCH
COMPLETE 3 BORINGS
BG1SBP37
↓ 40
50

THAT COMPLETES PSI BORINGS SETS (15) NO SAND WAS FOUND
START ON ABI BORING SETS
1530 TO SB BG1SBA28
1720 RETURN TO BLD 3245 DECON
RINSATE BLANK BGQC10060001
@ 1745
RESTOCK SUV
DEPART SITE

SCIENTIFIC BINDERY PRODUCTIONS CHICAGO 60605

Work continued to Page

SIGNATURE [signature] DATE 10-6-00

WITNESS DATE

TITLE NSWC CRANE
SAT 10.7.00

PROJECT NO. 0087
BOOK 2446

Work continued from Page

0645 KS & KM FROM BOQ TO BG1SBA25 & BG1SBA38
1050 RETURN TO BLD 3245 RESTOCK SUV PHONE CALLS
1230 TO BG1SBA29 & BG3SBA07

ALL SBs COMPLETE
1505 TO BLD 3245 CLEAN EQ. PACK EQ. FOR RENTAL. RETURN

TALKED WITH TOM JOHNSTON LAST WEEK AND HE SAID IT WAS OK TO SHIP BOTH AQ & SOIL SAMPLES FOR METAL ANALYSIS WITH NO ICE

COMPLETE DEMOB FOR CTO 83

1725 TO BOQ

END OF FIELD WORK FOR ADDENDUM WORK PLAN

SCIENTIFIC BINDERY PRODUCTIONS CHICAGO 60605

Work continued to Page

SIGNATURE [signature]
DATE 10.7.00
WITNESS
DATE

TITLE NSWC CRANE

PROJECT NO. 0087
BOOK 2446

Work continued from Page

BASEWIDE BACKGROUND SOIL INVESTIGATION SUMMARY

ALL SAMPLING WAS COMPLETED FOLLOWING THE ORIGINAL WORK PLAN (TtNUS FALL 1999) AND THE ADDENDUM WORK PLAN (TtNUS SEPT 2000)
BORING SETS WERE COMPLETED FOLLOWING THE ORDER LAYED-OUT ON TABLE 3-1. DRIVING AS-CLOSE-AS POSSIBLE TO EACH BORING LOCATION, THEN PROGRAMING THE COORDINATES (NORTHING/EASTING) FROM TABLE 3-4 INTO THE GPS UNIT. AND USING THE GPS NAVIGATION MODE THE BORING WAS LOCATED. ONCE AT THE LOCATION THE COORDINATES WERE LOGGED INTO THE GPS UNIT TO BE DOWN LOADED BACK IN THE OFFICE. EACH BORING WAS ADVANCED USING A HAND AUGER AND EACH 1 FOOT INTERVAL WAS LOGGED. SEE WP PG 3-2 FOR SAMPLING PROCEDURE.
A TOTAL OF 2 SOIL SAMPLES WERE SENT TO LAUCKS LAB FOR TAL METALS + LI., STRON., THORI, TIN

SCIENTIFIC BINDERY PRODUCTIONS CHICAGO 60605

Work continued to Page

SIGNATURE [signature]
DATE 10.9.00
WITNESS
DATE

TITLE ?WC CRANE
PROJECT NO. 0087
BOOK 2446

Work continued from Page

BG1 SB A28 0304
BG1 SB A25 0203
@ A25 ADDITIONAL VOC WAS SENT TO THE LAB FOR MS/MSD & A BLIND DUP - BGFD 10070001

ALSO SEE: COC, SAMPLE BORING LOGS, MULTI-SAMPLE LOG SHEETS & GPS INFORMATION

SCIENTIFIC BINDERY PRODUCTIONS CHICAGO 60605

Work continued to Page

SIGNATURE [signature]
DATE 10·9·00
WITNESS
DATE

TITLE
PROJECT NO.
BOOK

Work continued from Page

SCIENTIFIC BINDERY PRODUCTIONS CHICAGO 60605

Work continued to Page

SIGNATURE
DATE
WITNESS
DATE

A-4 EQUIPMENT CALIBRATION LOG

FIRST FIELD EVENT

EQUIPMENT CALIBRATION LOG

INSTRUMENT NAME/MODEL : PID PHOTOVAC 2020

PROJECT NAME : NSWC Crane

SERIAL NUMBER: EDFR 204

PROJECT NUMBER : '0087 CTO 083

MANUFACTURER : PHOTOVAC

CALIBRATIO DATE	INITIAL SETTINGS	STANDARDS USED	PROCEDURE	ADJUSTMENTS MADE	FINAL SETTINGS	SIGNATURE	COMMENTS
11-1-99	100.0	100 PPM	PER MANUF.	NONE	100.00	KSP	ISOBUTYLENE
11-2-99	100.0	100 PPM	"	"	100.00	KSP	"
11-3-99	100.0	100 PPm	"	"	100.00	SWN	"
11-4-99	100.0	100 PPm	"	"	100.00	SWN	"
11-5-99	100.0	100 PPm	"	"	100.00	KES	"
11-6-99	100.0	100 PPm	"	"	100.00	KES	"
11-7-99	100.0	100 PPM	"	"	100.00	KSP	"
11-8-99	100.0	100 PPm	"	"	100.00	KES	"

Instrument Rented From: TETRA TECH NUS PGH WAREHOUSE

SUPPLEMENTAL FIELD EVENT

EQUIPMENT CALIBRATION LOG

INSTRUMENT NAME/MODEL : PE Photo VAC

PROJECT NAME : NSWC Crane

SERIAL NUMBER: Model 2020/Serial # ED FK2e4

PROJECT NUMBER : CTO 83

MANUFACTURER : Photo VAC

CALIBRATION DATE	INITIAL SETTINGS	STANDARDS USED	PROCEDURE	ADJUSTMENTS MADE	FINAL SETTINGS	SIGNATURE	COMMENTS
100300	0.0 ppm	100 ppm Isob	Auto cal	None	100 ppm	[illegible]	
100400	0.0 ppm	" "	Span	Auto	100 ppm	[illegible]	
10.5.00	"	"	"	"	"	[illegible]	
10600							CAN'T CAL. NOT WORKING CORRECTLY

Instrument Rented From: PGH WAREHOUSE

A-5 SURVEY RESULTS

SURVEY RESULTS
BASEWIDE BACKGROUND SOIL INVESTIGATION
NAVAL SURFACE WARFARE CENTER
CRANE, INDIANA

Solo by Tripod Data Systems Inc. GPS Unit
Projection: NGS NADCON
State Plane 1983
NAD 1983, Indiana West
Coord: Northing-Easting Distance: US ft

PointName	Y (ft)	X (ft)	comments
First Field Event			
BG1SBA01	1287335.4	3014555.6	
BG1SBA02	465186	565000	location surveyed but not recorded; used proposed location coordinates
BG1SBA03	1285966.3	3008797.0	
BG1SBA04	1279529.6	3011059.8	
BG1SBA05	1280380.0	3017126.2	
BG1SBL01	1295708.5	3005152.0	
BG1SBL02	1293567.1	3008860.7	
BG1SBL03	1292151.8	3009217.3	
BG1SBL04	1292663.9	3009918.7	
BG1SBL05	1291968.5	3010551.4	
BG1SBP01	1293733.2	3007343.9	
BG1SBP02	1295043.1	3015036.9	
BG1SBP03	1295470.7	3016826.3	
BG1SBP04	1291088.1	3013929.7	
BG1SBP05	1288690.0	3012771.0	
BG1SBP06	1286744.8	3009026.7	
BG1SBP07	1285279.8	3015648.4	
BG1SBP08	1283603.1	3012911.9	
BG1SBP09	1277832.2	3008489.5	
BG1SBP10	1278598.8	3010679.0	
BG2SBG01	1325916.3	3006459.1	
BG2SBG02	1326107.4	3006323.8	
BG2SBG03	1326146.2	3006909.7	
BG2SBG04	1327870.1	3007892.1	
BG2SBG05	1327872.5	3008310.4	
BG3SBA01	1328625.3	3052197.6	
BG3SBA02	1327825.2	3052412.7	
BG3SBA03	1331268.6	3057444.7	
BG3SBA04	1325609.6	3065509.5	
BG3SBA05	1325272.9	3065983.8	
BG3SBM01	1331186.9	3049702.0	
BG3SBM02	1331014.3	3051614.5	
BG3SBM03	1328036.6	3053012.8	
BG3SBM04	1331401.4	3061647.1	
BG3SBM05	1329977.3	3063178.8	
BG3SBM06	1328659.0	3054131.2	
BG3SBM07	1328931.9	3064650.4	
BG3SBM08	1331152.2	3058873.9	
BG3SBM09	1328802.2	3062840.4	
BG3SBM10	1325781.3	3066076.7	

Trimble Model TSC1
State Plane 1983
NAD 1983, Indiana West
Coord: Northing-Easting Distance: US ft

PointName	Y (ft)	X (ft)	comments
Supplemental Field Event			
BG1SBA25	455908.9	556534.1	
BG1SBA28	456398.5	565075.8	
BG1SBA29	465981.8	564055.0	
BG1SBA38	464336.0	566086.2	
BG1SBP11	472252.7	559492.5	
BG1SBP13	472648.5	564180.0	
BG1SBP16	467836.0	564044.6	
BG1SBP22	459648.5	553888.3	
BG1SBP37	464013.1	559419.6	
BG1SBP39	468263.1	557950.8	
BG1SBP40	470106.8	556211.2	
BG1SBP42	472950.6	560502.9	
BG1SBP43	469606.8	561138.3	
BG1SBP44	470544.3	562544.6	
BG1SBP45	469096.4	562461.2	
BG1SBP50	473929.8	560482.1	

BG3SBA07	507275.9	599846.2	
BG3SBP01	510719.7	609427.4	
BG3SBP08	508563.4	600346.2	
BG3SBP09	509807.2	599314.9	

Notes:
GPS - Global Positioning System

APPENDIX B

BORING LOGS

FIRST FIELD EVENT

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NSWC Crane
PROJECT NUMBER: 0087 CTO 083
DRILLING COMPANY: not applicable
DRILLING METHOD: hand auger
BORING NUMBER: BG1SBL01
DATE: 11/8/99
GEOLOGIST: S. NEIL
DRILLER: K. SIMPSON / S. NEIL

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	Soil Density/ Consistency or Rock Hardness	Color	Material Classification	USCS*	Remarks	PID/FID Reading (ppm) Sample	Sampler BZ	Borehole**	Driller BZ
	0				LOOSE	BR	SILT SOME CLAY	ML	MOIST; ROOTS				
S-1	1				↓	↓	↓	↓	↓ ↓	0	0	0	0
	2				↓	LT BR	↓	↓	DRY				
S-3	3				STIFF	↓ [illegible]	BR CLAY SOME SILT OR MOT TR VF GR SAND	CL	DENSE	0	0	0	0
S-4	4				MED DENSE	GRAY	SILT W/SOME BR CLAY OR MOT TR VF GR SAND	ML		0	0	0	0
S-5	5				↓	LT BR/GRAY	↓	↓	↓ ↓	0	0	0	0
							TD = 5 FT. REFUSAL						

* When rock coring, enter rock brokeness.

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

Remarks: S-1 = BG1SBL0101; S-3 = BG1SBL0103; S-4 = BG1SBL0104; S-5 = BG1SBL0104.

Drilling Area Background (ppm): 0.0

Converted to Well: Yes ____ No ✓ Well I.D. #: ____

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NSWC Crane
BORING NUMBER: BGISBL02
PROJECT NUMBER: 0087 CTO 083
DATE: 11/8/99
DRILLING COMPANY: not applicable
GEOLOGIST: S. NEIL
DRILLING METHOD: hand auger
DRILLER: K. SIMPSON / S. NEIL

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	U S C S *	Remarks	PID/FID Reading (ppm): Sample	Sampler BZ	Borehole**	Driller BZ**
	0				LOOSE	Br	SILT TR CLAY TR VFGR SAND	ML	MOIST; ROOTS				
S-1	1				LOOSE	↓	↓	↓	↓ ↓	0	0	1.6	0
	2				MED DENSE		Clayey SILT TR VFGR SAND	↓	↓ DENSE				
S-3	3				STIFF	↓	BL CLAY SOME SILT TR OR/GRAY MOT ↓	CL	DRY	0	0	0	0
S-4	4				↓	LT Br	↓ ↓	↓		0	0	0	0
S-5	5				STIFF		SILT SOME BL CLAY SOME FGR SAND	ML		0	0	0	0
S-6	6				↓	↓	↓	↓	↓ ↓	0	0	0	0
							TD=6FT.						

* 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): 0.0

Remarks: S-1 = BGISBL0201; S-3 = BGISBL0203; S-4 = BGISBL0204; S-5 = BGISBL0205; S-6 = BGISBL0206

Converted to Well: Yes ______ No ✓ Well I.D. #: ______

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NSWC Crane
BORING NUMBER: BGISBL03
PROJECT NUMBER: 0087 CTO 083
DATE: 11/8/99
DRILLING COMPANY: not applicable
GEOLOGIST: S. NEIL
DRILLING METHOD: hand auger
DRILLER: K. SIMPSON / S. NEIL

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	Soil Density/ Consistency or Rock Hardness	Color	Material Classification	USCS*	Remarks	PID/FID Reading (ppm) Sample	Sampler BZ	Borehole**	Driller BZ**
	0				LOOSE	Br	SILT TR CLAY	ML	MOIST; ROOT MAT.				
S-1	1				↓	↓	↓	↓	↓	119	0	286	0
	2				↓	LT Br	↓	↓	DRY				
S-3	3				MED STIFF	Br/br	SILTY CLAY TR FGR SAND OR MOTTLE	CL	MOIST MED	551	0	480	0
S-4	4				↓	Br/Or	SILTY BL CLAY TR FGR SA	CL	↓	220	0	314	0
S-5	5				↓	↓	↓	↓	↓	133	0	112	0
S-6	6			6	STIFF	OR	BL CLAY OR MOTTLE TR ROCK FRAGS SOME SILT	↓	MOIST/DRY FE NODS DENSE	10	0	86	0
							TD = 6FT						

* When rock coring, enter rock brokeness.

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

Remarks: S-1 = BGISBL0301; S-3 = BGISBL0303; S-4 = BGISBL0304; S-5 = BGISBL0305; S-6 = BGISBL0306.

Drilling Area Background (ppm): 0.0

Converted to Well: Yes ____ No ✓ Well I.D. #: ____

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NSWC Crane
BORING NUMBER: BG1SBL04
PROJECT NUMBER: 0087 CTO 083
DATE: 11/8/99
DRILLING COMPANY: not applicable
GEOLOGIST: S. NEIL
DRILLING METHOD: hand auger
DRILLER: K. SIMPSON / S. NEIL

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	Soil Density/ Consistency or Rock Hardness	Color	Material Classification	USCS *	Remarks	PID/FID Reading (ppm) Sample	Sampler BZ	Borehole**	Driller BZ**
	0				LOOSE	Br	SILT TR CLAY	ML	MOIST; ROOTS				
S-1	1				↓	↓	↓	↓	↓	19	0	108	0
	2				MED STIFF	GRAY Br	SILTY BL CLAY TR FGR SAND	CL	MED				
S-3	3				↓	↓	↓ OR MOT	↓		211	0	108	0
S-4	4				↓	↓	↓	↓		55	0	80	0
S-5	5				MED DENSE	Br	CLAYEY SILT	ML		30	0	100	0
S-6	6				STIFF	↓	BL CLAY SOME SILT	CL		11	0	24	0
						SN	~~BL CLAY SOME SILT~~		↓				
							TD = 6 FT.						

* When rock coring, enter rock brokeness.

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

Remarks: S-1 = BG1SBL0401; S-3 = BG1SBL0403; S-4 = BG1SBL0404; S-5 = BG1SBL0405; S-6 = BG1SBL0406.

Drilling Area Background (ppm): 0.0

Converted to Well: Yes ______ No ✓ Well I.D. #: ______

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NSWC Crane
PROJECT NUMBER: 0087 CTO 083
DRILLING COMPANY: not applicable
DRILLING METHOD: hand auger

BORING NUMBER: BGISBL05
DATE: 11/8/99
GEOLOGIST: S. NEIL
DRILLER: K. SIMPSON / S. NEIL

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	U S C S *	Remarks	PID/FID Reading (ppm): Sample	Sampler BZ	Borehole**	Driller BZ**
	0				LOOSE	Br	SILT TR CLAY	ML	MOIST. ROOT MAT.				
S-1	1				↓	LT Br	↓	↓	↓ ↓	10	0	7	0
	2				↓	LT Br	↓	↓	↓ ↓				
S-3	3				MED DENSE	Br/Or	SILTY CLAY TR VFGR SAND	ML	DRY VERY DENSE	23	0	29	0
S-4	4				↓	↓	Clayey silt ↓	ML	↓ ↓	54	0	42	0
S-5	5				↓	↓	↓ ↓	↓	↓ ↓	88	0	110	0
S-6	6				STIFF	↓	BL CLAY Or MOT. SOME SILT ↓	CL	↓ ↓	147	0	139	0
							TD = 6FT.						

* When rock coring, enter rock brokeness.

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

Remarks: S-1 = BGISBL0501; S-3 = BGISBL0503; S-4 = BGISBL0504; S-5 = BGISBL0505; S-6 = BGISBL0506.

Drilling Area Background (ppm): 0.0

Converted to Well: Yes ____ No ✓ Well I.D. #: ____

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME:	NSWC Crane	BORING NUMBER:	BG1SBA01
PROJECT NUMBER:	0087 CTO 083	DATE:	11/4/99
DRILLING COMPANY:	not applicable	GEOLOGIST:	S. NEIL
DRILLING METHOD:	hand auger	DRILLER:	K. SIMPSON / S. NEIL

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	U S C S *	Remarks	PID/FID Reading (ppm): Sample	Sampler BZ	Borehole**	Driller BZ**
	0				LOOSE	Br	SILT TR VF GR SAND	ML	DRY ROOTS.				
S-1	1				↓	↓	↓	↓	↓	0	0	0	0
	2				LOOSE		GRAVEL / ROCK FRAGS SILT SOME CLAY TR F GR SAND						
S-3	3				↓		↓		REFUSAL – OFFSET	0	0	0	0
S-4	3.5/4				↓	↓	↓	↓	SAMPLE TAKEN @ 3RD BORING	0	0	0	0

TD = 3.5 FT. MOVED OFF OF ORIGINAL BORING TWICE. THIRD BORING WENT TO 3.5 FT BEFORE REFUSAL. 3-4 FT. SAMPLE TAKEN FROM THIRD BORING. 0-1 and 2-3 FT SAMPLES TAKEN FROM ORIGINAL BORING.

* When rock coring, enter rock brokeness.

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

Remarks: S-1 = BG1SBA0101; S-3 = BG1SBA0303; S-4 = BG1SBA0104;

Drilling Area Background (ppm): 0.0

Converted to Well: Yes ____ No ✓ Well I.D. #: ____

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NSWC Crane
PROJECT NUMBER: 0087 CTO 083
DRILLING COMPANY: not applicable
DRILLING METHOD: hand auger

BORING NUMBER: BGISBA02
DATE: 11/4/99
GEOLOGIST: S NEIL
DRILLER: K. SIMPSON / S. NEIL

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	U S C S *	Remarks	PID/FID Reading (ppm): Sample	Sampler BZ	Borehole**	Driller BZ**
	0				LOOSE	Br	SOME GRAVEL ROCK FRAGS Clayey silt TR VFG SAND	ML	MOIST. ROOT MAT				
S-1	1				↓	↓	↓	↓	↓ ↓	2.1	0	27	0
	2				↓		REFUSAL AT ≈ 2 FT. TRIED 3						
							ADDITIONAL BORINGS W/ SIMILAR						
							RESULTS. SAMPLE TAKEN FROM						
							ORIGINAL BORING.						

* 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): 0.0

Remarks: S-1 = BGISBA0201.
Only one sample taken due to refusal at 4 different locations

Converted to Well: Yes ____ No ✓ Well I.D. #: ____

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NSWC Crane
PROJECT NUMBER: 0087 CTO 083
DRILLING COMPANY: not applicable
DRILLING METHOD: hand auger
BORING NUMBER: BG1SBA03
DATE: 11/5/99
GEOLOGIST: S. NEIL
DRILLER: K. SIMPSON / S. NEIL

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	U S C S *	Remarks	PID/FID Reading (ppm): Sample	Sampler BZ	Borehole**	Driller BZ**
	0				Loose	Br	V FG SAND SOME SILT	SM	MOIST ROOT MAT				
S-1	1				↓	↓	↓	↓	↓ ↓	0	0	3.3	0
	2						SILT SOME V FG SAND	ML	DRY				
S-3	3						↓			0	0	1.5	0
S-4	4									0	0	0	0
S-5	5						Some Or Stain			0	0	0	0
S-6	6				↓	↓	↓ ↓	↓	↓	0	0	0	0
							TD = 6FT.						

* 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): 0.0

Remarks: S-1 = BG1SBA0301; S-3 = BG1SBA0303; S-4 = BG1SBA0304; S-5 = BG1SBA0305; S-6 = BG1SBA0306.

Converted to Well: Yes ____ No ✓ Well I.D. #: ____

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NSWC Crane
PROJECT NUMBER: 0087 CTO 083
DRILLING COMPANY: not applicable
DRILLING METHOD: hand auger

BORING NUMBER: BGISBA04
DATE: 11/5/99
GEOLOGIST: S. Neil
DRILLER: K. Simpson / S. Neil

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	U S C S *	Remarks	PID/FID Reading (ppm): Sample	Sampler BZ	Borehole**	Driller BZ**
	0				SOFT	Br	SILTY CLAY TR VFGR SAND	CL	MOIST				
S-1	1				MED STIFF	↓	↓	↓	↓	4.1	0	6.9	0
	2				↓	↓	↓	↓	↓				
S-3	3				↓	↓	↓ OF MOTTLING	↓	↓	10	0	12	0
S-4	4				STIFF	↓	CLAY SOME SILT TR VFGR SAND OF MOTTLING	↓	DENSER	28	0	20	0
S-5	5				HARD	↓	↓	↓	↓	31	0	41	0
S-6	6				↓	↓	↓ LESS MOTTLED	↓	DENSER	39	0	24	0
							TD = 6FT.						

* 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): 0.0

Remarks: S-1 = BGISBA0401; S-3 = BGISBA0403; S-4 = BGISBA0404; S-5 = BGISBA0405; S-6 = BGISBA0406.

Converted to Well: Yes ____ No ✓ Well I.D. #: ____

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NSWC Crane
BORING NUMBER: BG15BA05
PROJECT NUMBER: 0087 CTO 083
DATE: 11/4/99
DRILLING COMPANY: not applicable
GEOLOGIST: S. NEIL
DRILLING METHOD: hand auger
DRILLER: K. SIMPSON / S. NEIL

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	Soil Density/ Consistency or Rock Hardness	Color	Material Classification	U S C S *	Remarks	PID/FID Reading (ppm) Sample	Sampler BZ	Borehole**	Driller BZ**
	0				LOOSE	Br	SILTY VFGR SAND	ML	MOIST. ROOTS.				
S-1	1				↓	↓	↓	↓	↓ ↓	3.1	0	11	0
	2				↓	↓	↓	↓	DRY REFUSAL-OFF SET 10FT.				
S-3	3				↓	↓	SILT W/ TR FGR SAND	ML	V DRY	1.9	0	10	0
S-4	4				LOOSE	Or	FGR SAND TR SILT GRAVEL ROCK FRAGS	SP	↓			4.4	0

TD = FT. ON OFF SET. SAMPLED 0-1 FT INTERVAL AT ORIGINAL BORING. SAMPLED 2-3 + 3-4 FT INTERVAL AT OFF SET.

* When rock coring, enter rock brokeness.

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

Remarks: S-1 = BG15BA0501; S-3 = BG15BA0503; S-4 = BG15BA0504. Only 3 samples taken due to refusal.

Drilling Area Background (ppm): 0.0

Converted to Well: Yes ____ No ✓ Well I.D. #: ____

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NSWC Crane
BORING NUMBER: BGISBP01
PROJECT NUMBER: 0087 CTO 083
DATE: 11/6/99
DRILLING COMPANY: not applicable
GEOLOGIST: S. NEIL
DRILLING METHOD: hand auger
DRILLER: K. SIMPSON / S. NEIL

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	U S C S *	Remarks	PID/FID Reading (ppm): Sample	Sampler BZ	Borehole**	Driller BZ**
	0				LOOSE	Br	SILT SOME CLAY	ML	MOIST; ROOT MAT				
S-1	1				↓	↓	↓	↓	↓	*	*	*	*
	2				↓	↓	↓	↓	DRY				
S-3	3				↓	LT Br	SILT w/ BL CLAY	↓	V. DENSE	*	*	*	*
S-4	4				↓	↓	TR FGR SAND, RED STAIN Fe NODS.	↓	↓	↓	↓	↓	↓
S-5	4.5				↓	↓	ROCK FRAGS, RED STAIN TR VFGR SAND	↓	↓	↓	↓	↓	↓
							TD = 4.5 FT. Auger refusal.						

* 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): *

Remarks: S-1 = BGISBP01; S-3 = BGISBP0103; BGISBP0104; BGISBP0105. Sample BGISBP0106 was not taken due to auger refusal.
* PID MALFUNCTIONING.

Converted to Well: Yes ____ No ✓ Well I.D. #: ____

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NSWC Crane
PROJECT NUMBER: 0087 CTO 083
DRILLING COMPANY: not applicable
DRILLING METHOD: hand auger
BORING NUMBER: BG15BP02
DATE: 11/6/66
GEOLOGIST: S. NEIL
DRILLER: K. SIMPSON / S. NEIL

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**
	0				LOOSE	Br	SILT SOME CLAY	ML	MOIST, SOME ROOTS				
S-1	1				↓	↓	↓	↓	↓ ↓	*	*	*	*
	2				↓	LT Br	↓	↓	DRY				
S-3	3				STIFF		BL CLAY SOME SILT OR MOT.	CL	VERY DENSE	*	*	*	*
S-4	4				↓		↓	↓		*	*	*	*
S-5	5				MED. DENSE		SILT SOME BL CLAY OR MOT.	ML		*	*	*	*
S-6	6				↓	↓	ROCK FRAGS W/ TYPICAL SAND	↓	↓ ↓				
							TD = 6 FT.						

* 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): *

Remarks: S-1 = BG15BP0201; S-3 = BG15BP0203; S-4 = BG15BP0204; S-5 = BG15BP0205; S-6 = BG15BP0206.

Converted to Well: Yes ____ No ✓ Well I.D. #: ____

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NSWC Crane
PROJECT NUMBER: 0087 CTO 083
DRILLING COMPANY: not applicable
DRILLING METHOD: hand auger
BORING NUMBER: BG1SBP03
DATE: 11/6/99
GEOLOGIST: S. NEIL
DRILLER: K. SIMPSON / S. NEIL

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	U S C S *	Remarks	PID/FID Reading (ppm): Sample	Sampler BZ	Borehole**	Driller BZ**
	0				LOOSE	BR	SILT TR VF GR SAND TR CLAY	ML	MOIST TR ROOTS				
S-1	1				↓	↓	↓	↓	↓ ROCKY TERRAINE	0	0	0	0
	2				STIFF	↓	OR MOT. BL CLAY SOME SILT, ROCK TR VF GR SAND	CL	↓ OFFSET 10 FT				
S-3	3				V STIFF	LT BR	↓		DRY VERY DENSE	0	0	0	0
S-4	4					OR/GRAY	OR MOTTLE BL CLAY TR SILT			0	0	0	0
S-5	5					↓				0	0	0	0
S-6	6				↓	GRAY	↓ DISTINCT OR MOTTLING	↓	↓ ↓	0	0	0	0
							TD = 6 FT OFF SET 4 TIMES						

* 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): 0.0

Remarks: S-1 = BG1SBP0301; S-3 = BG1SBP0303; S-4 = BG1SBP0304; S-5 = BG1SBP0305; S-6 = BG1SBP0306.

Converted to Well: Yes ____ No ✓ Well I.D. #: ____

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NSWC Crane
PROJECT NUMBER: 0087 CTO 083
DRILLING COMPANY: not applicable
DRILLING METHOD: hand auger
BORING NUMBER: BG1SBP04
DATE: 11/6/99
GEOLOGIST: S. NEIL
DRILLER: K. SIMPSON / S. NEIL

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**
	0				LOOSE	Br	SILT SOME BL CLAY	ML	DRY ROOT MAT.				
S-1	1				↓	↓	↓	↓	DRIER	0	0	0	0
	2				↓	LT Br	↓	↓	↓				
S-3	3				↓	↓	OR STAIN ↓	↓	↓ V DENSE	0	0	0	0
S-4	4				STIFF	↓	BL CLAY SOME SILT TR FGR SAND	CL	↓	0	0	0	0
S-5	5				↓	↓	TR FGR SAND DR MOT. BL CLAY SOME SILT	CL	↓	0	0	0	0
S-6	6				↓	↓	↓	↓	↓				
							TD = 6 FT.						

* When rock coring, enter rock brokeness.

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

Remarks: S-1 = BG1SBP0401; S-3 = BG1SBP0403; S-4 = BG1SBP0404; S-5 = BG1SBP0405; S-6 = BG1SBP0406.

Drilling Area Background (ppm): 0.0

Converted to Well: Yes ____ No ✓ Well I.D. #: ____

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NSWC Crane
PROJECT NUMBER: 0087 CTO 083
DRILLING COMPANY: not applicable
DRILLING METHOD: hand auger

BORING NUMBER: BG15BP05
DATE: 1/15/99
GEOLOGIST: S. NEIL
DRILLER: K. SIMPSON / S. NEIL

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**
	0				LOOSE	Br	SILT SOME CLAY	ML	DRY ROOT MAT.				
S-1	1				↓	↓	↓	↓	↓	0	0	0	0
	2				↓	LT BR	↓	↓					
S-3	3				STIFF		SOME OF MOTTLING BLOCKY CLAY SOME SILT	CL	V DENSE	0	0	0	0
S-4	4									0	0	0	0
S-5	5						TR FGR SAND SOME ROCK FRAGS			0	0	0	0
S-6	6				↓	↓	↓ ↓ ↓	↓	↓ ↓	0	0	0	0
							TD = 6 FT.						

* 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): 0.0

Remarks: S-1 = BG15BP0501; S-3 = BG15BP0503; S-4 = BG15BP0504; S-5 = BG15BP0505; S-6 = BG15BP0506

Converted to Well: Yes ____ No ✓ Well I.D. #: ____

Tetra Tech NUS, Inc.

BORING LOG

Page 1 of 1

PROJECT NAME: NSWC Crane
PROJECT NUMBER: 0087 CTO 083
DRILLING COMPANY: not applicable
DRILLING METHOD: hand auger
BORING NUMBER: BG1SBP06
DATE: 11/5/99
GEOLOGIST: S. NEIL
DRILLER: K. SIMPSON / S. NEIL

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	Soil Density/ Consistency or Rock Hardness	Color	Material Classification	USCS *	Remarks	PID/FID Reading (ppm) Sample	Sampler BZ	Borehole**	Driller BZ**
	0				SOFT	Br	SILTY CLAY TR VF GR SAND	CL	MOIST ROOTS				
S-1	1				↓	↓	↓	↓	↓	0	0	1.5	0
	2				LOOSE	LBr	SILT SOME CLAY TR VF GR Sd	ML	DRY				
S-3	3				↓	↓	↓ WEATHERED BEDROCK FRAGS	↓	↓ REFUSAL @ 3FT - OFFSET ≈10 FT - HIT REFUSAL @ ≈ 2.4 FT -	0	0	0	0
							TD = 3 FT		OFFSET ≈ 20 FT - HIT REFUSAL @ ≈ 2.5 FT.				

* When rock coring, enter rock brokeness.

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

Remarks: S-1 = BG1SBP0601; S-3 = BG1SBP0603; SAMPLES TAKEN FROM ORIGINAL BORING.

Drilling Area Background (ppm): 0.0

Converted to Well: Yes ____ No ✓ Well I.D. #: ____

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NSWC Crane
BORING NUMBER: RGISBP07
PROJECT NUMBER: 0087 CTO 083
DATE: 11/5/99
DRILLING COMPANY: not applicable
GEOLOGIST: S. Neil
DRILLING METHOD: hand auger
DRILLER: K. Simpson / S. Neil

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	U S C S *	Remarks	PID/FID Reading (ppm): Sample	Sampler BZ	Borehole**	Driller BZ**
	0				Loose	SC	V FGR Sand, Rock Frags, Some Silt	SP	Dry				
S-1	1				↓	↓	↓	↓	Refusal @ 1 FT - Offset ≈ 10 FT -	7.0	0	5.6	0
									Refusal @ 1.5 FT - Offset ≈ 10 FT -				
							TD = 1.0 FT.		Refusal @ 1.0 FT - Offset ≈ 20 FT -				
									Refusal @ 0.5 FT - Offset ≈ 10 FT -				
								(5)	2nd Refusal @ 1.3 FT.				

* When rock coring, enter rock brokeness.

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

Remarks: S-1 = RGISBP0701 (Sample taken from original boring). Offset 4 times (5 borings); could not auger deeper than 1.5 FT.

Drilling Area Background (ppm): 0.0

Converted to Well: Yes ____ No ✓ Well I.D. #: ____

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NSWC Crane
PROJECT NUMBER: 0087 CTO 083
DRILLING COMPANY: not applicable
DRILLING METHOD: hand auger
BORING NUMBER: BG1SBP08
DATE: 11/6/99
GEOLOGIST: S. NEIL
DRILLER: K. SIMPSON / S. NEIL

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	U S C S *	Remarks	PID/FID Reading (ppm): Sample	Sampler BZ	Borehole**	Driller BZ**
	0				LOOSE	Br	SILT SOME CLAY TR VFGR SAND	ML	DRY. ROOT MAT.				
S-1	1				↓	↓	↓	↓	↓ ↓	0	0	0	0
	2					LT Br			MUCH DRIER; TR ROOTS				
S-3	3								↓ ↓	*	*	*	*
S-4	4						↓ TR FGR SAND	↓		*	*	*	*
S-5	5						FGR SAND SOME SILT SOME ROCK FRAGS	SP					
S-6	5.5				↓	↓	↓ MORE ROCK FRAGS	↓	↓				
							TD = 5.5 FT - REFUSAL						

* When rock coring, enter rock brokeness.

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

Remarks: S-1 = BG1SBP0801; S-3 = BG1SBP0803; S-4 = BG1SBP0804; S-5 = BG1SBP0805; S-6 = BG1SBP0806.
* PID MALFUNCTIONING.

Drilling Area Background (ppm): 0.0

Converted to Well: Yes ____ No ✓ Well I.D. #: ____

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NSWC Crane
PROJECT NUMBER: 0087 CTO 083
DRILLING COMPANY: not applicable
DRILLING METHOD: hand auger

BORING NUMBER: BG15BP09
DATE: 11/6/99
GEOLOGIST: S. NEIL
DRILLER: K. SIMPSON / S. NEIL

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	U S C S *	Remarks	PID/FID Reading (ppm): Sample	Sampler BZ	Borehole**	Driller BZ**
	0				LOOSE	BR	CLAYEY SILT TR ROCK FRAGS	ML	MOIST, ROOT MAT				
S-1	1				↓	↓	SOME VFG. SD / SOME ROCK FRAG	↓	↓ ↓	0	0	.4	0
	2				↓	↓	↓ ↓ ↓	↓	DRY REFUSAL - MOVE ≈ 15 FT. REFUSAL @ 1.3 FT. OFF SET ≈ 10 FT.	[illegible]	[illegible]		
							TD= 2 FT						

* 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): 0.0

Remarks: S-1 = BG15BP0901; Only one sample taken due to auger refusal - moved twice (3 borings).

Converted to Well: Yes ____ No ✓ Well I.D. #: ____

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NSWC Crane
PROJECT NUMBER: 0087 CTO 083
DRILLING COMPANY: not applicable
DRILLING METHOD: hand auger
BORING NUMBER: BG1SBP1004 (SD)
DATE: 11/5/99
GEOLOGIST: S. Neil
DRILLER: K. Simpson / S. Neil

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	Soil Density/ Consistency or Rock Hardness	Color	Material Classification	USCS*	Remarks	PID/FID Sample	Sampler BZ	Borehole**	Driller BZ**
	0				Soft	Br	Silty clay tr vf gr sand	CL	Moist				
S-1	1				↓	↓	↓	↓	↓	8.2	0	27	0
	2				Loose	LBr	Silt some clay some f gr sand rock frags	ML	Dry				
S-3	3				↓	↓	↓	↓		55	0	63	0
S-4	4				↓	↓	Silt some clay some f gr sd rock frags	↓	Refusal @ 3.4 ft.	21	0	27	0
									Moved upgradient				
							TD = 4.1 Ft.		≈ 20 ft. - refusal				
									@ 3 ft. Moved ≈				
									20 ft cross grad.				
									Augered to 4.1 ft.				
									Took 3-4 ft sample				
									from second boring				

* When rock coring, enter rock brokeness.

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

Remarks: S-1 = BG1SBP1001; S-3 = BG1SBP1003 (S-1 & S-3 taken from original boring); S-4 = BG1SBP1004 (taken from third boring).

Drilling Area Background (ppm): 0.0

Converted to Well: Yes ____ No ✓ Well I.D. #: ____

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NSWC Crane
PROJECT NUMBER: 0087 CTO 083
DRILLING COMPANY: not applicable
DRILLING METHOD: hand auger

BORING NUMBER: BG25BG01
DATE: 11/7/99
GEOLOGIST: S. Neil
DRILLER: K. Simpson / S. Neil

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	Soil Density/ Consistency or Rock Hardness (MATERIAL DESCRIPTION)	Color	Material Classification	U S C S *	Remarks	PID/FID Reading (ppm) Sample	Sampler BZ	Borehole**	Driller BZ**
	0				SOFT	BL	SILTY CLAY TR V FGRSD	CL	MOIST TR ROOTS				
S-1	1				MED STIFF	↓	↓	↓	↓ ↓	23	0	36	0
	2				STIFF	↓	↓	↓	DRY DENSER				
S-3	3				↓	↓	↓	↓	↓	14	0	47	0
S-4	4				MED DENSE	↓	FGR SAND SOME CLAY/SILT	SP	↓	0	0	44	0
S-5	5				↓	OR	↓ TR CLAY/SILT	↓	↓	0	0	46	0
S-6	6				↓	↓	↓	↓	↓	0	0	36	0
							6 FT TD						

* 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): 0.0

Remarks: S-1 = BG25BG0101; S-3 = BG25BG0103; S-4 = BG25BG0104; S-5 = BG25BG0105; S-6 = BG25BG0106

Converted to Well: Yes ____ No ✓ Well I.D. #: ____

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NSWC Crane
PROJECT NUMBER: 0087 CTO 083
DRILLING COMPANY: not applicable
DRILLING METHOD: hand auger
BORING NUMBER: BG2SBG02
DATE: 11/7/99
GEOLOGIST: S. NEIL
DRILLER: K. SIMPSON / S. NEIL

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	U S C S *	Remarks	PID/FID Reading (ppm): Sample	Sampler BZ	Borehole**	Driller BZ**
	0				LOOSE	Br	SILT TR VFGR SAND	ML	MOIST SOME ROOTS				
S-1	1				↓	↓	↓	↓	↓ ↓	5.4	0	53	0
	2				↓	↓			DRY ↓				
S-3	3				MED DENSE	LT Br	TR OR MOTTLING			49	0	128	0
S-4	4				↓		MN NODS ↓ ↓			24	0	62	0
S-5	5				↓	↓	SILT SOME GRAY CLAY SOME VFGR SAND	↓		50	0	28	0
S-6	6				STIFF	GRAY	BL CLAY OR MOT. TR SILT TR VFGR SAND	CL	↓ V DNSE	29	0	13	0
							TD = 6 FT.						

* 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): 0.0

Remarks: S-1 = BG2SBG0201; S-3 = BG2SBG0203; S-4 = BG2SBG0204; S-5 = BG2SBG0205; S-6 = BG2SBG0206.

Converted to Well: Yes ____ No ✓ Well I.D. #: ____

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NSWC Crane
BORING NUMBER: BG2SBG03
PROJECT NUMBER: 0087 CTO 083
DATE: 11/7/99
DRILLING COMPANY: not applicable
GEOLOGIST: S. NEIL
DRILLING METHOD: hand auger
DRILLER: K. Simpson / S. Neil

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	Soil Density/ Consistency or Rock Hardness	Color	Material Classification	USCS *	Remarks	PID/FID Sample	Sampler BZ	Borehole**	Driller BZ**
	0				Loose	LT BR	FGR SANDY SILT TR CLAY	ML	(SW) MOIST ~~DRY~~; SOME ROOT				
S-1	1				↓	↓	↓	↓	DRY	9.1	0	7.7	0
	2												
S-3	3					GRAY	FGR ~~FGSD~~ SAND TR ROCK FRAGS SOME SILT	SP		21	0	14	0
S-4	4						↓			0	0	33	0
S-5	5						FGR SAND TR SILT TR ROCK TR OR STAIN			16	0	122	0
S-6	6				↓	↓	↓	↓	↓	12	0	72	0
							TD = 6 FT.						

* 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): 0.0

Remarks: S-1 = BG2SBG0301; S-3 = BG2SBG0303; S-4 = BG2SBG0304; S-5 = BG2SBG0305; S-6 = BG2SBG0306

Converted to Well: Yes ____ No ✓ Well I.D. #: ____

Tetra Tech NUS, Inc.

BORING LOG

Page 1 of __

PROJECT NAME: NSWC Crane
PROJECT NUMBER: 0087 CTO 083
DRILLING COMPANY: not applicable
DRILLING METHOD: hand auger
BORING NUMBER: BG2SBG04
DATE: 11/7/99
GEOLOGIST: S. Neil
DRILLER: K. Simpson / S. Neil

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	U S C S *	Remarks	PID/FID Reading (ppm): Sample	Sampler BZ	Borehole**	Driller BZ**
	0				Loose	Br	Clayey silt	ML	Moist some roots				
S-1	1				↓	↓	↓	↓	↓ ↓	0	0	0	0
	2				↓	Lt Br	↓ Some F gr Sd	↓	Dry				
S-3	3				Med Dense	↓	Fencoss rock frags. Silt some clay ↓	↓	↓ Refusal @ 3 Ft. off	0	0	0	0
S-4	3.4				↓	↓	↓ ↓	↓	set ≈ 1 ft. Refusal @ ≈	0	0	0	0
									2 Ft. offset 12 Ft - Refusal				
							TD = 3.4 Ft.		@ 3.4 Ft.				

* When rock coring, enter rock brokeness.

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

Remarks: S-1 = BG2SBG0401; S-3 = BG2SBG0403
S-4 = BG2SBG0404.

Drilling Area Background (ppm): 0.0

Converted to Well: Yes ____ No ✓ Well I.D. #: ____

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NSWC Crane
PROJECT NUMBER: 0087 CTO 083
DRILLING COMPANY: not applicable
DRILLING METHOD: hand auger
BORING NUMBER: BG2SBG05
DATE: 11/7/99
GEOLOGIST: S. Neil
DRILLER: R. Simpson / S. Neil

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	Soil Density/ Consistency or Rock Hardness	Color	Material Classification	USCS*	Remarks	Sample	Sampler BZ	Borehole**	Driller BZ**
	0				SOFT	BR	SILTY CLAY	CL	MOIST TR ROOTS				
S-1	1				↓				↓ ↓	0	0	0	0
	2				MED STIFF	LT BR	TR FGR SD ↓ ROCK FRAGS	↓	DRY				
S-3	3				MED DENSE	↓	OR TINT FGR Sand SOME SILT ROCK FRAG	SP	REFUSAL @ 3FT - OFF SET 10 FT.	0	0	0	0
									REFUSAL @ 2FT - OFF SET ≈ 15 FT.				
							TD = 3 FT - Auger refusal. Rock frags at 2-3 ft interval are weathered bedrock.		REFUSAL @ 2 FT. END OF BORINGS.				

* When rock coring, enter rock brokeness.
** Include monitor reading in 6 foot intervals @ borehole. Increase reading frequency if elevated reponse read.

Remarks: S-1 = BG2SBG0501; S-3 = BG2SBG0503

Drilling Area Background (ppm): 0.0

Converted to Well: Yes ____ No ✓ Well I.D. #: ____

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NSWC Crane
PROJECT NUMBER: 0087 CTO 083
DRILLING COMPANY: not applicable
DRILLING METHOD: hand auger
BORING NUMBER: BG3SBA01
DATE: 11/2/99
GEOLOGIST: S. Neil
DRILLER: K. Simpson / K. Hebrn

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	U S C S *	Remarks	PID/FID Reading (ppm): Sample	Sampler BZ	Borehole**	Driller BZ**
—	0				Loose	Br	Silty Fgr sand	ML	Dry				
S-1	1				↓	Lgt Br	Rock Frags	↓	↓	20	0	39	0
—	2				↓	↓	↓	↓	↓				
S-3	3				↓	↓	↓	↓	Refusal - off set = 25 ft	27	0	50	0
							TD = 3 Ft. - Hit						
							Refusal @ 3 Ft. on						
							3 different borings						

* When rock coring, enter rock brokeness.

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

Remarks: S-1 = BG3SBA0101; S-3 = BG3SBA0103.

Drilling Area Background (ppm): 0.0

Converted to Well: Yes ____ No ✓ Well I.D. #: ____

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NSWC Crane
PROJECT NUMBER: 0087 CTO 083
DRILLING COMPANY: not applicable
DRILLING METHOD: hand auger

BORING NUMBER: BG3SBA02
DATE: 11/2/99
GEOLOGIST: S. NEIL
DRILLER: K. Simpson / K. HENN

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	U S C S *	Remarks	PID/FID Reading (ppm): Sample	Sampler BZ	Borehole**	Driller BZ**
—	0				V Loose	Br	Silt trace sand	ML	Heavy root mat. MOIST				
S-1	1				↓	↓	↓	↓	↓	0	0	0	0
—	2					Lgt Br	V F-gr Sand some silt	SM	Dry				
S-3	3					↓	Rock Frags.		↓	0	0	0	0
S-4	4					Lgt Or	↓	↓	↓ Offset ≈ 15 FT.	0	0	0	0
S-5	4.5				↓		V F-gr Sand w/ Rock Frags	SM	Dry				
							REFUSAL - TD = 4.5 FT						
							Off set twice.						

* 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): 0.0

Remarks: S-1 = BG3SBA0201; S-3 = BG3SBA0203; S-4 = BG3SBA0204; S-5 = BG3SBA0205
Only 4 samples taken - refusal @ 4.5 FEET.

Converted to Well: Yes ______ No ✓ Well I.D. #: ______

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NSWC Crane
PROJECT NUMBER: 0087 CTO 083
DRILLING COMPANY: not applicable
DRILLING METHOD: hand auger

BORING NUMBER: BG3SB03
DATE: 11/3/99
GEOLOGIST: S. Neil
DRILLER: K. Simpson / K. Henn

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**
	0				Loose	Br	Organic Silt w/ trace f. gr. sand	ML	Moist				
S-1	1				↓	↓	↓	↓	↓	0	0	0	0
	2				↓	Lt Br	Silt w/ trace sand trace gravel	↓	↓				
							TD = 2 FT. HIT REFUSAL: MOVED						
							TWICE.						

* When rock coring, enter rock brokeness.

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

Remarks: S-1 = BG3SBA03.
ONLY ONE SAMPLE TAKEN DUE TO REFUSAL – MOVED TWICE, BUT ENCOUNTERED REFUSAL AT THE TWO ADDITIONAL BORINGS.

Drilling Area Background (ppm): 0.0

Converted to Well: Yes ____ No ✓ Well I.D. #: ____

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NSWC Crane
PROJECT NUMBER: 0087 CTO 083
DRILLING COMPANY: not applicable
DRILLING METHOD: hand auger
BORING NUMBER: BG3SBA04
DATE: 11/4/99
GEOLOGIST: S. NEIL
DRILLER: K. SIMPSON / S. NEIL

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	U S C S *	Remarks	PID/FID Reading (ppm): Sample	Sampler BZ	Borehole**	Driller BZ**
	0				V Loose	Br	Silt some clay trace v fgr sand	ML	Moist				
S-1	1				↓	↓	↓	↓	↓	0	0	.3	0
	2				↓	LT Br	↓	↓	Dry				
S-3	3				Loose		FGR SANDY SILT TRACE CLAY	↓	↓	0	0	0	0
S-4	4				↓	↓	FGR SAND TRACE SILT	SM	MOIST	0	0	1.2	0
S-5	5.0					LBr/ Gray	FGR SAND	SP	↓	0	0	0.1	0
S-6	5.5				↓	↓	↓	↓		0	0	0	0
							TD = 5.5 FT. HIT REFUSAL/BEDROCK						
							COLLECTED ALL 5 SAMPLES.						

* 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): 0.0

Remarks: S-1 = BG3SBA0401; S-3 = BG3SBA0403; S-4 = BG3SBA0404; S-5 = BG3SBA0405; S-6 = BG3SBA0406.

Converted to Well: Yes ____ No ✓ Well I.D. #: ____

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NSWC Crane
PROJECT NUMBER: 0087 CTO 083
DRILLING COMPANY: not applicable
DRILLING METHOD: hand auger

BORING NUMBER: BG35SA05
DATE: 11/4/99
GEOLOGIST: S. NEIL
DRILLER: K. Simpson / S. Neil

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	U S C S *	Remarks	PID/FID Reading (ppm): Sample	Sampler BZ	Borehole**	Driller BZ**
	0				LOOSE	BR	FGR SANDY SILT	ML	DRY. SOME ROOTS				
S-1	1				↓	↓	↓	↓	↓	0	0	.7	0
	2												
S-3	3						FGR SANDY SILT TR CLAY			16	0	24	0
S-4	4						SILT TR CLAY TR FGR SAND	↓	↓	37	0	29	0
S-5	5				↓		FGR SAND SOME SILT	SM	MOIST TRACE RED STAIN	*	*	*	*
S-6	5.5				LOOSE	↓	FGR SAND TRACE SILT TRACE ROCK FRAG.	SP	↓	↓	↓	↓	↓
							TD = 5.5 FT. HIT REFUSAL; ALL						
							SAMPLES TAKEN (6).						

* When rock coring, enter rock brokeness.

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

Remarks: S-1 = BG35SA0501; S-3 = BG35SA0503; S-4 = BG35SA0504; S-5 = BG35SA0505; S-6 = BG35SA0506.
* PID MALFUNCTIONING.

Drilling Area Background (ppm): 0.0

Converted to Well: Yes ____ No ✓ Well I.D. #: ____

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NSWC Crane
PROJECT NUMBER: 0087 CTO 083
DRILLING COMPANY: not applicable
DRILLING METHOD: hand auger
BORING NUMBER: BG35BM01
DATE: 11/2/99
GEOLOGIST: S. Neil
DRILLER: K. Simpson / K. Hahn

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	Soil Density/ Consistency or Rock Hardness	Color	Material Classification	USCS *	Remarks	PID/FID Reading (ppm) Sample	Sampler BZ	Borehole**	Driller BZ**
	0				Loose	Br	Clayey silt	ML	Root mat. Dry	0	0	0	0
S-1	1				↓	↓	↓	↓		0	0	0	0
	2												
S-3	3				MED DENSE	↓	Iron Nods. mottled - Blocky clay	↓	off set 20 feet.	0	0	0	0
							Refusal at 3 ft. -						
							off set twice.						
							TD = 3 FT.						

* When rock coring, enter rock brokeness.
** Include monitor reading in 6 foot intervals @ borehole. Increase reading frequency if elevated reponse read.

Remarks: S-1 = BG35BM0101 ; S-3 = BG35BM0103
Only 2 samples taken due to refusal @ 3 FEET.

Drilling Area Background (ppm): 0.0

Converted to Well: Yes ____ No ✓ Well I.D. #: ____

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NSWC Crane
BORING NUMBER: BG3SBM02
PROJECT NUMBER: 0087 CTO 083
DATE: 11/2/99
DRILLING COMPANY: not applicable
GEOLOGIST: S. Neil
DRILLING METHOD: hand auger
DRILLER: K. Simpson / K. Henn

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	Soil Density/ Consistency or Rock Hardness	Color	Material Classification	USCS *	Remarks	PID/FID Sample	Sampler BZ	Borehole**	Driller BZ**
	0				Loose	Br	Clayey silt	ML	Moist - Heavy				
S-1	1								Roots	29	0	48	0
	2								Dry				
S-3	3								↓	148	0	279	0
S-4	4					↓	Clayey silt trace sand		V. Dry	14	0	171	0
S-5	5				↓	LT Br	↓	↓	↓	35	0	48	0
S-6	6				Med Dense	Br	Blocky clay w/ red mots.	CL	Dry	31	0	59	0
									End TD = 6 FT.				

* 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): 0.0

Remarks: S-1 = BG3SBM0201; S-3 = BG3SBM0203; S-4 = BG3SBM0204; S-5 = BG3SBM0205; S-6 = BG3SBM0206.

Converted to Well: Yes ____ No ✓ Well I.D. #: ____

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NSWC Crane
BORING NUMBER: BG35BM03
PROJECT NUMBER: 0087 CTO 083
DATE: 11/2/99
DRILLING COMPANY: not applicable
GEOLOGIST: S. NEIL
DRILLING METHOD: hand auger
DRILLER: K. Simpson / K. Henn

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	U S C S *	Remarks	PID/FID Reading (ppm): Sample	Sampler BZ	Borehole**	Driller BZ**
	0				LOOSE	Med Br	SILT - SOME CLAY	ML/MH	DRY - MOIST	12.3	0	101	0
S-1	1				↓	↓	↓	↓	↓	↓	↓	↓	↓
	2						↓	↓	DRY				
S-3	3						CLAYEY SILT	ML	↓	19.6	0	137	0
S-4	4						ORANGE STAIN		↓	6.0	0	37.3	0
S-5	5					LGT Br			V. DRY Fe Nod.	15.9	0	67.2	0
S-6	6				↓	Or	↓ SOME SAND	↓	↓	15	0	354	0
							TD = 6 FT.						

* 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): 0.0

Remarks: S-1 = BG35BM0301; S-3 = BG35BM0303; S-4 = BG35BM0304; S-5 = BG35BM0305; S-6 = BG35BM0306.

Converted to Well: Yes ____ No ✓ Well I.D. #: ____

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NSWC Crane
PROJECT NUMBER: 0087 CTO 083
DRILLING COMPANY: not applicable
DRILLING METHOD: hand auger
BORING NUMBER: BG3SBM04
DATE: 11/3/94
GEOLOGIST: S. Neil
DRILLER: K. Simpson / K. Henn

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	U S C S *	Remarks	PID/FID Reading (ppm): Sample	Sampler BZ	Borehole**	Driller BZ**
	0				Loose	Br	Silt w/ trace f.gr. sand	ML	Moist				
S-1	1				↓	↓	↓	↓	↓	0	0	0	0
	2				↓	Lt Br	↓	↓	Moist - dry				
S-3	3				Med Dense	LBr/	Blocky clay some silt trace sand	CL	Moved off of hole after 3 ft.	0	0	0	0
S-4	4				↓	LBr/Gray	↓	↓	Dry	1	0	31	0
S-5	5				Loose		Rock frags; Fe nods Vf.gr. sand trace silt	SP	Dry	4	0	40	0
S-6	6				↓	↓	↓	↓	Dry	6	0	81	0
							TD = 6 FT.						

* When rock coring, enter rock brokeness.

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

Remarks: S-1 = BG3SBM0401; S-3 = BG3SBM0403; S-4 = BG3SBM0404; S-5 = BG3SBM0405; S-6 = BG3SBM0406.

Drilling Area Background (ppm): 0.0

Converted to Well: Yes ____ No ✓ Well I.D. #: ____

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NSWC Crane
PROJECT NUMBER: 0087 CTO 083
DRILLING COMPANY: not applicable
DRILLING METHOD: hand auger

BORING NUMBER: BG3SBM05
DATE: 11/3/99
GEOLOGIST: S. NEIL
DRILLER: K. Simpson / S. NEIL

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	MATERIAL DESCRIPTION: Color	MATERIAL DESCRIPTION: Material Classification	U S C S *	Remarks	PID/FID Reading (ppm): Sample	Sampler BZ	Borehole**	Driller BZ**
	0				Loose	Br	Clayey silt	ML	MOIST; ROOT MAT				
S-1	1				↓	↓	↓	↓	↓	0	0	1.3	0
	2				↓		↓ vfgr Trce Sand	↓	Dry; lighter color			~~.5~~	
S-3	3				MED DENSE		Blocky clay vfgr Trce sand	CL	Silty	0	0	.3	0
S-4	4				Loose		Fgr sand some silt Tr Clay	SM	↓	28	0	96	0
S-5	5				↓	↓	Fgr sand trace silt ROCK FRAGS.	SP	Fe Nods Dry; darker color	19	0	23	0
S-6	6				↓ OR	~~OR~~	↓ or stain	↓	Dry – MOIST	1.7	0	4.2	0
							TD = 6 FT.						

* When rock coring, enter rock brokeness.

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

Remarks: S-1 = BG3SBM0501; S-3 = BG3SBM0503; S-4 = BG3SBM0504; S-5 = BG3SBM0505; S-6 = BG3SBM0506

Drilling Area Background (ppm): 0.0

Converted to Well: Yes ____ No ✓ Well I.D. #: ____

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NSWC Crane
PROJECT NUMBER: 0087 CTO 083
DRILLING COMPANY: not applicable
DRILLING METHOD: hand auger
BORING NUMBER: BG3SBM06
DATE: 11/2/99
GEOLOGIST: S. Neil
DRILLER: K. Simpson / K. Henn

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**
	0				V Loose	Drk Br	Organic silt	OL	Moist				
S-1	1				↓	↓	↓	↓	↓	25	0	43	0
	2				↓	Br	Silt w/Rd stain	MH	Dry				
S-3	3				Med Dense	↓	Clay w/some silt	[illegible]CL	↓	14	0	34	0
S-4	3.5				Loose	↓	Silty sand	ML	Rock Frags	21	0	50	0
									Refusal at				
									3.5 Feet -				
									3 different				
									locations				
									Augered.				

* When rock coring, enter rock brokeness.

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

Remarks: S-1 = BG3SBM0601, S-3 = BG3SBM0603, S-4 = ~~BGS~~ (SD) BG3SBM0604. Only 3 samples taken due to refusal @ 3.5 Feet.

Drilling Area Background (ppm): 0.0

Converted to Well: Yes ____ No ✓ Well I.D. #: ____

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NSWC Crane
BORING NUMBER: BG3SBM07
PROJECT NUMBER: 0087 CTO 083
DATE: 11/3/99
DRILLING COMPANY: not applicable
GEOLOGIST: S. Neil
DRILLING METHOD: hand auger
DRILLER: K. Simpson / S. Neil

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	Soil Density/ Consistency or Rock Hardness	Color	Material Classification	USCS *	Remarks	Sample	Sampler BZ	Borehole**	Driller BZ**
	0				Loose	Md-LtBr	Silt-Some Clay	ML	Dry. Root Mat				
S-1	1				↓	↓	↓	↓	↓	0	0	0	0
	2					Lt Gray	Tr VF Gr Sand		V. Dry				
S-3	3					LBr				0	0	0	0
S-4	4				↓		↓	↓		0	0	0	0
S-5	5				Med Dense		Blocky Clay Some Silt Tr VF Gr Snd	CL		0	0	0	0
S-6	6				↓	↓	↓	↓	↓	0	0	0	0
							TD = 6 FT.						

PID/FID Reading (ppm)

* 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): 0.0

Remarks: S-1 = BG3SBM0701; S-3 = BG3SBM0703; S-4 = BG3SBM0704; S-5 = BG3SBM0705; S-6 = BG3SBM0706.

Converted to Well: Yes ____ No ✓ Well I.D. #: ____

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NSWC Crane
BORING NUMBER: BG3SBM08
PROJECT NUMBER: 0087 CTO 083
DATE: 11/3/99
DRILLING COMPANY: not applicable
GEOLOGIST: S. NEIL
DRILLING METHOD: hand auger
DRILLER: K. SIMPSON / K. HENN

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**
	0				Loose	Br	Vfgr sandy silt w/	ML	MOIST				
S-1	1				↓	↓	trace clay some gravel	↓	↓	0	0	0	0
	2				Loose	Lt Br	Silty fgr sand	SM	Dry Refusal Moist ≈ 2.0 FT.				
S-3	2.5				Loose	↓	Fgr sand some silt Rock Frags.	~~SM~~	Dry	4	0	13	0
							TD = 2.5 FT.	SP					
							Refusal after moving						
							onto another hole						

* When rock coring, enter rock brokeness.

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

Remarks: S-1 = BG3SBM0801; S-3 = BG3SBM0803.
Only 2 samples taken due to refusal.

Drilling Area Background (ppm): 0.0

Converted to Well: Yes ____ No ✓ Well I.D. #: ____

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME:	NSWC Crane	BORING NUMBER:	BG3SBM09
PROJECT NUMBER:	0087 CTO 083	DATE:	11/3/99
DRILLING COMPANY:	not applicable	GEOLOGIST:	S. Neil
DRILLING METHOD:	hand auger	DRILLER:	K. Simpson / S. Neil

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	U S C S *	Remarks	PID/FID Reading (ppm): Sample	Sampler BZ	Borehole**	Driller BZ**
	0				Loose	Br	Silt w/ some clay tr vfgr sand	ML	Moist		0		
S-1	1				↓	↓	↓	↓	Moist.	0	0	0	0
	2				Loose	↓	Clayey silt tr vfgr sand	↓	Moist				
S-3	3				↓	↓	↓	↓	Dry	0	0	.3	0
S-4	4				↓	LBr/ Gray	Clayey silt some fgr sand Rock frags	↓	Dry	0	0	6	0
~~S-5~~	5						Refusal at 4 Ft. Moved	Boring Location					
							Upslope ≈ 10 Ft. - Refusal @ 3 Ft.						
							TD = 4 Ft. - 3 Samples Taken.						

* When rock coring, enter rock brokeness.

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

Remarks: S-1 = BG3SBM0901; S-3 = BG3SBM0903; S-4 = BG3SBM0904
Only 3 samples taken due to refusal / bedrock.

Drilling Area Background (ppm): 0.0

Converted to Well: Yes ____ No ✓ Well I.D. #: ____

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NSWC Crane
PROJECT NUMBER: 0087 CTO 083
DRILLING COMPANY: not applicable
DRILLING METHOD: hand auger
BORING NUMBER: BG35BM10
DATE: 11/4/99
GEOLOGIST: S. NEIL
DRILLER: K. SIMPSON / S. NEIL

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	U S C S *	Remarks	PID/FID Reading (ppm): Sample	Sampler BZ	Borehole**	Driller BZ
	0				SOFT	Br	SILTY CLAY	CL	MOIST; TR ROOTS				
S-1	1				↓	↓	↓ TR FGR SAND	↓	↓ ↓	4	0	550	0
	2								↓				
S-3	3				↓		↓ ↓	↓	DRY	67	0	88	0
S-4	4				LOOSE	↓	FE NODS SOME ROCK FRAGS SILT SOME CLAY SOME FGR SAND	ML	↓ REFUSAL - OFFSET ≈15 FT. WEST	27	0	59	0
—	—				—	—	REFUSAL AFTER OFFSET -		MOVE ≈ 10 FT. EAST				
S-5	4.5				LOOSE	Br	ROCK FRAGS FE NODS. SILT SOME FGR SAND	ML	DRY	12	0	27	0

TD = 4.5 FT. OFFSET TWICE AFTER INITIAL BORING WENT TO 4 FT. HIT REFUSAL @ 4 FT. ON FIRST OFFSET AND REFUSAL @ 4.5 FT. ON SECOND OFFSET. TOOK SAMPLES S-1, S-3, + S-4 OUT OF FIRST BORING AND S-5 OUT OF THE THIRD BORING.

* When rock coring, enter rock brokeness.

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

Remarks: S-1 = BG35BM1001; S-3 = BG35BM1003; S-4 = BG35BM1004; S-5 = BG35BM1005. Four out of five samples taken.

Drilling Area Background (ppm): 0.0

Converted to Well: Yes ___ No ✓ Well I.D. #: ___

SUPPLEMENTAL FIELD EVENT

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NSWC Crane
PROJECT NUMBER: 0087 CTO 083
DRILLING COMPANY: not applicable
DRILLING METHOD: hand auger

BORING NUMBER: BG-15BA25
DATE: 10 · 7 · 00
GEOLOGIST: K. SIMPSON / K. MARGETTS
DRILLER: NA

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	Soil Density/ Consistency or Rock Hardness	Color	Material Classification	USCS *	Remarks	PID/FID Reading (ppm) Sample	Sampler BZ	Borehole**	Driller BZ**	TIME
	0				SOFT	BRN	CLAY, SOME SILT	CL	MOIST ROOTS	—				0800
	1				↓	↓	↓	↓	↓					
* S1	2								TR RUST COLOR NODULES					
S2	3						SILTY CLAY		WET					
S3	4			▼					GRAY/RUST COLOR MOTTLING					0835
S4	5				↓	↓	↓	↓	↓					
	6						TD = 6'							
							WATER @ 4'							
							4 SAMPLES COLLECTED							
							1 SENT TO LAB		0203'					
							PID IS NOT WORKING							
							* = SENT TO LAB		0203'					
							ALSO FROM THIS SB		2x VOL.					
							FOR MS/MSD &							
							CONTAINER FOR DUP		BGFD10070001					

(Left margin: 0 at depth 0; 6 at depth 6)

* 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): —

Remarks: NORTH 455892
EAST 556538

Converted to Well: Yes ____ No ✓ Well I.D. #: ____

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NSWC Crane
BORING NUMBER: BG-1 SB A 28
PROJECT NUMBER: 0087 CTO 083
DATE: 10 · 6 · 00
DRILLING COMPANY: not applicable
GEOLOGIST: K. SIMPSON / K. MARGETTS
DRILLING METHOD: hand auger
DRILLER: NA

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**	TIME
	0				SOFT	BRN	SILTY CLAY	CL	MOIST ROOTS	—	—	—	—	1555
	1				↓	TAN	↓ TR F. SAND	↓	TR GRAY & RUST MOTTLING					
S1	2				MED STIFF	RUST GRAY	↓	↓	TR ROCK FRAGS					
* S2	3				↓	↓	↓	↓	GRAY & RUST MOTTLING					1635
	4													
	5													
	6						TD = 4.1' REFUSAL 3 ATTEMPTS							
							* = SENT TO LAB		0304'					
							PID IS NOT WORKING							

(Left margin depth marks: 0, 6)

* When rock coring, enter rock brokeness.

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

Remarks: NORTH 456402
EAST 565078

Drilling Area Background (ppm):

Converted to Well: Yes ____ No ✓ Well I.D. #: ____

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NSWC Crane
BORING NUMBER: BG-1 SBA29
PROJECT NUMBER: 0087 CTO 083
DATE: 10 · 7 · 00
DRILLING COMPANY: not applicable
GEOLOGIST: K. SIMPSON / K. MARGETTS
DRILLING METHOD: hand auger
DRILLER: NA

TIME 1305 1330

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**
	0				SOFT	BRN	SILTY CLAY TR. SAND STONE FRAGS.		MOIST ROOTS	—			
	1				↓	↓							
	2												
	3												
	4												
	5												
	6												

TD = 2' REFUSAL

5 ATTEMPTS TO 1 TO 2'

NUMEROUS SAND STONE BOULDERS / COBBLES ON SURFACE

PID IS NOT WORKING

* 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): —

Remarks: NORTH 465992
EAST 564054

Converted to Well: Yes ____ No ✓ Well I.D. #: ____

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NSWC Crane
PROJECT NUMBER: 0087 CTO 083
DRILLING COMPANY: not applicable
DRILLING METHOD: hand auger
BORING NUMBER: BG/SBA38
DATE: 10 · 7 · 00
GEOLOGIST: K. SIMPSON / K. MARGETTS
DRILLER: NA

TIME 0950

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	Soil Density/ Consistency or Rock Hardness	Color	Material Classification	USCS *	Remarks	PID/FID Reading (ppm) Sample	Sampler BZ	Borehole**	Driller BZ**
	0				SOFT	BRN	SILT, SOME CLAY	ML	MOIST ROOTS				
	1				↓	↓	↓ TR F. SAND	↓	↓ SOME ROCK FRAGS	→ SAND STONE			
	2				↓	↓	↓	↓	↓				
	3												
	4												
	5												
	6												
							TD = 2.5' REFUSAL						
							4 ATTEMPTS						
							PID IS NOT WORKING						

Margin: 0 (at depth 0), 6 (at depth 6)

* When rock coring, enter rock brokeness.

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

Remarks: NORTH 464336
EAST 566077

Drilling Area Background (ppm): ______

Converted to Well: Yes ______ No ✓ Well I.D. #: ______

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NSWC Crane
PROJECT NUMBER: 0087 CTO 083
DRILLING COMPANY: not applicable
DRILLING METHOD: hand auger
BORING NUMBER: BG-1SBP11
DATE: 10.5.00
GEOLOGIST: K. SIMPSON / K. MARGETTS
DRILLER: NA

TIME 0945

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**
	0				SOFT	BRN	CLAY, TR SILT	CL	MOIST ROOTS				
	1				↓	↓	↓	↓	SOME GRAY MOTTLING	0	0	0	0
	2				MED STIFF				↓				
	3				↓	↓			BRN/GRAY W. MOTTLING				
	4					BRN GRAY			TR. ROCK FRAG.	0	0	0	0
	5				↓	↓	↓	↓	1" Ø MAX				
	6								TR RUST COLOR				
							TD = 6'		NODULES LAST FOOT				

* 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: NORTH 472250
EAST 559484

Converted to Well: Yes ____ No ✓ Well I.D. #: ____

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NSWC Crane
PROJECT NUMBER: 0087 CTO 083
DRILLING COMPANY: not applicable
DRILLING METHOD: hand auger
BORING NUMBER: BG-1 SBP 13
DATE: 10·6·00
GEOLOGIST: K. SIMPSON / K. MARGETTS
DRILLER: NA

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	Soil Density/ Consistency or Rock Hardness	Color	Material Classification	USCS*	Remarks	Sample	Sampler BZ	Borehole**	Driller BZ**	TIME
	0				SOFT	BRN	CLAY & SILT	ML	MOIST ROOTS	0	0	0	0	1010
	1				↓	TAN	↓ ↓	↓	TR RUST COLOR NODULES					
	2				↓	↓	CLAYEY SILT	↓	TR SANDSTONE FRAGS.					1045
	3				STIFF	↓	↓ ↓	↓	↓					
	4													
	5													
	6													
							TD = 3.3'							
							REFUSAL							
							3 ATTEMPTS TO 3' ±							
							1 ATTEMPT TO 1.5' ±							

* When rock coring, enter rock brokeness.

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

Remarks: NORTH 472643
EAST 564188

Drilling Area Background (ppm): 0

Converted to Well: Yes ____ No ✓ Well I.D. #: ____

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NSWC Crane
BORING NUMBER: BG-SBP16
PROJECT NUMBER: 0087 CTO 083
DATE: 10.6.00
DRILLING COMPANY: not applicable
GEOLOGIST: K. SIMPSON / K. MARGETTS
DRILLING METHOD: hand auger
DRILLER: NA

TIME 0920 0935

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	Soil Density/ Consistency or Rock Hardness	Color	Material Classification	USCS*	Remarks	PID/FID Reading (ppm) Sample	Sampler BZ	Borehole**	Driller BZ**
	0				SOFT	BRN	SILT, SOME CLAY	CL	MOIST ROOTS	0	0	0	0
	1				↓	↓	↓ ↓	↓	↓ ↓				
	2												
	3												
	4												
	5												
	6						TD = 1 3/4'						
							REFUSAL						
							6 ATTEMPTS						

DRY STREAM BED ≈ 15' FROM LOCATION, STREAM BED LITTERED WITH BOLDERS
BED ROCK OUTCROP CLOSE TO LOCATION.
ROCK/BOLDERS ON SURFACE IN AREA

* When rock coring, enter rock brokeness.

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

Remarks: NORTH 467836
EAST 564065

Drilling Area Background (ppm): 0

Converted to Well: Yes ____ No ✓ Well I.D. #: ____

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NSWC Crane
BORING NUMBER: BG-1 SBP 22
PROJECT NUMBER: 0087 CTO 083
DATE: 10.5.00
DRILLING COMPANY: not applicable
GEOLOGIST: K. SIMPSON / K. MARGETTS
DRILLING METHOD: hand auger
DRILLER: NA

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	Soil Density/ Consistency or Rock Hardness	Color	Material Classification	U S C S *	Remarks	PID/FID Reading (ppm) Sample	Sampler BZ	Borehole**	Driller BZ**
	0				SOFT	TAN	CLAY, TR SILT	CL	MOIST ROOTS				
	1				MED STIFF		↓ ↓	↓	↓ GRAY MOTTLING	0	0	0	0
	2				↓				↓				
	3						CLAY SOME SILT	↓	↓	0	0	0	0
	4						TR SANDSTONE NODULES						
	5												
	6												
							TD = 4' REFUSAL						
							3 ATTEMPTS TO 4'						
							GPS UNIT NOT RESPONDING						
							AS GOOD AS 10.4.00 !						

TIME 0825

0905

* When rock coring, enter rock brokeness.

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

Remarks: NORTH 459628 (459629)
EAST 553875

Drilling Area Background (ppm): 0

Converted to Well: Yes ____ No ✓ Well I.D. #: ____

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NSWC Crane
PROJECT NUMBER: 0087 CTO 083
DRILLING COMPANY: not applicable
DRILLING METHOD: hand auger

BORING NUMBER: BG-1SBP37
DATE: 10.6.00
GEOLOGIST: K. SIMPSON / K. MARGETTS
DRILLER: NA

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	Soil Density/ Consistency or Rock Hardness	Color	Material Classification	USCS*	Remarks	PID/FID Reading (ppm) Sample	Sampler BZ	Borehole**	Driller BZ**	TIME
	0				SOFT	BRN	CLAY, SOME SILT	CL	MOIST, ROOTS	—	—	—	—	1345
	1				↓	TAN	↓ ↓	↓	↓					
	2				↓		↓ ↓	↓						
	3				MED STIFF		SILT, SOME CLAY	ML						
	4						↓ TR. F. SAND							
	5				↓	↓	SILT, TR CLAY	↓	↓					1415
	6						TR F. SAND →		→ TO SOME					
							TD = 6'							
							PID IS NOT WORKING							

Left margin: 0 (at depth 0), 6 (at depth 6)

* 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):

Remarks: NORTH 464023
EAST 559424

Converted to Well: Yes ____ No ✓ Well I.D. #: ____

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NSWC Crane
PROJECT NUMBER: 0087 CTO 083
DRILLING COMPANY: not applicable
DRILLING METHOD: hand auger

BORING NUMBER: BG-1 SB P39
DATE: 10.4.00
GEOLOGIST: K. SIMPSON
DRILLER: NA

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**	TIME
	0				SOFT	BRN	SILTY CLAY	CL	MOIST TR ROOTS	0	0	0	0	1300
	1				↓	↓	↓	↓	↓					
	2				MED STIFF		MOTTLED GRAY-RUST			0	0	0	0	
	3						↓							
	4						TR F. SAND			0	0	0	0	1340
	5					↓	↓							
	6				↓			↓	↓					
							6' BTM							

* 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: NORTH 468267
EAST 557947

Converted to Well: Yes ____ No ✓ Well I.D. #: ____

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NSWC Crane
PROJECT NUMBER: 0087 CTO 083
DRILLING COMPANY: not applicable
DRILLING METHOD: hand auger

BORING NUMBER: BG-1 SB P 40
DATE: 10 · 6 · 00
GEOLOGIST: K. SIMPSON / K. MARGETTS
DRILLER: NA

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**	TIME
	0				SOFT	BRN	SILT & CLAY	CL	MOIST ROOTS					1440
	1				↓	↓	↓	↓	↓					
	2				↓	↓	↓	↓	GRAY MOTTLING					
	3				MED STIFF	TAN	↓ TR FINE SAND	↓	↓					
	4				↓	↓	CLAY, SOME SILT	↓	↓					1510
	5				↓	↓	↓ *	↓	↓					
	6			6										
							TD = 6'							
							* GRAY w TR. TAN CLAY LAST ½' TR SILT							
							PID NOT WORKING							

* 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):

Remarks: NORTH 470104
EAST 556218

Converted to Well: Yes ____ No ✓ Well I.D. #: ____

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NSWC Crane
PROJECT NUMBER: 0087 CTO 083
DRILLING COMPANY: not applicable
DRILLING METHOD: hand auger
BORING NUMBER: BG1SBP42
DATE: 10.4.00
GEOLOGIST: K. SIMPSON
DRILLER: NA

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	Soil Density/ Consistency or Rock Hardness	Color	Material Classification	USCS*	Remarks	Sample	Sampler BZ	Borehole**	Driller BZ**	TIME
	0				SOFT	OR-BRN	SILTY CLAY	CL	MOIST TR ROOTS	0	0	0	0	1555
	1				MED STIFF	↓	SOME ROCK FRAG.	↓	↓					
	2				↓	TAN	↓ ↓	↓	MOIST TO DRY	0	0	0	0	
	3				STIFF	↓	↓ ↓	↓	↓					1630
	4													
	5													
	6													
							TD = 4' REFUSAL							
							4 ATTEMPTS							

PID/FID Reading (ppm)

* 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: North 472947
East 560509

Converted to Well: Yes ____ No ✓ Well I.D. #: ____

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NSWC Crane
PROJECT NUMBER: 0087 CTO 083
DRILLING COMPANY: not applicable
DRILLING METHOD: hand auger
BORING NUMBER: BG-1 SBP 43
DATE: 10.5.00
GEOLOGIST: K. SIMPSON / K. MARGETTS
DRILLER: NA

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	Soil Density/ Consistency or Rock Hardness	Color	Material Classification	USCS *	Remarks	PID/FID Sample	PID/FID Sampler BZ	PID/FID Borehole**	PID/FID Driller BZ**	TIME
	0				SOFT	BRN	SILT, TR VF SAND, TR CLAY	ML	MOIST ROOTS	0	0	0	0	1035
	1				↓	↓	↓ ↓							
	2				STIFF	TAN	SILT, TR V. F. SAND		TR. RUST COLOR NODULES					
	3				VERY STIFF	↓	↓ ↓	↓	↓	0	0	0	0	1105
	4													
	5													
	6						TD=4' REFUSAL							
							VERY STIFF							
							COULD NOT ADVANCE AUGER							

(Margin depth marks: 0, 6)

* 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: NORTH 469621
EAST 561147

Converted to Well: Yes ____ No ✓ Well I.D. #: ____

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NSWC Crane
PROJECT NUMBER: 0087 CTO 083
DRILLING COMPANY: not applicable
DRILLING METHOD: hand auger
BORING NUMBER: BG-15BP44
DATE: 10-6-00
GEOLOGIST: K. SIMPSON / K. MARGETTS
DRILLER: NA

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	Soil Density/ Consistency or Rock Hardness	Color	Material Classification	USCS*	Remarks	PID/FID Reading (ppm) Sample	Sampler BZ	Borehole**	Driller BZ**
	0				SOFT	BRN	SILT, SOME CLAY	ML	MOIST ROOTS	0	0	0	0
	1				↓	↓	CLAY, SOME SILT	CL					
	2				MED STIFF	LT BRN			GRAY MOTTLING	0	0	1.6	0
	3				↓								
	4				STIFF								
	5				↓	↓	↓	↓	↓				
	6												
							TD = 5.5'						
							REFUSAL						
							ROCK FRAGS. LAST 1/2 FOOT						

TIME 0800
0840

* When rock coring, enter rock brokeness.
** Include monitor reading in 6 foot intervals @ borehole. Increase reading frequency if elevated reponse read.

Remarks: NORTH 470552
EAST 562558

Drilling Area Background (ppm): 0

Converted to Well: Yes ____ No ✓ Well I.D. #: ____

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NSWC Crane
PROJECT NUMBER: 0087 CTO 083
DRILLING COMPANY: not applicable
DRILLING METHOD: hand auger

BORING NUMBER: BG1 SB P45
DATE: 10-4-00
GEOLOGIST: K. SIMPSON
DRILLER: NA

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**	TIME
	0				SOFT	TAN	SILTY CLAY	CL	MOIST TR ROOTS	0	0	0	0	1440
	1				↓		↓	↓	↓					
	2				MED STIFF			↓	SOME GRAY MOTTLING	0	0	0	0	
	3				↓		TRACE F. SAND	ML	↓					
	4													1510
	5													
	6													
							BTM = 4' REFUSAL							
							4 ATTEMPTS							

* 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: NORTH 469093
EAST 562457 AREA LOGGED IN THE PAST

Converted to Well: Yes ____ No ✓ Well I.D. #: ____

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NSWC Crane
PROJECT NUMBER: 0087 CTO 083
DRILLING COMPANY: not applicable
DRILLING METHOD: hand auger
BORING NUMBER: BG-1SB P50
DATE: 10·6·00
GEOLOGIST: K. SIMPSON / K. MARGETTS
DRILLER: NA

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	Soil Density/ Consistency or Rock Hardness	Color	Material Classification	USCS *	Remarks	PID/FID Reading (ppm) Sample	Sampler BZ	Borehole**	Driller BZ**	TIME
	0				SOFT	BRN	CLAYEY SILT TR F. SAND	ML	MOIST ROOTS	—	—	—	—	1240
	1				MED STIFF	TAN	↓ ↓ ↓	↓	↓ SOME SANDSTONE 1.5" Ø MAX					
	2				↓		~~KS SILTY~~							
	3				↓		↓ ↓ ↓	↓	↓ ↓					1312
	4													
	5													
	6													

TD = 3.6' REFUSAL
3 ATTEMPTS
3', 3', 3.6'

SBP50 IS ≈ 250' DOWN GRADIENT FROM SLUDGE AP. AREA SEE FIG.

PID IS NOT WORKING, NO READINGS
DAMP WEATHER?

* 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):

Remarks: NORTH 473937
EAST 560500

Converted to Well: Yes ____ No ✓ Well I.D. #: ____

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NSWC Crane
BORING NUMBER: BG3SBA07
PROJECT NUMBER: 0087 CTO 083
DATE: 10.7.00
DRILLING COMPANY: not applicable
GEOLOGIST: K. SIMPSON / K. MARGETTS
DRILLING METHOD: hand auger
DRILLER: NA

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**	TIME
	0				SOFT	BRN	CLAYEY SILT	ML	MOIST ROOTS	—	—	—	—	1420
	1				↓	↓	↓	↓	SOME RUST COLOR NODULES					
	2				↓	↓	↓	↓	↓					
	3			▼	↓	↓	↓	↓	↓					1450
	4				↓	↓	↓	↓	↓					
	5													
	6													
							TD = 3.5'		REFUSAL					
							4 ATTEMPTS							
							WATER @ 2.5'							
							PID IS NOT WORKING							

* 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): ___

Remarks: NORTH 507270
EAST 544851

Converted to Well: Yes ___ No ✓ Well I.D. #: ___

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NSWC Crane
PROJECT NUMBER: 0087 CTO 083
DRILLING COMPANY: not applicable
DRILLING METHOD: hand auger
BORING NUMBER: BG3SB P01
DATE: 10-4-00
GEOLOGIST: K. SIMPSON
DRILLER: NA

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**
	0				LOOSE	BR	CLAYEY SILT	ML	MOIST, ROOTS	0	0	0	0
	1				LOOSE	LT BR	W/F SAND	↓	↓ ↓				
	2				SOFT		SILTY CLAY	CL	↓	0	0	0	0
	3				↓		TR FINE SAND	↓	RUST COLOR				
	4				MED. STIFF	↓	SANDY SILT	ML	NODULES				
	5			BTM BS	↓	TAN	W/ TR FINE SAND	↓	MOIST SOME GRAVEL	0	0	0	0
	6			BTM					1" Ø MAX				
							TD = 5' REFUSAL						
							SOME SILT STONE		1" Ø IN				
							LAST 2' (4-5)						

TIME 0920 → 1015

* When rock coring, enter rock brokeness.
** Include monitor reading in 6 foot intervals @ borehole. Increase reading frequency if elevated reponse read.

Remarks: EAST 609434
NORTH 510726

Drilling Area Background (ppm): 0

Converted to Well: Yes ____ No ✓ Well I.D. #: ____

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NSWC Crane
PROJECT NUMBER: 0087 CTO 083
DRILLING COMPANY: not applicable
DRILLING METHOD: hand auger

BORING NUMBER: BG-3 SB P08
DATE: 10.5.00
GEOLOGIST: K. SIMPSON / K. MARGETTS
DRILLER: NA

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**
	0				SOFT	BRN	SILTY CLAY	CL	MOIST ROOTS				
	1				↓	TAN	CLAY, TR SILT		TR ROCK FRAG (SAND)	0	0	0	0
	2				MED STIFF	↓	↓		GRAY/RUST COLOR MOTTL NG				
	3				↓	GRAY	↓		↓				
	4				↓	↓	↓		↓	0	0	23	0
	5				STIFF	↓	↓		↓				
	6			—									
							TD = 6'						
							TR ROCK FRAG. SAND STONE 1' TO BTM W/ GRAY & RUST MOTTLING						

TIME 1600 (0 ft); 1650 (6 ft)

* 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: NORTH 508563
EAST 600344

Converted to Well: Yes ____ No ✓ Well I.D. #: ____

Tetra Tech NUS, Inc.

BORING LOG

PROJECT NAME: NSWC Crane
PROJECT NUMBER: 0087 CTO 083
DRILLING COMPANY: not applicable
DRILLING METHOD: hand auger
BORING NUMBER: BG3 SB P09
DATE: 10.4.00
GEOLOGIST: K. SIMPSON
DRILLER: NA

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	Soil Density/ Consistency or Rock Hardness	Color	Material Classification	USCS *	Remarks	PID/FID Reading (ppm) Sample	Sampler BZ	Borehole**	Driller BZ**	TIME
	0				SOFT	BRN	SILTY CLAY	CL	MOIST, ROOTS	0	0	0	0	1050
	1				↓	↓	↓	↓	↓ MOTTLED RUST/GRAY					
	2				MED STIFF	LT BRN	CLAY, TR SILT	↓	↓	0	0	0	0	
	3				STIFF	↓	↓ TR SANDSTONE	↓	↓					
	4				↓	↓	↓	↓	↓	0	0	0	0	
	5				MED STIFF	GRAY BRN	↓ SOME SILT STONE	↓	↓ SHALE					1125
	6													
							TD = 6'							

* 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: EAST 599316
NORTH 509802 SOME LOGGING IN THE PAST, ≈200' FROM BORING

Converted to Well: Yes ____ No ✓ Well I.D. #: ____

APPENDIX C

ANALYTICAL DATABASE

C-1 ANALYTICAL DATABASE

C-2 DATA VALIDATION SUMMARY

TABLE C-1
APPENDIX C-1

First Field Event

SUMMARY OF BACKGROUND SAMPLES
NAVAL SURFACE WARFARE CENTER
CRANE, INDIANA

Background Area/ Depostional Envir./ Sample Location	Soil Samples Collected in the Field Depth in Feet Below Ground Surface					Number of Samples Collected for Chemical Analysis
Background Area 1	0-1	2-3	3-4	4-5	5-6	
Loess/Glacial Outwash						
BG1SBL01	**silt**	**clay**	clay	**silt**	N/A	3
BG1SBL02	silt	silt	clay	clay	silt	0
BG1SBL03	silt	clay	clay	**clay**	clay	1
BG1SBL04	silt	**clay**	clay	**silt**	clay	2
BG1SBL05	**silt**	clay	**silt**	silt	**clay**	3
Alluvium						
BG1SBA01	**silt**	silt	**silt**	N/A	N/A	2
BG1SBA02	silt	N/A	N/A	N/A	N/A	0
BG1SBA03	sand	silt	silt	silt	**silt**	1
BG1SBA04	**clay**	clay	clay	**clay**	clay	2
BG1SBA05	sand	**silt**	**sand**	N/A	N/A	2
Residual Soil from Pennsylvanian Bedrock/Colluvium						
BG1SBP01	silt	**silt**	silt	silt	N/A	1
BG1SBP02	silt	clay	**clay**	silt	**silt**	2
BG1SBP03	silt	clay	clay	**clay**	clay	1
BG1SBP04	**silt**	silt	clay	clay	**clay**	2
BG1SBP05	silt	clay	clay	**clay**	clay	1
BG1SBP06	**clay**	**silt**	N/A	N/A	N/A	2
BG1SBP07	**sand**	N/A	N/A	N/A	N/A	1
BG1SBP08	**silt**	silt	**silt**	sand	**sand**	3
BG1SBP09	**silt**	N/A	N/A	N/A	N/A	1
BG1SBP10	clay	silt	**silt**	N/A	N/A	1
Background Area 2						
Glacial Outwash/Loess						
BG2SBG1	**clay**	clay	**sand**	sand	sand	2
BG2SBG2	**silt**	**silt**	silt	silt	**clay**	3
BG2SBG3	silt	**sand**	sand	sand	sand	1
BG2SBG4	**silt**	silt	**silt**	N/A	N/A	2
BG2SBG5	clay	**sand**	N/A	N/A	N/A	1
Background Area 3						
Alluvium						
BG3SBA01	**silt**	silt	N/A	N/A	N/A	1
BG3SBA02	silt	**sand**	sand	sand	N/A	1
BG3SBA03	**silt**	N/A	N/A	N/A	N/A	1
BG3SBA04	silt	**silt**	**sand**	sand	sand	2
BG3SBA05	**silt**	silt	**silt**	sand	**sand**	3
Residual Soils from Mississippian Bedrock/Colluvium						
BG3SBM01	silt	silt	N/A	N/A	N/A	0
BG3SBM02	**silt**	**silt**	silt	silt	**clay**	3
BG3SBM03	silt	silt	silt	**silt**	silt	1
BG3SBM04	**silt**	clay	**clay**	sand	**sand**	3
BG3SBM05	silt	clay	**sand**	sand	sand	1
BG3SBM06	**silt**	clay	**sand**	N/A	N/A	2
BG3SBM07	**silt**	silt	**silt**	clay	**clay**	3
BG3SBM08	**silt**	**sand**	N/A	N/A	N/A	2
BG3SBM09	silt	silt	**silt**	N/A	N/A	1
BG3SBM10	clay	**clay**	silt	silt	N/A	1
Total Number of Samples Collected for Chemical Analysis						65

Notes:
sand =Samples Collected for Chemical Analysis and the grain size classification
N/A - sample not collected in the field because one of the conditions discussed in Section 3.4.2.1 were encountered (i.e., borehole refusal, bedrock or the saturated zone was encounted).

TABLE C-1
APPENDIX C-1

Supplemental Field Event

SUMMARY OF BACKGROUND SAMPLES
NAVAL SURFACE WARFARE CENTER
CRANE, INDIANA

Background Area/ Depositional Envir./ Sample Location	Soil Samples Collected in the Field Depth in Feet Below Ground Surface					Number of Sample Collecteed for Chemical Analysis
Background Area 1	0-1	2-3	3-4	4-5	5-6	
Alluvium						
BG1SBA25	clay	clay	clay	clay	clay	1
BG1SBA28	clay	clay	clay	N/A	N/A	1
BG1SBA29	clay	N/A	N/A	N/A	N/A	0
BG1SBA38	silt	silt	N/A	N/A	N/A	0
Residual Soil from Pennsylvanian Bedrock/Colluvium						
BG1SBP11	clay	clay	clay	clay	clay	0
BG1SBP13	clay	clay	N/A	N/A	N/A	0
BG1SBP16	silt	N/A	N/A	N/A	N/A	0
BG1SBP22	clay	clay	clay	N/A	N/A	0
BG1SBP37	clay	clay	silt	silt	silt	0
BG1SBP39	clay	clay	clay	clay	clay	0
BG1SBP40	silt	clay	clay	clay	clay	0
BG1SBP42	clay	clay	clay	N/A	N/A	0
BG1SBP43	silt	silt	silt	N/A	N/A	0
BG1SBP44	silt	silt	silt	silt	silt	0
BG1SBP45	clay	clay	clay	N/A	N/A	0
BG1SBP50	silt	silt	silt	N/A	N/A	0
Background Area 3						
Alluvium						
BG3SBA07	silt	silt	silt	N/A	N/A	0
Residual Soil from Pennsylvanian Bedrock/Colluvium						
BG3SBP01	silt	clay	clay	silt	N/A	0
BG3SBP08	clay	clay	clay	clay	clay	0
BG3SBP09	clay	clay	clay	clay	clay	0
Total number of samples Collected for Chemical Analysis						2
Total number of samples Collected for Chemical Analysis (All Field Events)						**67**

C-1 ANALYTICAL DATABASE

TABLE C-2

ANALYTICAL DATABASE
SOIL RESULTS
NAVAL SURFACE WARFARE CENTER
CRANE, INDIANA

Location	BG1SBA01	BG1SBA01	BG1SBA03	BG1SBA04	BG1SBA04	BG1SBA05	BG1SBA05	BG1SBA25	BG1SBA25	BG1SBA25
nsample	BG1SBA0101	BG1SBA0104	BG1SBA0306	BG1SBA0401	BG1SBA0405	BG1SBA0503	BG1SBA0504	BG1SBA250203	BG1SBA250203-D	BG1SBA250203-MAX
sample	BG1SBA0101	BG1SBA0104	BG1SBA0306	BG1SBA0401	BG1SBA0405	BG1SBA0503	BG1SBA0504	BG1SBA250203	BGFD10070001	BG1SBA250203
Sample Date	11/04/99	11/04/99	11/05/99	11/05/99	11/05/99	11/04/99	11/04/99	10/06/00	10/07/00	10/06/00
QC Type	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM
Deposit. Env.	ALLUVIUM	ALLUVIUM	ALLUVIUM	ALLUVIUM	ALLUVIUM	ALLUVIUM	ALLUVIUM	ALLUVIUM	ALLUVIUM	ALLUVIUM
Grain Size	SILT	SILT	SILT	CLAY	CLAY	SILT	SAND	CLAY	CLAY	CLAY
depth	SS	SB	SB	SS	SB	SB	SB	SB	SB	SB
Duplicate	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	DUP	DUP	MAX
Matrix	SO	SO	SO	SO	SO	SO	SO	SO	SO	SO
Top Depth	0	3	5	0	4	2	3	2	2	2
Bottom Depth	1	4	6	1	5	3	4	3	3	3
Metal (mg/kg)										
ALUMINUM	8070 J	8180 J	6620 J	6920 J	7870 J	7040 J	6210 J	16000 J	16700 J	16700 J
ANTIMONY	0.53 U	0.39 U	1.8 U	0.37 U	0.36 U	0.46 U	0.52 U	0.45 U	0.49	0.49
ARSENIC	7.9	4	7.5	4	2.8 J	2.8	10	5.9	5.7	5.9
BARIUM	76.6 J	50.8 J	55.6 J	59.1 J	78.5 J	44.1 J	46 J	80.4 J	77.2 J	80.4 J
BERYLLIUM	1.4 U	0.69 U	0.96 U	0.35 U	0.65 U	0.56 U	0.8 U	0.82	0.74	0.82
CADMIUM	0.29 U	0.15 U	0.1 U	0.3 U	0.15 J	0.09 U	0.09 U	0.44 J	0.41 J	0.44 J
CALCIUM	5 U	121 J	279 J	896 J	406 J	299 J	269 J	313	287	313
CHROMIUM	21.7 J	12.1 J	12.1 J	10.2 J	10.5 J	9.4 J	19.6 J	17.3 J	14.6 J	17.3 J
COBALT	18	8.5	7.2	6	5.2	5.3	18	7.5	6.1	7.5
COPPER	9.8	6.9	6.7	8.8	6.5	6.8	9.9	10.1 J	10.3 J	10.3 J
IRON	36200 J	13000 J	19200 J	12100 J	9680 J	10500 J	29400 J	22700 J	17200 J	22700 J
LEAD	21.5 J	10 J	10.1 J	9.4 J	7.8 J	7.9 J	14.5 J	13.1	11.4	13.1
LITHIUM		15.8 J	10.6 J	13.6 J	17.4 J	17.1 J	16.3 J	20.3 J	20.7 J	20.7 J
MAGNESIUM	620 J	739 J	565 J	967 J	903 J	691 J	520 J	1400 J	1470 J	1470 J
MANGANESE	1950 J	554 J	461 J	417 J	505 J	356 J	1090 J	1030 J	713 J	1030 J
MERCURY	0.05	0.11	0.05 U	0.05 U	0.05 U	0.04 U	0.04 U	0.04	0.04	0.04
NICKEL	20 J	9.4 J	9.6 J	10.3 J	12.4 J	8.5 J	13.1 J	13	12	13
POTASSIUM	644	664	464 J	607 J	640 J	601	528	1370 J	1440 J	1440 J
SELENIUM	0.82 U	0.49 U	0.76 U	0.45 U	0.75	0.42 U	0.58 U	0.46 U	0.44 U	0.46 U
SILVER	0.05 J	0.05 J	0.05 J	0.05 J	0.05 J	0.05 J	0.04 J	0.23 U	0.22 U	0.23 U
SODIUM	2.4 U	3.7 J	5.5 U	2.5 U	24.7 U	4.3 J	2.2 U	80.3 J	77.1 J	80.3 J
STRONTIUM		7.0 J	5.5 J	13.7 J	11.6 J	7.9 J	8.2 J	12.7	12.8	12.8
THALLIUM	0.19 J	0.15 J	0.1 J	0.1 J	0.15 J	0.14 J	0.13 J	0.25 J	0.27 J	0.27 J
THORIUM		6.2 J	4.2 J	6.3 J	6.9 J	6.3 J	6.3 J	8.4 J	8.7 J	8.7 J
TIN	0.63 U	0.49 U	0.45 U	0.53 U	0.52 U	0.55 U	0.43 U	0.38 U	0.36 U	0.38 U
VANADIUM	30.7 J	19 J	19.4 J	17.5 J	16.7 J	15.6 J	22.8 J	26.3 J	26.1 J	26.3 J
ZINC	37.6 J	22.3 U	22.2 J	24.4 J	29.1 J	22.2 U	28.3 U	42.9	41.7	42.9

Notes:
NM - Normal soil sample
LD - Lab duplicate
MS - Matrix spike
RB - Rinsate Blank
LC - Lab Control Sample
PB - Lab Prep Blank
MG/KG - milligram per kilogram

TABLE C-2

ANALYTICAL DATABASE
SOIL RESULTS
NAVAL SURFACE WARFARE CENTER
CRANE, INDIANA

Location	BG1SBA28	BG1SBL01	BG1SBL01	BG1SBL01	BG1SBL03	BG1SBL04	BG1SBL04	BG1SBL05	BG1SBL05	BG1SBL05
nsample	BG1SBA280304	BG1SBL0101	BG1SBL0103	BG1SBL0105	BG1SBL0305	BG1SBL0403	BG1SBL0405	BG1SBL0501	BG1SBL0504	BG1SBL0504-D
sample	BG1SBA280304	BG1SBL0101	BG1SBL0103	BG1SBL0105	BG1SBL0305	BG1SBL0403	BG1SBL0405	BG1SBL0501	BG1SBL0504	BGFD11089901
Sample Date	10/07/00	11/08/99	11/08/99	11/08/99	11/08/99	11/08/99	11/08/99	11/08/99	11/08/99	11/08/99
QC Type	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM
Deposit. Env.	ALLUVIUM	LOESS	LOESS	LOESS	LOESS	LOESS	LOESS	LOESS	LOESS	LOESS
Grain Size	CLAY	SILT	CLAY	SILT	CLAY	CLAY	SILT	SILT	SILT	SILT
depth	SB	SS	SB	SB	SB	SB	SB	SS	SB	SB
Duplicate	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	DUP	DUP
Matrix	SO	SO	SO	SO	SO	SO	SO	SO	SO	SO
Top Depth	3	0	2	4	4	2	4	0	3	3
Bottom Depth	4	1	3	5	5	3	5	1	4	4
Metal (mg/kg)										
ALUMINUM	12000 J	13600 J	16100 J	12400 J	12500	14700	10900 J	13000	12800	11800
ANTIMONY	0.46 U	0.44 U	0.53 U	0.4 U	3.3 U	1.7 U	0.43 U	0.5 U	0.35 U	0.4 U
ARSENIC	5.6	6.8	3.8	4.9	3.8	4.4	4.8	5.7	4.9	5.5
BARIUM	36.9 J	155 J	72.4 J	52.9 J	94.4 J	55.8 J	47.5 J	122 J	80.6 J	65.1 J
BERYLLIUM	0.54	1.1 U	0.3 U	0.36 U	0.51 J	0.2 U	0.43 U	0.67 J	0.31 J	0.29 U
CADMIUM	0.33 J	0.26 U	0.3 U	0.21 U	0.04 U	0.05 U	0.17 U	0.05 U	0.04 U	0.08 U
CALCIUM	108	547	506	316	710	253	490	419	493	455
CHROMIUM	20.9 J	14.3 J	19.6 J	16.4 J	23.5 J	17.8 J	13.8 J	14.4 J	19.6 J	18.9 J
COBALT	2.2	17.1	4.1	3.6	4.7	4	5.1	16.8	6.5	5.5
COPPER	10 J	10.3	16.4	8.7	11.6	9.8	10.1	9.7	15.7	14.2
IRON	28900 J	15800 J	17400 J	17500 J	25400	18300	16800 J	15900	21100	20000
LEAD	10.1	17.1 J	9.3 J	8.8 J	9.3 J	9.6 J	9.3 J	15.8 J	11.7 J	9.4 J
LITHIUM	27.9 J	13.5 J	12.7 J	12.4 J	22.3 J	14.1 J	10.8 J	14.5 J	11.9 J	13.6 J
MAGNESIUM	755 J	1360 J	2350 J	1250 J	1740 J	1730 J	1440 J	1290 J	2340 J	2090 J
MANGANESE	86.4 J	1960 J	55.2 J	141 J	90.6 J	134 J	199 J	1840 J	236 J	212 J
MERCURY	0.05 U	0.05 U	0.05	0.04 U	0.05 U	0.07	0.04 U	0.05	0.05 U	0.04 U
NICKEL	9.5	17.4 J	10.3 J	7.3 J	11.8 J	8.8 J	8.9 J	15.8 J	12.6 J	10.8 J
POTASSIUM	1650 J	978	1240	496	729	830	629	896	848	814
SELENIUM	0.44 U	0.94 U	0.34 U	0.52 U	0.26 U	0.29 U	0.43 U	0.58 U	0.27 U	0.25 U
SILVER	0.22 U	0.05 J	0.04 J	0.05 J	0.04 U	0.05 U	0.04 J	0.05 U	0.04 U	0.04 U
SODIUM	97.8 J	7.2 J	54.1	90.2	129	81.9	133	17.8 J	98.1	92.6
STRONTIUM	12.2	12.6 J	16.2 J	9.7 J	17.0 J	10.5 J	11.4 J	10.9 J	13.3 J	14.3 J
THALLIUM	0.22 U	0.31 J	0.26 J	0.15 J	0.13 J	0.2 J	0.17 J	0.29 J	0.18 J	0.17 J
THORIUM	9 J	7.2 J	8.6 J	6.3 J	8.7 J	8.4 J	7.2 J	8.7 J	7.8 J	7.7 J
TIN	0.4 U	0.55 U	0.83 U	0.55 U	0.66 U	0.66 U	0.59 U	0.64 U	0.66 U	0.62 U
VANADIUM	19.9 J	30.7	31	29.8	34.3	31.4	25.4	28.6	30	31.1
ZINC	25.4	44.8 U	38.8 U	15.3 U	25.8 U	34.8 U	27.1 U	43.5 U	36.7 U	32.6 U

Notes:
NM - Normal soil sample
LD - Lab duplicate
MS - Matrix spike
RB - Rinsate Blank
LC - Lab Control Sample
PB - Lab Prep Blank
MG/KG - milligram per kilogram

TABLE C-2

ANALYTICAL DATABASE
SOIL RESULTS
NAVAL SURFACE WARFARE CENTER
CRANE, INDIANA

Location	BG1SBL05	BG1SBL05	BG1SBP01	BG1SBP02	BG1SBP02	BG1SBP03	BG1SBP04	BG1SBP04	BG1SBP04	BG1SBP04
nsample	BG1SBL0504-MAX	BG1SBL0506	BG1SBP0103	BG1SBP0204	BG1SBP0206	BG1SBP0305	BG1SBP0401	BG1SBP0406	BG1SBP0406-D	BG1SBP0406-MAX
sample	BG1SBL0504	BG1SBL0506	BG1SBP0103	BG1SBP0204	BG1SBP0206	BG1SBP0305	BG1SBP0401	BG1SBP0406	BGFD11069901	BG1SBP0406
Sample Date	11/08/99	11/08/99	11/06/99	11/06/99	11/06/99	11/06/99	11/06/99	11/06/99	11/06/99	11/06/99
QC Type	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM
Deposit. Env.	LOESS	LOESS	PENNSYLVANIAN	PENNSYLVANIAN	PENNSYLVANIAN	PENNSYLVANIAN	PENNSYLVANIAN	PENNSYLVANIAN	PENNSYLVANIAN	PENNSYLVANIAN
Grain Size	SILT	CLAY	SILT	CLAY	SILT	CLAY	SILT	CLAY	CLAY	CLAY
depth	SB	SB	SB	SB	SB	SB	SS	SB	SB	SB
Duplicate	MAX	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	DUP	DUP	MAX
Matrix	SO	SO	SO	SO	SO	SO	SO	SO	SO	SO
Top Depth	3	5	2	3	5	4	0	5	5	5
Bottom Depth	4	6	3	4	6	5	1	6	6	6
Metal (mg/kg)										
ALUMINUM	12800	16600	15700	15300	16200	9070	12200	10500	9550 J	10500
ANTIMONY	0.4 U	10.8 J	0.97 U	0.77 U	0.68 U	0.4 U	0.72 U	0.48 U	5.5 U	5.5 U
ARSENIC	5.5	5.5	8 J	8.5 J	6 J	5.6 J	5.2 J	1.4 J	1.1	1.4 J
BARIUM	80.6 J	81.3 J	55.4 J	79.5 J	73.6 J	25.1 J	72.2 J	52.6 J	53.5 J	53.5 J
BERYLLIUM	0.31 J	0.69 J	0.52 U	0.56 U	1.2 U	1 U	0.68 U	0.93 U	0.97 U	0.97 U
CADMIUM	0.08 U	0.04 U	0.29 J	0.36 J	0.64	0.1 J	0.26 J	0.05 U	0.08 U	0.08 U
CALCIUM	493	688	199	543	650	85.2 J	255	835	963	963
CHROMIUM	19.6 J	25.5 J	21.3 J	21.6 J	27.1 J	19.6 J	13.7 J	14.7 J	13.6 J	14.7 J
COBALT	6.5	5.3	9.1	6.8	12.5	12.1	15.1	5.9	6.2	6.2
COPPER	15.7	12.5	18	20.4	14.2	23.8	9.8	10.1	12.1	12.1
IRON	21100	27700	24500 J	24600 J	31500 J	40800 J	15600 J	14800 J	14500 J	14800 J
LEAD	11.7 J	11.7 J	13.7 J	11.1 J	14.6 J	13.9 J	13.6 J	8.2 J	8.6 J	8.6 J
LITHIUM	13.6 J	28.1 J	19.6 J	13.8 J	15.1 J	46.6 J	15.0 J	24.8 J	23.5 J	24.8 J
MAGNESIUM	2340 J	1810 J	2390 J	2870 J	2010 J	1100 J	1430 J	1660 J	1780 J	1780 J
MANGANESE	236 J	99.2 J	301 J	222 J	444 J	323 J	577 J	29 J	24.9 J	29 J
MERCURY	0.05 U	0.04 U	0.14	0.05 U	0.05 U	0.04 U	0.05 U	0.04 U	0.04 U	0.04 U
NICKEL	12.6 J	11.4 J	14.6 J	13.4 J	15.7 J	23.7 J	13.1 J	9.6 J	10 J	10 J
POTASSIUM	848	828	1170	1290	988	1290	831	697	801	801
SELENIUM	0.27 U	0.23 U	0.43 J	0.56	0.88	0.56	0.63	0.42 J	0.46 U	0.42 J
SILVER	0.04 U	0.04 U	0.05 J	0.05 J	0.1 J	0.05 J	0.11 J	0.05 U	0.04 U	0.05 U
SODIUM	98.1	153	10 J	76.8	145	25.9 J	16.1 J	191	205	205
STRONTIUM	14.3 J	17.0 J	10.3 J	19.2 J	10.4 J	11.8 J	9.4 J	20.3 J	17.9 J	20.3 J
THALLIUM	0.18 J	0.19 J	0.24 J	0.25 J	0.25 J	0.15 J	0.21 J	0.14 J	0.13 J	0.14 J
THORIUM	7.8 J	9.1 J	9.1 J	9.3 J	7.1 J	11.7 J	7.5 J	11.1 J	10.6 J	11.1 J
TIN	0.66 U	0.93 U	0.74 U	0.82 U	0.5 U	0.65 U	0.67 U	0.65 U	0.88 U	0.88 U
VANADIUM	31.1	42.4	37.8 J	38.2 J	48.5 J	26.6 J	28.4 J	20.9 J	18.7 J	20.9 J
ZINC	36.7 U	24.6 U	45.2 J	47.8 J	31.4 J	58.2 J	41.4 J	25.8 J	30.3 J	30.3 J

Notes:
NM - Normal soil sample
LD - Lab duplicate
MS - Matrix spike
RB - Rinsate Blank
LC - Lab Control Sample
PB - Lab Prep Blank
MG/KG - milligram per kilogram

TABLE C-2

ANALYTICAL DATABASE
SOIL RESULTS
NAVAL SURFACE WARFARE CENTER
CRANE, INDIANA

Location	BG1SBP05	BG1SBP06	BG1SBP06	BG1SBP06	BG1SBP06	BG1SBP07	BG1SBP08	BG1SBP08	BG1SBP08	BG1SBP09
nsample	BG1SBP0505	BG1SBP0601	BG1SBP0601-D	BG1SBP0601-MAX	BG1SBP0603	BG1SBP0701	BG1SBP0801	BG1SBP0804	BG1SBP0806	BG1SBP0901
sample	BG1SBP0505	BG1SBP0601	BGFD11059901	BG1SBP0601	BG1SBP0603	BG1SBP0701	BG1SBP0801	BG1SBP0804	BG1SBP0806	BG1SBP0901
Sample Date	11/05/99	11/05/99	11/05/99	11/05/99	11/05/99	11/05/99	11/06/99	11/06/99	11/06/99	11/06/99
QC Type	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM
Deposit. Env.	PENNSYLVANIAN	PENNSYLVANIAN	PENNSYLVANIAN	PENNSYLVANIAN	PENNSYLVANIAN	PENNSYLVANIAN	PENNSYLVANIAN	PENNSYLVANIAN	PENNSYLVANIAN	PENNSYLVANIAN
Grain Size	CLAY	CLAY	CLAY	CLAY	SILT	SAND	SILT	SILT	SAND	SILT
depth	SB	SS	SS	SS	SB	SS	SS	SB	SB	SS
Duplicate	NORMAL	DUP	DUP	MAX	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL
Matrix	SO	SO	SO	SO	SO	SO	SO	SO	SO	SO
Top Depth	4	0	0	0	2	0	0	3	5	0
Bottom Depth	5	1	1	1	3	1	1	4	6	1
Metal (mg/kg)										
ALUMINUM	13800 J	14800 J	14900 J	14900 J	13200 J	6770 J	17400	12500	5430	9300
ANTIMONY	11.3 J	0.61 U	0.56 U	0.61 U	0.42 U	0.26 U	1.8 U	1.2 U	0.76 U	3.2 U
ARSENIC	2.5 J	6.8 J	7.9	7.9 J	5.9 J	2.4 J	8.5 J	6.4 J	2.9 J	4.7 J
BARIUM	83.4 J	66.7 J	69.3 J	69.3 J	36.9 J	46.1 J	75 J	56.1 J	24.8 J	77.1 J
BERYLLIUM	0.7 U	0.6 U	0.69 U	0.69 U	0.49 U	0.96 U	0.56 U	0.55 U	0.28 U	0.84 U
CADMIUM	0.05 J	0.45 J	0.16 U	0.45 J	0.2 J	0.19 J	0.61	0.35 J	0.14 J	0.1 J
CALCIUM	970 J	405 J	401 J	405 J	340 J	115 J	418	144	53.6 J	278
CHROMIUM	19.1 J	17.6 J	17.1 J	17.6 J	24.7 J	8.5 J	19.9 J	14.2 J	7.7 J	13.3 J
COBALT	6	10.4	11.5	11.5	6.7	10.2	8.5	10.3	8.8	13.1
COPPER	11	12.2	12.2	12.2	13.6	5.4	17.1	11.9	5.6	9.4
IRON	19500 J	19700 J	19300 J	19700 J	27200 J	12300 J	23400 J	18300 J	11300 J	15900 J
LEAD	9.3 J	13 J	14.3 J	14.3 J	15.2 J	10.7 J	13.8 J	11.3 J	11.7 J	13.7 J
LITHIUM	31.7 J	19.0 J	18.1 J	19 J	28.7 J	14.7 J	14.5 J	14.5 J	8.6 J	29.9 J
MAGNESIUM	1800 J	1910 J	1880 J	1910 J	1810 J	712 J	2250 J	1960 J	654 J	988 J
MANGANESE	71.8 J	389 J	444 J	444 J	274 J	606 J	268 J	457 J	327 J	1480 J
MERCURY	0.05 U	0.05 U	0.07	0.07	0.05 U	0.05	0.04	0.05 U	0.04 U	0.05 U
NICKEL	10.3 J	14.6 J	14 J	14.6 J	11.3 J	13.2 J	15.9 J	12.5 J	4.6 J	15.2 J
POTASSIUM	718 J	1110 J	1100 J	1110 J	900 J	418 J	1490	866	353	889
SELENIUM	0.28 U	0.55	0.8 U	0.55	0.39 J	0.58	0.51	0.45 J	0.28 J	0.64
SILVER	0.05 J	0.1 J	0.05 J	0.1 J	0.05 J	0.05 J	0.1 J	0.05 J	0.05 J	0.05 J
SODIUM	125 U	22.6 U	12.4 U	22.6 U	30.6 U	2.41 U	18.1 J	11.7 J	2.3 U	14.2 J
STRONTIUM	17.2 J	13.7 J	11.4 J	13.7 J	13.0 J	8.7 J	10.7 J	10.0 J	5.4 J	12.7 J
THALLIUM	0.19 J	0.25 J	0.27 J	0.27 J	0.2 J	0.14 J	0.25 J	0.2 J	0.09 J	0.2 J
THORIUM	8.8 J	8.4 J	8.3 J	8.4 J	8.8 J	5.9 J	8.5 J	8.0 J	4.9 J	7.9 J
TIN	0.91 U	0.61 U	0.77 U	0.77 U	0.6 U	0.51 U	0.8 U	0.6 U	0.43 U	0.6 U
VANADIUM	30 J	34.6 J	34.6 J	34.6 J	38.5 J	17.1 J	40 J	30 J	14.1 J	20.4 J
ZINC	24.3 J	43.1 J	41.9 J	43.1 J	29.4 J	32.7 J	52.6 J	35.5 J	11.4 J	36.2 J

Notes:
NM - Normal soil sample
LD - Lab duplicate
MS - Matrix spike
RB - Rinsate Blank
LC - Lab Control Sample
PB - Lab Prep Blank
MG/KG - m[illegible]m per kilogram

TABLE C-2

ANALYTICAL DATABASE
SOIL RESULTS
NAVAL SURFACE WARFARE CENTER
CRANE, INDIANA

Location	BG1SBP10	BG2SBG01	BG2SBG01	BG2SBG02	BG2SBG02	BG2SBG02	BG2SBG03	BG2SBG03	BG2SBG03	BG2SBG04
nsample	BG1SBP1004	BG2SBG0101	BG2SBG0104	BG2SBG0201	BG2SBG0203	BG2SBG0206	BG2SBG0303	BG2SBG0303-D	BG2SBG0303-MAX	BG2SBG0401
sample	BG1SBP1004	BG2SBG0101	BG2SBG0104	BG2SBG0201	BG2SBG0203	BG2SBG0206	BG2SBG0303	BGFD11079901	BG2SBG0303	BG2SBG0401
Sample Date	11/05/99	11/07/99	11/07/99	11/07/99	11/07/99	11/07/99	11/07/99	11/07/99	11/07/99	11/07/99
QC Type	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM
Deposit. Env.	PENNSYLVANIAN	GLACIAL	GLACIAL	GLACIAL	GLACIAL	GLACIAL	GLACIAL	GLACIAL	GLACIAL	GLACIAL
Grain Size	SILT	CLAY	SAND	SILT	SILT	CLAY	SAND	SAND	SAND	SILT
depth	SB	SS	SB	SS	SB	SB	SB	SB	SB	SS
Duplicate	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	DUP	DUP	MAX	DUP
Matrix	SO	SO	SO	SO	SO	SO	SO	SO	SO	SO
Top Depth	3	0	3	0	2	5	2	2	2	0
Bottom Depth	4	1	4	1	3	6	3	3	3	1
Metal (mg/kg)										
ALUMINUM	10900 J	14300 J	13700 J	7940 J	7570 J	16000 J	9340 J	11100 J	11100 J	9560 J
ANTIMONY	0.31 U	0.51 U	0.41 U	0.38 U	0.39 U	0.2 U	0.36 U	0.23 U	0.36 U	0.4 U
ARSENIC	5.3 J	5.8	4.9	3.6	2.2	1.1	1.3	1.2	1.3	3.9
BARIUM	49.1 J	114 J	79.1 J	90.8 J	42.4 J	41.7 J	38.1 J	44.5 J	44.5 J	115 J
BERYLLIUM	0.42 U	0.6 J	0.3 J	0.48 J	0.18 U	0.37 J	0.21 U	0.24 U	0.24 U	0.73 J
CADMIUM	0.28 J	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.04 U	0.05 U	0.05 U	0.1 U
CALCIUM	333 J	521 J	430 J	345 J	277 J	411 J	370 J	397 J	397 J	1040 J
CHROMIUM	17 J	15.1 J	15.7 J	9.8 J	9.2 J	14.7 J	9.5 J	10.3 J	10.3 J	10.5 J
COBALT	5.2	13	7.3	9.3	3.8	2.7	1.7	1.8	1.8	14.1
COPPER	13	11.3	12.6	6.5	4.3	4.6	4.1	4.3	4.3	7
IRON	18600 J	17400 J	17500 J	10100 J	9130 J	13900 J	7090 J	7140 J	7140 J	11400 J
LEAD	8.9 J	13.5 J	8.9 J	12 J	6.9 J	10.8 J	6.8 J	7.3 J	7.3 J	14.7 J
LITHIUM	13.7 J	13.2 J	14.5 J	10.0 J	9.2 J	10.8 J	9.7 J	11.3 J	11.3 J	12.3 J
MAGNESIUM	1900 J	1810 J	1900 J	1030 J	760 J	959 J	847 J	930 J	930 J	1180 J
MANGANESE	249 J	1060 J	376 J	936 J	268 J	23.2 J	56.3 J	40.3 J	56.3 J	1410 J
MERCURY	0.05 U	0.05 U	0.04 U	0.05 U	0.04 U	0.05 U	0.04 U	0.05 U	0.05 U	0.05
NICKEL	11.3 J	17.1 J	13.1 J	11 J	6.1 J	10 J	4.6 J	4.9 J	4.9 J	13.9 J
POTASSIUM	744 J	1250 J	921 J	525 J	425 J	552 J	438 J	474 J	474 J	699 J
SELENIUM	0.37 J	0.6 U	0.3 U	0.43 U	0.28 U	0.32 U	0.25 U	0.29 U	0.29 U	0.47 U
SILVER	0.05 J	0.06 U	0.05 U	0.05 U	0.05 U	0.05 U	0.04 U	0.05 U	0.05 U	0.05 U
SODIUM	46.7 U	14.7 U	9.1 U	19 U	4.8 U	31.1 U	69.6 U	94.2 U	94.2 U	27.7 U
STRONTIUM	11.6 J	14.2 J	11.7 J	9.7 J	8.1 J	10.0 J	9.7 J	10.8 J	10.8 J	17.0 J
THALLIUM	0.14 J	0.27 J	0.15 J	0.22 J	0.14 J	0.27 J	0.12 J	0.14 J	0.14 J	0.21 J
THORIUM	7.3 J	7.9 J	5.7 J	6.4 J	5.8 J	6.3 J	5.2 J	5.0 J	5.2 J	6.9 J
TIN	0.61 U	0.56 U	0.59 U	0.48 U	0.43 U	0.54 U	0.64 U	0.46 U	0.64 U	0.55 U
VANADIUM	28.3 J	32.2 J	30.4 J	19 J	18.1 J	19.3 J	15.6 J	17.1 J	17.1 J	21.7 J
ZINC	32 J	49.6 J	34.6 J	29.7 J	16.2 J	15.8 J	13.3 J	13.6 J	13.6 J	38.2 J

Notes:
NM - Normal soil sample
LD - Lab duplicate
MS - Matrix spike
RB - Rinsate Blank
LC - Lab Control Sample
PB - Lab Prep Blank
MG/KG - milligram per kilogram

TABLE C-2

ANALYTICAL DATABASE
SOIL RESULTS
NAVAL SURFACE WARFARE CENTER
CRANE, INDIANA

Location	BG2SBG04	BG2SBG04	BG2SBG04	BG2SBG05	BG3SBA01	BG3SBA01	BG3SBA01	BG3SBA02	BG3SBA03	BG3SBA04
nsample	BG2SBG0401-D	BG2SBG0401-MAX	BG2SBG0404	BG2SBG0503	BG3SBA0101	BG3SBA0101-D	BG3SBA0101-MAX	BG3SBA0203	BG3SBA0301	BG3SBA0403
sample	BGFD11079902	BG2SBG0401	BG2SBG0404	BG2SBG0503	BG3SBA0101	BGFD11029901	BG3SBA0101	BG3SBA0203	BG3SBA0301	BG3SBA0403
Sample Date	11/07/99	11/07/99	11/07/99	11/07/99	11/02/99	11/02/99	11/02/99	11/02/99	11/03/99	11/04/99
QC Type	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM
Deposit. Env.	GLACIAL	GLACIAL	GLACIAL	GLACIAL	ALLUVIUM	ALLUVIUM	ALLUVIUM	ALLUVIUM	ALLUVIUM	ALLUVIUM
Grain Size	SILT	SILT	SILT	SAND	SILT	SILT	SILT	SAND	SILT	SILT
depth	SS	SS	SB	SB	SS	SS	SS	SB	SS	SB
Duplicate	DUP	MAX	NORMAL	NORMAL	DUP	DUP	MAX	NORMAL	NORMAL	NORMAL
Matrix	SO	SO	SO	SO	SO	SO	SO	SO	SO	SO
Top Depth	0	0	3	2	0	0	0	2	0	2
Bottom Depth	1	1	4	3	1	1	1	3	1	3
Metal (mg/kg)										
ALUMINUM	10700 J	10700 J	12300 J	10500 J	8240 J	7780	8240 J	9060 J	9600 J	9770 J
ANTIMONY	0.49 U	0.49 U	0.42 U	0.45 U	0.71 U	1.1 U	1.1 U	1.1 U	0.71 U	0.5 U
ARSENIC	4.3	4.3	5.8	6	3.7	4.2	4.2	7.5	4.8	5.7
BARIUM	111 J	115 J	45.8 J	51.6 J	74.3 J	75.6 J	75.6 J	83.4 J	105 J	64.8 J
BERYLLIUM	0.74 J	0.74 J	0.32 J	0.4 J	0.64 U	0.49 J	0.49 J	0.63 U	0.69 U	0.66 U
CADMIUM	0.05 U	0.1 U	0.04 U	0.05 U	0.2 U	0.04 U	0.2 U	0.15 U	0.29 U	0.33 U
CALCIUM	924 J	1040 J	157 J	122 J	334	313 J	334	570	957 J	576 J
CHROMIUM	13.1 J	13.1 J	24.3 J	24 J	9.2 J	11.3 J	11.3 J	19.1 J	15 J	10.1 J
COBALT	13.8	14.1	9.2	6.7	8.8	9.6	9.6	11.9	14.4	8.7
COPPER	7.2	7.2	12.1	11.8	6.5	5.7	6.5	7.1	8 J	6.6
IRON	12000 J	12000 J	21200 J	22100 J	9340 J	11800	11800	19500 J	16900 J	11900 J
LEAD	14.8 J	14.8 J	9.8 J	11.4 J	12.3 J	13.1 J	13.1 J	12.2 J	19 J	9.3 J
LITHIUM	12.8 J	12.8 J	14.9 J	15.2 J	8.2 J	9.1 J	9.1 J	12.1 J	10.2 J	10.9 J
MAGNESIUM	1260 J	1260 J	1510 J	1480 J	876 J	846 J	876 J	772 J	1310 J	1100 J
MANGANESE	1360 J	1410 J	351 J	119 J	721 J	776 J	776 J	861 J	1560 J	720 J
MERCURY	0.06	0.06	0.05 U	0.05 U	0.05 U	0.05	0.05	0.05 U	0.05	0.04 U
NICKEL	13.8 J	13.9 J	10.6 J	11.6 J	8.8 J	9.2 J	9.2 J	12.3 J	13.2 J	9.8 J
POTASSIUM	831 J	831 J	814 J	896 J	584	496	584	768	1060	676
SELENIUM	0.79 U	0.79 U	0.24 U	0.3 U	0.64 U	0.4 U	0.64 U	0.39 U	1 U	0.43 U
SILVER	0.05 U	0.05 U	0.04 U	0.05 U	0.05 J	0.04 U	0.05 J	0.05 J	0.06 J	0.05 J
SODIUM	24 U	27.7 U	16.8 U	17.1 U	2.5 U	11.9 J	11.9 J	5.2 J	2.9 U	2.3 U
STRONTIUM	17.3 J	17.3 J	9.1 J	8.0 J	7.4 J	7.8 J	7.8 J	7.1 J	10.1 J	8.8 J
THALLIUM	0.26 J	0.26 J	0.16 J	0.15 J	0.15 J	0.18 J	0.18 J	0.15 J	0.17 J	0.14 J
THORIUM	6.6 J	6.9 J	7.6 J	7.4 J	4.8 J	5.9 J	5.9 J	5.9 J	6.4 J	6.2 J
TIN	0.57 U	0.57 U	0.6 U	0.64 U	0.66 U	0.62 U	0.66 U	0.6 U	0.82 U	0.5 U
VANADIUM	23.6 J	23.6 J	31.5 J	28.9 J	16.9	18.2	18.2	23.9	23.5	20.5 J
ZINC	36.2 J	38.2 J	28.4 J	35.3 J	34.1 J	31.2 J	34.1 J	26.5 J	37.7 J	26.5 U

Notes:
NM - Normal soil sample
LD - Lab duplicate
MS - Matrix spike
RB - Rinsate Blank
LC - Lab Control Sample
PB - Lab Prep Blank
MG/KG - mi[illegible]m per kilogram

TABLE C-2

ANALYTICAL DATABASE
SOIL RESULTS
NAVAL SURFACE WARFARE CENTER
CRANE, INDIANA

Location	BG3SBA04	BG3SBA05	BG3SBA05	BG3SBA05	BG3SBM02	BG3SBM02	BG3SBM02	BG3SBM03	BG3SBM04	BG3SBM04
nsample	BG3SBA0404	BG3SBA0501	BG3SBA0504	BG3SBA0506	BG3SBM0201	BG3SBM0203	BG3SBM0206	BG3SBM0305	BG3SBM0401	BG3SBM0404
sample	BG3SBA0404	BG3SBA0501	BG3SBA0504	BG3SBA0506	BG3SBM0201	BG3SBM0203	BG3SBM0206	BG3SBM0305	BG3SBM0401	BG3SBM0404
Sample Date	11/04/99	11/04/99	11/04/99	11/04/99	11/02/99	11/02/99	11/02/99	11/02/99	11/03/99	11/03/99
QC Type	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM
Deposit. Env.	ALLUVIUM	ALLUVIUM	ALLUVIUM	ALLUVIUM	MISSISSIPPIAN	MISSISSIPPIAN	MISSISSIPPIAN	MISSISSIPPIAN	MISSISSIPPIAN	MISSISSIPPIAN
Grain Size	SAND	SILT	SILT	SAND	SILT	SILT	CLAY	SILT	SILT	CLAY
depth	SB	SS	SB	SB	SS	SB	SB	SB	SS	SB
Duplicate	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL
Matrix	SO	SO	SO	SO	SO	SO	SO	SO	SO	SO
Top Depth	3	0	3	5	0	2	5	4	0	3
Bottom Depth	4	1	4	6	1	3	6	5	1	4
Metal (mg/kg)										
ALUMINUM	12200 J	9800 J	10100 J	7810 J	10400	15600	17000	11400	9900	10900
ANTIMONY	0.53 U	0.41 U	0.41 U	0.4 U	0.38 U	0.58 U	0.46 U	0.52 U	5.6 J	2.9 J
ARSENIC	3.2	8	3	3.7	5.9 J	9 J	4.4 J	6.6 J	5.5 J	6.1 J
BARIUM	46.1 J	128 J	57 J	56.9 J	71.8 J	62.3 J	87.9 J	41.8 J	118 J	51.1 J
BERYLLIUM	0.56 U	0.73 U	0.76 U	0.38 U	0.65 U	0.42 U	1.1 U	0.45 U	0.94 U	0.37 U
CADMIUM	0.2 U	0.28 U	0.29 U	0.14 U	3.6 J	1 J	0.06 J	0.25 J	1.2 J	0.26 J
CALCIUM	817 J	595 J	506 J	396 J	303 J	351 J	1260 J	152 J	424 J	239 J
CHROMIUM	14.6 J	11.1 J	10.6 J	10.8 J	17.8 J	22.6 J	25.1 J	18.9 J	12.2 J	17.3 J
COBALT	7.5	8.7	7.3	7.5	15.2	6.4	8.2	6.8	13.5	4.1
COPPER	8.4	7.5	6.9	6.5	7.6	19	10.7	12.1	8.1 J	12.4 J
IRON	15600 J	10700 J	12900 J	12700 J	15700	25400	26400	21000	12400	18300
LEAD	9.3 J	12.3 J	9.4 J	9.3 J	16.6 J	13.6 J	10.9 J	10.9 J	14.2 J	9.2 J
LITHIUM	11.5 J	11.5 J	14.0 J	9.6 J	13.8 J	20.8 J	30.6 J	17.8 J	14.8 J	13.3 J
MAGNESIUM	1230 J	1000 J	1200 J	812 J	1210 J	2590 J	2070 J	1440 J	1310 J	1810 J
MANGANESE	306 J	1430 J	719 J	674 J	851 J	192 J	35.3 J	318 J	1380 J	127 J
MERCURY	0.05 U	0.05 U	0.05 U	0.05 U	0.05 U	0.06	0.05 U	0.06	0.05 U	0.04 U
NICKEL	9.5 J	12.8 J	9.5 J	9.3 J	11.2 J	14.3 J	14.7 J	9.8 J	13.8 J	9.5 J
POTASSIUM	1020	821	731	689	688	1170	1270	851	801	810
SELENIUM	0.56 U	0.73 U	0.48 U	0.33 U	0.98 U	0.69 U	0.46 U	0.3 U	0.94 U	0.57 U
SILVER	0.04 J	0.06 J	0.05 J	0.05 J	0.05 J	0.05 J	0.06 U	0.05 J	0.06 J	0.05
SODIUM	2 U	2.8 U	2.4 U	2.4 U	9.4 J	9.1 J	182	22.9 J	2.8 U	14.3 U
STRONTIUM	9.2 J	9.9 J	10.6 J	7.2 J	8.6 J	16.3 J	25.7 J	8.5 J	13.3 J	12.7 J
THALLIUM	0.12 J	0.22 J	0.19 J	0.14 J	0.16 J	0.21 J	0.17 J	0.15 J	0.22 J	0.16 J
THORIUM	5.9 J	5.3 J	5.7 J	4.5 J	7.1 J	9.4 J	10.0 J	7.8 J	7.3 J	6.5 J
TIN	0.62 U	0.56 U	0.56 U	0.45 U	0.65 U	0.84 U	1.3 U	0.57 U	0.59 U	0.6 U
VANADIUM	26.9 J	19.4 J	21.4 J	18.1 J	26.9	37.7	33	32.6	23.1	28.8
ZINC	26.8 U	30.2 U	26.4 U	22.8 U	35.1 J	47.7 J	14.9 J	28.5 J	37.2 J	27.9 J

Notes:
NM - Normal soil sample
LD - Lab duplicate
MS - Matrix spike
RB - Rinsate Blank
LC - Lab Control Sample
PB - Lab Prep Blank
MG/KG - milligram per kilogram

TABLE C-2

ANALYTICAL DATABASE
SOIL RESULTS
NAVAL SURFACE WARFARE CENTER
CRANE, INDIANA

Location	BG3SBM04	BG3SBM05	BG3SBM06	BG3SBM06	BG3SBM07	BG3SBM07	BG3SBM07	BG3SBM08	BG3SBM08	BG3SBM08
nsample	BG3SBM0406	BG3SBM0504	BG3SBM0601	BG3SBM0604	BG3SBM0701	BG3SBM0704	BG3SBM0706	BG3SBM0801	BG3SBM0803	BG3SBM0803-D
sample	BG3SBM0406	BG3SBM0504	BG3SBM0601	BG3SBM0604	BG3SBM0701	BG3SBM0704	BG3SBM0706	BG3SBM0801	BG3SBM0803	BGFD11039901
Sample Date	11/03/99	11/03/99	11/02/99	11/02/99	11/03/99	11/03/99	11/03/99	11/03/99	11/03/99	11/03/99
QC Type	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM
Deposit. Env.	MISSISSIPPIAN	MISSISSIPPIAN	MISSISSIPPIAN	MISSISSIPPIAN	MISSISSIPPIAN	MISSISSIPPIAN	MISSISSIPPIAN	MISSISSIPPIAN	MISSISSIPPIAN	MISSISSIPPIAN
Grain Size	SAND	SAND	SILT	SILT	SILT	SILT	CLAY	SILT	SAND	SAND
depth	SB	SB	SS	SB	SS	SB	SB	SS	SB	SB
Duplicate	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	NORMAL	DUP	DUP
Matrix	SO	SO	SO	SO	SO	SO	SO	SO	SO	SO
Top Depth	5	3	0	3	0	3	5	0	2	2
Bottom Depth	6	4	1	4	1	4	6	1	3	3
Metal (mg/kg)										
ALUMINUM	5020	10400	9320	10100	12300	11900	9330	8450	7500	7400
ANTIMONY	1.2 J	1.2 J	0.44 U	0.69 U	1.4 J	0.63 U	0.41 U	0.36 U	0.19 U	0.23 U
ARSENIC	2.5 J	5.6 J	7.8 J	8 J	10.2 J	6.5 J	2.6 J	4.6 J	2 J	1.6 J
BARIUM	27 J	55.4 J	153 J	116 J	143 J	59.6 J	64 J	65.2 J	30.9 J	30 J
BERYLLIUM	0.2 U	0.37 U	0.77 U	1.2 U	1.2 U	0.47 U	0.56 U	0.61 U	0.3 U	0.35 U
CADMIUM	0.34 J	0.32 J	0.83 J	0.77 J	0.72 J	2.1 J	0.21 J	0.83 J	2.8 J	1.2 J
CALCIUM	92.6 J	309 J	35300 J	5320 J	286 J	257 J	479 J	370 J	133 J	130 J
CHROMIUM	10.9 J	15.2 J	13.1 J	30.6 J	16.4 J	17.2 J	13.3 J	17.6 J	14.5 J	12.6 J
COBALT	4.5	4.7	13.7	11.8	27.1	6.9	4.5	8.4	3.3	3.1
COPPER	3.5 J	12.9 J	7.6	7.5	7.1 J	13.1 J	5.3 J	7.9 J	5.7 J	5.1 J
IRON	8850	17300	15000	22300	20900	20100	12000	13200	9640	8820
LEAD	7.5 J	9.6 J	17.8 J	15.4 J	20.6 J	12.8 J	7.6 J	14.3 J	6.4 J	6.1 J
LITHIUM	7.8 J	14.7 J	13.9 J	20.6 J	15.9 J	14.8 J	18.4 J	11.2 J	10.4 J	10.3 J
MAGNESIUM	496 J	1890 J	1330 J	1210 J	1110 J	2000 J	1590 J	1040 J	925 J	910 J
MANGANESE	266 J	177 J	1690 J	1410 J	3040 J	311 J	89.4 J	666 J	87.8 J	85.5 J
MERCURY	0.04 U	0.05 U	0.05 U	0.04 U	0.05 U	0.05 U	0.05 U	0.05	0.04 U	0.04 U
NICKEL	4.6 J	10.2 J	14.2 J	17.3 J	13.6 J	11.8 J	11 J	10.2 J	11.3 J	10.7 J
POTASSIUM	280	768	1340	1330	791	975	960	630	926	884
SELENIUM	0.29 U	0.53 U	1 U	0.56 U	1.3 U	0.42 U	0.72 U	0.72 U	0.3 U	0.3 U
SILVER	0.05 J	0.05 J	0.06 J	0.05 J	0.06 J	0.05 J	0.05 U	0.06 J	0.05 J	0.05 J
SODIUM	2.4 U	16.7 U	23.7 J	21.9 J	13.7 U	51.4 U	119 J	4.4 U	8.6 U	16.5 U
STRONTIUM	4.2 J	13.3 J	63.2 J	15.9 J	11.1 J	16.2 J	15.4 J	7.4 J	5.0 J	5.6 J
THALLIUM	0.05 J	0.16 J	0.18 J	0.1 J	0.22 J	0.21 J	0.1 J	0.17 J	0.05 J	0.05 J
THORIUM	4.1 J	6.7 J	5.9 J	6.9 J	7.8 J	8.3 J	8.1 J	5.8 J	4.6 J	5.1 J
TIN	0.44 U	0.6 U	1.2 U	0.64 U	1.2 U	0.67 U	0.68 U	0.52 U	0.48 U	0.5 U
VANADIUM	16.9	27.1	21.6	26.1	37.4	28.7	18	22.3	14.1	13.2
ZINC	9.4 J	30.8 J	40.2 J	31.5 J	60.2 J	35.7 J	17.1 J	28.1 J	13.2 J	12.9 J

Notes:
NM - Normal soil sample
LD - Lab duplicate
MS - Matrix spike
RB - Rinsate Blank
LC - Lab Control Sample
PB - Lab Prep Blank
MG/KG - milligram per kilogram

TABLE C-2

ANALYTICAL DATABASE
SOIL RESULTS
NAVAL SURFACE WARFARE CENTER
CRANE, INDIANA

Location	BG3SBM08	BG3SBM09	BG3SBM10
nsample	BG3SBM0803-MAX	BG3SBM0904	BG3SBM1003
sample	BG3SBM0803	BG3SBM0904	BG3SBM1003
Sample Date	11/03/99	11/03/99	11/04/99
QC Type	NM	NM	NM
Deposit. Env.	MISSISSIPPIAN	MISSISSIPPIAN	MISSISSIPPIAN
Grain Size	SAND	SILT	CLAY
depth	SB	SB	SB
Duplicate	MAX	NORMAL	NORMAL
Matrix	SO	SO	SO
Top Depth	2	3	2
Bottom Depth	3	4	3
Metal (mg/kg)			
ALUMINUM	7500	14300	13800 J
ANTIMONY	0.23 U	0.97 U	0.6 U
ARSENIC	2 J	8.5 J	6.3 J
BARIUM	30.9 J	56.6 J	55.8 J
BERYLLIUM	0.35 U	0.59 U	0.46 U
CADMIUM	2.8 J	0.75 J	0.57 J
CALCIUM	133 J	131 J	312 J
CHROMIUM	14.5 J	19.4 J	18.7 J
COBALT	3.3	6.4	6.4
COPPER	5.7 J	19.7 J	12.9
IRON	9640	22300	18500 J
LEAD	6.4 J	14.9 J	12.1 J
LITHIUM	10.4 J	15.4 J	16.4 J
MAGNESIUM	925 J	2530 J	1840 J
MANGANESE	87.8 J	269 J	266 J
MERCURY	0.04 U	0.05	0.05 U
NICKEL	11.3 J	14.2 J	12.5 J
POTASSIUM	926	1150	1020
SELENIUM	0.3 U	0.54 U	0.88 U
SILVER	0.05 J	0.05 J	0.05 J
SODIUM	16.5 U	14.8 U	7.8 J
STRONTIUM	5.6 J	14.4 J	10.1 J
THALLIUM	0.05 J	0.21 J	0.21 J
THORIUM	5.1 J	9.0 J	7.0 J
TIN	0.5 U	0.66 U	0.65 U
VANADIUM	14.1	33.7	31.5 J
ZINC	13.2 J	46.6 J	36.2 J

Notes:
NM - Normal soil sample
LD - Lab duplicate
MS - Matrix spike
RB - Rinsate Blank
LC - Lab Control Sample
PB - Lab Prep Blank
MG/KG - milligram per kilogram

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TABLE C-3

ANALYTICAL DATABASE
QC SAMPLES
NAVAL SURFACE WARFARE CENTER
CRANE, INDIANA

nsample	BG1SBA0306S	BG1SBA280304	BG1SBL0504S	BG1SBP0603S	BG3SBM0803S	BGRB11029901S	BGSW11029901S	LCSS1-C8301	LCSS1-C8303
sample	BG1SBA0306S	BG1SBA280304	BG1SBL0504S	BG1SBP0603S	BG3SBM0803S	BGRB11029901S	BGSW11029901S	LCSS1-C8301	LCSS1-C8303
sample_dat	11/05/99	10/06/00	11/08/99	11/05/99	11/03/99	11/02/99	11/02/99	11/03/99	11/16/99
qc_type	MS	MS	MS	MS	MS	RB/MS	MS	LC	LC
samp_type									
Depos. Envirn.	ALLUVIUM	ALLUVIUM	LOESS	PENNSYLVANIAN	MISSISSIPPIAN				
top_depth	5	3	3	2	2				
bottom_dep	6	4	4	3	3				
dups									
M ALUMINUM %						103		91.2	88.2
M ANTIMONY %	98.4	103	110	97.3	94.5	111		98.7	96.1
M ARSENIC %	91.1	91.6	81.2	84.2	94.1	111		96.3	93.4
M BARIUM %	79.1	108.9	79.1	83.2	94.4	106		95.8	93.8
M BERYLLIUM %	109	92.7	93.2	108	116	104		112	98.0
M CADMIUM %	92.1	96.6	82.3	94.1	36.0 N	106		86.0	80.0
M CALCIUM %						112		96.8	99.7
M CHROMIUM %	97.9	135.2 N	67.5 N	121	77.0	103		97.0	96.0
M COBALT %	83.0	78.8	82.7	86.7	93.4	109		95.8	92.4
M COPPER %	89.9	118	87.7	92.8	97.3	108		99.6	99.2
M IRON %						109		101	95.1
M LEAD %	80.2	98	77.4	80.5	92.5	105		96.4	92.2
M LITHIUM %	84.6	94.8	104	68.5 N	111		99.7		
M MAGNESIUM %						102		94.1	94.3
M MANGANESE %	61.2	73.1 N	-11.80	31.9	62.9 N	102		96.0	94.4
M MERCURY %	99.5	95.5	94.3	101	98.9	94.8		100	96.0
M NICKEL %	79.4	80.4	81.8	84.7	92.4	104		96.4	92.4
M POTASSIUM %						98.8		93.2	93.5
M SELENIUM %	86.0	93.4	79.4	84.1	94.6	107		99.2	90.9
M SILVER %	92.1	94.7	85.9	92.1	87.9	104		86.0	92.0
M SODIUM %						95.4		102	82.7
M STRONTIUM %	81	117.5	106	105	105		102		
M THALLIUM %	88.6	91.2	86.8	88.6	89.5	102		90.5	91.0
M THORIUM %	94.2	87.2	108	116	105		109		
M TIN %	96.8	89	93.1	92.8	84.6	103		93.2	84.8
M VANADIUM %	85.5	104.7	77.1	74.5 N	89.4	107		98.0	97.0
M ZINC %	74.1 N	108.1	75.3	81.2	89.3	107		94.0	92.8

Notes:
NM - Normal soil sample
LD - Lab duplicate
MS - Matrix spike
RB - Rinsate Blank
LC - Lab Control Sample
PB - Lab Prep Blank
UG/L - microgram per liter

TABLE C-3

ANALYTICAL DATABASE
QC SAMPLES
NAVAL SURFACE WARFARE CENTER
CRANE, INDIANA

nsample	LCSS1-C8304	LCSS1-C8305	LCSS1-C3806	LCSS1-C3807	LCSS1-C3808	LCSS1-C3809	LCSW1-C8302	LCSW1-C8310
sample	LCSS1-C8304	LCSS1-C8305	LCSS1-C3806	LCSS1-C3807	LCSS1-C3808	LCSS1-C3809	LCSW1-C8302	LCSW1-C8310
sample_dat	11/18/99	11/18/99	05/04/00	05/04/00	05/04/00	05/05/00	11/11/99	05/04/00
qc_type	LC	LC	LC	LC	LC	LC	LC	LC
samp_type								
Depos. Envirn.								
top_depth								
bottom_dep								
dups								
M ALUMINUM %	83.7	89.0					105	
M ANTIMONY %	103	107					117	
M ARSENIC %	86.0	92.2					109	
M BARIUM %	86.1	93.8					110	
M BERYLLIUM %	120	88.0					105	
M CADMIUM %	96.0	84.0					108	
M CALCIUM %	93.1	97.9					108	
M CHROMIUM %	89.5	94.5					103	
M COBALT %	87.2	93.0					109	
M COPPER %	91.2	98.4					107	
M IRON %	93.8	98.2					110	
M LEAD %	87.4	94.4					108	
M LITHIUM %			104	105	93.6	101		109
M MAGNESIUM %	88.1	94.8					102	
M MANGANESE %	88.6	93.8					103	
M MERCURY %	96.0	96.0					88.5	
M NICKEL %	87.2	93.8					105	
M POTASSIUM %	88.1	93.2					97.3	
M SELENIUM %	116	93.2					110	
M SILVER %	106	96.0					108	
M SODIUM %	88.1	92.2					96.7	
M STRONTIUM %			100	101	100	99.6		110
M THALLIUM %	105	94.1					105	
M THORIUM %			102	106	110	102		116
M TIN %	92.5	99.3					106	
M VANADIUM %	90.0	95.8					109	
M ZINC %	87.4	92.4					108	

Notes:
NM - Normal soil sample
LD - Lab duplicate
MS - Matrix spike
RB - Rinsate Blank
LC - Lab Control Sample
PB - Lab Prep Blank
UG/L - microgram per liter

TABLE C-4

ANALYTICAL DATABASE
QC SAMPLES
NAVAL SURFACE WARFARE CENTER
CRANE, INDIANA

nsample sample sample_dat qc_type	BGRB11029901 BGRB11029901 11/02/99 RB	BGRB11029901D BGRB11029901D 11/02/99 RB/LD	BGRB11039901 BGRB11039901 11/03/99 RB	BGRB11049901 BGRB11049901 11/04/99 RB	BGRB11059901 BGRB11059901 11/05/99 RB	BGRB11069901 BGRB11069901 11/06/99 RB	BGRB11079901 BGRB11079901 11/07/99 RB	BGRB11089901 BGRB11089901 11/08/99 RB	BGSW11029901 BGSW11029901 11/02/99 NM
M ALUMINUM UG/L	27.4 U	55.6 U	27.4 U	104	114	27.4 U	369	27.4 U	27.4 U
M ANTIMONY UG/L	0.11 U	1.1 U	0.11 U	0.11 U	0.11 U	0.11 U	0.33 J	0.11 U	0.11 U
M ARSENIC UG/L	0.22 U	1.1 U	0.22 U	0.78 J	0.22 U	0.22 U	0.22 U	0.22 U	0.22 U
M BARIUM UG/L	0.11 U	1.1 U	0.56 J	0.11 U	1.0 J	0.11	3.8	0.89 J	4.7
M BERYLLIUM UG/L	0.11 U	1.1 U	0.11 U	0.11 U	0.11 U	0.11 U	0.11 U	0.11 U	0.11 U
M CADMIUM UG/L	0.11 U	1.1 U	0.11 U	0.11 U	0.11 U	0.11 U	0.11 J	0.11 J	0.11 U
M CALCIUM UG/L	18 J	111 U	14.2 J	12.6 J	25.8 J	10.8 U	36.2 J	0.11 U	0.11 U
M CHROMIUM UG/L	0.22 J	5.6 U	0.22 J	0.22 J	033 J	0.11 J	0.44 J	0.22 J	0.22 J
M COBALT UG/L	0.11 U	3.3 U	0.11 U	0.11 U	0.11 U	0.11 U	0.11 U	0.22 U	0.22 U
M COPPER UG/L	0.22 U	2.2 U	0.33 J	0.22 U	0.22 U	0.22 U	0.22 U	0.11 U	0.11 U
M IRON UG/L	15.6 U	22.2 U	15.6 U	54.6	30.9	15.6 U	99.4	0.22 U	0.22 U
M LEAD UG/L	0.11 U	1.1 U	0.33 J	0.11 U	0.11 U	0.11 U	0.11 J	0.11 J	0.11 J
M LITHIUM UG/L	0.22 UJ		0.22 J	0.22 UJ	0.22 UJ	0.22 UJ	0.22 UJ	0.22 UJ	0.22 UJ
M MAGNESIUM UG/L	12.7 J	111 U	5.4 J	9.9 J	13.4 J	3.0 J	44.4 J	5.6 J	5.6 U
M MANGANESE UG/L	0.22 J	5.6 U	0.11 J	0.33 J	0.44 J	0.11 U	1.0 J	0.22 J	0.22 U
M MERCURY UG/L	0.20 J	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U	0.20 U
M NICKEL UG/L	0.11 J	11.1 U	0.11 U	0.11 J	0.11 J	0.11 J	0.11 J	0.11 J	0.11 J
M POTASSIUM UG/L	21.4 U	111 U	21.4 U	21.4 U	64.7 J	21.4 U	41.3 J	21.4 U	21.4 U
M SELENIUM UG/L	0.67 U	1.1 U	0.67 U	0.67 U	0.67 U	0.67 U	0.67 U	0.78 J	0.67 J
M SILVER UG/L	0.11 U	3.3 U	0.11 U	0.11 U	0.11 U	0.11 U	0.11 U	0.11 U	0.11 U
M SODIUM UG/L	13.6 U	111 U	18.7 J	13.6 U	76.3 J	13.6 U	53.1 J	13.6 U	13.6 U
M STRONTIUM UG/L	0.22 UJ		0.22 UJ	0.22 UJ	0.22 UJ	0.22 UJ	0.22 UJ	0.22 UJ	0.22 UJ
M THALLIUM UG/L	0.11 U	1.1 U	0.11 U	0.11 U	0.11 U	0.11 U	0.11 U	0.11 U	1.1 U
M THORUM UG/L	0.33 J		0.22 UJ	0.22 UJ	0.22 UJ	0.22 UJ	0.22 UJ	0.22 UJ	0.22 UJ
M TIN UG/L	0.11 U	11.1 U	0.11 J	0.11 U	0.22 J	0.11 U	2.3 J	0.11 J	0.33 J
M VANADIUM UG/L	0.11 U	2.2 U	0.11 U	0.11 J	0.11 J	0.11 U	0.44 J	0.11 U	0.11 U
M ZINC UG/L	5.8 J	11.1 U	1.4 J	60.3	7.8 J	2.2 J	1.9 J	99.4	1.8 J

Notes:
NM - Normal soil sample
LD - Lab duplicate
MS - Matrix spike
RB - Rinsate Blank
LC - Lab Control Sample
PB - Lab Prep Blank
UG/L - microgram per liter

TABLE C-4

ANALYTICAL DATABASE
QC SAMPLES
NAVAL SURFACE WARFARE CENTER
CRANE, INDIANA

nsample sample sample_dat qc_type	BGSW1102 BGSW11029901D 11/02/99 SW	PBW1-C8302 PBW1-C8302 11/11/99 PB	PBW1-C8310 PBW1-C8310 05/05/00 PB	BGRB10060001 BGRB10060001 10/06/00 RB	BGRB10070001 BGRB10070001 10/06/00 RB
M ALUMINUM UG/L		55.6 U		55.9 J	55.6 U
M ANTIMONY UG/L		1.1 U		1.1 U	1.1 U
M ARSENIC UG/L		1.1 U		1.1 U	1.1 U
M BARIUM UG/L		1.1 U		0.68 J	0.56 U
M BERYLLIUM UG/L		1.1 U		0.56 U	0.56 U
M CADMIUM UG/L		1.1 U		0.56 U	0.56 U
M CALCIUM UG/L		111 U		124 U	124 U
M CHROMIUM UG/L		5.6 U		0.56 U	0.56 J
M COBALT UG/L		3.3 U		0.56 U	0.56 U
M COPPER UG/L		2.2 U		0.56 U	0.56 U
M IRON UG/L		22.2 U		24.9 J	20.2 J
M LEAD UG/L		1.1 U		0.56 U	0.56 U
M LITHIUM UG/L	0.22 U		0.20 U	0.36 J	0.22 U
M MAGNESIUM UG/L		111 U		36.7 U	36.7 U
M MANGANESE UG/L		5.6 U		1.7 U	1.7 U
M MERCURY UG/L		0.20 U		0.20 U	0.20 U
M NICKEL UG/L		11.1 U		0.56 U	0.56 U
M POTASSIUM UG/L		111 U		163 U	163 U
M SELENIUM UG/L		1.1 U		1.1 U	1.1 U
M SILVER UG/L		3.3 U		0.56 U	0.56 U
M SODIUM UG/L		111 U		31.1 U	31.1 U
M STRONTIUM UG/L	0.22 U		0.20 U	0.22 U	0.22 U
M THALLIUM UG/L		1.1 U		0.56 U	0.56 U
M THORUM UG/L	0.22 U		0.20 U	0.43 J	0.22 U
M TIN UG/L		11.1 U		0.11 U	0.11 U
M VANADIUM UG/L		2.2 U		0.56 U	0.56 U
M ZINC UG/L		11.1 U		5.6 U	5.6 U

Notes:
NM - Normal soil sample
LD - Lab duplicate
MS - Matrix spike
RB - Rinsate Blank
LC - Lab Control Sample
PB - Lab Prep Blank
UG/L - microgram per liter

C-2 DATA VALIDATION SUMMARY

Tetra Tech NUS INTERNAL CORRESPONDENCE

TO:	**K. HENN**	**DATE:**	**OCTOBER 23, 2000**
FROM:	**GRETCHEN A. PHIPPS**	**COPIES:**	**DV FILE / REV 2**

SUBJECT: **INORGANIC DATA VALIDATION – TAL METALS AND TIN**
CTO 083 – NSWC CRANE
SDG – C8301

SAMPLES: 18/Soils/

BG3SBM0201	BG3SBM0203	BG3SBM0206
BG3SBM0305	BG3SBM0401	BG3SBM0404
BG3SBM0406	BG3SBM0504	BG3SBM0601
BG3SBM0604	BG3SBM0701	BG3SBM0704
BG3SBM0706	BG3SBM0801	BG3SBM0803
BG3SBM0904	BG3SBM1003	BGFD11039901

Overview

'he sample set for CTO 083, NSWC Crane, SDG C8301, consists of eighteen (18) soil environmental samples. One (1) ,ield duplicate pair (BG3SBM0803 / BGFD11039901) was included within this SDG.

All samples were analyzed for target analyte list (TAL) metals and tin. The samples were collected by Tetra Tech NUS on November 2-4, 1999 and analyzed by Laucks Testing Labs, Inc. under Naval Facilities Engineering Service Center (NFESC) Quality Assurance/Quality Control (QA/QC) criteria. Aluminum, barium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, nickel, potassium, vanadium and zinc analyses were conducted using SW 846 method 6010B via ICP instrumentation. Arsenic, beryllium, cadmium, selenium, silver, sodium, thallium, antimony and tin analyses were conducted using SW 846 method 6020 via ICP/MS instrumentation. Mercury analyses were conducted using SW 846 method 7471A via CVAA instrumentation.

These data were evaluated based on the following parameters:

* ∗ Data Completeness
* ∗ Holding Times
* Calibration Verifications
* Laboratory Blank Analyses
* Field Quality Control Blank Analyses
* ∗ ICP Interference Check Sample Results
* Matrix Spike Results
* Laboratory Duplicate Results
* Field Duplicate Results
* ∗ Post Digestion Spike Results
* ∗ Laboratory Control Sample Results
* ∗ ICP Serial Dilution Results
* ∗ Sample Quantitation
* Detection Limits

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

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

Samples affected: All

Analyte	Maximum Concentration	Action Level (soil)
Antimony[1]	0.150 mg/kg	0.75 mg/kg
Arsenic	0.2µg/L	0.10 mg/kg
Beryllium[1]	0.250 mg/kg	1.25 mg/kg
Selenium	0.6µg/L	0.300 mg/kg
Tin[1]	0.210 mg/kg	1.05 mg/kg

[1] Maximum concentration found in a soil preparation blank.

An action level of 5X the maximum concentration has been 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 less than the action level for antimony, beryllium, selenium and tin were qualified as nondetected "U". Positive results greater than the action level for antimony, arsenic and barium were qualified as estimated, "J".

All positive results reported for any analyte present in a field quality control blank were qualified as estimated, "J".

Matrix Spike Results

The Matrix Spike (MS) Percent Recoveries (%Rs) for cadmium and manganese were <75% quality control limit. The positive results reported for cadmium and manganese were qualified as estimated, "J".

Laboratory Duplicate Results

Laboratory Duplicate imprecision was noted for cadmium. The positive results reported for cadmium were qualified as estimated, "J".

Field Duplicate Results

Field Duplicate imprecision (50%) was noted for cadmium. The positive results reported for cadmium were qualified as estimated, "J".

Notes

The Contract Required Detection Limit (CRDL) Percent Recoveries (%Rs) for antimony, arsenic, cadmium, lead and silver were outside the 80-120% quality control limits. No validation action is required per regional guidance.

A comparison of field duplicate pair (BG3SBM0803 / BGFD11039901) is included in Appendix C.

As noted in the Case Narrative, the soil adjusted IDLs were not met for all metals analyzed via ICP instrumentation.

The metals analyzed via MS/ICP instrumentation were conducted at a 5X dilution.

Selenium and sodium exceeded the soil adjusted limits requested in the QAPP.

Executive Summary

Laboratory Performance: Several analytes were present in the laboratory method / preparation blanks.

Other Factors Affecting Data Quality: All positive results reported for any analyte present in a field quality control blank were qualified as estimated, "J". Several analytes were present in the field quality control blanks. The MS %Rs for cadmium and manganese were <75% quality control limit. Laboratory and field duplicate imprecisions were noted for cadmium.

The data for these analyses were reviewed with reference to the "National Functional Guidelines for Inorganic Review", February 1994, "EPA Region V Standard Operating Procedures for Validation of CLP Inorganic Review", September 1993 and the NFESC document entitled "Navy Installation Restoration Laboratory Quality Assurance Guide " (NFESC 2/96). 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
Gretchen A. Phipps
Chemist

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

Tetra Tech NUS **INTERNAL CORRESPONDENCE**

TO:	**K. HENN**	**DATE:**	**JANUARY 26, 2000**
FROM:	**GRETCHEN A. PHIPPS**	**COPIES:**	**DV FILE**

SUBJECT: **INORGANIC DATA VALIDATION – TAL METALS AND TIN**
CTO 083 – NSWC CRANE
SDG – C8302

SAMPLES: 8/Aqueous/

BGRB11029901	BGRB11039901	BGRB11049901
BGRB11059901	BGRB11069901	BGRB11079901
BGRB11089901	BGSW11029901	

Overview

The sample set for CTO 083, NSWC Crane, SDG C8302, consists of seven (7) rinsate blanks and one (1) source water blank (BGSW11029901).

All samples were analyzed for target analyte list (TAL) metals and tin. The samples were collected by Tetra Tech NUS on November 2-8, 1999 and analyzed by Laucks Testing Labs, Inc. under Naval Facilities Engineering Service Center (NFESC) Quality Assurance/Quality Control (QA/QC) criteria. All metals analyses, with the exception of mercury, were conducted using SW 846 method 6020 via ICP/MS instrumentation. Mercury analyses were conducted using SW 846 method 7471A via CVAA instrumentation.

These data were evaluated based on the following parameters:

- * Data Completeness
- * Holding Times
- Calibration Verifications
- * ICP Interference Check Sample Results
- * Laboratory Duplicate Results
- * Matrix Spike/ Matrix Spike Duplicate Analyses
- Post Digestion Spike Analyses
- * Laboratory Control Sample Results
- * Sample Quanitation
- Detection Limits

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

Post Digestion Spike Analyses

The Post Digestion Spike (PDS) Percent Recovery (%R) for cadmium was >125% quality control limit. The positive results reported for cadmium were qualified as estimated, "J".

Notes

The Contract Required Detection Limit (CRDL) Percent Recoveries (%Rs) for arsenic, cobalt and selenium were outside the 80-120% quality control limits. No validation action is required per regional guidance.

Please, note that field quality control samples are not qualified for blank contamination.

All metals, with exception to mercury, were reported at IDLs lower than requested in the QAPP. The laboratory reported results to the IDL listed on the Form 10 included in Appendix C. It was requested that mercury be reported to 0.06μg/L. The laboratory reported mercury at 0.2μg/L. No changes were made to adapt the data to meet the QAPP requested IDLs. Results, as submitted by the laboratory were used for data validation purposes.

Executive Summary

Laboratory Performance: None.

Other Factors Affecting Data Quality: The PDS %R for cadmium was >125% quality control limit.

The data for these analyses were reviewed with reference to the "National Functional Guidelines for Inorganic Review", February 1994, "EPA Region V Standard Operating Procedures for Validation of CLP Inorganic Review", September 1993 and the NFESC document entitled "Navy Installation Restoration Laboratory Quality Assurance Guide " (NFESC 2/96). 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
Gretchen A. Phipps
Chemist

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
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/PCB D% 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 = % Solid content is less than 30%

CTO083-NSWC CRANE
WATER DATA
LAUCKS
SDG: C8302

SAMPLE NUMBER:	BGRB11029901			BGRB11039901			BGRB11049901			BGRB11059901		
SAMPLE DATE:	11/02/99			11/03/99			11/04/99			11/05/99		
LABORATORY ID:	9911159-01			9911159-03			9911159-04			9911195-01		
QC_TYPE:	NORMAL			NORMAL			NORMAL			NORMAL		
% SOLIDS:	0.0 %			0.0 %			0.0 %			0.0 %		
UNITS:	UG/L			UG/L			UG/L			UG/L		
FIELD DUPLICATE OF:												
	RESULT	QUAL	CODE	RESULT	QUAL	CODE	RESULT	QUAL	CODE	RESULT	QUAL	CODE
INORGANICS												
ALUMINUM	27.4	U		27.4	U		104			114		
ANTIMONY	0.11	U		0.11	U		0.11	U		0.11	U	
ARSENIC	0.22	U		0.22	U		0.78	J	P	0.22	U	
BARIUM	0.11	U		0.56	J	P	0.11	U		1.0	J	P
BERYLLIUM	0.11	U		0.11	U		0.11	U		0.11	U	
CADMIUM	0.11	U		0.11	U		0.11	U		0.11	U	
CALCIUM	18	J	P	14.2	J	P	12.6	J	P	25.8	J	P
CHROMIUM	0.22	J	P	0.22	J	P	0.22	J	P	033	J	P
COBALT	0.11	U		0.11	U		0.11	U		0.11	U	
COPPER	0.22	U		0.33	J	P	0.22	U		0.22	U	
IRON	15.6	U		15.6	U		54.6			30.9		
LEAD	0.11	U		0.33	J	P	0.11	U		0.11	U	
MAGNESIUM	12.7	J	P	5.4	J	P	9.9	J	P	13.4	J	P
MANGANESE	0.22	J	P	0.11	J	P	0.33	J	P	0.44	J	P
MERCURY	0.20	J	P	0.20	U		0.20	U		0.20	U	
NICKEL	0.11	J	P	0.11	U		0.11	J	P	0.11	J	P
POTASSIUM	21.4	U		21.4	U		21.4	U		64.7	J	P
SELENIUM	0.67	U		0.67	U		0.67	U		0.67	U	
SILVER	0.11	U		0.11	U		0.11	U		0.11	U	
SODIUM	13.6	U		18.7	J	P	13.6	U		76.3	J	P
THALLIUM	0.11	U		0.11	U		0.11	U		0.11	U	
TIN	0.11	U		0.11	J	P	0.11	U		0.22	J	P
VANADIUM	0.11	U		0.11	U		0.11	J	P	0.11	J	P
ZINC	5.8	J	P	1.4	J	P	60.3			7.8	J	P

CTO083-NSWC CRANE
WATER DATA
LAUCKS
SDG: C8302

SAMPLE NUMBER:	BGRB11069901			BGRB11079901			BGRB11089901			BGSW11029901		
SAMPLE DATE:	11/06/99			11/07/99			11/08/99			11/02/99		
LABORATORY ID:	9911195-02			9911195-03			9911195-04			9911159-02		
QC_TYPE:	NORMAL			NORMAL			NORMAL			NORMAL		
% SOLIDS:	0.0 %			0.0 %			0.0 %			0.0 %		
UNITS:	UG/L			UG/L			UG/L			UG/L		
FIELD DUPLICATE OF:												
	RESULT	**QUAL**	**CODE**	**RESULT**	**QUAL**	**CODE**	**RESULT**	**QUAL**	**CODE**	**RESULT**	**QUAL**	**CODE**
INORGANICS												
ALUMINUM	27.4	U		369			27.4	U		27.4	U	
ANTIMONY	0.11	U		0.33	J	P	0.11	U		0.11	U	
ARSENIC	0.22	U		0.22	U		0.22	U		0.22	U	
BARIUM	0.11			3.8			0.89	J	P	4.7		
BERYLLIUM	0.11	U		0.11	U		0.11	U		0.11	U	
CADMIUM	0.11	U		0.11	J	DP	0.11	J	DP	0.11	U	
CALCIUM	10.8	U		36.2	J	P	0.11	U		0.11	U	
CHROMIUM	0.11	J	P	0.44	J	P	0.22	J	P	0.22	J	P
COBALT	0.11	U		0.11	U		0.22	U		0.22	U	
COPPER	0.22	U		0.22	U		0.11	U		0.11	U	
IRON	15.6	U		99.4			0.22	U		0.22	U	
LEAD	0.11	U		0.11	J	P	0.11	J	P	0.11	J	P
MAGNESIUM	3.0	J	P	44.4	J	P	5.6	J	P	5.6	U	
MANGANESE	0.11	U		1.0	J	P	0.22	J	P	0.22	U	
MERCURY	0.20	U		0.20	U		0.20	U		0.20	U	
NICKEL	0.11	J	P	0.11	J	P	0.11	J	P	0.11	J	P
POTASSIUM	21.4	U		41.3	J	P	21.4	U		21.4	U	
SELENIUM	0.67	U		0.67	U		0.78	J	P	0.67	J	P
SILVER	0.11	U		0.11	U		0.11	U		0.11	U	
SODIUM	13.6	U		53.1	J	P	13.6	U		13.6	U	
THALLIUM	0.11	U		0.11	U		0.11	U		1.1	U	
TIN	0.11	U		2.3	J	P	0.11	J	P	0.33	J	P
VANADIUM	0.11	U		0.44	J	P	0.11	U		0.11	U	
ZINC	2.2	J	P	1.9	J	P	99.4			1.8	J	P

Tetra Tech NUS **INTERNAL CORRESPONDENCE**

TO:	**K. HENN**	**DATE:**	**OCTOBER 24, 2000**
FROM:	**GRETCHEN A. PHIPPS**	**COPIES:**	**DV FILE / REV 2**

SUBJECT: **INORGANIC DATA VALIDATION – TAL METALS AND TIN**
CTO 083 – NSWC CRANE
SDG – C8303

SAMPLES: 20/Soils/

BG1SBA0101	BG1SBA0104	BG1SBA0306
BG1SBA0401	BG1SBA0503	BG1SBA0504
BG1SL0101	BG1SL0103	BG1SL0105
BG1SL0405	BG3SBA0101	BG3SBA0203
BG3SBA0301	BG3SBA0403	BG3SBA0404
BG3SBA0501	BG3SBA0504	BG3SBA0506
BGFD11059901	BGFD11069901	

Overview

The sample set for CTO 083, NSWC Crane, SDG C8303, consists of twenty (20) soil environmental samples. Two (2) field duplicate samples (BGFD11059901 and BGFD11069901) were included within this SDG.

All samples were analyzed for target analyte list (TAL) metals and tin. The samples were collected by Tetra Tech NUS on November 3-8, 1999 and analyzed by Laucks Testing Labs, Inc. under Naval Facilities Engineering Service Center (NFESC) Quality Assurance/Quality Control (QA/QC) criteria. Aluminum, barium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, nickel, potassium, vanadium and zinc analyses were conducted using SW 846 method 6010B via ICP instrumentation. Arsenic, beryllium, cadmium, selenium, silver, sodium, thallium, antimony and tin analyses were conducted using SW 846 method 6020 via ICP/MS instrumentation. Mercury analyses were conducted using SW 846 method 7471A via CVAA instrumentation.

These data were evaluated based on the following parameters:

- * • Data Completeness
- * • Holding Times
- • Calibration Verifications
- • Laboratory Blank Analyses
- • Field Quality Control Blank Analyses
- * • ICP Interference Check Sample Results
- • Matrix Spike Results
- • Laboratory Duplicate Results
- * • Post Digestion Spike Results
- * • Laboratory Control Sample Results
- • ICP Serial Dilution Results
- * • Sample Quantitation
- • Detection Limits

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

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

Samples affected: All

Analyte	Maximum Concentration	Action Level (soil)
Antimony[(1)]	0.250 mg/kg	1.25 mg/kg
Beryllium[(1)]	0.150 mg/kg	0.75 mg/kg
Cadmium	0.2µg/L	0.10 mg/kg
Tin[(1)]	0.2mg/kg	1.0 mg/kg

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

An action level of 5X the maximum concentration has been 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 less than the action level for antimony, beryllium, cadmium and tin were qualified as nondetected "U".

All positive results reported for any analyte present in a field quality control blank were qualified as estimated, "J".

Matrix Spike Results

ne Matrix Spike (MS) Percent Recovery (%R) for zinc was <75% quality control limit. The positive results reported for zinc were qualified as estimated, "J".

Laboratory Duplicate Results

Laboratory Duplicate imprecision (>35%) was noted for manganese. The positive results reported for manganese were qualified as estimated, "J".

ICP Serial Dilution Results

The ICP Serial Dilution Percent Differences (%Ds) for aluminum, barium, iron and manganese were >10% quality control limit. The positive results reported for aluminum, barium, iron and manganese were qualified as estimated, "J".

Notes

The Contract Required Detection Limit (CRDL) Percent Recovery (%R) for antimony was <80% quality control limits. No validation action is required per regional guidance.

The original samples associated with the field duplicate samples were not included within this SDG. Therefore, a comparison was not included.

As noted in the Case Narrative, the soil adjusted IDLs were not met for the metals analyzed via ICP instrumentation.

The metals analyzed via MS/ICP instrumentation were conducted at a 5X dilution.

Selenium and sodium exceeded the soil adjusted limits requested in the QAPP.

Executive Summary

Laboratory Performance: Several analytes were present in the laboratory method / preparation blanks.

Other Factors Affecting Data Quality: All positive results reported for any analyte present in a field quality control blank were qualified as estimated, "J". Several analytes were present in the field quality control blanks. The MS %R for zinc was <75% quality control limit. Laboratory duplicate imprecision was noted for manganese. The ICP Serial Dilution %Ds for aluminum, barium, iron and manganese were >10% quality control limit.

The data for these analyses were reviewed with reference to the "National Functional Guidelines for Inorganic Review", February 1994, "EPA Region V Standard Operating Procedures for Validation of CLP Inorganic Review", September 1993 and the NFESC document entitled "Navy Installation Restoration Laboratory Quality Assurance Guide " (NFESC 2/96). 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)."

Gretchen A. Phipps

Tetra Tech NUS
Gretchen A. Phipps
Chemist

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

Tetra Tech NUS **INTERNAL CORRESPONDENCE**

TO:	**K. HENN**	**DATE:**	**OCTOBER 24, 2000**
FROM:	**GRETCHEN A. PHIPPS**	**COPIES:**	**DV FILE / REV 2**

SUBJECT: **INORGANIC DATA VALIDATION – TAL METALS AND TIN**
CTO 083 – NSWC CRANE
SDG – C8304

SAMPLES: 16/Soils/

BG1SBA0405	BG1SBP0103	BG1SBP0204
BG1SBP0206	BG1SBP0305	BG1SBP0401
BG1SBP0406	BG1SBP0505	BG1SBP0601
BG1SBP0603	BG1SBP0701	BG1SBP0801
BG1SBP0804	BG1SBP0806	BG1SBP0901
BG1SBP1004		

<u>Overview</u>

he sample set for CTO 083, NSWC Crane, SDG C8304, consists of sixteen (16) soil environmental samples.

All samples were analyzed for target analyte list (TAL) metals and tin. The samples were collected by Tetra Tech NUS on November 5-6, 1999 and analyzed by Laucks Testing Labs, Inc. under Naval Facilities Engineering Service Center (NFESC) Quality Assurance/Quality Control (QA/QC) criteria. Aluminum, barium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, nickel, potassium, vanadium and zinc analyses were conducted using SW 846 method 6010B via ICP instrumentation. Arsenic, beryllium, cadmium, selenium, silver, sodium, thallium, antimony and tin analyses were conducted using SW 846 method 6020 via ICP/MS instrumentation. Mercury analyses were conducted using SW 846 method 7471A via CVAA instrumentation.

These data were evaluated based on the following parameters:

* * • Data Completeness
* * • Holding Times
* • Calibration Verifications
* • Laboratory Blank Analyses
* • Field Quality Control Blank Analyses
* * • ICP Interference Check Sample Results
* • Matrix Spike Results
* • Laboratory Duplicate Results
* * • Post Digestion Spike Results
* * • Laboratory Control Sample Results
* * • ICP Serial Dilution Results
* * • Sample Quantitation
* • Detection Limits

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

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

Samples affected: All

Analyte	Maximum Concentration	Action Level (soil)
Antimony[(1)]	0.20 mg/kg	1.0 mg/kg
Arsenic	0.2µg/L	0.10 mg/kg
Beryllium[(1)]	0.05 mg/kg	0.25 mg/kg
Tin[(1)]	0.350 mg/kg	1.75 mg/kg

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

An action level of 5X the maximum concentration has been 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 less than the action level for antimony, beryllium and tin were qualified as nondetected "U". Positive results greater than the action level for arsenic were qualified as estimated, "J".

All positive results reported for any analyte present in a field quality control blank were qualified as estimated, "J".

Matrix Spike Results

The Matrix Spike (MS) Percent Recovery (%R) for vanadium was <75% quality control limit. The positive results reported for vanadium were qualified as estimated, "J".

Laboratory Duplicate Results

Laboratory Duplicate imprecision (>35%) was noted for arsenic, chromium, iron, lead and manganese. The positive results reported for arsenic, chromium, iron, lead and manganese were qualified as estimated, "J".

Notes

The Contract Required Detection Limit (CRDL) Percent Recovery (%R) for arsenic was <80% quality control limits. No validation action is required per regional guidance.

As noted in the Case Narrative, the soil adjusted IDLs were not met for all metals analyzed via ICP instrumentation.

The metals analyzed via MS/ICP instrumentation were conducted at a 5X dilution.

Selenium and sodium exceeded the soil adjusted limits requested in the QAPP.

Executive Summary

Laboratory Performance: Several analytes were present in the laboratory method / preparation blanks.

Other Factors Affecting Data Quality: All positive results reported for any analyte present in a field quality control blank were qualified as estimated, "J". Several analytes were present in the field quality control blanks. The MS %R for vanadium was <75% quality control limit. Laboratory duplicate imprecision was noted for arsenic, chromium, iron, lead and manganese.

The data for these analyses were reviewed with reference to the "National Functional Guidelines for Inorganic Review", February 1994, "EPA Region V Standard Operating Procedures for Validation of CLP Inorganic Review", September 1993 and the NFESC document entitled "Navy Installation Restoration Laboratory Quality Assurance Guide " (NFESC 2/96). 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
Gretchen A. Phipps
Chemist

Tetra Tech NUS
Joseph A. Samchuck
Quality Assurance Officer

'ttachments:

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

Tetra Tech NUS **INTERNAL CORRESPONDENCE**

TO:	**K. HENN**	**DATE:**	**OCTOBER 23, 2000**
FROM:	**GRETCHEN A. PHIPPS**	**COPIES:**	**DV FILE / REV 2**

SUBJECT: **INORGANIC DATA VALIDATION – TAL METALS AND TIN**
CTO 083 – NSWC CRANE
SDG – C8305

SAMPLES: 18/Soils/

BG1SBL0305	BG1SBL0403	BG1SBL0501
BG1SBL0504	BG1SBL0506	BG2SBG0101
BG2SBG0104	BG2SBG0201	BG2SBG0203
BG2SBG0206	BG2SBG0303	BG2SBG0401
BG2SBG0404	BG2SBG0503	BGFD11029901
BGFD11079901	BGFD11079902	BGFD11089901

Overview

The sample set for CTO 083, NSWC Crane, SDG C8305, consists of eighteen (18) soil environmental samples. Three (3) field duplicate pairs (BG2SBG0303 / BGFD11079901, BG2SBG0401 / BGFD11079902 and BG1SBL0504 / BGFD11089901) were included within this SDG.

All samples were analyzed for target analyte list (TAL) metals and tin. The samples were collected by Tetra Tech NUS on November 2, 7 and 8, 1999 and analyzed by Laucks Testing Labs, Inc. under Naval Facilities Engineering Service Center (NFESC) Quality Assurance/Quality Control (QA/QC) criteria. Aluminum, barium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, nickel, potassium, vanadium and zinc analyses were conducted using SW 846 method 6010B via ICP instrumentation. Arsenic, beryllium, cadmium, selenium, silver, sodium, thallium, antimony and tin analyses were conducted using SW 846 method 6020 via ICP/MS instrumentation. Mercury analyses were conducted using SW 846 method 7471A via CVAA instrumentation.

These data were evaluated based on the following parameters:

- * • Data Completeness
- * • Holding Times
- • Calibration Verifications
- • Laboratory Blank Analyses
- • Field Quality Control Blank Analyses
- * • ICP Interference Check Sample Results
- • Matrix Spike Results
- * • Laboratory Duplicate Results
- * • Post Digestion Spike Results
- * • Laboratory Control Sample Results
- * • ICP Serial Dilution Results
- * • Sample Quantitation
- • Detection Limits

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

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

Samples affected: All

Analyte	Maximum Concentration	Action Level (soil)
Antimony[(1)]	0.3 mg/kg	1.5 mg/kg
Beryllium	0.1μg/L	0.05 mg/kg
Cadmium	1.6μg/L	0.80 mg/kg
Silver	0.1μg/L	0.05 mg/kg
Tin[(1)]	0.40 mg/kg	2.0 mg/kg

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

An action level of 5X the maximum concentration has been 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 less than the action level for antimony, beryllium, cadmium, silver and tin were qualified as nondetected "U". Positive results greater than the action level for antimony and beryllium were qualified as estimated, "J".

All positive results reported for any analyte present in a field quality control blank were qualified as estimated, "J".

/latrix Spike Results

The Matrix Spike (MS) Percent Recovery (%R) for chromium was <75% quality control limit. The positive results reported for chromium were qualified as estimated, "J".

Notes

The Contract Required Detection Limit (CRDL) Percent Recoveries (%Rs) for arsenic, cadmium, lead and silver were outside the 80-120% quality control limits. No validation action is required per regional guidance.

As noted in the Case Narrative, the soil adjusted IDLs were not met for all metals analyzed via ICP instrumentation.

A comparison of field duplicate pairs (BG2SBG0303 / BGFD11079901, BG2SBG0401 / BGFD11079902 and BG1SBL0504 / BGFD11089901) is included in Appendix C.

The metals analyzed via MS/ICP instrumentation were conducted at a 5X dilution.

Selenium and sodium exceeded the soil adjusted limits requested in the QAPP.

The original sample associated with field duplicate sample BGFD11029901 was not included in this SDG. Therefore, a comparison was not made.

Executive Summary

Laboratory Performance: Several analytes were present in the laboratory method / preparation blanks.

Other Factors Affecting Data Quality: All positive results reported for any analyte present in a field quality control blank were qualified as estimated, "J". Several analytes were present in the field quality control blanks. The MS %R for chromium was <75% quality control limit.

The data for these analyses were reviewed with reference to the "National Functional Guidelines for Inorganic Review", February 1994, "EPA Region V Standard Operating Procedures for Validation of CLP Inorganic Review", September 1993 and the NFESC document entitled "Navy Installation Restoration Laboratory Quality Assurance Guide " (NFESC 2/96). 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
Gretchen A. Phipps
Chemist

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

Tetra Tech NUS **INTERNAL CORRESPONDENCE**

TO:	**K. HENN**	**DATE:**	**JUNE 1, 2000**
FROM:	**GRETCHEN A. PHIPPS**	**COPIES:**	**DV FILE**

SUBJECT: **INORGANIC DATA VALIDATION – LITHIUM, STRONTIUM AND THORIUM**
CTO 083 – NSWC CRANE
SDG – C8306

SAMPLES: 18/Soils/

BG3SBM0201	BG3SBM0203	BG3SBM0206
BG3SBM0305	BG3SBM0401	BG3SBM0404
BG3SBM0406	BG3SBM0504	BG3SBM0601
BG3SBM0604	BG3SBM0701	BG3SBM0704
BG3SBM0706	BG3SBM0801	BG3SBM0803
BG3SBM0904	BG3SBM1003	BGFD11039901

Overview

The sample set for CTO 083, NSWC Crane, SDG C8306, consists of eighteen (18) soil environmental samples. One (1) field duplicate pair (BG3SBM0803 / BGFD11039901) was included within this SDG.

All samples were analyzed for lithium, strontium and thorium. The samples were collected by Tetra Tech NUS on November 2-4, 1999 and analyzed by Laucks Testing Labs, Inc. under Naval Facilities Engineering Service Center (NFESC) Quality Assurance/Quality Control (QA/QC) criteria. Metals analyses were conducted using SW 846 method 6020 via ICP/MS instrumentation.

These data were evaluated based on the following parameters:

* * Data Completeness
* Holding Times
* * Calibration Verifications
* Laboratory Blank Analyses
* * ICP Interference Check Sample Results
* * Matrix Spike Results
* * Laboratory Duplicate Results
* * Field Duplicate Results
* * Post Digestion Spike Results
* * Laboratory Control Sample Results
* ICP Serial Dilution Results
* * Sample Quantitation
* Detection Limits

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

Holding Times

The 180 day holding time for metals analyses was exceeded by 7-9 days. However, the request for analysis of the additional metals was made as hold times were about to expire. The positive results reported were qualified as estimated, "J".

Laboratory Blank Analyses

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

Samples affected: All

Analyte	Maximum Concentration	Action Level (soil)
Lithium	0.2µg/L	0.10 mg/kg
Thorium	0.4µg/L	0.20 mg/kg

An action level of 5X the maximum concentration has been 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 greater than the action level lithium and thorium were qualified as estimated, "J".

ICP Serial Dilution

The ICP Serial Dilution Percent Differences (%Ds) for lithium, strontium and thorium were >10% quality control limit. The positive results reported for lithium, strontium and thorium were qualified as estimated, "J".

Notes

A comparison of field duplicate pair (BG3SBM0803 / BGFD11039901) is included in Appendix C.

The metals analyzed via ICP/MS instrumentation were conducted at a 5X dilution.

Executive Summary

Laboratory Performance: Lithium and strontium were present in the laboratory method / preparation blanks.

Other Factors Affecting Data Quality: The holding time was exceeded. The ICP Serial Dilution %Ds for lithium, strontium and thorium were >10% quality control limit.

The data for these analyses were reviewed with reference to the "National Functional Guidelines for Inorganic Review", February 1994, "EPA Region V Standard Operating Procedures for Validation of CLP Inorganic Review", September 1993 and the NFESC document entitled "Navy Installation Restoration Laboratory Quality Assurance Guide " (NFESC 2/96). 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)."

Gretchen A. Phipps

Tetra Tech NUS
Gretchen A. Phipps
Chemist

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
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

CTO083-NSWC CRANE

SOIL DATA
LAUCKS
SDG: C8306

SAMPLE NUMBER:	BG3SBM0201			BG3SBM0203			BG3SBM0206			BG3SBM0305		
SAMPLE DATE:	11/02/99			11/02/99			11/02/99			11/02/99		
LABORATORY ID:	0004692-02			0004692-03			0004692-04			0004692-07		
QC_TYPE:	NORMAL			NORMAL			NORMAL			NORMAL		
% SOLIDS:	82.0 %			86.4 %			82.2 %			90.5 %		
UNITS:	MG/KG			MG/KG			MG/KG			MG/KG		
FIELD DUPLICATE OF:												
	RESULT	**QUAL**	**CODE**	**RESULT**	**QUAL**	**CODE**	**RESULT**	**QUAL**	**CODE**	**RESULT**	**QUAL**	**CODE**
INORGANICS												
LITHIUM	13.8	J	AHI	20.8	J	AHI	30.6	J	AHI	17.8	J	AHI
STRONTIUM	8.6	J	HI	16.3	J	HI	25.7	J	HI	8.5	J	HI
THORIUM	7.1	J	AHI	9.4	J	AHI	10.0	J	AHI	7.8	J	AHI

CTO083-NSWC CRANE
SOIL DATA
LAUCKS
SDG: C8306

SAMPLE NUMBER:	BG3SBM0401			BG3SBM0404			BG3SBM0406			BG3SBM0504		
SAMPLE DATE:	11/03/99			11/03/99			11/03/99			11/03/99		
LABORATORY ID:	0004692-10			0004692-11			0004692-12			0004692-13		
QC_TYPE:	NORMAL			NORMAL			NORMAL			NORMAL		
% SOLIDS:	84.4 %			88.6 %			93.8 %			87.9 %		
UNITS:	MG/KG			MG/KG			MG/KG			MG/KG		
FIELD DUPLICATE OF:												
	RESULT	**QUAL**	**CODE**	**RESULT**	**QUAL**	**CODE**	**RESULT**	**QUAL**	**CODE**	**RESULT**	**QUAL**	**CODE**
INORGANICS												
LITHIUM	14.8	J	AHI	13.3	J	AHI	7.8	J	AHI	14.7	J	AHI
STRONTIUM	13.3	J	HI	12.7	J	HI	4.2	J	HI	13.3	J	HI
THORIUM	7.3	J	AHI	6.5	J	AHI	4.1	J	AHI	6.7	J	AHI

CTO083-NSWC CRANE
SOIL DATA
LAUCKS
SDG: C8306

SAMPLE NUMBER:	BG3SBM0601			BG3SBM0604			BG3SBM0701			BG3SBM0704		
SAMPLE DATE:	11/02/99			11/02/99			11/03/99			11/03/99		
LABORATORY ID:	0004692-05			0004692-06			0004692-15			0004692-16		
QC_TYPE:	NORMAL			NORMAL			NORMAL			NORMAL		
% SOLIDS:	80.3 %			90.3 %			83.4 %			87.2 %		
UNITS:	MG/KG			MG/KG			MG/KG			MG/KG		
FIELD DUPLICATE OF:												
	RESULT	QUAL	CODE	RESULT	QUAL	CODE	RESULT	QUAL	CODE	RESULT	QUAL	CODE
INORGANICS												
LITHIUM	13.9	J	AHI	20.6	J	AHI	15.9	J	AHI	14.8	J	AHI
STRONTIUM	63.2	J	HI	15.9	J	HI	11.1	J	HI	16.2	J	HI
THORIUM	5.9	J	AHI	6.9	J	AHI	7.8	J	AHI	8.3	J	AHI

CTO083-NSWC CRANE
SOIL DATA
LAUCKS
SDG: C8306

SAMPLE NUMBER:	BG3SBM0706			BG3SBM0801			BG3SBM0803			BG3SBM0904		
SAMPLE DATE:	11/03/99			11/03/99			11/03/99			11/03/99		
LABORATORY ID:	0004692-17			0004692-08			0004692-09			0004692-14		
QC_TYPE:	NORMAL			NORMAL			NORMAL			NORMAL		
% SOLIDS:	90.2 %			84.9 %			92.0 %			87.1 %		
UNITS:	MG/KG			MG/KG			MG/KG			MG/KG		
FIELD DUPLICATE OF:												
	RESULT	**QUAL**	**CODE**	**RESULT**	**QUAL**	**CODE**	**RESULT**	**QUAL**	**CODE**	**RESULT**	**QUAL**	**CODE**
INORGANICS												
LITHIUM	18.4	J	AHI	11.2	J	AHI	10.4	J	AHI	15.4	J	AHI
STRONTIUM	15.4	J	HI	7.4	J	HI	5.0	J	HI	14.4	J	HI
THORIUM	8.1	J	AHI	5.8	J	AHI	4.6	J	AHI	9.0	J	AHI

CTO083-NSWC CRANE
SOIL DATA
LAUCKS
SDG: C8306

SAMPLE NUMBER:	BG3SBM1003			BGFD11039901								
SAMPLE DATE:	11/04/99			11/03/99			/ /			/ /		
LABORATORY ID:	0004692-18			0004692-01								
QC_TYPE:	NORMAL			NORMAL								
% SOLIDS:	88.3 %			91.9 %			100.0 %			100.0 %		
UNITS:	MG/KG			MG/KG								
FIELD DUPLICATE OF:				BG3SBM0803								
	RESULT	**QUAL**	**CODE**	**RESULT**	**QUAL**	**CODE**	**RESULT**	**QUAL**	**CODE**	**RESULT**	**QUAL**	**CODE**
INORGANICS												
LITHIUM	16.4	J	AHI	10.3	J	AHI						
STRONTIUM	10.1	J	HI	5.6	J	HI						
THORIUM	7.0	J	AHI	5.1	J	AHI						

Tetra Tech NUS **INTERNAL CORRESPONDENCE**

TO:	**K. HENN**	**DATE:**	**JUNE 7, 2000**
FROM:	**GRETCHEN A. PHIPPS**	**COPIES:**	**DV FILE**

SUBJECT: **INORGANIC DATA VALIDATION – LITHIUM, STRONTIUM AND THORIUM**
CTO 083 – NSWC CRANE
SDG – C8307

SAMPLES: 19/Soils/

BG1SBA0104	BG1SBA0306	BG1SBA0401
BG1SBA0503	BG1SBA0504	BG1SBL0101
BG1SBL0103	BG1SBL0105	BG1SBL0405
BG3SBA0101	BG3SBA0203	BG3SBA0301
BG3SBA0403	BG3SBA0404	BG3SBA0501
BG3SBA0504	BG3SBA0506	BGFD11059901
BGFD11069901		

Overview

The sample set for CTO 083, NSWC Crane, SDG C8307, consists nineteen (19) soil environmental samples. Two (2) field duplicate samples (BGFD11059901 and BGFD11069901) were included within this SDG. The corresponding sample duplicates (BG1SBP0601 and BG1SBP0406) were not contained within this SDG.

All samples were analyzed for lithium, strontium and thorium. The samples were collected by Tetra Tech NUS on November 3-8, 1999 and analyzed by Laucks Testing Labs, Inc. under Naval Facilities Engineering Service Center (NFESC) Quality Assurance/Quality Control (QA/QC) criteria. Metals analyses were conducted using SW 846 method 6020 via ICP/MS instrumentation.

These data were evaluated based on the following parameters:

- Data Completeness
- Holding Times
- * Calibration Verifications
- Laboratory Blank Analyses
- * ICP Interference Check Sample Results
- * Matrix Spike Results
- * Laboratory Duplicate Results
- * Post Digestion Spike Results
- * Laboratory Control Sample Results
- * ICP Serial Dilution Results
- * Sample Quantitation
- * Detection Limits

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

Holding Times

The 180 day holding time for metals analyses was exceeded by 3-9 days. However, the request for analysis of the additional metals was made as hold times were about to expire. The positive results reported were qualified as estimated, "J".

Laboratory Blank Analyses

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

Samples affected: All

Analyte	Maximum Concentration	Action Level (soil)
Lithium	0.2µg/L	0.1 mg/kg
Strontium[(1)]	0.02 mg/kg	0.1 mg/kg
Thorium	0.4µg/L	0.2 mg/kg

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

An action level of 5X the maximum concentration has been 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 greater than the action level for lithium, strontium and thorium were qualified as estimated, "J".

Notes

The original samples associated with the field duplicate samples were not included within this SDG.

The metals analyzed via ICP/MS instrumentation were conducted at a 5X dilution.

Sample BG1SBA101 was not analyzed because the laboratory could not locate the sample.

Positive results reported between the IDL and the reporting limits were qualified as estimated, "J".

Executive Summary

Laboratory Performance: Lithium, strontium and thorium were present in the laboratory method / preparation blanks.

Other Factors Affecting Data Quality: The holding time was exceeded.

The data for these analyses were reviewed with reference to the "National Functional Guidelines for Inorganic Review", February 1994, "EPA Region V Standard Operating Procedures for Validation of CLP Inorganic Review", September 1993 and the NFESC document entitled "Navy Installation Restoration Laboratory Quality Assurance Guide " (NFESC 2/96). 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
Gretchen A. Phipps
Chemist

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
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

CTO083-NSWC CRANE
SOIL DATA
LAUCKS
SDG: C8307

SAMPLE NUMBER:	BG1SBA0104			BG1SBA0306			BG1SBA0401			BG1SBA0503		
SAMPLE DATE:	11/04/99			11/05/99			11/05/99			11/04/99		
LABORATORY ID:	0004695-13			0004695-02			0004695-16			0004695-14		
QC_TYPE:	NORMAL			NORMAL			NORMAL			NORMAL		
% SOLIDS:	91.2 %			88.7 %			80.3 %			89.5 %		
UNITS:	MG/KG			MG/KG			MG/KG			MG/KG		
FIELD DUPLICATE OF:												
	RESULT	**QUAL**	**CODE**	**RESULT**	**QUAL**	**CODE**	**RESULT**	**QUAL**	**CODE**	**RESULT**	**QUAL**	**CODE**
INORGANICS												
LITHIUM	15.8	J	AH	10.6	J	AH	13.6	J	AH	17.1	J	AH
STRONTIUM	7.0	J	AH	5.5	J	AH	13.7	J	AH	7.9	J	AH
THORIUM	6.2	J	AH	4.2	J	PAH	6.3	J	AH	6.3	J	AH

CTO083-NSWC CRANE
SOIL DATA
LAUCKS
SDG: C8307

SAMPLE NUMBER:	BG1SBA0504			BG1SBL0101			BG1SBL0103			BG1SBL0105		
SAMPLE DATE:	11/04/99			11/08/99			11/08/99			11/08/99		
LABORATORY ID:	0004695-15			0004695-18			0004695-19			0004695-20		
QC_TYPE:	NORMAL			NORMAL			NORMAL			NORMAL		
% SOLIDS:	91.0 %			80.5 %			85.2 %			89.0 %		
UNITS:	MG/KG			MG/KG			MG/KG			MG/KG		
FIELD DUPLICATE OF:												
	RESULT	QUAL	CODE	RESULT	QUAL	CODE	RESULT	QUAL	CODE	RESULT	QUAL	CODE
INORGANICS												
LITHIUM	16.3	J	AH	13.5	J	AH	12.7	J	AH	12.4	J	AH
STRONTIUM	8.2	J	AH	12.6	J	AH	16.2	J	AH	9.7	J	AH
THORIUM	6.3	J	AH	7.2	J	AH	8.6	J	AH	6.3	J	AH

CTO083-NSWC CRANE
SOIL DATA
LAUCKS
SDG: C8307

SAMPLE NUMBER:	BG1SBL0405	BG3SBA0101	BG3SBA0203	BG3SBA0301
SAMPLE DATE:	11/08/00	11/02/99	11/02/99	11/03/99
LABORATORY ID:	0004695-17	0004695-05	0004695-04	0004695-06
QC_TYPE:	NORMAL	NORMAL	NORMAL	NORMAL
% SOLIDS:	87.7 %	84.3 %	89.2 %	80.1 %
UNITS:	MG/KG	MG/KG	MG/KG	MG/KG
FIELD DUPLICATE OF:				

	RESULT	QUAL	CODE	RESULT	QUAL	COD.	RESULT	QUAL	CODE	RESULT	QUAL	CODE
INORGANICS												
LITHIUM	10.8	J	AH	8.2	J	AH	12.1	J	AH	10.2	J	AH
STRONTIUM	11.4	J	AH	7.4	J	AH	7.1	J	AH	10.1	J	AH
THORIUM	7.2	J	AH	4.8	J	AH	5.9	J	AH	6.4	J	AH

CTO083-NSWC CRANE
SOIL DATA
LAUCKS
SDG: C8307

SAMPLE NUMBER:	BG3SBA0403			BG3SBA0404			BG3SBA0501			BG3SBA0504		
SAMPLE DATE:	11/04/99			11/04/99			11/04/99			11/04/99		
LABORATORY ID:	0004695-07			0004695-08			0004695-09			0004695-10		
QC_TYPE:	NORMAL			NORMAL			NORMAL			NORMAL		
% SOLIDS:	90.3 %			88.9 %			82.9 %			85.2 %		
UNITS:	MG/KG			MG/KG			MG/KG			MG/KG		
FIELD DUPLICATE OF:												
	RESULT	**QUAL**	**CODE**	**RESULT**	**QUAL**	**CODE**	**RESULT**	**QUAL**	**CODE**	**RESULT**	**QUAL**	**CODE**
INORGANICS												
LITHIUM	10.9	J	AH	11.5	J	AH	11.5	J	AH	14.0	J	AH
STRONTIUM	8.8	J	AH	9.2	J	AH	9.9	J	AH	10.6	J	AH
THORIUM	6.2	J	AH	5.9	J	AH	5.3	J	AH	5.7	J	AH

CTO083-NSWC CRANE
SOIL DATA
LAUCKS
SDG: C8307

SAMPLE NUMBER:	BG3SBA0506			BGFD11059901			BGFD11069901					
SAMPLE DATE:	11/04/99			11/05/99			11/06/99			/ /		
LABORATORY ID:	0004695-11			0004695-01			0004695-03					
QC_TYPE:	NORMAL			NORMAL			NORMAL					
% SOLIDS:	88.9 %			82.6 %			89.8 %			100.0 %		
UNITS:	MG/KG			MG/KG			MG/KG					
FIELD DUPLICATE OF:				BG1SBP0601			BG1SBP0406					
	RESULT	QUAL	CODE	RESULT	QUAL	CODE	RESULT	QUAL	CODE	RESULT	QUAL	CODE
INORGANICS												
LITHIUM	9.6	J	AH	18.1	J	AH	23.5	J	AH			
STRONTIUM	7.2	J	AH	11.4	J	AH	17.9	J	AH			
THORIUM	4.5	J	AH	8.3	J	AH	10.6	J	AH			

Tetra Tech NUS

INTERNAL CORRESPONDENCE

TO:	**K. HENN**	**DATE:**	**JUNE 7, 2000**
FROM:	**GRETCHEN A. PHIPPS**	**COPIES:**	**DV FILE**

SUBJECT: **INORGANIC DATA VALIDATION – LITHIUM, STRONIUM, AND THORIUM**
CTO 083 – NSWC CRANE
SDG – C8308

SAMPLES: 16/Soils/

BG1SBA0405	BG1SBP0103	BG1SBP0204
BG1SBP0206	BG1SBP0305	BG1SBP0401
BG1SBP0406	BG1SBP0505	BG1SBP0601
BG1SBP0603	BG1SBP0701	BG1SBP0801
BG1SBP0804	BG1SBP0806	BG1SBP0901
BG1SBP1004		

Overview

The sample set for CTO 083, NSWC Crane, SDG C8308, consists of sixteen (16) soil environmental samples.

All samples were analyzed for lithium, strontium and thorium. The samples were collected by Tetra Tech NUS on November 5-6, 1999 and analyzed by Laucks Testing Labs. under Naval Facilities Engineering Service Center (NFESC) Quality Assurance/Quality Control (QA/QC) criteria. Metals analyses were conducted using SW 846 method 6020 via ICP/MS instrumentation.

These data were evaluated based on the following parameters:

- * Data Completeness
- Holding Times
- * Calibration Verifications
- Laboratory Blank Analyses
- * ICP Interference Check Sample Results
- Matrix Spike Results
- * Laboratory Duplicate Results
- * Post Digestion Spike Results
- * Laboratory Control Sample Results
- * ICP Serial Dilution Results
- * Sample Quantitation
- * Detection Limits

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

Holding Times

The 180 day holding time for metals analyses was exceeded by 5-6 days. However, the request for analysis of the additional metals was made as hold times were about to expire. The positive results reported were qualified as estimated, "J".

Laboratory Blank Analyses

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

Samples affected: All

Analyte	Maximum Concentration	Action Level (soil)
Lithium	0.2μg/L	0.1 mg/kg
Thorium	0.4μg/L	0.2 mg/kg

An action level of 5X the maximum concentration has been 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 greater than the action level for lithium and thorium were qualified as estimated, "J".

Matrix Spike Results

The Matrix Spike (MS) Percent Recovery (%R) for lithium was <75% quality control limit. The positive results reported for lithium were qualified as estimated, "J".

Notes

The metals analyzed via ICP/MS instrumentation were conducted at a 5X dilution.

Executive Summary

Laboratory Performance: Lithium and thorium were present in the laboratory method / preparation blanks.

Other Factors Affecting Data Quality: The holding time was exceeded. The MS %R for lithium was <75% quality control limit.

The data for these analyses were reviewed with reference to the "National Functional Guidelines for Inorganic Review", February 1994, "EPA Region V Standard Operating Procedures for Validation of CLP Inorganic Review", September 1993 and the NFESC document entitled "Navy Installation Restoration Laboratory Quality Assurance Guide " (NFESC 2/96). 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)."

Gretchen A. Phipps

Tetra Tech NUS
Gretchen A. Phipps
Chemist

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
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

CTO083-NSWC CRANE
SOIL DATA
LAUCKS
SDG: C8308

SAMPLE NUMBER:	BG1SBA0405			BG1SBP0103			BG1SBP0204			BG1SBP0206		
SAMPLE DATE:	11/05/99			11/06/99			11/06/99			11/06/99		
LABORATORY ID:	0004699-01			0004699-11			0004699-12			0004699-13		
QC_TYPE:	NORMAL			NORMAL			NORMAL			NORMAL		
% SOLIDS:	80.2 %			87.7 %			85.5 %			90.1 %		
UNITS:	MG/KG			MG/KG			MG/KG			MG/KG		
FIELD DUPLICATE OF:												
	RESULT	QUAL	CODE	RESULT	QUAL	CODE	RESULT	QUAL	CODE	RESULT	QUAL	CODE
INORGANICS												
LITHIUM	17.4	J	ADH	19.6	J	ADH	13.8	J	ADH	15.1	J	ADH
STRONTIUM	11.6	J	H	10.3	J	H	19.2	J	H	10.4	J	H
THORIUM	6.9	J	AH	9.1	J	AH	9.3	J	AH	7.1	J	AH

CTO083-NSWC CRANE
SOIL DATA
LAUCKS
SDG: C8308

SAMPLE NUMBER:	BG1SBP0305			BG1SBP0401			BG1SBP0406			BG1SBP0505		
SAMPLE DATE:	11/06/99			11/06/99			11/06/99			11/05/99		
LABORATORY ID:	0004699-16			0004699-14			0004699-15			0004699-06		
QC_TYPE:	NORMAL			NORMAL			NORMAL			NORMAL		
% SOLIDS:	86.7 %			85.5 %			90.9 %			89.6 %		
UNITS:	MG/KG			MG/KG			MG/KG			MG/KG		
FIELD DUPLICATE OF:												
	RESULT	**QUAL**	**CODE**	**RESULT**	**QUAL**	**CODE**	**RESULT**	**QUAL**	**CODE**	**RESULT**	**QUAL**	**CODE**
INORGANICS												
LITHIUM	46.6	J	ADH	15.0	J	ADH	24.8	J	ADH	31.7	J	ADH
STRONTIUM	11.8	J	H	9.4	J	H	20.3	J	H	17.2	J	H
THORIUM	11.7	J	AH	7.5	J	AH	11.1	J	AH	8.8	J	AH

CTO083-NSWC CRANE
SOIL DATA
LAUCKS
SDG: C8308

SAMPLE NUMBER:	BG1SBP0601			BG1SBP0603			BG1SBP0701			BG1SBP0801		
SAMPLE DATE:	11/05/99			11/05/99			11/05/99			11/06/99		
LABORATORY ID:	0004699-04			0004699-05			0004699-03			0004699-08		
QC_TYPE:	NORMAL			NORMAL			NORMAL			NORMAL		
% SOLIDS:	82.7 %			89.6 %			87.9 %			83.9 %		
UNITS:	MG/KG			MG/KG			MG/KG			MG/KG		
FIELD DUPLICATE OF:												
	RESULT	QUAL	CODE	RESULT	QUAL	CODE	RESULT	QUAL	CODE	RESULT	QUAL	CODE
INORGANICS												
LITHIUM	19.0	J	ADH	28.7	J	ADH	14.7	J	ADH	14.5	J	ADH
STRONTIUM	13.7	J	H	13.0	J	H	8.7	J	H	10.7	J	H
THORIUM	8.4	J	AH	8.8	J	AH	5.9	J	AH	8.5	J	AH

CTO083-NSWC CRANE
SOIL DATA
LAUCKS
SDG: C8308

SAMPLE NUMBER:	BG1SBP0804			BG1SBP0806			BG1SBP0901			BG1SBP1004		
SAMPLE DATE:	11/06/99			11/06/99			11/06/99			11/05/99		
LABORATORY ID:	0004699-09			0004699-10			0004699-07			0004699-02		
QC_TYPE:	NORMAL			NORMAL			NORMAL			NORMAL		
% SOLIDS:	90.4 %			94.1 %			82.3 %			89.2 %		
UNITS:	MG/KG			MG/KG			MG/KG			MG/KG		
FIELD DUPLICATE OF:												
	RESULT	**QUAL**	**CODE**	**RESULT**	**QUAL**	**CODE**	**RESULT**	**QUAL**	**CODE**	**RESULT**	**QUAL**	**CODE**
INORGANICS												
LITHIUM	14.5	J	ADH	8.6	J	ADH	29.9	J	ADH	13.7	J	ADH
STRONTIUM	10.0	J	H	5.4	J	H	12.7	J	H	11.6	J	H
THORIUM	8.0	J	AH	4.9	J	AH	7.9	J	AH	7.3	J	AH

Tetra Tech NUS **INTERNAL CORRESPONDENCE**

TO:	**K. HENN**	**DATE:**	**JUNE 8, 2000**
FROM:	**GRETCHEN A. PHIPPS**	**COPIES:**	**DV FILE**

SUBJECT: **INORGANIC DATA VALIDATION – LITHIUM, STRONTIUM AND THORIUM**
CTO 083 – NSWC CRANE
SDG – C8309

SAMPLES: 18/Soils/

BG1SBL0305	BG1SBL0403	BG1SBL0501
BG1SBL0504	BG1SBL0506	BG2SBG0101
BG2SBG0104	BG2SBG0201	BG2SBG0203
BG2SBG0206	BG2SBG0303	BG2SBG0401
BG2SBG0404	BG2SBG0503	BGFD11029901
BGFD11079901	BGFD11079902	BGFD11089901

Overview

The sample set for CTO 083, NSWC Crane, SDG C8309, consists of eighteen (18) soil environmental samples. Three (3) field duplicate pairs (BG2SBG0303 / BGFD11079901, BG2SBG0401 / BGFD11079902 and BG1SBL0504 / BGFD11089901) were included within this SDG.

All samples were analyzed for lithium, strontium and thorium. The samples were collected by Tetra Tech NUS on November 2, 7 and 8, 1999 and analyzed by Laucks Testing Labs under Naval Facilities Engineering Service Center (NFESC) Quality Assurance/Quality Control (QA/QC) criteria. Metals analyses were conducted using SW 846 method 6020 via ICP/MS instrumentation.

These data were evaluated based on the following parameters:

* * Data Completeness
* Holding Times
* * Calibration Verifications
* Laboratory Blank Analyses
* * ICP Interference Check Sample Results
* * Matrix Spike Results
* * Laboratory Duplicate Results
* * Field Duplicate Results
* * Post Digestion Spike Results
* * Laboratory Control Sample Results
* * ICP Serial Dilution Results
* * Sample Quantitation
* * Detection Limits

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

Holding Times

The 180 day holding time for metals analyses was exceeded by 3-4 days. However, the request for analysis of the additional metals was made as hold times were about to expire. The positive results reported were qualified as estimated, "J".

Laboratory Blank Analyses

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

Samples affected: All

Analyte	Maximum Concentration	Action Level (soil)
Lithium	0.2µg/L	0.1 mg/kg
Thorium	0.4µ/L	0.2 mg/kg

An action level of 5X the maximum concentration has been 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 greater than the action level for lithium and thorium were qualified as estimated, "J".

ICP Serial Dilution

The ICP Serial Dilution Percent Difference (%D) for lithium was >10% quality control limit. The positive results reported for lithium were qualified as estimated, "J".

Notes

A comparison of field duplicate pairs (BG2SBG0303 / BGFD11079901, BG2SBG0401 / BGFD11079902 and BG1SBL0504 / BGFD11089901) is included in Appendix C.

The metals analyzed via ICP/MS instrumentation were conducted at a 5X dilution.

The original sample associated with field duplicate sample BGFD11029901 was not included in this SDG. Therefore, a comparison was not made.

The incorrect results were reported for sample BG2SBG0503 due to an error on behalf of the laboratory. A transcription error caused the incorrect electronic data to be uploaded. A corrected Form 1 was requested by the data reviewer. The laboratory submitted the corrected Form 1 on June 8, 2000.

Executive Summary

Laboratory Performance: Several analytes were present in the laboratory method / preparation blanks.

Other Factors Affecting Data Quality: The holding time was exceeded. The ICP Serial Dilution %D for lithium was >10% quality control limit.

The data for these analyses were reviewed with reference to the "National Functional Guidelines for Inorganic Review", February 1994, "EPA Region V Standard Operating Procedures for Validation of CLP Inorganic Review", September 1993 and the NFESC document entitled "Navy Installation Restoration Laboratory Quality Assurance Guide " (NFESC 2/96). 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)."

Gretchen Phipps

Tetra Tech NUS
Gretchen A. Phipps
Chemist

Tetra Tech NUS
Joseph A. Samchuck
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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
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

CTO083-NSWC CRANE
SOIL DATA
LAUCKS
SDG: C8309

SAMPLE NUMBER:	BG1SBL0305			BG1SBL0403			BG1SBL0501			BG1SBL0504		
SAMPLE DATE:	11/08/99			11/08/99			11/08/99			11/08/99		
LABORATORY ID:	0004698-16			0004698-17			0004698-13			0004698-14		
QC_TYPE:	NORMAL			NORMAL			NORMAL			NORMAL		
% SOLIDS:	87.5 %			85.3 %			82.0 %			89.3 %		
UNITS:	MG/KG			MG/KG			MG/KG			MG/KG		
FIELD DUPLICATE OF:												
	RESULT	QUAL	CODE	RESULT	QUAL	CODE	RESULT	QUAL	CODE	RESULT	QUAL	CODE
INORGANICS												
LITHIUM	22.3	J	AHI	14.1	J	AHI	14.5	J	AHI	11.9	J	AHI
STRONTIUM	17.0	J	H	10.5	J	H	10.9	J	H	13.3	J	H
THORIUM	8.7	J	AH	8.4	J	AH	8.7	J	AH	7.8	J	AH

CTO083-NSWC CRANE
SOIL DATA
LAUCKS
SDG: C8309

SAMPLE NUMBER:	BG1SBL0506			BG2SBG0101			BG2SBG0104			BG2SBG0201		
SAMPLE DATE:	11/08/99			11/07/99			11/07/99			11/07/99		
LABORATORY ID:	0004698-15			0004698-05			0004698-06			0004698-07		
QC_TYPE:	NORMAL			NORMAL			NORMAL			NORMAL		
% SOLIDS:	89.3 %			80.5 %			89.7 %			81.5 %		
UNITS:	MG/KG			MG/KG			MG/KG			MG/KG		
FIELD DUPLICATE OF:												
	RESULT	**QUAL**	**CODE**	**RESULT**	**QUAL**	**CODE**	**RESULT**	**QUAL**	**CODE**	**RESULT**	**QUAL**	**CODE**
INORGANICS												
LITHIUM	28.1	J	AHI	13.2	J	AHI	14.5	J	AHI	10.0	J	AHI
STRONTIUM	17.0	J	H	14.2	J	H	11.7	J	H	9.7	J	H
THORIUM	9.1	J	AH	7.9	J	AH	5.7	J	AH	6.4	J	AH

CTO083-NSWC CRANE
SOIL DATA
LAUCKS
SDG: C8309

SAMPLE NUMBER:	BG2SBG0203			BG2SBG0206			BG2SBG0303			BG2SBG0401		
SAMPLE DATE:	11/07/99			11/07/99			11/07/99			11/07/99		
LABORATORY ID:	0004698-08			0004698-09			0004698-04			0004698-11		
QC_TYPE:	NORMAL			NORMAL			NORMAL			NORMAL		
% SOLIDS:	91.9 %			82.1 %			90.2 %			82.0 %		
UNITS:	MG/KG			MG/KG			MG/KG			MG/KG		
FIELD DUPLICATE OF:												
	RESULT	**QUAL**	**CODE**	**RESULT**	**QUAL**	**CODE**	**RESULT**	**QUAL**	**CODE**	**RESULT**	**QUAL**	**CODE**
INORGANICS												
LITHIUM	9.2	J	AHI	10.8	J	AHI	9.7	J	AHI	12.3	J	AHI
STRONTIUM	8.1	J	H	10.0	J	H	9.7	J	H	17.0	J	H
THORIUM	5.8	J	AH	6.3	J	AH	5.2	J	AH	6.9	J	AH

CTO083-NSWC CRANE
SOIL DATA
LAUCKS
SDG: C8309

SAMPLE NUMBER:	BG2SBG0404			BG2SBG0503			BGFD11029901			BGFD11079901		
SAMPLE DATE:	11/07/99			11/07/99			11/02/99			11/07/99		
LABORATORY ID:	0004698-12			0004698-10			0004698-18			0004698-01		
QC_TYPE:	NORMAL			NORMAL			NORMAL			NORMAL		
% SOLIDS:	88.8 %			86.9 %			84.7 %			89.6 %		
UNITS:	MG/KG			MG/KG			MG/KG			MG/KG		
FIELD DUPLICATE OF:							BG3SBA0101			BG2SBG0303		
	RESULT	QUAL	CODE	RESULT	QUAL	CODE	RESULT	QUAL	CODE	RESULT	QUAL	CODE
INORGANICS												
LITHIUM	14.9	J	AHI	205	J	AHI	9.1	J	AHI	11.3	J	AHI
STRONTIUM	9.1	J	H	108	J	H	7.8	J	H	10.8	J	H
THORIUM	7.6	J	AH	99.5	J	AH	5.9	J	AH	5.0	J	AH

CTO083-NSWC CRANE
SOIL DATA
LAUCKS
SDG: C8309

SAMPLE NUMBER:	BGFD11079902			BGFD11089901								
SAMPLE DATE:	11/07/99			11/08/99			/ /			/ /		
LABORATORY ID:	0004698-02			0004698-03								
QC_TYPE:	NORMAL			NORMAL								
% SOLIDS:	81.4 %			89.2 %			100.0 %			100.0 %		
UNITS:	MG/KG			MG/KG								
FIELD DUPLICATE OF:	BG2SBG0401			BG1SBL0504								
	RESULT	QUAL	CODE	RESULT	QUAL	CODE	RESULT	QUAL	CODE	RESULT	QUAL	CODE
INORGANICS												
LITHIUM	12.8	J	AHI	13.6	J	AHI						
STRONTIUM	17.3	J	H	14.3	J	H						
THORIUM	6.6	J	AH	7.7	J	AH						

Tetra Tech NUS **INTERNAL CORRESPONDENCE**

TO:	**K. HENN**	**DATE:**	**JUNE 7, 2000**
FROM:	**GRETCHEN A. PHIPPS**	**COPIES:**	**DV FILE**

SUBJECT: **INORGANIC DATA VALIDATION – LITHIUM, STRONTIUM AND THORIUM**
CTO 083 – NSWC CRANE
SDG – C8310

SAMPLES: 8/Aqueous/

BGRB11029901	BGRB11039901	BGRB11049901
BGRB11059901	BGRB11069901	BGRB11079901
BGRB11089901	BGSW11029901	

Overview

The sample set for CTO 083, NSWC Crane, SDG C8310, consists of seven (7) rinsate blanks and one (1) source water blank (BGSW11029901).

All samples were analyzed for lithium, strontium and thorium. The samples were collected by Tetra Tech NUS on November 2-8, 1999 and analyzed by Laucks Testing Labs. under Naval Facilities Engineering Service Center (NFESC) Quality Assurance/Quality Control (QA/QC) criteria. Metals analyses were conducted using SW 846 method 6020 via ICP/MS instrumentation.

These data were evaluated based on the following parameters:

- * • Data Completeness
- • Holding Times
- * • Calibration Verifications
- * • ICP Interference Check Sample Results
- * • Laboratory Duplicate Results
- * • Matrix Spike/ Matrix Spike Duplicate Analyses
- * • Post Digestion Spike Analyses
- * • Laboratory Control Sample Results
- * • Sample Quanitation
- • Detection Limits

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

Holding Times

The 180 day holding time for metals analyses was exceeded by 4-10 days. However, the request for analysis of the additional metals was made as hold times were about to expire. The positive and nondetected results reported were qualified as estimated, "J" and "UJ", respectively.

Notes

Please, note that field quality control samples are not qualified for blank contamination.

All metals were reported at IDLs marginally higher than requested in the QAPP. No validation action was taken on this basis.

Positive results reported between the IDL and the reporting limits were qualified as estimated, "J".

Executive Summary

Laboratory Performance: None.

Other Factors Affecting Data Quality: The holding time was exceeded.

The data for these analyses were reviewed with reference to the "National Functional Guidelines for Inorganic Review", February 1994, "EPA Region V Standard Operating Procedures for Validation of CLP Inorganic Review", September 1993 and the NFESC document entitled "Navy Installation Restoration Laboratory Quality Assurance Guide " (NFESC 2/96). 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)."

Gretchen A Phipps

Tetra Tech NUS
Gretchen A. Phipps
Chemist

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
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

CTO083-NSWC CRANE
WATER DATA
LAUCKS
SDG: C8310

SAMPLE NUMBER:	BGRB11029901			BGRB11039901			BGRB11049901			BGRB11059901	
SAMPLE DATE:	11/02/99			11/03/99			11/04/99			11/05/99	
LABORATORY ID:	0004700-01			0004700-03			0004700-04			0004700-05	
QC_TYPE:	NORMAL			NORMAL			NORMAL			NORMAL	
% SOLIDS:	0.0 %			0.0 %			0.0 %			0.0 %	
UNITS:	UG/L			UG/L			UG/L			UG/L	
FIELD DUPLICATE OF:											

	RESULT	QUAL	CODE	RESULT	QUAL	CODE	RESULT	QUAL	CODE	RESULT	QUAL	CODE
INORGANICS												
LITHIUM	0.22	UJ	H	0.22	J	HP	0.22	UJ	H	0.22	UJ	H
STRONTIUM	0.22	UJ	H	0.22	UJ	H	0.22	UJ	H	0.22	UJ	H
THORIUM	0.33	J	HP	0.22	UJ	H	0.22	UJ	H	0.22	UJ	H

CTO083-NSWC CRANE
WATER DATA
LAUCKS
SDG: C8310

SAMPLE NUMBER:	BGRB11069901			BGRB11079901			BGRB11089901			BGSW11029901		
SAMPLE DATE:	11/06/99			11/07/99			11/08/99			11/02/99		
LABORATORY ID:	0004700-06			0004700-07			0004700-08			0004700-02		
QC_TYPE:	NORMAL			NORMAL			NORMAL			NORMAL		
% SOLIDS:	0.0 %			0.0 %			0.0 %			0.0 %		
UNITS:	UG/L			UG/L			UG/L			UG/L		
FIELD DUPLICATE OF:												
	RESULT	**QUAL**	**CODE**	**RESULT**	**QUAL**	**CODE**	**RESULT**	**QUAL**	**CODE**	**RESULT**	**QUAL**	**CODE**
INORGANICS												
LITHIUM	0.22	UJ	H	0.22	UJ	H	0.22	UJ	H	0.22	UJ	H
STRONTIUM	0.22	UJ	H	0.22	UJ	H	0.22	UJ	H	0.22	UJ	H
THORIUM	0.22	UJ	H	0.22	UJ	H	0.22	UJ	H	0.22	UJ	H

Tetra Tech NUS **INTERNAL CORRESPONDENCE**

TO:	**K. HENN**	**DATE:**	**JANUARY 10, 2001**
FROM:	**JENNIFER M. MALLE**	**COPIES:**	**REVISION 1** **DV FILE**

SUBJECT: **INORGANIC DATA VALIDATION – TAL METALS,TIN, LITHIUM, STRONTIUM AND THORIUM**
CTO 083 – NSWC CRANE
SDG – C8311

SAMPLES: 3/Soil/

BG1SBA250203 BG1SBA280304 BGFD10070001

2/Aqueous/

BGRB10060001 BGRB10070001

Overview

The sample set for CTO 083, NSWC Crane, SDG C8311, consists of three (3) soil environmental samples and two (2) aqueous field quality control samples. One (1) field duplicate pair (BG1SBA250203 / BGFD10070001) was included within this SDG.

All samples were analyzed for target analyte list (TAL) metals plus tin, lithium, strontium and thorium. The samples were collected by Tetra Tech NUS on October 6-7, 2000 and analyzed by Laucks Testing Labs, Inc. under Naval Facilities Engineering Service Center (NFESC) Quality Assurance/Quality Control (QA/QC) criteria. Aluminum, beryllium, calcium, iron, magnesium, manganese, potassium and sodium analyses were conducted using SW 846 method 6010B via ICP instrumentation. Antimony, arsenic, barium, cadmium, chromium, cobalt, copper, lead, nickel, selenium, silver, thallium, vanadium, zinc, lithium, strontium, thorium and tin analyses were conducted using SW 846 method 6020 via ICP/MS instrumentation. Mercury analyses were conducted using SW 846 method 7471A via CVAA instrumentation.

These data were evaluated based on the following parameters:

- * Data Completeness
- * Holding Times
- * Calibration Verifications
- Laboratory Blank Analyses
- Field Quality Control Blank Analyses
- ICP Interference Check Sample Results
- 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.

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

Samples affected: All

Analyte	Maximum Concentration	Action Level (soil)	Action Level (aqueous)
Chromium [(1)]	0.088 mg/kg	0.44 mg/kg	NA
Copper	1.7 ug/L	0.85 mg/kg	NA
Iron	27.9 ug/L	13.9 mg/kg	NA
Magnesium [(1)]	52.8 ug/L	26.4 mg/kg	NA
Sodium	88.9 ug/L	44.4 mg/kg	NA
Tin [(1)]	0.072 mg/kg	0.36 mg/kg	NA
Thorium	0.2 ug/L	NA	0.10 ug/L

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

An action level of 5X the maximum concentration has been 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 less than the action level for tin were qualified as nondetected "U". Positive results greater than the action level for chromium, copper, iron, magnesium, sodium, and thorium were qualified as estimated, "J".

It should be noted that field quality control blanks were not used to establish an action level. All positive results reported for the analytes aluminum, barium, chromium, iron, lithium and thorium, which were present in a field quality control blank, were qualified as estimated, "J".

ICP Interference Check Sample Results

The percent recovery (%R) for sodium in solution A was 64%. This percentage falls below the 80-120 quality control limits. The positive results reported for sodium were qualified as estimated, "J".

Matrix Spike/Post Digestion Spike Results

Revisions to this data validation letter were required due to a laboratory error in regards to the calculation of the MS/MSD percent recoveries for the soil samples. The laboratory originally reported results for most analytes (13 out of 18) in the spiked sample result (SSR) and spike added (SA) columns incorrectly. Noncompliant percent recoveries were reported for chromium, copper, lead and manganese. The original MS/MSD %Rs were questioned by the analytical chemist for NSWC Crane, Tom Johnston, in part, due to a low %R (5.3 %) for chromium. The laboratory was contacted by Mr. Johnston in regards to the questionable %R. Upon examination of the matrix spike results, the laboratory discovered that calculation errors had occurred. The laboratory resubmitted the MS/MSD results for the soil samples. The resubmitted matrix spike results affected the data qualifiers for copper and lead (qualifiers were removed since the percent recoveries were now within quality control limits). Additionally, although the percent recovery changed for chromium, a noncompliance (a high %R) still existed and the qualifiers for this analyte remained the same. Finally, manganese was not affected by the laboratory error and therefore qualifiers remained unchanged. The following qualifiers are based on the resubmitted MS/MSD results from the lab:

The Matrix Spike (MS) Percent Recovery (%R) for chromium was greater than 125% affecting the soil matrix. The positive results reported for chromium in the affected samples were qualified as estimated, "J".

The Matrix Spike (MS) Percent Recovery (%R) for manganese was less than 75% quality control limit affecting the soil matrix. The positive results reported for manganese in the affected samples were qualified as estimated, "J".

ICP Serial Dilution

ICP Serial Dilution Percent Difference was greater than 10% and 50x the respective IDL affecting the soil matrix for chromium, lithium, magnesium, potassium and vanadium. The positive results reported in the affected samples for these analytes were qualified as estimated, "J".

Notes

The Contract Required Detection Limit (CRDL) Percent Recovery (%R) for thorium affecting the aqueous matrix was greater than the 120% quality control limits. However, no validation action is required per regional guidance.

The Contract Required Detection Limit (CRDL) Percent Recoveries (%Rs) for copper, strontium and thorium affecting the soil matrix was greater than the 120% quality control limits. However, no validation action is required per regional guidance.

A comparison of field duplicate pair (BG1SBA250203 / BGFD10070001) is included in Appendix C.

Instrument detection limits (IDLs) for calcium, iron, sodium and zinc exceed the soil adjusted limits requested in the QAPP.

Aqueous IDLs for mercury, lithium, strontium and thorium marginally exceeded the requested IDLs requested in the QAPP. No validation action was taken.

Analyses performed on the ICP/MS instrumentation were performed at a 5x dilution.

Executive Summary

Laboratory Performance: Several analytes were present in the laboratory method / preparation blanks.

Other Factors Affecting Data Quality: Several analytes were present in the field quality control blanks. The MS %Rs for copper, lead and manganese were less than the 75% quality control limit affecting the soil matrix. Chromium MS %R in the soil samples was less than 30%. ICP serial dilution noncompliances were noted for chromium, magnesium, potassium, vanadium, and lithium affecting the soil matrix.

The data for these analyses were reviewed with reference to the "National Functional Guidelines for Inorganic Review", February 1994, "EPA Region V Standard Operating Procedures for Validation of CLP Inorganic Review", September 1993 and the NFESC document entitled "Navy Installation Restoration Chemical Data Quality Manual" (NFESC 9/99).
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)."

Jennifer Malle

Tetra Tech NUS
Jennifer M. Malle
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
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/PCB D% 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 = % Solid content is less than 30%

CTO083-NSWC CRANE
SOIL DATA
LAUCKS
SDG: C8311

SAMPLE NUMBER:	BG1SBA250203			BG1SBA280304			BGFD10070001					
SAMPLE DATE:	10/07/00			10/06/00			10/07/00			/ /		
LABORATORY ID:	0010266-04			0010266-02			0010266-03					
QC_TYPE:	NORMAL			NORMAL			NORMAL					
% SOLIDS:	79.1 %			85.7 %			79.5 %			100.0 %		
UNITS:	MG/KG			MG/KG			MG/KG					
FIELD DUPLICATE OF:							BG1SBA250203					
	RESULT	QUAL	CODE	RESULT	QUAL	CODE	RESULT	QUAL	CODE	RESULT	QUAL	CODE
INORGANICS												
ALUMINUM	16000	J	B	12000	J	B	16700	J	B			
ANTIMONY	0.45	U		0.46	U		0.49					
ARSENIC	5.9			5.6			5.7					
BARIUM	80.4	J	B	36.9	J	B	77.2	J	B			
BERYLLIUM	0.82			0.54			0.74					
CADMIUM	0.44	J	P	0.33	J	P	0.41	J	P			
CALCIUM	313			108			287					
CHROMIUM	17.3	J	BAID	20.9	J	BAID	14.6	J	BAID			
COBALT	7.5			2.2			6.1					
COPPER	10.1	J	A	10	J	A	10.3	J	A			
IRON	22700	J	AB	28900	J	AB	17200	J	AB			
LEAD	13.1			10.1			11.4					
LITHIUM	20.3	J	IB	27.9	J	IB	20.7	J	IB			
MAGNESIUM	1400	J	AI	755	J	AI	1470	J	AI			
MANGANESE	1030	J	D	86.4	J	D	713	J	D			
MERCURY	0.04			0.05	U		0.04					
NICKEL	13			9.5			12					
POTASSIUM	1370	J	I	1650	J	I	1440	J	I			
SELENIUM	0.46	U		0.44	U		0.44	U				
SILVER	0.23	U		0.22	U		0.22	U				
SODIUM	80.3	J	AKP	97.8	J	AKP	77.1	J	AKP			
STRONTIUM	12.7			12.2			12.8					
THALLIUM	0.25	J	P	0.22	U		0.27	J	P			
THORIUM	8.4	J	B	9	J	B	8.7	J	B			
TIN	0.38	U	A	0.4	U	A	0.36	U	A			
VANADIUM	26.3	J	I	19.9	J	I	26.1	J	I			
ZINC	42.9			25.4			41.7					

CTO(NSWC CRANE
WATE. ATA
LAUCKS
SDG: C8311

SAMPLE NUMBER:	BGRB10060001	BGRB10070001		
SAMPLE DATE:	10/06/00	10/07/00	/ /	/ /
LABORATORY ID:	0010266-01	0010266-05		
QC_TYPE:	NORMAL	NORMAL		
% SOLIDS:	0.0 %	0.0 %	100.0 %	100.0 %
UNITS:	UG/L	UG/L		
FIELD DUPLICATE OF:				

	RESULT	QUAL	CODE	RESULT	QUAL	CODE	RESULT	QUAL	CODE	RESULT	QUAL	CODE
INORGANICS												
ALUMINUM	55.9	J	P	55.6	U							
ANTIMONY	1.1	U		1.1	U							
ARSENIC	1.1	U		1.1	U							
BARIUM	0.68	J	P	0.56	U							
BERYLLIUM	0.56	U		0.56	U							
CADMIUM	0.56	U		0.56	U							
CALCIUM	124	U		124	U							
CHROMIUM	0.56	U		0.56	J	P						
COBALT	0.56	U		0.56	U							
COPPER	0.56	U		0.56	U							
IRON	24.9	J	P	20.2	J	P						
LEAD	0.56	U		0.56	U							
LITHIUM	0.36	J	P	0.22	U							
MAGNESIUM	36.7	U		36.7	U							
MANGANESE	1.7	U		1.7	U							
MERCURY	0.20	U		0.20	U							
NICKEL	0.56	U		0.56	U							
POTASSIUM	163	U		163	U							
SELENIUM	1.1	U		1.1	U							
SILVER	0.56	U		0.56	U							
SODIUM	31.1	U		31.1	U							
STRONTIUM	0.22	U		0.22	U							
THALLIUM	0.56	U		0.56	U							
THORIUM	0.43	J	AP	0.22	U							
TIN	0.11	U		0.11	U							
VANADIUM	0.56	U		0.56	U							
ZINC	5.6	U		5.6	U							

APPENDIX D

METHODOLOGY and SUMMARY OF STATISTICAL ANALYSIS

D-1 METHODOLOGY FOR STATISTICAL ANALYSIS

Appendix D-1

D.1.1 Non-detected Results and Field Duplicate Samples

In the chemical analysis of environmental samples, some analytes may be present at concentrations which are below the detection limit (DL) of the analytical procedure. The results are generally reported as not detected (rather than zero), and the appropriate limit of detection is given. The amount of data that are below the detection limit plays an important role in selecting the method of addressing the limit of detection problem. The nondetects in this investigation site were replaced with the DL divided by two prior to statistical analysis. Clearly, if all the observations are nondetect results, no statistical analysis is warranted.

Duplicate samples also pose a special situation because two results are available for what is essentially one sampling location. To address this, a maximum value for each field duplicate pair was calculated and counted as one sample for use in the statistical analyses.

D.1.2 The Shapiro-Wilk Test of Normality

The Shapiro-Wilk W-test (Gilbert, 1987) is an effective method for determining whether a data set has been drawn from an underlying normal distribution. In addition, by conducting the Shapiro-Wilk W-test on the log-transformed data, the test may be used to determine whether the data have been drawn from an underlying lognormal distribution. The null hypothesis (H_0) that is tested is:

> H_O *The population has a normal (or lognormal when the data is log-transformed) distribution.*

The alternate hypothesis (H_A) is:

> H_A *The population does not have a normal (or lognormal when the data is log-transformed) distribution.*

If H_O is rejected, then H_A is accepted. If H_0 is not rejected, the data set is consistent with the H_0 distribution.

A "W" statistic (W_{calc}) is computed for a data set (or a log transformed data set) and compared to a test statistic (W_{test}). If $W_{calc} \geq W_{test}$, then the null hypothesis is not rejected (i.e. the data are assumed to be normally distributed [or lognormally distributed if log transformed data are tested]). If $W_{calc} < W_{test}$, then the null hypothesis is rejected and the alternate hypothesis is accepted (i.e., the data are not assumed to be normally distributed [or not lognormally distributed if log transformed data are tested]).

The following equations present a step-by-step procedure for conducting the W-test on the residuals.

The equation for conducting the W-Test is:

$$W_{calc} = \left[\frac{b}{S_R \sqrt{n-1}} \right]^2$$

where

$$b = \sum_{i=1}^{k} a_i \left(R_{[n-i+1]} - R_i \right) = \sum_{i=1}^{k} b_i$$

and n is the total number of samples.

- Step 1. Order the n samples from smallest to largest to obtain the sample order statistics:

$$x_1 \leq x_2 \leq x_3 \leq \ldots \leq x_n$$

- Step 2. Compute the standard deviation by:

$$S_R = \sqrt{\sum_{i=1}^{n} \frac{\left(R_{ij} - \overline{R}\right)^2}{(n-1)}}$$

- Step 3. Determine the coefficients $a_1, a_2, a_3, \ldots, a_k$ for the sample size n using Table D-1 where:

$$k = \frac{n}{2} \ \textit{if n is even}; \text{ and}$$

$$k = \frac{n-1}{2} \ \textit{if n is odd}$$

- Step 4. Determine b by the formula:

$$b = \sum_{i=1}^{k} a_i \left(R_{[n-i+1]} - R_i\right) = \sum_{i=1}^{k} b_i$$

- Step 5. Calculate W_{calc} using b from above:

$$W_{calc} = \left[\frac{b}{S_R\sqrt{n-1}}\right]^2$$

- Step 6. Determine W_{test} at the 5% significance level from Table D-2.

- Step 7. Reject H_O at the 5% significance level if W_{calc} is less than W_{test}.

To test the null hypothesis that the data set has been drawn from an underlying lognormal distribution, transform the data to $y_{1j}, y_{2j}, y_{3j}, \ldots, y_{km}$ where $y_{ij} = \ln R_{ij}$. Repeat steps 1 through 7 as described in the preceding paragraphs.

D.1.3 Normal Probability Plots

The expected normal probability for the j^{th} value ranked from lowest to highest (Z_j) is defined as:

$$Z_j = \Phi^{-1}\{(3j - 1)/(3N + 1)\}$$

Where:
Φ^{-1} denotes the inverse of the cumulative normal distribution function (from Table 1)
j is the rank of the value from lowest to highest
N denotes the total number of samples in the dataset
$\{(3j - 1)/(3N + 1)\} = p$ is the probability that a value falls below that result
Z_j denotes the probability p normalized to a Z score to give linear results

A probability plot is a graph of data plotted *versus* the expected probability of a user-specified distribution. If the distribution is normal the plot is a normal probability plot and the expected normal probability is used. The goal of constructing a probability plot is to visually evaluate whether the data fit the proposed underlying distribution. If the graph of plotted points appears linear, the data fit well to the specified distribution. Deviations from a straight line may indicate the existence of outliers.

A distinction is made between "statistical" outliers and "real" outliers. A statistical outlier is a point which appears to be inconsistent with all or most of the other points in the data set, based on some assumed or apparent pattern of those points, e.g., a normal distribution. The various outlier tests found in the statistical literature are all devoted to identifying statistical outliers. Outlier identification should be used as a screening tool. Statistical outliers should not be automatically discarded but rather should be investigated to determine whether they are real outliers. A real outlier is a result which because of outside contamination or because of mistakes such as deviations from protocol, instrument errors, computational errors or transcription errors, really does not belong in the data set. If, upon investigation, a statistical outlier is determined to be a real outlier, then it should be discarded. However, if a statistical outlier cannot be clearly identified as a real outlier, then careful consideration should be given to leaving it in the data set and rethinking the assumptions that led to it being identified as a statistical outlier.

Generally, when concentrations of inorganic constituents cannot be linked to a specific contamination source and appear to be randomly distributed, those constituents are suspected to be naturally occurring. The background datasets for each metal were statistically analyzed in order to determine whether they represented members of one population (background) or multiple distinct populations. The analysis involved determining the underlying distribution (normal or lognormal) of each data set by using the Shapiro-Wilk W Test. The theory is that when sampling in soil for constituents of concern, the concentrations of the metals should be normally or lognormally distributed except in locations where metals were introduced into the soil matrix by release due to activities at the base.

To aid in classification of metal results, probability plots were generated on either the non-transformed or log-transformed data (based on the underlying distribution) for each inorganic constituent for the purpose of analyzing the data graphically. Probability plots offer a simple, yet useful graphical presentation of the data that is used to investigate the distribution of a dataset and to identify possible outliers in a dataset (i.e., identify data points that do not reflect background conditions). If analytic data are drawn from the same population (e.g., background), the data points when plotted will approximate a straight line. Curves, gaps, or inflection points suggest that the data come from dissimilar datasets or that outliers exist.

A 95% confidence ellipse was plotted onto each of the probability plots. This type of ellipse is based on the assumption that the two variables follow the bivariate normal distribution. Two variables follow the bivariate normal distribution if for each value of one variable, the corresponding values of another variable are normally distributed. The orientation of this ellipse is determined by the sign of the linear correlation between two variables (the longer axis of the ellipse is superimposed on the regression line). The value of the coefficient, in this case 0.95 or 95%, determines the probability that the values will fall within the area marked by the ellipse.

Confidence in the 'best-fit' trend line tends to be higher for values close to the mean and lower at extremes away from the mean. The reason for this is that in a normally distributed dataset (which can be thought of as a bell-shaped frequency curve) the bulk of the data points are toward the center (near the mean). This instill more confidence in the results. At the extremes (away from the mean) there are only a small number of data points, reducing the confidence.

Outliers were identified by visually inspecting the plotted data relative to the confidence ellipse for each inorganic constituent. Statistical outliers were defined as any point which fell outside of the confidence ellipse.

D.1.4 95% Upper Tolerance Limits (UTLs)

A Tolerance interval establishes a concentration range that is constructed to contain a specified proportion (P%) of the population with a specified confidence coefficient, *Y*. The proportion of the population included, *P*, is referred to as the coverage. The probability with which the Tolerance interval includes the proportion *P*% of the population is referred to as the tolerance coefficient of the interval.

A coverage of 95% is is commonly recommended and was used here. With this specification, random observations from the same distribution as the background data would exceed the upper Tolerance limit less than 5% of the time. Similarly, a tolerance coefficient of 95% was used. This means that one has a confidence level of 95% that the 95% Upper Tolerance Limit (95% UTL) will contain at least 95% of the distribution of observations from background data.

The following equations present a step-by-step procedure for conducting the W-test on the data

- Step 1. Take the mean, $\overline{x}$, and the standard deviation, S_R, calculated during the Shapiro and Wilk W-test statistical analyses.

- Step 2. Construct the one-sided upper Tolerance limit ($UTL_{0.95}$) as:

  $$UTL_{0.95} = \overline{x} + k\,S_R$$

  where *k* is the one-sided normal Tolerance factor found in Table D-3.

D.1.5 Non-parametric ANOVA: Wilcoxon Rank-Sum Test (a.k.a. Mann-Whitney U Test)

The Wilcoxon Rank-Sum test was used to test the null hypothesis that the soil types come from the same population distribution against the alternate hypothesis that they do not come from the same distribution. This test makes no assumptions concerning the shape (e.g., normal or log-normal) of the data distributions. The Wilcoxon Rank-Sum test is equivalent to the Mann-Whitney U test. The following equations present a step-by-step procedure for conducting the Wilcoxon Rank-Sum test.

The null hypothesis (H_0) that is tested is:

H_O *The metal concentration distribution of soil type 1 IS THE SAME AS the metal concentration distribution of soil type 2.*

The alternate hypothesis (H_A) is:

H_A *The metal concentration distribution of soil type 1 IS NOT THE SAME AS the metal concentration distribution of soil type 2.*

If H_O is rejected, then H_A is accepted. If H_0 is not rejected, the data set is consistent with the H_0 hypothesis.

1 $$W = \sum_{i=1}^{n} E_i - \frac{1}{2} n(n + 1)$$

- Step 2. Compute the Wilcoxon statistic *W*:

where E_i are the ranks of the soil type 1 samples (Large values of the statistic *W* give evidence of higher concentrations in soil type 1).

- Step 3. Compute an approximate *Z-score*. To find the critical value of *W*, a normal approximation to its distribution is used. The expected value and standard deviation of *W* under the null hypothesis (i.e., no contamination exists) are given by the formulas

2 $$E(W) = \frac{1}{2} mn; \qquad SD(W) = \sqrt{\frac{1}{12} mn(N + 1)}$$

An approximate *Z-score* for the Wilcoxon Rank-Sum test may be calculated by the following equations:

3 $$Z = \frac{W - E(W) - \frac{1}{2}}{SD(W)}$$

The factor of 1/2 in the numerator serves as a continuity correction since the discrete distribution of the statistic W is being approximated by the continuous normal distribution. If $n,m > 10$ and ties are present, an adjustment to the approximate *Z-score* must be made:

4 $$Z_{ADJUSTED} = \frac{W - E(W) - \frac{1}{2}}{S'D(W)}$$

$$\text{where: } SD'(W) = \left(\frac{mn}{12} \left[N + 1 - \frac{\sum_{j=1}^{g} t_j (t_j^2 - 1)}{N(N-1)} \right] \right)^{\frac{1}{2}}$$

g = the number of tied groups and t_j is the number of tied data in the j^{th} group.

- Step 4. For a two-tailed 95% confidence level test for H_0 versus the, reject H_0 and accept H_A if $Z_{ADJUSTED} > Z_{0.95} = +1.96$.

D.1.6 **95% Confidence Interval**

The 100(1-a) Confidence Interval of the population mean ($\bar{x}$) consists of an Lower Confidence Limit and an Upper Confidence Limit ($LCL_{100(1-\square)}$) - $UCL_{100(1-\square)}$). When □ = 0.05, the 95 percent upper confidence limit (one-tailed test) may be calculated as follows:

$$UCL_{0.95} = \bar{x} + t_{0.95,n-1} \frac{S_x}{\sqrt{n}}$$

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$$LCL_{0.95} = \bar{x} - t_{0.95,n-1} \frac{S_x}{\sqrt{n}}$$

$$\bar{X} = \frac{1}{n} \sum_{i=1}^{n} x_i = \textit{arithmetic mean}$$

$$\text{where: } S_x = \sqrt{\frac{\sum_{i=1}^{n} (x_i - \bar{x})^2}{n-1}} = \textit{the sample standard deviation}$$

$$t_{0.95,n-1} = \textit{Value from t - distribution (Table ?)}$$

Table D-3

It should be noted that the 95 percent confidence interval for a second sample of size n drawn from the same population will most likely not be the same as that for the first sample. In theory if an interval estimate is calculated for the means of a very large set of samples of size n, the true population mean will be within 95 percent of this limit.

D.1.7 **Satterwaite's t Test**

The Satterthwaite t test is an alternative to the Student's t test, and is used when the assumption that the two populations have equal variances seems unreasonable. It provides a t statistic that asymptotically (that is, as the sample sizes become large) approaches a t distribution, allowing for an approximate t test to be calculated when the population variances are not equal.

Compute the Satterwaite two-sample t statistic (Ts):

$$Ts = (\bar{x} - \bar{y}) / (s_x^2/n_x + s_y^2/n_y)^{0.5}$$

Where $\bar{x}$ = the arithmetic mean of n_x site measurements
$\bar{y}$ = the arithmetic mean of n_y background measurements
s_x^2 = the sample variance of the n_x site measurements
s_y^2 = the sample variance of the n_y background measurements

Compute the approximate degrees of freedom, f, as follows:

$$f = \frac{\left(\frac{S_x^2}{n_x} + \frac{S_y^2}{n_y}\right)^2}{\left(\frac{S_x^4}{n_x^2(n_{x-1})} + \frac{S_y^4}{n_y^2(n_{y-1})}\right)}$$ rounded down to nearest integer.

For computation of minimal detectable difference the site standard deviation (s_y) was assumed to be twice the background standard deviation (s_x) and the number of site samples (n_y) was assumed to be 5.

The minimal difference $(\bar{x} - \bar{y}) = \Delta$ can be calculated by:

$$t_{(1-\alpha,f)} = \frac{\bar{X} - \bar{Y} - \delta_0}{\sqrt{\frac{s_x^2}{n_x} + \frac{s_y^2}{n_y}}}$$

Let $\sigma_0 = 0$. Then:

$$\Delta = t_{(1-\alpha,f)}\sqrt{\frac{s_x^2}{n_x} + \frac{s_y^2}{n_y}}$$

Let $S_y = 2S_x$ and $n_y = 5$:

$$\Delta = t_{(1-\alpha,f)}\sqrt{\frac{S_x^2}{n_x} + \frac{4S_x^2}{5}}$$

Divide both sides by S_x and square both sides:

$$\left(\frac{\Delta}{S_x}\right)^2 = \left(t_{(1-\alpha,f)}\right)^2\left(\frac{1}{n_x}+\frac{4}{5}\right)$$

Take the square root of both sides:

$$\left(\frac{\Delta}{S_x}\right) = t_{(1-\alpha,f)}\sqrt{\left(\frac{1}{n_x}+\frac{4}{5}\right)}$$

D.1.8 **Binomial Probability**

Given that 24 metal concentrations were analyzed in each soil sample, a large number of data set comparisons were generated. With this many comparisons, random statistical fluctuations alone would be likely to generate *apparent* differences between soil types where none exist. To counter this effect, binomial probabilities were used to compute the tolerable number of observed differences when the soil types being compared are the same. Assuming complete independence between metal concentrations, there is a 22% chance that two metals could yield statistically significant concentration differences in similar soil samples, there is a 9% chance that three metal concentration differences would be observed, and so on. Recognizing that the metal concentrations within a sample may not be independent, the conservative significance level of 22% was selected as a tolerable probability. Thus, up to two metals were allowed to show statistically significant concentration differences before an actual difference in soil type was inferred to exist. If three or more metals exhibited a difference at the 5% significance level, the soil types were inferred to differ and were not combined into the same soil group.

A binomial experiment is an experiment which satisfies these four conditions

- A fixed number of trials
- Each trial is independent of the others
- There are only two outcomes
- The probability of each outcome remains constant from trial to trial.
- These can be summarized as: An experiment with a fixed number of independent trials, each of which can only have two possible outcomes.

The fact that each trial is independent actually means that the probabilities remain constant.

The probability of getting exactly x success in n trials, with the probability of success on a single trial being p is:

P(X=x) = nCx * p^x * q^(n-x)

Where nCx = the number of combinations of x out of n = n! / x!(n-x)!
p = probability of success of one event
q = probability of failure of one event = 1-p

For example:
24 metals from two soil groups are compared. What is the probability that exactly 21 of the metals will 'pass' a 95% confidence Wilcoxon Rank-Sum test, 1.e., 3 metals will fail.

1. Success = "A metal from the two soil groups passes the Wilcoxon Rank-Sum test"
2. p = 0.95
3. q = 0.05
4. n = 24
5. x = 21

$P(x=21) = {}_{24}C_{21}$ * 0.95^21 * 0.05^3 = ((22*23*24)/(1*2*3))* 0.34056 * 0.000125 = 0.0862

The probability that exactly 21 of the metals will 'pass' a 95% confidence Wilcoxon Rank-Sum test is 0.0862 or approximately 9%.

TABLE D-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 D-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

TABLE D-3

TOLERANCE FACTORS (K) FOR ONE-SIDED NORMAL TOLERANCE INTERVALS WITH CONFIDENCE FACTOR Y=0.95 AND COVERAGE P=95%

n	K
3	7.655
4	5.145
5	4.202
6	3.707
7	3.399
8	3.188
9	3.031
10	2.911
11	2.815
12	2.736
13	2.670
14	2.614
15	2.566
16	2.523
17	2.486
18	2.543
19	2.423
20	2.396
21	2.371
22	2.350
23	2.329
24	2.309
25	2.292
30	2.220
35	2.166
40	2.126
45	2.092
50	2.065
55	2.036
60	2.017
65	2.000
70	1.986
75	1.972
100	1.924
125	1.891

n	K
150	1.868
175	1.850
200	1.836
225	1.824
250	1.814
275	1.806
300	1.799
325	1.792
350	1.787
375	1.782
400	1.777
425	1.773
450	1.769
475	1.766
500	1.763
525	1.760
550	1.757
575	1.754
600	1.752
625	1.750
650	1.748
675	1.746
700	1.744
725	1.742
750	1.740
775	1.739
800	1.737
825	1.736
850	1.734
875	1.733
900	1.732
925	1.731
950	1.729
975	1.728
1000	1.727

TABLE D-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
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

$F = 1 - \alpha$

CLIENT NSWC Crane	JOB NUMBER 0087
SUBJECT Sample Calculations of Statistical Analyses	
BASED ON Sitewide Soil Background	DRAWING NUMBER
BY BEL / CHECKED BY MBP	APPROVED BY / DATE 6/19/00

SAMPLE CALCULATIONS WERE PERFORMED FOR THE FOLLOWING STATISTICAL PROCEDURES USED IN SUPPORT OF THIS REPORT:

1. Shapiro-Wilk W Test of Normality
2. Wilcoxon Rank-Sum Test
3. 95% UPPER Tolerance Limit
4. 95% Confidence Interval
5. Minimum Detectable Differences Between Data Sets
6. Binomial Probabilities

LOESS/GLACIAL SURFACE SOIL RESULTS FOR ARSENIC:

SAMPLE	RESULT (MG/KG)	GROUP
BG1SBL0101	6.8	LS
BG1SBL0501	5.7	LS
BG2SBG0101	5.8	LS
BG2SBG0201	3.6	LS
BG2SBG0401-MAX	4.3	LS

1. SHAPIRO-WILK W TEST OF NORMALITY

a. The arithmetic mean ($\bar{X}$) can be calculated by:

$$\bar{X} = \frac{\sum_{i=1}^{n} X_i}{n}$$

$$\sum_{i=1}^{n} X_i = 6.8 + 5.7 + 5.8 + 3.6 + 4.3 = 26.2 \text{ MG/KG}$$

$$\bar{X} = \frac{26.2}{5} = 5.24 \text{ MG/KG}$$

CLIENT NSWC Crane		JOB NUMBER 0087	
SUBJECT Sample Calculations of Statistical Analyses			
BASED ON Sitewide Soil Background		DRAWING NUMBER	
BY BEL	CHECKED BY MBP	APPROVED BY	DATE 6/19/00

b. The standard deviation (S_x) can be calculated by:

$$S_x = \sqrt{\frac{\sum_{i=1}^{n} (x_i - \bar{x})^2}{n-1}}$$

$$\sum_{i=1}^{n} (x_i - \bar{x})^2 = (6.8-5.24)^2 + (5.7-5.24)^2 + (5.8-5.24)^2 + (3.6-5.24)^2 + (4.3-5.24)^2 = 1.56^2 + 0.46^2 + 0.56^2 + (-1.64)^2 + (-0.94)^2$$

$$\text{"} = 2.4336 + 0.2116 + 0.3136 + 2.6896 + 0.8836 = 6.532$$

$$S_x = \sqrt{\frac{6.532}{4}} = \sqrt{1.633} = 1.278 \text{ MG/KG}$$

c. Calculate b:

$$b = \sum_{i=1}^{k} b_i = \sum_{i=1}^{k} a_{(n-i+1)} \left[X_{(n-i+1)} - X_i \right]$$

where k is the greatest integer $\leq n/2$

$a_{(n-i+1)}$ can be found in Table 1.

i	X_i	$X_{(n-i+1)}$	$X_{(n-i+1)} - X_i$	$a_{(n-i+1)}$	b_i
1	3.6	6.8	3.2	0.6646	2.12672
2	4.3	5.8	1.5	0.2413	0.36195
3	5.7	5.7			
4	5.8	4.3			
5	6.8	3.6			
	[LOWEST TO HIGHEST]	[HIGHEST TO LOWEST]			

$$b = \sum_{i=1}^{2} b_i = 2.48867$$

CLIENT NSWC Crane	JOB NUMBER 0087
SUBJECT SAMPLE CALCULATIONS OF STATISTICAL ANALYSES	
BASED ON SITEWIDE SOIL BACKGROUND	DRAWING NUMBER
BY BGL	CHECKED BY MBP	APPROVED BY	DATE 6/19/00

d. The Shapiro-Wilk W Statistic (W) can be calculated by:

$$W = \left[\frac{b}{S_x \sqrt{n-1}}\right]^2$$

$$W = \left[\frac{2.48867}{(1.278)\sqrt{4}}\right]^2 = \left[\frac{2.48867}{2.55578}\right]^2 = [0.9737]^2 = 0.9481$$

e. Compare W with Wtest from Table 2:

$$W = 0.9481 > 0.762 = W_{test}$$

Since W > Wtest, we accept the null hypothesis (Ho) that the arsenic data has a normal distribution.

2. Wilcoxon Rank-Sum Test (Non-parametric ANOVA)

LOESS / GLACIAL SUBSURFACE SOIL - SAND RESULTS FOR ARSENIC:

SAMPLE	RESULT (MG/KG)	GROUP
BG2SBG0104	4.9	LBS
BG2SBG0303-MAX	1.3	LBS
BG2SBG0503	6.0	LBS

Combine both data sets and rank from smallest to largest:

SAMPLE	RESULT (MG/KG)	GROUP	RANK
BG2SBG0303-MAX	1.3	LBS	1
BG2SBG0201	3.6	LS	2
BG2SBG0401-MAX	4.3	LS	3
BG2SBG0104	4.9	LBS	4
	5.7	LS	5
	5.8	LS	6
	6.0	LBS	7
	6.8	LS	8

CLIENT NSWC CRANE	JOB NUMBER 0087
SUBJECT SAMPLE CALCULATIONS OF STATISTICAL ANALYSES	
BASED ON SITEWIDE SOIL BACKGROUND	DRAWING NUMBER
BY BEL / CHECKED BY MBP	APPROVED BY / DATE 6/19/00

W_{rs} = Rank-Sum of LBS = 1 + 4 + 7 = 12

$$Z_{rs} = \frac{W_{rs} - \frac{n_1(m+1)}{2}}{\sqrt{\frac{n_1 n_2 (m+1)}{12}}}$$

where n_1 = # of LBS results = 3

n_2 = # of LS results = 5

$m = n_1 + n_2 = 8$

$$Z_{rs} = \frac{12 - \frac{3(8+1)}{2}}{\sqrt{\frac{(3)(5)(8+1)}{12}}} = \frac{12 - 13.5}{\sqrt{11.25}}$$

$$Z_{rs} = \frac{-1.5}{3.354} = -0.4472$$

FROM TABLE 3 $Z = -0.4472 \Rightarrow p = 0.6547$

Since $p = 0.6547 > 0.05$, we accept the null hypothesis (H_0) that LB'S and LS are statistically similar.

CLIENT NSWC CRANE		JOB NUMBER 0087	
SUBJECT SAMPLE CALCULATIONS OF STATISTICAL ANALYSES			
BASED ON SITEWIDE SOIL BACKGROUND		DRAWING NUMBER	
BY BEL	CHECKED BY MGP	APPROVED BY	DATE 6/19/00

3. 95% Upper Tolerance Limit (95% UTL):

$$95\%\ UTL = \bar{X} + kS_x$$

where k = tolerance factor for one-sided tolerance intervals with confidence factor $\gamma = 0.95$ and coverage $P = 95\%$ from Table 4.

$$95\%\ UTL = 5.24 + (4.202)(1.278) = 5.24 + 5.37$$

95% UTL = 10.61 MG/KG

4. 95% Confidence Interval (95% CI):

$$95\%\ CI = \bar{X} \pm t_{1-\frac{\alpha}{2},n} \frac{S_x}{\sqrt{n}}$$

FROM TABLE 5, $t_{0.975,5} = 2.776$

$$95\%\ CI = 5.24 \pm (2.776)\frac{(1.278)}{\sqrt{5}}$$

$$95\%\ CI = 5.24 \pm \frac{3.5477}{2.2361}$$

$$95\%\ CI = 5.24 \pm 1.587$$

95% CI = 3.653 MG/KG TO 6.827 MG/KG

CLIENT NSWC CRANE		JOB NUMBER 0087	
SUBJECT SAMPLE CALCULATIONS OF STATISTICAL ANALYSSS			
BASED ON SITEWIDE SOIL BACKGROUND		DRAWING NUMBER	
BY BGL	CHECKED BY MBP	APPROVED BY	DATE 6/19/00

5. Minimum Detectable Differences Between Data Sets.

To determine the minimum detectable differences between means of these background data sets and site data sets, assumptions must be made about the site data sets. We assume that 5 samples (i.e., m=5) will be taken at the site and that the sample standard deviation of the site data will be the same as the background data (i.e., $S_Y = S_X$)

FOR ARSENIC IN GROUP LS:

$$\bar{X} - \bar{Y} = t_{1-\alpha, f} S_{NE}$$

$$S_{NE} = \sqrt{\frac{S_x^2}{m} + \frac{S_Y^2}{n}} = \sqrt{\frac{(1.278)^2}{5} + \frac{(1.278)^2}{5}}$$

$$S_{NE} = \sqrt{0.6533} = 0.8083 \text{ MG/KG}$$

$$f = \frac{\left[\frac{S_x^2}{m} + \frac{S_Y^2}{n}\right]^2}{\frac{S_x^4}{m^2(m-1)} + \frac{S_Y^4}{n^2(n-1)}} = \frac{\left[\frac{(1.278)^2}{5} + \frac{(1.278)^2}{5}\right]^2}{\frac{(1.278)^4}{5^2(4)} + \frac{(1.278)^4}{5^2(4)}}$$

$$f = \frac{(0.6533)^2}{0.0534} = 8.000$$

$t_{0.95,8} = 1.860$ FROM TABLE 5

CLIENT NSWC CRANE		JOB NUMBER 0087	
SUBJECT SAMPLE CALCULATIONS OF STATISTICAL ANALYSES			
BASED ON SITEWIDE SOIL BACKGROUND		DRAWING NUMBER	
BY BCL	CHECKED BY MBP	APPROVED BY	DATE 6/19/00

$$\bar{X} - \bar{Y} = (1.860)(0.8083 \text{ MG/KG})$$

$$\bar{X} - \bar{Y} = 1.503 \text{ MG/KG}$$

EXPRESSED AS STANDARD DEVIATIONS:

$$\bar{X} - \bar{Y} = 1.503 \text{ MG/KG} \times \frac{S_x}{1.278 \text{ MG/KG}} = 1.176\, S_x$$

6. Binomial Probabilities

FOR A FIXED NUMBER OF INDEPENDENT TRIALS WITH TWO OUTCOMES.

n is the number of trials

X is the number of successes out of those trials

p is the probability of success

1-p is the probability of failure

f(x) is the probability of getting exactly X successes

$$f(x) = \frac{n!}{x!(n-x)!} p^x (1-p)^{n-x}$$

n = 27

X = 1

p = 0.05

$$f(1) = \frac{27!}{1!\,26!} 0.05^1\, 0.95^{26}$$

$$f(1) = (27)(0.05)(0.2635) = 0.3557$$

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

Sample Calculations 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 Calculation Table 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

TOLERANCE FACTORS (K) FOR ONE-SIDED NORMAL TOLERANCE INTERVALS WITH CONFIDENCE FACTOR Y=0.95 AND COVERAGE P=95%

n	K	n	K
3	7.655	**150**	1.868
4	5.145	**175**	1.850
5	4.202	**200**	1.836
6	3.707	**225**	1.824
7	3.399	**250**	1.814
8	3.188	**275**	1.806
9	3.031	**300**	1.799
10	2.911	**325**	1.792
11	2.815	**350**	1.787
12	2.736	**375**	1.782
13	2.670	**400**	1.777
14	2.614	**425**	1.773
15	2.566	**450**	1.769
16	2.523	**475**	1.766
17	2.486	**500**	1.763
18	2.543	**525**	1.760
19	2.423	**550**	1.757
20	2.396	**575**	1.754
21	2.371	**600**	1.752
22	2.350	**625**	1.750
23	2.329	**650**	1.748
24	2.309	**675**	1.746
25	2.292	**700**	1.744
30	2.220	**725**	1.742
35	2.166	**750**	1.740
40	2.126	**775**	1.739
45	2.092	**800**	1.737
50	2.065	**825**	1.736
55	2.036	**850**	1.734
60	2.017	**875**	1.733
65	2.000	**900**	1.732
70	1.986	**925**	1.731
75	1.972	**950**	1.729
100	1.924	**975**	1.728
125	1.891	**1000**	1.727

Sample Calculations Table 5
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
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

$F = 1 - \alpha$

D-2 STATISTICAL ANALYSIS OF ENVIRONMENTAL DATA

Appendix D-2

D.2.1 **Examples of Shapiro-Wilk Test of Normality Result**

48 Test result (Normal & Lognormal for 27 metals) for Alluvial Subsurface Silt

D.2.2 **Examples of Normal Probability Plot**

27 plots (Normal or Lognormal for 24 metals) for Alluvial Subsurface Silt

D.2.3 **Examples of 95% Confidence Interval Results**

27 comparisons (one for each of 27 metals) of Pennsylvanian Subsurface Sand results with the 95% Confidence Interval of combined Pennsylvanian Subsurface Clay / Pennsylvanian Subsurface Silt

D.2.4 **Example of Wilcoxon Rank-Sum Test Results**

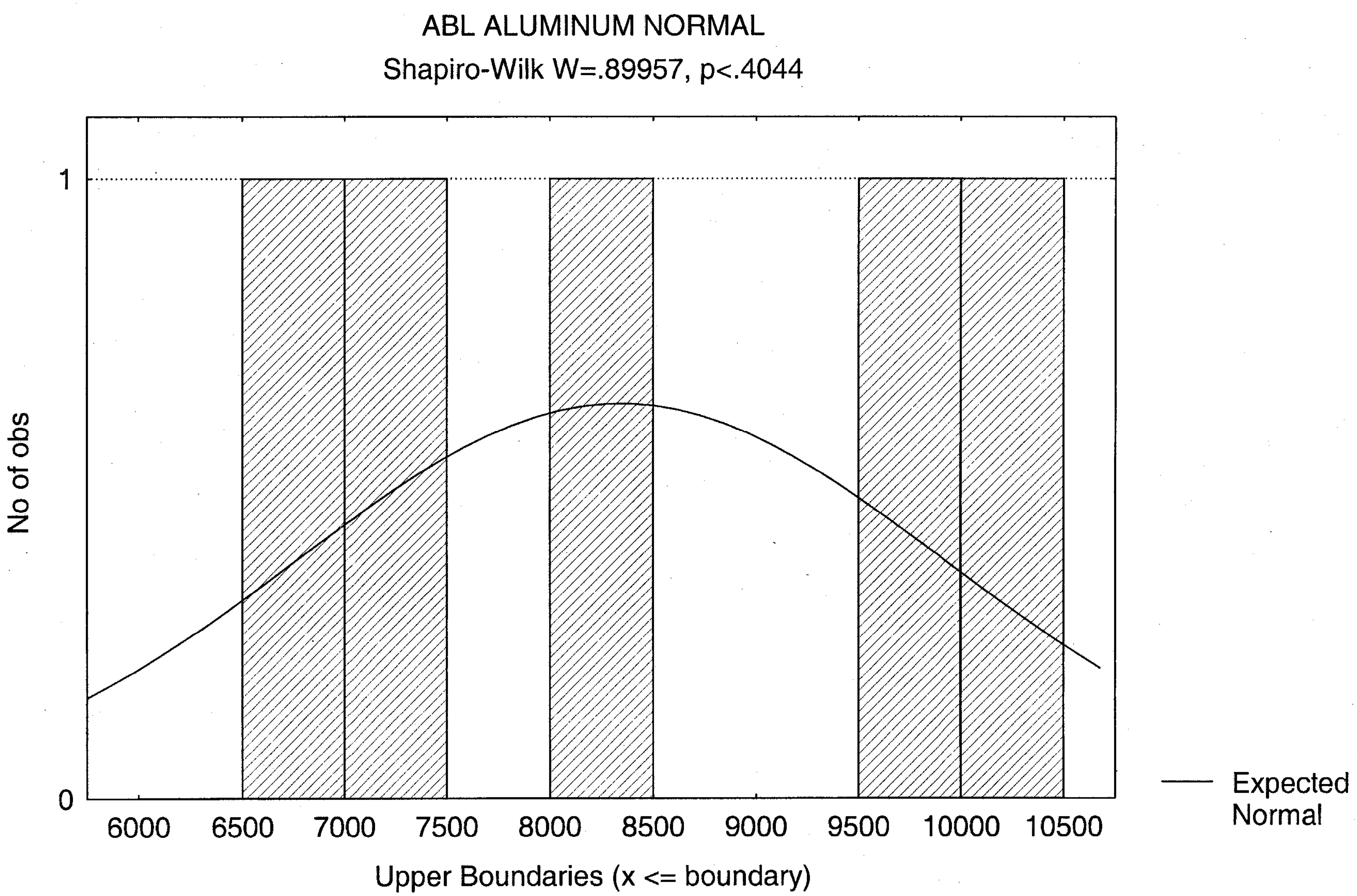
27 comparisons (one for each of 27 metals) of combined Pennsylvanian Subsurface Clay versus Pennsylvanian Subsurface Silt

D.2.5 **Matrices Conveying Combinations of Soil Types due to Wilcoxon Rank-Sum Test Results**

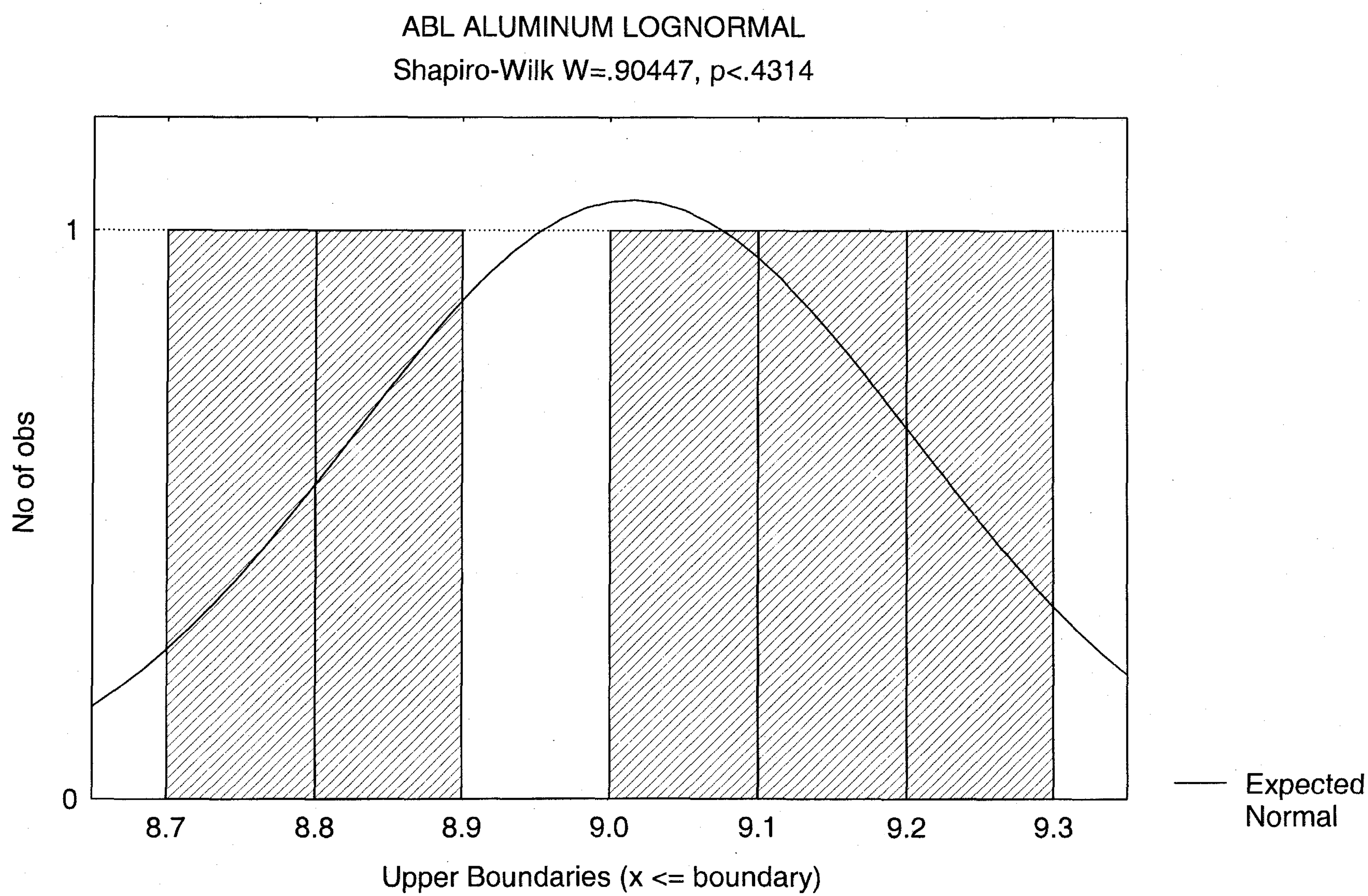
Note: The remainder of the statistical analysis results are available on request.

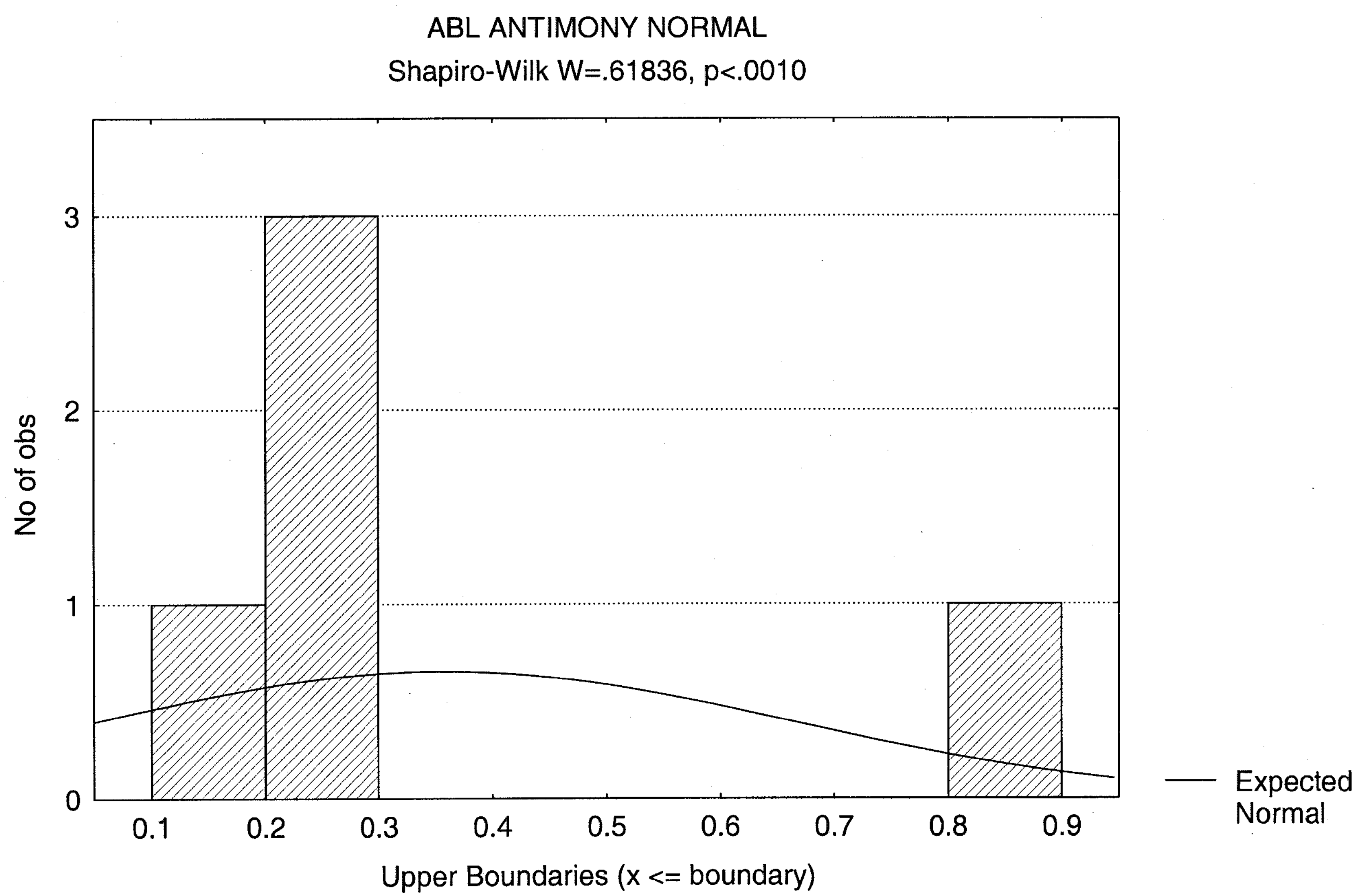
D.2.1 **Examples of Shapiro-Wilk Test of Normality Result**

48 Test result (Normal & Lognormal for 27 metals) for Alluvial Subsurface Silt



ABL ALUMINUM NORMAL
Shapiro-Wilk W=.89957, p<.4044
No of obs
1
0
6000
6500
7000
7500
8000
8500
9000
9500
10000
10500
Upper Boundaries (x <= boundary)
Expected Normal

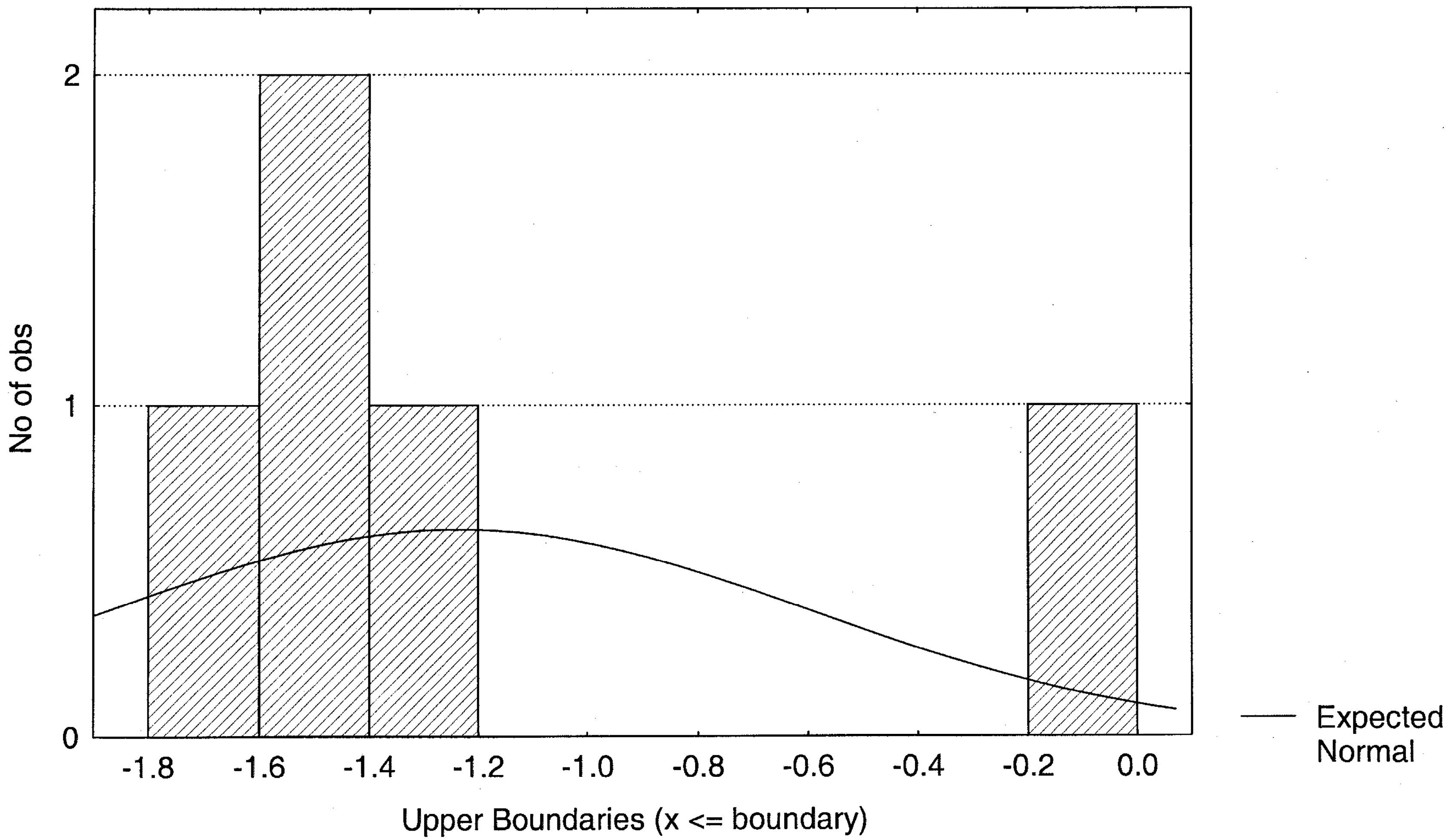

ABL ALUMINUM LOGNORMAL
Shapiro-Wilk W=.90447, p<.4314
No of obs
1
0
8.7
8.8
8.9
9.0
9.1
9.2
9.3
Upper Boundaries (x <= boundary)
Expected Normal

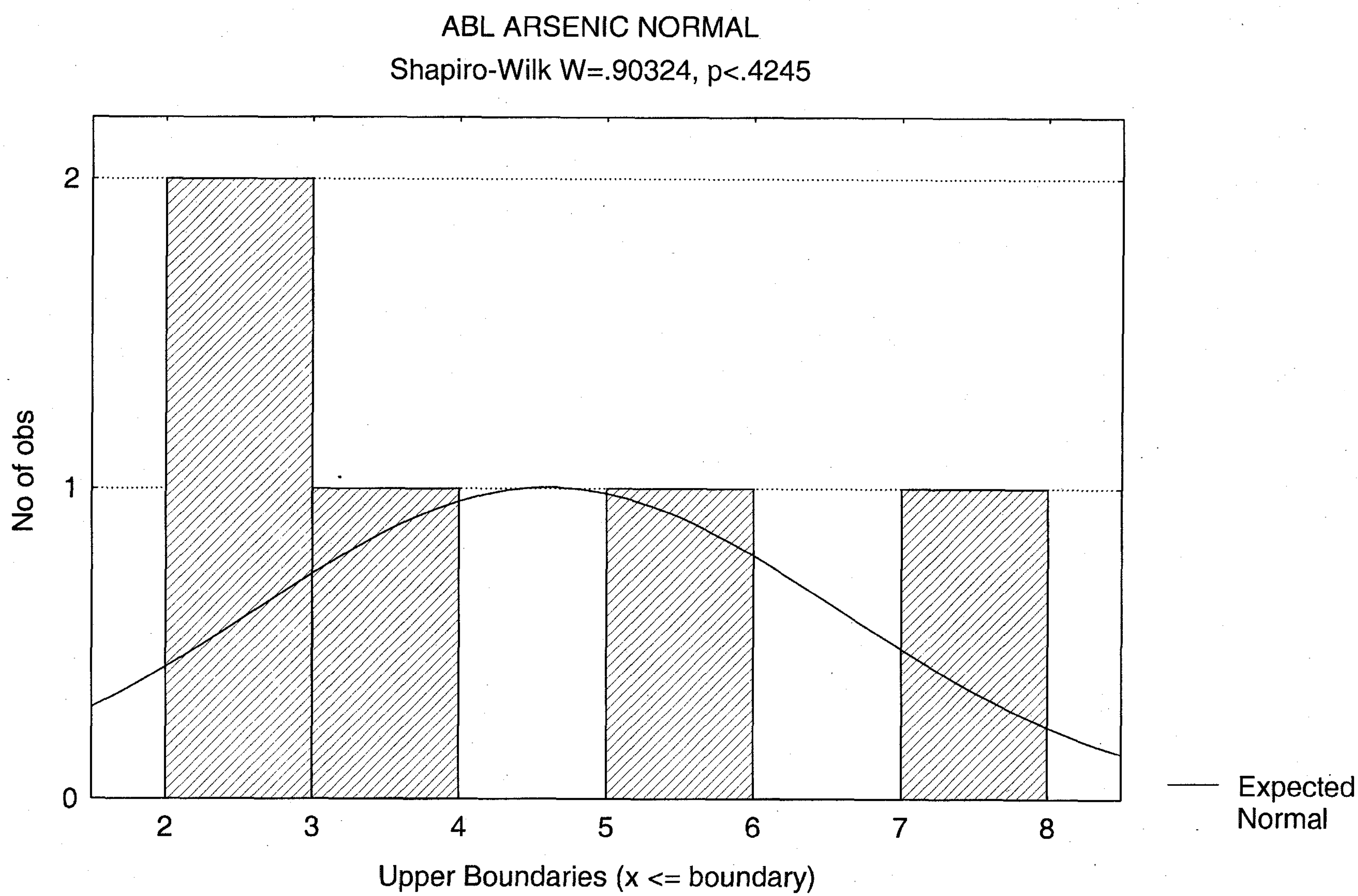


ABL ANTIMONY NORMAL
Shapiro-Wilk W=.61836, p<.0010
No of obs
0
1
2
3
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
Upper Boundaries (x <= boundary)
Expected Normal

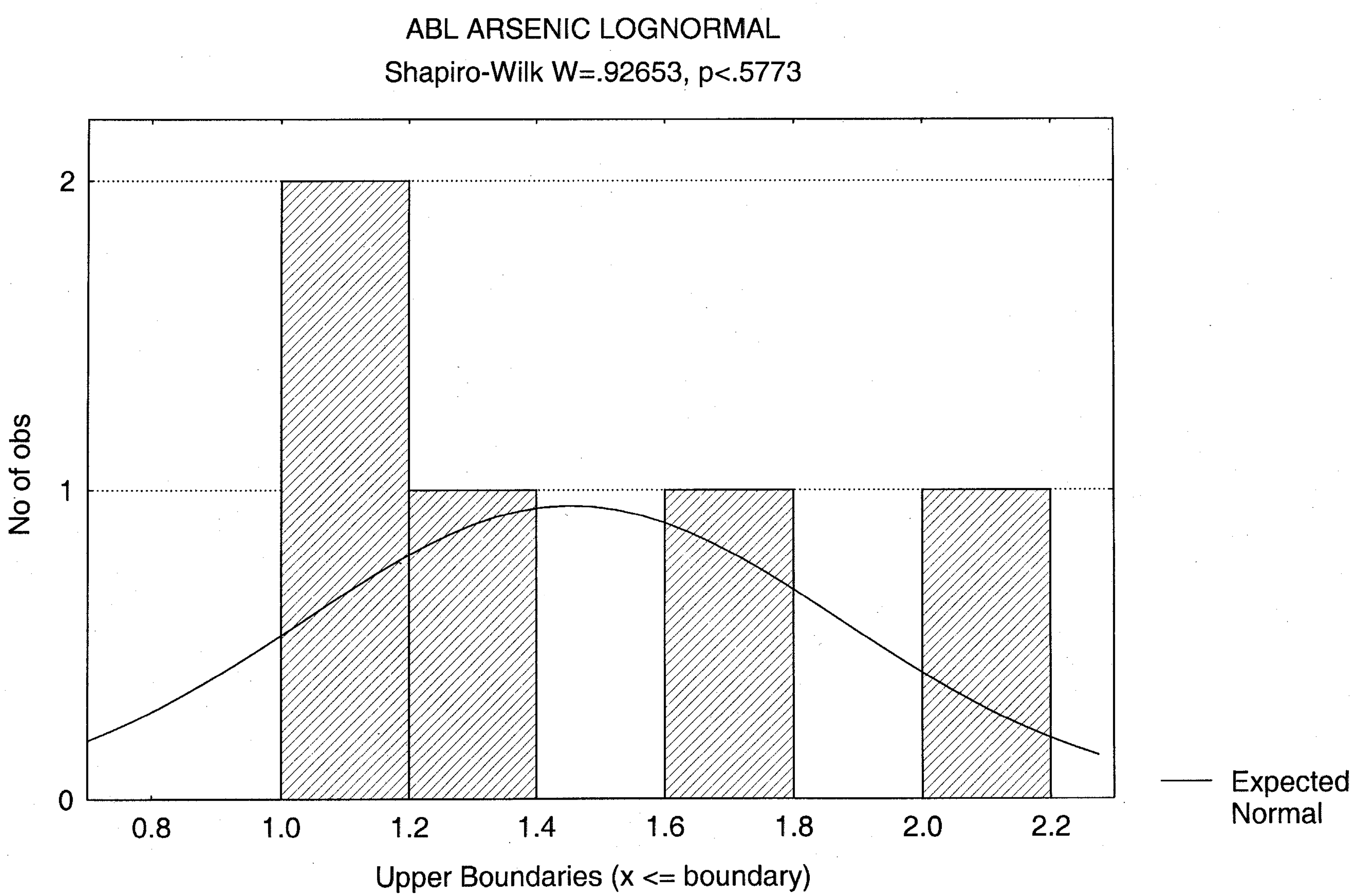
ABL ANTIMONY LOGNORMAL

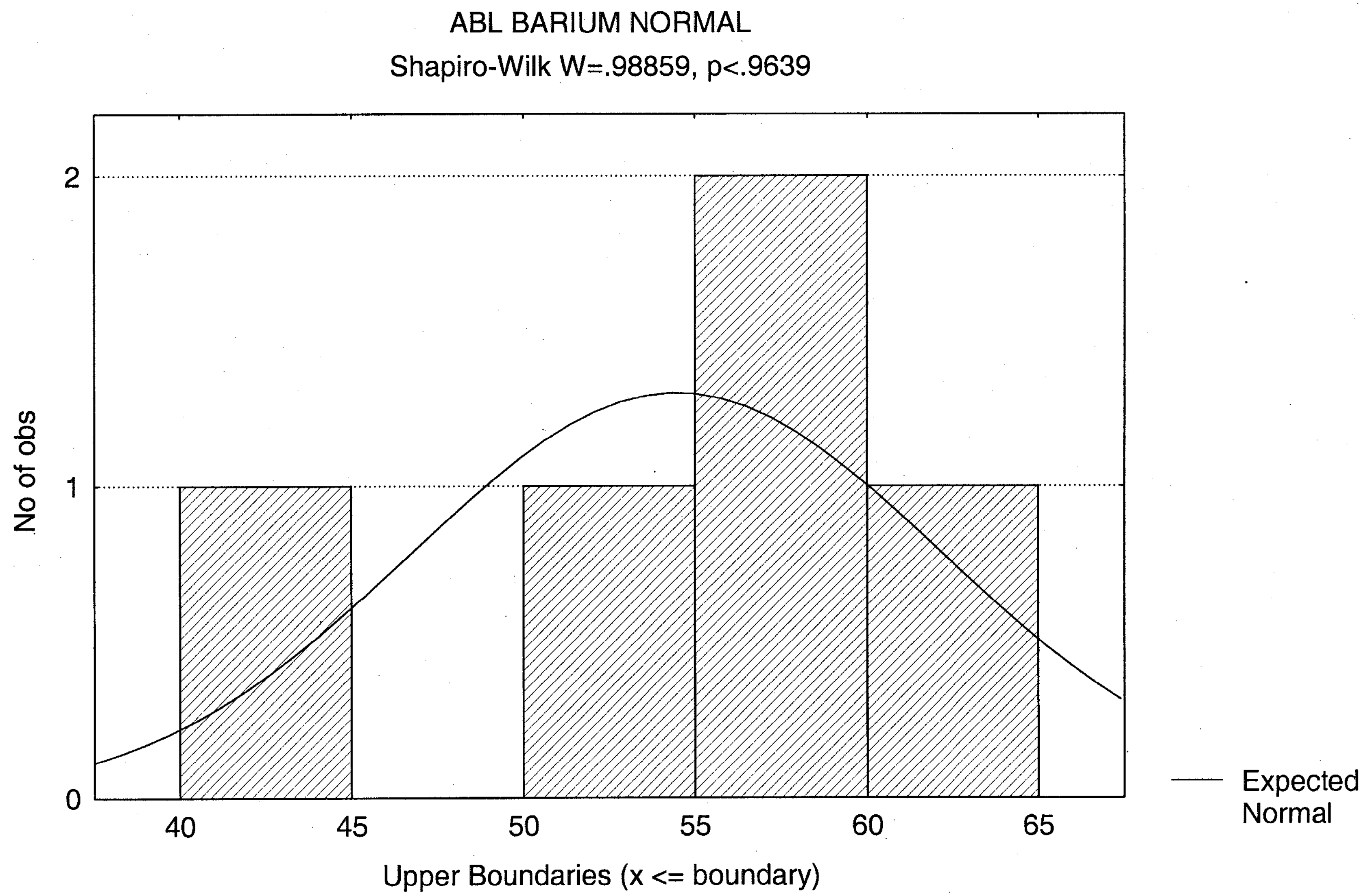
Shapiro-Wilk W=.69251, p<.0094



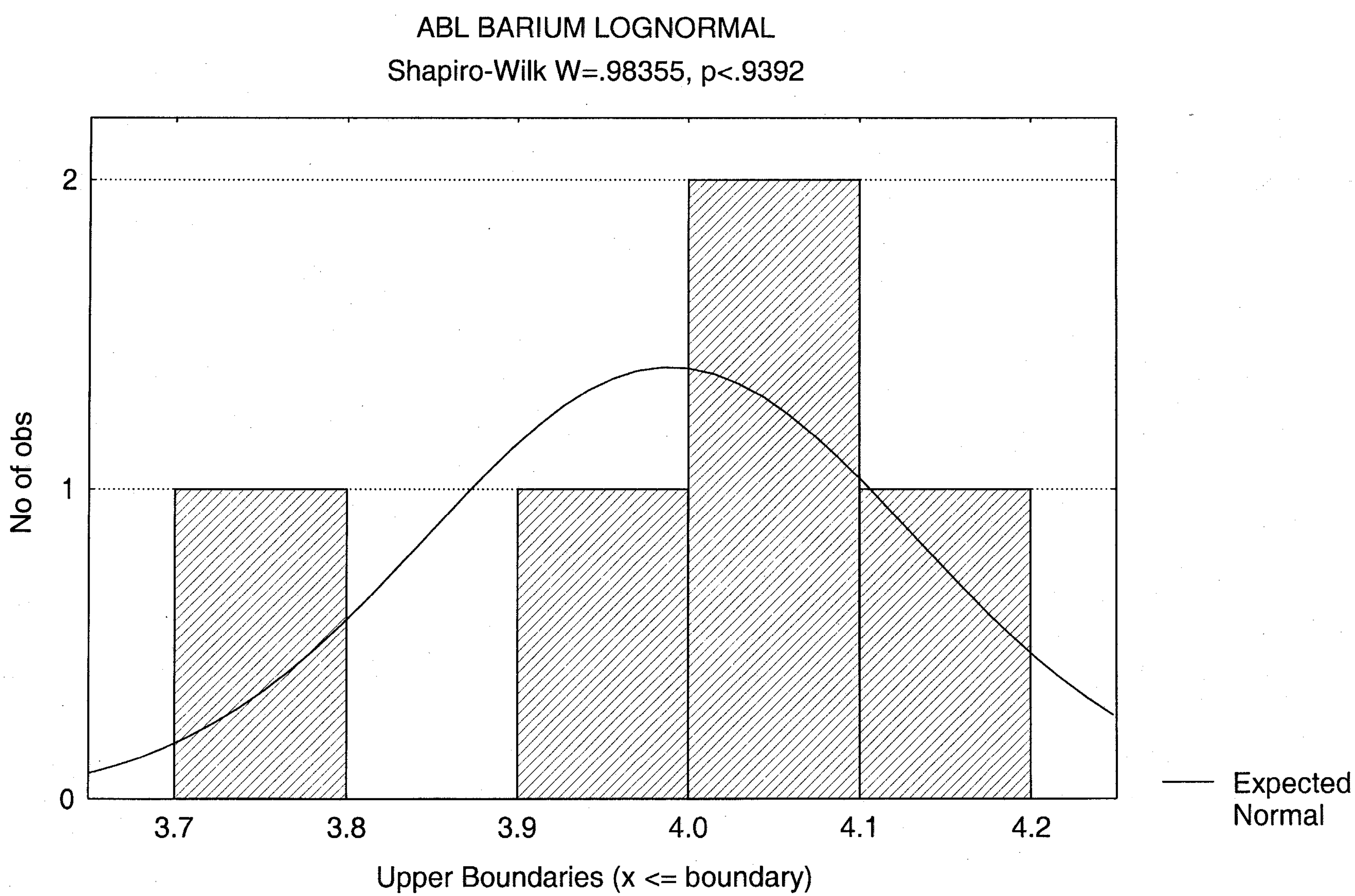


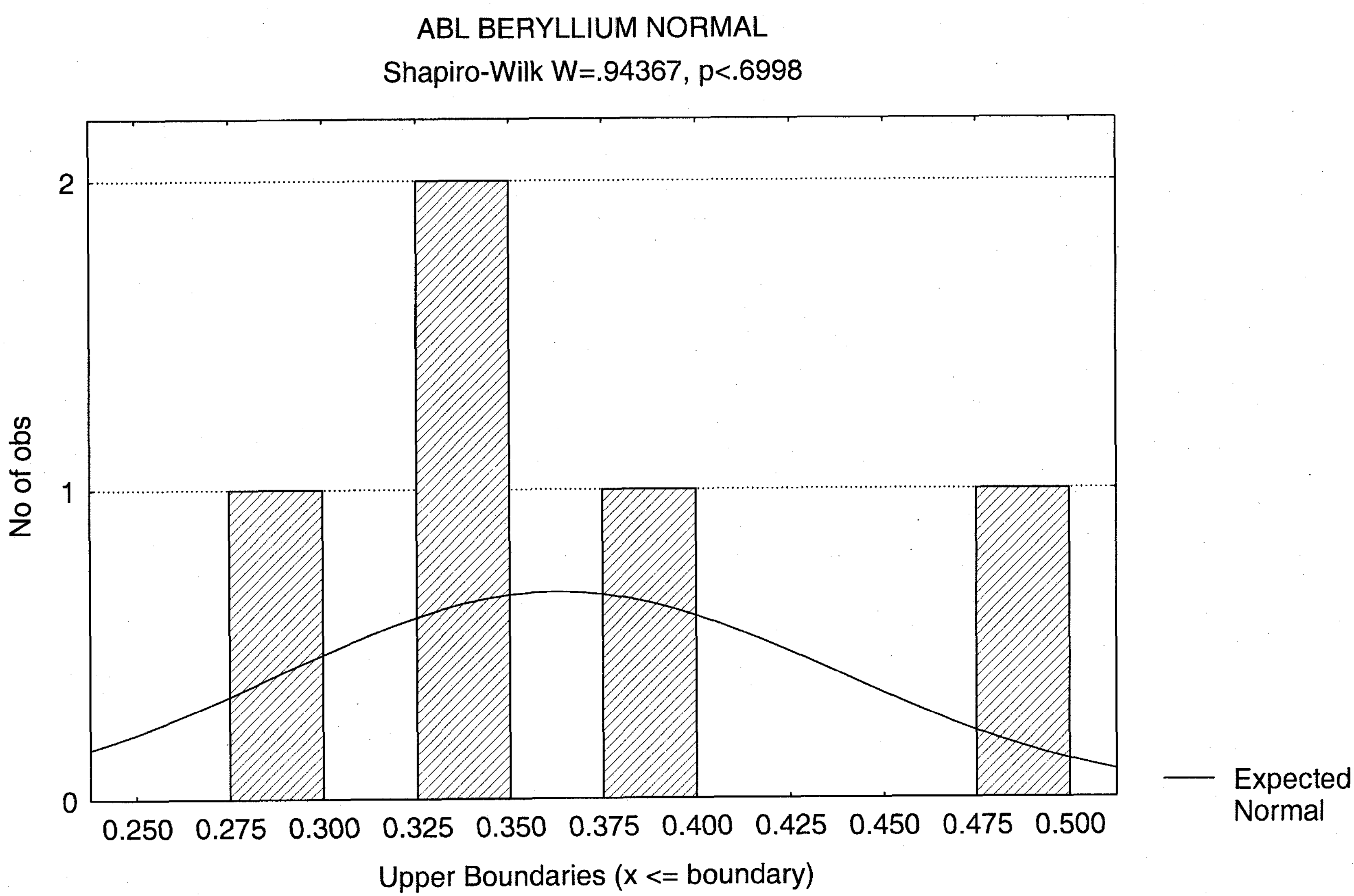
ABL ARSENIC NORMAL
Shapiro-Wilk W=.90324, p<.4245
No of obs
0
1
2
2
3
4
5
6
7
8
Upper Boundaries (x <= boundary)
Expected Normal


ABL ARSENIC LOGNORMAL
Shapiro-Wilk W=.92653, p<.5773
No of obs
2
1
0
0.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
Upper Boundaries (x <= boundary)
Expected Normal

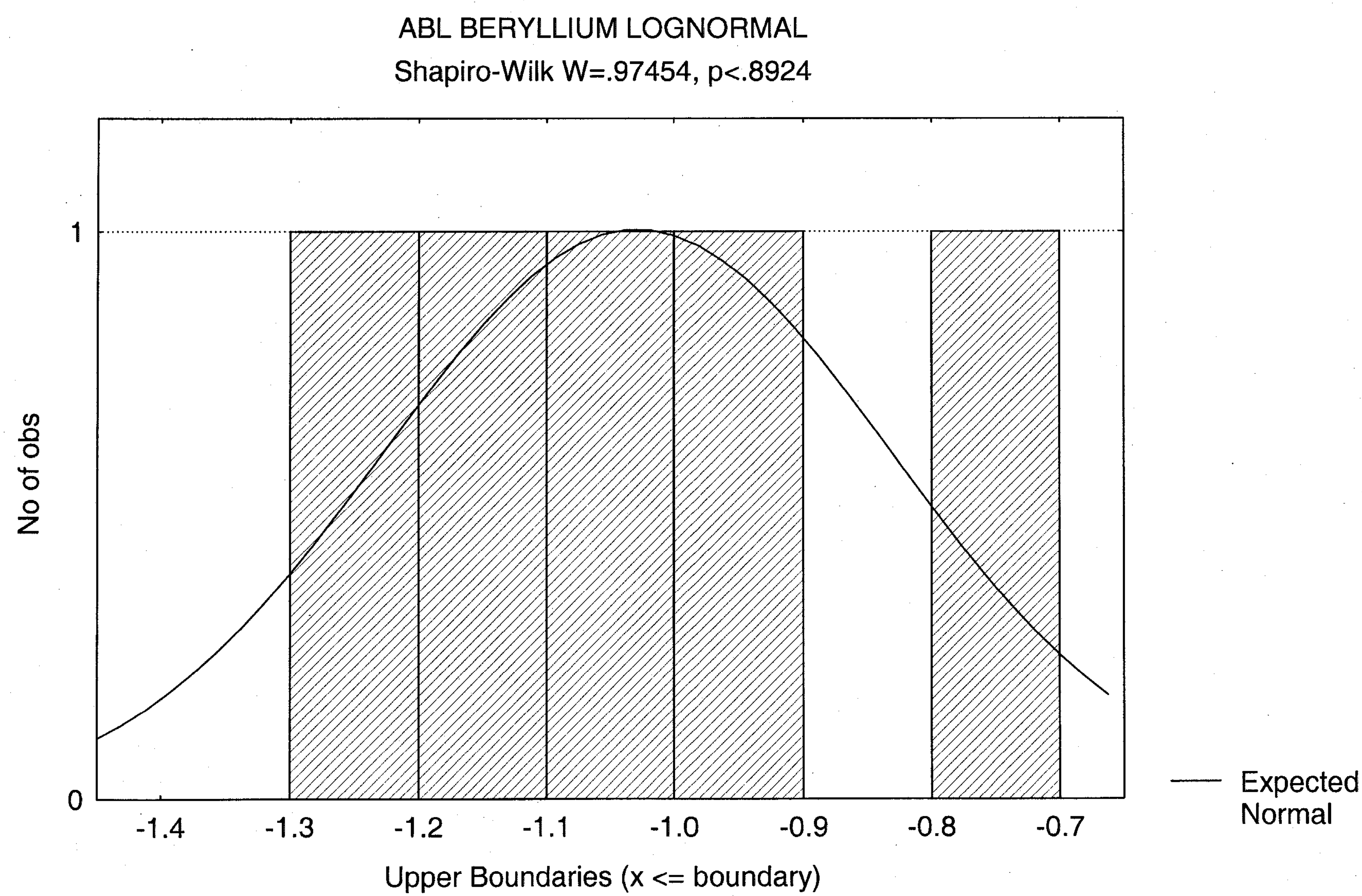


ABL BARIUM NORMAL
Shapiro-Wilk W=.98859, p<.9639
No of obs
0
1
2
40
45
50
55
60
65
Upper Boundaries (x <= boundary)
Expected Normal

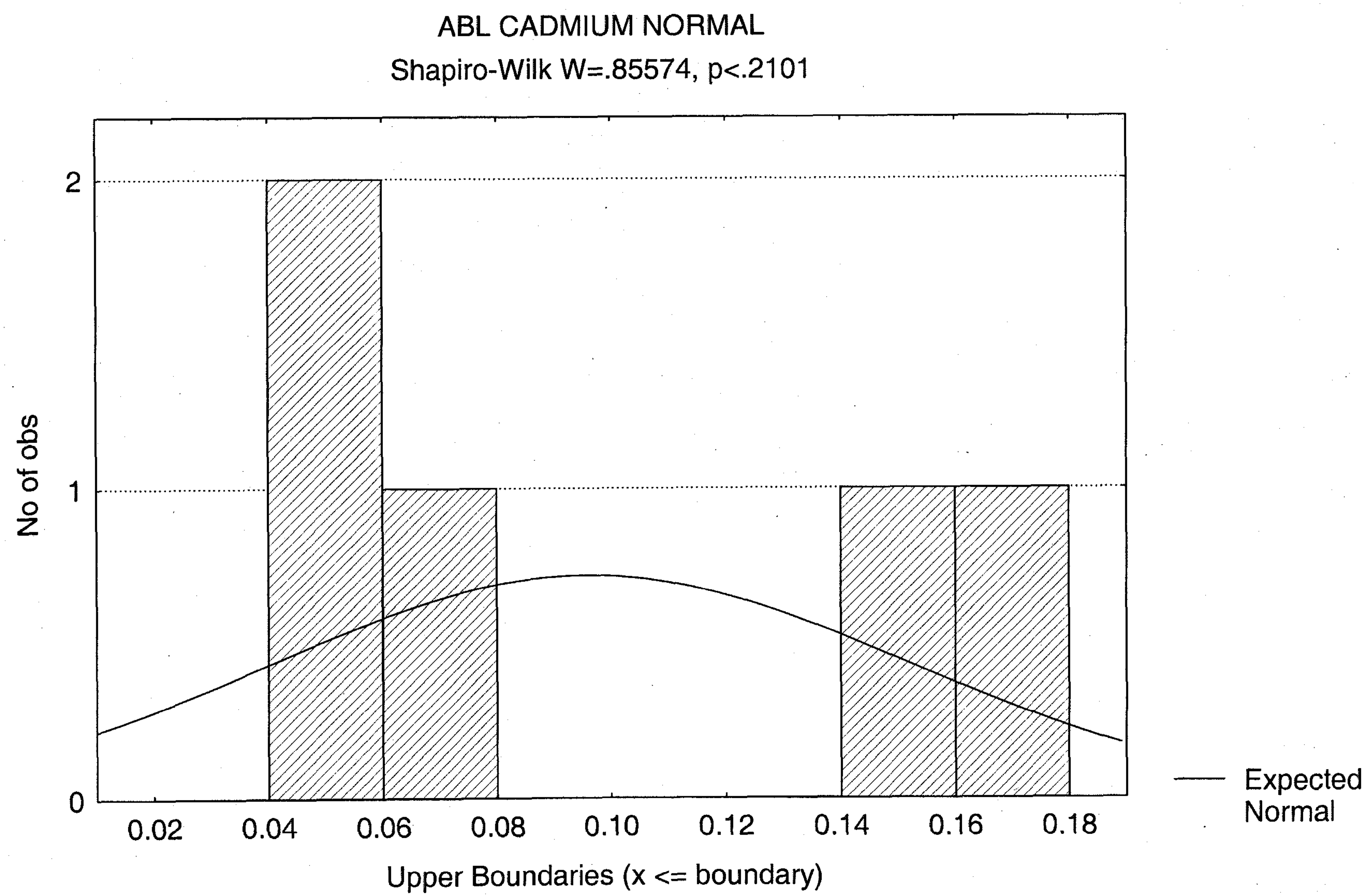

ABL BARIUM LOGNORMAL
Shapiro-Wilk W=.98355, p<.9392
No of obs
0
1
2
3.7
3.8
3.9
4.0
4.1
4.2
Upper Boundaries (x <= boundary)
Expected Normal

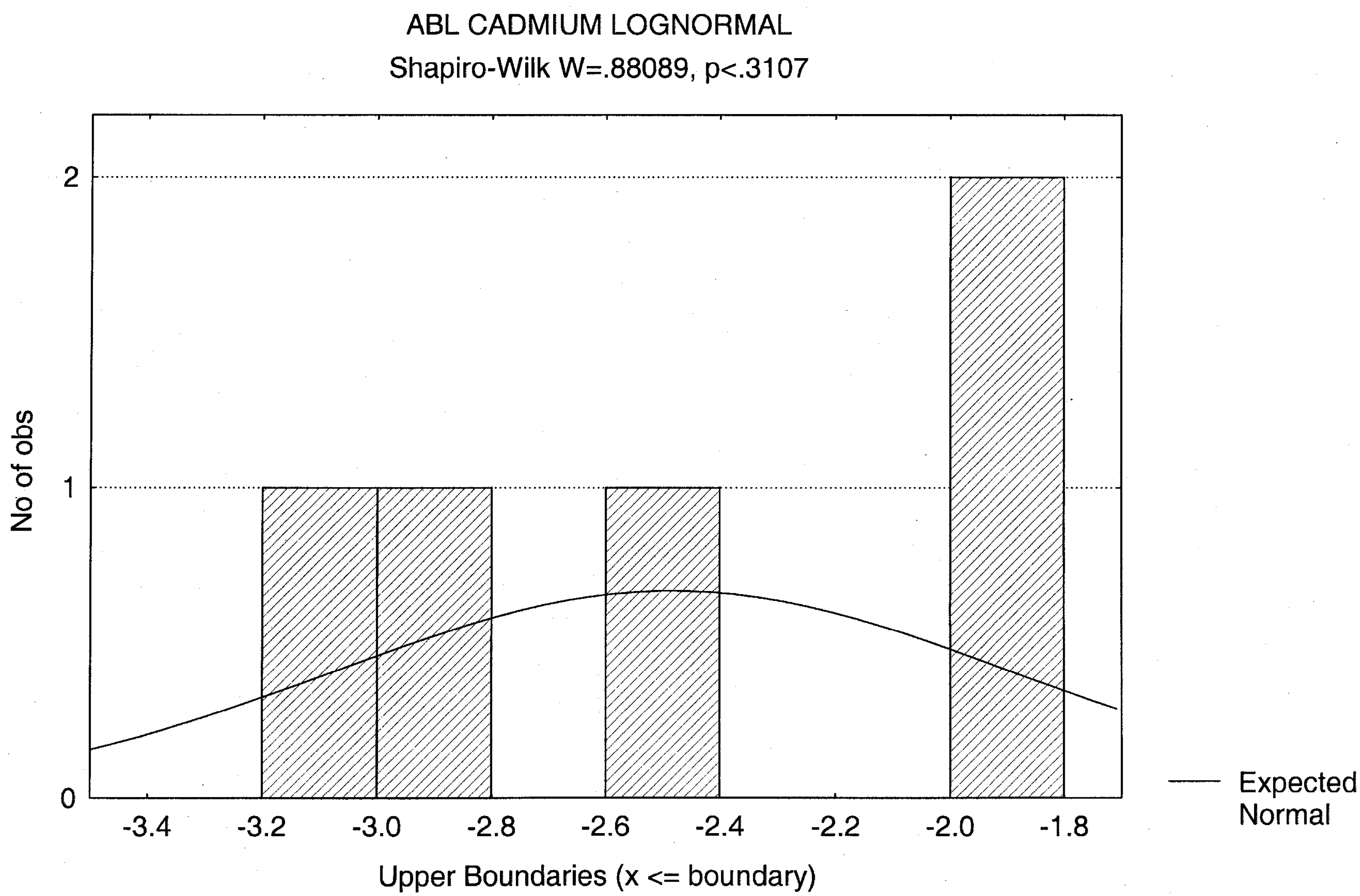


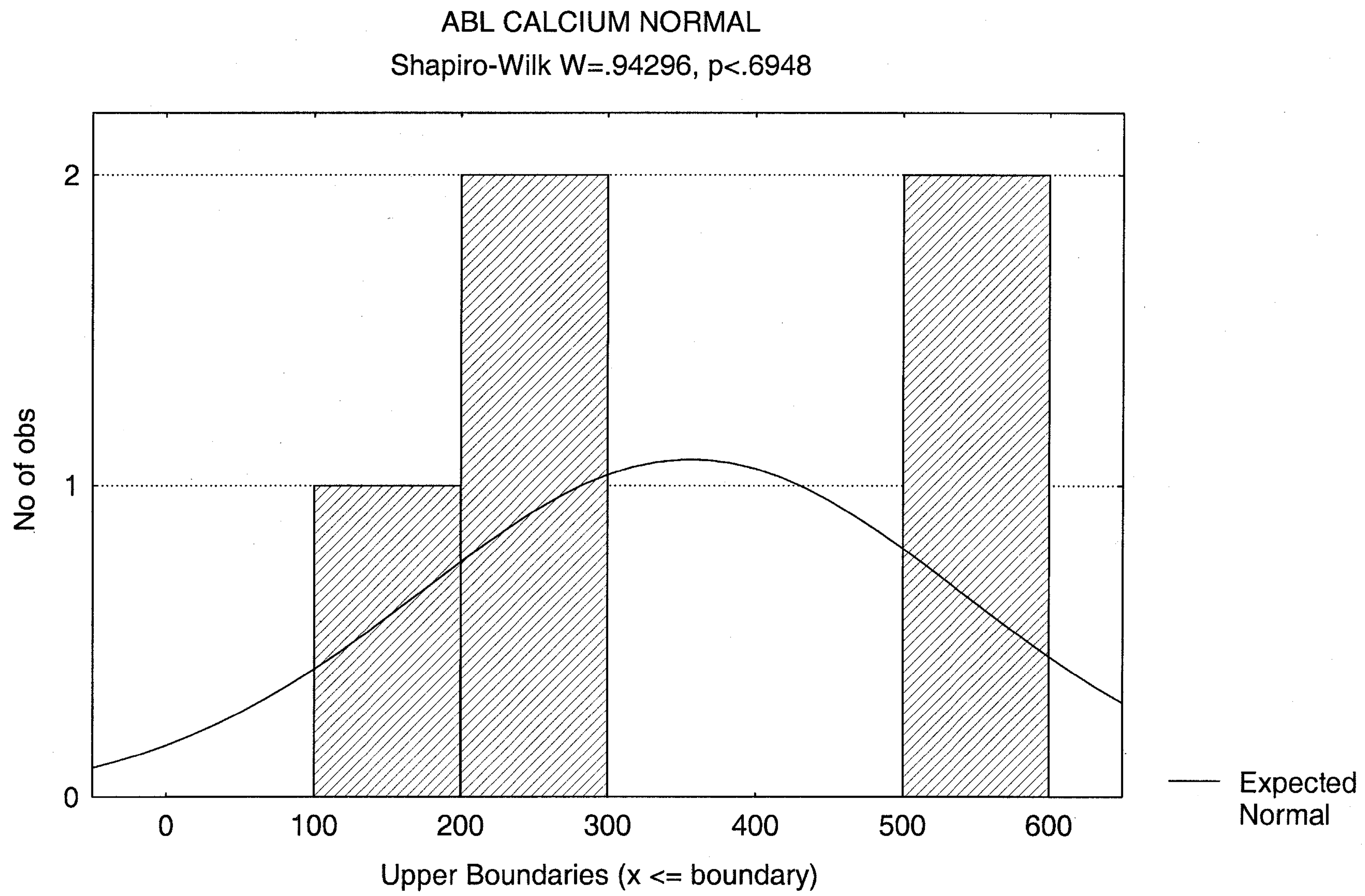
ABL BERYLLIUM NORMAL
Shapiro-Wilk W=.94367, p<.6998
No of obs
0
1
2
0.250 0.275 0.300 0.325 0.350 0.375 0.400 0.425 0.450 0.475 0.500
Upper Boundaries (x <= boundary)
Expected Normal

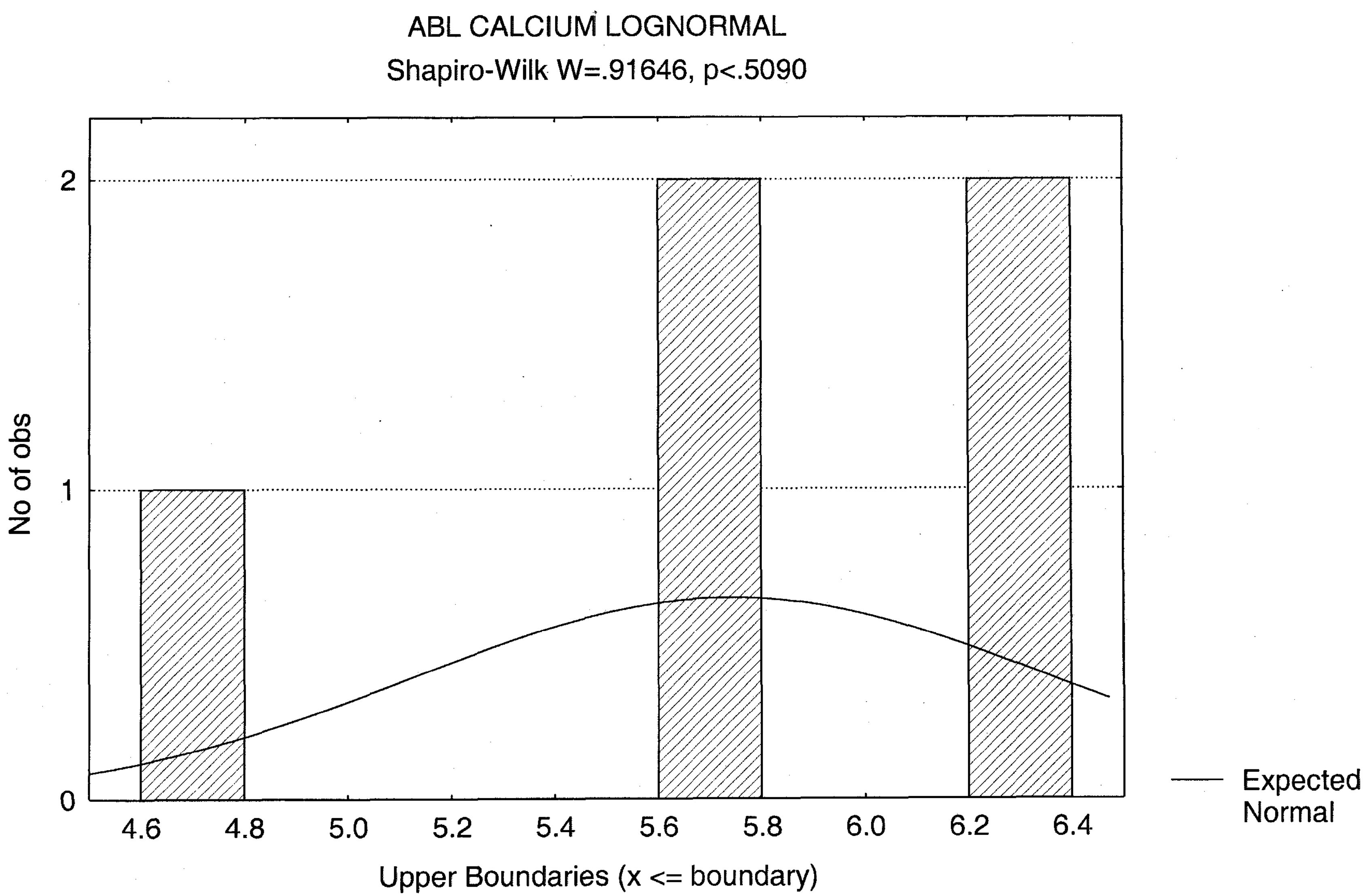


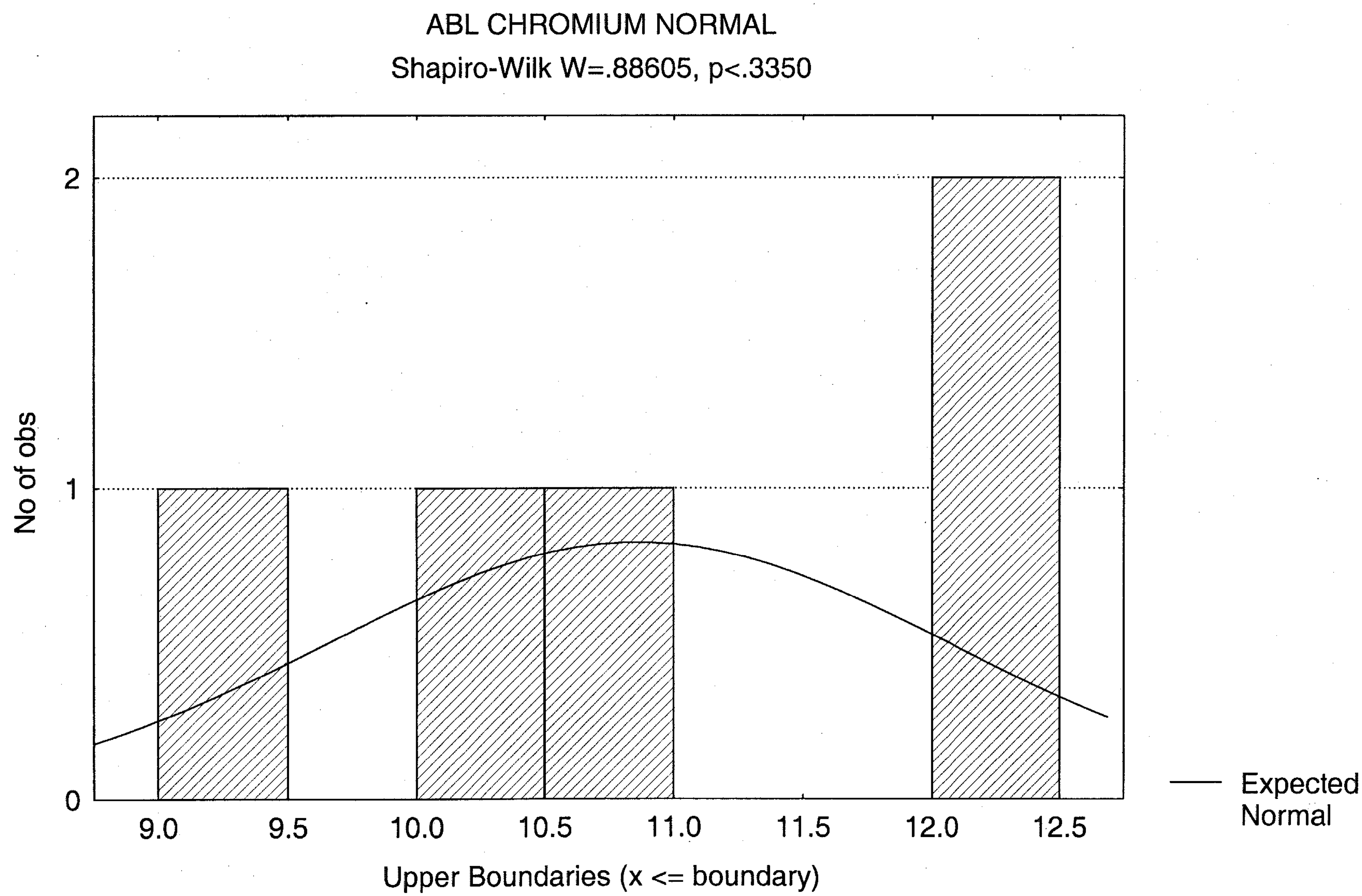
ABL BERYLLIUM LOGNORMAL
Shapiro-Wilk W=.97454, p<.8924
No of obs
1
0
-1.4
-1.3
-1.2
-1.1
-1.0
-0.9
-0.8
-0.7
Upper Boundaries (x <= boundary)
Expected Normal

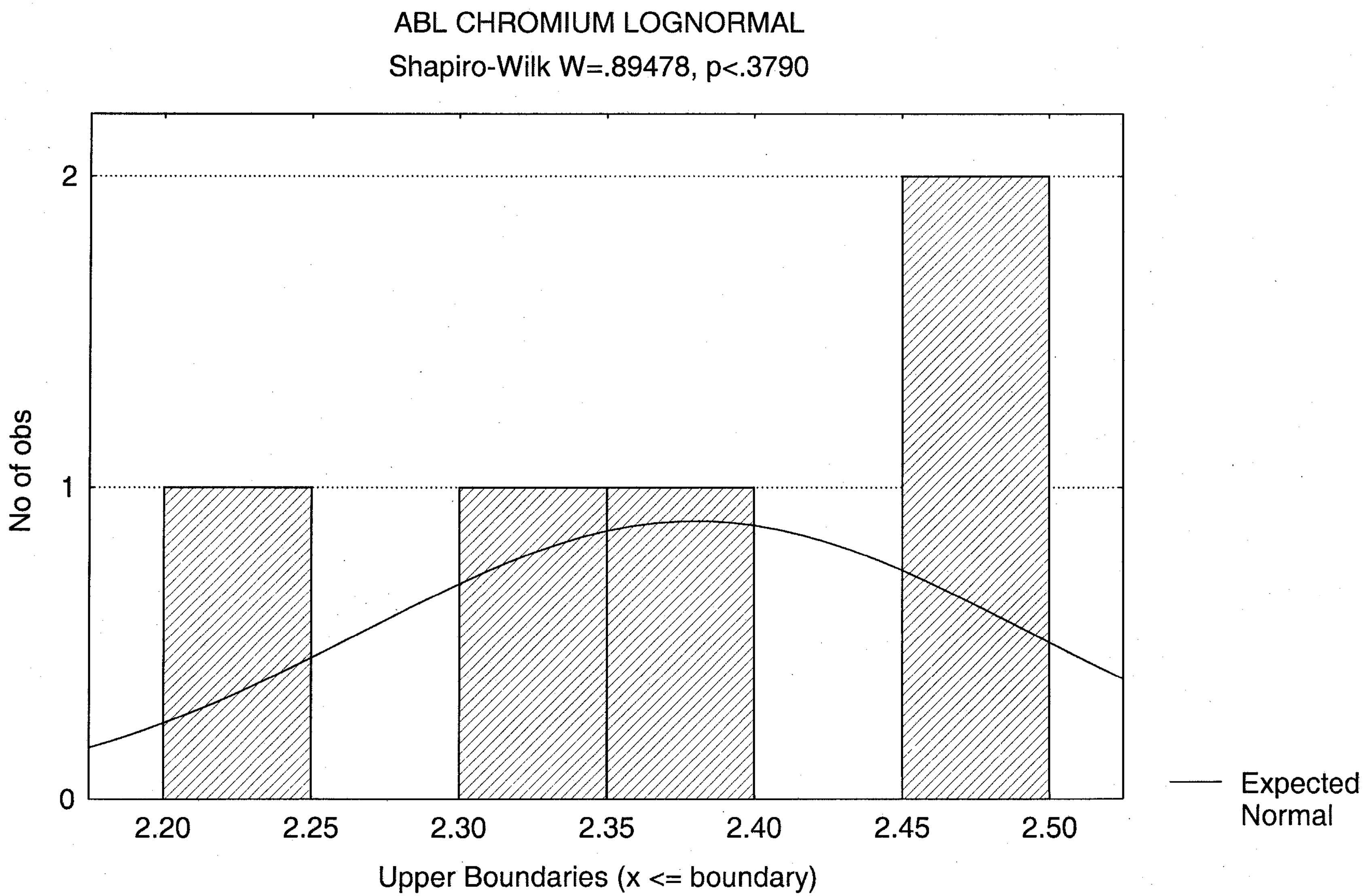

ABL CADMIUM NORMAL
Shapiro-Wilk W=.85574, p<.2101
No of obs
0
1
2
0.02
0.04
0.06
0.08
0.10
0.12
0.14
0.16
0.18
Upper Boundaries (x <= boundary)
Expected Normal


ABL CADMIUM LOGNORMAL
Shapiro-Wilk W=.88089, p<.3107
No of obs
0
1
2
-3.4
-3.2
-3.0
-2.8
-2.6
-2.4
-2.2
-2.0
-1.8
Upper Boundaries (x <= boundary)
Expected Normal


ABL CALCIUM NORMAL
Shapiro-Wilk W=.94296, p<.6948
No of obs
0
1
2
0
100
200
300
400
500
600
Upper Boundaries (x <= boundary)
Expected
Normal

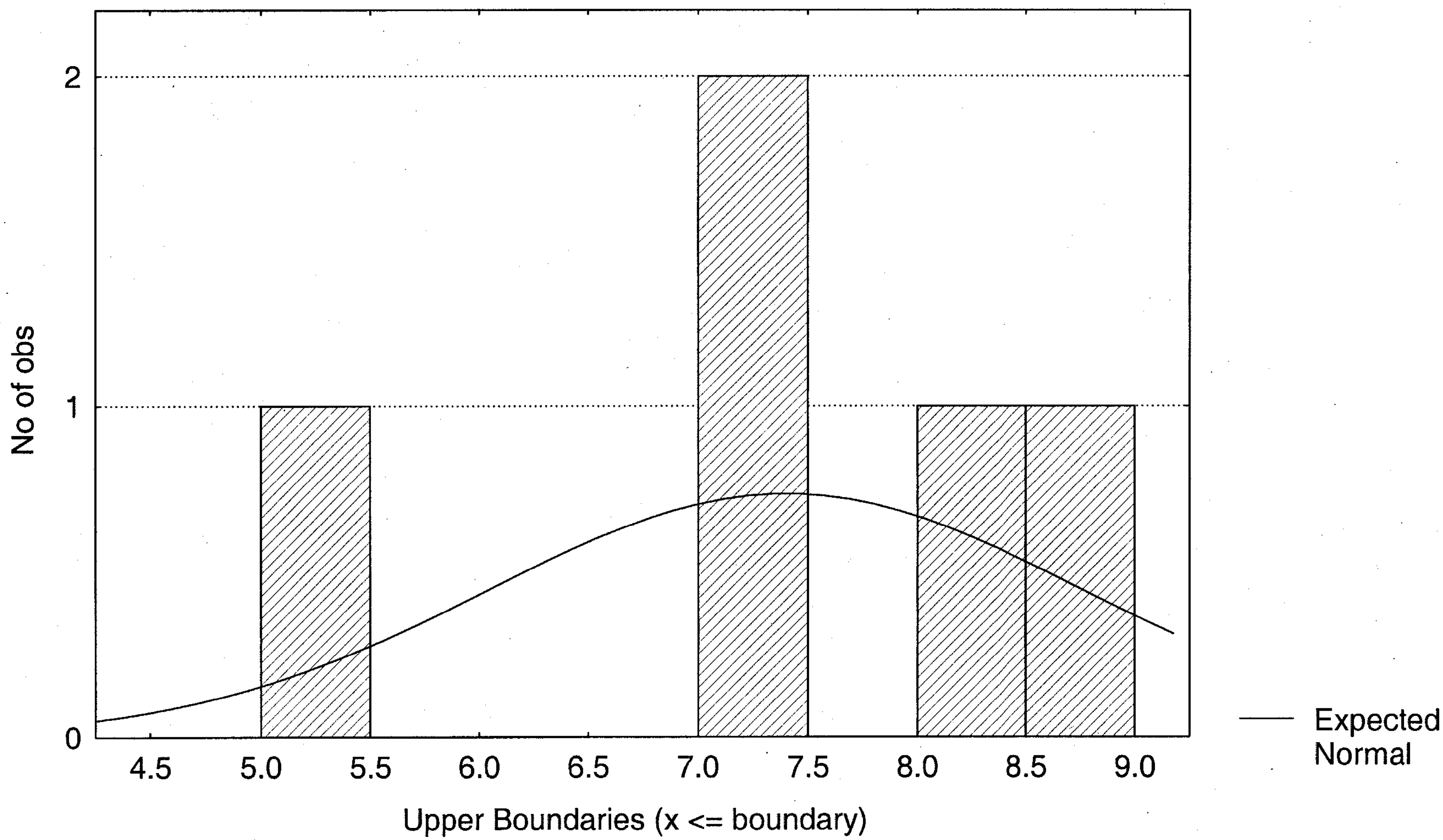

ABL CALCIUM LOGNORMAL
Shapiro-Wilk W=.91646, p<.5090
No of obs
0
1
2
4.6
4.8
5.0
5.2
5.4
5.6
5.8
6.0
6.2
6.4
Upper Boundaries (x <= boundary)
Expected Normal

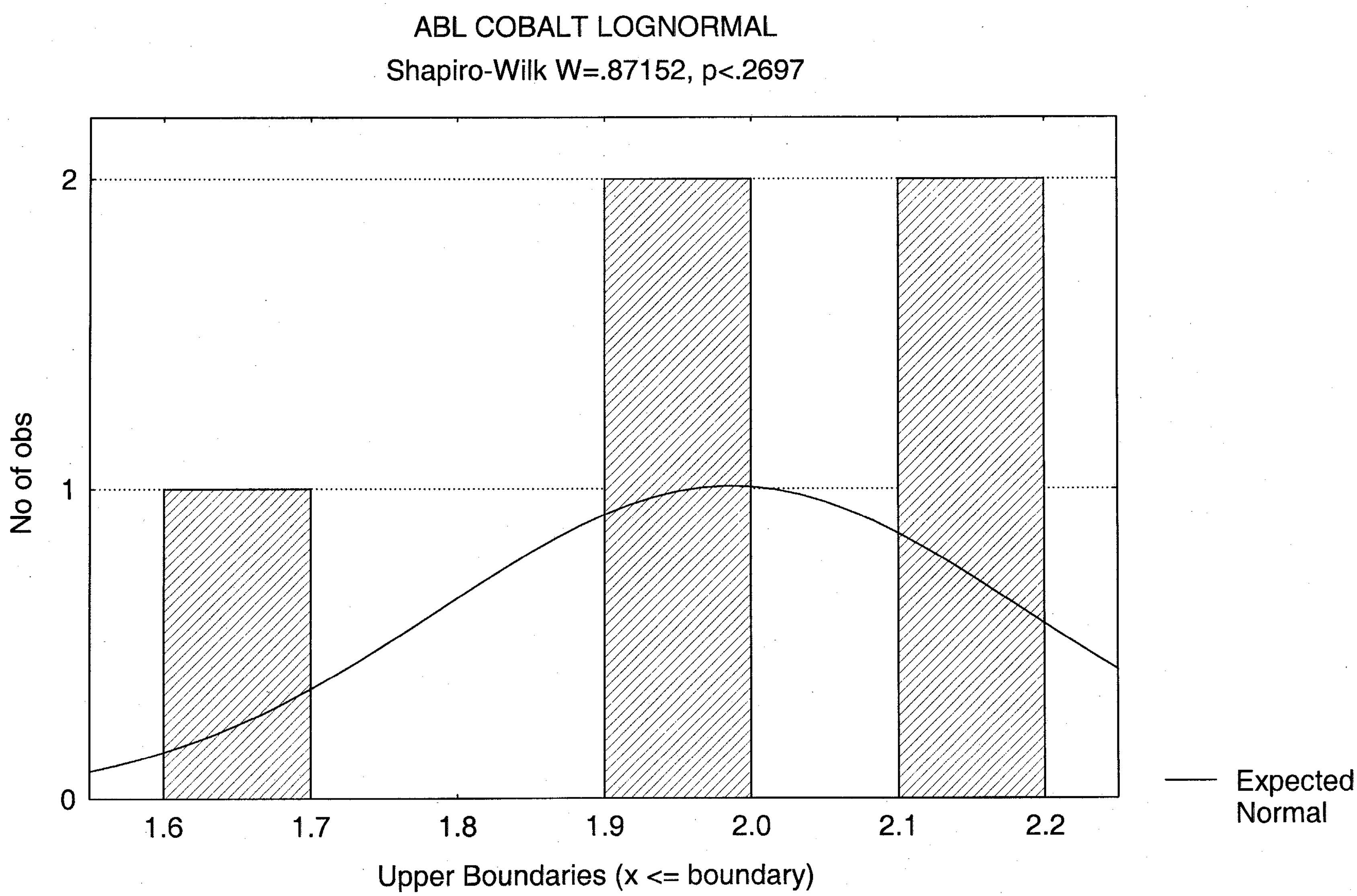

ABL CHROMIUM NORMAL
Shapiro-Wilk W=.88605, p<.3350
No of obs
0
1
2
9.0
9.5
10.0
10.5
11.0
11.5
12.0
12.5
Upper Boundaries (x <= boundary)
Expected
Normal

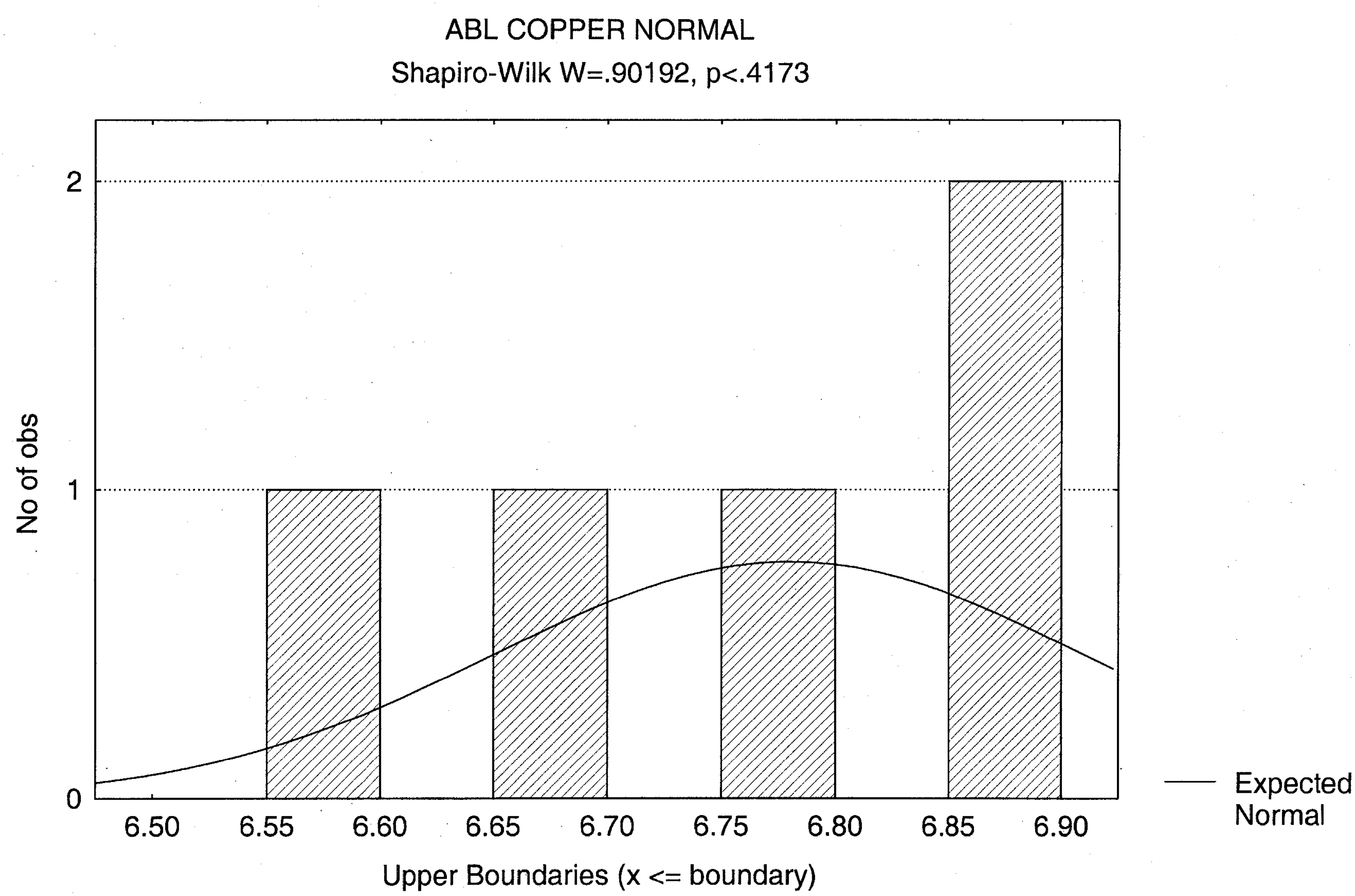

ABL CHROMIUM LOGNORMAL
Shapiro-Wilk W=.89478, p<.3790
No of obs
0
1
2
2.20
2.25
2.30
2.35
2.40
2.45
2.50
Upper Boundaries (x <= boundary)
Expected Normal

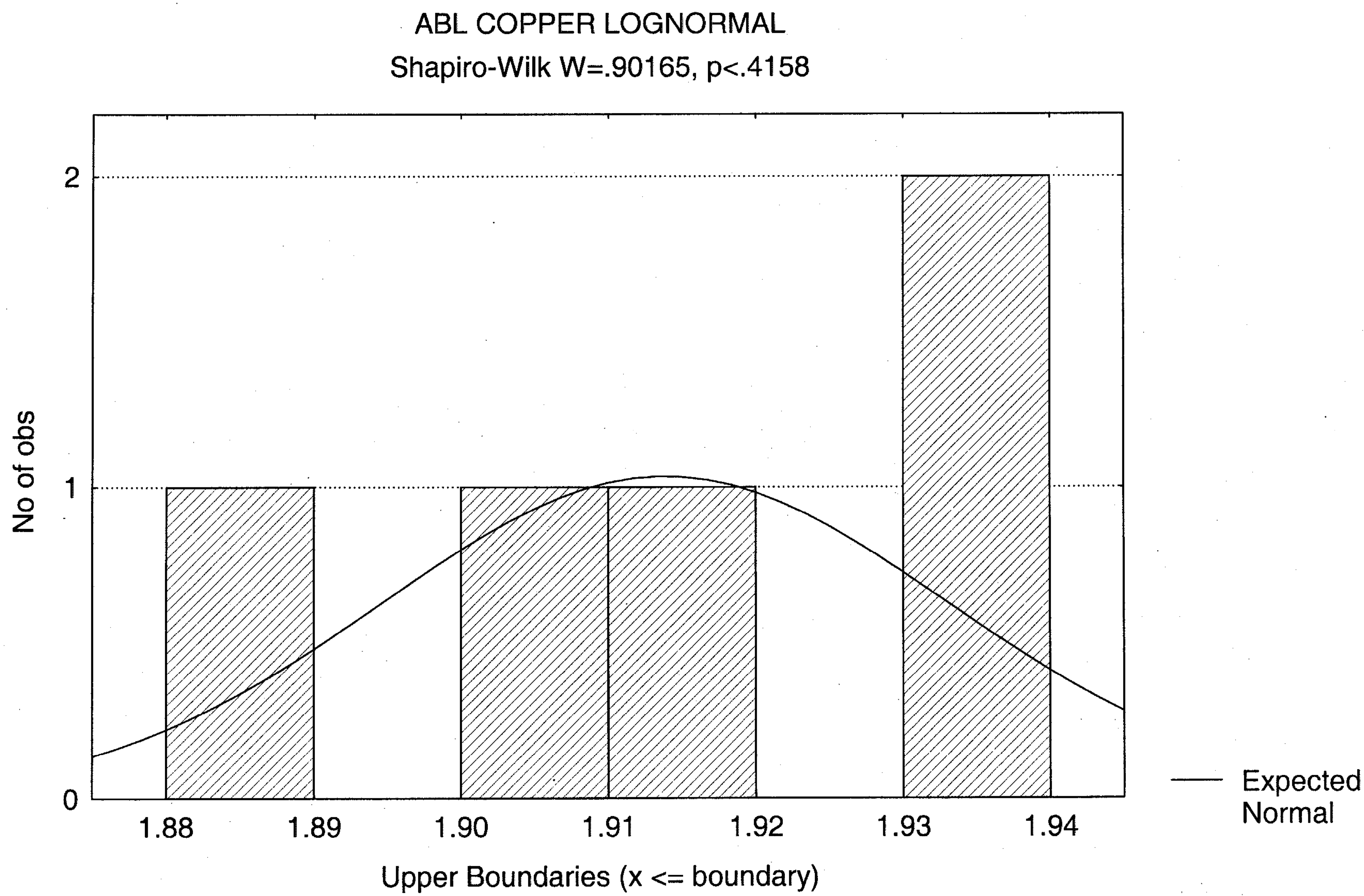
ABL COBALT NORMAL

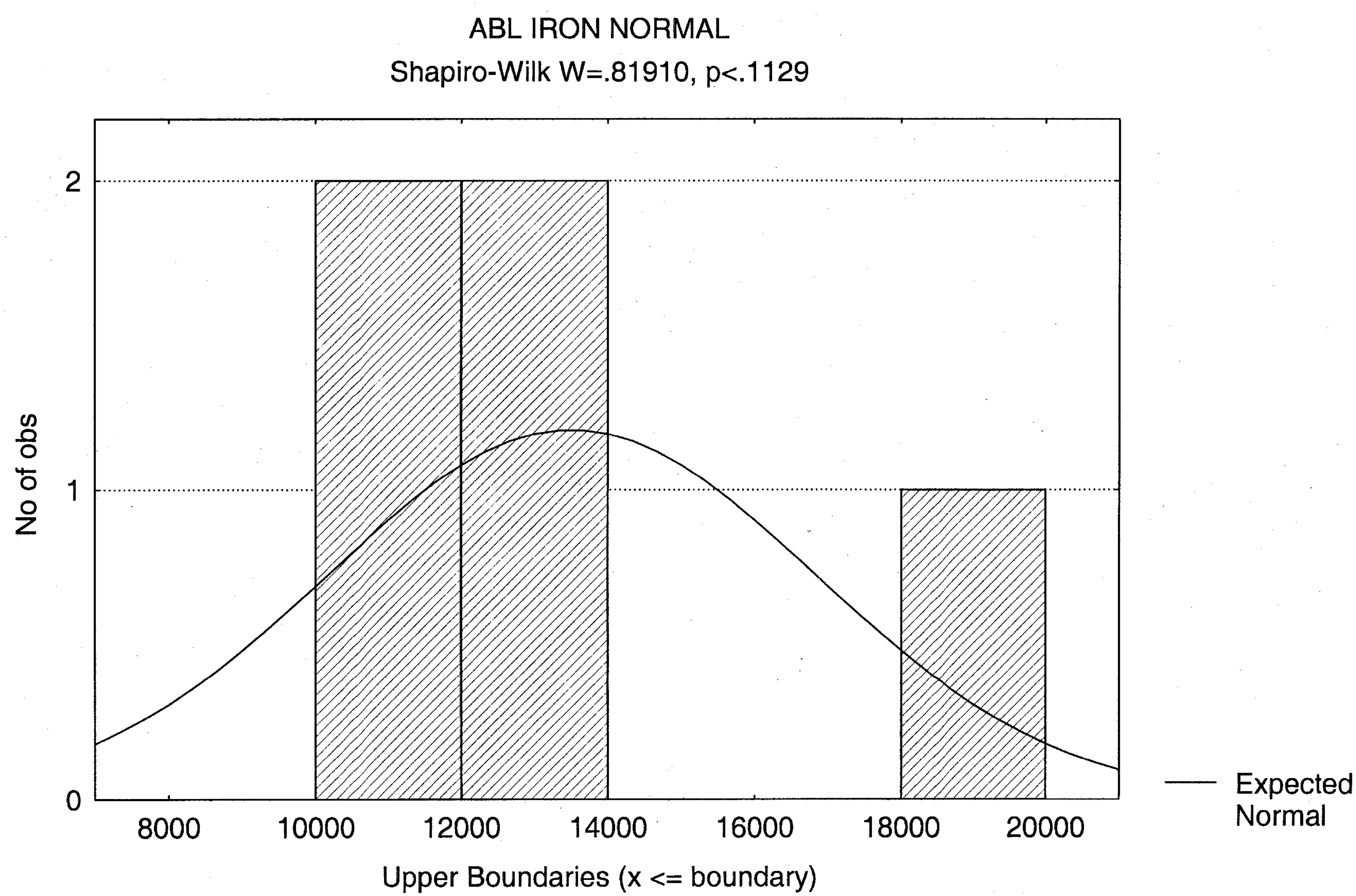
Shapiro-Wilk W=.89988, p<.4061



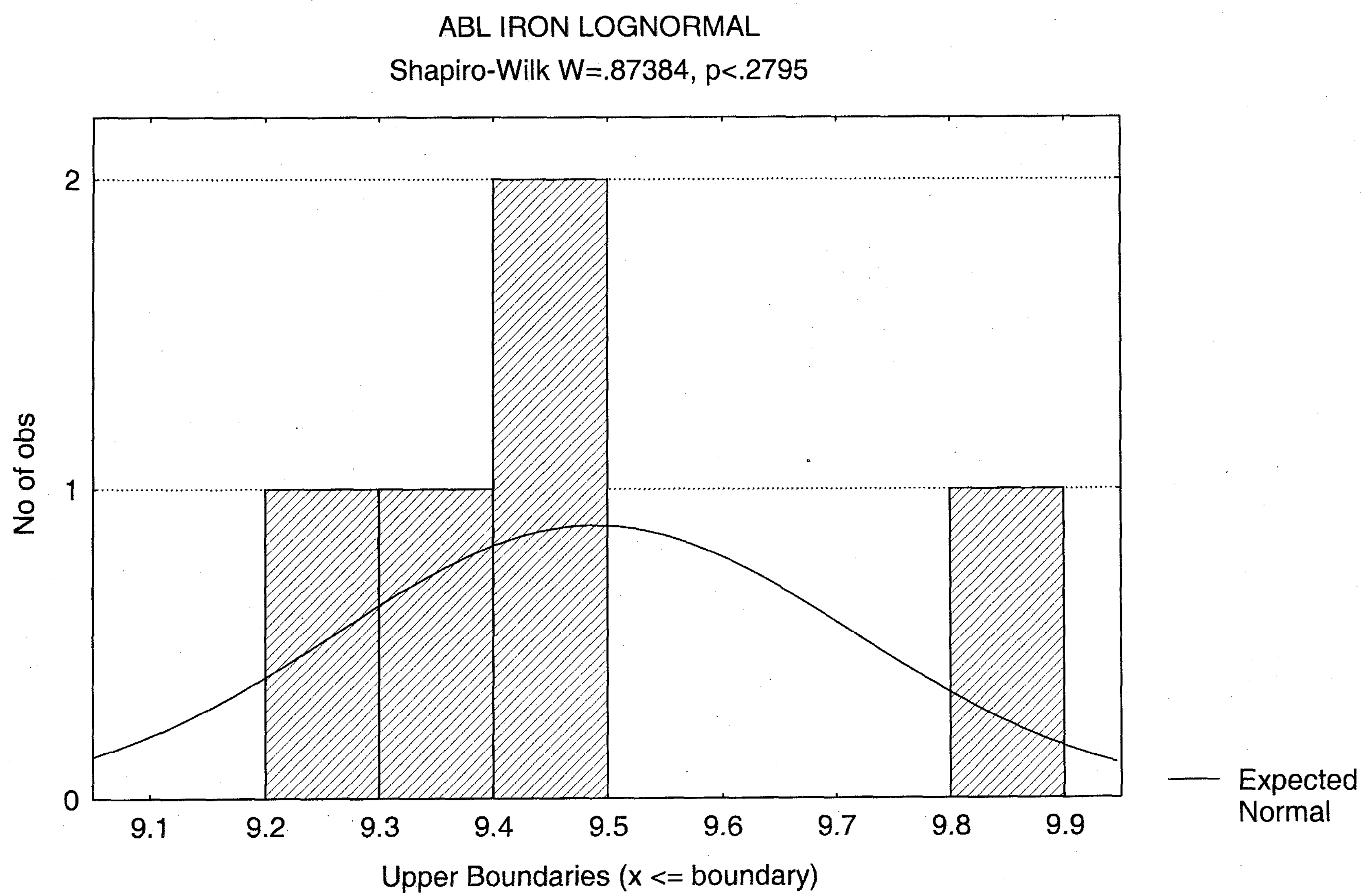

ABL COBALT LOGNORMAL
Shapiro-Wilk W=.87152, p<.2697
No of obs
0
1
2
1.6
1.7
1.8
1.9
2.0
2.1
2.2
Upper Boundaries (x <= boundary)
Expected Normal

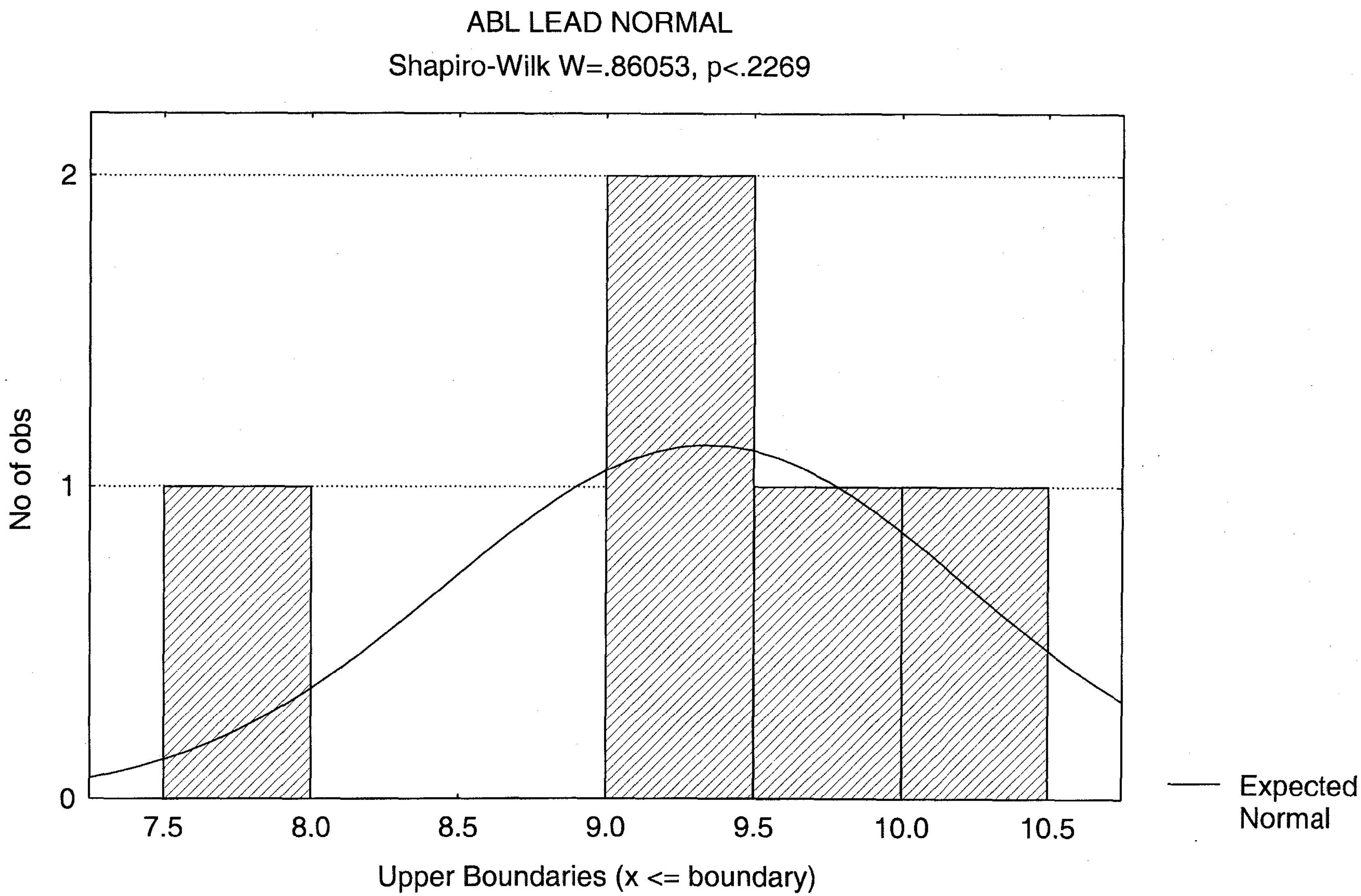

ABL COPPER NORMAL
Shapiro-Wilk W=.90192, p<.4173
No of obs
0
1
2
6.50
6.55
6.60
6.65
6.70
6.75
6.80
6.85
6.90
Upper Boundaries (x <= boundary)
Expected Normal


ABL COPPER LOGNORMAL
Shapiro-Wilk W=.90165, p<.4158
No of obs
0
1
2
1.88
1.89
1.90
1.91
1.92
1.93
1.94
Upper Boundaries (x <= boundary)
Expected Normal



ABL IRON NORMAL
Shapiro-Wilk W=.81910, p<.1129
No of obs
2
1
0
8000
10000
12000
14000
16000
18000
20000
Upper Boundaries (x <= boundary)
Expected Normal

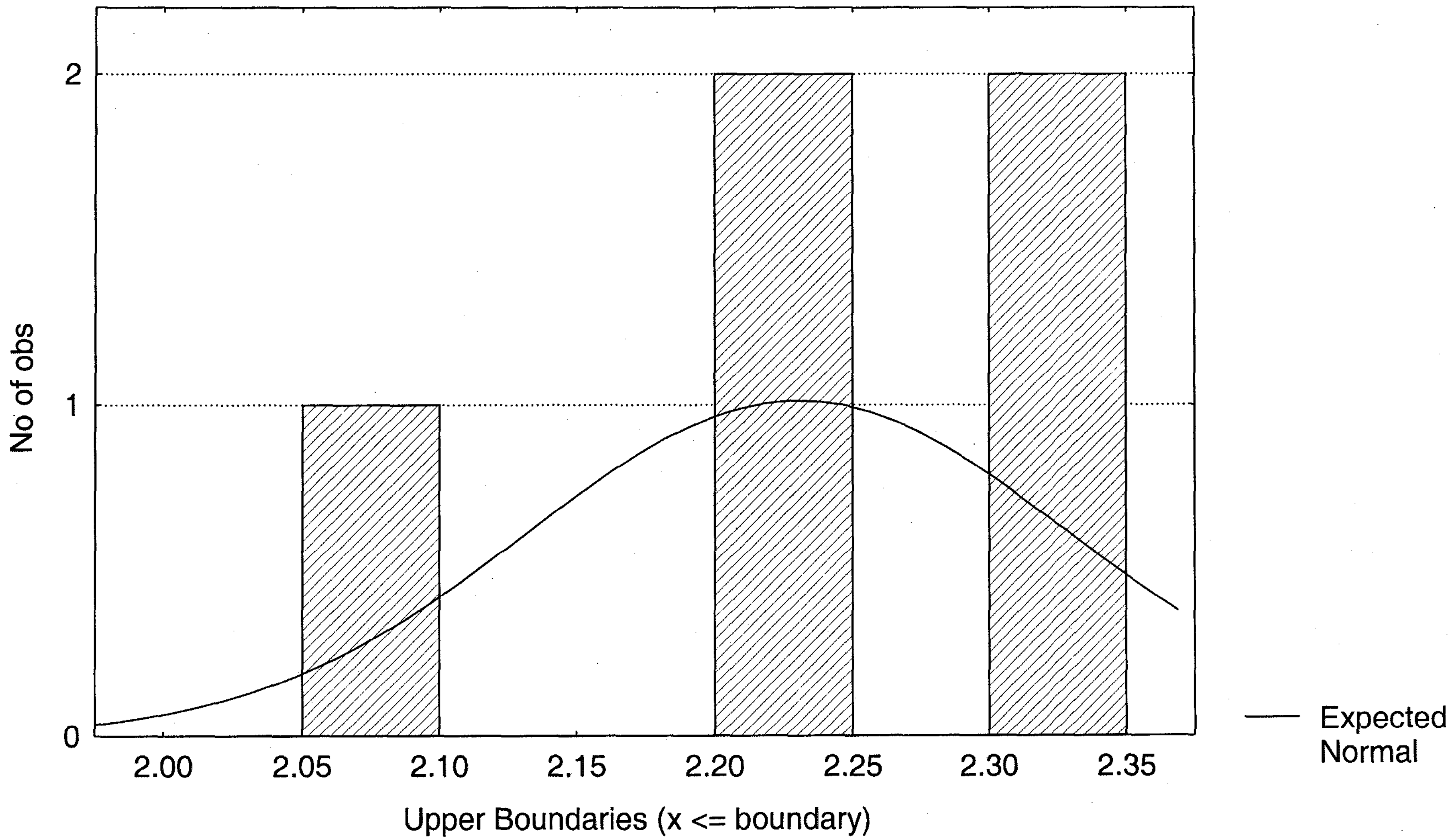

ABL IRON LOGNORMAL
Shapiro-Wilk W=.87384, p<.2795
No of obs
2
1
0
9.1
9.2
9.3
9.4
9.5
9.6
9.7
9.8
9.9
Upper Boundaries (x <= boundary)
Expected Normal



ABL LEAD NORMAL
Shapiro-Wilk W=.86053, p<.2269
No of obs
0
1
2
7.5
8.0
8.5
9.0
9.5
10.0
10.5
Upper Boundaries (x <= boundary)
Expected Normal

ABL LEAD LOGNORMAL

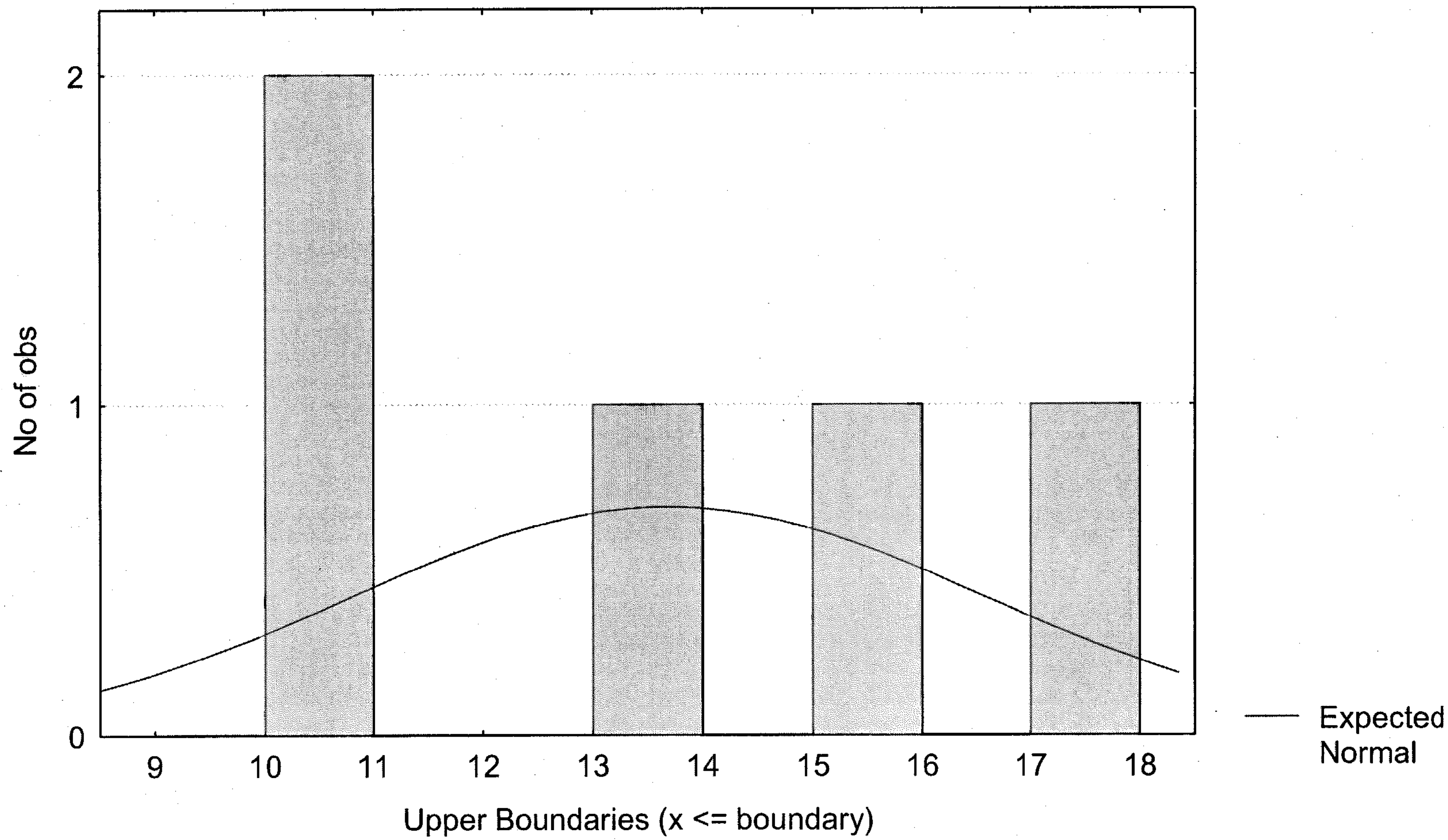
Shapiro-Wilk W=.84235, p<.1684



(ABL)

Alluvail Subsurface Silt - Normal Lithium

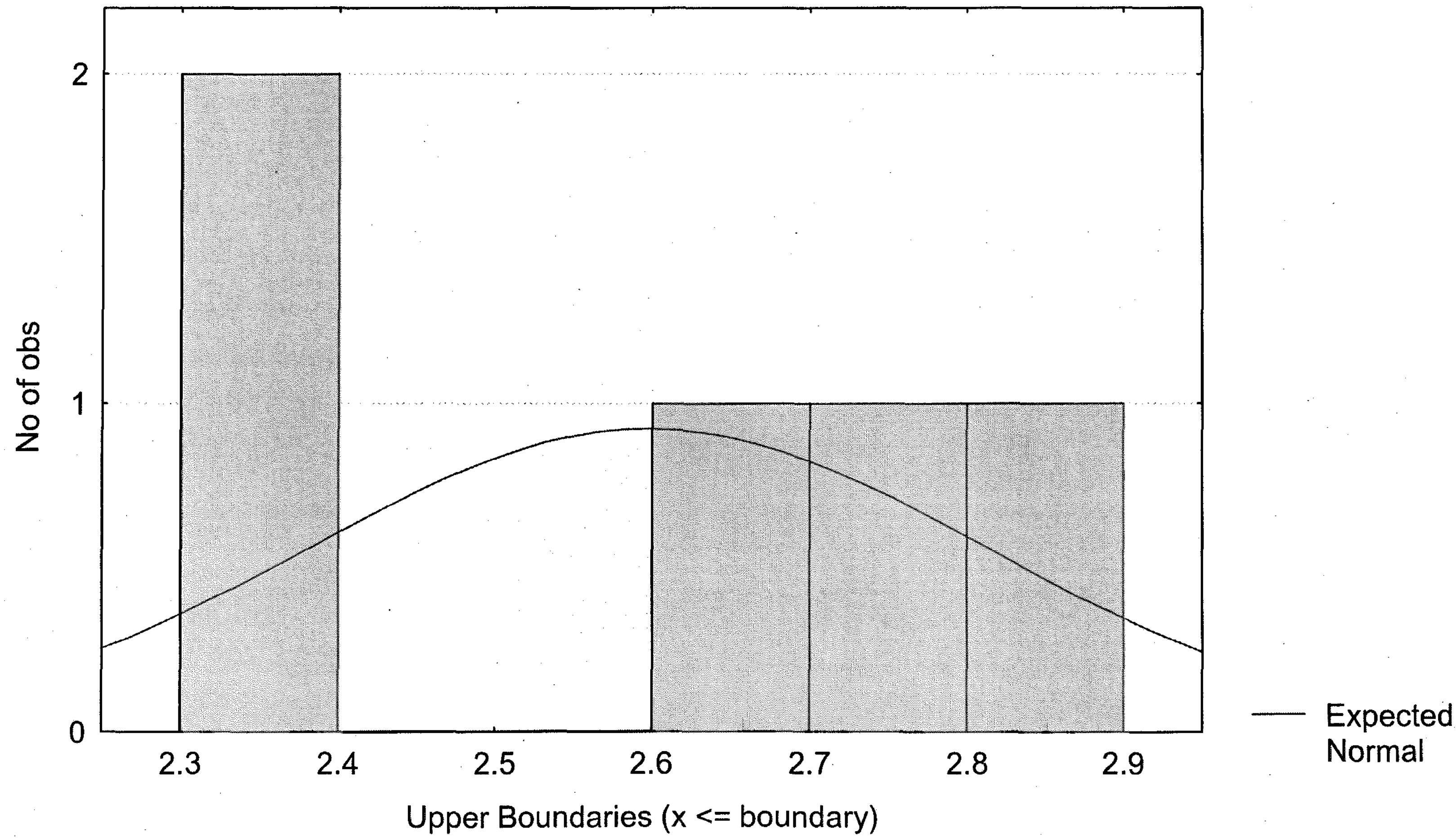
Shapiro-Wilk W=.90357



(ABL)

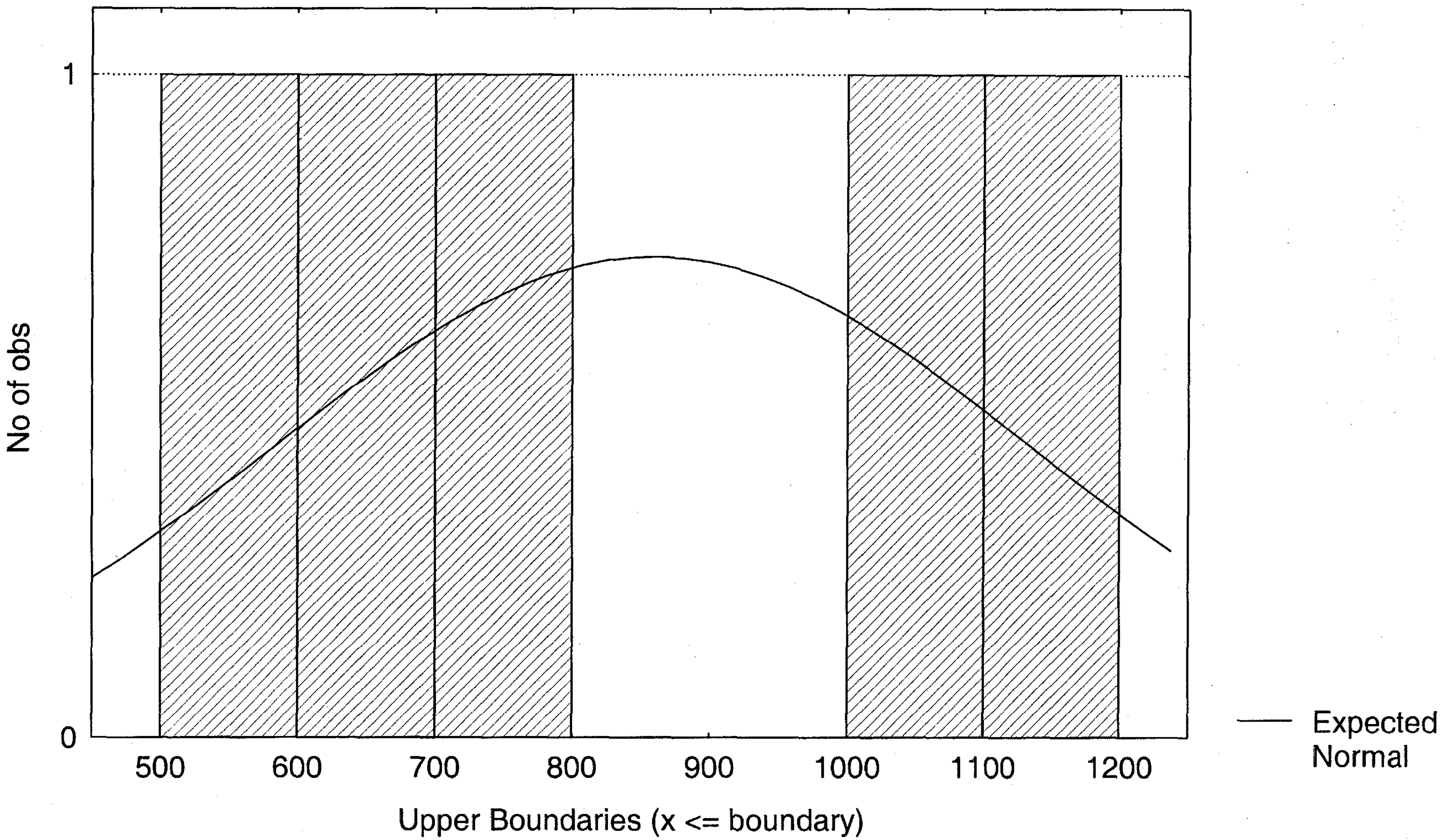
Alluvial Subsurface Silt - Lithium - Lognormal

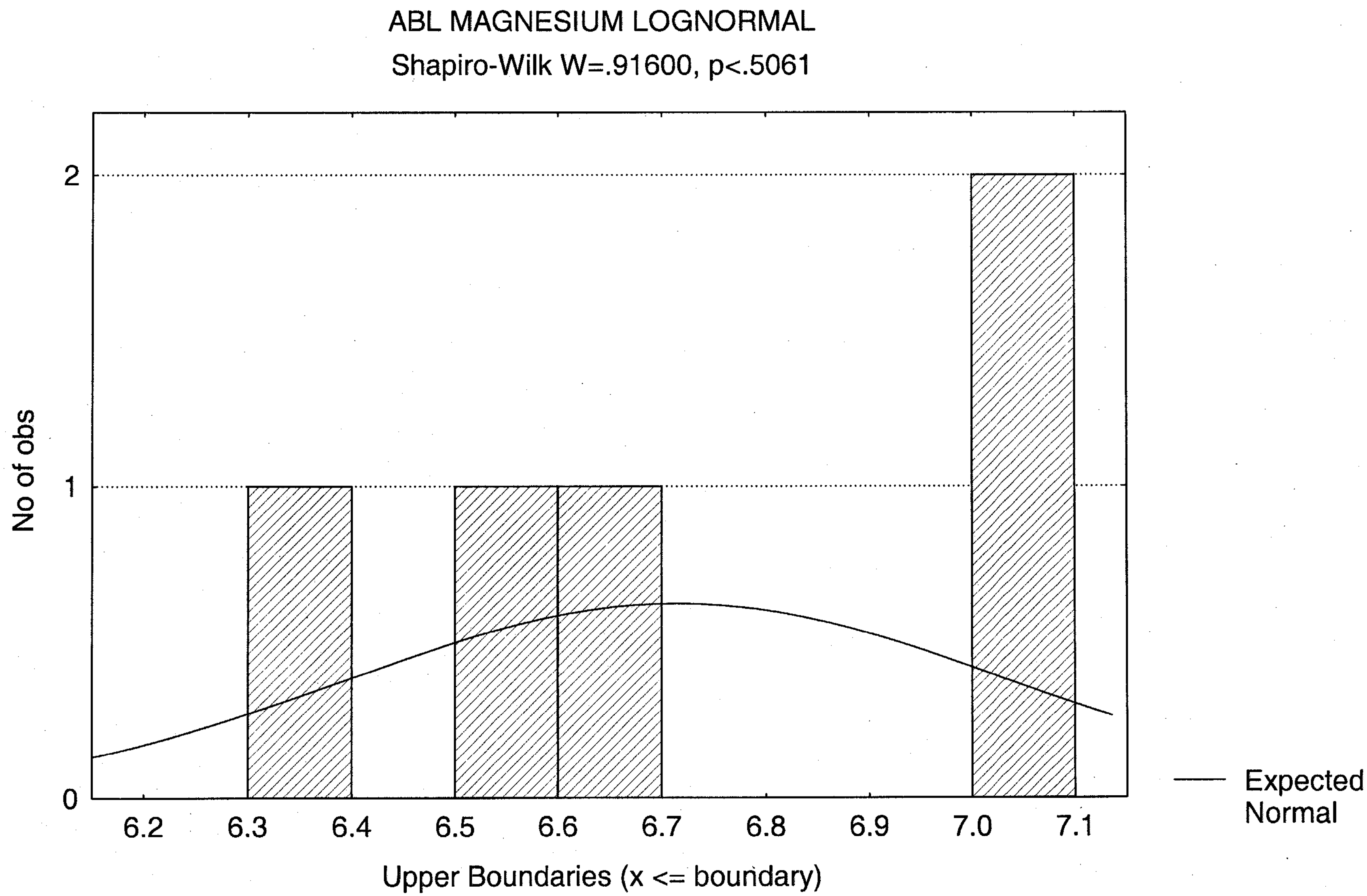
Shapiro-Wilk W=.89210

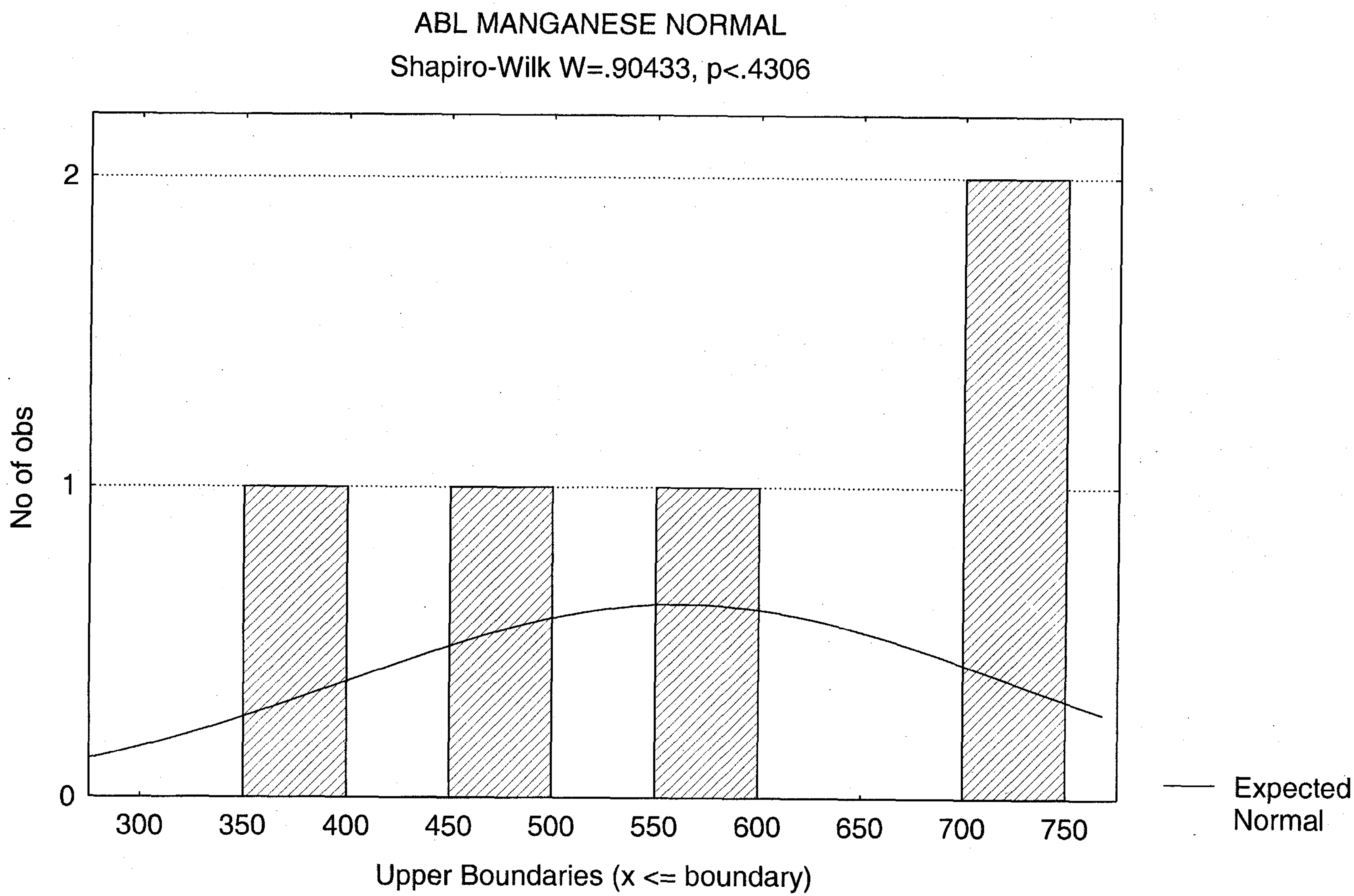


ABL MAGNESIUM NORMAL

Shapiro-Wilk W=.89369, p<.3733

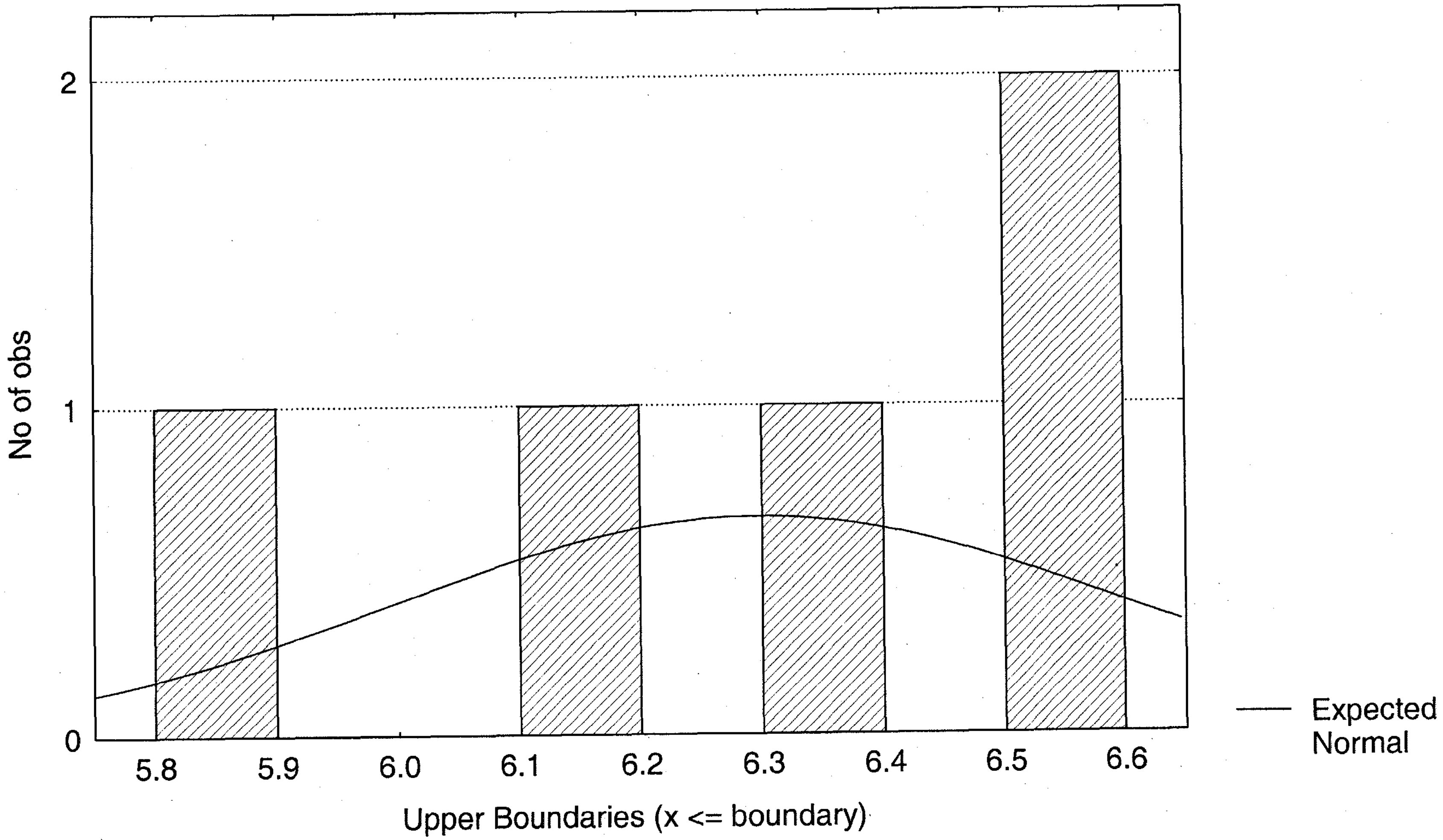


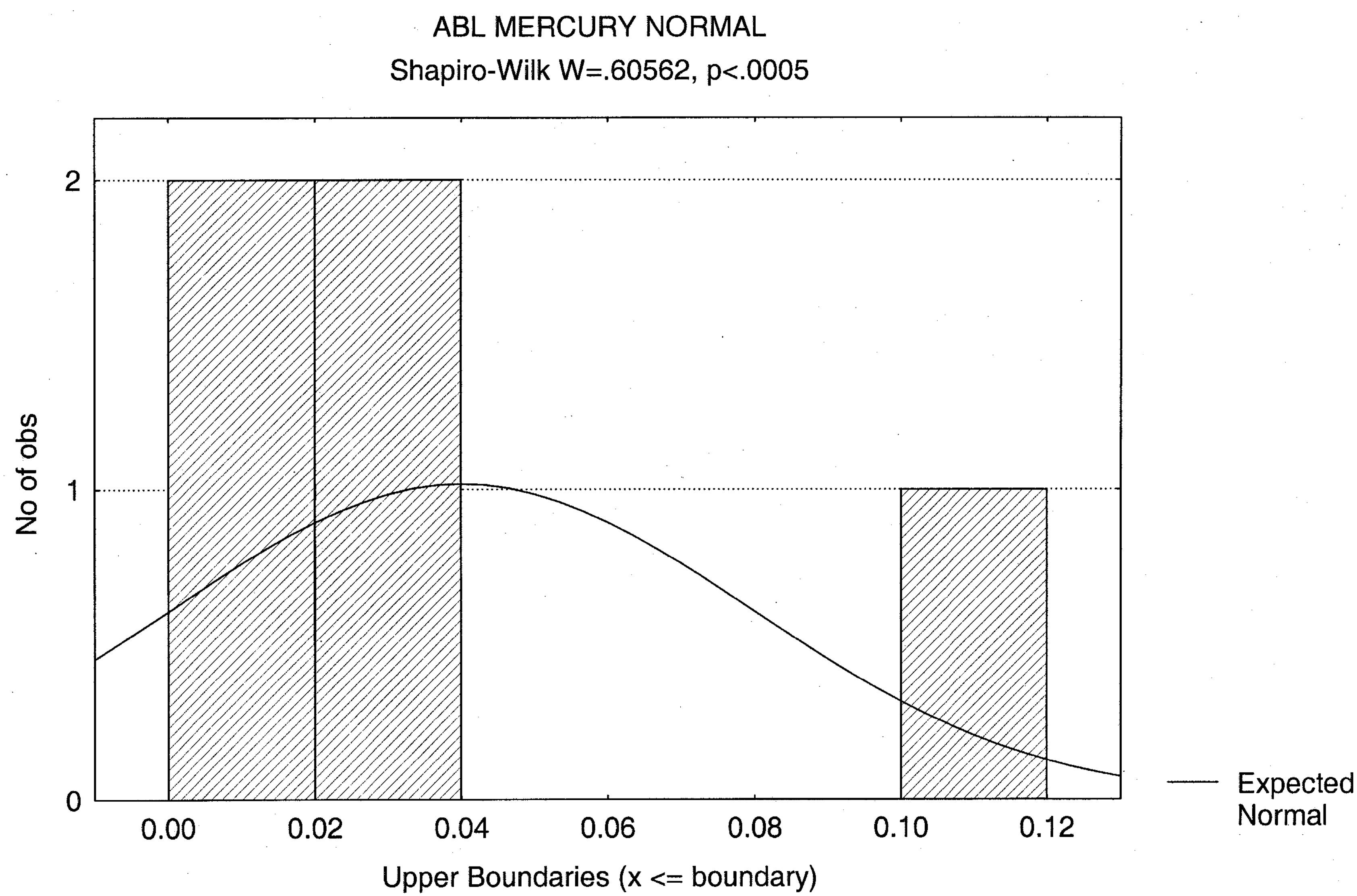

ABL MAGNESIUM LOGNORMAL
Shapiro-Wilk W=.91600, p<.5061
No of obs
0
1
2
6.2
6.3
6.4
6.5
6.6
6.7
6.8
6.9
7.0
7.1
Upper Boundaries (x <= boundary)
Expected Normal

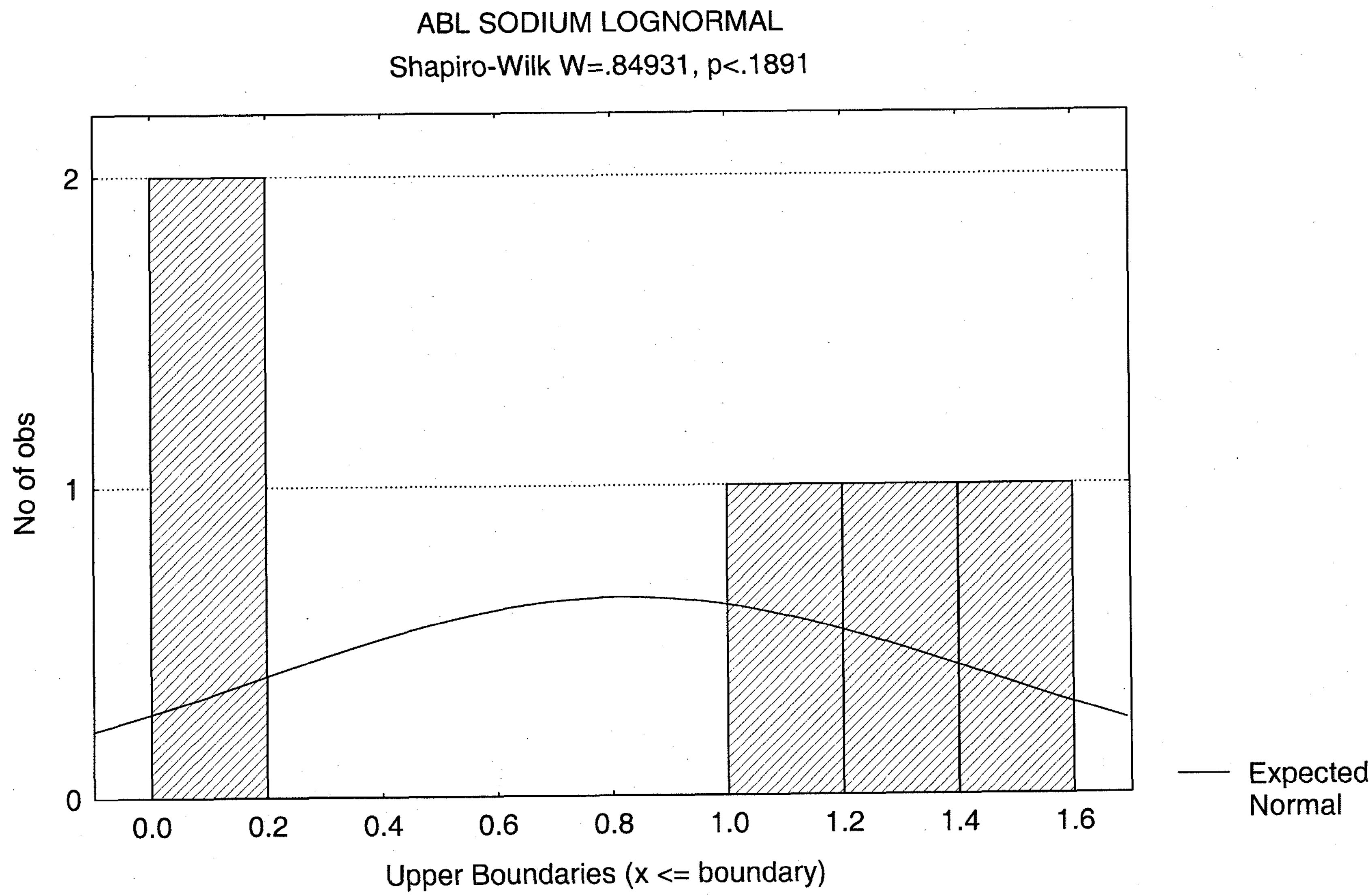

ABL MANGANESE NORMAL
Shapiro-Wilk W=.90433, p<.4306
No of obs
0
1
2
300
350
400
450
500
550
600
650
700
750
Upper Boundaries (x <= boundary)
Expected Normal

ABL MANGANESE LOGNORMAL

Shapiro-Wilk W=.90981, p<.4617

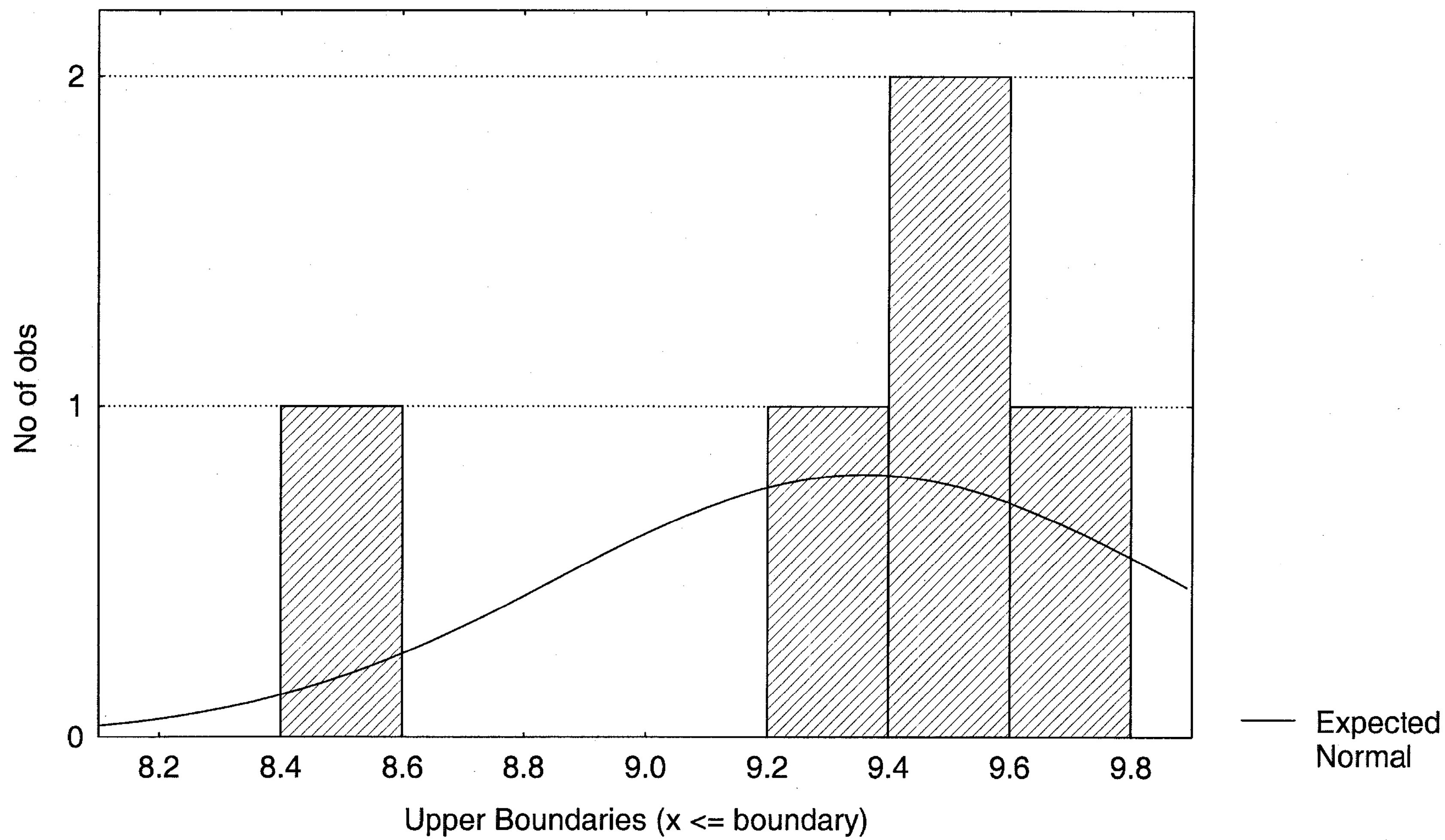


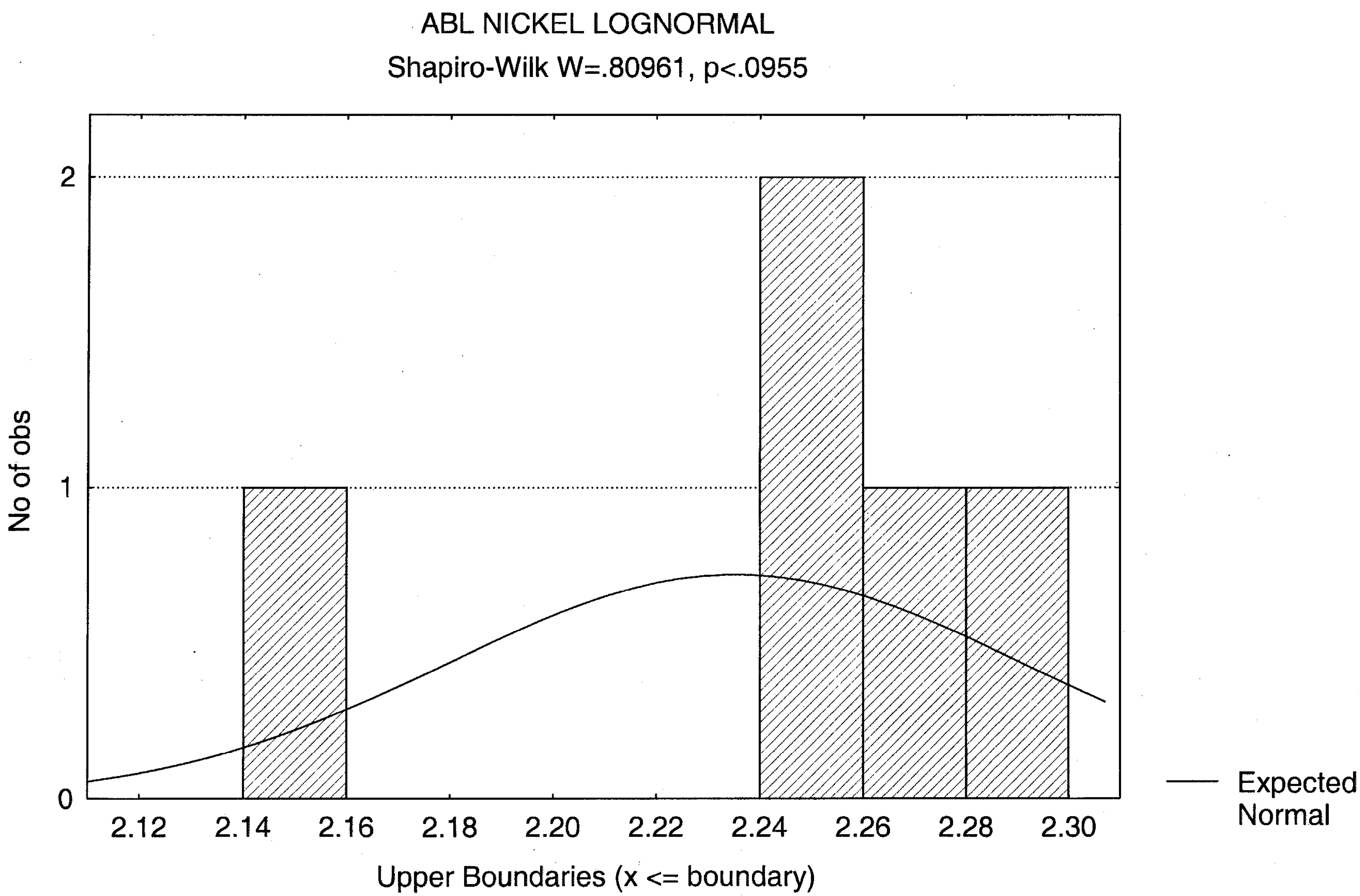

ABL MERCURY NORMAL
Shapiro-Wilk W=.60562, p<.0005
No of obs
2
1
0
0.00
0.02
0.04
0.06
0.08
0.10
0.12
Upper Boundaries (x <= boundary)
Expected Normal


ABL SODIUM LOGNORMAL
Shapiro-Wilk W=.84931, p<.1891
No of obs
0
1
2
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
Upper Boundaries (x <= boundary)
Expected Normal

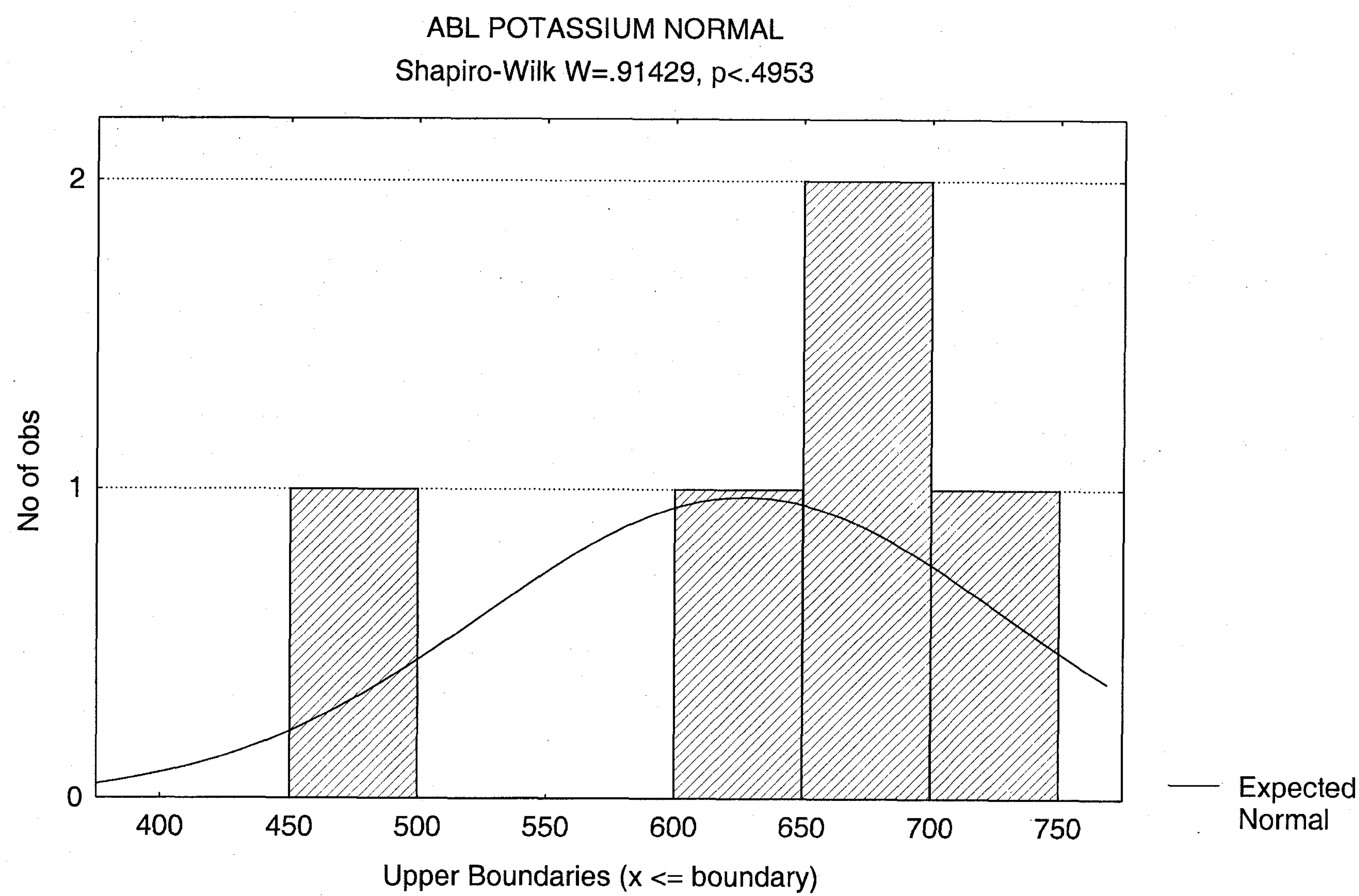
ABL NICKEL NORMAL

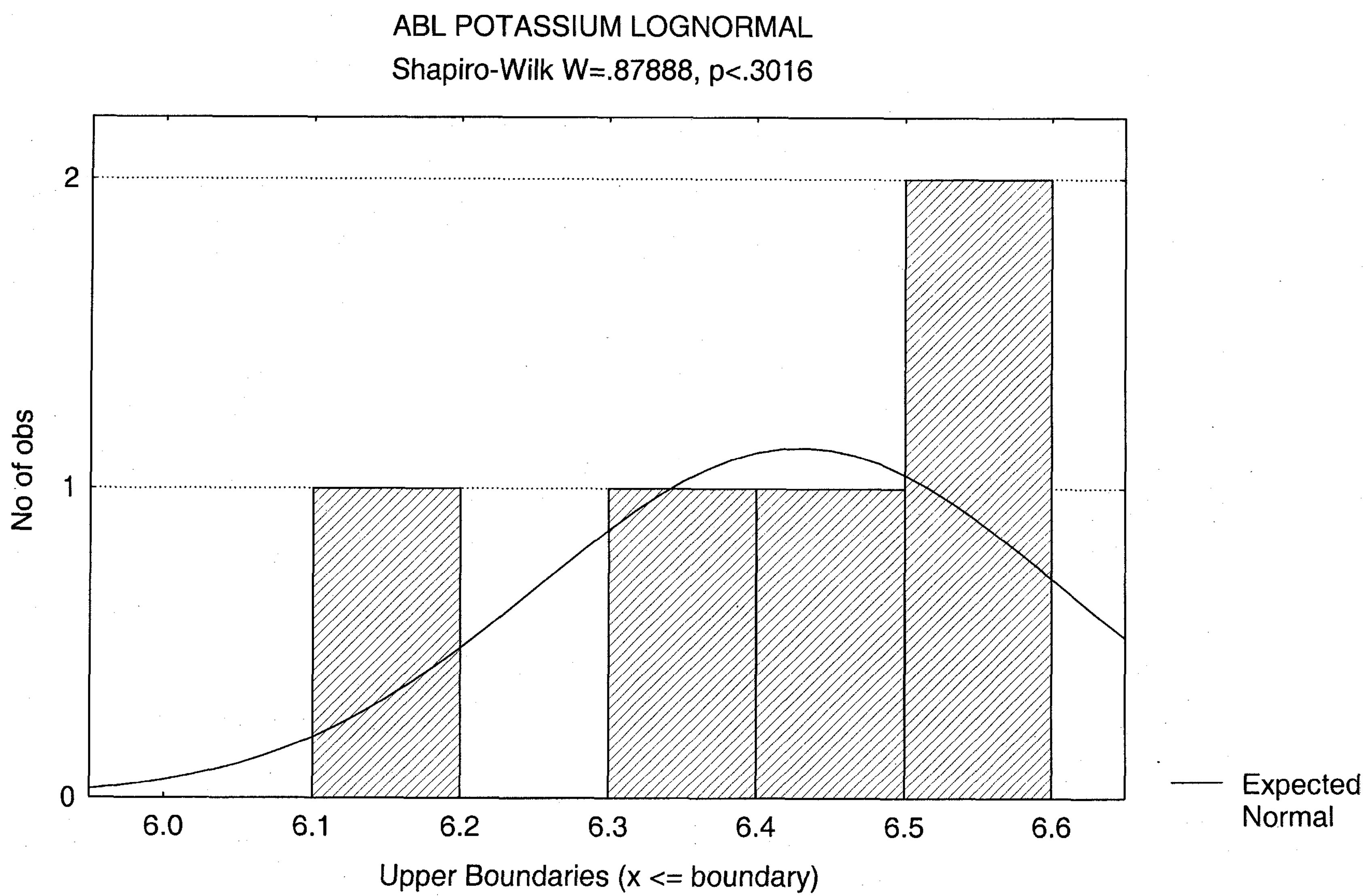
Shapiro-Wilk W=.82251, p<.1199

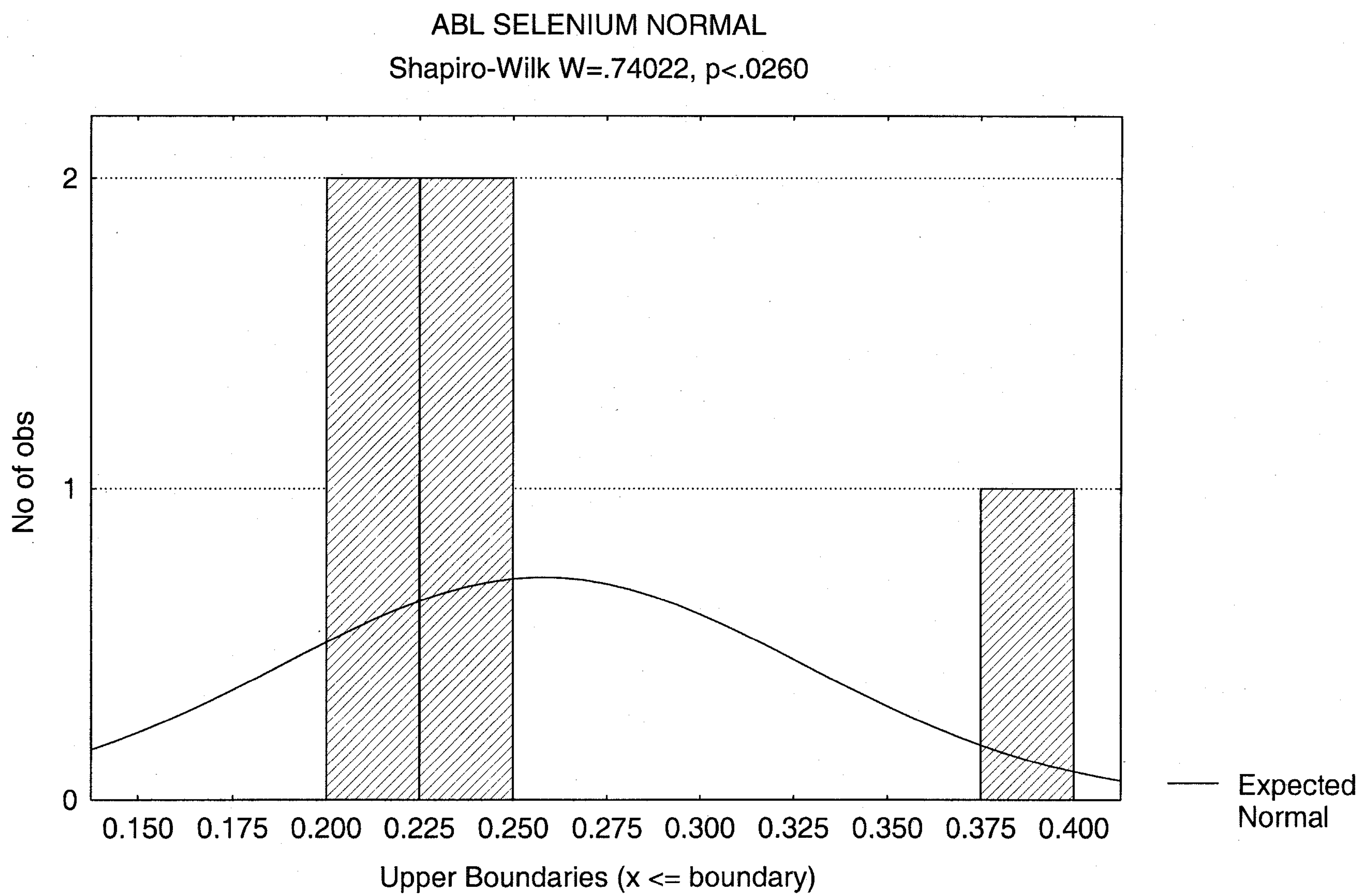




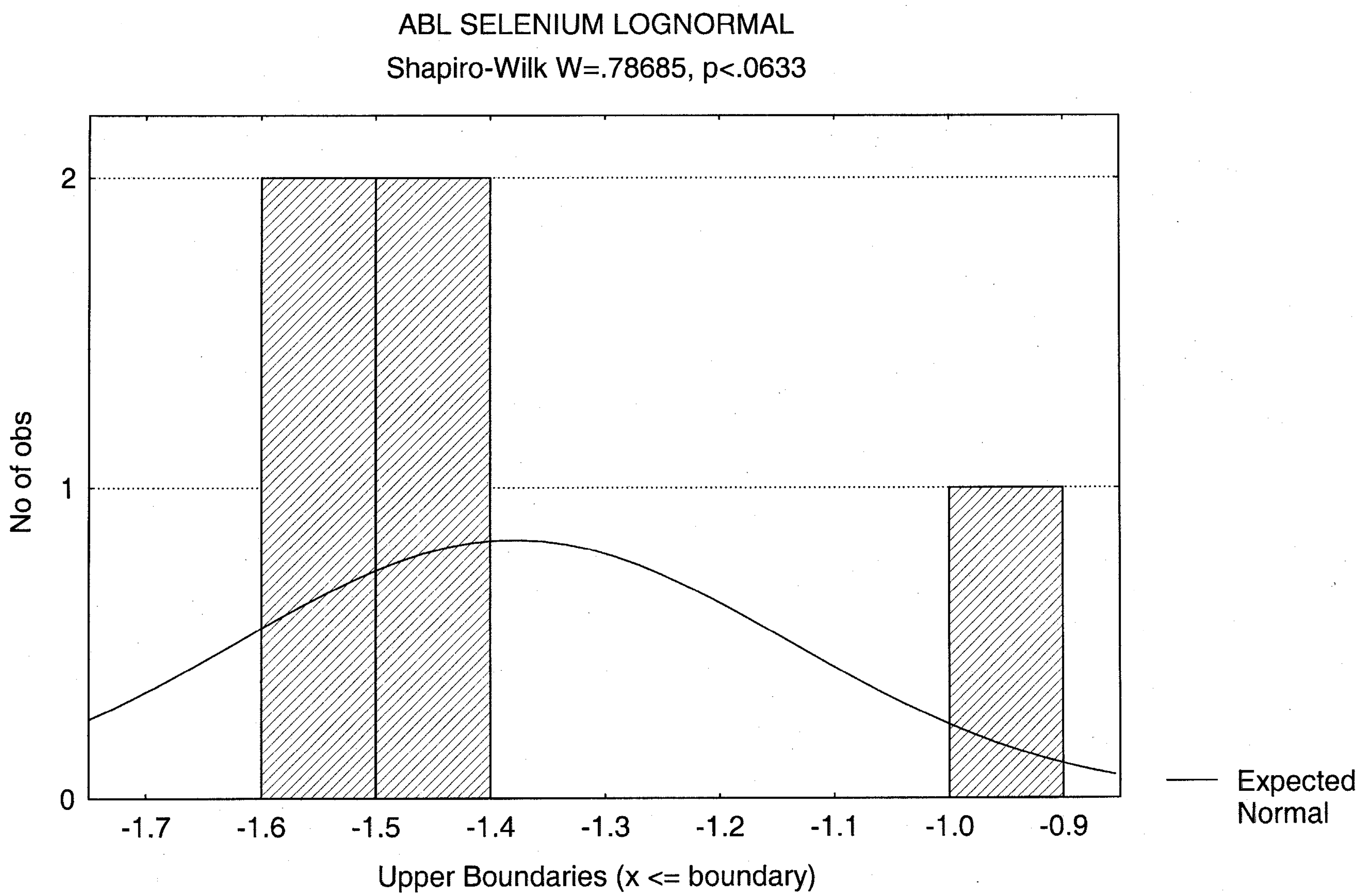
ABL NICKEL LOGNORMAL
Shapiro-Wilk W=.80961, p<.0955
No of obs
2
1
0
2.12
2.14
2.16
2.18
2.20
2.22
2.24
2.26
2.28
2.30
Upper Boundaries (x <= boundary)
Expected Normal


ABL POTASSIUM NORMAL
Shapiro-Wilk W=.91429, p<.4953
No of obs
0
1
2
400
450
500
550
600
650
700
750
Upper Boundaries (x <= boundary)
Expected
Normal

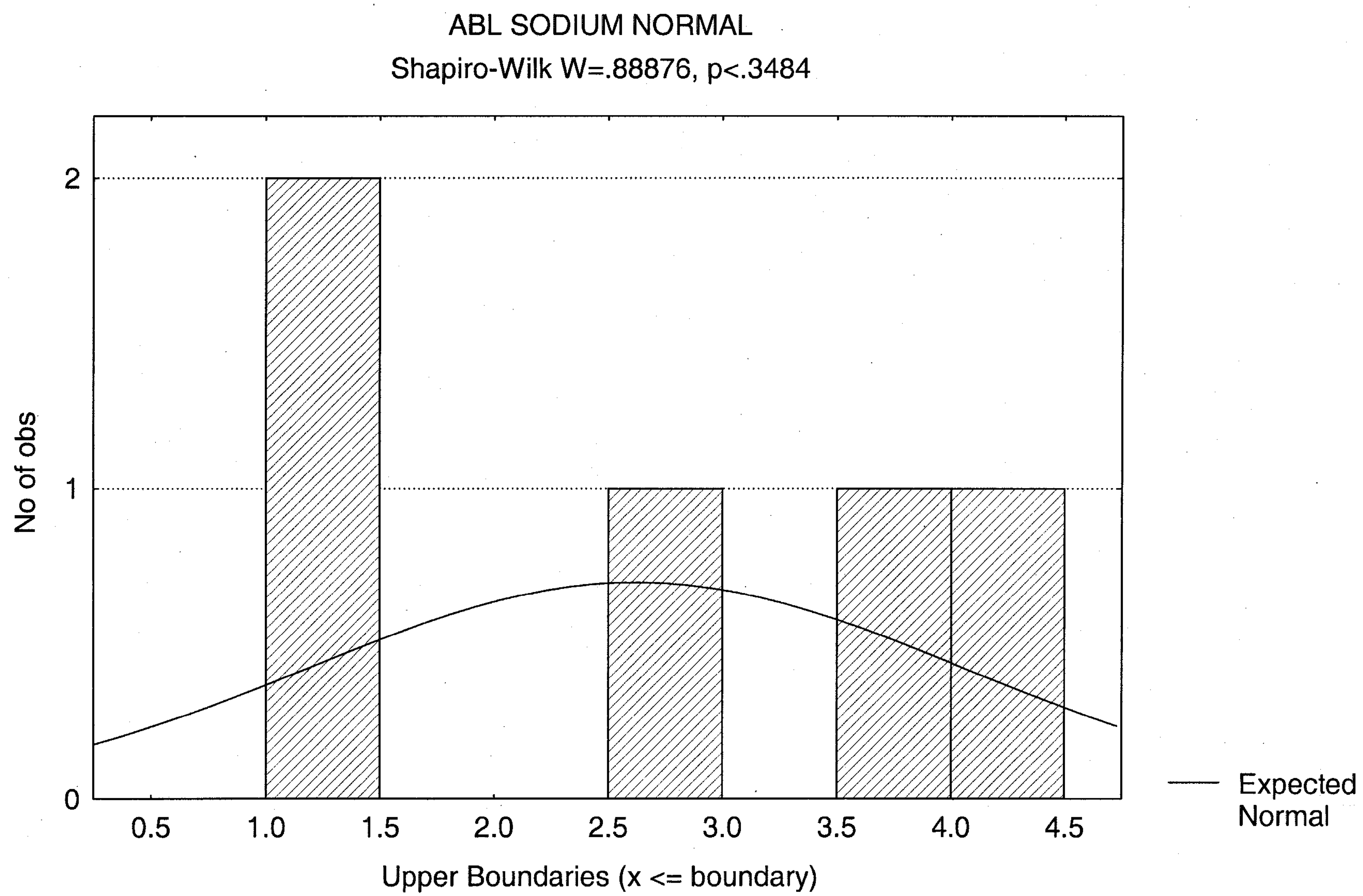

ABL POTASSIUM LOGNORMAL
Shapiro-Wilk W=.87888, p<.3016
No of obs
2
1
0
6.0
6.1
6.2
6.3
6.4
6.5
6.6
Upper Boundaries (x <= boundary)
Expected Normal

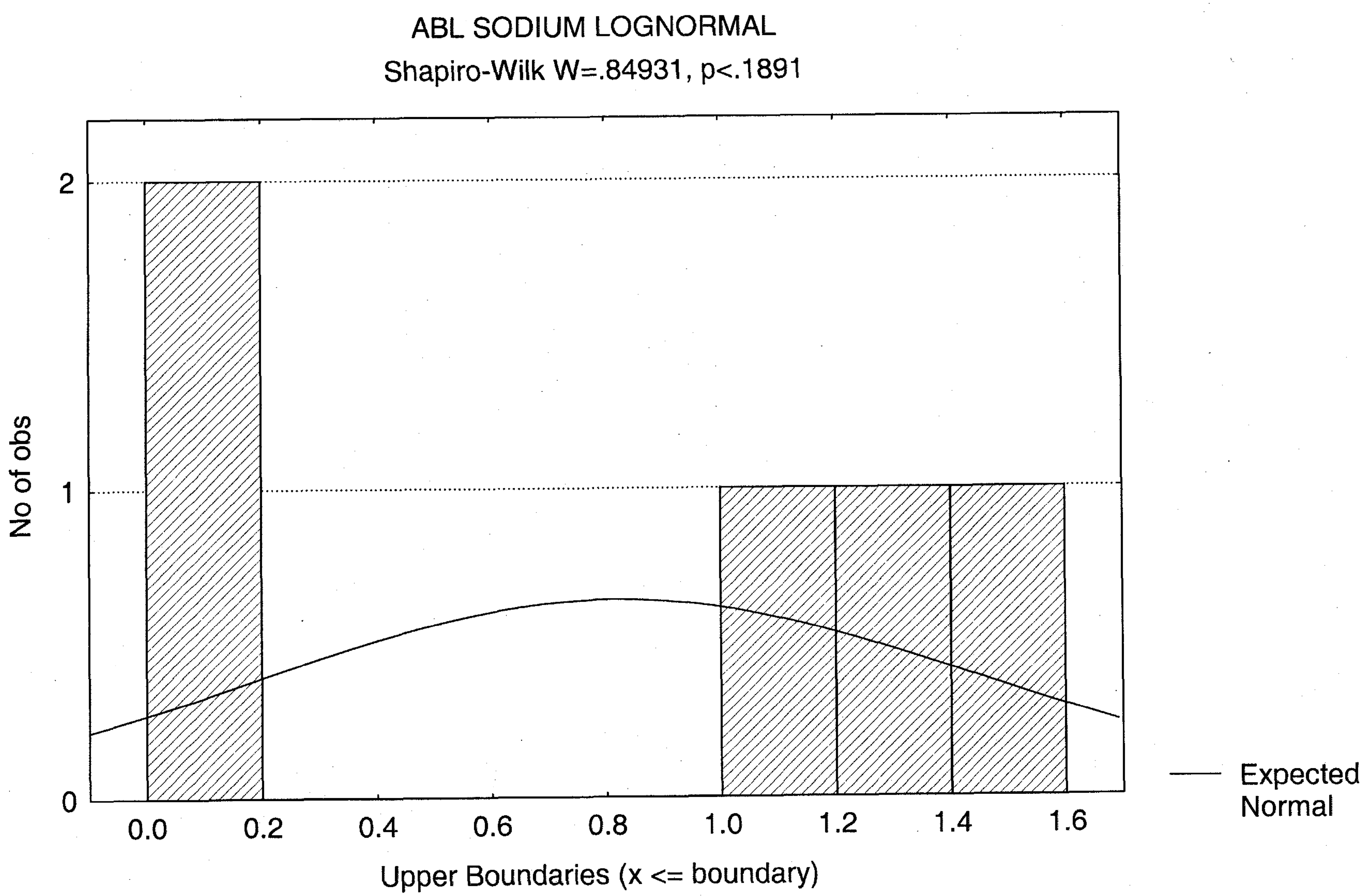


ABL SELENIUM NORMAL
Shapiro-Wilk W=.74022, p<.0260
No of obs
0
1
2
0.150 0.175 0.200 0.225 0.250 0.275 0.300 0.325 0.350 0.375 0.400
Upper Boundaries (x <= boundary)
Expected Normal



ABL SELENIUM LOGNORMAL
Shapiro-Wilk W=.78685, p<.0633
No of obs
0
1
2
-1.7
-1.6
-1.5
-1.4
-1.3
-1.2
-1.1
-1.0
-0.9
Upper Boundaries (x <= boundary)
Expected Normal


ABL SODIUM NORMAL
Shapiro-Wilk W=.88876, p<.3484
No of obs
0
1
2
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
Upper Boundaries (x <= boundary)
Expected Normal

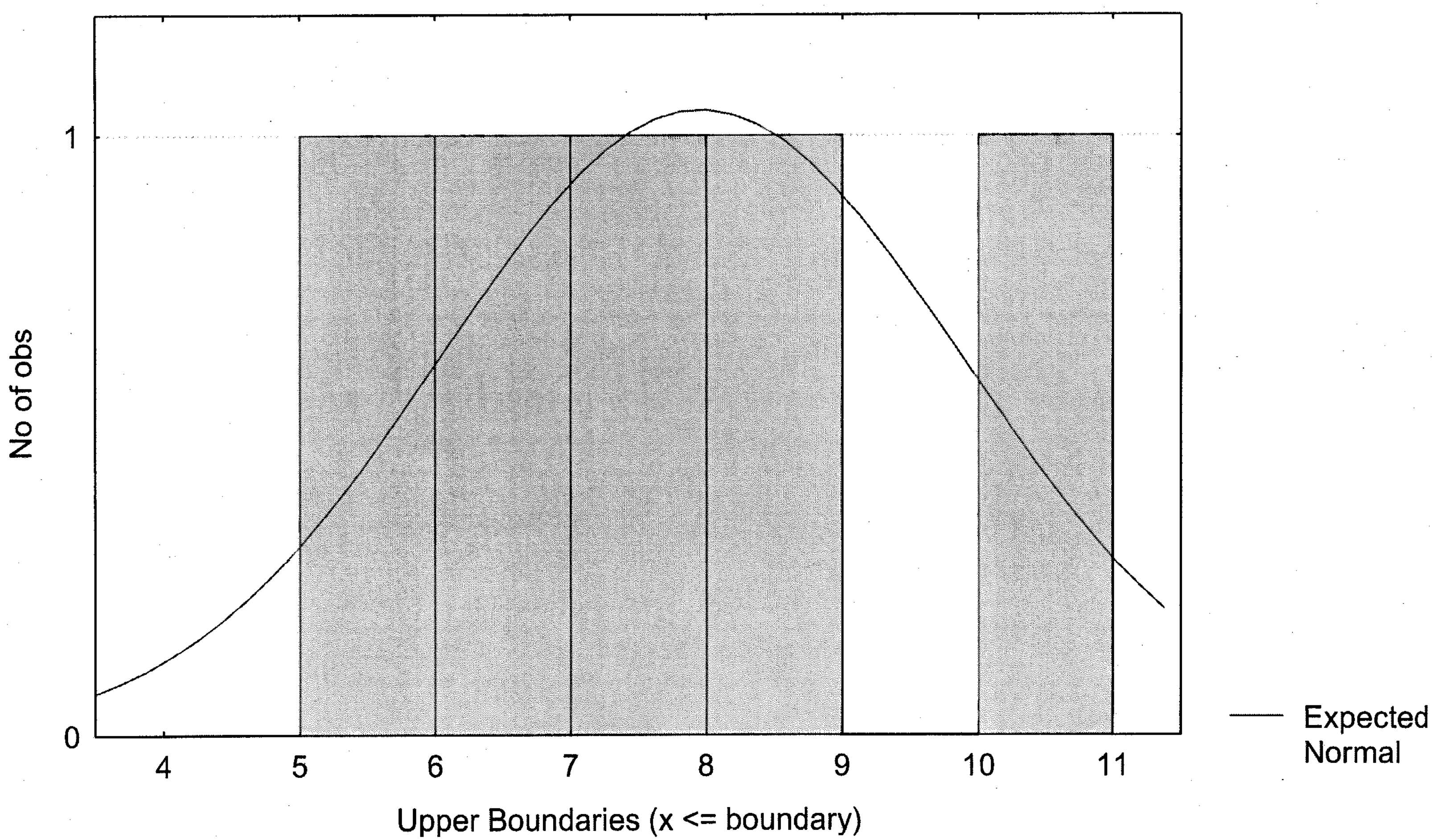


ABL SODIUM LOGNORMAL
Shapiro-Wilk W=.84931, p<.1891
No of obs
2
1
0
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
Upper Boundaries (x <= boundary)
Expected Normal

(ABL)

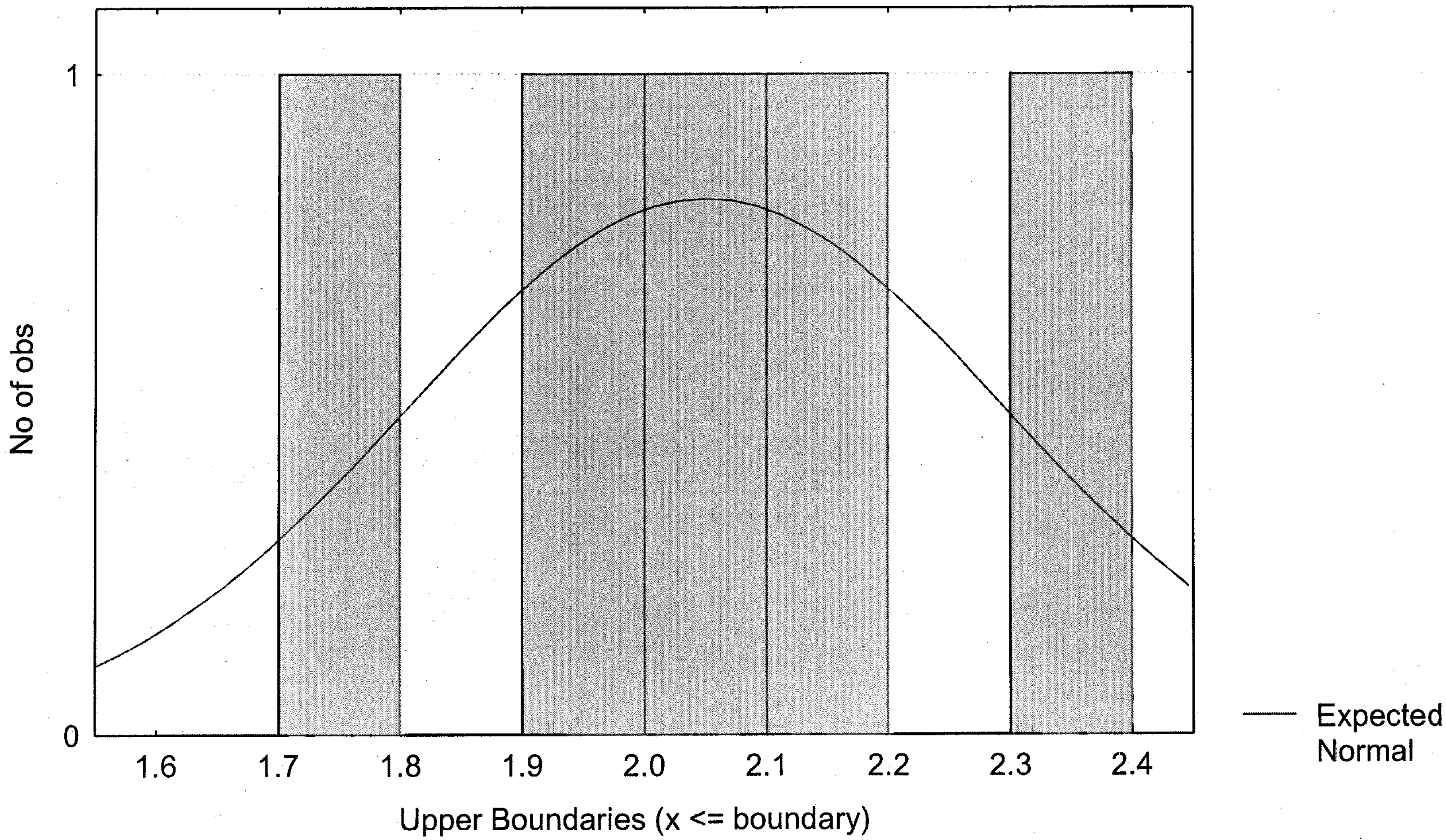
Alluvial Subsurface Silt - Strontium - Normal

Shapiro-Wilk W=.99809

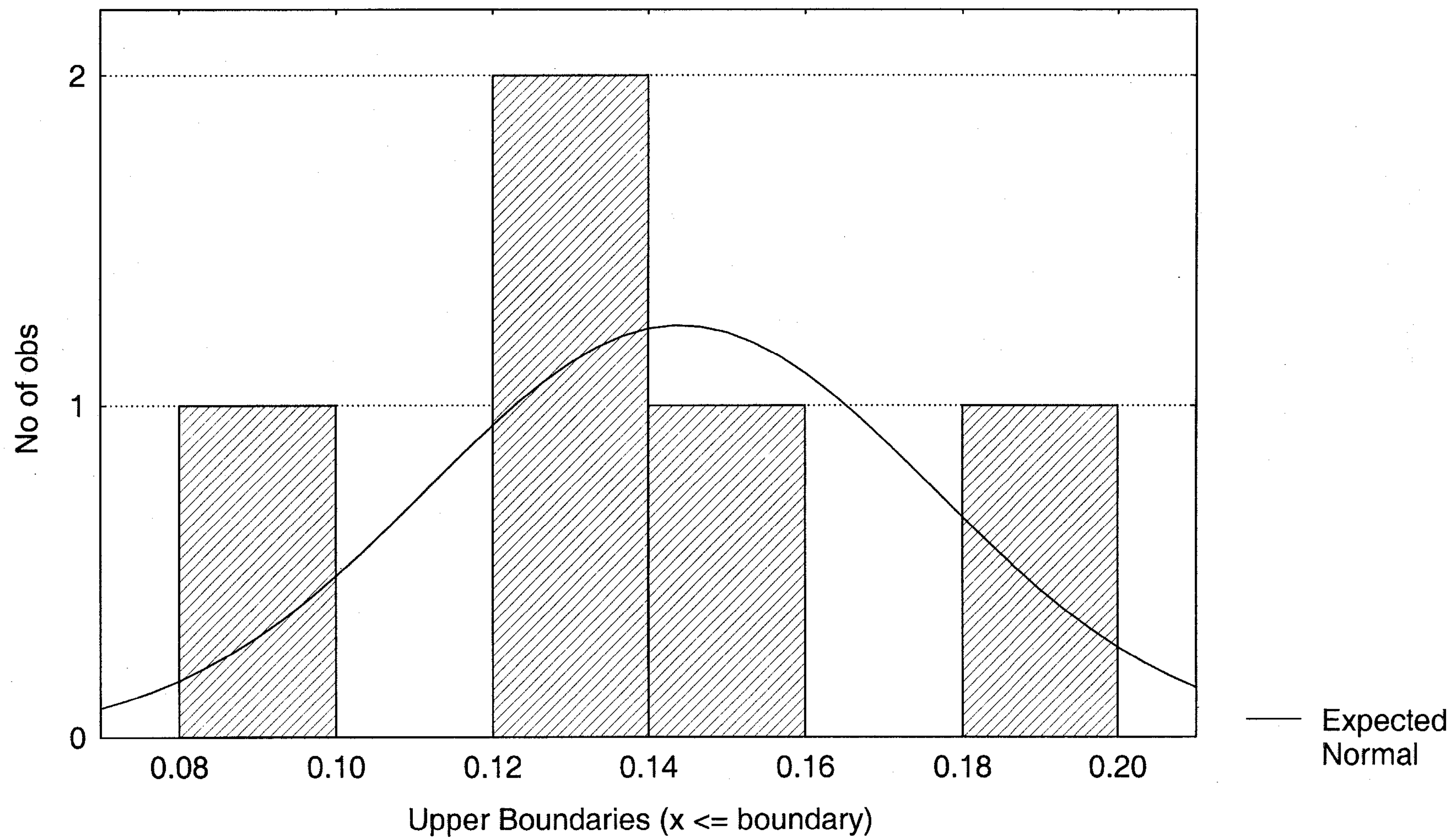


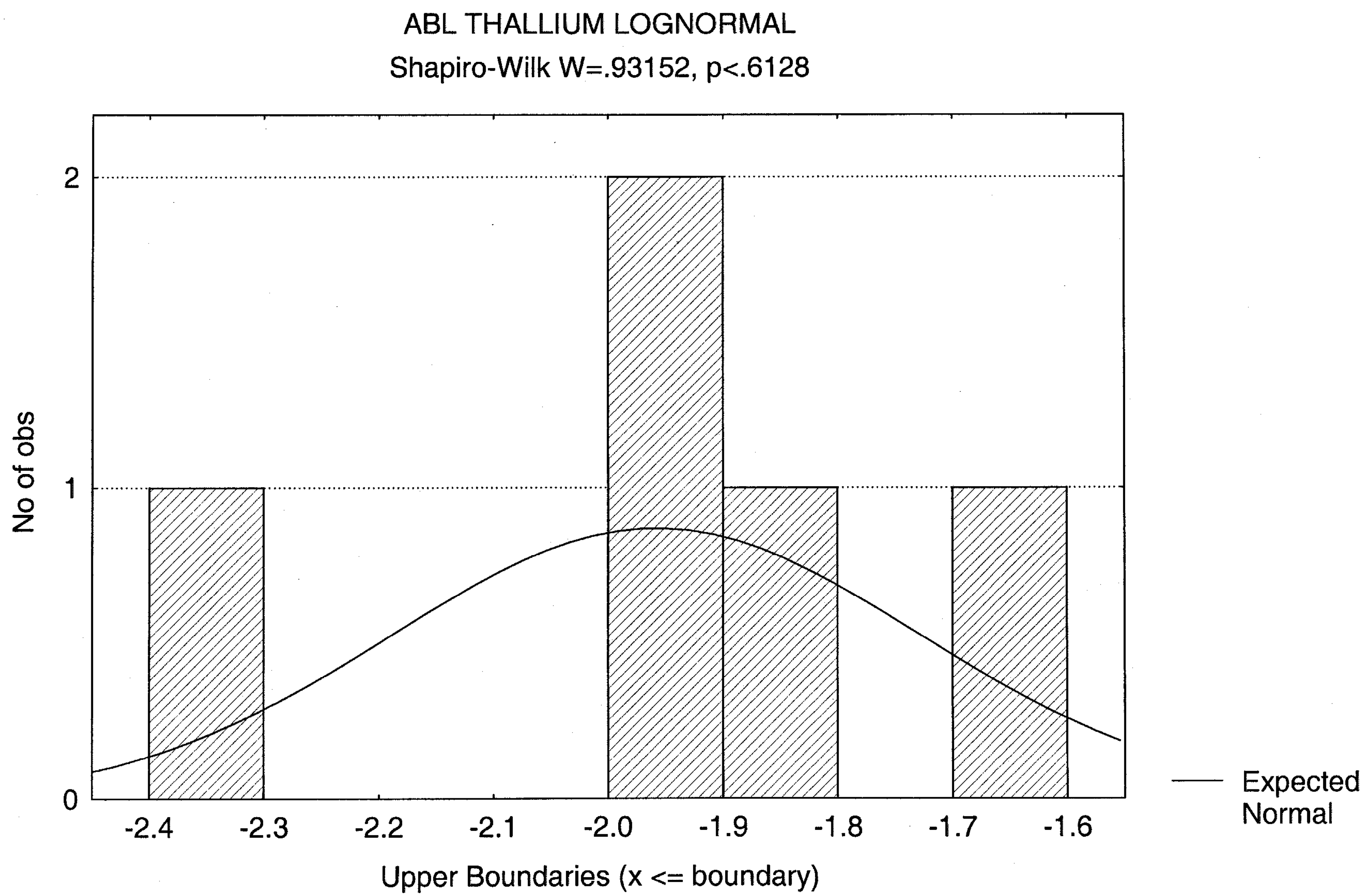
(ABL)

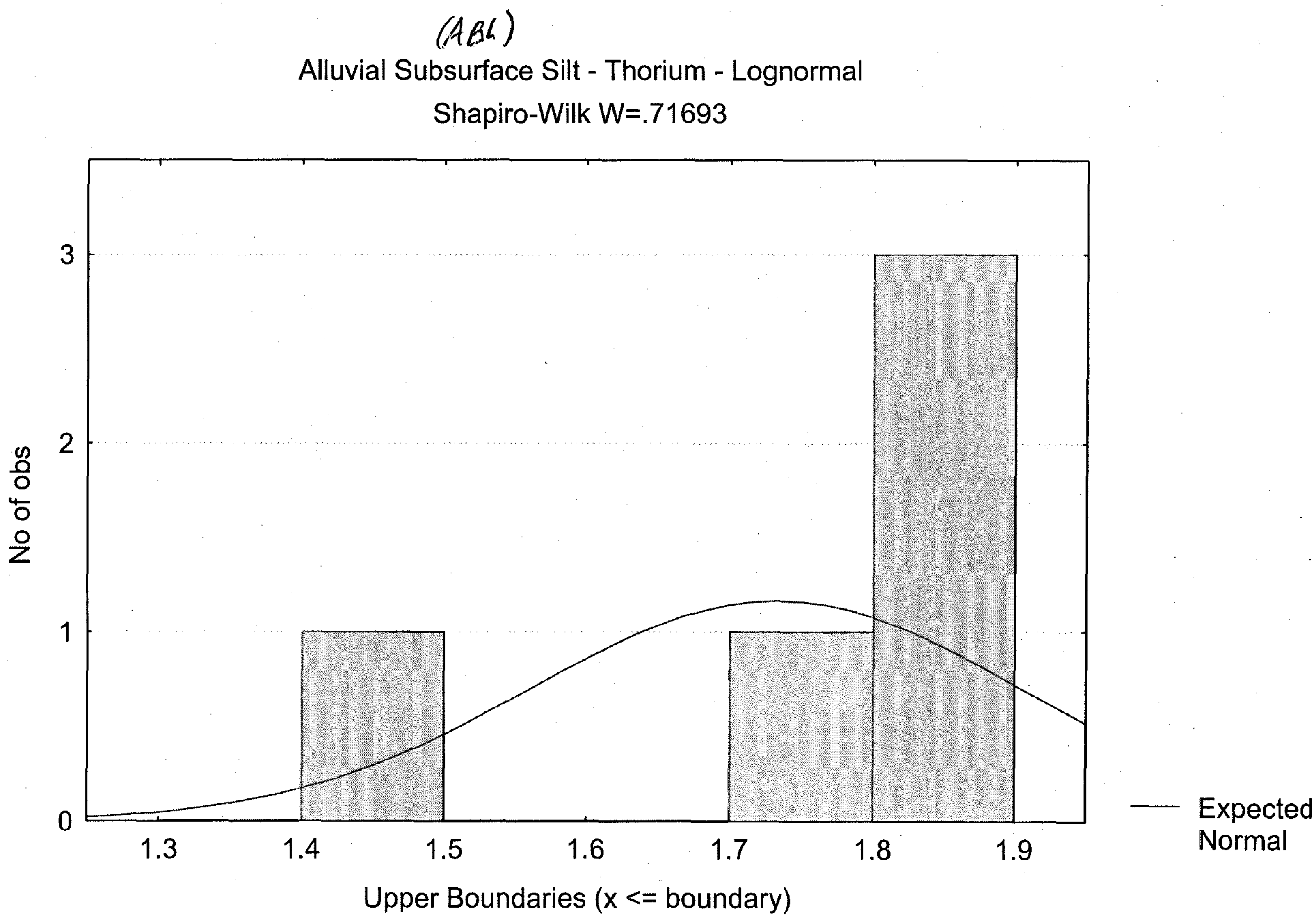
Alluvial Subsurface Silt - Strontium - Lognormal
Shapiro-Wilk W=.99537



ABL THALLIUM NORMAL
Shapiro-Wilk W=.94010, p<.6744



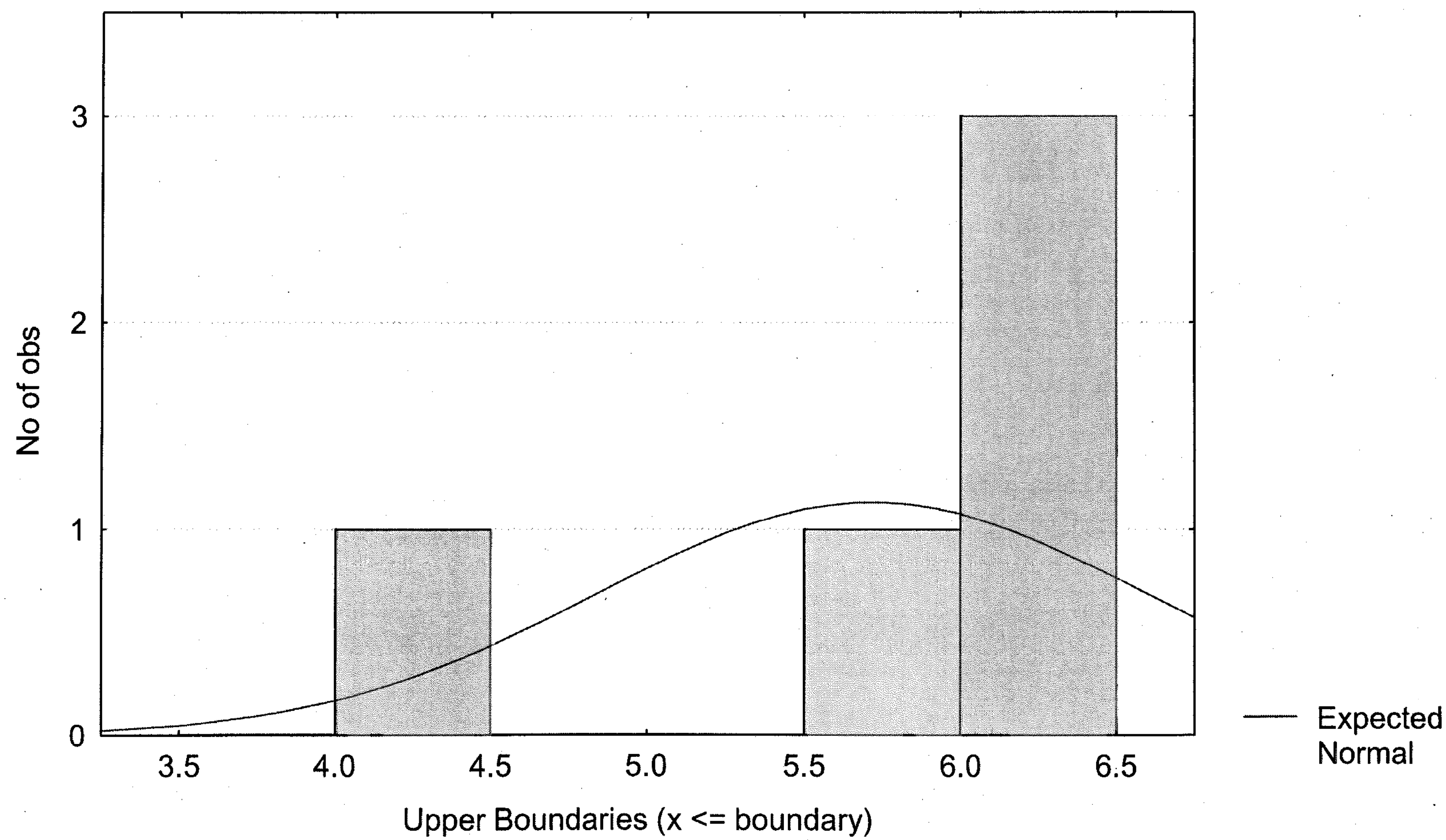

ABL THALLIUM LOGNORMAL
Shapiro-Wilk W=.93152, p<.6128
No of obs
0
1
2
-2.4
-2.3
-2.2
-2.1
-2.0
-1.9
-1.8
-1.7
-1.6
Upper Boundaries (x <= boundary)
Expected Normal

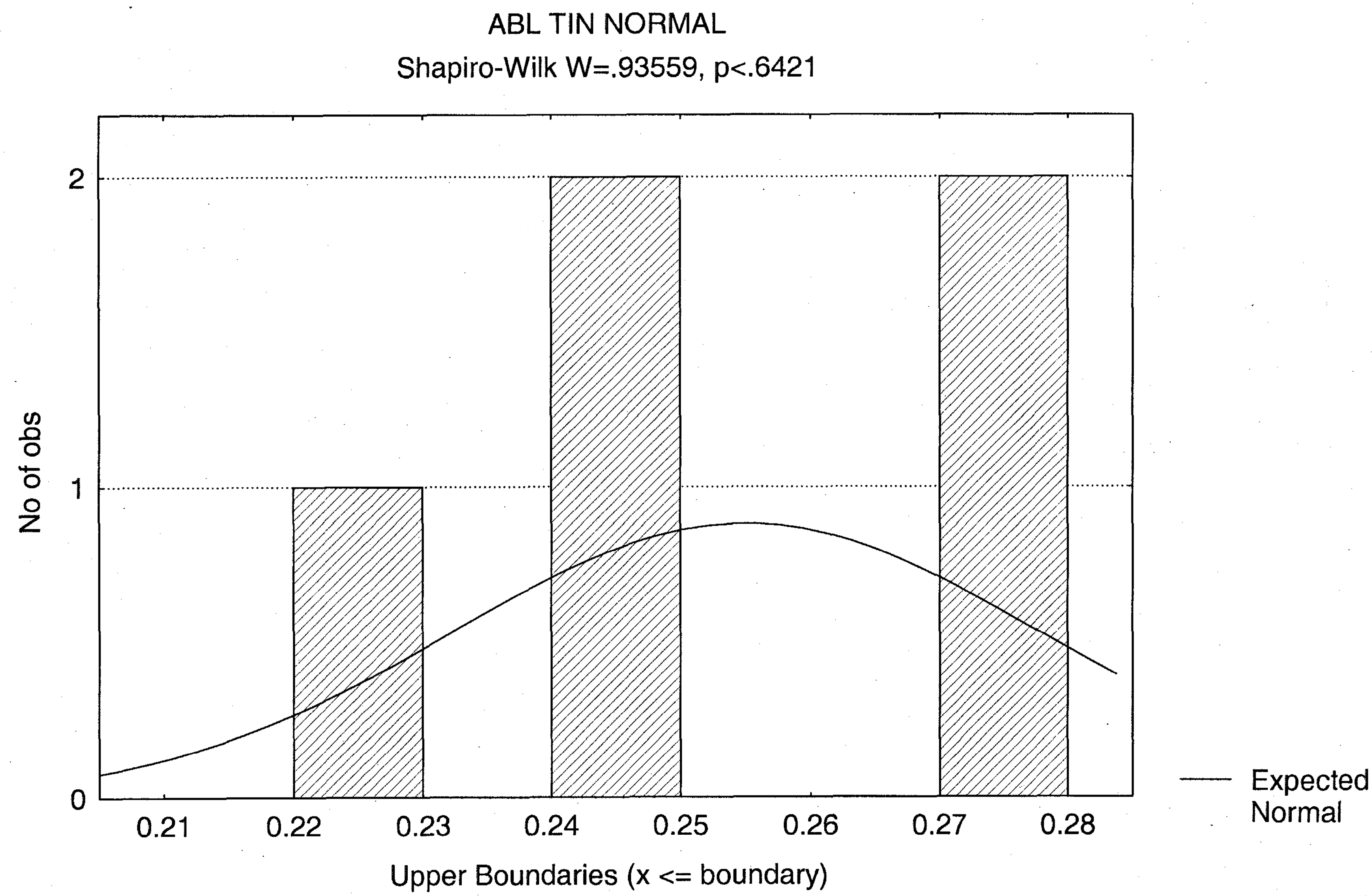

(ABL)
Alluvial Subsurface Silt - Thorium - Lognormal
Shapiro-Wilk W=.71693
No of obs
0
1
2
3
1.3
1.4
1.5
1.6
1.7
1.8
1.9
Upper Boundaries (x <= boundary)
Expected Normal

(ABL)

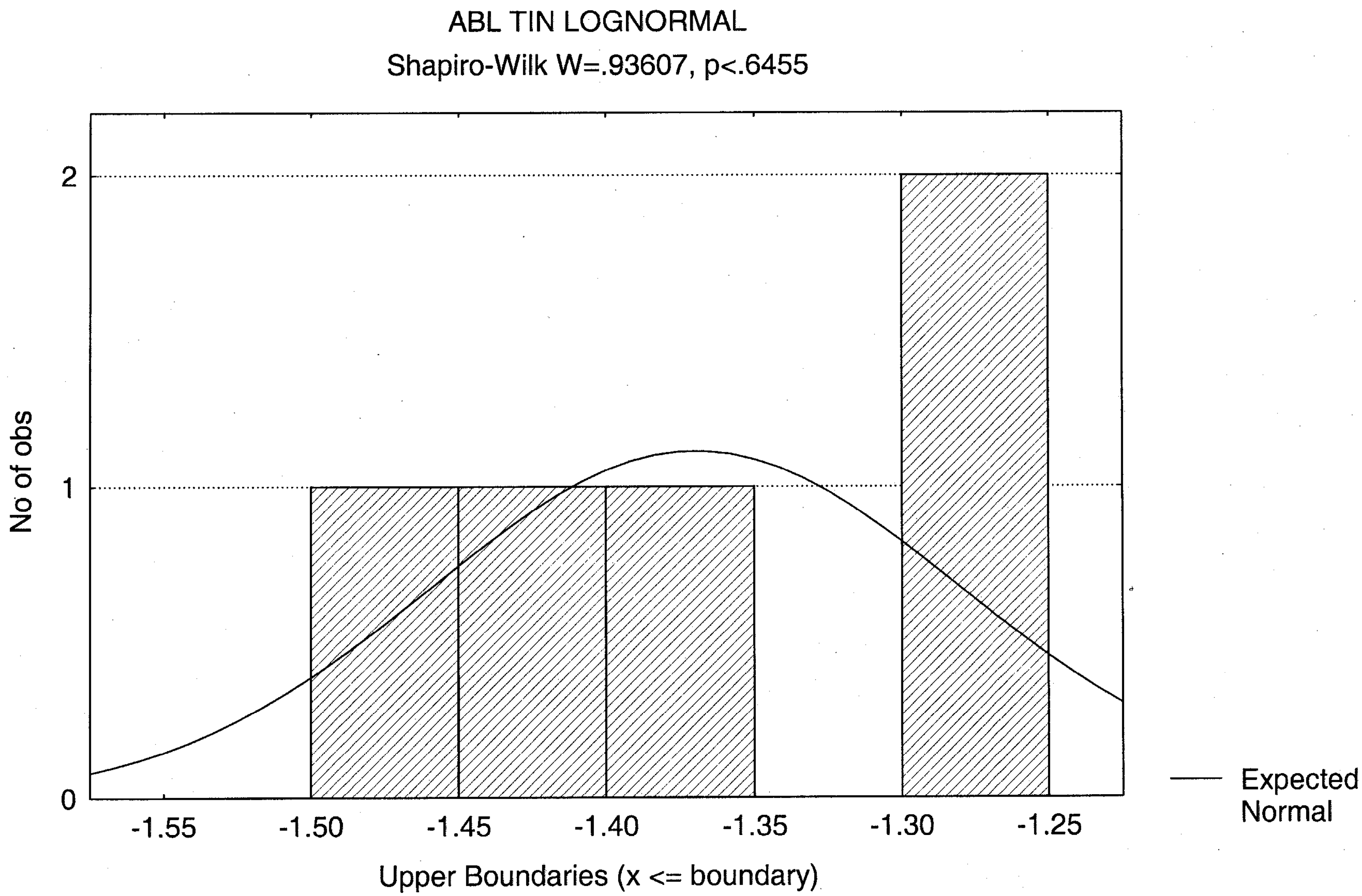
Alluvial Subsurface Silt - Thorium - Normal

Shapiro-Wilk W=.73992



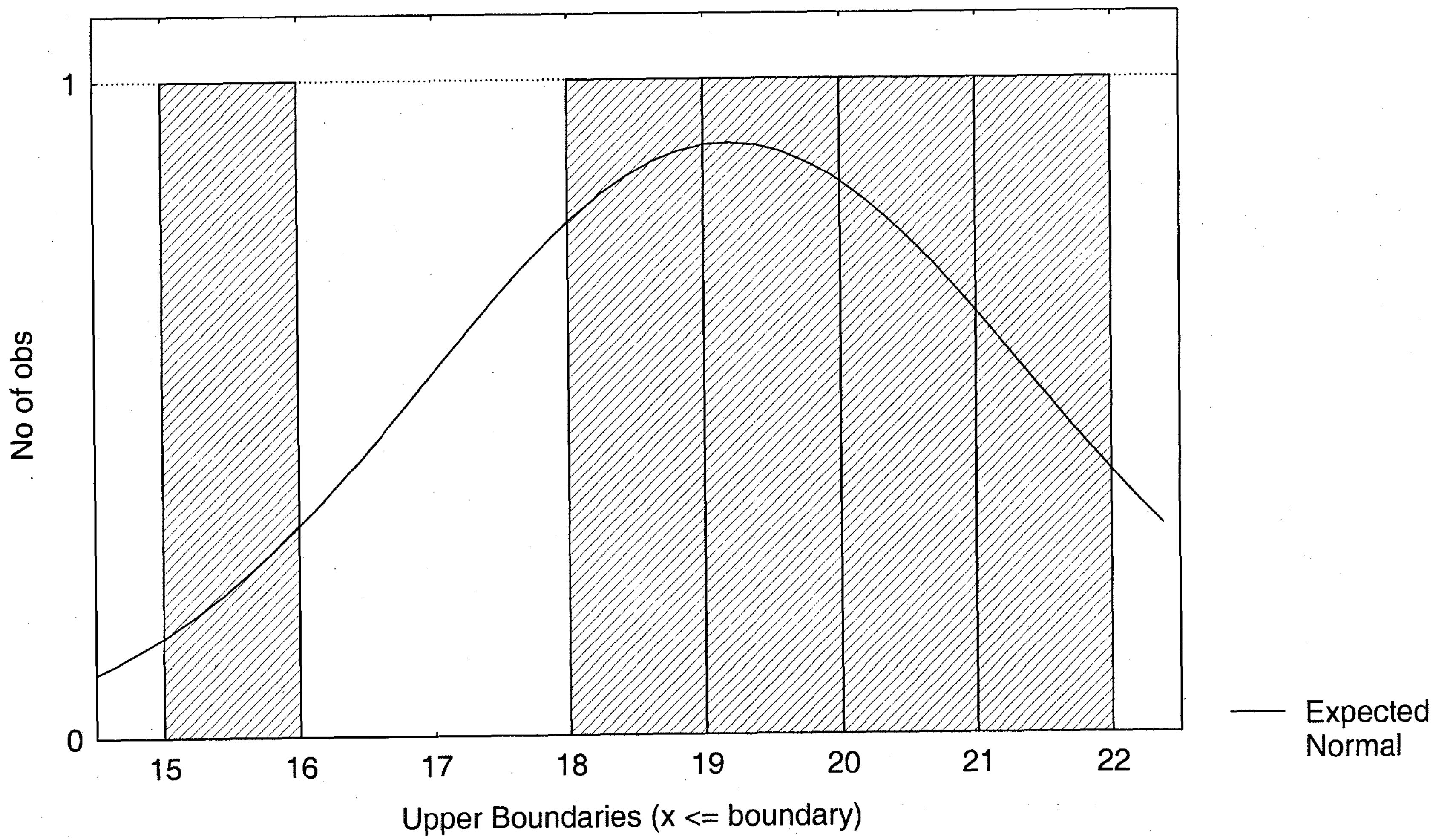


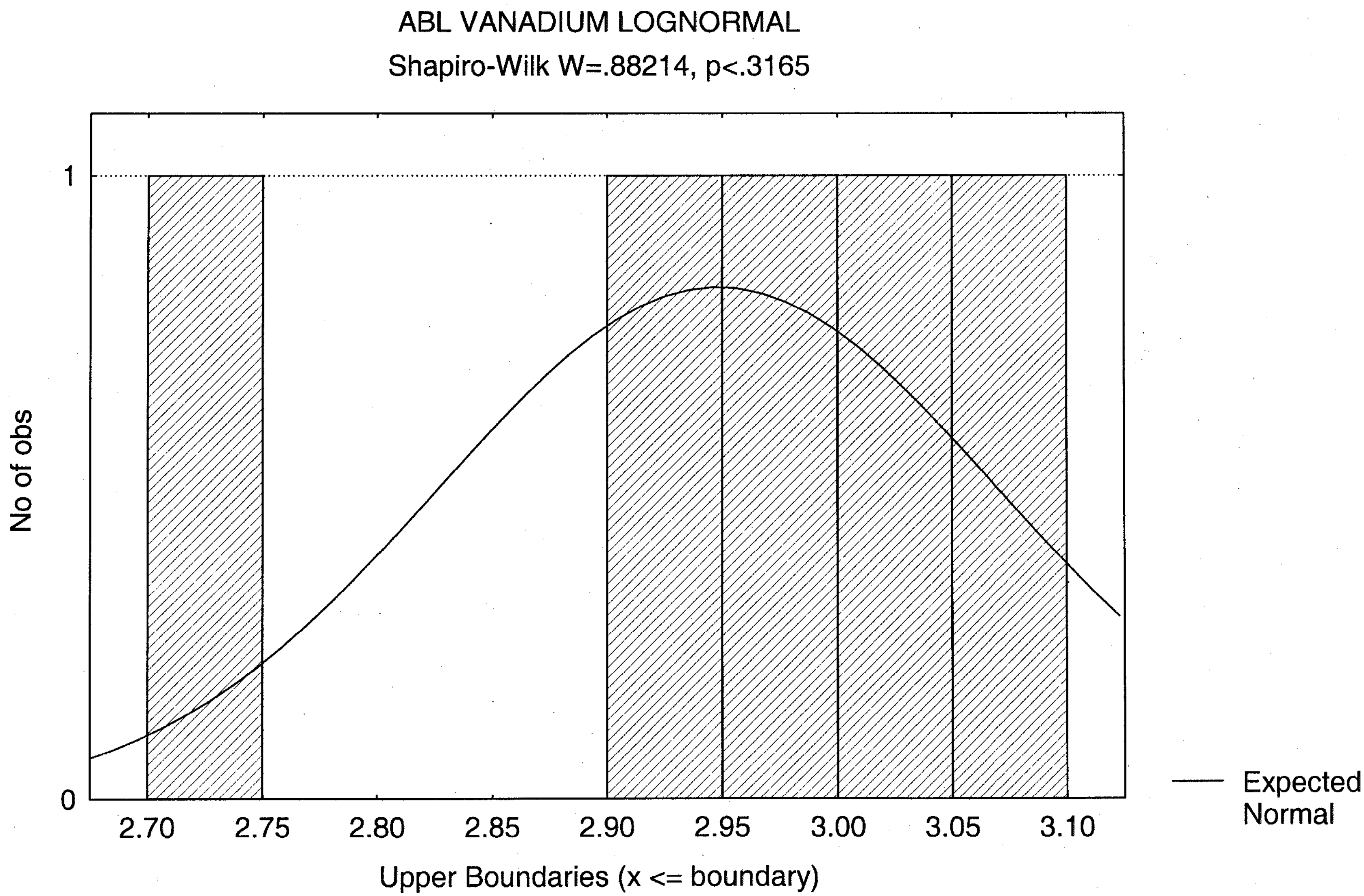
ABL TIN NORMAL
Shapiro-Wilk W=.93559, p<.6421
No of obs
0
1
2
0.21
0.22
0.23
0.24
0.25
0.26
0.27
0.28
Upper Boundaries (x <= boundary)
Expected Normal


ABL TIN LOGNORMAL
Shapiro-Wilk W=.93607, p<.6455
No of obs
2
1
0
-1.55
-1.50
-1.45
-1.40
-1.35
-1.30
-1.25
Upper Boundaries (x <= boundary)
Expected Normal

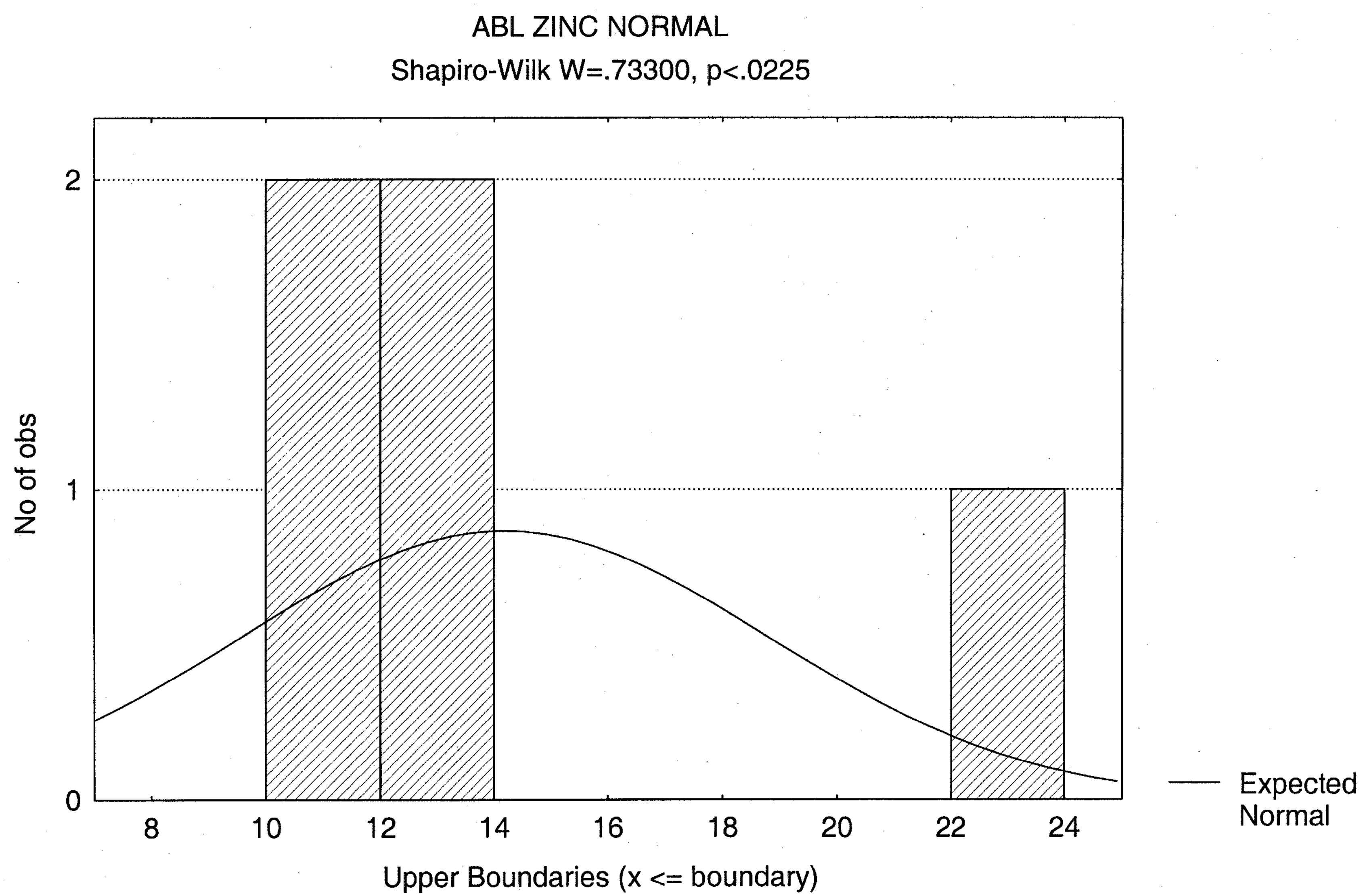
ABL VANADIUM NORMAL

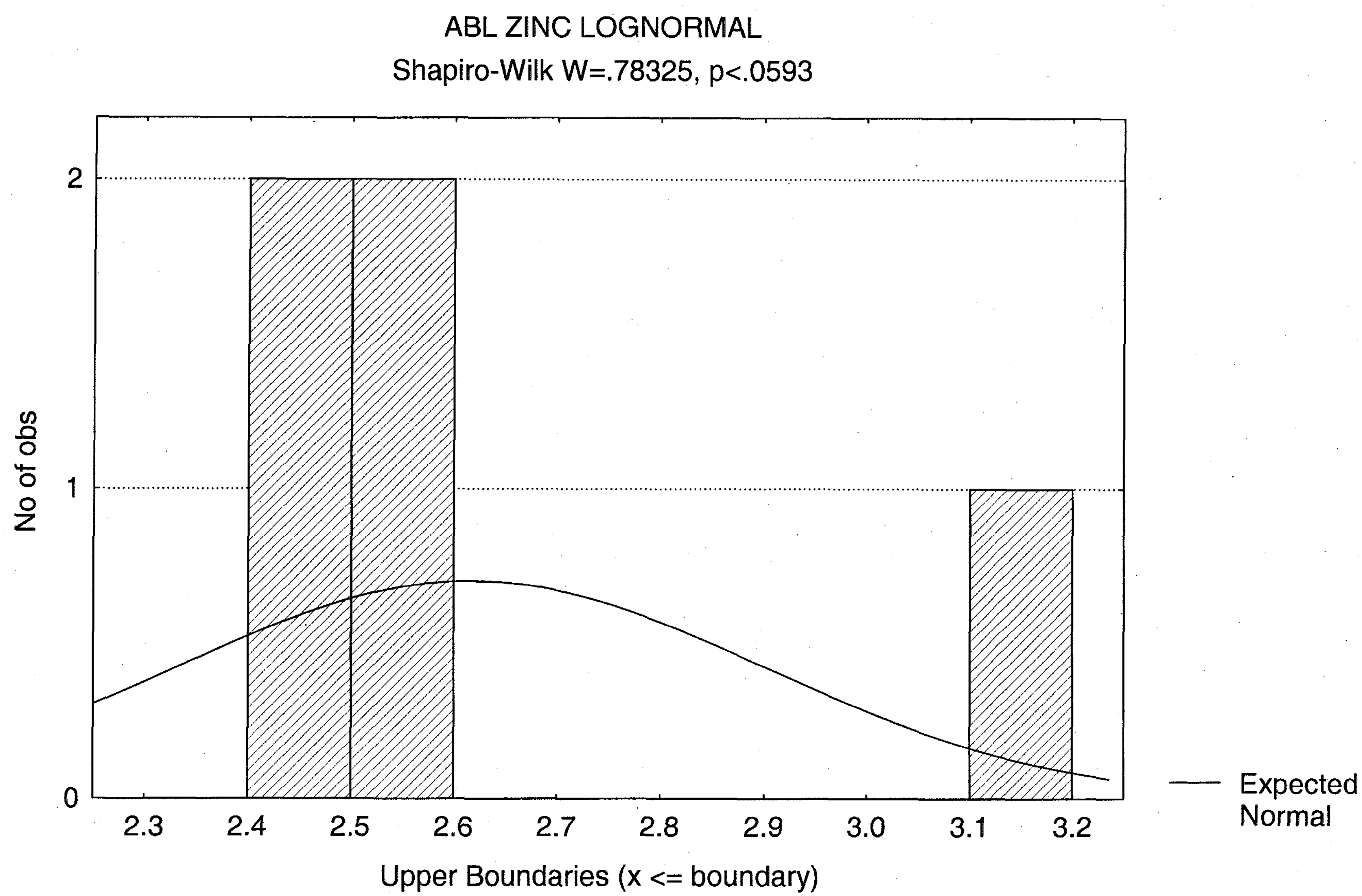
Shapiro-Wilk W=.90881, p<.4560





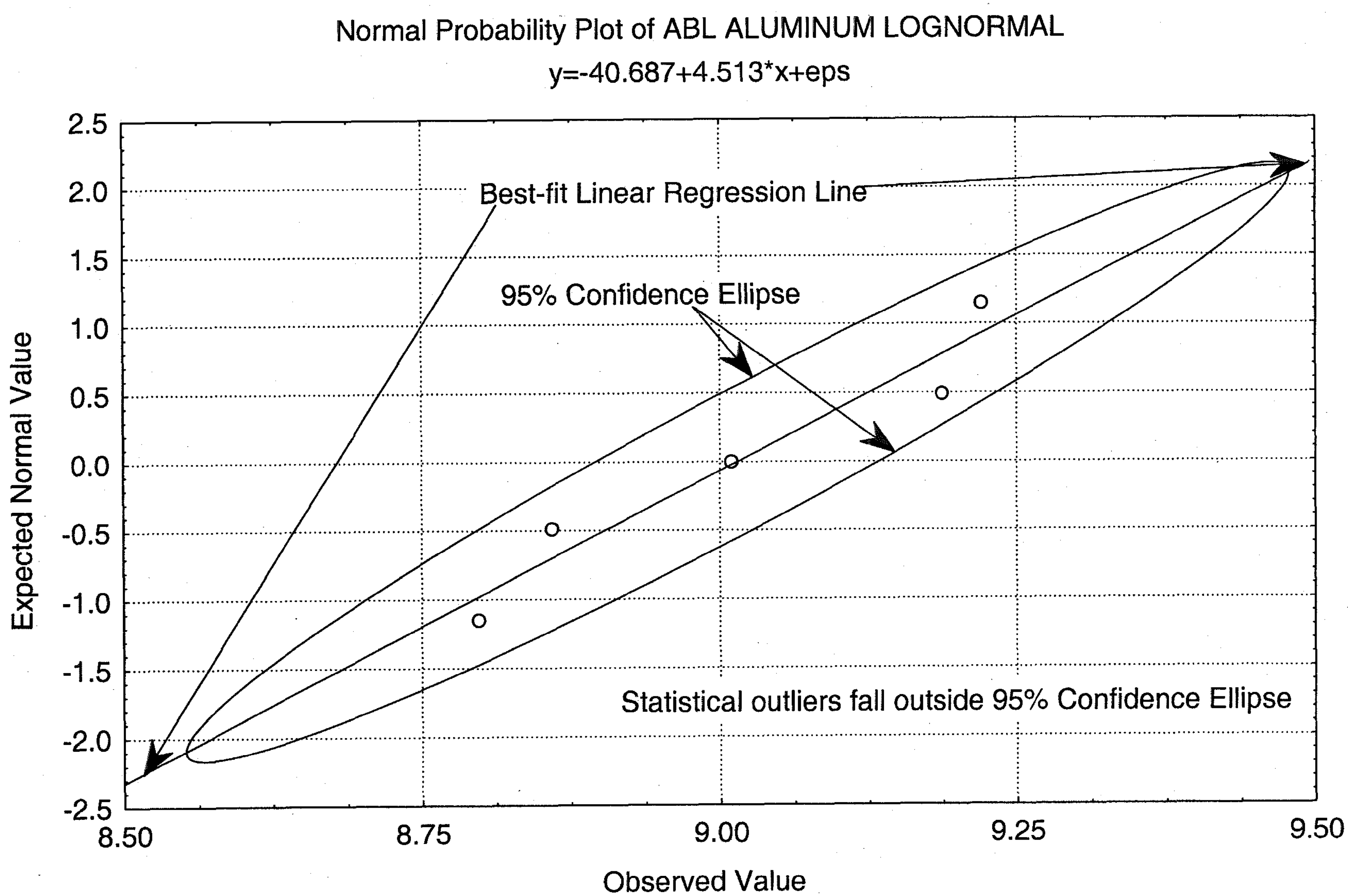
ABL VANADIUM LOGNORMAL
Shapiro-Wilk W=.88214, p<.3165
No of obs
1
0
2.70
2.75
2.80
2.85
2.90
2.95
3.00
3.05
3.10
Upper Boundaries (x <= boundary)
Expected Normal


ABL ZINC NORMAL
Shapiro-Wilk W=.73300, p<.0225
No of obs
0
1
2
8
10
12
14
16
18
20
22
24
Upper Boundaries (x <= boundary)
Expected Normal

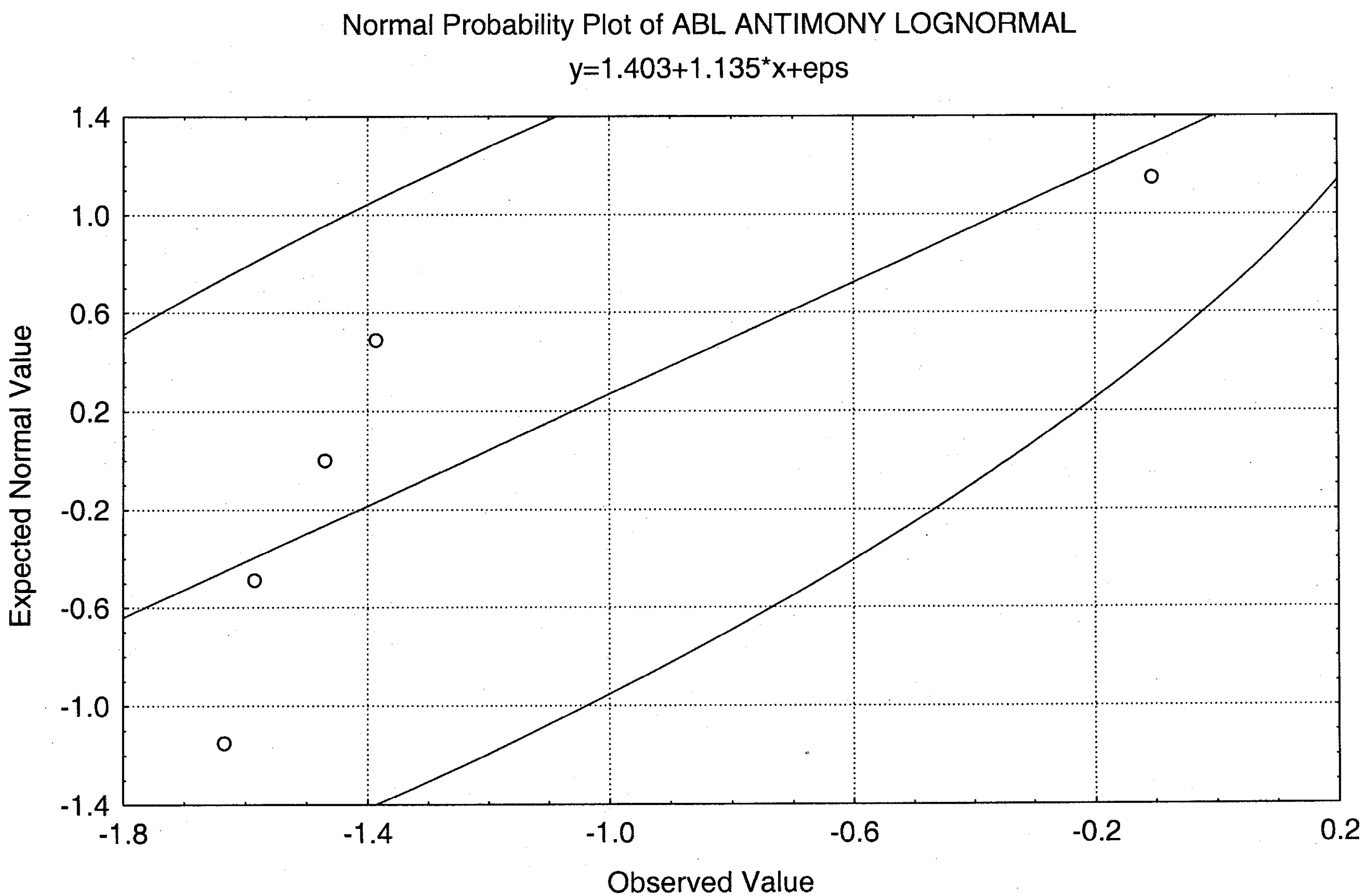

ABL ZINC LOGNORMAL
Shapiro-Wilk W=.78325, p<.0593
No of obs
0
1
2
2.3
2.4
2.5
2.6
2.7
2.8
2.9
3.0
3.1
3.2
Upper Boundaries (x <= boundary)
Expected Normal

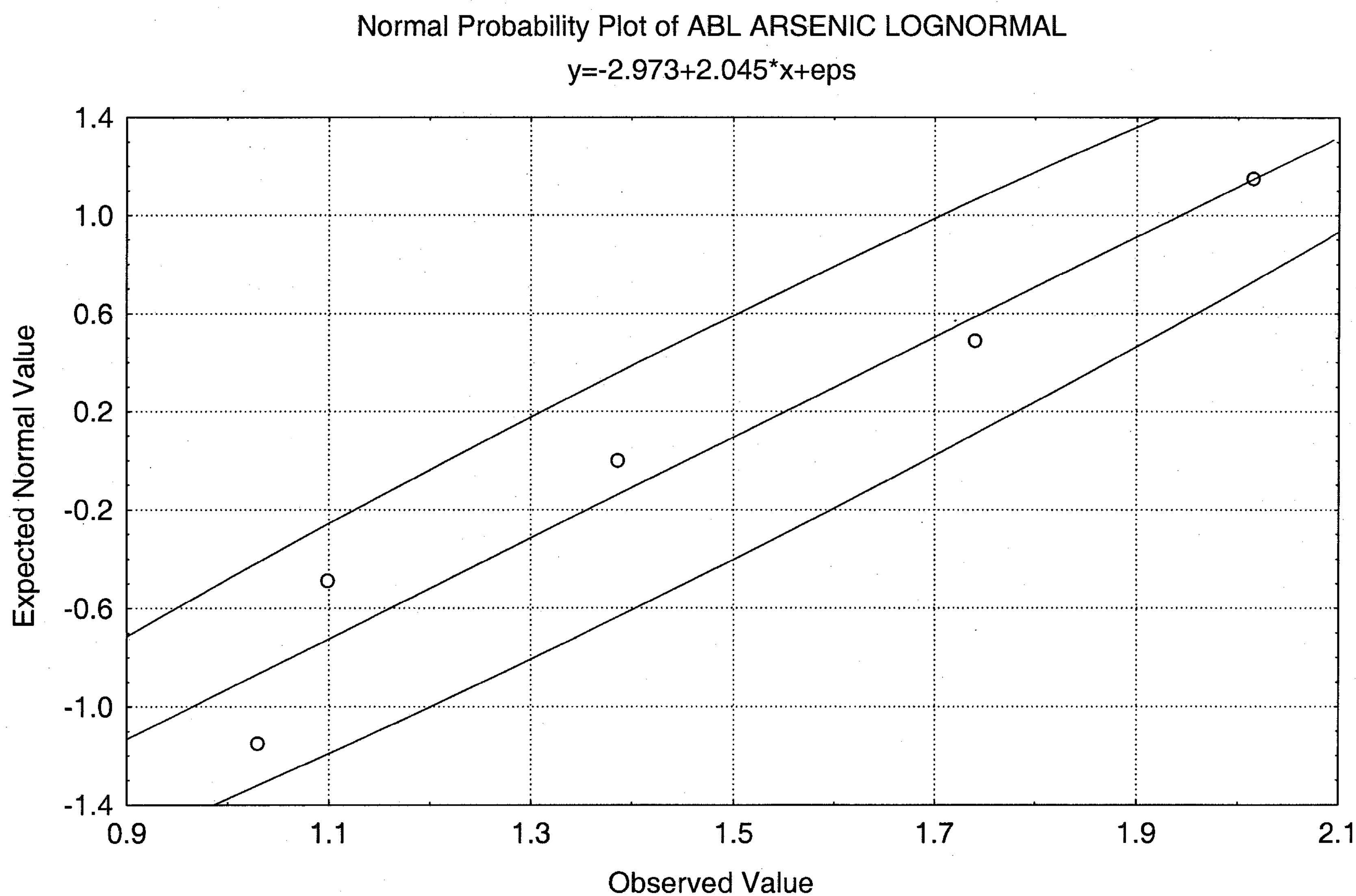
D.2.2 Examples of Normal Probability Plot

27 plots (Normal or Lognormal for 27 metals) for Alluvial Subsurface Silt



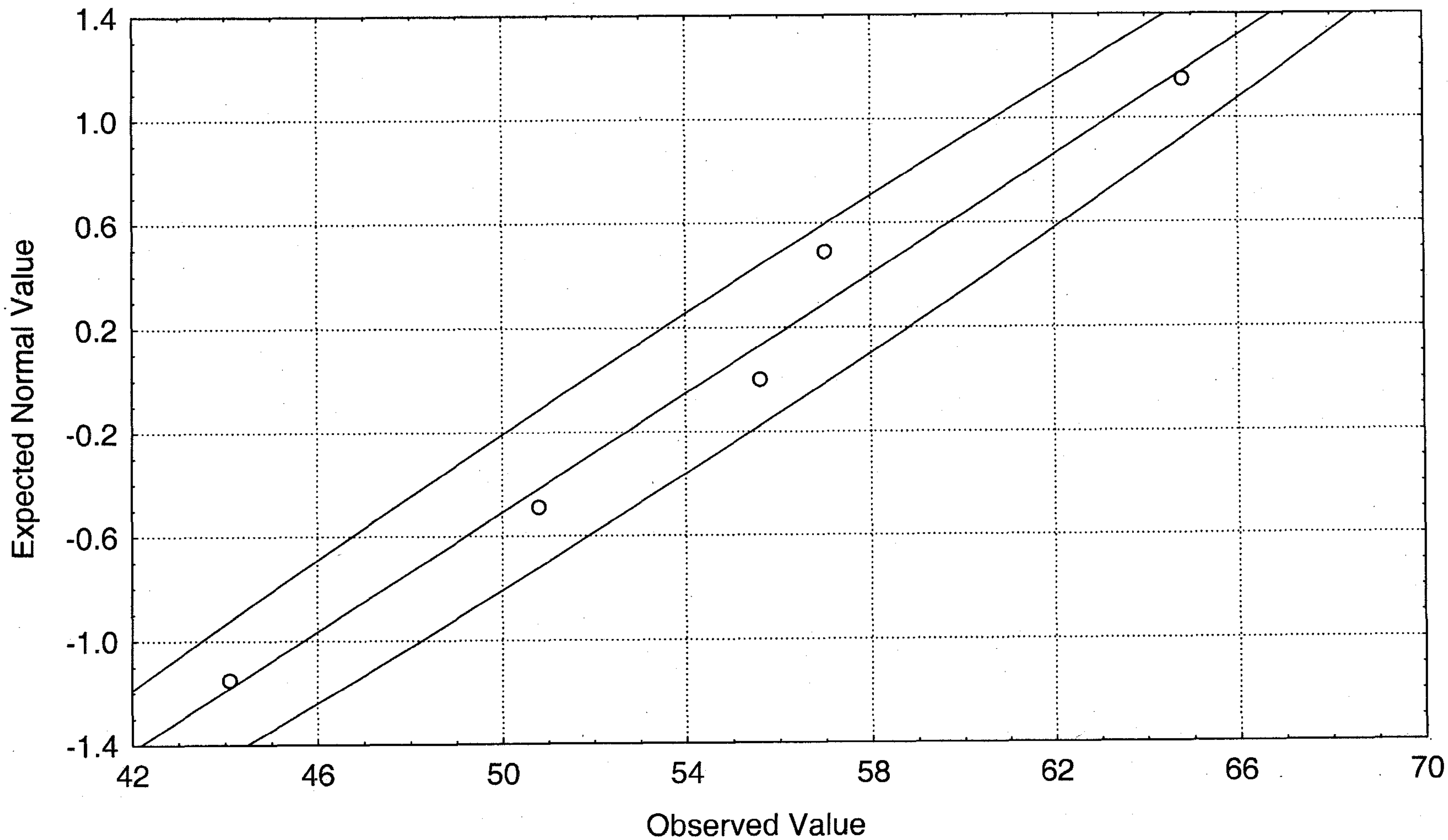
Normal Probability Plot of ABL ALUMINUM LOGNORMAL
y=-40.687+4.513*x+eps
Best-fit Linear Regression Line
95% Confidence Ellipse
Statistical outliers fall outside 95% Confidence Ellipse
Expected Normal Value
Observed Value
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
8.50
8.75
9.00
9.25
9.50

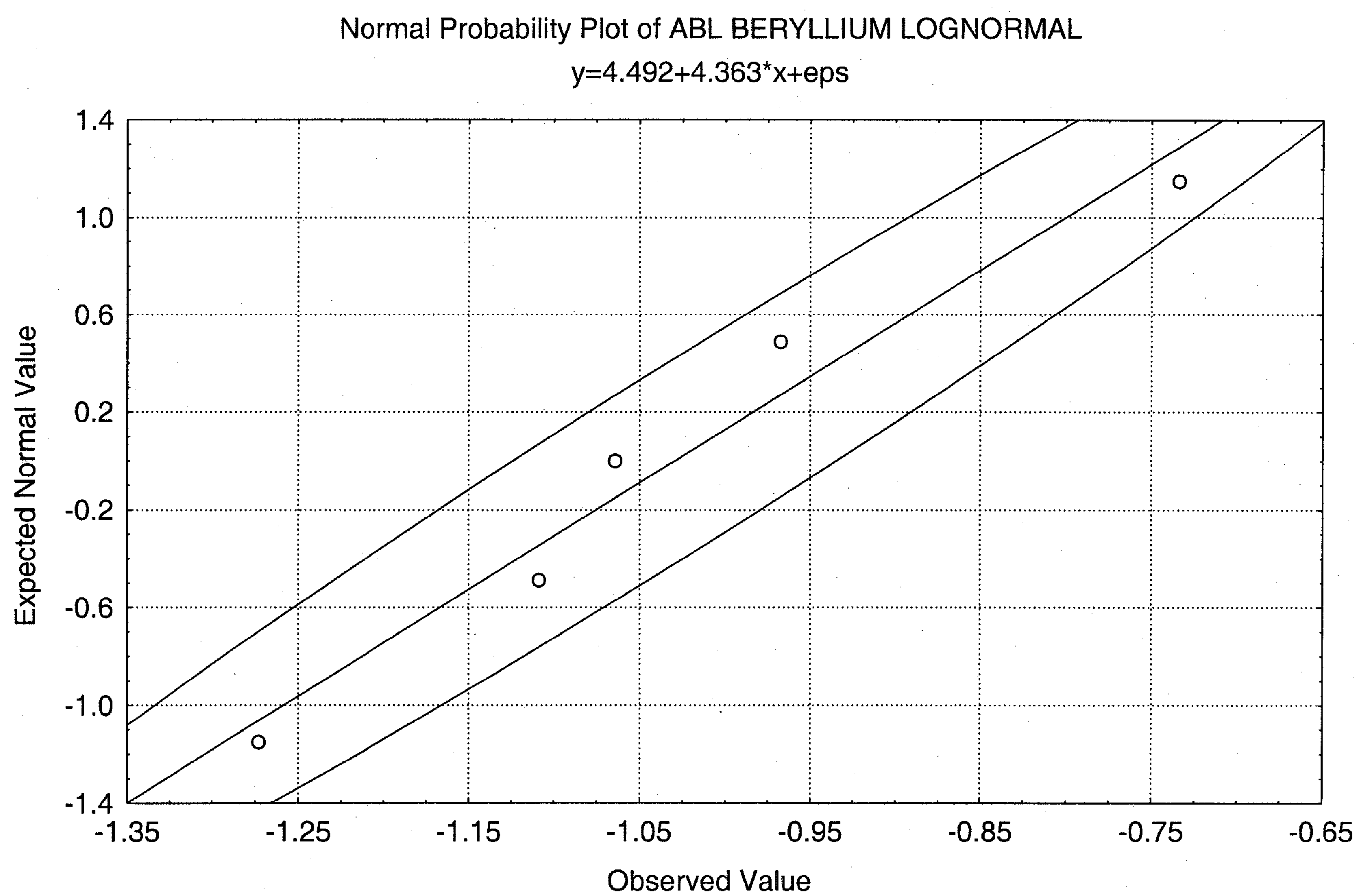

Normal Probability Plot of ABL ANTIMONY LOGNORMAL
y=1.403+1.135*x+eps
Expected Normal Value
1.4
1.0
0.6
0.2
-0.2
-0.6
-1.0
-1.4
-1.8
-1.4
-1.0
-0.6
-0.2
0.2
Observed Value

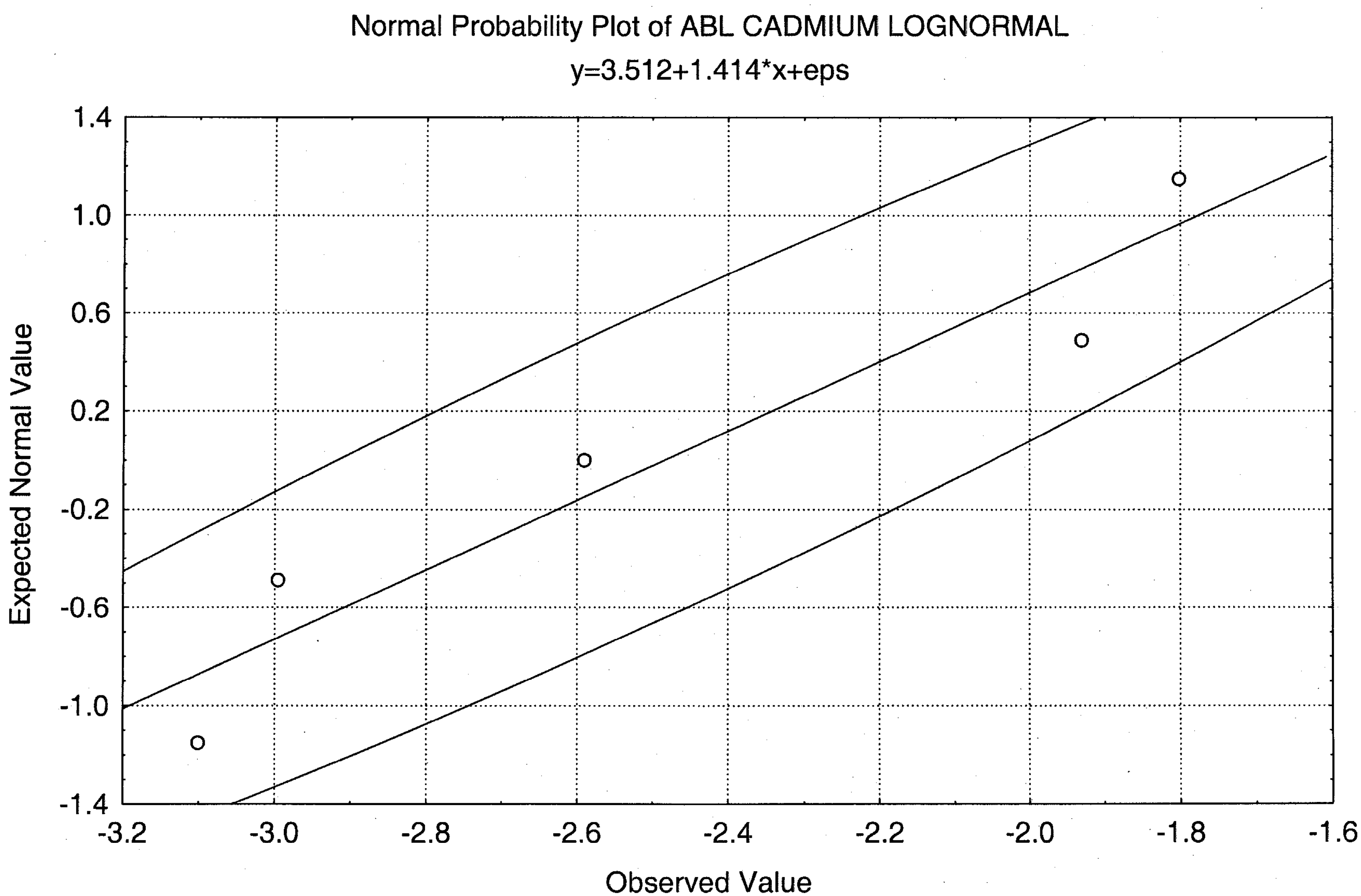

Normal Probability Plot of ABL ARSENIC LOGNORMAL
y=-2.973+2.045*x+eps
1.4
1.0
0.6
0.2
-0.2
-0.6
-1.0
-1.4
0.9
1.1
1.3
1.5
1.7
1.9
2.1
Observed Value
Expected Normal Value

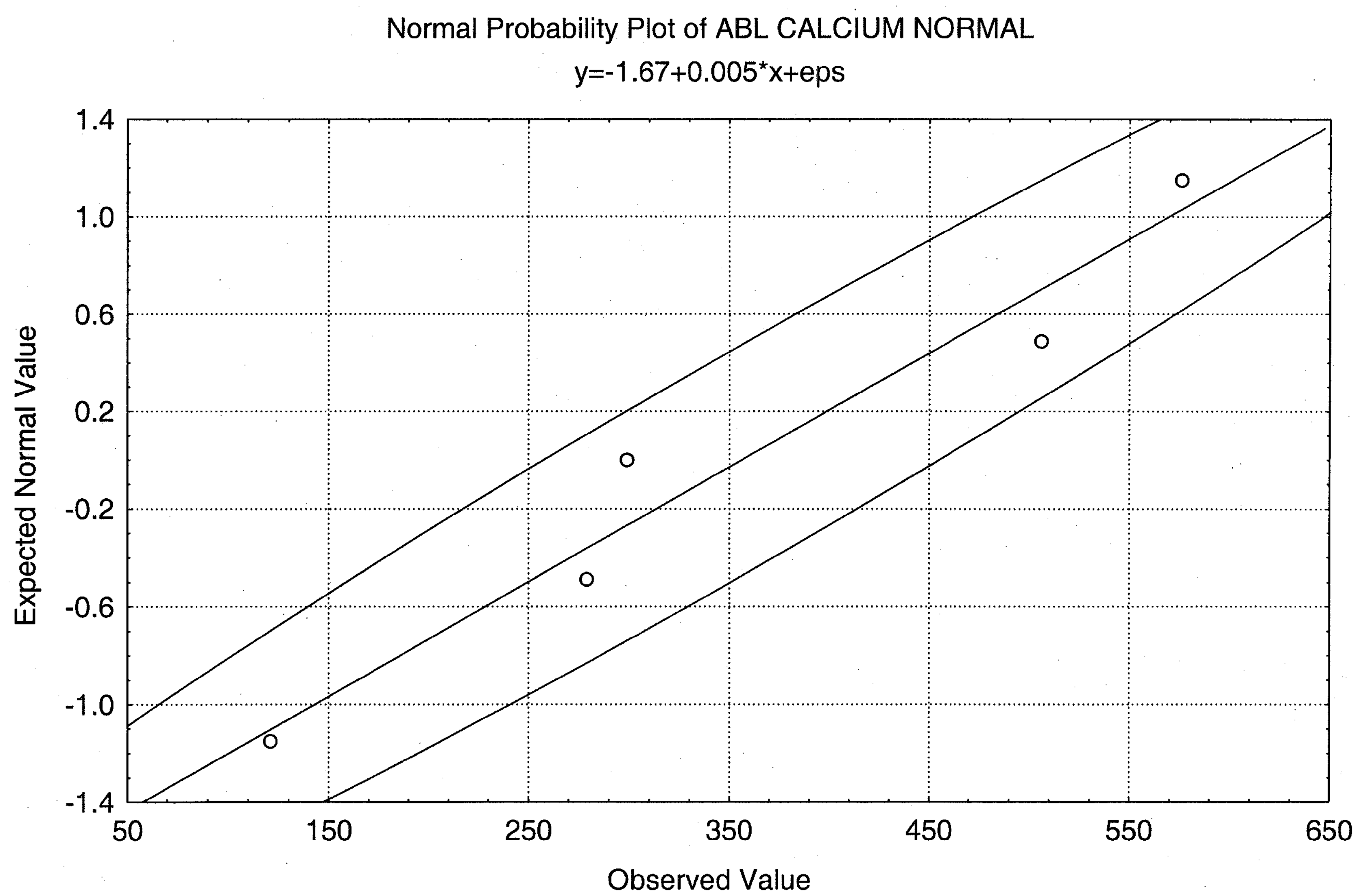
Normal Probability Plot of ABL BARIUM NORMAL

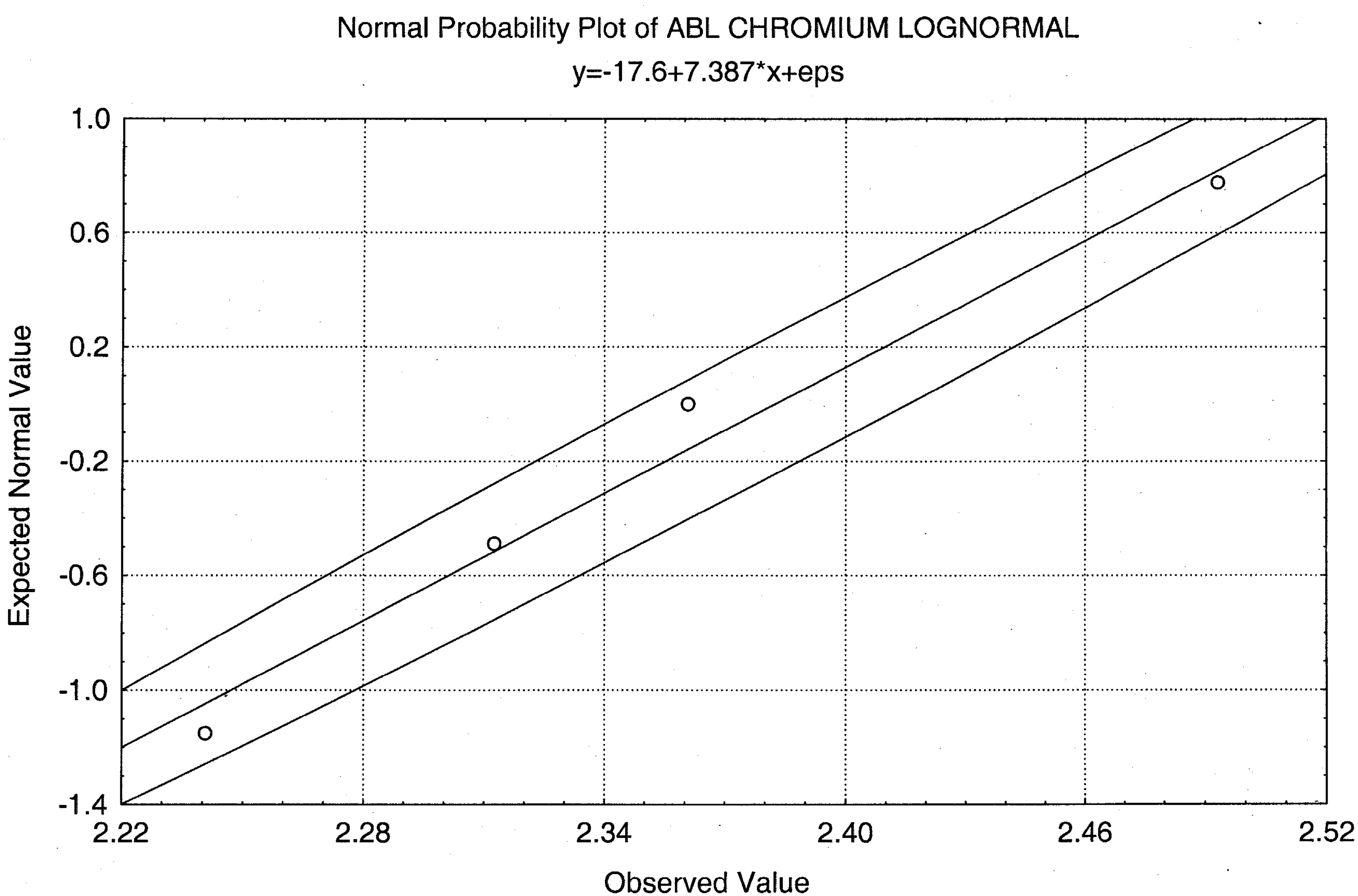
y=-6.21+0.114*x+eps

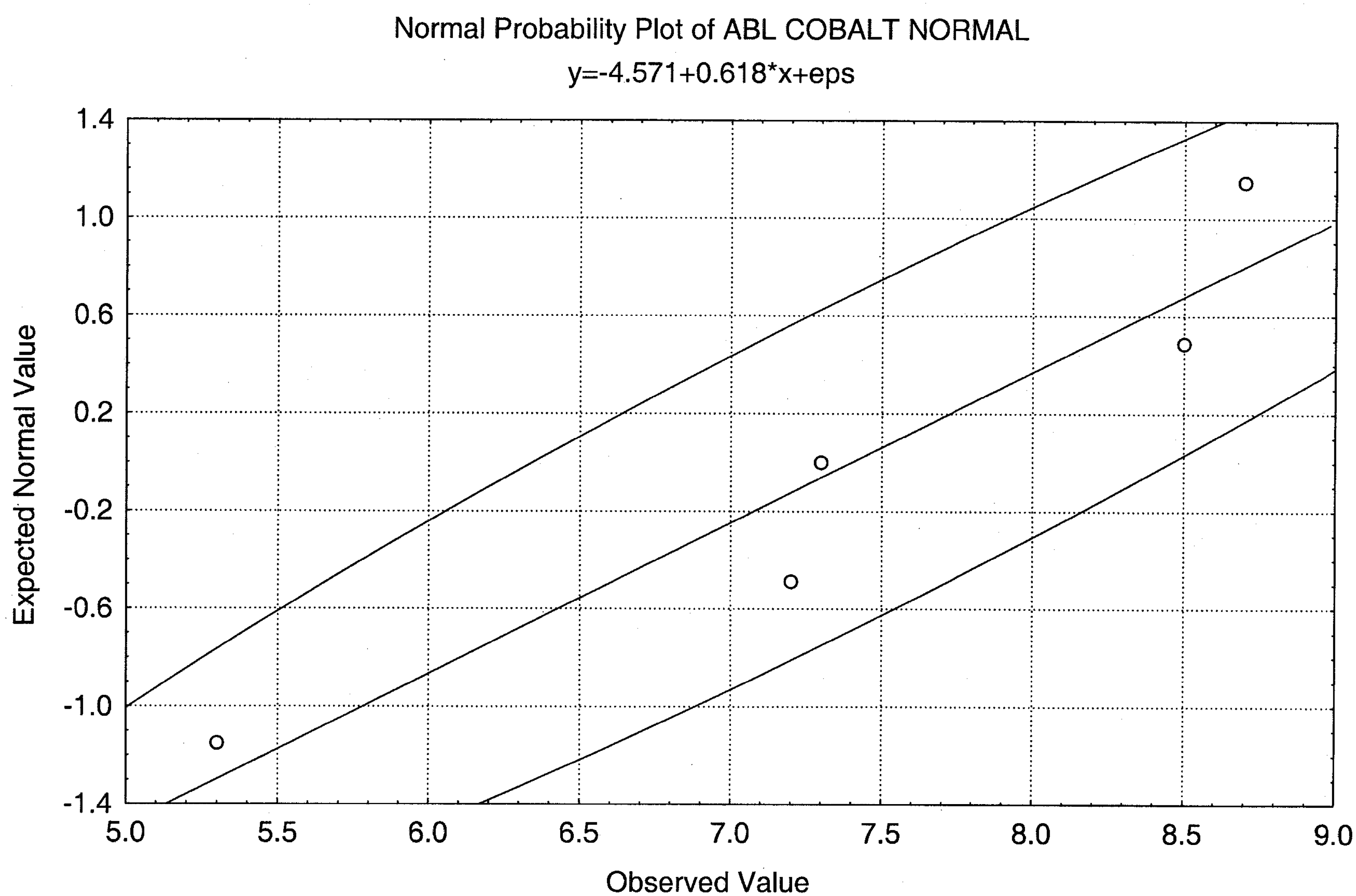


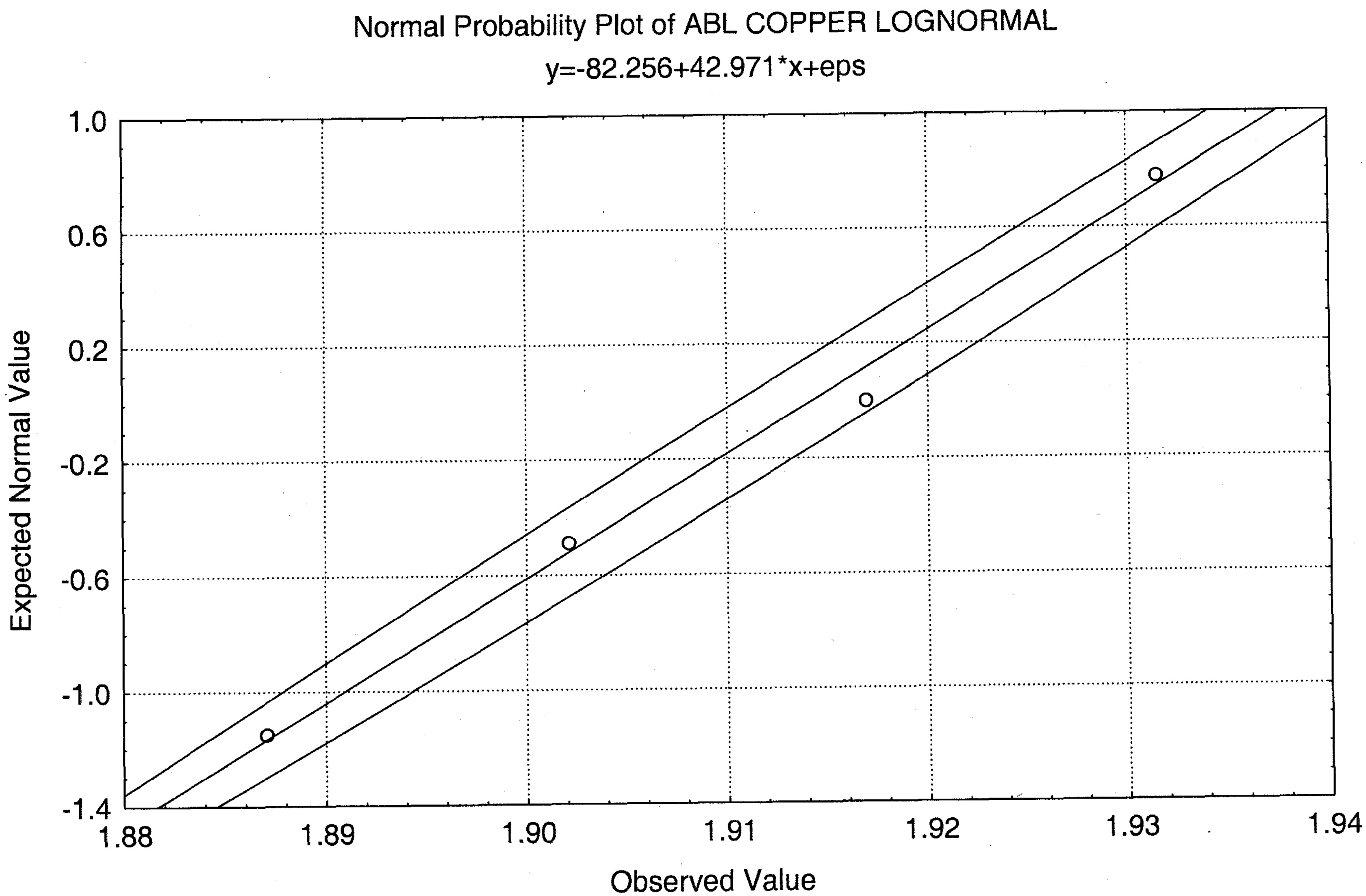

Normal Probability Plot of ABL BERYLLIUM LOGNORMAL
y=4.492+4.363*x+eps
Expected Normal Value
1.4
1.0
0.6
0.2
-0.2
-0.6
-1.0
-1.4
-1.35
-1.25
-1.15
-1.05
-0.95
-0.85
-0.75
-0.65
Observed Value

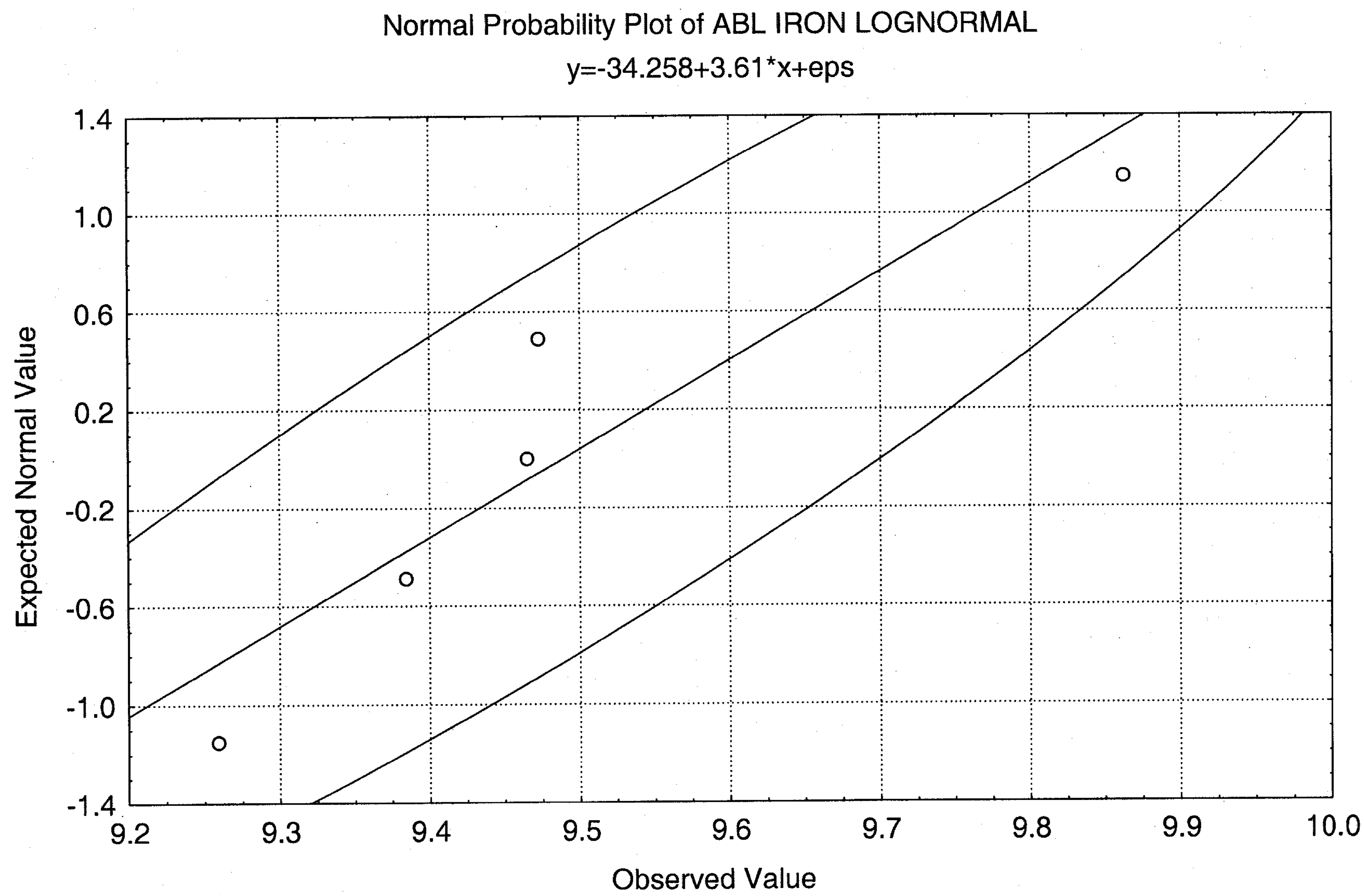

Normal Probability Plot of ABL CADMIUM LOGNORMAL
y=3.512+1.414*x+eps
Expected Normal Value
Observed Value
1.4
1.0
0.6
0.2
-0.2
-0.6
-1.0
-1.4
-3.2
-3.0
-2.8
-2.6
-2.4
-2.2
-2.0
-1.8
-1.6


Normal Probability Plot of ABL CALCIUM NORMAL
y=-1.67+0.005*x+eps
1.4
1.0
0.6
0.2
-0.2
-0.6
-1.0
-1.4
50
150
250
350
450
550
650
Observed Value
Expected Normal Value


Normal Probability Plot of ABL CHROMIUM LOGNORMAL
y=-17.6+7.387*x+eps
Expected Normal Value
1.0
0.6
0.2
-0.2
-0.6
-1.0
-1.4
2.22
2.28
2.34
2.40
2.46
2.52
Observed Value

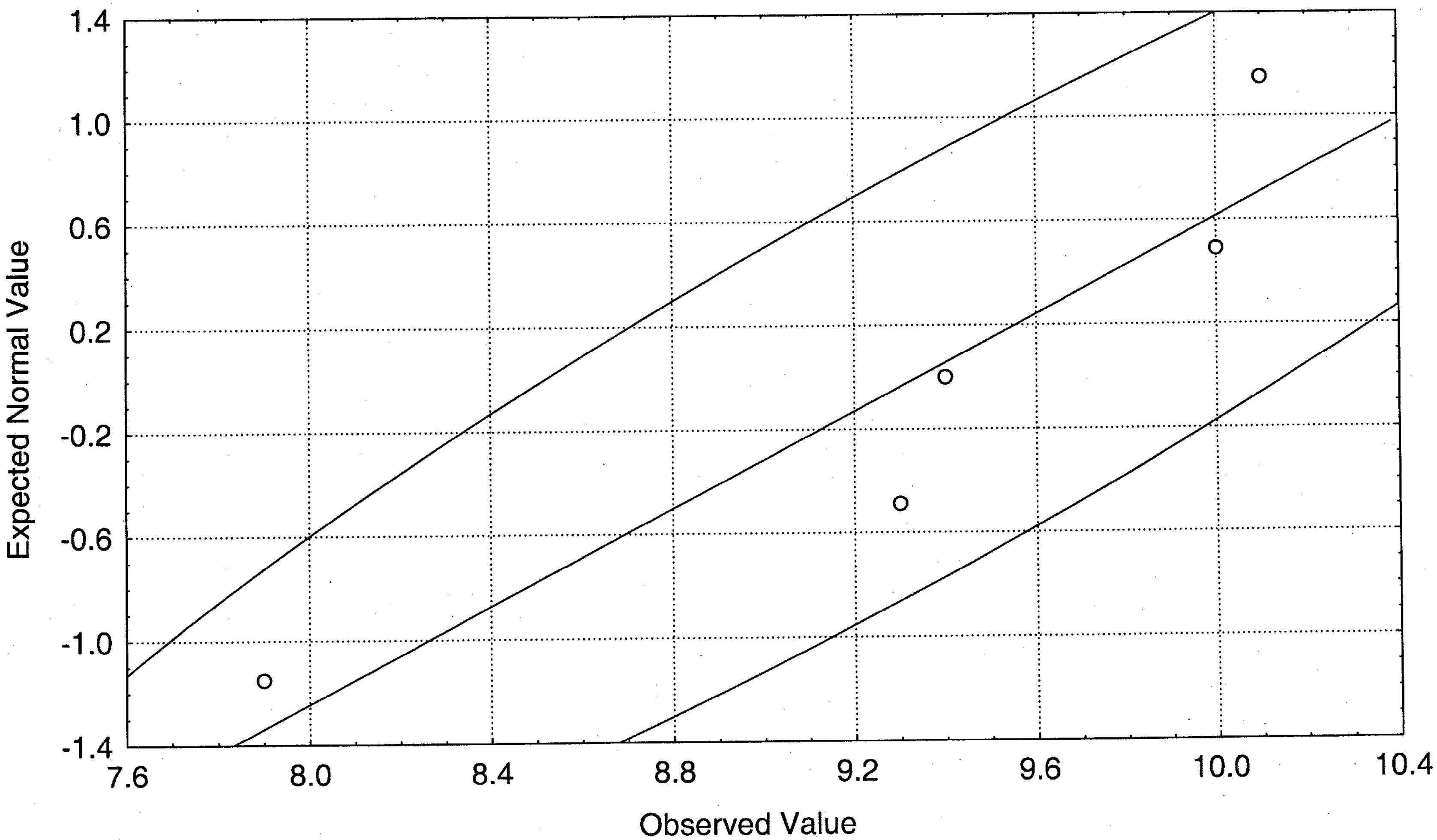

Normal Probability Plot of ABL COBALT NORMAL
y=-4.571+0.618*x+eps
Expected Normal Value
1.4
1.0
0.6
0.2
-0.2
-0.6
-1.0
-1.4
5.0
5.5
6.0
6.5
7.0
7.5
8.0
8.5
9.0
Observed Value

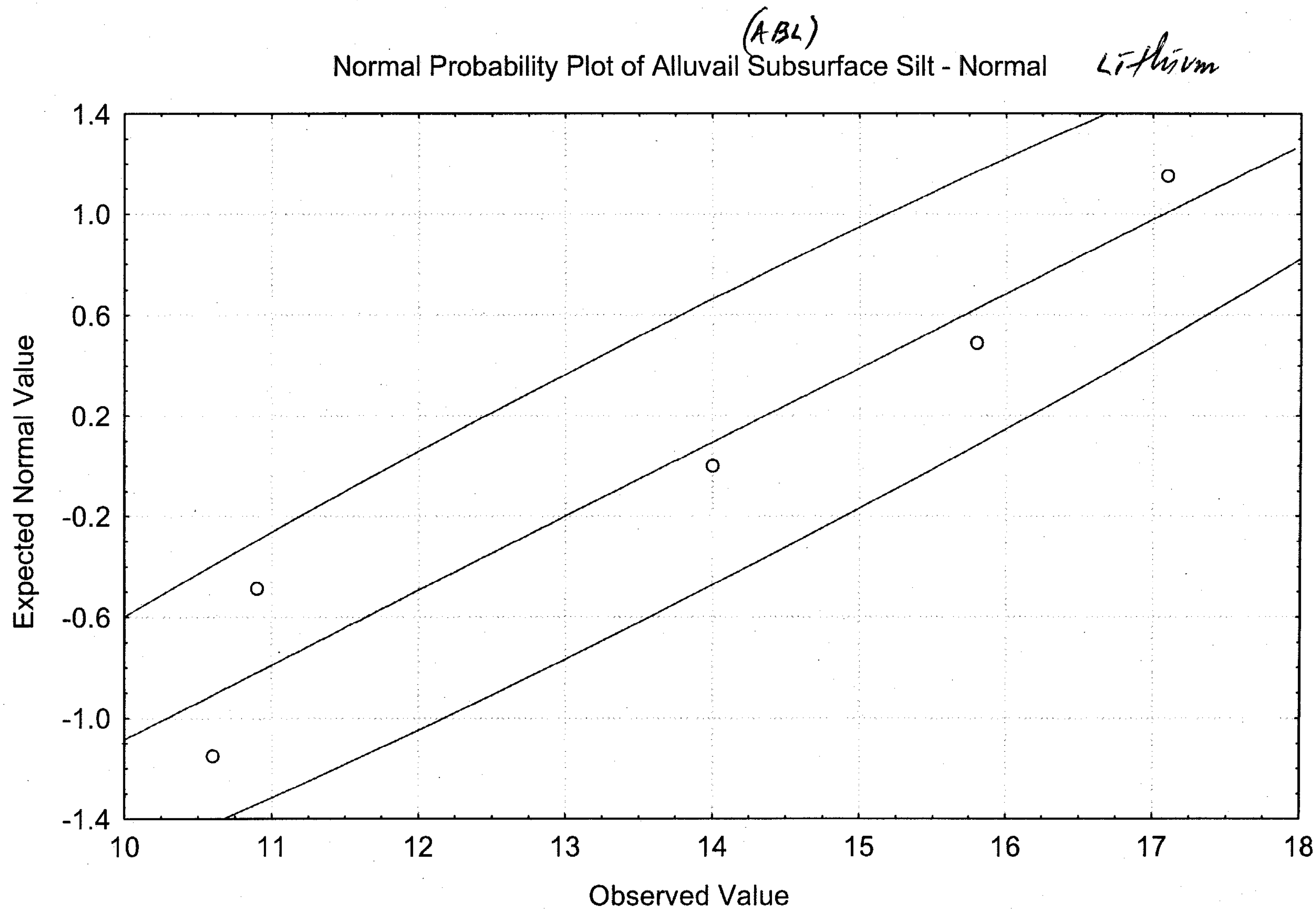

Normal Probability Plot of ABL COPPER LOGNORMAL
y=-82.256+42.971*x+eps
Expected Normal Value
1.0
0.6
0.2
-0.2
-0.6
-1.0
-1.4
1.88
1.89
1.90
1.91
1.92
1.93
1.94
Observed Value

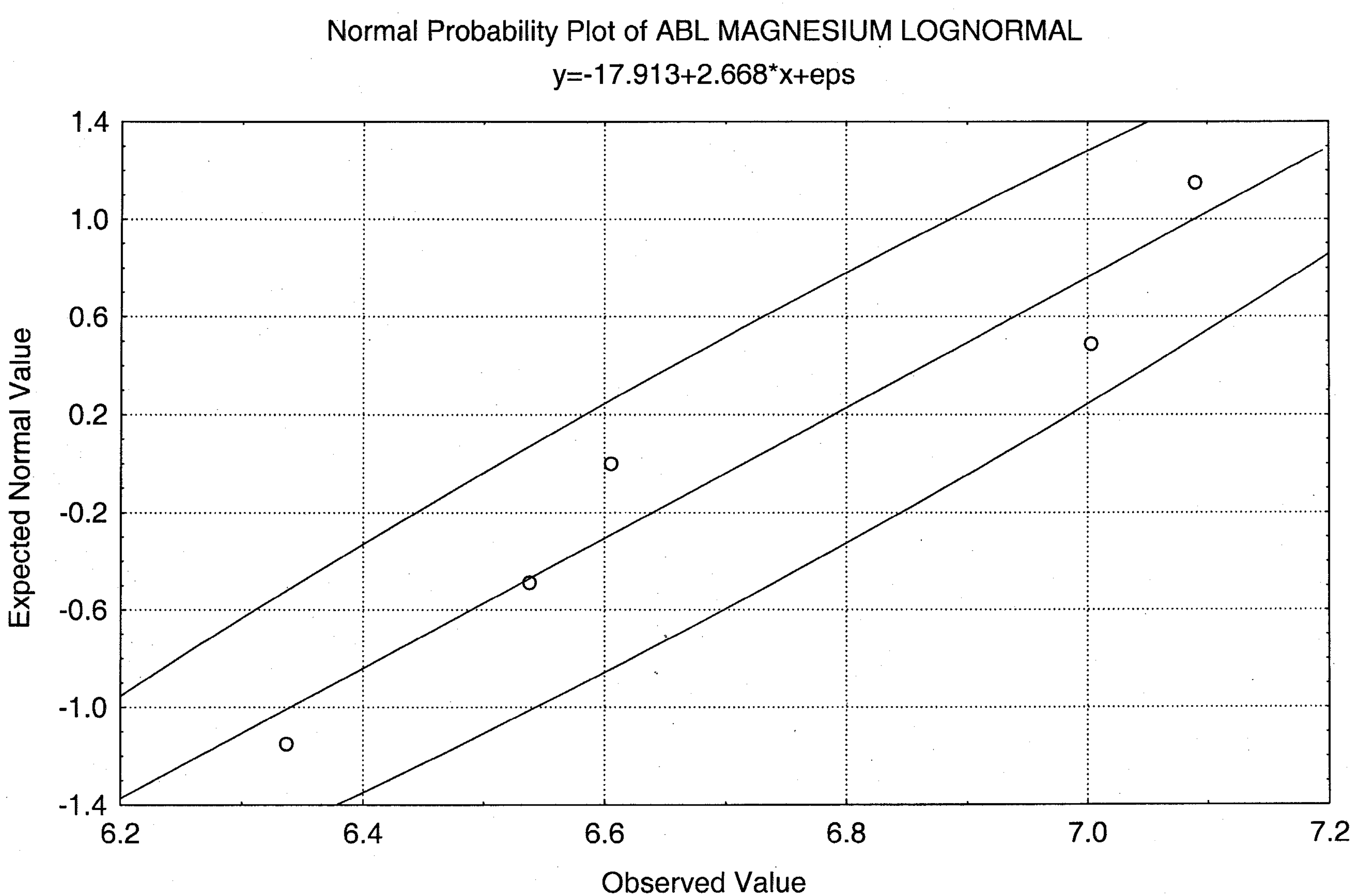

Normal Probability Plot of ABL IRON LOGNORMAL
y=-34.258+3.61*x+eps
Expected Normal Value
1.4
1.0
0.6
0.2
-0.2
-0.6
-1.0
-1.4
9.2
9.3
9.4
9.5
9.6
9.7
9.8
9.9
10.0
Observed Value

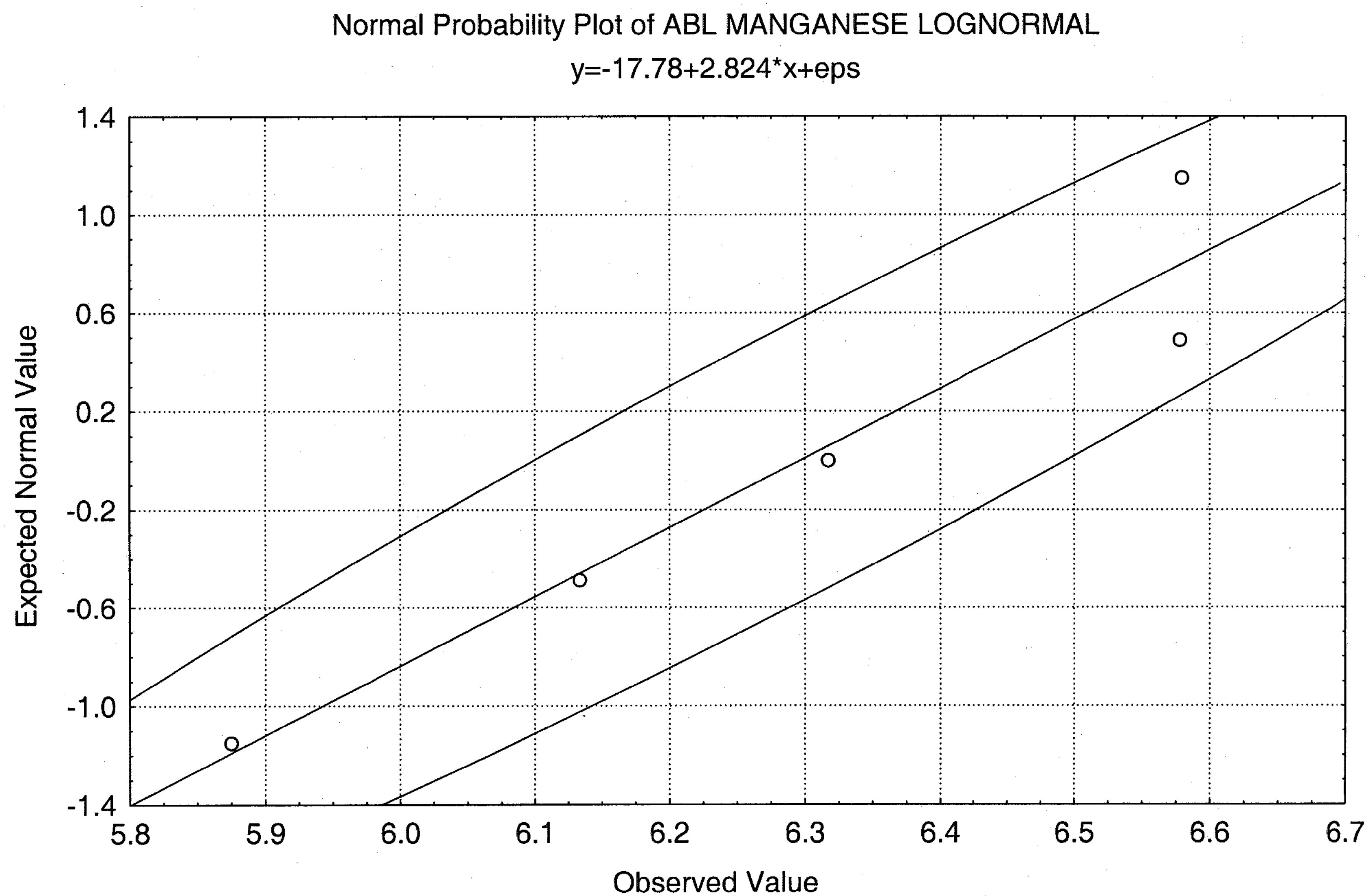
Normal Probability Plot of ABL LEAD NORMAL

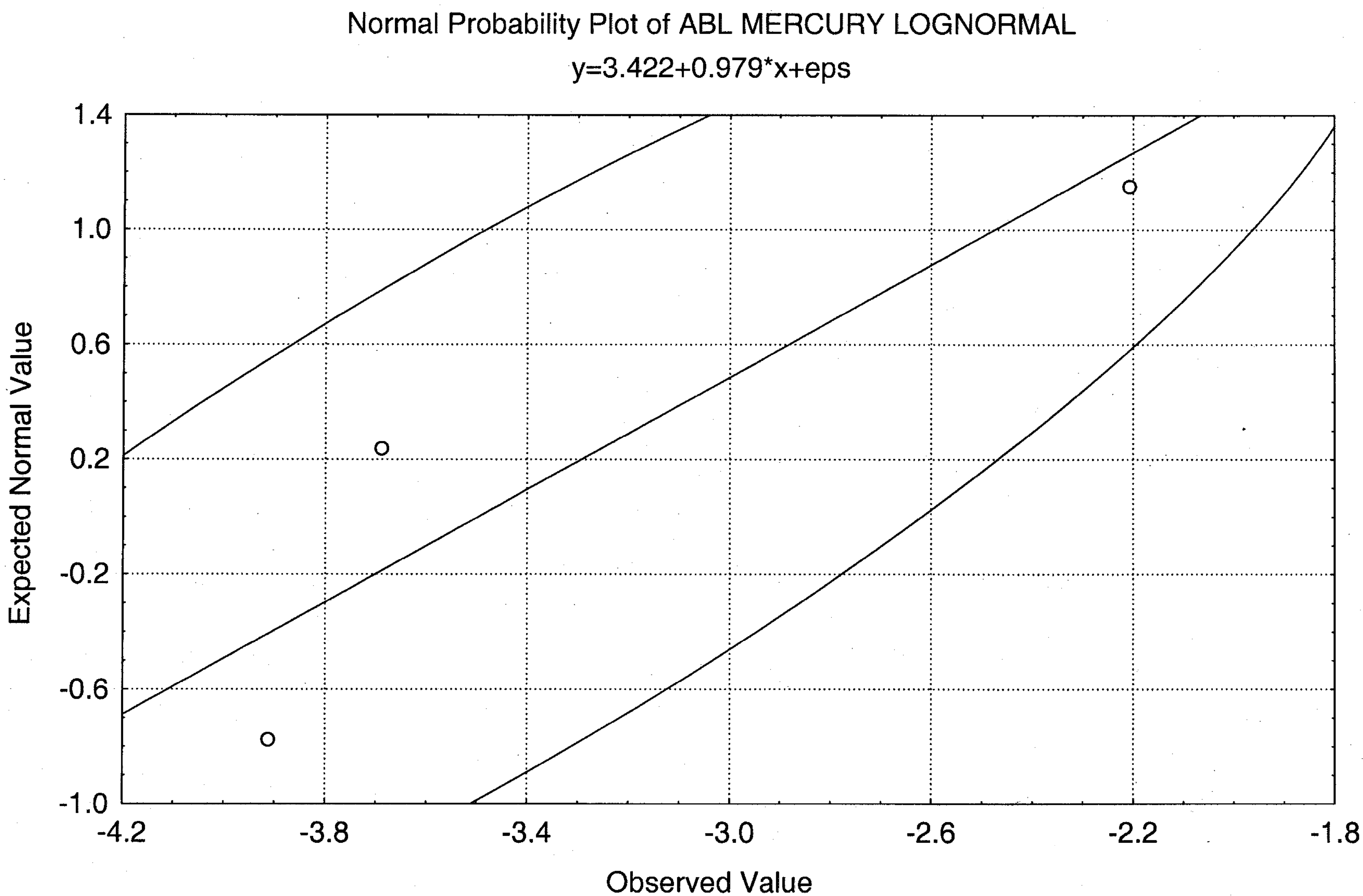
y=-8.678+0.929*x+eps

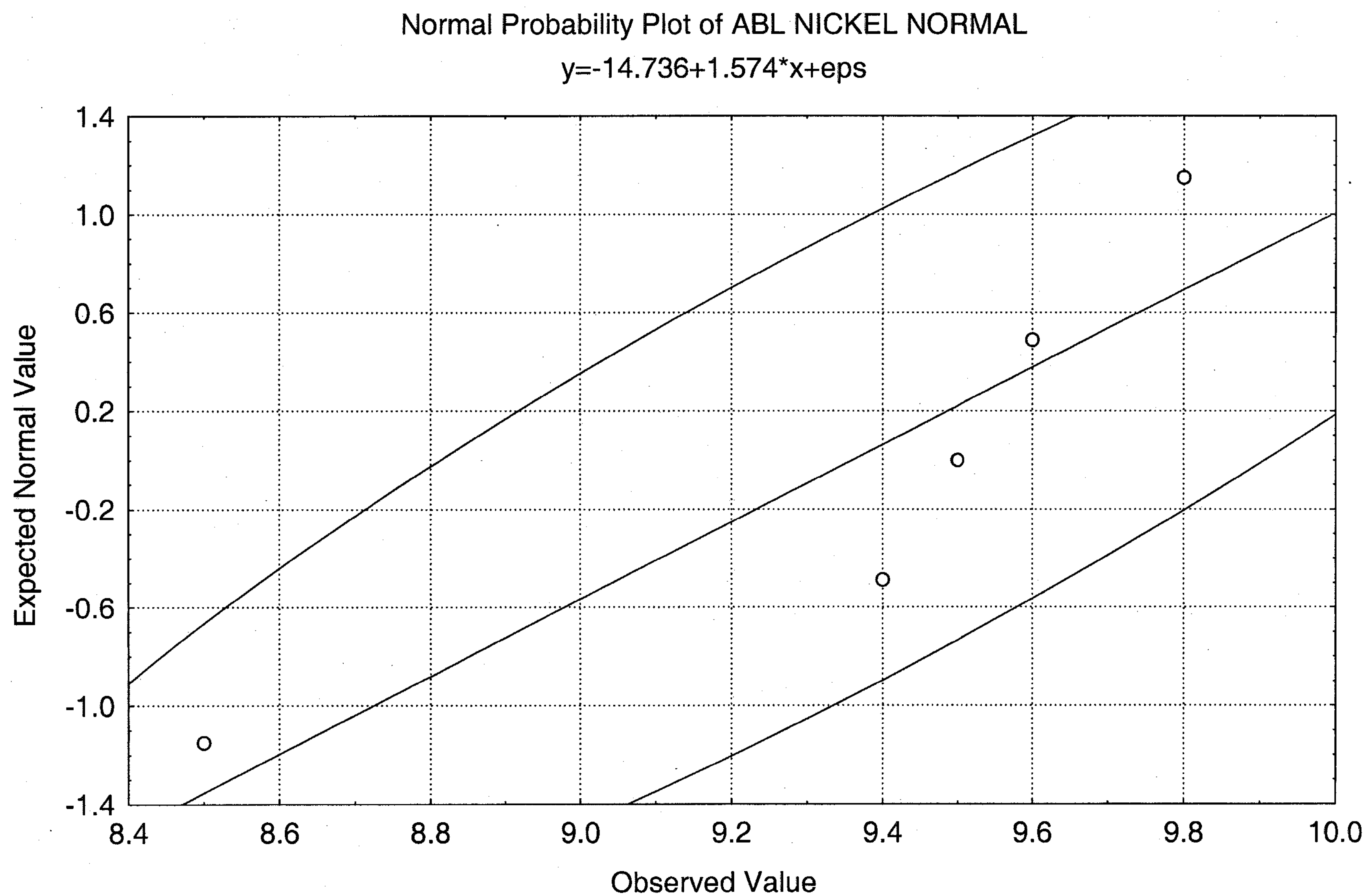



(ABL)
Normal Probability Plot of Alluvail Subsurface Silt - Normal
Lithium
Expected Normal Value
1.4
1.0
0.6
0.2
-0.2
-0.6
-1.0
-1.4
10
11
12
13
14
15
16
17
18
Observed Value

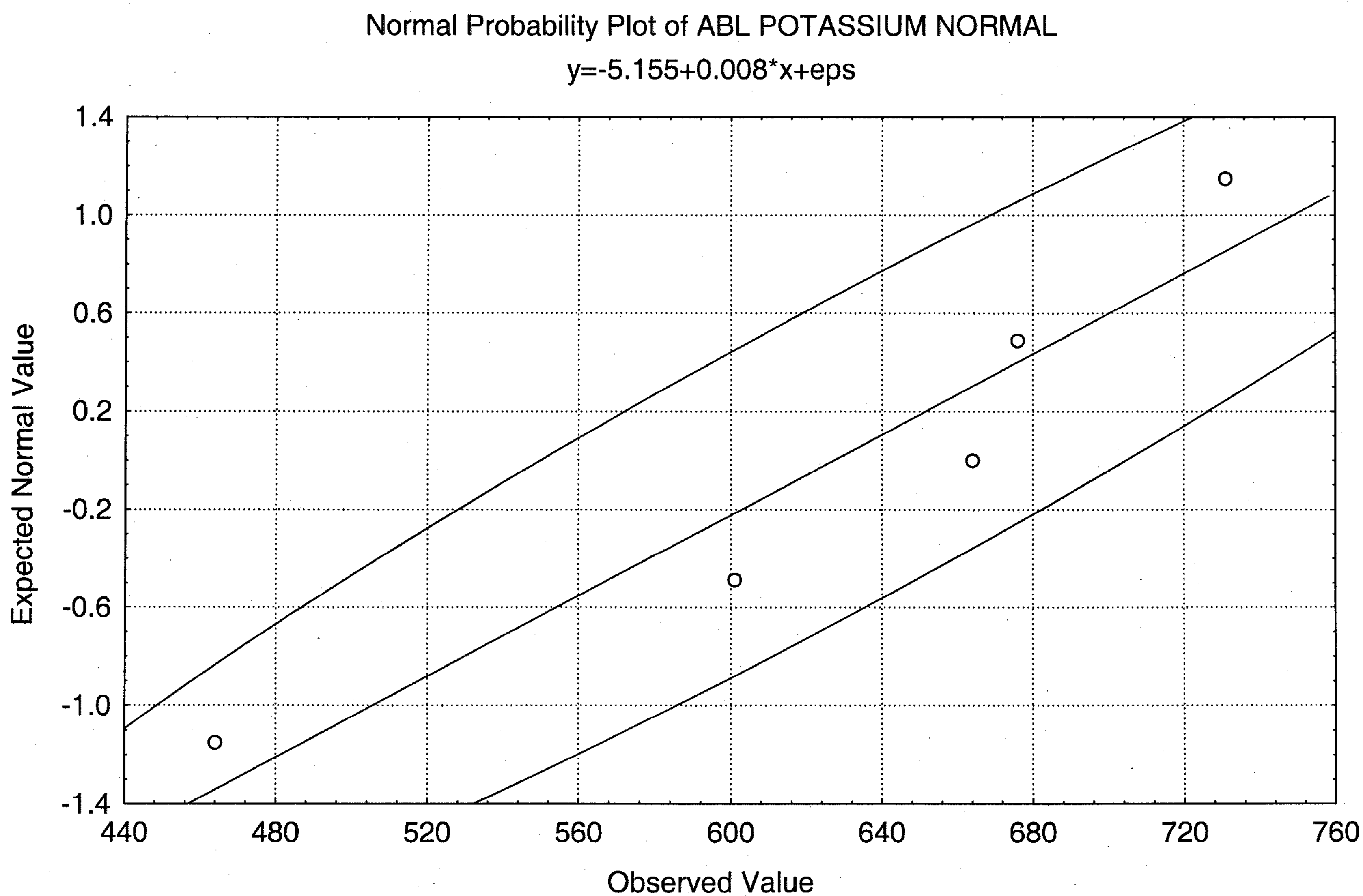

Normal Probability Plot of ABL MAGNESIUM LOGNORMAL
y=-17.913+2.668*x+eps
Expected Normal Value
1.4
1.0
0.6
0.2
-0.2
-0.6
-1.0
-1.4
6.2
6.4
6.6
6.8
7.0
7.2
Observed Value


Normal Probability Plot of ABL MANGANESE LOGNORMAL
y=-17.78+2.824*x+eps
Expected Normal Value
1.4
1.0
0.6
0.2
-0.2
-0.6
-1.0
-1.4
5.8
5.9
6.0
6.1
6.2
6.3
6.4
6.5
6.6
6.7
Observed Value


Normal Probability Plot of ABL MERCURY LOGNORMAL
y=3.422+0.979*x+eps
Expected Normal Value
1.4
1.0
0.6
0.2
-0.2
-0.6
-1.0
-4.2
-3.8
-3.4
-3.0
-2.6
-2.2
-1.8
Observed Value



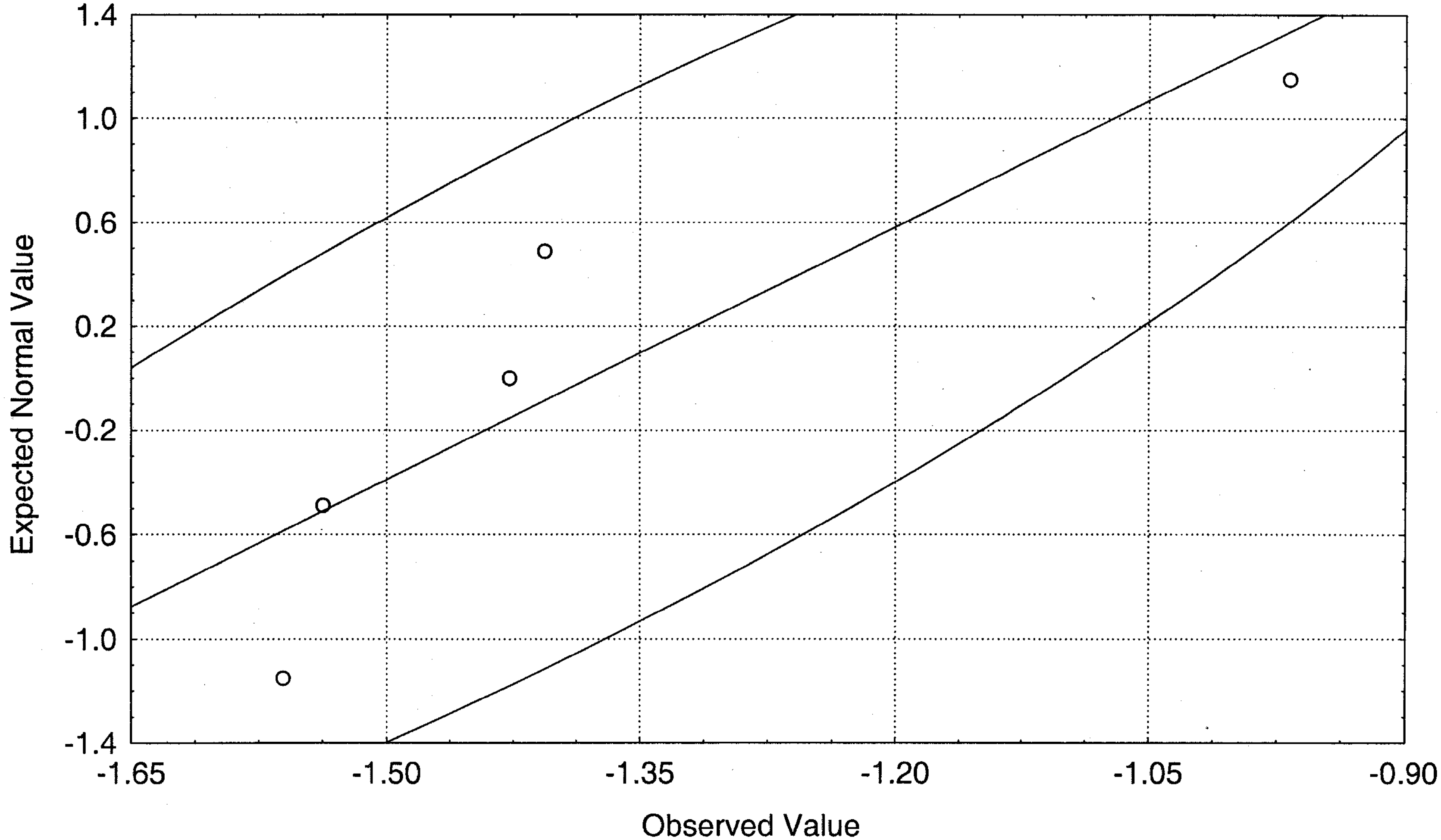
Normal Probability Plot of ABL NICKEL NORMAL
y=-14.736+1.574*x+eps
Expected Normal Value
1.4
1.0
0.6
0.2
-0.2
-0.6
-1.0
-1.4
8.4
8.6
8.8
9.0
9.2
9.4
9.6
9.8
10.0
Observed Value

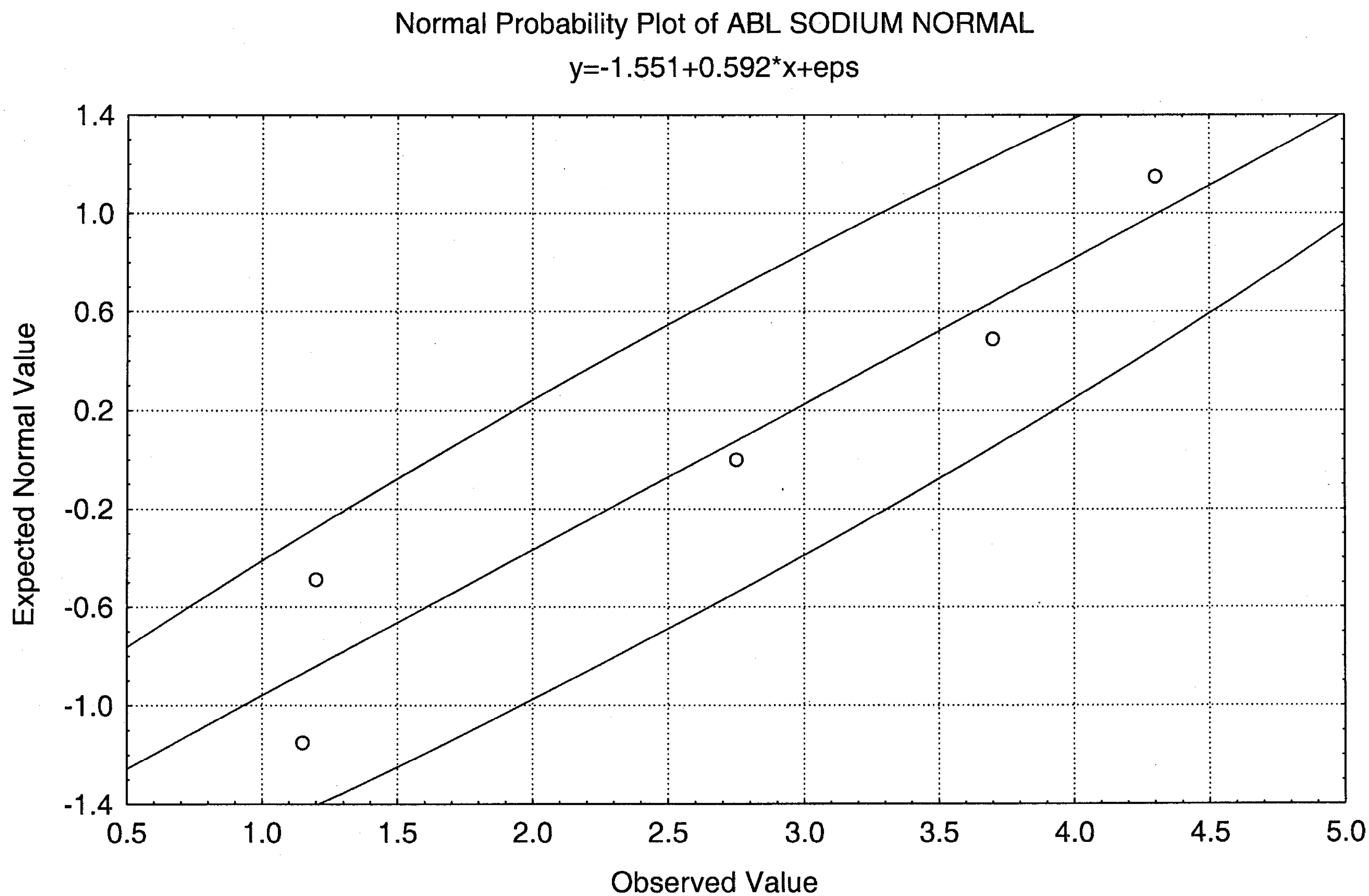


Normal Probability Plot of ABL POTASSIUM NORMAL
y=-5.155+0.008*x+eps
Expected Normal Value
1.4
1.0
0.6
0.2
-0.2
-0.6
-1.0
-1.4
440
480
520
560
600
640
680
720
760
Observed Value

Normal Probability Plot of ABL SELENIUM LOGNORMAL

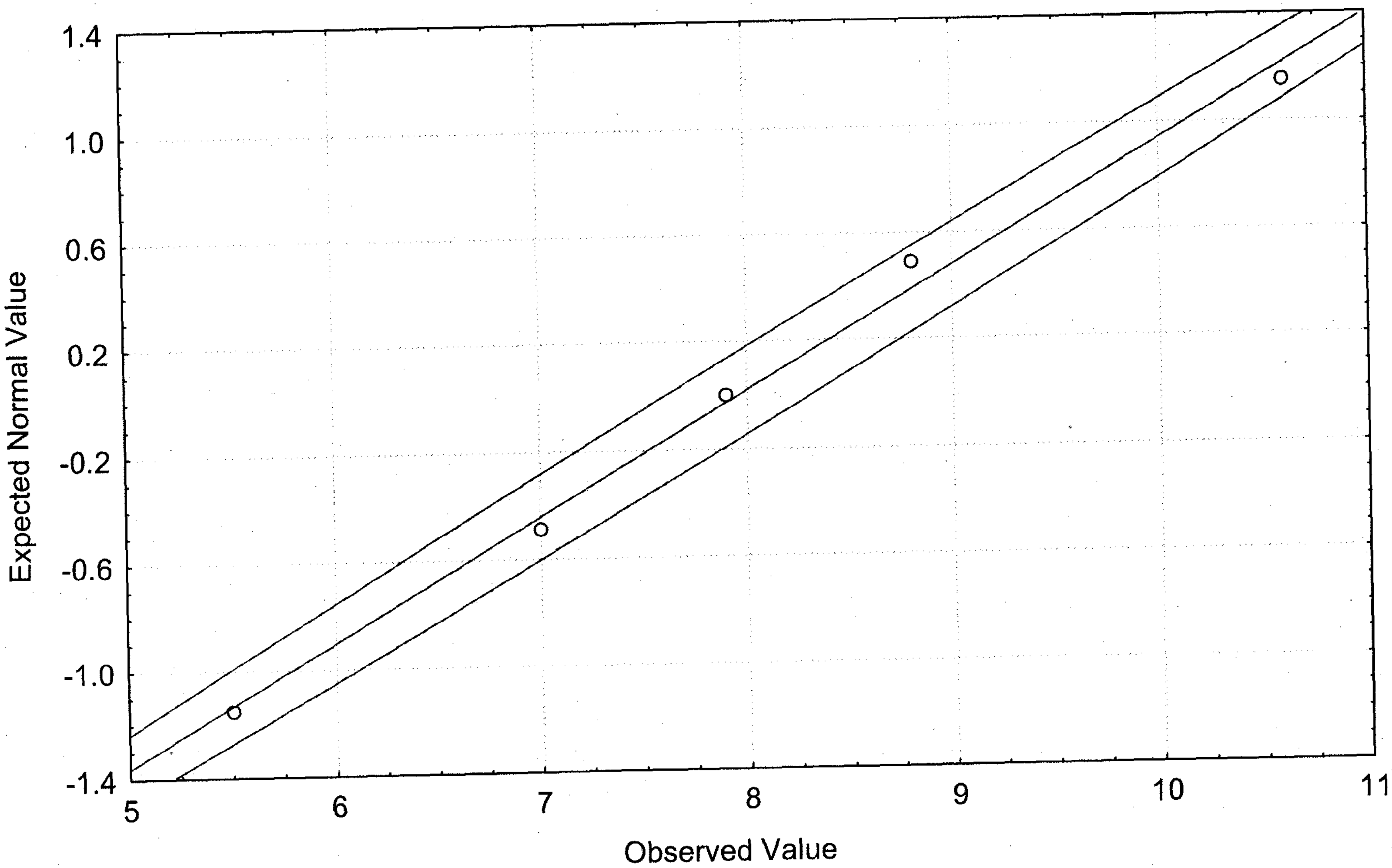
y=4.469+3.239*x+eps

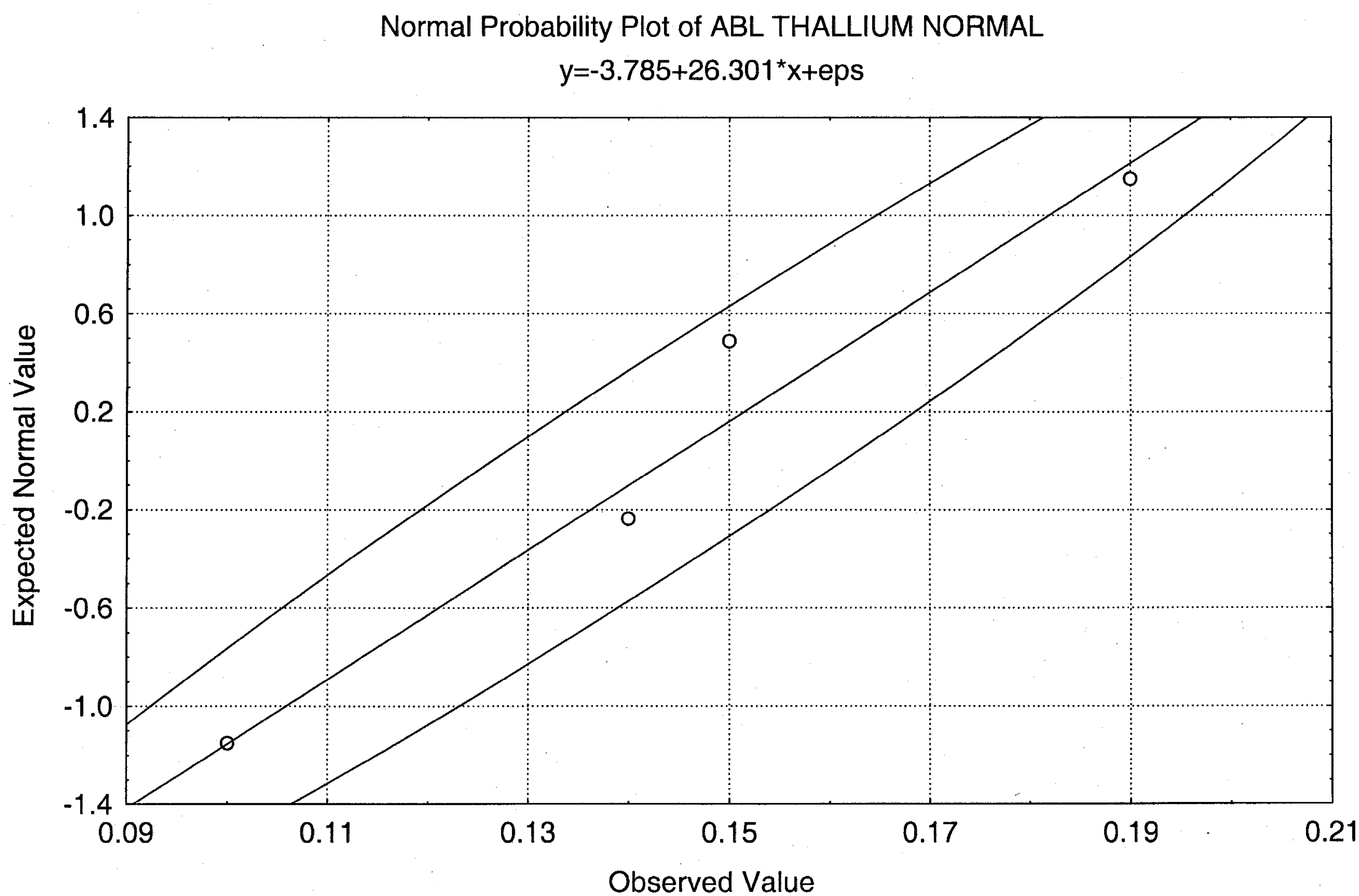



Normal Probability Plot of ABL SODIUM NORMAL
y=-1.551+0.592*x+eps
Expected Normal Value
1.4
1.0
0.6
0.2
-0.2
-0.6
-1.0
-1.4
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
Observed Value

(ABi)

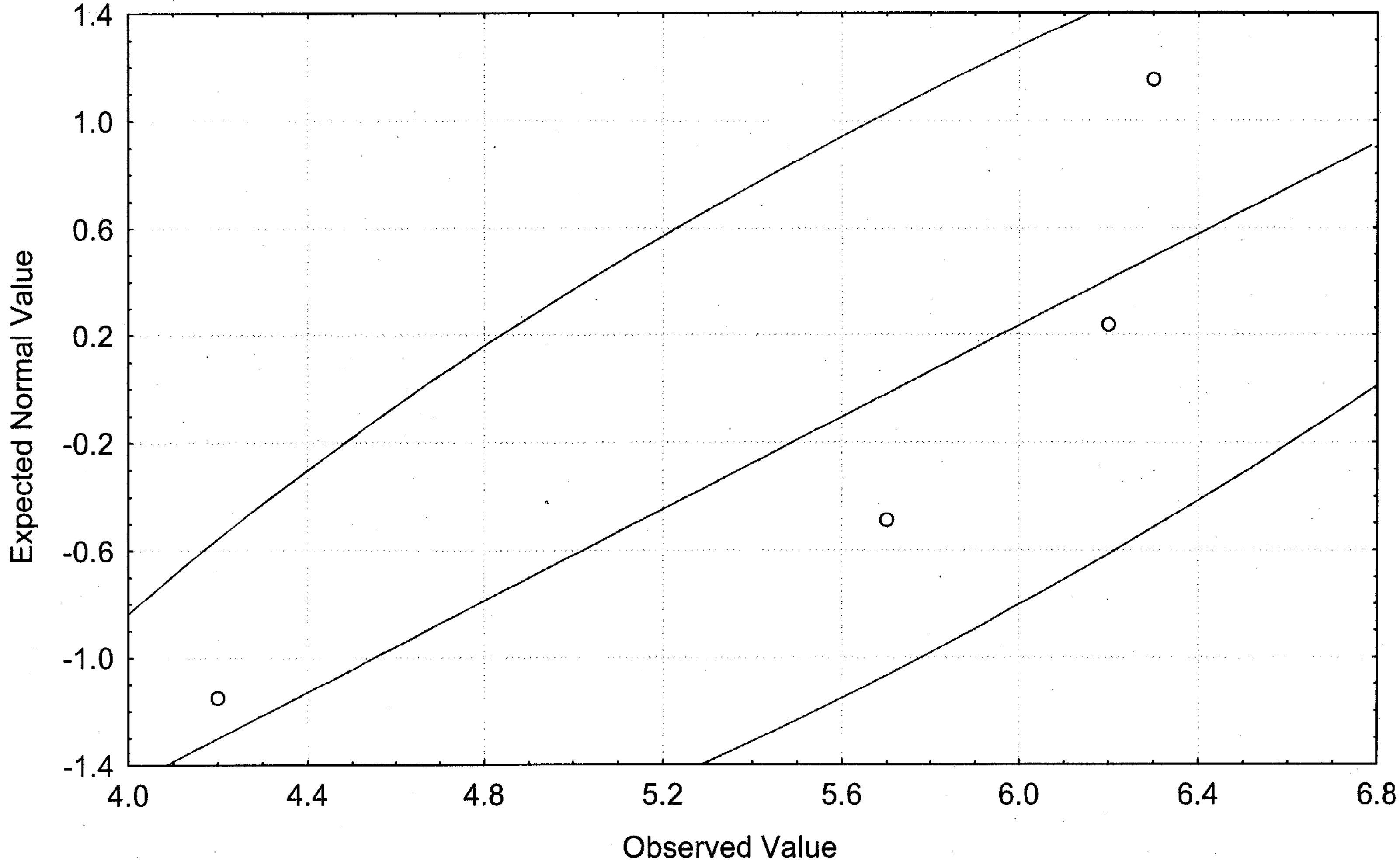
Normal Probability Plot of Alluvial Subsurface Silt - Strontium - Normal

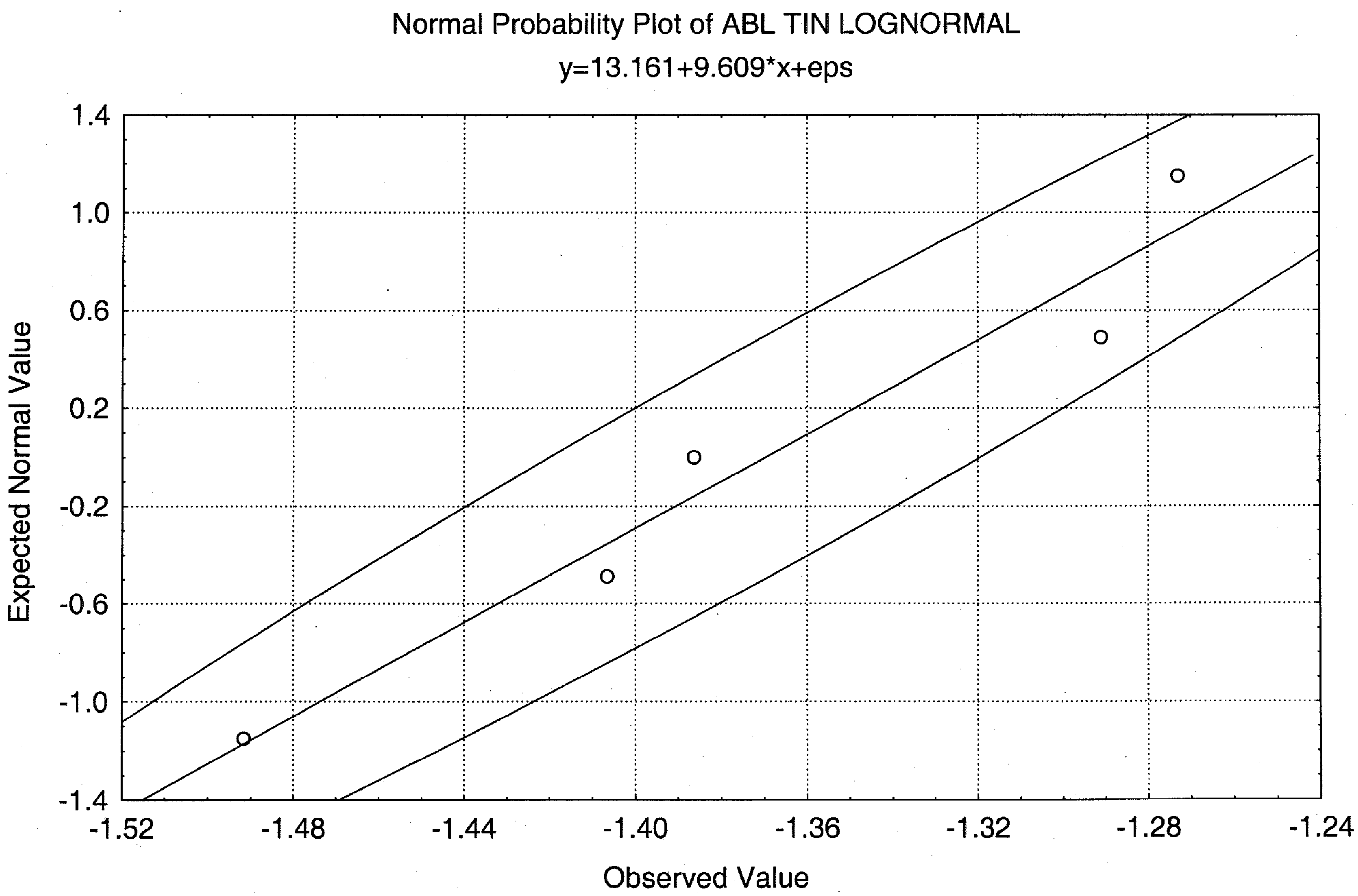


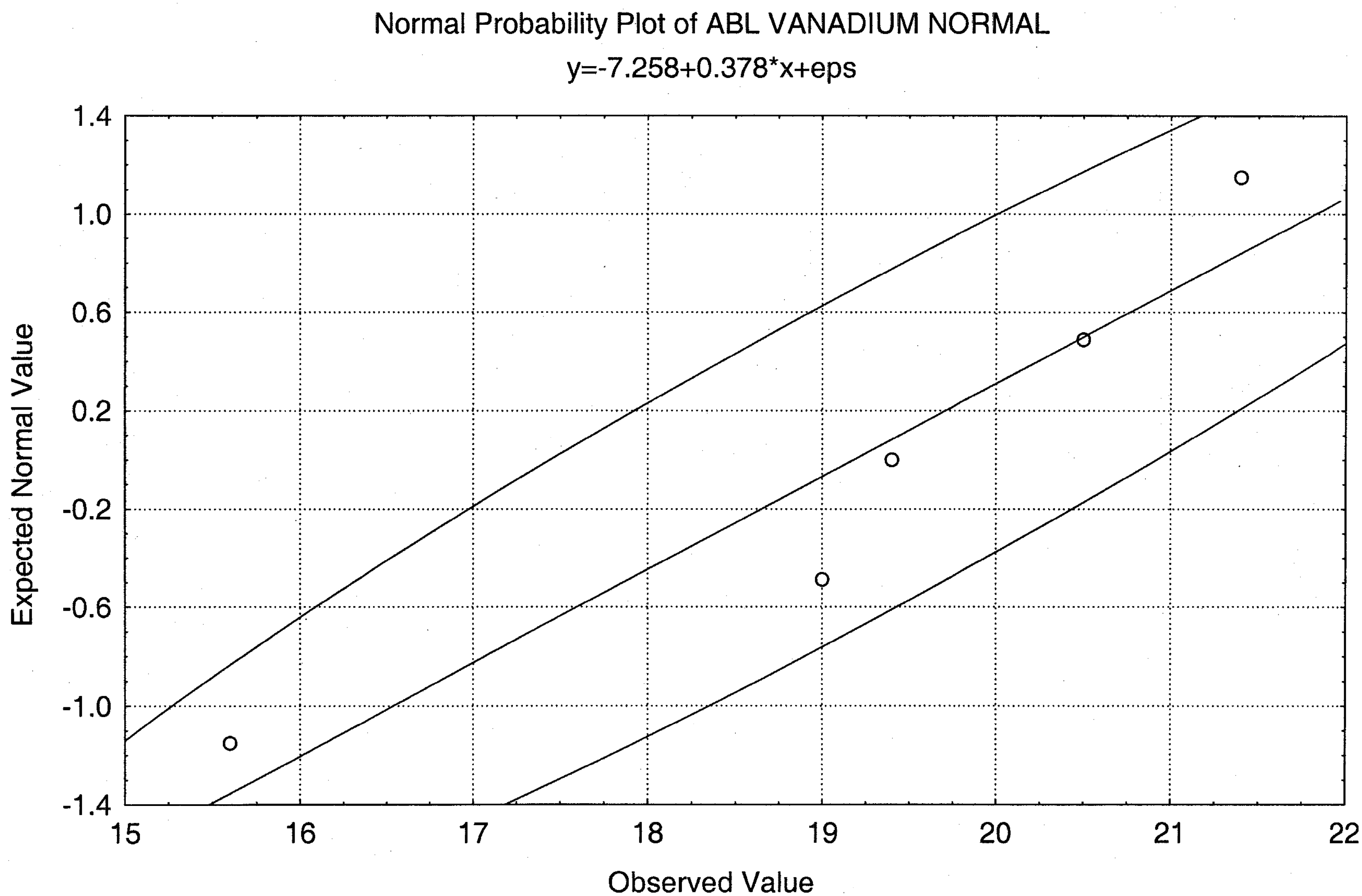

Normal Probability Plot of ABL THALLIUM NORMAL
y=-3.785+26.301*x+eps
Expected Normal Value
1.4
1.0
0.6
0.2
-0.2
-0.6
-1.0
-1.4
0.09
0.11
0.13
0.15
0.17
0.19
0.21
Observed Value

(ABL)

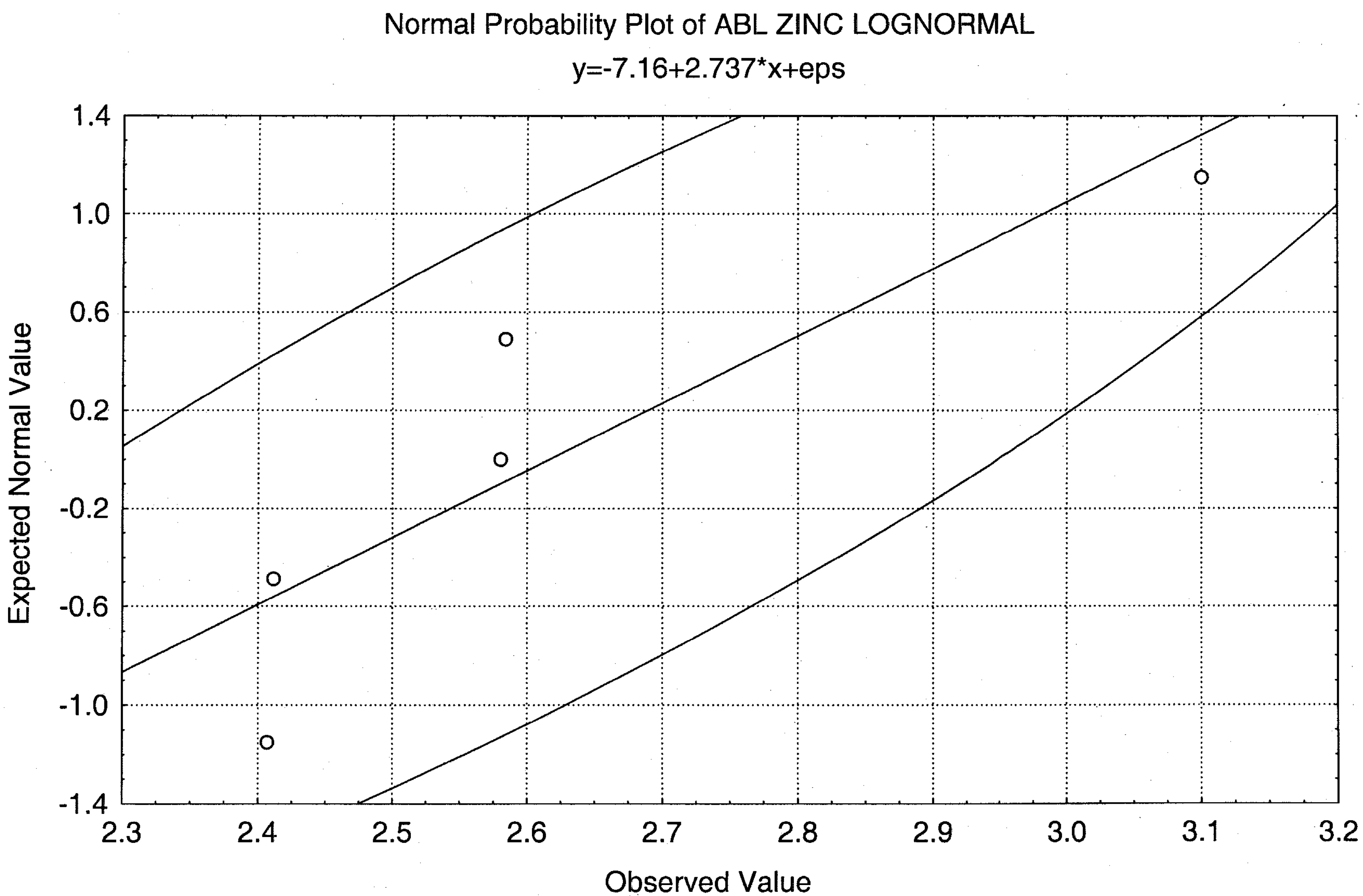
Normal Probability Plot of Alluvial Subsurface Silt - Thorium - Normal




Normal Probability Plot of ABL TIN LOGNORMAL
y=13.161+9.609*x+eps
1.4
1.0
0.6
0.2
-0.2
-0.6
-1.0
-1.4
Expected Normal Value
-1.52
-1.48
-1.44
-1.40
-1.36
-1.32
-1.28
-1.24
Observed Value



Normal Probability Plot of ABL VANADIUM NORMAL
y=-7.258+0.378*x+eps
Expected Normal Value
1.4
1.0
0.6
0.2
-0.2
-0.6
-1.0
-1.4
15
16
17
18
19
20
21
22
Observed Value


Normal Probability Plot of ABL ZINC LOGNORMAL
y=-7.16+2.737*x+eps
Expected Normal Value
Observed Value
1.4
1.0
0.6
0.2
-0.2
-0.6
-1.0
-1.4
2.3
2.4
2.5
2.6
2.7
2.8
2.9
3.0
3.1
3.2

D.2.3 **Examples of 95% Confidence Interval Results**

27 comparisons (one for each of 27 metals) of Pennsylvanian Subsurface Sand results with the 95% Confidence Interval of combined Pennsylvanian Subsurface Clay / Pennsylvanian Subsurface Silt

Appendix D.2.3
Comparison of Pennsylvanian Subsurface Sand (PBS) Results
with 95% Confidence Intervals of Penssylvanian Subsurface Clay and Sand (PB)

PARAMETER	PBS Result	Group PB 95% Confidence Interval (95% CR)		Group PB Range (Min - Max)		PB Result Within PB 95% CI?	PB Result Within PB Range?
ALUMINUM	5,430	11,500	14,200	9,070	16,200	NO (LOW)	NO (LOW)
ANTIMONY	0.38	0	3.00	0.155	11.3	YES	YES
ARSENIC	2.9	5.03	7.57	1.4	9.0	NO (LOW)	YES
BARIUM	24.8	47.7	73.6	25.1	116	NO (LOW)	NO (LOW)
BERYLLIUM	0.14	0.258	0.423	0.21	0.60	NO (LOW)	NO (LOW)
CADMIUM	0.14	0.200	0.826	0.04	2.1	NO (LOW)	YES
CALCIUM	53.6	0	1,520	85.2	5,320	YES	NO (LOW)
CHROMIUM	7.7	17.9	23.2	14.2	30.6	NO (LOW)	NO (LOW)
COBALT	8.8	6.62	9.55	5.2	12.5	YES	YES
COPPER	5.6	12.4	17.6	7.5	23.8	NO (LOW)	NO (LOW)
IRON	11,300	19,900	27,400	14,800	40,800	NO (LOW)	NO (LOW)
LEAD	11.7	11.1	13.8	8.6	15.4	YES	YES
LITHIUM	8.6	16.0	26.6	13.7	46.6	NO (LOW)	NO (LOW)
MAGNESIUM	654	1,660	2,250	1,100	2,870	NO (LOW)	NO (LOW)
MANGANESE	327	159	537	29	1,410	YES	YES
MERCURY	0.02	0.0202	0.0576	0.02	0.14	NO (LOW)	YES
NICKEL	4.6	11.5	15.7	9.8	23.7	NO (LOW)	NO (LOW)
POTASSIUM	353	894	1,140	718	1,330	NO (LOW)	NO (LOW)
SELENIUM	0.28	0.278	0.501	0.14	0.88	YES	YES
SILVER	0.05	0.0429	0.0607	0.025	0.1	YES	YES
SODIUM	1.15	13.4	81.3	7.4	205	NO (LOW)	NO (LOW)
STRONTIUM	5.4	11.8	16.1	8.5	20.3	NO (LOW)	NO (LOW)
THALLIUM	0.09	0.162	0.215	0.1	0.25	NO (LOW)	NO (LOW)
THORIUM	4.9	7.96	9.56	6.9	11.70	NO (LOW)	NO (LOW)
TIN	0.215	0.310	0.382	0.25	0.455	NO (LOW)	NO (LOW)
VANADIUM	14.1	28.6	36.7	20.9	48.5	NO (LOW)	NO (LOW)
ZINC	11.4	31.7	43.1	24.3	58.2	NO (LOW)	NO (LOW)

If the PBS results are statistically similar to the 15 PB results, the probability that PBS would exhibit 18 or more of the 27 lowest values is 1.76×10^{-15} % (1 in 567 trillion).

D.2.4 **Example of Wilcoxon Rank-Sum Test Results**

27 comparisons (one for each of 27 metals) of combined Pennsylvanian Subsurface Clay versus Pennsylvanian Subsurface Silt

Appendix D.2.4
Wilcoxon Rank-Sum (WRS) Results of
Pennsylvanian Subsurface Clay versus Pennsylvanian Subsurface Silt

PARAMETER	Rank Sum PBC	Rank Sum PBL	Valid N PBC	Valid N PBL	Rank Avg PBC	Rank Avg PBL	U	Z	p-level	Z adjusted	p-level	PBC and PBL Similar?
ALUMINUM	16	29	4	5	4.00	5.80	6	-0.9798	0.3272	-0.9798	0.3272	YES
ANTIMONY	24	21	4	5	6.00	4.20	6	0.9798	0.3272	0.9798	0.3272	YES
ARSENIC	16	29	4	5	4.00	5.80	6	-0.9798	0.3272	-0.9798	0.3272	YES
BARIUM	22	23	4	5	5.50	4.60	8	0.4899	0.6242	0.4899	0.6242	YES
BERYLLIUM	26	19	4	5	6.50	3.80	4	1.4697	0.1417	1.4697	0.1417	YES
CADMIUM	14	31	4	5	3.50	6.20	4	-1.4697	0.1417	-1.4697	0.1417	YES
CALCIUM	24	21	4	5	6.00	4.20	6	0.9798	0.3272	0.9798	0.3272	YES
CHROMIUM	18	27	4	5	4.50	5.40	8	-0.4899	0.6242	-0.4899	0.6242	YES
COBALT	18	27	4	5	4.50	5.40	8	-0.4899	0.6242	-0.4899	0.6242	YES
COPPER	21	24	4	5	5.25	4.80	9	0.2449	0.8065	0.2449	0.8065	YES
IRON	20	25	4	5	5.00	5.00	10	0.0000	1.0000	0.0000	1.0000	YES
LEAD	15	30	4	5	3.75	6.00	5	-1.2247	0.2207	-1.2247	0.2207	YES
LITHIUM	25	20	4	5	6.25	4.00	5	1.2247	0.2207	1.2247	0.2207	YES
MAGNESIUM	15	30	4	5	3.75	6.00	5	-1.2247	0.2207	-1.2247	0.2207	YES
MANGANESE	13	32	4	5	3.25	6.40	3	-1.7146	0.0864	-1.7146	0.0864	YES
MERCURY	14	31	4	5	3.50	6.20	4	-1.4697	0.1417	-1.7566	0.0790	YES
NICKEL	18	27	4	5	4.50	5.40	8	-0.4899	0.6242	-0.4920	0.6228	YES
POTASSIUM	21	24	4	5	5.25	4.80	9	0.2449	0.8065	0.2460	0.8057	YES
SELENIUM	20	25	4	5	5.00	5.00	10	0.0000	1.0000	0.0000	1.0000	YES
SILVER	16	29	4	5	4.00	5.80	6	-0.9798	0.3272	-1.3416	0.1797	YES
SODIUM	27	18	4	5	6.75	3.60	3	1.7146	0.0864	1.7146	0.0864	YES
STRONTIUM	29	16	4	5	7.25	3.20	1	2.2045	0.0275	2.2045	0.0275	NO
THALLIUM	17	28	4	5	4.25	5.60	7	-0.7348	0.4624	-0.7442	0.4568	YES
THORIUM	28.5	16.5	4	5	7.13	3.30	1.5	2.0821	0.0373	2.0908	0.0366	NO
TIN	29	16	4	5	7.25	3.20	1	2.2045	0.0275	2.2138	0.0269	NO
VANADIUM	14.5	30.5	4	5	3.63	6.10	4.5	-1.3472	0.1779	-1.3529	0.1761	YES
ZINC	21	24	4	5	5.25	4.80	9	0.2449	0.8065	0.2449	0.8065	YES

D.2.5 Matrices Conveying Combinations of Soil Types due to Wilcoxon Rank-Sum Test Results

TABLE D-5
SUMMARY OF WILCOXON RANK-SUM RESULTS OF COMPARISONS OF SUBSURFACE SOIL TYPES WITHIN DEPOSITIONAL ENVIRONMENTS

ABS and ABL combined

	ABC	ABL	ABS
ABC		5 (~~X~~)	5 (~~X~~)
ABL			0
ABS			

MBC and MBS combined

	MBC	MBL	MBS
MBC		3	0
MBL			6
MBS			

LBC, LBL, and LBS combined

	LBC	LBL	LBS
LBC		2 AL P=0.016, MN P=0.009	0
LBL			0
LBS			

PBC and PBL combined

	PBC	PBL	PBS
PBC		1 SN P = 0.027	X
PBL			X
PBS			

IN MATRIX INDICATES # OF THE 24 METALS THAT WHERE STATISTICALLY DIFFERENT
X INDICATES THAT SAMPLE SIZE TOO SMALL FOR COMPARISON

Table D-6
Number of Statistically Different Metals (out of 27) between Soil Groups Across Depositional Environments

	AB	ABC	AS	LB	LS	MB	MBL	MS	PB	PBS	PS	
AB				13	12	6	13	12	15		9	AB
ABC				10	8	5	10	6	11		5	ABC
AS				9	5	6	8	1 CD 0.009	8		1 SE 0.009	AS
LB						**3 CD 0.0008 SE 0.01 AG 0.007**	10	12	9		8	LB
LS						8	10	4	13		7	LS
MB									4		8	MB
MBL									**3 AS 0.028 CD 0.020 SE 0.020**		1 SE 0.009	MBL
MS									10		**3 CD 0.009 PB 0.022 MN 0.047**	MS
PB												PB
PBS												PBS
PS												PS
	AB	ABC	AS	LB	LS	MB	MBL	MS	PB	PBS	PS	

METALS
AS = ARSENIC
AG = SILVER
CD = CADMIUM
MN = MANGANESE
PB = LEAD
SE = SELENIUM

D-3 DETAILED DISCUSSION OF SOIL TYPE CHARACTERIZATION AND CONSOLIDATION

Appendix D-3

Detailed Discussion of Soil Type Characterization and Consolidation

Two different data analyses were conducted in an effort to identify unique soil groups that could be used for background comparisons during site investigations. The first analysis included 24 metals and identified nine different soil groups. Later, three metals were added to the list of original 24 metals. The analyses were then repeated with the entire set of 27 metals. The result of the second analysis was seven (compare to nine) different soil groups. How each analysis was conducted and how the difference in the number of soil groups generated by each analysis was reconciled is described below. These descriptions apply to each of the two data analyses unless otherwise indicated.

As planned, an attempt was made to combine analytical data sets from different soil types for two reasons: (1) to increase the statistical power achievable when performing comparisons of site data to background data, and (2) to minimize, if warranted, the number of background data sets that would be required when performing background comparisons as part of site investigations. Combinations of analytical data from different soil types into groups are referred to herein as soil groups.

Initially, data sets were compared for each of 24 metals within a DE for different grain sizes using a non-parametric Wilcoxon Rank Sum comparison method (methodology outlined in Appendix D-1). The data distribution of each soil type was compared against the data distribution for each of the other 15 soil types (if available), metal by metal, to determine whether a difference exists at the 5% significance level.

With the many comparisons that were done, random statistical fluctuations alone were likely to generate *apparent* differences between soil types where none exist. To counter this effect, binomial probabilities were used to compute the tolerable number of observed differences when the soil types being compared are the same (methodology in Appendix D-1). When considering data for just 24 metals, those probabilities allowed up to two metals to show statistically significant concentration differences before an actual difference in soil type was inferred to exist. If three or more metals exhibited a difference at the 5% significance level, the soil types were inferred to differ and were not combined into the same soil group. When data for 27 metals were considered, the allowable number of differences for soil types combined into a single soil group changed from two to three. The significance of this is explained below, where appropriate.

Based on the Wilcoxon Rank Sum (WRS) comparisons for 24 metals, two or three data sets, each representing soil types, were combined within each DE because the two or three data sets were statistically similar (i.e., not statistically different). The new data sets within a DE were then compared to similarly generated data sets in the other DEs. Based upon a comparison of data sets for statistical similarity, those soil types which were similar were combined into soil groups. These groups are illustrated in Figure 4-1 and the number of soil samples in the combined soil group data sets are displayed on the bottom portion of the figure.

Analysis after the First Field Event

Combination of soil types resulted in nine soil groups. A total of 5 soil groups were derived from the combination of two to three soil types showing statistically similar data distributions, as discussed above. However, loess/glacial outwash surface soil (LS) and residual soil from Mississippian subsurface silt (MBL) soil types exhibited no statistical similarities with other soil types. As a result these two soil types are maintained as separate soil groups. Finally, two soil types, alluvial subsurface clay (ABC) and residual Pennsylvanian subsurface sand (PBS), each had only one sample. Because statistical comparisons could not be performed on data sets of only one sample, these two soil types were not compared with other soil types, resulting in the two remaining soil groups.

The infrequency of encountering the ABC and PBS soil types during the first field investigation (tabulated in page 1, Table C-1, Appendix C-1) explains why each soil type is represented by only one sample. Statistically, there also were numerous metal concentration differences between these two soil types and the other soil types. A 95% confidence interval (CI; see Appendix D-1) was calculated for each metal in the combined alluvial subsurface (ABL and ABS) and Pennsylvanian subsurface (PBC and PBL) soil groups. The ABC and PBS data sets were then compared to their counterpart CIs to determine whether the values fell within the interval. In both cases a large proportion of the results (11 of 24 for ABC; and 17 of 24 for PBS) fell outside of their respective confidence interval. Even though incorporating these soil data sets into other data sets would have simplified the data analysis, the numerous differences between these data sets and the other data sets were too significant to justify this consolidation. The significance of the lack of sufficient samples for the ABC and PBS soil types is discussed further in Section 4.3.

The soil groups established for the first 24 metals using statistical analyses were evaluated from a geological/geochemical perspective to ensure that the soil groups are logical. Because the soil parent material largely determines the chemical composition it is likely that soil from similar DEs will exhibit similar metals concentrations. The statistical evaluation of surface soil and several subsurface soil type combinations are consistent with this expectation. In addition to the geological/geochemical evaluation, box and whisker plots (shown in Appendix D-2) were also used to aid in this review. Those plots provide a visual aid for inspecting the data sets to determine whether significant differences exist.

The statistical evaluations indicate that surface soil exhibits similar metal concentration data distributions across three of four DEs and that the similar data sets can be combined into soil group 3 shown in Figure 4-1. This conclusion is supported by accounts that describe surface soil as having been deposited in a similar manner over the entire facility (McElrath, 1988; see Section 2.7.2.2). Because the parent material is likely the same, the soil metals concentrations are also similar. It is also noted that the surface soil results were statistically different from the subsurface soil results. This is also supported geologically because the parent material is likely different for the surface and subsurface soil. Unexpectedly, the loess/glacial surface soil (LS) is not statistically similar to the metals concentrations of surface soil from the other DEs. This dissimilarity does not appear to be an artifact of the chemical analyses. Because of the differences between the LS soil type and the other surface soil types, the LS soil type is referred to as separate soil group (soil group 1). Also notable is that all of the loess/glacial outwash subsurface soil types have been grouped into one soil group (soil group 2). This indicates that the metals concentrations are similar in this DE's subsurface soil irrespective of soil grain size. Because these samples originated from the same parent material it is likely that they would have similar metals concentrations.

Subsurface soil within the Mississippian DE was also combined. In this DE subsurface Mississippian residual clay (MBC) and subsurface residual Mississippian sand (MBS) were combined into soil group 6 because of their chemical similarity. However, the Mississipian subsurface silt (MBL) in the same DE, which would be expected to exhibit metal concentrations intermediate to clay and sand, is measurably different from the clay and sand. It is unclear why the metals concentrations of subsurface silt in this DE are measurably different. This difference does not appear to be an artifact of the chemical analyses. With no basis for maintaining separation between the MBC and MBS soil types, they were combined. Because of the differences between the MBL soil type and the other soil types within the Mississipian DE, it is referred to as a unique soil group (soil group 7). From the observed data set differences, it is clear that soil grain size has an affect on how the subsurface soil from the Mississippian DE is grouped.

Other examples of subsurface soil type combinations according to DE include the subsurface soil from the alluvium DE and the subsurface residual soil from the Pennsylvanian DE. As expected, similarity between soil within each DE was apparent. Two out of the three subsurface soil types in each of these DEs were combined. However, one soil type in each DE (i.e., alluvial subsurface clay or ABC and Pennsylvanian subsurface sand or PBS) was statistically dissimilar to the other soil types within each respective DE. Coincidentally, only one sample was collected for chemical analysis for each of these two soil types.

As introduced above, with the increase from 24 metals to 27 metals, the cutoff for declaring statistically significant differences between soil groups was increased from 3 metals with statistically significant differences to 4 metals with statistically significant differences. If soil data sets are statistically similar there is a 11.6 % chance of obtaining 3 or more differences out of 24 metals and there is a 3.0% chance of obtaining 4 or more differences out of 24 metals. There is a 15.0 % chance of detecting 3 or more differences out of 27 metals and there is a 4.4% chance of detecting 4 or more differences out of 27 metals if the soil groups are actually statistically similar. Setting the acceptance criterion for detectable differences at the 5% significance level, 3 differences out of 24 and 4 differences out of 27 were selected as the cutoff points for detectable differences between data sets.

The primary Wilcoxon Rank-Sum (WRS) tests were repeated on data from 27 metals within each depositional environment (DE). Within the Loess/Glacial DE, all the subsurface soils are similar to each other (0 - 2 metals statistically different) while the surface soil is different (7 - 10 metals statistically different) the subsurface soils. So groups LBS, LBL, and LBS were combined into one group LB while group LS remains its own group (see Table 4-13).

Within the Mississippian DE, MBC is similar to both MBS and MBL (1 and 3 metals statistically different respectively) while MBL and MBS are dissimilar (9 metals statistically different). Because MBC is more similar to MBS than to MBL, MBC and MBS were combined into one group, MB, while MBL was relegated to its own group (see Table 4-13). The surface soil in this DE (i.e., MS) is different (7 - 9 metals statistically different) from the subsurface soils so MS remains its own group (see Table 4-13).

Within the Pennsylvanian DE, PBL is similar to both PBC and PS (3 and 0 metals that are statistically different, respectively) while PBC and PS are dissimilar (4 metals that are statistically different). PBL and PBC were combined into one group, AB, with preference to combining soil types at different depths within a DE rather than combining soil types of similar grain size across DEs. PS and PBS (only one sample) remain in their own groups (see Table 4-13).

Within the Alluvial DE, ABS is similar to both ABL and AS (1 metal statistically different) while ABL and AS are dissimilar (4 metals statistically different). ABS and ABL were combined into one group, AB, again with preference given to combining data within a DE rather than across DEs (see Table 4-13). AS and PBC (only one sample) remain in their own groups.

At this point, 11 soil groups had been generated based on the analysis of data for 27 metals. Two of the soil groups contained only one sample whereas the other nine groups each contained more than one sample. A secondary WRS comparison was made to determine whether any of the soil groupings were similar enough that they could be consolidated.

In the secondary WRS comparisons, the 9 (out of 11) remaining soil groupings with more than 1 sample were all compared to each other. PS was similar to AS, MS, MBL, and PB. While AS and MS are similar to each other and MBL and PB are similar to each other, neither MBL nor PB are similar to AS (10 and 9 metals statistically different, respectively) or MS (9 and 12 metals statistically different, respectively). On this basis PS, AS, and MS were combined into group S, while PBC/PBL and MBL (3 metals statistically different) were combined into a group (see Table 4-13). Groups LBC/LBL/LBC and MBC/MBS (3 metals statistically different) were combined into a group (see Table 4-13).

The two soil groups containing one sample (PBS and ABC) each were then compared to the remaining soil groups using a 95% confidence limit test to determine whether they could be combined statistically with any other group. Both soil groups had more than ten differences from the other soil groups. PBS had 17 out of the 27 metals outside the 95% confidence interval for the PBC/PBL/MBL group while ABC had 15 out of the 27 metals outside the 95% confidence interval for the PBC/PBL/MBL group. Because these values didn't seem similar to the other groups from their DE they were retained as their own soil groups.

At this point 7 combined soil groups remained (also see Table 4-13):

1. LS = Loess/Glacial Surface Soil (LS)
2. L/MB = Loess/Glacial Subsurface Clay (LBC), Loess/Glacial Subsurface Silt (LBL), Loess/Glacial Subsurface Sand (LBS), Mississippian Subsurface Clay (MBC) and Mississippian Subsurface Sand (MBS)
3. S = Mississippian Surface Soil (MS), Pennsylvanian Surface Soil (PS), and Alluvial Surface Soil (AS)
4. PB/MBL = Pennsylvanian Subsurface Clay (PBC),Pennsylvanian Subsurface Silt (PBL), and Mississippian Subsurface Silt (MBS
5. PBS = Pennsylvanian Subsurface Sand (PBS) [only 1 sample]
6. ABC = Alluvial Subsurface Clay (ABC)) [only 1 sample]
7. AB = Alluvial Subsurface Silt (ABL) and Alluvial Subsurface Sand (ABS)

The seven soil groups illustrated in Table 4-13 appears to be valid from a purely statistical perspective. However, combining the subsurface loess/glacial soil with subsurface Mississippian clay and sand soil (MBC and MBS) to form a soil group and combining subsurface Pennsylvanian clay and silt (PBC and PBL) to form a soil group is problematic from a geological point of view. As stated above and in Sections 3 and 4, soil within a DE are expected to have similar metal concentrations and as a result group together because they have a similar parent material. On the other hand, because the parent material is different from DE to DE it is less likely these soil types would be similar. This is especially the case for the loess/glacial soil and the Pennsylvanian and Mississippian derived soil because their parent material is expected to be geochemically different. It is noted that the differences between the alluvial soil and the soil in other DEs would be less different because the alluvial soil may be derived, at least in part, from soil in other DEs. Furthermore, it is unlikely that certain soil grain sizes would be similar to other grains sizes across DEs, while others would not as was shown by the pure statistical result (i.e., outcome of 7 soil groups).

It is also noted that the three additional metals analyzed (lithium, strontium, and thorium) did not generate any statistically detectable differences among metals in various soil types. Instead, the reclassifications of soil types into different soil groups resulted from a change in the acceptance criterion for detectable differences (i.e., three differences instead of four). This criterion was used as a guide to accommodate the realization that the number of observed differences among metals is likely to increase with the number of metals included in the data analysis. As such it is not considered to carry the same importance as similarities or differences among DEs. Finally, the differences between the two soil grouping schemes (7 versus 9 soil groups) are relatively minor. Thus, the outcome of background comparisons during site investigations should be similar no matter which of the two grouping schemes is used. Given all of these considerations, the original nine soil groupings determined using only the 24 metals (Figure 4-1) were selected as the final soil groupings because the geological considerations were judged to outweigh the purely statistical evaluations.

Analysis after the Supplemental Field Event

Two additional samples of type ABC were collected and analyzed during the supplemental field event in October 2000. With the addition of these two samples the ABC soil group now had three samples, enough for WRS comparisons to the other soil groups. Comparisons of the ABC metals to each Alluvial soil type (AS, ABS, and ABL) as well as each soil type in the other DEs produced at least 5 of 27 metals statistically different, so the ABC remained in its own soil group.

Summary

A summary of analytical results table was generated for each of the nine soil groups to provide an overview of each soil group. These tables are numbered Tables 4-2 through 4-10. Each group represents soil types that have similar metal concentration distributions. Four of the soil types could not be combined with any other soil type. Within a DE a maximum of three soil groups exists. Thus, for any SWMU that lies entirely within a single DE, no more than three background data sets will be needed for comparisons with site data to determine whether the site metal concentrations exceed background concentrations. For each DE two of the soil groups exist solely because of differences between surface and subsurface soil. One soil group (PBS or soil group #9, Figure 4-1) remains which does not have a sufficient number of samples for background comparison. Please refer to Sections 4.4 and Section 6.2 for more information on the data collection in these soil groups.

APPENDIX E

HUMAN HEALTH AND ECOLOGICAL RISK-BASED CRITERIA

TABLE E-1

HUMAN HEALTH AND ECOLOGICAL RISK-BASED CRITERIA
BASEWIDE BACKGROUND SOIL INVESTIGATION REPORT
NAVAL SURFACE WARFARE CENTER
CRANE, INDIANA

Chemical	U.S. EPA SSL[1] Ingestion (mg/kg)	U.S. EPA SSL[1] Inhalation (mg/kg)	U.S. EPA SSL[1] Migration to Ground Water (mg/kg)	Region 9 PRG[2] Residential Land Use (mg/kg)	Region 9 PRG[2] Industrial Land Use (mg/kg)	IDEM Tier 1 Default Cleanup Level[3] Residential Land Use Surface Soil (mg/kg)	IDEM Tier 1 Default Cleanup Level[3] Residential Land Use Subsurface Soil (mg/kg)	IDEM Tier 1 Default Cleanup Level[3] Non-Residential Land Use Surface Soil (mg/kg)	IDEM Tier 1 Default Cleanup Level[3] Non-Residential Land Use Subsurface Soil (mg/kg)	Region 5 EDQL[4] (mg/kg)
Aluminum				75000	100000					
Antimony	31		0.3	30	750					0.1423
Arsenic	0.4	750	1	0.38	3	3.9	29.2	19.6	29.2	5.7
Barium	5500	690000	82	5200	100000	1000	1000	1000	1000	1.04
Beryllium	0.1	1300	3	0.14	1.2	1.87	63.2	10.1	63.2	1.06
Cadmium	78	1800	0.4	37	930	24	7.52	1000	154	0.18095
Calcium										
Chromium	390	270	2	30[5]	64[5]	1000	38.4	1000	196	0.4
Cobalt				3300	29000					0.14033
Copper				2800	70000					0.3132
Iron				22000	100000					
Lead	400[6]			400[6]	1000[6]					0.45053
Lithium				1,500	37,000					
Magnesium										
Manganese				3100	45000					
Mercury	23	10	0.1	22	560	54.7	2.09	147	32	0.0079
Nickel	1600	13000	7	1500	37000	1000	130	1000	1000	13.6
Potassium										
Selenium	390		0.3	370	9400	1000	5.2	1000	53.1	0.02765
Silver	390		2	370	9400	1000	31	1000	86.9	4.04
Sodium										
Strontium				45,000	100,000					
Thallium			0.04	6[7]	150[7]	1000	2.85	1000	1000	0.05692
Thorium										
Tin				45000	100000					7.62
Vanadium	550		300	520	13000					1.59
Zinc	23000		620	22000	100000	1000	1000	1000	1000	6.62

1 U.S. EPA Soil Screening Levels. (Soil Screening Guidance Technical Background Document. EPA/540/R-95/128. Office of Solid Waste and Emergency Response, Washington, D.C. Directive 9355.4-17A, May 1996.) For migration to ground water, values associated with a dilution and attenuation factor (DAF) of 1 are used.
2 U.S. EPA Region 9 Preliminary Remediation Goal. (U.S. EPA Region 9, May 1998.)
3 Risk-Integrated System of Cleanups. Indiana Department of Environmental Management. October 21, 1997.
4 U.S. EPA Region 5 Ecological Data Quality Levels (April 1998).
5 Hexavalent chromium.
6 OSWER soil screening level for residential land use (U.S. EPA, July 1994).
7 Thallium carbonate.

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Environmental Protection Department Manager
TITLE

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